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B. T. GALLOWAY, Chief of Bureau.

THE DISTINGUISHING CHARACTERS OF THE SEEDS OF QUACK-GRASS AND OF CERTAIN WHEAT-GRASSES.

BY

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THE DISTINGUISHING CHARACTERS OF THE SEEDS OF QUACK-GRASS AND OF CERTAIN WHEAT-GRASSES.[a]

INTRODUCTION.

In view of the noxious character of quack-grass, quitch-grass, or couch-grass (*Agropyron repens* L.), the recognition of its seeds as an impurity of commercial seeds is important and desirable. This matter has special significance in connection with the seed of the forage plant known as awnless, or Hungarian, brome-grass (*Bromus inermis* Leyss). Brome-grass is extensively handled in the American market, and much of the seed offered is imported either from Europe or from the western provinces of Canada.

Examination of samples of brome-grass seed taken from imported lots shows that seed from Europe invariably contains seed of quack-grass, which is rarely found in seed from Canada. In the place of quack-grass seed the Canadian brome-grass seed usually contains seed of one or another of the wheat-grasses which are native to the Western States and to Canada and which have much the same habit of growth as quack-grass. Since these wheat-grasses are native to this country and to Canada, their seeds do not appear in brome-grass seed imported from Europe. The seeds of the wheat-grasses are so similar to those of quack-grass that they may readily be mistaken for the latter. It becomes important, therefore, that the presence of the seed of quack-grass in brome-grass seed be detected with certainty and that lots of brome-grass seed carrying seed of wheat-grass only may be distinguished and not rejected as suspected of containing quack-grass seed.

The purpose of this paper is to so point out the distinguishing characters of the seeds of quack-grass and of the two kinds of wheat-grasses chiefly involved that their presence as an impurity of brome-grass or other forage-plant seeds may be practically determined.

[a] The distinguishing of the seeds of quack-grass, one of the greatest weed pests in the Northwest, from seeds of similar appearance is of importance in all regions where quack-grass may become troublesome. In the present paper the characteristic differences between the seeds of quack-grass and the seeds of other grasses of similar appearance have been pointed out in such a practical way as to furnish a means of readily determining the presence or absence of quack-grass seed in commercial seed.—Wm. A. Taylor, *Acting Chief of Bureau.*

Quack-grass and the wheat-grasses are closely related botanically, belonging to the same genus, Agropyron. The wheat-grasses commonly appearing in brome-grass seed are slender wheat-grass (*Agropyron tenerum* Vasey) and western wheat-grass (*Agropyron occidentale* Scribn.),[a] known also in the West as Colorado bluestem.

Owing to the close relationship of these grasses, their seeds, taken individually at least, appear to be practically indistinguishable. The structure and fruiting habits of the seed clusters, however, afford means for their recognition which appear to be well founded.

NATURE OF THE SEEDS OF AGROPYRON.

The individual seeds, or ripened florets, of Agropyron are produced in clusters termed "spikelets," each spikelet containing several seeds. At maturity the spikelets usually tend to break apart, permitting the seeds to separate. Not all the spikelets thus wholly go to pieces, but some appear in their entirety or in part in samples of seed. Thus, the term "seed," as popularly employed, refers in this case both to whole or partial spikelets and to individual seeds.

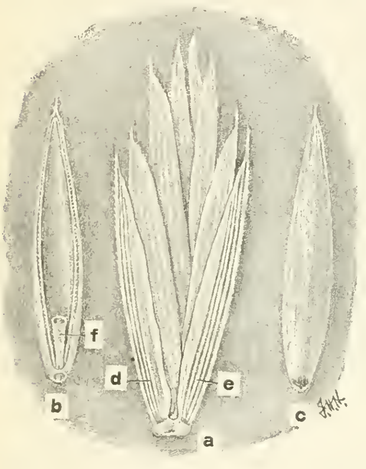

Fig. 1.—A spikelet and seeds of quack-grass, showing the general structure of the spikelets and seeds of Agropyron: *a*, A complete spikelet; *b*, the inner face of a seed, showing the grooved palea and the rachilla segment (*f*); *c*, a seed, showing the rounded back of the lemma; *d* and *e*, glumes of the spikelet. (Enlarged.)

The complete spikelet (see fig. 1, *a*) consists of a pair of oppositely placed, somewhat unequal, slender scales, or glumes (*d* and *e*), united at the base of the spikelet, and several alternately arranged "seeds," or ripened florets, situated between and above the glumes. The glumes are united side by side or on the same level, which is a readily observed mark of distinction in spikelets of Agropyron. They are more or less distinctly veined lengthwise, the veins varying from three to seven in the kinds under consideration. The variation in size and form of spikelet and in form, venation, etc., exhibited in the glumes of these kinds of Agropyron affords marks of distinction.

The individual seeds (see fig. 1, *b* and *c*), or ripened florets, consist of the grain inclosed between two scales, one of which, the lemma, is

[a] *Agropyron occidentale* Scribn. is described in the seventh edition of Gray's Manual under *A. smithii* Rydb., and in Britton's Manual under *A. spicatum* (Pursh) Scribn. and Sm.

larger than the other, the palea. The seeds are broadly grooved on the side bearing the palea (*b*) and rounded on that bearing the lemma (*c*). A portion of the cluster axis, termed the "rachilla segment" (*f*), appears at the base of the grooved palea of the seed. The individual seeds of Agropyron are so similar that no attempt is made here to distinguish the kinds by them. The number of seeds per spikelet varies from four or five to twelve. Both glumes and seeds may be either acute or awn pointed at the tips.

The spikelets are attached facewise to the axis bearing them (see fig. 2, *a* and *b*), differing from other grasses in which the spikelets are attached edgewise to the axis.

The spikelets and seeds of Agropyron are generally straw colored or tinged with green.

Fig. 2.—A section of the seed cluster of quack-grass, showing the mode of attachment of the spikelets to the rachis, or cluster axis: *a*, Side view; *b*, edge view. (Enlarged.)

THE SEEDS OF AGROPYRON AND OF BROME-GRASS COMPARED.

Seeds of awnless brome-grass (see fig. 3, *a*) are about three-eighths of an inch long, flattened and thin, light brown, the darker grain evident through the thin palea, which is more or less wrinkled and bears two slender, hairy veins. The slender rachilla segment is hairy. The rounded back, or lemma, of the seed is more or less distinctly five veined. The seeds of brome-grass are larger than those of quack-grass (fig. 3, *d*) and smaller than all except the smallest of the spikelets of the latter (fig. 3, *c*). Samples of brome-grass seed usually contain partial spikelets of brome-grass (fig. 3, *b*), which are not likely to be confounded with the spikelets of quack-grass when compared with the latter. The generally lighter color of the quack-grass seeds and spikelets, together with the opposite attachment of their glumes, serves to distinguish them from the brome-grass seeds.

THE SEEDS OF QUACK-GRASS, SLENDER WHEAT-GRASS, AND WESTERN WHEAT-GRASS DESCRIBED.

The following descriptions are designed to point out the contrasting characters of the mature spikelets of quack-grass, slender wheat-grass, and western wheat-grass, as they appear in commercial samples of seed.

QUACK-GRASS (AGROPYRON REPENS, L).

The spikelets of quack-grass (fig. 4) vary from one-half to three-fourths of an inch in length and contain four to seven seeds. Both glumes and individual seeds may be merely acute or may bear a short awn at the apex. The glumes may diverge somewhat, well exposing the seeds, or they may be nearly parallel, nearly covering the lower seeds. The two faces of the spikelet may be about equally convex and the angles between the glumes about equal on the two faces, or the faces may be unequally convex and the glumes more widely separated on the more convex face than on

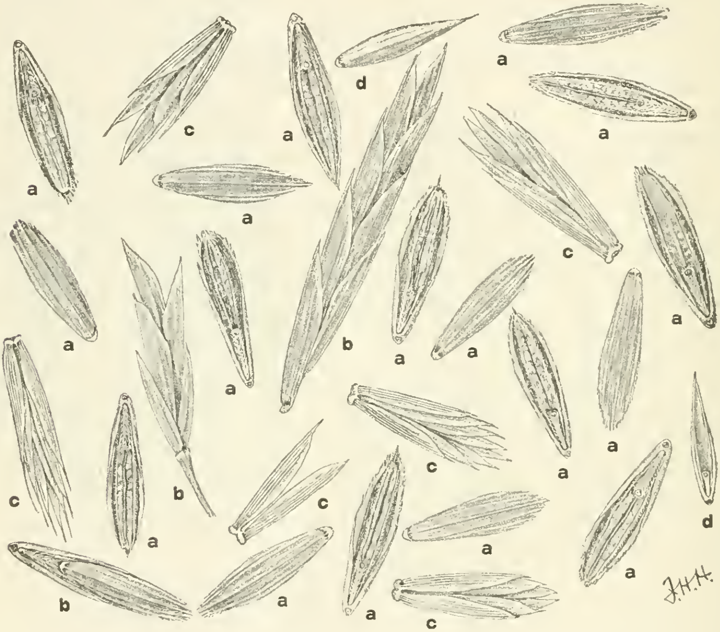

FIG. 3.—A mixture of seeds of awnless brome-grass (*a*), partial spikelets of brome-grass (*b*), spikelets and glumes of quack-grass (*c*), and seeds of quack-grass (*d*). (Enlarged about 2½ times.)

the other. The seeds extend beyond the tips of the glumes from slightly to half the length of the glumes. The glumes (see figs. 4 and 5) are five veined or seven veined, the veins distinct, the central or keel vein a little coarser than the others, giving the glumes a slightly keeled form. The margins of the glumes are thin, papery, narrowing to the apex, and usually merge abruptly into the pointed or awned tip.

Mature spikelets of quack-grass tend to retain the individual seeds and in consequence whole or partial spikelets always appear along with the comparatively few individual seeds in samples of brome-grass seed containing seeds of quack-grass.

SLENDER WHEAT-GRASS (AGROPYRON TENERUM, VASEY).

The spikelets of slender wheat-grass (fig. 6) vary from one-half to three-fourths of an inch in length and contain four to seven seeds. Both glumes and seeds may be slenderly acute or short awned at the apex. The glumes may diverge somewhat in mature spikelets, but they are commonly nearly parallel and curved at the back, the tips curving inwardly over the seeds, which exceed the glumes scarcely at all or by as much as one-third the length of the glume. The spikelets usually taper from the center to both ends both facewise and edgewise, the two faces being unequally convex, the glumes being more widely separated on the more convex face. (See fig. 6, *c*, *d*, and *e*.) The spikelets are generally narrower than those of quack-grass, the base being smaller as a rule.

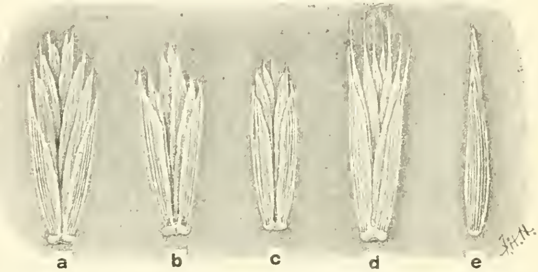

FIG. 4.—Spikelets of quack-grass, showing different forms. Note the forms of the glumes in *a*, *b*, *c*, *d*, and the awned form of glumes and seeds shown in *d*; *e*, edge view of spikelet. (Enlarged.)

The glumes (see fig. 6) are relatively broader than those of quack-grass, five veined to seven veined, the veins slender and distinct, the middle or keel vein scarcely coarser than the adjacent ones, and the glume rounded at the back rather than keeled or angled. The thin, papery margins of the glumes narrow gradually to the tapering or awned apex.

FIG. 5.—Empty glumes of quack-grass spikelets, showing common forms. (Enlarged.)

Mature spikelets of slender wheat-grass tend to break apart readily, only occasional complete spikelets appearing in commercial samples of seed. Empty glumes (see fig. 6, *a*) often remain united and appear both free from and attached to a part of the seed-cluster axis. As an impurity of brome-grass seed, slender wheat-grass, therefore, usually appears as free seed, with occasional spikelets or glumes to be depended upon for identification.

WESTERN WHEAT-GRASS (AGROPYRON OCCIDENTALE, SCRIBN.).

Well-developed spikelets of western wheat-grass (see fig. 7, *a*) are larger than those of either quack-grass or slender wheat-grass, often equaling an inch in length, but are commonly between five-eighths and three-fourths of an inch in length, lance shaped and compressed facewise. The slender glumes are more or less divergent, exposing the lower seeds. In the larger spikelets the seeds exceed the glumes equal to the length of the latter, making the larger spikelets twice as long as the glumes. The seeds are narrowly acute or awn pointed at the apex.

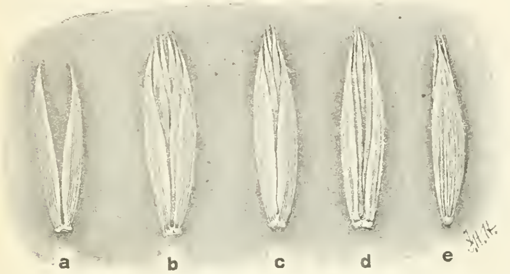

FIG. 6.—Empty glumes (*a*) and spikelets of slender wheat-grass. Note the forms of the glumes: *c*, *d*, Opposite sides of a spikelet, showing the relative position of the glumes, *d* being the inner, more convex side; *e*, edge view. (Enlarged.)

The glumes (see fig. 7) are stiffish, narrowly lance shaped, and awn pointed, three veined or five veined, the middle vein somewhat coarser than the others, giving the glumes a slightly keeled form, the veins distinct or often obscure. The margins of the glumes are thin and papery, chiefly below the middle, and taper gradually to the pointed apex.

FIG. 7.—Spikelets and glumes of western wheat-grass: *a*, One of the larger spikelets having the maximum number of seeds; *b* and *d*, small spikelets having few seeds; *c*, edge view of a spikelet; *e*, free, empty glumes; *f*, empty glumes attached to a portion of the cluster axis. Note the form of the glumes. (Enlarged.)

Mature spikelets of western wheat-grass break apart readily, the seeds separating from the glumes. Samples of commercial seed, such as brome-grass seed, containing seed of western wheat-grass have few empty glumes (fig. 7, *e*), some of which may remain attached to the spikelet axis (fig. 7, *f*).

SUMMARY.

(1) Seed of quack-grass is a common impurity of certain kinds of commercial seed, especially of the seed of awnless brome-grass (*Bromus inermis*).

(2) Quack-grass seed appears in all lots of brome-grass seed imported from Europe and may occur in brome-grass seed produced in Canada or the Western States.

(3) Brome-grass seed produced in Canada or the United States often contains seed of wheat-grasses, which is likely to be mistaken for quack-grass seed. It is therefore desirable to distinguish between quack-grass seed and the similar seed of the wheat-grasses.

(4) Seeds of quack-grass in brome-grass seed appear chiefly as whole or partial spikelets, while few such spikelets of the wheat-grasses occur in samples containing seed of these grasses.

(5) The most evident identifying characters of quack-grass and wheat-grass seeds appear in the spikelets and their glumes.

(6) While it is usually possible to determine which kind of Agropyron is in a sample of seed, the presence or absence of quack-grass seed with reference to awnless brome-grass seed should be determinable without difficulty.

Approved:

James Wilson,

Secretary of Agriculture.

Washington, D. C., *October 28, 1910.*

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B. T. GALLOWAY, Chief of Bureau.

THE SULPHUR BLEACHING OF COMMERCIAL OATS AND BARLEY.

BY

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THE SULPHUR BLEACHING OF COMMERCIAL OATS AND BARLEY.

INTRODUCTION.

When a crop of oats or of barley is harvested under adverse weather conditions, or in a careless manner, there is generally a deterioration in both the quality and condition of the grain which reduces its market value. In order to make grain thus damaged appear sound, healthy, and bright, and also to remove the objectionable odors which are usually present, such grain is often artificially bleached with sulphurous acid, thereby making it possible to realize a higher price from its sale.

The bleaching of grain, and especially the bleaching of oats, with sulphurous acid has been practiced in many of the larger grain markets for a considerable number of years, but with the comparatively recent developments in apparatus for bleaching grain rapidly and inexpensively the practice has become common also in the smaller grain centers. The process of bleaching is ordinarily referred to in the grain markets as "purifying," and grain so treated is sometimes sold as "purified" grain, no mention being made of its having been bleached or of sulphur having been used in the process of bleaching.

Based on investigations carried on at 13 grain markets in 3 of the leading oat-producing States, it is estimated that 18,732,000 bushels of oats and barley were bleached in those markets during the six months from October, 1908, to March, 1909, inclusive. The best data available show that during the same period approximately 75 per cent of the low-grade oats, ordinarily No. 4 White or below, received at those markets were sulphur bleached.

Sulphur-bleached oats are marketed chiefly in New England and in such of the Eastern and Southern States as do not produce enough oats for home consumption. On account of the bright and attractive appearance of the bleached grain, it is often selected in preference to the unbleached.

Laws have been enacted in several of the States under the authority of which the food commissions of those States have held it to be unlawful to offer sulphur-bleached or chemically treated grain for sale within those States except when it is so labeled.

The views of the Board of Food and Drug Inspection of the United States Department of Agriculture[a] with respect to the use of sulphur dioxid in foods are as follows:

No objection will be made to foods which contain the ordinary quantities of sulphur dioxid if the fact that such foods have been so prepared is plainly stated upon the label of each package. An abnormal quantity of sulphur dioxid placed in food for the purpose of marketing an excessive moisture content will be regarded as fraudulent adulteration under the food and drugs act of June 30, 1906, and will be proceeded against accordingly.

In some States the laws and in other States the grade rules under which the grain-inspection departments work prohibit the grading of bleached or chemically treated oats and barley, but owing to the difficulty of distinguishing, except in extreme or exceptional cases, between the bleached and unbleached grain without submitting it to a chemical test, these prohibitions are not always carried out. When such grain is refused a grade it is designated as "purified" by the inspectors and sold by sample instead of by grade.

Selling bleached oats by sample has always been more or less unsatisfactory and has led to many disputes between buyer and seller. In marketing this class of grain, when it is not designated as "purified" it is customary to make up standard samples to which trade names are often given. These samples are sent to prospective buyers invariably in cloth sacks of open fiber which allow the sulphurous-acid odor to be dissipated. Upon delivery of the grain on the basis of these samples, the odor of sulphurous acid is readily detected and the buyer is dissatisfied because he believes the car of grain delivered is not like the original sample.

METHOD OF SULPHUR BLEACHING.

There are several types of grain bleachers in use, the most common of which is the "tower" or "chimney" bleacher, so called because of the style of its construction. The different forms of this type vary principally in the manner of distributing the grain at the top and in the way in which it passes through the bleacher. These tower bleachers are constructed of brick, masonry, or wood covered with galvanized iron; and for convenience in handling the grain through them the towers are built close to the elevator, the top of the tower usually corresponding with the upper working floor of the elevator, which may be at a height of 25 to 60 feet above the ground. On the interior of the bleaching tower, which is about 3 or 4 feet square, are alternating series of deflecting shelves set at an angle of about 45° to the horizontal plane. The purpose of these shelves is to retard the movement of the grain and to distribute it evenly through the tower after it falls from the spout at the top, as shown in figure 1.

[a] Food Inspection Decision No. 89, U. S. Department of Agriculture, Mar. 5, 1908.

As practiced commercially, sulphur is burned in a furnace or oven located some distance from the bleaching tower as a precaution against fire. The burning sulphur coming in contact with the oxygen of the air forms sulphur-dioxid gas, which is forced into the bleaching tower 8 or 10 feet from its base through a pipe leading from the furnace.

In order that the bleaching may be accomplished this sulphur-dioxid gas must come in contact with water and unite with it, in which case it forms sulphurous acid, which is the bleaching agent. For this reason the grain, as it passes into the bleaching tower at the top, is dampened with either a jet of steam or small sprays of water. The sulphur-dioxid gas, circulating upward, unites with the moisture adhering to the outside of the downward-moving grain, thereby making the bleaching possible.

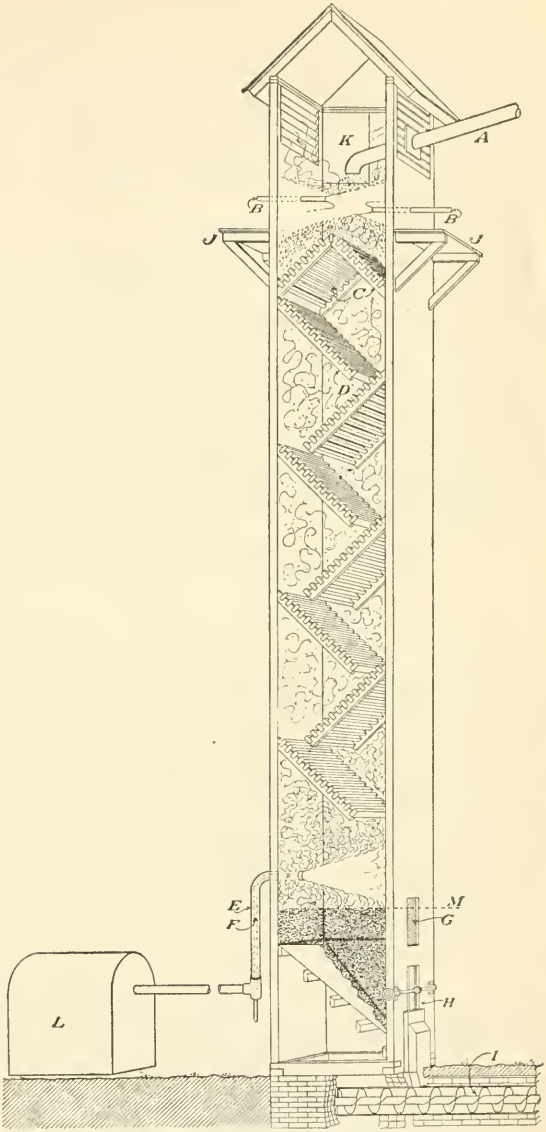

FIG. 1.—A common type of tower or chimney grain bleacher. *A*, Elevator leg which conveys grain from elevator to bleacher; *B*, steam jets which moisten grain; *C*, first break for stream of grain; *D*, deflecting shelves; *E*, pipe which conveys sulphur dioxid to bleacher; *F*, steam jet which creates suction draft in sulphur pipe; *G*, glass gauge through which height of grain in the tower is observed; *H*, regulator for grain outlet; *I*, screw conveyor which returns grain to elevator; *J*, landing on tower; *K*, door opening into tower for purpose of cleaning grain break; *L*, sulphur furnace in which the sulphur dioxid is generated; *M*, pocket in which grain accumulates, allowing better action of sulphur dioxid.

The base of the tower bleacher forms a pocket in which the grain is allowed to accumulate to a point underneath the inlet for the sulphur dioxid. Owing to the accumulation of the grain in this pocket, better action of the sulphurous acid upon the stained and discolored grain is afforded by lengthening the time it is confined in the bleacher. With this method of bleaching, the grain is in the tower about two or three minutes.

After treatment in the bleaching tower the grain is returned to the elevator bins, where it is customarily left from 24 to 48 hours, and where a large part of the actual bleaching takes place. If one bleaching fails to produce the desired result, the process is repeated.

Before loading for shipment, the grain thus treated is "run" or "handled" in the elevator for the purpose of cooling it and also to remove the sulphurous-acid odor, which is only partly accomplished. More or less moisture is lost during the handling, but the operator aims to remove no more moisture than is necessary, because the addition of moisture is one of the sources of profit in the bleaching process.

RESULTS OF SULPHUR BLEACHING.

APPEARANCE IMPROVED BY BLEACHING.

As shown in figure 2, the oats subjected to sulphur bleaching are the lower grades of white oats, the commercial grades of No. 3, No. 4, and "Sample" or "No grade" white oats usually being used. The reason that such oats receive low grades may be due to several causes, such as stain, field or mold damage, bad odors, or a low-test weight per measured bushel. When the damage is stain or mold the outward appearance of the grain is greatly changed by sulphur bleaching, and it is often difficult to distinguish between the sulphur-bleached grain and that which is naturally bright and sound, without subjecting it to a chemical test.

For the purpose of determining to what extent the outward appearance of oats is changed through sulphur bleaching, samples representing 9 lots of oats before and after bleaching were submitted to several experienced grain inspectors for grading in the regular manner, with the exception that they did not take into consideration the odor of sulphurous acid on the samples of bleached oats.

The results of this test were that 6 of the sulphur-bleached samples were classed the equivalent of a full grade higher than the samples representing the corresponding lots of oats before bleaching and 3 of the samples were raised from the average to the top of the same grade.[a]

[a] In the trading upon the grain exchanges there is at times a range of 1 to 3 cents or more per bushel in the market price of a single grade of oats, depending on the apparent quality and condition of the grain, and in order to compare values more definitely than can be done by the present specifications for grades, the terms "top" and "bottom" of the grade are used.

A comparison of the grades of oats before and after bleaching is shown in figure 2.

CHANGE IN MOISTURE CONTENT AND WEIGHT PER BUSHEL.

Samples of oats before and after bleaching were collected at various places throughout the oat-producing sections. The samples before bleaching were taken as the grain was being elevated to the bleaching tower and the samples after bleaching were obtained as the grain was being conveyed back to the storehouse or elevator bin.

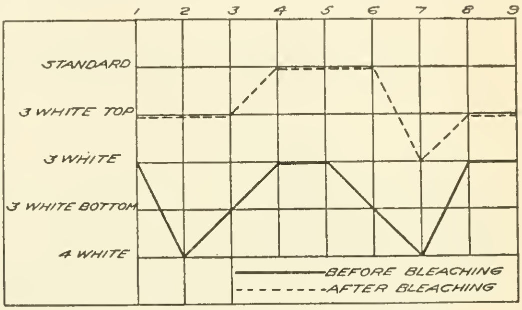

FIG. 2.—Diagram comparing the grades of oats before and after bleaching.

The moisture content of every sample was found to be higher after bleaching. The detail of samples is shown in figure 3 and the statement of percentages is given in Table I.

TABLE I.—*Moisture content and weight per measured bushel of samples of oats before and after bleaching.*

Stage of process.	Moisture content (per cent).				Weight per measured bushel (pounds).			
	Maximum.	Minimum.	Average.	Average increase.	Maximum.	Minimum.	Average.	Average decrease.
Before bleaching	14	10	11.38	....	32	24.75	27.46	....
After bleaching	15.6	11.6	13.17	1.79	30.5	23	26.12	1.34

The average increase in moisture, due to the bleaching, without deducting the loss due to evaporation in handling between the bleacher, the elevator, and the car (0.50 of 1 per cent), was 1.79 per cent. The relative increase in moisture was not constant, the variations being due largely to different methods of operating the various bleachers as well as to the quality and condition of the grain before bleaching.

In this connection it must be borne in mind that within certain limits an increase in moisture content results in a decrease of the weight per measured bushel. In the samples used in these investigations the average decrease in weight per bushel was 1.34 pounds as compared with an average increase in moisture content of 1.79 per cent. The difference in individual samples is graphically shown in detail in the upper portion of figure 3, and the weights per measured bushel before and after bleaching are given in Table I. The average decrease in the weight per bushel due to the addition of moisture during the process of bleaching was 1.34 pounds; however, this decrease in weight per bushel was not sufficient to prevent the oats from being given a higher grade on account of the improvement in appearance after bleaching, as shown in figure 2.

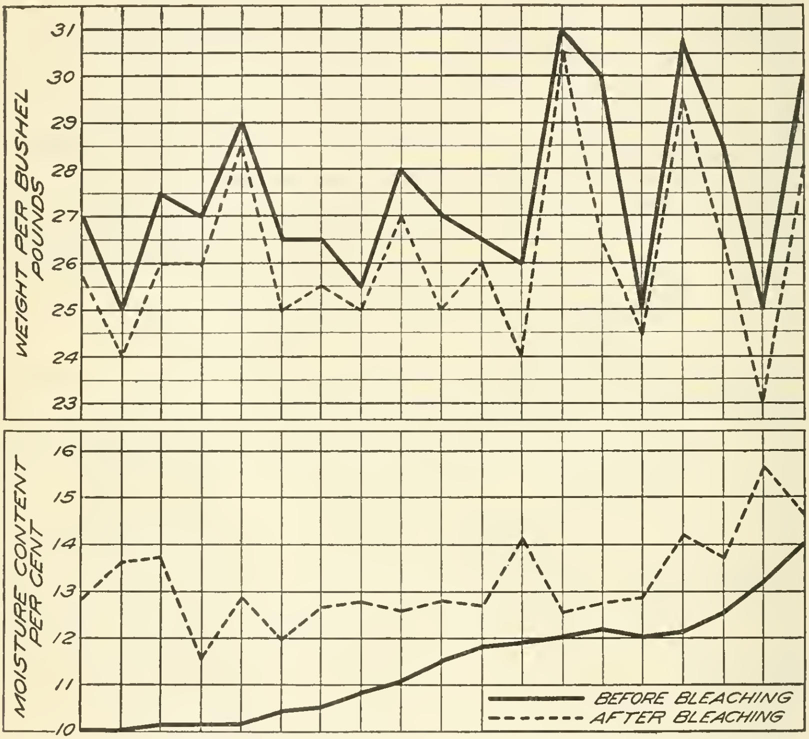

FIG. 3.—Diagram comparing the moisture content and the weight per measured bushel of oats before and after bleaching.

ODOR BEFORE AND AFTER BLEACHING.

Commercial oats, as they reach the grain markets, vary greatly in quality, condition, and color. The odors range from a natural odor common to oats when harvested under favorable conditions down through a series of odors acquired from various weeds, the most common of which is the ragweed, and from different kinds of damage, such as "ground damage," mold, heat damage, etc.

The sulphur bleaching of oats changes these odors and generally removes or overcomes them entirely, leaving a strong sulphurous-acid odor when the oats are freshly bleached. The odor of sulphurous acid has a tendency to disappear, especially as the oats become drier. The absence of the odors commonly found in natural oats usually arouses suspicion that they have been bleached; therefore, in order to supply the desired odor and to make the detection of sulphur-bleached oats difficult or impossible by physical examination, it is a common practice to mix unbleached oats with bleached oats. The mixed grain is seldom questioned as having been bleached; nevertheless, a trace of sulphurous acid remains and may be detected by subjecting the grain to a simple, qualitative, chemical test recommended by Carroll.[a]

GROWTH OF FUNGI RETARDED BY BLEACHING.

Mrs. Flora W. Patterson, Mycologist in Charge of Pathological Collections, Bureau of Plant Industry, made tests of samples taken from six lots of oats and barley, before and after bleaching, in order to ascertain how the bleaching process affects the fungi commonly found on the grain, of which the following is a partial report:

> The contents of all tubes were agitated in water, which was then added to sterilized culture media in petri dishes, 8 dishes being prepared from each number. These cultures now clearly demonstrate the fact that the process of bleaching inhibits the development of fungi, as the number of species is greatly reduced. Their growth is not only greatly retarded, but it is in no instance so luxuriant, even with the same species, as in the cultures made from the unbleached grain.

Unless the grain is properly cooled and dried after having been bleached it will contain an excess of heat and moisture, two factors favorable for the growth of fungi, which may result in the deterioration of the grain. On the other hand, since the fungi are partly destroyed and their growth retarded by the sulphur-bleaching process, it is probable that bleached grain will carry a higher percentage of moisture without danger of deterioration than unbleached grain of the same quality. Observations on grain in commerce seem to indicate that this is true.

GERMINATION REDUCED BY BLEACHING.

As bleached oats and barley are frequently selected for seeding purposes because of their exceptionally bright appearance, germination tests were made of both grains before and after bleaching in order to ascertain whether or not the vitality is affected by the bleaching process. The results of these tests are given in Table II.

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[a] Carroll, W. P. A Simple Method of Detecting Sulphured Barley and Oats. Circular 40, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1909.

TABLE II.—*Vitality of oats and barley before and after bleaching.*

Kind of grain and laboratory No.	Final test, end of sixth day (per cent).		Kind of grain and laboratory No.	Final test, end of sixth day (per cent).		Kind of grain and laboratory No.	Final test, end of sixth day (per cent).	
	Before bleaching.	After bleaching.		Before bleaching.	After bleaching.		Before bleaching.	After bleaching.
Oats:			Oats—Con.			Barley:		
1	92.5	89.5	21	73.0	77.0	101	84.5	83.0
2	90.0	78.5	22	79.0	67.0	102	94.0	46.5
3	90.5	82.5	23	98.5	98.0	103	97.5	97.5
4	95.0	86.5	24	88.5	73.0	104	96.5	97.5
5	90.0	81.0	25	87.0	74.5	105	97.5	94.5
6	66.5	35.5	26	84.5	82.5	106	96.0	97.5
7	90.5	69.0	27	89.5	71.0	107	78.5	67.0
8	83.5	94.0	28	99.0	80.5	108	91.0	76.7
9	92.5	90.0	29	33.0	21.5	109	91.5	94.0
10	90.0	90.0	30	93.5	73.0	110	94.0	37.5
11	75.0	96.5	31	95.0	95.5	111	90.0	90.5
12	88.5	87.0	32	95.0	53.5	112	95.0	5.5
13	85.5	0.	33	89.0	40.0	113	89.5	96.5
14	92.5	9.0	34	77.5	60.0	114	94.0	97.0
15	78.0	.25	35	93.0	94.0	115	94.0	5.0
16	92.5	1.0	36	99.5	87.5	116	84.0	89.0
17	83.5	86.0	37	87.0	74.5			
18	95.5	82.5						
19	87.0	55.5				Average for barley	97.72	73.45
20	95.5	84.0	Average for oats ..	86.92	68.14			

According to Arthur,[a] bleached oats upon which experiments were made for the purpose of removing smut from seed grain showed 9 per cent less germination than those that had not been treated with sulphurous acid.

From Table II it will be noted that an average of 86.92 per cent of the kernels of the unbleached oats germinated, whereas an average of only 68.14 per cent of the sulphur-bleached kernels germinated, being an average of 18.78 per cent less germination in the sulphur-bleached than in the unbleached oats.

With barley the percentage of germination was also found to be lowered by the treatment. As shown in Table II, the average germination of the unbleached barley was 91.72 per cent, while the average of the sulphur-bleached barley was only 73.45 per cent, being 18.27 per cent lower than the unbleached barley. In a few instances, it will be noted, the percentage of germination of the bleached grain was decidedly lower than the check, which is accounted for by the fact that these particular lots had been twice bleached, showing that the vitality of the grain is reduced in proportion to the severity of the treatment.

FEEDING EXPERIMENT WITH BLEACHED AND UNBLEACHED OATS.

In these investigations no attempt was made to determine the effect of sulphur-bleached oats on the health of animals. However, for the purpose of ascertaining whether or not horses would eat sulphur-

[a] Arthur, J. C. Bulletin 103, Agricultural Experiment Station, Purdue University, Lafayette, Ind., 1905.

bleached oats as readily as unbleached oats, a feeding experiment was carried on at the Arlington Experiment Farm, near Washington, D. C., in cooperation with Prof. L. C. Corbett, Horticulturist in Charge, with two teams of farm horses and one team of carriage horses used by the Department of Agriculture.

The first part of the experiment extended through a period of 15 days and was confined to 2 teams of horses, which were being worked on the farm at the time, after which, for a 5-day period, the carriage team was fed. Sulphur-bleached and unbleached oats in equal quantities were fed in separate boxes at the same time to each horse of the 3 teams. In order to exclude a possible error due to the convenience in the positions of the feed boxes, which were placed side by side, the bleached and unbleached oats were fed in different boxes on alternate days. It was observed that each horse ate the bleached oats as readily as the unbleached oats. Frequently the horses ate from the boxes alternately, so that they finished eating both the bleached and the unbleached oats at practically the same time.

PROFITS RESULTING FROM BLEACHING.

There are two sources through which a profit is derived by the process of bleaching oats. (1) By purchasing low grades of oats, improving their appearance, and selling them at approximately the price of unbleached oats of similar appearance, and (2) by increasing the original weight by the addition of moisture during the bleaching process.

GAIN BY IMPROVED APPEARANCE.

From a comparison of the grades before and after bleaching, as shown in figure 2, it is obvious that sulphur-bleached oats bring a higher price than unbleached oats because of the improvement in appearance brought about by the bleaching. In order to ascertain to what extent prices are increased by bleaching, the market value of the bleached oats from the standpoint of appearance was compared with the prices current for the various grades of oats on "track" on the days when the bleaching was done.

As shown in figure 4 the range in price before and after treatment was not always constant. This was due largely to the variation in efficiency of the bleaching processes employed at the various places where the samples were collected. On the basis of the before-mentioned oat quotations, before bleaching, the minimum price per bushel was 49 cents; the maximum, 55 cents; and the average, 52.39 cents. After bleaching, the minimum price per bushel was 51½ cents; the maximum, 56 cents; and the average, 53.96 cents. An average increase in price of 1.73 cents per bushel was due to bleaching.

GAIN BY INCREASED MOISTURE CONTENT.

As shown in figure 3, the average increase in moisture by bleaching was 1.79 per cent, as determined by samples taken as the grain was being drawn from the bleaching tower. It was found, however, that in "running" and cooling the oats prior to loading into cars, approximately one-half of 1 per cent of moisture was lost by evaporation, leaving a net increase in the moisture content of 1.29 per cent, which is equivalent to 1.48 per cent increase in weight.[a]

NET GAIN RESULTING FROM BLEACHING.

The cost of bleaching grain with sulphur depends largely upon the facilities available for handling and the quantity of grain bleached. The average capacity of a bleacher is about 3,000 bushels per hour. The cost of the sulphur (20 to 30 pounds) required to bleach 1,000 bushels of grain should not exceed 50 cents. The steam required for the process is not an expensive item, as it is usually at hand for running other elevator machinery. From estimates obtained from various persons engaged in this line of work the cost of bleaching, when the plants are running full capacity, varies from about one-eighth to one-quarter of 1 cent per bushel.

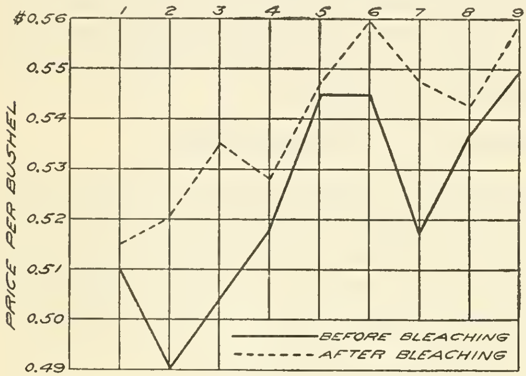

FIG. 4.—Diagram comparing the price per bushel of oats before and after bleaching.

Computed on a basis of 54 cents per bushel for the oats (the average price at the time of bleaching), the gain in weight of 1.48 per cent shows an average gain in the price received of 0.78 of 1 cent per bushel from the addition of moisture alone, which, added to the average gain of 1.73 cents per bushel from advanced grades by reason of the improved appearance of the oats, shows an average gross gain of 2.51 cents per bushel. Deducting from this the greatest estimated cost of bleaching (one-quarter of 1 cent per bushel), the net profit due to the process of bleaching would be 2.26 cents per bushel, which, on the average carload of 1,600 bushels, would amount to $36.

[a] Circular 32, Bureau of Plant Industry, U. S. Dept. of Agriculture, entitled "Moisture Content and Shrinkage of Grain," explains the reason for this difference and how it is calculated.

SUMMARY.

(1) Oats and barley of inferior quality and condition may be made to resemble that of a better quality by bleaching.

(2) A profit is derived not only from changing the appearance of the grain but also by increasing the original weight by the addition of moisture.

(3) Because of the fungi being partially destroyed by the bleaching it is probable that bleached oats will carry a higher moisture content than unbleached oats with less danger of deterioration.

(4) The vitality of oats and barley is impaired by bleaching and a heavy bleaching is especially harmful.

(5) Preliminary feeding experiments with both bleached and natural oats showed that horses ate one as readily as the other.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *December 16, 1910.*

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B. T. GALLOWAY, Chief of Bureau.

AGRICULTURAL SURVEY OF FOUR TOWNSHIPS IN SOUTHERN NEW HAMPSHIRE.

BY

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in Cooperation with the New Hampshire College
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AGRICULTURAL SURVEY OF FOUR TOWNSHIPS IN SOUTHERN NEW HAMPSHIRE.

INTRODUCTION.[1]

The agriculture of New England has undergone very marked changes within the last 50 years. Previous to 1860 the area of improved farm land increased, but upon the opening of cheap land in the West large areas of New England farm land commenced to revert to forest. This change was desirable on some areas that were cleared in early days and which never were adapted to farming purposes. The popular belief that New England farm land is a deserted waste is untrue, as the much-talked-of abandoned farms that are commonly pictured as lying idle, with bare fields growing up to weeds, are not to be found. On these farms, many of which are abandoned agriculturally, nature has been remarkably quick to start reforestation. No one in traveling through the New England States can fail to note the large area of woodland as compared to the improved farm land. The 1899 census figures for New Hampshire show only 29 per cent of the State to be in improved land, which means that the other 71 per cent is practically all in forest. The curve in figure 1, showing the increase in the area of unimproved farm land, is an index of the extent to which this country has become reforested.

PURPOSE OF THE SURVEY.

A farm survey was undertaken during 1909 by the New Hampshire College Agricultural Experiment Station and the Office of Farm Management of the Bureau of Plant Industry of the United States Department of Agriculture. The purpose of the survey was to determine the relative condition of the farms in the region, the pre-

[1] During 1909, at the request of the New Hampshire College Agricultural Experiment Station, Mr. Thomson was assigned to make a careful study of the equipment, expenses, and income on the farms in four townships in southern New Hampshire. These townships were selected as representative areas for that section of the State. The expenses of this investigation were borne jointly by the Department of Agriculture and the New Hampshire College Agricultural Experiment Station. The results are of much interest in connection with the general status of agriculture in that section and they also furnish valuable data concerning the relative profitableness of several types of farming.—WM. A. TAYLOR, *Acting Chief of Bureau.*

vailing types of farming, and the profitableness of these types for that section; also to learn the distribution of capital, income, and expenses, so as to gain a correct view of the agriculture as it now exists. The plan of the work was to visit personally each farmer within a certain area and obtain from him the information desired. In this way fairly accurate data were collected and these were checked up by careful inspection on the part of the person making the survey.

ACCURACY OF THE RESULTS OBTAINED.

The information obtained has been carefully tabulated and averaged so that the results as given may be considered fairly accurate. This accuracy depends on the law of averages. For instance, the individual farmer in giving the amount of his expenses for the year might make a considerable error, but he is just as apt to overestimate as to underestimate. According to the law of averages, therefore, when a considerable number of farms are taken into consideration the amount of the overestimate will about equal the amount of underestimate, so that the average is for practical purposes fairly accurate.

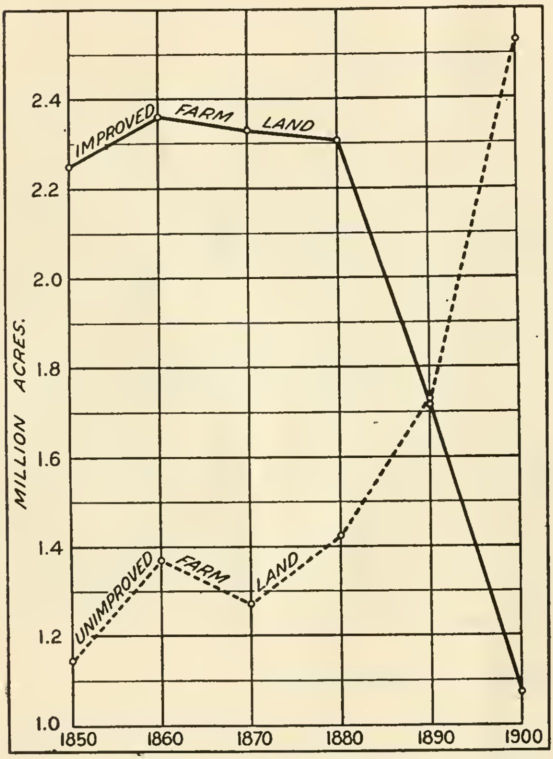

FIG. 1.—Diagram showing the decrease in improved and the increase in unimproved farm land in New Hampshire from 1850 to 1900. (U. S. Census.)

To explain this a little more fully, suppose that a hundred men who know something of the weight of horses estimate the weight of a given horse. Some of them will estimate too much and others too little. But if the men have a fair idea of the weight of horses the average of all their estimates will be very close to the correct weight of the horse. The figures here given are in each case only averages of a considerable number of farms.

AREA SURVEYED.

The area selected for the survey was a group of four townships in the southern part of Hillsboro County, N. H. They represent a typical locality in the southern portion of the State, extending from the Nashua River on the east to the higher and rougher land on the west. The town [1] of Hollis may be considered to be an upland town, partially surrounded by a belt of lowland made up of sandy soils. All the central part of this town is devoted to varied types of farming, while to the west and north are considerable areas of woodland. Amherst lies directly north of Hollis and extends to the town of New Boston on the north. This town includes two types of agricultural land, part of it being river bottom with many varieties of soil, while all the western and northern part of the town is more or less hilly. Milford, the smallest in area, includes considerable hilly land in the southern part and the wide valley of the Souhegan River. The soils in this river valley are considerably heavier than those on most of the low land. Lyndeboro is distinctly an upland town, having practically no low lands, and is of a rough, hilly nature. Its soils on the whole are heavier than those in the Merrimac Valley or sand plain.

In all the towns the types of farming vary widely. Fruit growing is confined chiefly to Hollis and Lyndeboro, poultry raising to Milford, while dairying is practiced about equally in all the four towns. One of the chief objects of the survey was to study the relation between these types of farming.

The agriculture of the region as a whole is as varied as its topography and its soils. No one type of farming predominates and no system of definite rotations is found. In fact the farming operations of the region are merely remnants of the system which was prevalent 50 years ago. Everywhere one finds examples where habit has continued a type of farming long after that type has ceased to be profitable. A farmer who has grown up with the agriculture of the community is slow to see that his type of farming is no longer suited to present conditions. The results shown in some of the tables that follow bear out this statement.

The tables are arranged (1) to show a comparison of the farms in the different towns and (2) to compare the different types of farming. A farm is classed with a particular type if 50 per cent or more of its income is derived from the products characteristic of that type.

METHODS OF CALCULATION USED.

The capital or investment is the average inventory for two years of the real estate and equipment that the farmer owns.

[1] The word "town" is used here in the sense in which it is commonly used in New England. In this sense it is synonymous with the word "township" as used in most parts of the United States.

The receipts include all the cash receipts plus any increase in the value of the property at the end of the year.

The expenses include all cash paid out plus any decrease in the value of property; the value of the labor by members of the family other than the farmer is not added to the expenses, but is stated as a separate item and must be deducted from the farm income when determining the amount that the owner receives for his labor. No household or personal expenses are included except the value of board furnished to hired help.

The farm income represents the difference between the receipts and expenses. It is not net profit to the owner, for the interest on the investment and the value of the family labor have not been deducted.

The labor income represents the farmer's salary or what he makes as a result of his own labor after deducting 5 per cent on the investment. To illustrate, suppose a farmer's labor income is $400; this means that he has made 5 per cent on the investment and in addition has cleared $400 above all farm expenses, besides having the use of the house, fuel, and water, and such farm products as were consumed in the house.

To find the per cent on investment which a farmer makes, the pay for his own labor and that of his family must be deducted. Assuming that $300 is a reasonable allowance for the actual labor which a farmer does, if $300 is deducted for the owner's labor and also the value of his family's labor from the farm income and the remainder is then divided by the average investment, the result is the per cent which the farmer has made as a result of his farming operations for the year.

RESULTS OF THE SURVEY.

Throughout the whole region surveyed, and the same holds true throughout the State, the acreage of tillable land is very small. Furthermore, the tillable land on each farm is usually made up of small, irregular fields. Extensive cultivation of large areas is impossible.

TABLE I.—*Average areas, capital, receipts, expenses, and profits for 266 farms, by towns.*

Items covered by survey.	Amherst (60 farms).	Hollis (95 farms).	Lyndeboro (43 farms).	Milford (68 farms).	Average (266 farms).
Area.........acres..	127	97.3	139.3	86.4	108
Tillable area.........do....	31.1	37.8	30.1	25.4	31.9
Capital invested	$5,008.00	$5,401.00	$6,066.00	$5,130.00	$5,350.00
Receipts	1,323.00	1,534.00	2,059.00	1,575.00	1,582.00
Expenses	808.00	919.00	1,191.00	881.00	928.00
Farm income	515.00	615.00	868.00	694.00	654.00
Interest on investment, at 5 per cent	250.00	270.00	303.00	256.00	267.00
Unpaid family labor	27.00	61.00	68.00	43.00	50.00
Labor income, after deducting 5 per cent interest on investment	238.00	284.00	497.00	395.00	337.00
Wages per day (313 days)	.76	.91	1.58	1.25	1.07
Profit on investment ($300 for owner's labor deducted)	*Per cent.* 3.8	*Per cent.* 4.7	*Per cent.* 8.2	*Per cent.* 6.8	*Per cent.* 5.7

In Table I the wages per day are figured from the labor income on a basis of 313 days. Many hired men on farms receive $30 a month, which averages $1.15 for each working day, together with room and board. The average farmer in these four towns receives $1.07 per day, his house rent, and what the farm produces toward his own living. It must be remembered, however, that if the farmer owns his farm, thus having no interest to pay, he will have the amount of this interest in addition to use for living expenses. Aside from the 266 farms from which complete records were obtained there were in the four townships 156 other farms, which have been divided into the four following classes:

(1) There were 28 vacant farms, a few of which were partly worked by neighbors, but others were entirely abandoned agriculturally.

(2) There were 62 farms on which persons were living but doing practically no farm work. Most of those in this class had a garden, kept one horse and a cow, and perhaps had a small tillable field from which they cut hay enough for the horse and the cow.

(3) There were 41 farms the owners of which worked the greater part of all of the year at other than farm work. Many teamsters are in this class. A few of them did some farming, but the greater part of their income was from sources not connected with farming operations.

(4) There were 25 farmers who were doing some real farm work, but from whom the records received were not complete enough to be used in the tabulations. Four of this number were on rented farms, and nearly all of the others had moved to the farm within a year, so that a complete yearly record was not available.

The average size of these 156 farms is about 80 acres, with a very small percentage of tillable land.

TABLE II.—*Average distribution of investment of capital on 266 farms, by towns.*

Town.	Number of farms.	Real estate.		Machinery.		Live stock.		Miscellaneous.		Total capital.
		Value.	Per cent.	Value.	Per cent.	Value.	Per cent.	Value.	Per cent.	
Amherst	60	$3,784	76	$265	5	$775	15	$184	4	$5,008
Hollis	95	4,162	77	365	7	776	14	98	2	5,401
Lyndeboro	43	4,729	78	408	7	812	13	117	2	6,066
Milford	68	3,989	78	273	5	739	14	129	3	5,130
Average for 266 farms		4,124	77	311	6	772	14	128	3	5,350

Table II shows that the distribution of capital is very uniform in the towns. The average farmer has practically three-fourths of his capital in real estate, including permanent improvements, and one-fourth in equipment. The amount that each farmer has in each item varies somewhat in the different towns, but the percentage or proportionate amount in each item is practically identical. In a survey of 178 farms in the State of New York, by Mr. M. C. Burritt, the results of which are published in Bulletin 271 of the Cornell University Agricultural Experiment Station, he found that the average farmer had invested 77 per cent in real estate, 14 per cent in live stock, 5 per cent in machinery and tools, and 4 per cent in miscellaneous items.

TABLE III.—*Average distribution of profits on 266 farms in their relation to capital invested.*

Labor income.	Capital.	Number of farms.
From −$600 to −$1	$4,660	80
From 0 to 200	4,665	52
From 201 to 400	4,271	46
From 401 to 600	4,874	29
From 601 to 800	5,799	18
From 801 to 1,000	6,456	13
From 1,001 to 2,000	9,906	28

The distribution of profits in Table III shows that some farmers are receiving very good salaries for their work, while on the other hand nearly one-third of them receive an income insufficient to pay 5 per cent on the capital invested, to say nothing of additional pay for their own time and labor. The statement of some farmers that they work for nothing is shown to be true in many cases.

TABLE IV.—*Average income from different sources on 266 farms, by towns.*

Source of income.	Amherst (60 farms).	Hollis (95 farms).	Lyndeboro (43 farms).	Milford (68 farms).
Crop:				
Apples	$38	$186	$239	$47
Potatoes	27	24	11	12
Hay	16	89	15	41
Lumber and wood	68	82	234	86
Miscellaneous crops	41	124	195	27
Total crop receipts	190	505	694	213
Live stock and miscellaneous:				
Sales of live stock	152	168	222	235
Milk and butter	612	553	712	537
Eggs	137	137	295	501
Inventory increase	50	50	40	39
Outside labor	183	121	95	49
Summary—(percentages):	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Crops	14.3	32.8	33.7	13.5
Live stock	11.4	10.8	10.7	15.3
Live-stock products	56.6	45.0	48.9	65.6
Inventory increase	3.7	3.2	1.9	2.5
Outside labor	13.8	7.8	4.6	3.0

Table IV shows from what crops the average farmer in the portion of New Hampshire under consideration receives most of his income. The receipts from lumber and wood are significant of the area of unimproved land. The fact that the two towns of Hollis and Lyndeboro are mostly upland explains their income from apples. Milford has an unusually large number of poultry men as shown by the amount received from the sale of eggs in that town.

By outside labor is meant receipts from hauling or any other outside work performed at odd times. There seems to be some relation between the proportion of outside work which a farmer does and his profits. In other words, it would appear that farmers who are not making enough money at farming gradually let their farm business go and take up teaming, thus changing from farmers to laborers. The large percentage of total receipts coming from stock and stock products shows that live stock is the basis of the agriculture in this region.

Table V indicates the expenditures in connection with the management of these farms.

TABLE V.—*Average distribution of expenses on 266 farms, by towns.*

Object of outlay.	Amherst (60 farms).	Hollis (95 farms).	Lyndeboro (43 farms).	Milford (68 farms).	Average (266 farms).	
					Amount.	Per cent.
Labor	$187	$280	$237	$139	$216	23
Grain	405	377	512	558	451	49
Hay	12	15	28	14	16	2
Fertilizer	20	48	18	13	28	3
Live stock	28	25	79	28	35	4
Inventory decrease	59	36	173	57	69	7
Miscellaneous	97	138	144	72	113	12
Total	808	919	1,191	881	928	100

The expenses for labor include only the paid labor and the board of laborers. The very large decrease in the value of farms in the town of Lyndeboro is due to the large sales of lumber in that town, thus bringing down the inventoried farm value for the second year. Very often one hears a farmer say that he pays out everything for fertilizer, but this expense is comparatively insignificant if compared with the amount paid out for western grain. The exceedingly large expenditure for this item is partly explained by the charts shown in figures 2 and 3. On the other hand, figure 3 shows that the quantity of hay and forage produced in recent years has, on the whole, increased.

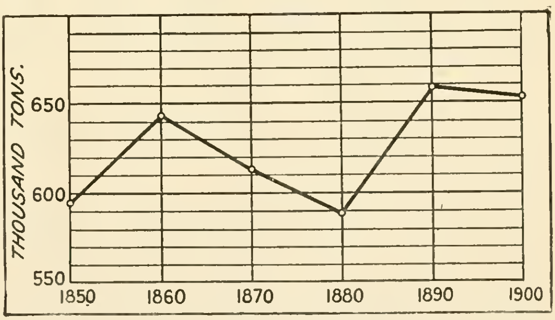

FIG. 2.—Diagram showing the total production of hay and forage in New Hampshire from 1850 to 1900. (U. S. Census.)

TABLE VI.—*Average area, capital, receipts, expenses, and profits for 266 farms, by types of farming.*

Items covered by survey.	Dairy (118 farms).	Poultry (40 farms).	Fruit (9 farms).	General (99 farms).
Area .... acres..	133.7	65.4	45.7	100.1
Tillable area .... do....	37.6	18.2	21.1	31.6
Capital invested	$6,134	$4,066	$4,730	$4,972
Receipts	$1,633	$1,754	$2,300	$1,386
Expenses, including unpaid family labor	$1,071	$1,072	$908	$838
Interest at 5 per cent	$306	$203	$236	$248
Labor income	$256	$479	$1,156	$300
Profit on investment .... per cent..	4.27	9.39	23.08	5.0

In Table VI the farms are classified according to the sources of income.[1] The wide difference in the profits between some of the types would seem to indicate that under present conditions poultry and fruit growing are much better adapted to that locality than either dairying or general farming. The results shown under the heading of fruit farms can not be taken as fairly representative of that type, because of the few farms in that class. But there is every reason to believe that the fruit industry is particularly well suited to portions of southern New Hampshire and should be given special attention. Inasmuch as dairying and general farming are usually associated with extensive farming operations, these types are limited in this respect by the rugged character of the country.

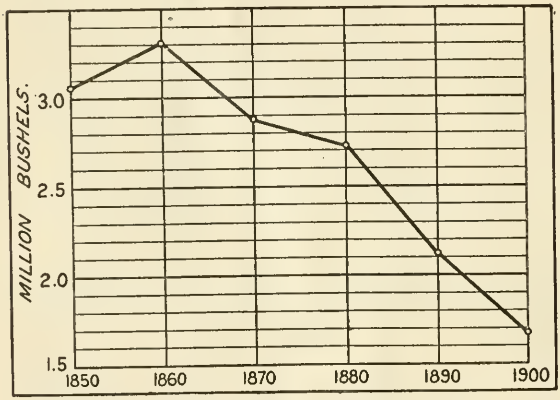

FIG. 3.—Diagram showing the total production of cereals in New Hampshire from 1850 to 1900. (U. S. Census.)

The figures in Table VI should not be taken to indicate that dairy farming is not a desirable type of farming. One of the troubles is that the farms in this region are too small for dairy and general farming. If their area was larger so that the farmer could either raise his own grain or else raise hay—which, under existing circumstances, is very high priced in New Hampshire—and thereby have an income to offset the enormous grain bills shown in Table V, even these dairy farms would show a satisfactory profit. More intensive

[1] Average prices of farm products during 1908, in the region surveyed: Milk, 3¾ cents a quart; eggs, 28 to 32 cents a dozen; hay, the better grades, $20 a ton; concentrated mill feed, $30 a ton.

cultural methods and better cows would also increase the profits in dairy farming. Table V shows that the grain bill averages 49 per cent of the total expenses of the farms in the four townships. Raising the grain would probably cost much less than buying it, but on the other hand enough hay can be grown on the same land to more than buy the equivalent of the grain that could be raised there. It is in this direction that the chief difficulty lies, as the farms are so small that there is not enough land on which to raise either grain or hay. It must be understood, however, that there are many farms of each type that are very successful and that are yielding their owners a good profit.

Another phase of farming which has not been mentioned, but which is very important in many respects, is the farm wood lot. There are large areas of nonagricultural land throughout New Hampshire which should be kept in woodland. Many such areas have been cleared in the past and are now being rapidly reforested. This nonagricultural land, which should grow timber, must not be confused with tillable or pasture land which has been partly depleted of its crop-producing power, and which in many cases is being left to grow up to bushes. A good system of forest management should be given special attention in many parts of the State.

TABLE VII.—*Comparison of average areas, capital, receipts, expenses, and profits for the better and the poorer dairy farms.*

Items covered by survey.	Better 61 farms.	Poorer 57 farms.	Average.
Area .... acres..	145	122	134
Tillable area .... do....	42.6	32.2	38
Capital invested	$6,712	$5,515	$6,134
Receipts	2,162	1,068	1,633
Expenses	1,175	861	1,024
Unpaid family labor	43	52	47
Labor income	608	−121	256

By comparing various factors on the better and poorer farms of each type, it is possible to learn where one succeeded and the other failed. The dairy farms are divided into two classes according to the labor incomes. All those receiving a labor income of $200 or more are placed in the better class, while those having a labor income of less than $200 are included in the poorer class. The most striking difference between the two, as shown by Table VII, is in the gross receipts, the better farmers taking in more than twice as much as the poorer ones. Furthermore, the expenses of the better dairymen, although larger than those of the poorer, were not at all in the same proportion as the receipts. The better dairymen earned, on the average, $608 for their year's work after all their expenses, interest, and family labor were paid, while the poorer dairymen lacked $121 of coming out even. Such results lead to further inquiry into the true conditions of the dairy farm.

TABLE VIII.—*Average distribution of investment of total capital on the better and the poorer dairy farms.*

Capital invested in—	Better 61 farms.		Poorer 57 farms.	
	Value.	Per cent.	Value.	Per cent.
Real estate	$4,885	72.8	$4,219	76.5
Machinery	385	5.7	329	5.9
Dairy cattle	786	11.7	473	8.6
Other live stock	393	5.9	352	6.4
Miscellaneous	263	3.9	142	2.6
Total	6,712	100.0	5,515	100.0

Table VIII shows that the average dairy farmer of the better class has a smaller proportion of his capital invested in real estate than one of the other class, owing to his having more invested in live stock. The only important difference in the distribution of capital on the better and the poorer classes of farms is in the amount invested in dairy cattle. It would seem that one of the reasons why the receipts are so small on the poorer farms is that they do not have enough dairy cows. They have the machinery and the live stock, such as horses, but have not the cows, which are the producing factor on an ordinary dairy farm. In this connection the size of the farm is one of several controlling factors as to the number of cows that a successful dairyman can keep. Referring to Table VII, it is found that the unsuccessful dairymen have one-fourth less area of tillable land than the successful ones. They do not have tillable land enough to support the fixed stock and also to keep a sufficient number of dairy cows to earn a satisfactory income. Whether or not the farmer should increase the size of his farm in order to have more cows or whether he should practice more intensive methods of culture, thereby obtaining larger crop yields, are matters which must be settled by each farmer according to his own individual judgment.

TABLE IX.—*Average of various factors showing the relation between the better and the poorer dairy farms.*

Items covered by survey.	Better 61 farms.	Poorer 57 farms.
Number of cows per farm	15.60	10.00
Tillable area per cow ... acres	2.70	3.20
Receipts per cow	$89.00	$67.00
Receipts from dairy products for each dollar invested in dairy cattle	1.94	1.54
Expenses for grain	551.00	410.00
Cash paid for grain for each dollar invested in all live stock	.46	.50
Expense for labor, not including family labor	341.00	227.00
Receipts from crops	282.00	119.00

Table IX shows that not only has the average dairyman of the poorer class one-third fewer cows than the average of the better, but the receipts per cow are one-fourth less than those of the better ones—a difference of $22 per cow. This fact alone makes a difference of $220 a year. That the poorer dairymen are not spending all their time and energy in other farm work is shown by the receipts from crops, the better receiving $282, while the poorer receive $119. A small number of poor cows seems to go with a few poor crops. To summarize, it seems that the lower returns on these poorer dairy farms result from smaller farms, poorer cows, lower crop yields, and poorer farming in general.

The proportionate expense for concentrated feeds is nearly the same for both classes. This fact does not account for the small profit of the poorer class.

TABLE X.—*Comparison of average areas, capital, receipts, expenses, and profits for the better and the poorer poultry farms.*

Items covered by survey.	Better 20 farms.	Poorer 20 farms.
Area, acres	75	55
Capital invested	$4,902	$3,330
Receipts	2,718	790
Expenses	1,445	583
Unpaid family labor	93	22
Labor income	935	19

The poultry farms were divided according to the labor income; the 20 farms which are placed in the better class received a labor income of $300 or more, while the poorer 20 each received less than $300. Table X indicates that the average poultry man of the better class is doing better, partly at least because of larger business. His gross receipts are three and one-third times as great and his expenses are two and one-third times as great as the average of the poorer class.

TABLE XI.—*Average distribution of investment of capital on the better and poorer poultry farms.*

Capital invested in—	Better 20 farms.		Poorer 20 farms.	
	Value.	Per cent.	Value.	Per cent.
Real estate	$3,617	73.8	$2,700	81.1
Machinery	283	5.8	153	4.6
Poultry	492	10.0	186	5.6
Other live stock	359	7.3	211	6.3
Miscellaneous	151	3.1	80	2.4
Total	4,902	100.0	3,300	100.0

Table XI shows that the poorer poultry men have about all their money in real estate, while those of the better class not only have larger farms, but have live stock and equipment to run these farms. The poorer 20 farmers do little or nothing, and get $19 a year for their work. The better 20 farmers are utilizing the farm and equipment, and receive $935 for their year's work.

TABLE XII.—*Average of various factors showing the relation between the better and the poorer poultry farms.*

Items covered by survey.	Better 20 farms.	Poorer 20 farms.
Number of hens per farm	618	232
Receipts from poultry and poultry products sold for each dollar invested in poultry	$4.39	$3.30
Total sales of poultry and poultry products	2,145.00	613.00
Crop receipts	288.00	102.00
Expenditure for grain	1,138.00	420.00
Amount paid for grain per dollar invested in all live stock	1.33	1.06

According to Table XII the average poultry farmer of the poorer class not only has a small number of hens, but does not take care of what he has. The gross receipts for every dollar invested in poultry can not be counted as the receipts from hens alone, because several poultry men raised broilers, the receipts from which are all figured in the amount given in the table. The poorer 20 poultry men, having but a few hens to care for, might be expected to devote their time to growing crops. That they do not do this is shown by the amount received for crops by the two classes of farmers. Comparison of the quantity of grain purchased does not show that the poorer men are spending all their income for grain, but rather the reverse, the good farmers spending proportionately more.

TABLE XIII.—*Comparison of average areas, capital, receipts, expenses, and profits for the better and the poorer general farms.*

Items covered by survey.	Better 46 farms.	Poorer 53 farms.
Area ... acres	108	93
Tillable area ... do	35.2	28.4
Capital invested	$6,252	$3,861
Receipts	2,173	703
Expenses	1,114	505
Unpaid family labor	54	17
Labor income	693	−42

The general farm represents variations or combinations of some of the other types, as poultry and fruit or dairy and poultry.

There were 46 general farms which had a labor income above $150, and 53 which were below this amount.

Table XIII gives the findings of the survey as applied to general farming in the territory under consideration.

This type of farming follows the others in most respects. The poorer men have considerably less capital and do very little work in any one farming operation.

The general farmers have more invested in real estate than those in any of the other types and less invested in live stock, as shown by a comparison of Table XIV with the table previously presented.

TABLE XIV.—*Average distribution of investment of the capital on the better and the poorer general farms.*

Capital invested in—	Better 46 farms.		Poorer 53 farms.	
	Value.	Per cent.	Value.	Per cent.
Real estate	$4,911	78.6	$3,104	80.4
Machinery	381	6.1	220	5.6
Live stock	768	12.3	441	11.4
Miscellaneous	192	3.0	96	2.6
Total	6,252	100	3,861	100

Some interesting comparisons are also given in Table XV in regard to the relative quantities of grain bought and raised in connection with the three different types of farming.

TABLE XV.—*Comparison between the average quantity of grain bought and the average quantity grown on farms of three different types.*

Items of comparison.	Dairy farms.		Poultry farms.		General farms.	
	Better 61.	Poorer 57.	Better 20.	Poorer 20.	Better 46.	Poorer 53.
Cash paid for grain for each dollar invested in live stock	$0.46	$0.50	$1.33	$1.06	$0.53	$0.51
Value of grain raised for each dollar invested in live stock	.075	.081	.036	.031	.085	.065

The value of the grain raised is figured at $30 per ton, or 1½ cents per pound. Western competition in growing cheap grain during the period of 1880–1900 was the means of getting New England farmers out of the habit of growing their own grain. The buying of grain has become so firmly fixed in their systems of farming that although grain has almost doubled in price very little if any more is at present grown on their farms. It was during the period of cheap grain in the eastern markets that such large areas of farm lands were allowed to revert to woodland. At the present time, when concentrated feed has increased in price, the average farmer tills only about half the land that his father did. He has not the tillable land upon which to raise grain or to raise other crops with which to buy grain. With a yield of one ton of grain to the acre it would require more than 4,000 acres in grain to grow the equivalent of what was purchased during the past year on the 266 farms. There is no question that grain can be grown more cheaply on good tillable land in the East than it can be bought at present prices. However, it is impossible for the farmers in southern New Hampshire to raise anywhere near enough concentrates on the present area of tillable land and yet keep the same number of live stock. Furthermore, when hay is bringing $20 a ton, and when it is necessary to pay $30 a ton for concentrated feeds, it will not pay to raise the small grains on land that will grow two tons of first-class hay to the acre, except as those grains are grown in connection with a rotation of ensilage and a nurse crop for reseeding. The results of this survey show that the quantity of grain that the poorer farmer buys is not alone responsible for his low labor income.

Table XVI shows the increase or decrease in the number of animals on the farms under consideration during a period of one year, and the average value of these animals in the different towns.

TABLE XVI.—*Comparison of total number and individual value of certain kinds of farm animals on 266 farms, by towns.*

Items of comparison.	Amherst (60 farms).	Hollis (95 farms).	Lyndeboro (43 farms).	Milford (68 farms).	Total (266 farms).
Number of cows on Apr. 1, 1908	592	756	429	468	2,245
Number of cows on Apr. 1, 1909	551	700	427	433	2,111
Average value per head	$38	$43	$36	$39	
Number of fowls on Apr. 1, 1908	4,934	5,549	5,935	15,308	31,726
Number of fowls on Apr. 1, 1909	4,862	5,640	5,883	15,932	32,317
Average value per head	$0.66	$0.77	$0.68	$0.90	
Number of horses	137	252	96	129	614
Average value per head	$115	$117	$120	$121	

Table XVI shows that the number of dairy cows has decreased in every town, while the poultry, which has increased in two and decreased in the other two towns, shows an increase in the total of all the towns.

The table also shows some interesting data as to the average value of the individual animals in the separate towns where one type of farming is developed more than another.

TABLE XVII.—*Average relation of the labor incomes to the ages of the farmers.*

Labor income.	Average age.	Number of farms.
From −$500 to −$1	57.5	80
From 0 to 400	50.2	98
From 401 to 800	51	47
From 801 to 2,000	47	41
Average and total	52	266

The relation between the age of the farmer and his earning capacity is set forth in Table XVII. A general correlation exists between the ages of the farmers and their profits, but there are many exceptions to this rule. Not all the old men are losing money. It is interesting to note what a large percentage of the farmers in that region are over 50 years of age. The results would seem to show that a farmer's greatest earning capacity is before he reaches the age of 50 years.

SYSTEMS OF FARMING.

When the farmers stopped raising grain some 30 years ago, they let their fields stay down in grass very much longer than formerly and eventually forgot all about a rotation of crops. A great many fields when they would no longer yield a fair crop of hay were turned into pasture. Young pine, as well as other trees, soon sprang up in these pasture fields, and to-day, instead of tillable fields, they are young forests. Thus it is that the farmers of this region have no definite system of management. Their present rotation, if it may be called such, is corn, oats for hay, and then hay from four to six years. Sometimes corn is planted twice in succession, and a few farmers let the oats ripen and thrash them. It is significant that only one thrashing machine was found in all the four towns surveyed. Many farmers follow the method of seeding after haying or after the oats have been taken off for hay. One great fault of this method is that clover is frequently omitted from the seeding and is not added the following spring. Many farmers stated that they were not sowing clover at all. By neglecting to get a good stand of clover whenever their land is seeded they are making a vital mistake, for clover is, without doubt, the basis of a successful rotation in this section. Whatever practice is followed, a shorter rotation must be used if the supply of humus is to be maintained in the lighter soils of this region. It is very probable that the use of lime on most of the soils in this territory would help materially in obtaining a stand of clover.

APPLICATION OF MANURE.

In the application of fertilizers in this portion of New Hampshire the common practice is to put all the manure on the corn ground, either plowing it under or harrowing it into the soil after plowing. Each of these methods seems to have produced good results on the corn crop. The trouble is that when all the manure is put on the corn crop nothing more is put on that field until five or six years later, when corn is again planted. A much better plan is not to make such heavy applications to the corn land and to top-dress the new seeding of clover with part of the manure.

FRUIT GROWING.

Very little fruit except strawberries is grown on the lowlands of this region on account of the early and late frosts that are of frequent occurrence in the valleys. Apples thrive especially well on the uplands, and peaches and grapes are cultivated to a considerable extent in a few localities. Many orchards are not carefully managed. If spraying were universally practiced, it would mean greatly increased returns to many farmers.

Fruit growing when properly carried on promises to be one of the best types of farming for this region. Many instances were found where a combination of fruit and poultry has proved very successful.

PASTURES.

To the dairymen and live-stock farmers of New Hampshire one of the greatest problems is that of pasture. The topography of a large proportion of eastern dairy farms is such that pasture land can not be used for any other crop, and for this reason good, permanent grazing land is a necessity. The once fertile grazing lands of all the southern part of the State are fast disappearing. No attention has been given them and their loss is being sharply felt by the dairymen. The usual excuse for their present condition is that it pays better to let them grow up to pine, yet the common value of land which is allowed to grow up to timber is not more than \$4 to \$6 an acre. In this case the land suited to pasture should not be confused with the areas that are adapted to nothing but forest. Any crop which furnishes from 35 to 40 per cent of the yearly maintenance of the cattle should receive attention. A good, rich pasture not only furnishes a supply of roughage and concentrates for five months in the year but also provides this supply at a very reasonable cost as compared with other crops.

With the present prices of all feeding stuffs, the next few years will show more than ever the striking need of improvement of these hillside grazing lands, and until they are restored to somewhere near their former condition all live-stock farmers will seriously feel their loss.

SUMMARY.

(1) The area of improved land in New Hampshire has decreased rapidly within the last 40 years, the decrease from 1880 to 1900 being 54 per cent.

(2) The average farmer in the region surveyed received \$337 for his year's work, or at the rate of \$1.07 a day for 313 days.

(3) Dairying and general farming, even though they represent 81 per cent of the total number of farms, are not so profitable in this region as either fruit or poultry, owing partly to the fact that dairying and general farming require comparatively large areas for their profitable operation, while in this section the farms are in the main too small to yield satisfactory profits. Thus it would seem that many of these farms should either be combined into larger ones or changed to some type which is better adapted to a small area.

(4) Fruit growing is especially well adapted to the uplands. This industry promises to be one of the most profitable for that region.

(5) Poultry farming is yielding very satisfactory profits on many of the farms investigated. It appears to be well suited to small areas in both the valleys and uplands.

(6) A careful study of the conditions seems to show that a combination of fruit and poultry, especially winter egg production, would be very satisfactory on many of the smaller hill farms.

(7) Inasmuch as several farmers engaged in each of the types of farming are making good profits, it would seem that the particular type is not so important as the management of the farm. At the same time it is a matter of no small importance that the type of farming should be adapted to the local conditions of topography, soil, and markets.

(8) The most successful farmers are not as a rule following methods of farm practice different from those of the unsuccessful, but are utilizing their land and equipment to much better advantage.

(9) The better farmers are making greater profits, not by spending less but by taking in more.

Approved:
JAMES WILSON,
Secretary.

WASHINGTON, D. C., *January 5, 1911.*

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 76.
B. T. GALLOWAY, Chief of Bureau.

THE RELATION OF CROWN-GALL TO LEGUME INOCULATION.

BY

KARL F. KELLERMAN,

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BUREAU OF PLANT INDUSTRY.

B. P. I.—660.

THE RELATION OF CROWN-GALL TO LEGUME INOCULATION.

INTRODUCTION.

The relative merits of the inoculation of legumes by the pure-culture method and by the scattering of soil taken from old well-inoculated fields have been widely discussed, and both methods have been recommended by this Bureau. In case old soil is used, the fields from which it is secured should be free from objectionable weeds and insect pests and free from plant diseases.

From time to time specimens of supposedly well-inoculated plants of alfalfa, crimson clover, and alsike clover have been forwarded to the Laboratory of Soil-Bacteriology Investigations with the explanation that although nodules were produced in abundance the leguminous crop was not satisfactory. In these cases the appearance of the nodules was abnormal and the bacteria isolated from them, although resembling the nodule-forming organism, did not have the power of fixing nitrogen in culture solutions, and as a tentative explanation it was suggested [1] that this was but an extreme case of pleomorphism of *Pseudomonas radicicola*, which could be of no symbiotic advantage to the leguminous host.

During 1909 the organism occurring in the abnormal nodules of alfalfa was studied more extensively, and it was decided that this organism represented a new, although not a destructive, disease of alfalfa. Through the courtesy of Drs. Smith and Townsend a comparative study was made of material furnished by the Laboratory of Soil-Bacteriology Investigations, which showed that the bacteria causing the abnormal nodules upon alfalfa were practically identical with those causing the crown-gall of orchard trees.

In a recent bulletin [2] Smith, Brown, and Townsend have reported extensive studies upon the crown-gall of fruit trees, proving con-

[1] Moore, George T. Soil Inoculation for Legumes; with Reports upon the Successful Use of Artificial Cultures by Practical Farmers. Bulletin 71, Bureau of Plant Industry, 1905.

[2] Smith, Erwin F., Brown, Nellie A., and Townsend, C. O. Crown-Gall of Plants; Its Cause and Remedy. Bulletin 213, Bureau of Plant Industry, 1911.

clusively that this is not only an infectious disease caused by a specific micro-organism (*Bacterium tumefaciens*), but that it can infect many kinds of plants. For instance, the bacteria isolated from the crown galls of peach trees will produce excrescences upon the stems or upon the roots of tomatoes, sugar beets, salsify, rose bushes, apple trees, certain of the legumes, etc. The same is true of bacteria isolated from these abnormal galls, or tumors, upon sugar beets, and, in fact, it is probable that the crown-gall bacteria isolated from any one of the kinds of plants showing the disease will produce similar diseases in any of the other kinds of plants which have been found infected.

THE DISTINCTION BETWEEN CROWN-GALL TUMORS AND NITROGEN-FIXING NODULES.

Fortunately, the difference between nodules produced by the beneficial nodule-forming organism of the legumes and those produced by the crown-gall organism is sufficiently typical to be easily recognized by an experienced observer. If it is desired to use soil for inoculating new fields, an examination of the roots of the legume growing upon the old field would readily show whether the soil is suitable for distribution. The slight external difference between the crown-gall tumor and the nitrogen-fixing nodule is shown in Plate I, in which figure 1 shows the nitrogen-fixing nodules of alfalfa; figure 2, the crown-gall tumors; figure 3, the nitrogen-fixing nodules of crimson clover; figure 4, the crown-gall tumors. Though it may be possible to confuse these during a hasty examination, it is obvious upon close inspection that the nitrogen-fixing nodule is an outgrowth from the plant root, and that it has no more apparent effect upon the root than has an ordinary branch of the root. The interior of the nodule contains flesh-colored cells full of bacteria, which may be easily seen under the microscope. The crown-gall tumor, on the other hand, causes much distortion of the root, frequently forcing it to branch into many small roots, which project from the tumor itself. The interior of the tumor is white and it is difficult, if not impossible, to see any bacteria in any of the cells, even in the most carefully prepared sections of the tumor tissue.

With the facilities of a bacteriological laboratory it is not especially difficult to determine whether cultures distributed for inoculating legumes contain the crown-gall bacteria or the nodule-producing bacteria. The three tests most useful for a rapid diagnosis are as follows: Pour petri-dish plates with special colored agar.[1] The nodule-forming organism does not absorb the color, and grows as

[1] Water, 1,000 cubic centimeters; sugar, 10 grams; potassium phosphate (monobasic), 1 gram; magnesium sulphate, 0.2 gram; agar, 15 grams; and congo red, 0.1 gram.

FIG. 1.—NITROGEN-FIXING NODULES OF ALFALFA.

FIG. 2.—CROWN-GALL TUMORS OF ALFALFA.

FIG. 3.—NITROGEN-FIXING NODULES OF CRIMSON CLOVER.

FIG. 4. CROWN-GALL TUMORS OF CRIMSON CLOVER.

NITROGEN-FIXING NODULES AND CROWN-GALL TUMORS.

(Natural size.)

a whitish, semitranslucent, wet, shining colony. The crown-gall organism frequently absorbs the stain very freely and produces an intense red colony; even when not strongly colored the colonies are usually tinged with red, at least at the center. The clear whitish, shining colonies should be inoculated into Dunham's solution containing 2 per cent of nitrate and into a special synthetic broth.[1] After incubation for 10 days at 25° C., or 2 days at 37° C., the crown-gall organism from alfalfa produces sufficient nitrite to give an intense nitrite reaction with Griess's solution; the nodule organism produces no such reaction. In the synthetic broth the nodule organism reduces the nitrate sufficiently to give an appreciable nitrite reaction, and the alfalfa crown-gall organism does not.

CROWN-GALL INFECTION THROUGH LEGUMINOUS CROPS.

The fact that must be emphasized especially in connection with farm practice is that the excrescences, or tumors, formed on certain legumes by the crown-gall organism have occasionally been confused with the desirable nitrogen-fixing nodules. It is obvious, therefore, that in all orchard or sugar-beet regions the possible danger of crown-gall infection through leguminous crops must be considered. The use of soil for inoculating alfalfa or clover, if selected at random, may be a serious menace. In the few years that this matter has been under observation many records of the shipping of alfalfa soil infected with crown-gall under the designation of inoculated alfalfa soil have been obtained.

It is not impossible that cultures prepared by bacteriologists unfamiliar with the slight, though characteristic, physiological differences between the nodule organism and the crown-gall organism might serve as a means of infecting a clean field planted with culture-treated seed. As it is the custom of the bacteriologists of the agricultural experiment stations, and also of the bacteriologists connected with commercial firms, to isolate cultures only from well-grown normal nodules, it is not probable that this second possible source of crown-gall infection is important.

Whether a leguminous crop infected with crown-gall constitutes an unusually serious menace to succeeding crops of sugar beets or to orchards has not yet been determined. The three leguminous crops, alfalfa, crimson clover, and alsike clover, seem to serve as very favorable hosts for *Bacterium tumefaciens*, and the organism isolated from these legumes appears to be at least as viable as when isolated from its other hosts. It is well known that most leguminous

[1] Water, 1,000 cubic centimeters; sugar, 10 grams; potassium phosphate (monobasic), 1 gram; magnesium sulphate, 0.2 gram, and 0.2 per cent of potassium nitrate.

crops greatly magnify the severity of nematode infection for succeeding crops in regions where this pest occurs, and this analogy emphasizes the necessity, at least until the lack of the necessity for such caution has been demonstrated, of using the utmost care in guarding against the dissemination and the favoring of crown-gall through the agency of these crops.

LOCALITIES WHERE CROWN-GALL HAS BEEN FOUND.

At this time we have records of the occurrence of crown-gall tumors upon alfalfa in central Kentucky, southwestern Alabama, northern Virginia, southern Maryland, and northern Pennsylvania.

In greenhouse plants grown at Washington, D. C., in infected soil received from Kentucky, alsike clover, crimson clover, red clover, and alfalfa showed extensive infection, and it is probable that these plants will be found naturally infected in different parts of the United States.

CONCLUSIONS.

(1) The crown-gall organism has been found in tumors somewhat resembling the normal nitrogen-fixing nodules upon the roots of alfalfa, crimson clover, and alsike clover.

(2) Great care should be taken in using soil or cultures for inoculating legumes in regions which may eventually be used for sugar beets or for orchards.

(3) It is usually possible to distinguish the tumor produced by the crown-gall bacteria from the nodule formed by the nitrogen-fixing bacteria by their external appearance.

(4) By the use of special media it is possible to distinguish between the bacterium which causes crown-gall and the nitrogen-fixing bacterium which forms the desired nodules upon the roots of leguminous plants.

(5) It is not known what other leguminous crops are susceptible to crown-gall infection. It is believed, however, that there is reason to suspect all of the clovers.

Approved:

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *March 17, 1911.*

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Issued June 2, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 77.

B. T. GALLOWAY, Chief of Bureau.

A STUDY OF THE IMPROVEMENT OF CITRUS FRUITS THROUGH BUD SELECTION.

BY

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Physiologist, Field Investigations in Pomology.

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BUREAU OF PLANT INDUSTRY.

Chief of Bureau, BEVERLY T. GALLOWAY.
Assistant Chief of Bureau, WILLIAM A. TAYLOR.
Editor, J. E. ROCKWELL.
Chief Clerk, JAMES E. JONES.

A STUDY OF THE IMPROVEMENT OF CITRUS FRUITS THROUGH BUD SELECTION.[1]

INTRODUCTION.

In April, 1909, under instructions of the Chief of the Bureau of Plant Industry, the writer visited a large number of orange, lemon, and pomelo groves in southern California, accompanied by Mr. G. Harold Powell, at that time in charge of fruit transportation and storage investigations of the Bureau.

In all of the groves it was easily apparent that great differences existed in the quantity and size of the fruit, in the proportion of irregular and abnormal fruits, and in the habit of growth and leaf characters of the trees among neighboring trees of the same variety, in the same grove, and under uniform conditions.

One of the largest and most successful citrus growers in California, at Riverside, when questioned as to the cause of these striking differences, suggested that it might be due to variation in the buds from which the trees were propagated. He stated further that he believed that 60 per cent of the trees in his orange groves produced his crops and that the remaining 40 per cent were light producers or barren and practically worthless.

Little or no selection of buds from select trees has thus far been practiced in the propagation of citrus trees. In most instances the propagator secures buds from successful growers of a given variety, taking the buds without regard to the past or present crops of fruit borne by individual trees. In some cases the buds for propagation are cut from nursery stock, where no selection of buds based on crop performance is possible. Where selection of buds has been practiced, almost invariably the propagator has selected the largest and most vigorous trees without regard to the crop of fruit borne by them.

Owing to the fact that the introduction into California of the commercially successful varieties of citrus fruits is of comparatively

[1] This circular has been prepared with a view to supplying information regarding the methods of work used in investigating the variation in the yield of citrus fruits in California. It is not intended here to present definite results of this work. Many investigators and fruit growers in different parts of the United States are interested in this type of investigation, and it is believed that a description of the Bureau work at this time will aid materially in assisting those who desire to pursue similar lines.—WM. A. TAYLOR, *Acting Chief of Bureau.*

recent date, the demand for trees of these varieties has been greater than could be supplied, and it has not been practicable to wait until performance records of individual trees could be secured. It was only possible to propagate stock true to variety, which under the existing conditions thus far has been the one consideration of vital importance to the growers of citrus fruits. In fact, it was usually considered that any bud from a Washington Navel tree, for example, would produce a Washington Navel tree like its parent, and the possibilities of bud variation were not seriously considered.

The owner of a pomelo grove in San Diego County observed that a few of the trees purchased a number of years ago, after reaching bearing age, produced large crops of fine seedless fruits, while others near by were not only light bearers but produced a large proportion of fruits containing many seeds and of undesirable size and otherwise unprofitable. In planning for the planting of a new and larger grove this owner selected the two trees in the original plantation which he had observed were consistently larger yielders of desirable fruits. He cut all of the buds for propagating the trees for his new grove from these two trees. The new grove is now in full bearing and produces uniformly a large yield of seedless fruits of desirable size and shape. This grove is a striking example of the benefits to be gained from bud selection, as shown by comparison with the older groves where bud selection was not practiced.

These observations were made preliminary to the undertaking of an investigation by the Bureau of Plant Industry of the effect of bud selection in response to the urgent desire of the citrus growers of California. After going over the ground and noting many examples of individual variation it was decided to undertake a systematic study of the variation of citrus trees in southern California, and the writer was directed to begin work. Several months were spent in a study of groves in different sections, so that suitable locations could be selected where the conditions were such that the data obtained would be reliable and of permanent value. As a result of the friendly and generous spirit of cooperation evinced by the growers it was possible, in every case where it was thought best to undertake this work, to make satisfactory arrangements to carry on the investigations without expense to the Bureau for as long a period as might prove necessary. Owing to various causes of variation in the yield of trees, such as seasonal changes, it is planned to continue the study of a given tree for at least five years before conclusions are drawn as to its productive behavior or its relative value as a source of buds for propagation.

The work has been carried through one season, and although the data obtained are far too meager to be conclusive in any way they are very suggestive as to the practical possibilities and commercial importance of this line of work. In response to the general desire of citrus growers and others for information regarding the object and plan of the work, this brief preliminary report is presented. The data are presented only in an illustrative way, so that an intelligent idea may be gained of the methods used. While these investigations must, as a matter of necessity, cover a long period of time, it is not unreasonable to expect that the data obtained from the second and successive years will yield interesting and valuable results, and reports giving the data secured and the progress of the work in all its aspects will be issued.

The writer hopes that this circular will lead more citrus growers to interest themselves in the investigations to the extent of securing data on the yield of individual trees in their groves where the conditions of soil and other factors are uniform and comparative. All the equipment that is needed is a fairly accurate scale that can be taken into the orchard and moved readily from tree to tree, a set of rings corresponding to the sizes of the fruit studied for aid in dividing the product of each tree into commercial sizes, and a notebook arranged for keeping the data in a systematic manner. All of the fruit of an orange tree may be picked at one time, and the sizing, grading, and note taking should be done, as soon as the fruit is picked, by the grower or some one who can do this work consistently and continuously for a period of several years. The method used by the writer of securing data of individual trees will be outlined in the following pages as a suggestion for a practicable method of note keeping. If this method is not suitable for any reason, it can probably be modified or changed so as to permit of satisfactory practical use by the grower.

OBJECT OF THE INVESTIGATIONS.

The first object of these investigations is to determine definitely the performance of individual citrus trees of the same variety, in the same grove, and under uniform conditions for a period of at least five years.

If, as the data obtained during the past season show, it is found that there is consistently a great variation in the quantity, quality, and value of the fruit borne by different trees of the same variety under like conditions, it will be determined whether these crop characteristics are transmissible and whether the progeny of these trees behave like their parents.

If it is found that one tree of a given variety yields consistently larger crops of more valuable fruit than other trees of the same variety under comparative conditions and that trees propagated from this tree inherit this tendency, it follows that the propagation of an improved type of the variety from the desirable tree should be both possible and practicable.

The influence of the seedling stock on the development of the buds from select parent trees will be investigated, and the importance of the selection of seedlings for budding purposes will be studied. There is no question as to the fact that citrus seedlings vary greatly in vigor and habit of growth and in other characteristics, but the effect of these variations on the development of the scions is a matter as yet undetermined, although they are probably of importance so far as the development and behavior of the tree is concerned.

At the time of picking careful photographic and other notes are made of each tree. its fruit, and other characteristics, so that, if results warrant, score cards and standards of selection may be devised intelligently for the different varieties of citrus fruits to aid in the study and selection of breeding stock.

The demonstration of methods for the elimination of unproductive or worthless trees in established citrus groves by rebudding or replanting and the establishment of reliable sources of uniform stock of citrus fruits for new plantings are the ultimate aim and object of this work. The data secured in the course of this work will constitute "pedigree records," based on the performance of the trees studied. The value of such pedigrees will depend on the conditions under which the data are obtained and the accuracy and care used in picking, sizing, sorting, and weighing the fruit.

VARIETIES OF CITRUS FRUITS SELECTED FOR PERFORMANCE RECORDS.

The Washington Navel orange was the variety selected with which to start the work. The commercial success of this variety is fully established in California. Its introduction into southern California is of comparatively recent date and all of the details relative to its introduction and distribution are fully known. There is probably less variation in the groves of this variety than in groves of other varieties now growing in southern California, so that if bud variation is found to be important in the case of the Washington Navel orange it is probably of more importance to the other varieties. As the two parent trees from which all the trees of the Washington Navel orange in southern California have descended are now growing at Riverside, Cal., there is an unparalleled opportunity to study the influences of change of environment and bud variation, as shown by a comparison of the parents with their descendants, many groves of which are growing under widely differing conditions of soil, altitude, climate, and culture. The history of practically every Washington Navel tree in California can easily and definitely be traced to the two original trees, so that clear-cut conclusions can be drawn as to the influence of different factors on the development of the variety since its introduction. The fine quality of the Washington Navel orange and its high value when grown under favorable conditions were other factors that entered into the decision regarding the selection of this variety for the work. As the work progresses the trees which consistently yield favorable data should become the source of improved stock for planting, thus greatly enhancing their value for experimental demonstration purposes and making possible the early practical utilization of the information obtained.

In addition to the Washington Navel orange, work with the Marsh pomelo was begun during the season of 1910. The picking of the fruit from the selected Washington Navel orange trees began January 1, 1910, and continued until April 15. The pomelos were picked from April 15 to June 15. The different picking periods of the two fruits enabled work upon both to be carried on without interference. The Marsh pomelo was selected for the reason that it is the most important commercial variety of pomelo grown in California, on account of the importance and desirability of securing uniform types of this fruit similar to the splendid individual trees both as regards quantity and quality of fruit found in some of the established groves of the variety, and because it offered the most promising field for the production of a perfectly seedless and valuable pomelo for southern California conditions.

The extension of this work to other classes of citrus fruits is highly desirable. In southern California numerous requests have been made urging that lemons be included in the work, in order that reliable select stock may be obtained for extensive new plantings of this fruit. In some cases prospective lemon planters are carrying on the work for themselves, with the writer's advice and direction, with every prospect of success in the securing of reliable data for their own information and use.

This type of investigation should ultimately be extended to all valuable varieties of citrus or other fruits. All varieties do not behave alike and may differ in their hereditary tendencies, so that in order to draw conclusions regarding the behavior of any variety it will be necessary first to demonstrate the facts by actual tests.

LOCATION OF PERFORMANCE-RECORD PLATS.

The Washington Navel orange improvement work is done on the Eureka and Vivienda ranches belonging to the National Orange Co., near Riverside, Cal. The Marsh pomelo work is conducted on the Dixon ranch, operated by Mr. L. V. W. Brown, near Riverside, and on the Mutual ranch of the National Orange Co., near Corona, Cal.

The term "performance-record plat" is here used to designate the collection of trees selected for obtaining comparative data as to variation in the performance of individual trees. The Washington Navel orange plats will be described in order to illustrate the methods by which these data are obtained.

The Washington Navel orange performance-record plats are located on the Eureka ranch of about 175 acres belonging to the National Orange Co. The ranch lies on an elevated mesa surrounded on the north, east, and south sides by the Box Spring Mountains, and sloping gently westward to the Santa Ana River. The elevation is such that cold weather has never injured either the trees or the fruit, and a deep arroyo running between the ranch and the mountains and on the west side perfectly isolates and protects the groves. The ranch itself is divided by an arroyo running approximately north and south, so that it really consists of east and west sections, or groves, of about the same area. The two sections are planted to the same stock of Washington Navel trees, now 12 years old and in perfect health and bearing condition.

After careful consideration it was decided to locate two performance-record plats, one in each section, of 50 trees each, in order to secure duplicate data and more fully check the results of the investigations. Both plats were chosen to eliminate all possible factors other than heredity. They are located about in the center of each grove, and where the conditions of soil, planting, culture, lay of the land, and health of the trees are as uniform and comparable as it is possible to find in this region. The land was not cultivated before planting the grove and, since planting, all parts of the grove have been treated the same in every respect. The grove has produced, since coming into bearing, regular crops of fruit the high quality of which has made a national reputation, and not a single diseased or unhealthy tree has been found in the grove. The trees are free from insect pests and fungous diseases.

The soil is a granite loam of an unknown depth, typical of the soil producing the finest navel oranges. In the performance-record plats the trees are all in a normal, healthy condition and are set at regular distances, and in no case are there any vacant spaces, roadways, replants, or other factors to interfere with their similarity. The record plats are treated exactly like the rest of the grove, the only difference in any respect being that the fruit is picked under the immediate supervision of the writer instead of by the regular picking gang.

The plats consist of five rows of trees side by side 10 trees long, making a total of 50 trees for each plat. Particular care was taken to secure in each plat an average lot of trees representing the average of each grove. No dwarfed or markedly inferior trees or any trees producing abnormal fruit were included.

SELECTION OF INDIVIDUAL TREES.

In addition to the performance-record plats on the Eureka ranch, 21 individual trees, representing different types of the Washington

Navel orange so far as could be determined, were selected and picked in various parts of the groves for illustrative purposes.

On the Vivienda ranch, lying west and below the Eureka ranch, 50 individual trees were selected on the basis of high yield. These 50 trees are all of the type of the Washington Navel orange and are located under conditions similar to those in the remainder of the grove. A record of the yield of each size and grade of fruit from both the Eureka and Vivienda ranches is kept by the National Orange Co., so that the yield of the select trees can be compared to the average yield per tree of the groves.

TREE MARKERS AND NUMBERS.

Strips of heavy white cotton cloth about 4 feet long and 2 inches wide were tied in conspicuous places at four regular intervals around the tree and at a height of 6 or 7 feet above the ground. These streamers can be plainly seen from any side of the tree and were placed to prevent the picking of the trees by the regular picking gang.

In the case of the Washington Navel orange every select tree was given a number, from one consecutively to the total number of trees studied. This number was stamped with a metallic die in a strip of copper 1 by 4 inches in size, so as to be ineffaceable. A heavy copper wire 12 inches long was soldered to this tag, and the tag corresponding to the number of the tree was attached to the tree by twisting the wire loosely around one of the main branches near the tree trunk.

In order to assist in finding the tree numbers readily and conveniently, the number was also painted with white paint on the tree trunk in large numerals and always on the same side of the tree.

A diagram was made of each grove, showing the location of each tree marked, in order to assist in finding individual select trees scattered over the groves. It is evident that great care must be exercised in preserving the tree numbers in order to avoid the loss and confusion of the data through a period of years.

PERFORMANCE RECORDS.

By "performance records" is meant the data obtained from the individual trees as to the yield and quality of fruit each year. A consecutive series of these records constitutes a performance record of the trees from which the data are obtained. "Quality" in this work means the proportion of the different sizes and grades of fruit, thus determining the commercial value of the fruit from each tree. No definite means of recording the flavor, sweetness, acidity, quantity of juice, rind, etc., has been evolved as yet, although a serious attempt is being made to secure these additional data for future records. These performance-record data are obtained in the grove and one tree is finished before any other is picked. The fruit from each is picked, graded, sized, weighed, and counted, and the notes are taken in order to avoid any possible confusion, mistake, or loss of fruit. The fruit is then taken to the packing house and packed with the other fruit from the grove. To anyone familiar with the difficulty in securing

FIG. 1.—Ideal type of tree of the Washington Navel orange, the most productive tree in 1910. The crop is practically all borne on inside branches.

reliable data in corn, tobacco, or other breeding work it is apparent that this work is simply done and is more valuable as a basis for selection than in the case of data secured from cross-fertilized plants or annual crops of any kind.

PHOTOGRAPHS.

Two photographs are taken of each tree—one before and one after picking. The photograph before picking gives an idea of the distribution of the fruit on the tree. After picking, the boxes of fruit are assembled side by side at the foot of the tree in one continuous row, slightly inclined to show the fruit in the boxes, so that the photograph gives a complete illustration of the total quantity of fruit from each tree. These photographs preserve better than language can express the habits of growth and other characteristics of the individual trees. Figures 1 to 4 give an idea of some of the striking differences in the character and

FIG. 2.—Typical heavy-producing Washington Navel orange tree, showing a large proportion of outside fruit.

habits of growth of the different trees, as shown by the photographic records. No notes or descriptions would serve so adequately to preserve these data or to present them in such comparable form.

The photographs are attached to the sheet bearing the data secured from the study of the fruit and are invaluable aids in interpreting the results.

PICKING.

The picking of each tree is done by an expert regular picker furnished by the grower, under the immediate supervision of the writer. Every possible care is used to prevent injury to the fruits, both in picking and in all other operations. The fruit is picked in the usual manner and placed in picking boxes. All of the fruit is picked, the boxes are assembled, and the photograph of each tree is made before

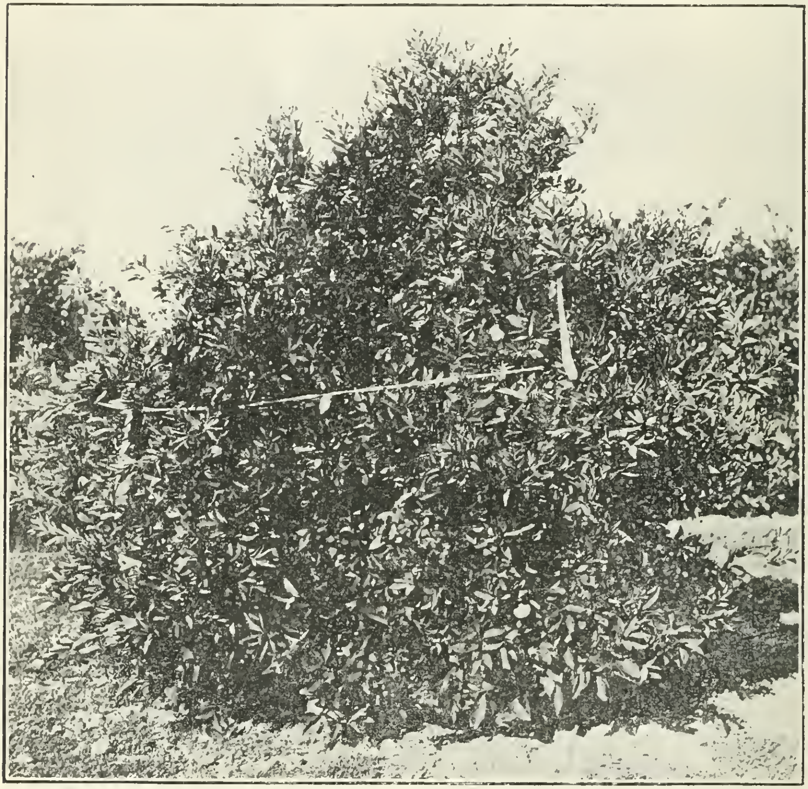

FIG. 3.—Typical "barren" type of Washington Navel orange tree.

the sorting or any other operation is begun. No fruit is picked and allowed to stand overnight before the several operations are completed.

GRADING AND SIZING.

The fruit of each Washington Navel tree is sorted into three grades by the writer: (1) Orchard grade, representing all of the perfect fruit, without injury or blemish; (2) standard grade, or fruits of irregular shape, blemish, or discoloration, but still suitable for shipment as an inferior grade; and (3) culls, or fruits so badly malformed or with such marked blemishes as to render them unfit for shipment or sale.

The orchard and standard grades are sized with a small automatic sizer into 11 different commercial sizes, viz., 80, 96, 112, 126, 150, 176, 200, 216, 250, 288, and 300 to a box.

In the beginning of the Washington Navel orange work, rings of the corresponding sizes were used and the sizing was done by hand.

FIG. 4.—"Australian" type, a barren and worthless type of the Washington Navel orange.

This is a perfectly satisfactory method, but with the large number of trees studied the automatic grader is more efficient. In the case of pomelos or lemons the sizing must of necessity be done with rings, as there is at present no satisfactory automatic sizer available. The orange sizer is small and compact and easily moved about the grove by two men. Figure 5 shows the mechanical sizer at work and illustrates the method used in grading the fruit from the select trees. The small platform scale for weighing the fruit, mounted on a truck, is also shown.

The fruits of each size of each grade are counted and weighed separately and the results noted in the regular blank form, except in the case of culls, where no sizes are made and the weight is taken as a whole. By adding the totals of the three grades the total product of the tree is obtained. These data, including the number and weight of fruits of each grade and size from each tree, form a definite basis for scoring a tree as to its performance and make possible an accurate

FIG. 5.—Portable mechanical orange sizer and scales for weighing the different lots of grades and sizes of fruit from individual trees.

and comprehensive comparison of the value of individual trees under the same conditions. When, as is usually the case, the growers keep a record of the product of each size and grade from the grove as a whole, these data are of further comparative value. While oranges are frequently divided into additional grades commercially, for bud-selection purposes the three grades mentioned above are sufficient to give reliable data as to the quality of the fruit, and the personal equation in sorting into extra fancy and other grades of fine-drawn distinction is thus eliminated. Moreover, the quantity of sound, free-from-blemish, marketable fruit of good quality that the tree produces is the most important factor to be considered in this work. This matter, however, may vary under different conditions and can be adjusted to meet the prevailing methods of grading and sizing practiced in the locality where performance records are to be made.

COUNTING AND WEIGHING.

It was found most convenient systematically to pick up five oranges at one time in the case of the smaller sizes, three in the right hand and two in the left, in order to make an accurate count. In the case of the large sizes a definite number is taken up, the same each time, in order to avoid mistakes in the count. This may seem to be a very simple matter, but errors are very easily made, especially after long-continued work, and it is probable that most workers along this line should practice checking up results in order to become absolutely accurate before attempting to count the fruit from select trees.

A small platform balance scale weighing from 1 ounce to 250 pounds is used to obtain the weights of fruits. The weigher is frequently balanced to avoid mistakes in weighing, and great care is taken to secure exact weights of each lot of fruit. The balance is mounted on a small hand truck for convenience in moving about the grove. (See fig. 5.)

RECORD BLANKS.

The following outline illustrates the method used in this work of recording data on the performance records of individual trees. A separate sheet is necessary for each tree.

Orange performance record.

Date.................. Series ....

Location.............. Grower................ Grove ....

Variety............... Picker................ No. of tree..........

Designation of sizes.	Number of fruits.				Weight of fruit.			
	Orchard.	Standard.	Culls.	Total.	Orchard.	Standard.	Culls.	Total.
300								
288								
250								
216								
200								
176								
150								
126								
112								
96								
80								
Total								

Description of tree..

....

....

Remarks..

....

....

In order to bring these data together so that the records of different years may be easily compared, the following form for showing the total data from each tree for a period of five years is suggested:

Orange pedigree record.

Dates		Series ....
Location	Grower	Grove ....
Variety	Picker	No. of tree ....

Grades and sizes.	Number.					Weight.				
	Date.	Date.	Date.	Date.	Date.	Date.	Date.	Date.	Date.	Date.
Grades:										
Orchard	....	....	....	....	....	....	....	....	....	....
Standard	....	....	....	....	....	....	....	....	....	....
Culls	....	....	....	....	....	....	....	....	....	....
Total	....	....	....	....	....	....	....	....	....	....
Sizes:										
300	....	....	....	....	....	....	....	....	....	....
288	....	....	....	....	....	....	....	....	....	....
250	....	....	....	....	....	....	....	....	....	....
216	....	....	....	....	....	....	....	....	....	....
200	....	....	....	....	....	....	....	....	....	....
176	....	....	....	....	....	....	....	....	....	....
150	....	....	....	....	....	....	....	....	....	....
126	....	....	....	....	....	....	....	....	....	....
112	....	....	....	....	....	....	....	....	....	....
96	....	....	....	....	....	....	....	....	....	....
80	....	....	....	....	....	....	....	....	....	....
Total	....	....	....	....	....	....	....	....	....	....

Description of tree ....

....

The arrangement of the record blanks used for pomelo and lemon data is based on the same principle as the orange record blanks and depends on the prevailing commercial practice of grading and sizing these fruits. These data are obtained in the grove, but where the fruit is held for curing or other purposes additional notes on the condition of the stored fruit can be taken when desired.

ARRANGEMENT OF DATA AND PHOTOGRAPHS.

The arrangement of data sheets and photographs can be made of great assistance in interpreting the results. The writer uses sheets of paper for the data and photographic prints of convenient size and arranged to fit loose-leaf ledger covers. In this way the sheets may be moved and grouped into any classification desired. It is desirable in the case of the pedigree records to arrange the leaves so that when the book is opened the photographs on one page face the data on the other page. Convenient arrangements will suggest themselves to those interested in studying the question of filing these records.

NOTE TAKING.

Detailed descriptions or notes of trees or fruits have not been extensively made. Such general notes are usually somewhat vague and unsatisfactory as a means of preserving definite ideas of the objects described. There are, however, certain notes that are very valuable, for example, the history of the trees; a description of the past and present methods of orchard management, particularly methods of soil treatment; the history of the cultivation of the grove; the kinds and quantities of fertilizers used or other sources of soil improvement; the methods and system of irrigation; the methods of pruning, if any; and any other facts bearing on the maintenance of the grove. One objection to the taking of extensive notes in this type of work is that the time and energy devoted to this phase are likely to defeat the principal object of the work. The most eminently successful plant breeders with whom the writer has been acquainted have used but few notes, preferring to have the plants themselves as notes and to devote their attention to a first-hand study of the plants. There is, perhaps, a happy medium, which must be discovered by each worker for himself, which will permit of the study of a sufficiently large number of plants and the preservation of all necessary data.

CITRUS-IMPROVEMENT CLUBS.

The writer suggests the organization of citrus-improvement clubs in the various citrus-growing localities for mutual assistance in the study of this subject. Such clubs, with a membership consisting of interested citrus growers, could hold regular meetings for the purpose of discussing individual results and the criticism of methods of work. It would be possible for such clubs to maintain a set of record books in which a copy of each member's data could be kept, similar to the plan of certain live-stock breeders' associations. The membership in such organizations should be undertaken only by growers who are willing to devote the necessary time, care, and thought to their work, so that the results will be reliable and of permanent value. It would be possible for the local clubs to have a central organization through which annual or other meetings might be held for the purpose of bringing together interesting information from the different clubs. Some such active cooperation would be of great value in promoting a widespread and general interest in this work.

IMPORTANCE OF UNIFORMLY PRODUCTIVE TREES.

The great difference between the yield of the best trees in a grove and the average yield per tree of that grove, found so far in every grove of Washington Navel oranges and Marsh pomelos, indicates that in the established groves there is a great lack of uniformity in fruit production. For instance, in the case of one orange grove the best tree produced 432 pounds of fruit, while the average of the grove was about 175 pounds. Similar proportions were observed in all other groves studied. The differences in the yield of the best and average pomelo trees were even greater than in the case of the orange trees. Conservative growers have frequently estimated that uniform trees like the best ones in their groves would more than double their crops. The yield test for individual trees, like the Babcock test for dairy cattle, should discover the "boarders," or worthless trees, that cost just as much to maintain as the productive, profitable ones. There is a certain definite investment in every tree in the grove which can easily be figured out by the grower, and the loss or profit of the trees can be determined by means of the yield test and the selling price of the fruit. Such information must be of intense interest to every fruit grower and can be secured at little expense of time or money.

THE VALUE OF RELIABLE SELECT TREES.

To every prospective planter of citrus trees the reliability and character of trees planted are of paramount importance. The expense for buds is a comparatively small item in the planting of a grove, not in any sense commensurate with their importance to the planter. It is probable that the additional expense necessary for the production of selected stock will be gladly borne by the planter provided he is assured of its improved value. Performance records from trees which are extra heavily fertilized or favored in any way might prove misleading. Therefore it will be necessary to avoid the error of depending on records that have been secured under unfair conditions. Too much emphasis can not be laid on this point, as dishonest and unscrupulous nurserymen might mislead purchasers of their stock in order to reap a temporary, dishonest reward. The reputation of the grower of select buds of trees must be taken into account as well as the performance records of his breeding stock.

SUMMARY.

The object of these investigations is the demonstration of methods for the elimination of unprofitable trees in citrus groves and the production of reliable select citrus trees for new plantings.

These investigations, begun in April, 1909, are being carried on with Washington Navel oranges and Marsh pomelos near Riverside, Cal. If desirable, this work will be extended to other sections of the citrus belt and to deciduous and other fruits as soon as men are provided to conduct the work.

A series of consecutive performance records is necessary to secure reliable select stock, and methods of securing these data and tabulating them for intelligent interpretation are described in the foregoing pages.

The yield of established orange and pomelo trees of the same variety varied greatly in the same grove and under similar conditions during the past season. Further data are necessary in order to know whether the high and low yielders of the past season are consistent in their behavior.

The importance of uniformly high-yielding trees bearing a large proportion of valuable fruit is apparent by comparing the yield of the best with that of the poorest trees in any grove. It is probable that the yield can be greatly increased and improved by securing trees of uniformly good performance.

The development of reliable select stock is of the greatest possible importance to the prospective planter.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *March 21, 1911.*

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Issued June 1, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 78.

B. T. GALLOWAY, Chief of Bureau.

AGRICULTURAL OBSERVATIONS ON THE TRUCKEE-CARSON IRRIGATION PROJECT.

BY

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AND

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AGRICULTURAL OBSERVATIONS ON THE TRUCKEE-CARSON IRRIGATION PROJECT.

INTRODUCTION.

The Truckee-Carson Irrigation Project in western Nevada was one of the first of the new regions to be opened for settlement under the reclamation act of 1902. Practically all of the public land for which irrigation water is available has now been taken up by settlers. The Bureau of Plant Industry of the United States Department of Agriculture, in cooperation with the Nevada Agricultural Experiment Station, has operated an experiment farm on this project since 1906.[1]

There appears to be considerable popular interest in the agricultural conditions and possibilities of this project, and many letters asking for information concerning the region are received at the experiment farm. This circular has been prepared with a view to answering these inquiries and also to give to the settlers already on the project the results of the experiments and observations made during the past two seasons. It will be noticed that much of the material presented is fragmentary and incomplete. This is due to the fact that the agriculture of the region is still new and that comparatively little definite knowledge as to the agricultural possibilities and the best farming methods has as yet been accumulated.

The Truckee-Carson Experiment Farm is situated 1 mile south of Fallon, Nev. On this farm tests are being made of the adaptability of various field, fruit, and garden crops, including some varieties newly imported from foreign countries. Methods of reducing the salt content of the alkali soil on portions of the experiment farm, so as to make it more suitable for crop growth, are being worked out. The agricultural problems of the project as a whole are being studied in a limited way and cooperative work is being conducted in two of the older orchards in the project.

A small library has been provided at the experiment farm, consisting of a number of agricultural books and periodicals and some of the bulletins from the United States Department of Agriculture and from the State agricultural experiment stations. The farmers on the project are invited to make use of these publications in obtaining information on subjects in which they may be interested.

[1] For additional information on this subject, see Bulletin 157, Bureau of Plant Industry, U. S. Dept. of Agriculture, entitled "The Truckee-Carson Experiment Farm," issued August 11, 1909.

They are also invited to notify the superintendent or to bring specimens to him of diseases or insect pests and to report other difficulties they may be having in connection with growing their crops, so that help may be given if possible.

PHYSICAL FEATURES OF THE PROJECT.

About 35,000 or 40,000 acres of land are now under cultivation on the Truckee-Carson project, most of it lying near the town of Fallon, Nev., which has a population of about 1,000.

Most of the soil is a light sandy loam, but there are also large areas of fertile black soil on the east and south sides of the project. Both the sandy and black soils are good and produce abundant crops, but there are also to be found in most parts of the project small, irregular areas of hard, impervious soil, which are difficult to work and do not usually produce satisfactory crops.

UNDERGROUND WATER.

Portions of some of the farms and also a few larger areas in the project have at present a soil too salty to grow crops. Salt has accumulated mostly in those soils where the ground-water table rises to within a short distance of the surface, establishing a capillary connection and by evaporation leaving deposits of salt on the surface. In those cases where the water table is very close to the surface little or no advantage results from an attempt to wash out the accumulated salt by flooding, the result being, instead, a still higher rise of the ground water, which tends to increase the difficulty. To remedy these conditions deep ditches should be put through, so as permanently to lower the water table. After this is done heavy applications of water to the surface may percolate through the soil and carry with it the excess of the soluble salts. A comprehensive drainage system has been planned for the lower lands of the project, and it only remains for this system to be completed and for farm drains to be constructed; it should then be possible to keep the ground water below the limit of serious harm.

WINDS.

The wind is an important factor on a large part of the Truckee-Carson project, where the soil is sandy and can be easily blown. Windstorms occur occasionally in the spring and are sometimes severe enough to kill new seedings of alfalfa. They are also injurious to small garden stuff that is just appearing above the ground. The winds usually come from the west and, since the damage is due chiefly to the blowing of the sand, young crops may be planted quite safely on the east side of a field on which grain or alfalfa is growing, or sandy fields may be protected by brush fences or hedges.

TEMPERATURES.

Table I, compiled from the records of the United States Weather Bureau, shows approximately the temperature conditions that exist in the region under discussion. It will be noted that the maximum temperature recorded is 103° F. and the minimum −15° F. As a general rule, plowing and leveling land and digging ditches are carried on throughout the winter months: but the winter of 1909–10 was an exception to the rule, the ground remaining frozen for about two months.

TABLE I.—*Maximum, minimum, and mean temperatures, by months, at Fallon, Nev., for six years, 1904–1910.*

Month.	1904		1906		1907.		1908.		1909		1910		Mean of the means.
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
January	56	0	60	6	64	−2	56	12	51	29	42	−15	30.2
February	65	9	69	11	72	22	71	16	62	13	64	−12	38.2
March	69	15	...	...	70	12	78	15	68	15	73	24	43.7
April	83	20	84	18	81	29	89	18	77	21	89	22	52.1
May	85	28	84	31	88	29	80	25	88	26	102	30	56.6
June	93	39	90	38	93	33	93	35	97	43	101	40	64.9
July	98	48	101	53	99	44	101	51	98	39	103	38	74.3
August	...	...	98	42	99	40	103	36	98	43	98	39	71.8
September	...	...	90	34	95	29	94	26	90	31	90	32	61.4
October	76	30	88	22	...	...	82	15	80	24	88	23	51.2
November	...	...	81	−1	76	18	68	6	70	12	75	13	40.8
December	...	...	59	−2	72	15	56	−2	55	8	66	12	32.8

[1] The records for 1905 are not obtainable.

FROSTS.

The length of the summer period between frosts is shown in Table II. This table is only approximately correct, for the reason that the dates of the killing frosts are reported from the different parts of the project by various individuals, who may have a diversity of opinion as to what constitutes a "killing" frost. The table will, however, be helpful in indicating approximately the length of the growing season.

TABLE II.—*Dates of the last killing frost in spring and the first killing frost in autumn at various points on the Truckee-Carson project, 1905–1910, inclusive.*[1]

Locality.	Time of year.	Dates of killing frosts. 1905.	1906.	1907.	1908.	1909.	1910.
Carson Dam	Last in spring	...	...	Apr. 20	May 15	May 11	Apr. 22
	First in autumn	...	Sept. 4	Oct. 29	Sept. 26	Oct. 30	Oct. 13
Leetville	Last in spring	...	...	May 2	May 9	May 13	Apr. 12
	First in autumn	...	Oct. 4	Sept. 19	Sept. 26	Sept. 22	Oct. 13
Soda Lake	Last in spring	...	...	...	May 16	May 14	Apr. 15
	First in autumn	...	Oct. 18	Sept. 18	Sept. 25	Oct. 22	Oct. 13
Fallon	Last in spring	...	May 31	May 14	May 30	May 24	May 16
	First in autumn	...	Oct. 4	Sept. 19	Sept. 25	Sept. 22	Sept. 13
Hazen	Last in spring	...	May 28	June 15	...	...	...
	First in autumn	Oct. 8	Oct. 18	...	...	...	...
Fernley	Last in spring	...	...	June 14	May 8	May 28	Apr. 21
	First in autumn	...	...	Oct. 4	Sept. 26	Oct. 8	Oct. 13

[1] Compiled from the official reports of the United States Weather Bureau.

The occurrence of frosts is markedly influenced by the local topography of the land, as the cold air settles into the low places when the air is calm. Some observations made at the experiment farm in the spring of 1910 show the extent of this influence in a typical location. Two registering minimum thermometers were placed 190 feet apart, one of them in a hollow between two long, low hills, and the other on the highest point on one of the hills at an elevation of 13½ feet above the level of the one in the hollow. During April, 1910, the average minimum temperature on the hill was 4.2 degrees warmer than in the hollow. The record was kept 17 days in May, during which time the average minimum hill temperature was 3.2 degrees warmer than in the hollow. The greatest differences occurred on those nights when there was little or no wind. A maximum difference of 10 degrees occurred on the night of April 25. No instance is recorded when the minimum temperature was higher in the hollow than on the hill. These results, given in detail in Table III, indicate that tender fruits and vegetables will be in less danger of being injured by late spring frosts when planted on the higher lands.

TABLE III.—*Daily minimum temperatures recorded by two thermometers, one on a hill and the other in a low place, on the Truckee-Carson Experiment Farm, Fallon, Nev., during the months of April and May, 1910.*[1]

Date.	Temperature.		Difference.	Date.	Temperature.		Difference.
	On hill.	In draw.			On hill.	In draw.	
1910.	° *F.*	° *F.*	° *F.*	1910.	° *F.*	° *F.*	° *F.*
Apr. 1	36	32	4	Apr. 28	44	41	3
2	39	37	2	29	36	33	3
3	38	36	2	30	47	46	1
4	23	19	4				
5	29	22	7	Average for month	39.0	34.8	4.2
6	46	41	2				
7	34	31	3	May 1	35	34	1
8	38	34	4	2	38	36	2
9	40	35	5	3	43	42	1
10	40	37	3	4	38	38	0
11	41	40	1	5	26	24	2
12	30	28	2	6	34	28	6
13	39	35	4	7	42	38	4
14	38	36	2	8	45	37	8
15	28	23	5	9	(2)	50	....
16	32	24	8	10	42	41	1
17	36	29	7	11	39	38	1
18	39	31	8	12	40	35	5
19	50	44	6	13	48	45	3
20	43	42	1	14	49	46	3
21	34	31	3	15 to 27	(2)	(2)	....
22	37	30	7	28	44	40	4
23	40	32	8	29	54	51	3
24	45	37	8	30	54	47	7
25	45	35	10	31	56	52	4
26	50	48	2				
27	53	51	2	Average for month	42.7	39.5	3.2

[1] Distance apart of thermometers, 190 feet; difference in elevation, 13½ feet.
[2] Records not obtained.

RAINFALL.

The rainfall in the region of the Truckee-Carson project is so light as to be of little benefit to growing crops. Table IV gives the monthly precipitation for the five years 1906 to 1910, inclusive.

TABLE IV.—*Annual rainfall at Fallon, Nev., 1906–1910.*[1]

Month.	1906.	1907.	1908.	1909.	1910.	Average.
January	....	0.39	0.49	0.60	1.98	0.86
February	....	.30	.48	.25	.04	.29
March	....	1.40	.02	.74	.10	.56
April	0.76	1.06	.28	.19	.28	.51
May	72	.39	.92	.02	.0	.41
June	.57	.66	.05	.27	.10	.33
July	.01	Trace.	.15	Trace.	.05	.04
August	Trace.	.38	.02	.06	.0	.09
September	.29	.12	.62	.41	.45	.38
October	Trace.	.41	.17	.70	.46	.35
November	.44	.21	Trace.	.71	.02	.28
December	1.56	.48	.07	1.30	.66	.81
Total annual	....	5.80	3.27	5.25	4.14	4.91

[1] Compiled from official reports of the United States Weather Bureau.

TREE PLANTING ON THE PROJECT.

Tree planting should be one of the first things undertaken by each farmer, so that windbreaks may be established as soon as possible. They should be arranged so as to protect the gardens, farm buildings, and orchards from the south and west winds. The larger fields may also be protected by planting rows of trees along the west sides. The best trees to use for the purpose are the Carolina poplar, balm of Gilead, black locust, Russian oleaster, and tamarisk.

CAROLINA POPLAR.

The Carolina poplar (*Populus deltoides carolinensis*) is a rapid-growing tree that can be propagated easily from cuttings. It is closely related to the common cottonwood, but is more symmetrical in shape and seems to make more rapid growth. Ten-inch cuttings set out in April, 1910, at the experiment farm made a growth of 4 to 8 feet during that season. Nurserymen have propagated it by means of cuttings from staminate or male trees only; therefore, it does not have the disagreeable habit of shedding "cotton" each spring. The chief value of the Carolina poplar is for fuel, windbreak, and ornamental purposes. The wood is too soft to be of much value for timber or for fence posts unless a preservative is used. Cuttings may be obtained by local farmers from the Truckee-Carson Experiment Farm.

NORWAY POPLAR.

The Norway poplar is very similar to the Carolina poplar in appearance. Some nurserymen claim that it makes a more rapid growth, but we have been unable to observe any difference between the two varieties on the Truckee-Carson project.

COTTONWOOD AND BALM OF GILEAD.

The cottonwood (*Populus deltoides*) and balm of Gilead (*Populus balsamifera*) are desirable species of the poplar family. Both species have a more spreading habit than the Carolina poplar and probably do not make such rapid growth. The pistillate or female cottonwoods are not so desirable, on account of their habit of shedding "cotton." Cuttings from staminate or male stocks produce trees that do not have this defect. Either species is easily propagated from cuttings, or seedlings of the cottonwood may be obtained along the watercourses, where they grow abundantly.

BLACK LOCUST.

The black locust (*Robinia pseudacacia*) makes a rapid growth and produces an excellent timber for farm purposes. The wood is hard and tough, making it valuable for fuel, whiffletrees, crossbars, ax handles, and general repair work. It is slow to decay when in contact with the soil, so that it is one of the best materials to use for fence posts. When the black locust is cut down new shoots put out from the stump and grow straighter and with greater rapidity than the original tree. It has the bad habit of suckering, so that the locust plantation is liable to grow up into an impenetrable thicket unless it is well cared for. The tree is easily grown from seed, or it may be propagated from root cuttings. Seed can be obtained from nurseries in the Central States at about 70 cents a pound, or 1-year-old seedling trees can be purchased for about $3 a thousand.

TAMARISK.

The tamarisk (*Tamarix* sp.) is a quick-growing tree or shrub, useful for windbreaks and hedges. The foliage is light and feathery and decidedly ornamental. It is easily grown from cuttings, which will be supplied by the experiment station during the early spring months. These cuttings are from 8 to 10 inches in length, and for windbreaks or hedges should be set in the ground 2 feet apart in the row. This will make a beautiful, dense hedge within two years. Cutting back the ends of the branches each winter will cause it to branch more and result in a thicker hedge.

RUSSIAN OLEASTER.

The Russian oleaster (*Elaeagnus angustifolia*), a close relative of the native buffalo berry, is a very desirable tree to use for hedges and windbreaks. It should find a place about every farm home on the Truckee-Carson project to protect the house, garden, and orchard from the winds, to outline driveways, or to hide unsightly buildings. When the seedlings are planted 3 or 4 feet apart it makes a dense hedge in two or three years that will turn live stock. Cutting back a little each year causes the hedge to thicken. When grown isolated, it makes a symmetrical tree with a round top.

It is sometimes referred to as the Russian wild olive, but since it does not belong to the olive family, but to the oleaster family, the

FIG. 1.—Hedge of Russian oleaster (*Elaeagnus angustifolia*) on the Truckee-Carson Experiment Farm. This hedge was set out in the spring of 1908, 1-year-old seedlings being used. (Photographed in August, 1910.)

name Russian oleaster is more accurate and should be used. This species is native to northern Persia, southern Siberia, and northern China. Seed can be obtained in small quantities from the experiment farm each year, or the seedlings may be obtained from some nurserymen in the western part of the Mississippi Valley.

A row of several hundred 1-year seedlings was set out at the experiment farm in April, 1908. In the fall of 1909 the hedge was 7 feet high and so dense as to be impenetrable. During 1910 this hedge was kept pruned back to a height of 7 feet, and the result was a beautiful, symmetrical hedge, as shown in the accompanying figure (fig. 1). Some trees that were not pruned are now from 10 to 15 feet in height, the result of three years' growth from the 1-year seedlings. An abundant crop of seed was produced the third year after planting. In Dakota the tree is said to reach a height of 25 to 35 feet in 10 years.

CLEARING AND LEVELING THE LAND.

To prepare the desert soil for irrigation it is first necessary to clear the land of the brush that grows on practically all the soil suitable for crop production. The vegetation which has to be cleared away in the preparation of the land is chiefly greasewood (Sarcobatus), rabbit brush (Chrysomanthus), and sagebrush (Artemesia). This brush may be removed by grubbing, dragging a railroad iron over it, or, where it is not too large, by the use of the common disk harrow. The brush can often be used for fuel or for the building of windbreaks or corrals. It is important not to clear the brush off more land than can be irrigated and put into crop at once, as clearing it exposes the soil to the action of the wind, which often causes serious damage to crops lying to leeward.

Some of the land on the project is naturally almost level, and the cost of getting it ready for crops is very low. Other areas are covered with small sand hills, and the cost of leveling these is considerable. The cost of clearing and leveling the land varies from $8 to $100 per acre. Most of it can be cleared and leveled at a cost of $15 to $35 per acre.

AGRICULTURE OF THE PROJECT.

Alfalfa has been in the past the principal source of income to the farmers on the project, and this will probably continue to be true for some years. Barley and other grains have been grown to some extent on portions of the project, but under most conditions grain has not been as profitable as alfalfa.

On account of the distance to large markets, an overproduction of alfalfa or any bulky crop results in a low price for that product; hence, it is well to avoid as far as possible any local overproduction of bulky products. If the crop production of the project were to be limited to alfalfa, without at the same time providing live stock for its consumption, the result would be unprofitable market conditions. These conditions were approached at Fallon in the fall of 1910, when the price of alfalfa dropped to $6.50 a ton in the stack.

No commercial orchards have been planted, but there are sections of the project on the higher lands having good drainage where fruit growing might become commercially profitable. If such plantings are made, care should be taken to put them only on land which is not subject to a high water table and where the air drainage is good, for under other conditions the trees are almost sure to be short lived and to suffer from spring frosts. There are numerous small orchards on the project and in some of them the trees are doing well.

FORAGE CROPS.

ALFALFA.

Alfalfa is the great money crop of this region. It is seeded any time after March 1 until the end of August, although April, May, and August are probably the best months in which to seed. June and July are so hot that there is a tendency for the soil to dry out rapidly and check the growth of the tender seedlings.

The rate of seeding is from 12 to 20 pounds per acre. Twelve pounds per acre is sufficient seed for a good stand in the lighter soils, where there is little trouble in getting the seed to germinate. In the heavier soils, or in land that crusts badly, it is often advisable to sow more than 15 pounds per acre. It is generally broadcasted and harrowed in, but it is preferable to put it in with the grain drill. In the light sandy soils the alfalfa may be safely sown $1\frac{1}{2}$ inches deep, but this is too deep for the heavier soils. The seed should be sown as deep as is consistent with the character of the soil, as the deep-sown seed is less liable to dry out after germinating.

Fields should be irrigated and well prepared immediately before seeding. The seed is then sown in the moist soil and should germinate at once. If the character of the soil will permit it is best to let the seed come up before again irrigating, as the water always packs and cools the soil and sometimes causes a crust to form, through which the alfalfa does not readily penetrate.

The usual method of irrigating alfalfa about Fallon is by flooding in checks. Near Fernley the practice is to irrigate by the furrow or corrugation system.

While the alfalfa is young rather frequent irrigations are needed, but as the alfalfa grows older and the roots penetrate deeper, fewer irrigations should be given. Where there is poor drainage and danger from a high water table special care should be taken not to overirrigate, and water should be applied only when the alfalfa shows signs of actually needing it. Where there is good drainage more frequent applications of water are not so liable to produce bad results.

It is often difficult to get a satisfactory stand of alfalfa, either from the crusting of the soil, so that the alfalfa seedlings can not break through, or from the blowing of sand, which sometimes cuts off the young plants at the surface of the ground.

These difficulties may be partly overcome by first seeding grain on the land in the spring and when the grain is a few inches high seeding in the alfalfa with a grain drill. The stand of grain partially shades the ground, thus somewhat preventing the crusting of the soil, and it effectually protects the alfalfa seedlings from the drifting of the sands. The grain should be cut for hay before it is mature, in order to give the alfalfa a chance to make a good growth before cold weather sets in.

Only the purest alfalfa seed should be sown. Much alfalfa seed has been sown in the vicinity of Fallon that contains dodder and sweet clover. Both of these are highly undesirable weeds in an alfalfa field. The dodder especially is hard to get rid of. Before purchasing seed the farmer should test its germinating power. This can be done by putting some of the seed between two layers of moist cloth in a covered dish, which is kept for two or three days in a moderately warm room. If there is any doubt as to whether or not the alfalfa seed contains dodder, a sample may be sent to the experiment farm for examination.

In breaking an alfalfa sod to use the land for another crop, the alfalfa should be "crowned"—that is, the land plowed to a depth of 2 or 3 inches with a plow having a sharp share. After "crowning" the field should lie without irrigation for six weeks or more, when it may be plowed deep and put into crop without serious trouble. If an alfalfa field is plowed deep the first time, the crowns have sufficient roots still attached to them to permit the development of new shoots and it is very hard to keep these reestablished plants in subjection.

On the Truckee-Carson project three cuttings of alfalfa are obtained each year and the average yield is probably about 4 tons per acre. To secure the maximum yield the alfalfa should be cut before the new basal shoots (that appear soon after the alfalfa begins blossoming) are high enough to be cut by the mower. To cut off these basal shoots retards the new growth. Alfalfa may be safely pastured in the fall after the third cutting, provided care is taken to see that it is not cropped too closely.

At the present time alfalfa is grown for hay production almost to the exclusion of every other forage crop. To replace alfalfa any other crop must possess some point of superiority, either in the yield or in the quality of forage produced. Such a crop has not yet been found for this region.

GRAIN HAY.

Grain hay is an excellent crop in connection with alfalfa when the latter is first seeded. The grain protects the young alfalfa from the winds and to some extent prevents the crusting of the soil. A small early crop of hay is produced that may prove very acceptable to the farmer who has as yet no well-established field of alfalfa.

PEARL MILLET AND SORGHUM.

Pearl millet and sorghum produce about the same yield per acre as alfalfa, but they are more expensive to raise and the quality of the forage is not so good. Sorghum, however, may be seeded on new land in preference to alfalfa when a hay crop is necessary the first season. Sorghum usually grows well on new land and is fairly tolerant of alkali. It will probably give better yields if sown thickly in rows about 3 feet apart and cultivated once or twice during the season, though where the soil is in good tilth a better quality of hay may result from sowing the seed broadcast or with a grain drill.

CORN.

Corn sown thickly, either in rows to be cultivated or with a grain drill, so as to produce small stalks, may prove valuable to grow in a small way for the feeding of dairy stock. Corn should produce from 4 to 10 tons of fodder per acre and it is a crop that is used extensively in the dairy sections for feeding milch cows. On some of the rich black lands of the project corn planted for grain is a profitable crop, and with the development of a demand for this grain for feeding live stock it will probably be extensively grown.

PASTURE CROPS.

There are not at present any successful pastures in the Truckee-Carson project where a mixture of grasses has been used. With a pasture of pure alfalfa or clover there is always danger of bloat with dairy and beef cattle. At Fernley there is a field of mixed alfalfa and smooth brome-grass (*Bromus inermis*) which has been cut annually for hay. This field could probably be safely pastured without danger of bloat, but it is not known whether brome-grass can be successfully grown on the lower land of the project at Fallon. Since brome-grass starts very slowly when first sown, it might be well to sow the seed with a grain crop and allow the grass to get fairly well started and then seed the alfalfa the following year. Or where an alfalfa stand has become thin from hard pasturing, brome-grass might be seeded in with a grain drill after disking the land thoroughly.

SUGAR BEETS.

Now that a sugar-beet factory has been built, sugar beets are likely to become one of the principal money-making crops of the Truckee-Carson project. Good beets have been produced experimentally on the river-bottom soil, sandy-desert soil, and the black soil of the Stillwater and Douglass districts. Sugar beets are quite tolerant of alkali, but beets of good form and quality are not produced on low, wet soils. Sugar beets grown on plats having a high water table (less than 2½ feet) have a tendency to be short and much branched.

It has been the experience of sugar-beet growers in other sections where alfalfa is grown that the beets should not be planted on freshly plowed alfalfa lands, as the undecayed roots and crowns of the alfalfa seriously interfere with the proper seeding and cultivation of the beets. It is therefore usually advisable to grow some intervening crop, such as potatoes, between alfalfa and sugar beets. Wherever possible, land that is to be used for sugar beets should be plowed the previous autumn and before the beets are planted the land should be thoroughly irrigated and worked into a fine tilth. This will not only insure a more uniform germination of the seed, but will also make the first cultivation and hand weeding much easier.

Table V presents the results of analyses of sugar beets made during the four years 1907 to 1910, inclusive. In 1907 and 1908 the beets analyzed were rather small, which probably partly accounts for the higher sugar content shown for those years. The analyses in 1907 and 1908 were made by the United States Department of Agriculture; those in 1909 and 1910 by Prof. Sanford Dinsmore, of the University of Nevada. Accurate yields of beets in tons per acre have not been obtained.

TABLE V.—*Analyses of sugar beets grown on the Truckee-Carson Experiment Farm, 1907 to 1910, inclusive.*

Year.	Number of samples.	Type of soil.	Sugar in juice.	Sugar in beet.	Purity.
			Per cent.	*Per cent.*	*Per cent.*
1907	18		21.55		87.3
1908	21	Adobe	18.2		87.8
	21	Sandy	20.0		89.95
1909	34	All types	16.26	15.5	86.0
	7	New land	15.8	15.0	86.9
	8	Gardens and alfalfa land	16.95	16.1	86.4
	6	Stillwater and Douglass districts	17.1	16.4	89.78
	13	Unknown	15.74	14.93	81.8
1910	3	Miscellaneous	17.0	16.11	87.5

VEGETABLES.

Most of the common vegetables are so easily grown that every farmer should have a garden large enough to supply his family throughout the season. On account of the distance to large markets, market gardening on a large scale is not likely to be profitable, except possibly with potatoes and onions.

The following vegetables are the kinds most easily grown: Watermelons, muskmelons, squashes, pumpkins, cucumbers, tomatoes, turnips, carrots, table beets, radishes, lettuce, kohl-rabi, onions, potatoes, egg-plant, wonderberries, and garden huckleberries.

The reports of the vegetables that follow are from results obtained at the Truckee-Carson Experiment Farm.

WATERMELONS.

Watermelons are easy to grow and are very productive on the sandy soils of the project. On the experiment farm 12,104 pounds of marketable melons were harvested from one-seventh of an acre. At this rate the yield was over 42 tons per acre. As the growing season for melons is somewhat short in this section only the quick-growing varieties should be grown. Table VI shows the results obtained at the experiment farm during the season of 1910.

TABLE VI.—*Watermelon yields, etc., on the Truckee-Carson Experiment Farm in 1910.*

Varieties.	Total yield.[1]	Average weight.	Remarks.
	Pounds.	*Pounds.*	
Kentucky Wonder	1,172	12	
Fordhook Early	1,025	10	Generally good; solid.
Harris Early	947	7½	Generally hollow and stringy.
Kleckley's Sweet	944	12½	Sweetest melon on trial.
Pride of Nebraska	921	9½	Seems identical with Kleckley's Sweet.
Sweetheart	825	15½	
Kolb's Gem	820	13	
Cole's Early	819	10	Much like Harris; often hollow.
Dixie	755	10	Very good quality.
Ironclad	707	14	

[1] Yields given are from rows 80 feet long.

The best results with watermelons and similar vegetables will probably be secured by first opening a deep furrow with a plow, filling this furrow with well-rotted manure, and turning the earth back over the manure and planting the seed on the ridge thus formed. When putting in the seed the ground should be firmed down with a hoe to insure bringing the seed into contact with the moist earth, so that it may germinate promptly. Care should be used to prevent flooding the soil above the seed and causing it to form a hard crust.

MUSKMELONS.

Muskmelons are easily grown and especially on the lighter soils are very productive. The following table gives the names of the varieties grown and the comparative yields from rows 80 feet in length. The Rocky Ford was the most popular variety. The Khiva is a late-maturing variety, but will keep long into the winter.

TABLE VII.—*Muskmelon yields, etc., on the Truckee-Carson Experiment Farm in 1910.*

Variety.	Date of first picking.	Yield.	Remarks.
		Pounds.	
Rocky Ford	Aug. 9	355	No rotted or cracked melons; high average of quality and market condition.
Extra Early Hackensack	Aug. 5	112	A good early melon.
Strawberry	Aug. 12	357	Fine grain and quality; varies as to sweetness.
Osage	Aug. 22	293	Deep salmon flesh.
Burrell's Gem	Aug. 27	264	Best melon on Sept. 6.
Paul Rose	Aug. 16	210	
Khiva	(?)	(?)	A good variety for winter use.

PUMPKINS AND SQUASHES.

Pumpkins and squashes should be grown in every farmer's garden, as they are very prolific and are valuable for table use. The common field pumpkin and Japanese pie pumpkin are good varieties. The Golden Crookneck squash is one of the best for summer use, while the warty Hubbard is probably the best variety to store away for winter. The White Bush Scalloped is a commonly grown summer variety, but it does not have the richness of flavor of the Golden Crookneck.

CUCUMBERS.

The White Spine, Klondike, Long Green, and Everbearing cucumbers are desirable varieties for this section. The Gherkin is a small prickly variety that is used only for pickling. It is an abundant producer, and probably more people would grow this variety were its qualities better known.

TOMATOES.

Tomatoes usually produce a satisfactory crop, but are subject to the attack of a disease known as tomato wilt (*Fusarium* sp.). This disease attacks individual plants in the tomato plat. The first indication is a wilting of the leaves of the affected plants. The wilt becomes more noticeable from day to day and finally results in the death of the plants. No remedy is known, but the disease can be checked by growing tomatoes always on soil that has not recently been in that crop and by pulling and burning all diseased plants as fast as they appear. The following varieties of tomatoes are recommended for planting: Early Jewell, Dwarf Champion, New Stone, New Coneless, New Globe, Golden Queen.

At the experiment farm 1,190 pounds of tomatoes were produced from one-nineteenth of an acre, or a yield of over 11 tons per acre, in spite of the fact that over 25 per cent of the plants were affected with tomato wilt.

ONIONS.

On some of the soils of the Truckee-Carson project onions grow well, so that it is profitable to grow them for the market, but it would not be safe to attempt to grow them on a large scale on newly cleared land. They grow so well, however, that each farmer can easily grow enough for table use.

Good varieties for trial are the Mammoth Pompeii, Silver King, Prizetaker, and Red Wethersfield.

WONDERBERRIES AND GARDEN HUCKLEBERRIES.

The fruit of the wonderberry is about the size of the blueberry. It is quite agreeable to eat raw, and it makes good jams and pies. On account of its small size the fruit is slow to gather. The garden huckleberry is larger than the wonderberry, but is thicker skinned, requires more cooking, and does not have a pleasant taste when eaten raw. The pies and jams made from these two kinds of berries have a very similar taste. While these two fruits are far from perfection, they seem to be popular, at least in this section, and deserve a place in the family garden until more desirable fruits can be grown.

OTHER VEGETABLES.

Varieties of peppers grow well on some of the soils about Fallon, but on some of the newly worked desert soil they do not produce satisfactorily.

Potatoes grow best following alfalfa. To get the best results very careful irrigation must be given, so that the crop may make continuous growth without check until it approaches maturity, when no more water should be given, otherwise a second growth will result. Good varieties to grow are the Burbank, Peachblow, and Early Ohio.

FRUIT GROWING.

The following notes are the results of observations made during the autumn seasons of 1909 and 1910 while inspecting the orchards located on the older ranches in the project.

The first settlers along the Carson River made some fruit plantations at an early date after their settlement in the valley. These plantings were not large, as they were intended for home use. Many trees 25 and 30 years old are still to be seen. No extensive plantings are being made at this time, but many of the new settlers are putting out home orchards.

The old orchards have suffered in various ways. Before the more efficient irrigation system of the Reclamation Service was installed much damage was caused by drought in the latter part of the season. Overcrowding and general neglect have caused unthrifty trees and poor fruit. In these old apple orchards the trees were usually set 16 by 16 or 20 by 20 feet, with the result that the branches were soon interlocked and the vigor of the trees lessened. Many of the new settlers are making the same mistake. The right distance for apple trees in this region is about 30 by 30 feet.

The high-water table under some of the orchards seems to be killing out the trees.

The codling moth is the most troublesome orchard pest. No remedial measures have been taken to stay its ravages. Other insects noted are the flat-headed borer, woolly aphis, and red spider. The aphis does not appear to do great damage, but it is present in practically all orchards. Diseases of fruit trees do not appear prevalent. Pear blight has been noted, but it is not general.

Home orchards have been profitable in the past, and in view of the fact that orchard heaters have proved practical in many places it is not unreasonable to expect that large orchards may be commercially profitable, especially on the higher lands where there is good natural drainage. There are bench and sloping lands containing thousands of acres which could not be utilized before the opening of the Truckee-Carson project. These lands appear to be less frosty, and can not be troubled by the rise of ground water.

The mature home orchards that are found on the old ranches have not as a rule had good care, so it is hard to judge how well the various fruits would produce if they were given proper cultivation, pruning, thinning, and frost protection.

The kinds of fruit now growing on the project, chiefly on the old ranches, are as follows: Apples, pears, peaches, domestica plums, prunes, quinces, apricots, nectarines, cherries, grapes, and such small fruits as currants, gooseberries, and strawberries. Apples and pears are the surest bearers. Specific varieties of fruits can not at this time be recommended.

SUMMARY.

The Truckee-Carson Irrigation Project, in western Nevada, was one of the first of the new regions to be opened under the reclamation act of 1902. Practically all of the land for which water is available has now been taken up, about 35,000 or 40,000 acres being now under cultivation, most of it lying near the town of Fallon.

Near Fallon the United States Department of Agriculture operates an experiment farm, where farm tests are being made of the adaptability of various field, fruit, and garden crops, and where methods of reducing the salt content of the soil are being worked out.

Most of the soil is a light sandy loam, but there are large areas of fertile black soil, both of which types produce abundant crops. There are small, irregular areas of hard, impervious soil difficult to work and usually not producing satisfactory crops.

In those areas where it is impossible to grow crops on account of the high salt content of the soil, little or no advantage can result from flooding. Deep ditches should be put through to lower the water table. A comprehensive drainage system for the lower lands has been planned and partly constructed, and this when completed will make it possible to keep the ground water below the limit of serious harm.

Windstorms severe enough to kill new seedings of alfalfa and injure small garden stuff occur occasionally in the spring. This difficulty may be obviated by planting windbreaks, which should be one of the first things undertaken. Carolina poplar, Norway poplar, cottonwood, balm of Gilead, black locust, tamarisk, and Russian oleaster are desirable trees for this purpose.

Records for six years show a maximum temperature at Fallon of 103° F. and a minimum of −15° F. As a general rule, farm operations are carried on throughout the winter months. The length of the summer period varies in different parts of the project, and the local topography has considerable influence on the occurrence of frosts. The rainfall of the project is so light as to be of little benefit to crops, the average fall for the past five years at Fallon being 4.91 inches.

The land may be cleared of brush by grubbing, dragging, or disking. Most of the land can be cleared and leveled at a cost of $15 to $35 an acre.

Alfalfa is the principal source of income to the farmers. Three cuttings are secured, and the average yield is about 4 tons per acre. Barley and wheat have been grown to some extent, but under most conditions grain is not as profitable as alfalfa. The overproduction of alfalfa without sufficient live stock to consume it, with a consequent low price of the hay, is a possible danger. Grain, pearl millet, sorghum, and corn may be grown as hay crops, but as yet no forage crop has been found to replace alfalfa.

There are at present no successful pastures on the project where a mixture of grasses has been used. With pure alfalfa or clover there is always danger of bloat with dairy and beef cattle, and suitable grasses for pasture are much needed.

There are as yet no commercial orchards on the project, but there are sections where fruit growing might become commercially profitable. Home orchards have been profitable in the past. Apples and pears are the surest bearers, but peaches, domestica plums, prunes, quinces, apricots, nectarines, cherries, grapes, and such small fruits as currants, gooseberries, and strawberries are also grown. Specific varieties of fruits can not at this time be recommended.

Experiments with sugar beets show that this crop may be profitably grown on river-bottom soil, sandy-desert soil, and the black soil of certain districts. The establishment of a sugar-beet factory on the project will probably give impetus to this industry.

Most of the common garden vegetables are easily grown, watermelons and muskmelons being especially productive on the sandy soils of the project.

Potatoes grow best following alfalfa. To get the best results careful irrigation should be given to insure continuous growth. Good varieties to grow are the Burbank, Peachblow, and Early Ohio.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *March 27, 1911.*

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 79.

B. T. GALLOWAY, Chief of Bureau.

WINTER WHEAT IN WESTERN SOUTH DAKOTA.

BY

CECIL SALMON.

Plant Physiologist, Office of Grain Investigations.

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BUREAU OF PLANT INDUSTRY.

B. P. I.—677.

WINTER WHEAT IN WESTERN SOUTH DAKOTA.

INTRODUCTION.

The value of winter wheat as a dry-land crop in western South Dakota has been the subject of much discussion during the past few years. The production of winter wheat in this area has not reached proportions of commercial importance. Wyoming and Montana, however, produced during the past season more than 7,250,000 bushels, and as the soil and climate of western South Dakota are very similar to those of the States mentioned there is good reason to believe that profitable returns may be obtained from the crop in this region.

The advantages in favor of winter wheat, where it can be successfully grown, are better distribution of labor by fall seeding and early harvest; early maturity, and therefore less danger from hail, hot winds, disease, etc.; greater drought resistance; and larger yields. Its importance as a dry-land crop is due largely to its early maturity and to its ability to produce a fair yield even in seasons of severe drought.

Winter wheat has been grown at several points in western South Dakota, in some instances for a number of years. While not uniformly successful, the crop promises good results when properly handled. The aim of this paper is to outline the best methods of growing this grain as shown by observation and by experiments that have been conducted. So little has been done, however, that it is not possible to say that any method is certainly the best. Yet it is thought that a summary of results obtained will be of value both in pointing out some of the mistakes most commonly made and in indicating the methods most likely to be successful.

DIFFICULTIES LIKELY TO BE ENCOUNTERED.

THE WINTERKILLING OF WHEAT.

Winterkilling is the injury most commonly feared in growing winter wheat and is the principal limiting factor in the northward extension of the winter-wheat belt. It is due to extreme cold, to exposure and injury of the roots by the heaving of the soil, and to other causes. The extent of injury differs widely with the different varieties grown and is affected to a less extent by the preparation of the soil and seed and by the time, rate, and method of seeding.

During the three years in which tests have been conducted at the Bellefourche Experiment Farm,[1] situated near Newell, S. Dak., the winterkilling of the best varieties has seldom exceeded 25 per cent, while the average is less than 15 per cent. The stooling of these varieties has been such that the actual loss in bushels has probably been slight. At the present writing (Apr. 1, 1911), the fourth crop has come through the winter apparently in good condition.

It seems that a field may be greatly injured by winterkilling and yet produce a good yield, especially if the damage is evenly distributed throughout the field. Winterkilling of over 50 per cent at the Bellefourche Experiment Farm has in some cases been followed by yields of 20 bushels per acre and over.

The soil of the Bellefourche Experiment Farm is a heavy clay of the Pierre clay formation, commonly known as gumbo. Apparently it does not heave, and this fact has undoubtedly diminished the loss from winterkilling. On the other hand the winters have sometimes been severe and the plats have been so located that they received very little protection from snow.

THE BLOWING OF THE SOIL.

Damage from the blowing of the soil in high winds is an important consideration on the dry lands. The danger is greatest on soils containing sand or fine gravel and in fields fully exposed to the wind. In the late winter and early spring months, the velocity of the wind is often great enough to carry the soil particles rapidly across the field, cutting off the plants near the ground and exposing the roots to the weather. This condition is especially trying on dry farms, as dry winters are common and the plants and soil are left in a condition most favorable to rapid evaporation. Undoubtedly much of the loss ascribed to winterkilling may be traced to this cause.

The extent of injury likely to be done is affected by the location of the field, ridges being exposed to and valleys or swales being more or less protected from the full violence of the wind. Consequently fields partly protected are less likely to be damaged than are those fully exposed to the prevailing northwest winds.

Little progress has been made in devising methods of handling cultivated fields to prevent blowing. The problem is especially difficult for the dry-land farmer, as the fine soil mulch, which is so

[1] The Bellefourche Experiment Farm is in charge of the Office of Western Agricultural Extension of the Bureau of Plant Industry. The investigations reported in this circular were conducted in cooperation with that office.

necessary to conserve moisture, increases the danger from blowing. It is necessary, as far as possible, to choose some middle course which will involve the least loss of moisture and at the same time minimize this danger. Implements with cutting blades that fine the soil out of all proportion to the value of the work done should not be used. The disk and spring-tooth harrow are preferable, as they tend to bring the larger particles and lumps of dirt to the surface and allow the finer particles to reach lower levels of the soil stratum.

It is important that some method of crop rotation be followed that will supply humus to the soil, as possibly no other factor is so efficient in cementing the soil particles together and preventing blowing.

PREPARATION OF THE SOIL.

Several methods of preparing the soil for winter wheat have been advocated, such as seeding in small-grain stubble without previous preparation; seeding on corn ground between the standing rows with a 1-horse drill; seeding on corn ground after preparing with a disk and harrow; seeding on early fall plowing; and seeding on land prepared by summer-fallowing.

The first two methods are employed to catch and hold the snow and thus prevent winterkilling. The average snowfall in western South Dakota is rather light and the snow seldom stays on the ground during the entire winter. For this reason the benefit likely to be derived is not so great as in sections where the snowfall is heavier. On the other hand, there is apparently not as much danger from alternate thawing and freezing as in sections where there is more moisture, so that protection is not so necessary.

Possibly the chief difficulty likely to be encountered in growing this crop on any but summer-tilled land is to conserve sufficient moisture in the soil to germinate the grain and properly maintain its growth until the spring rains begin. The same difficulty also applies to summer fallow not properly cultivated or when the rainfall is so deficient that no moisture can be stored in the soil. The autumn precipitation is usually very light and so distributed that it is often insufficient to start the crop. It frequently happens that there is sufficient moisture to germinate the grain but not enough to maintain its growth, in which case it may be greatly injured or killed by continued drought. On the other hand summer tillage is likely to increase the danger from blowing, as the tilth necessary to conserve the moisture leaves the soil in such a condition that it is easily carried away by the wind.

The lack of experimental data makes it impossible to say just how essential is summer fallow in the production of winter wheat. The relative cost, yield, and chances of failure of grain grown on summer fallow and by other methods form a complex problem which will probably require several years to solve. Summer-fallowing is the method most widely advocated in Montana and western Nebraska and will apparently give the most satisfactory results in western South Dakota.

When heavy rains occur in the late summer and early autumn months, it may be found advisable to increase the winter-wheat acreage by seeding on corn ground or on early fall plowing. The former is probably preferable. In either case there should be sufficient moisture in the soil to keep the crop in good condition until spring. Otherwise, the plants may die or go into the winter in a weakened condition.

A good summer fallow consists essentially in early plowing and sufficient cultivation afterwards to conserve the moisture. A good plan is to plow in the spring as soon as possible after seeding, or earlier if desired. The ground may then be worked at once with disk and harrow, or it may be allowed to remain as left by the plow in the expectation of heavy rains in May and June. The method to be followed depends upon the quantity of moisture in the soil at the time of plowing. In either case cultivation should follow every rain sufficiently heavy to connect with the moisture below or to supply more moisture to the soil than will be lost by the cultivation. A practice sometimes advocated is that of plowing in the fall soon after the crop is removed and allowing the ground to remain rough until spring, when it is cultivated as in the former case.

No matter by what method winter wheat is grown, a firm seed bed is essential. This is, perhaps, one of the most important factors connected with the preparation of the soil, as upon it depend to a large extent the supply of available moisture and the germination and growth of the plant.

VARIETIES TO GROW.

The growing of varieties not adapted to the locality is a great drawback to the success of a crop. This fact has been clearly demonstrated by experiments conducted on the Great Plains and by the experience of farmers. Tests of the value of different varieties have been conducted for three years at the Bellefourche Experiment Farm, with the result that no wheat has been found superior to the Russian winter wheats, Kharkof and Turkey. Many other varieties from various parts of the United States and Canada have been grown in comparative tests, but practically all of them winterkilled entirely or to such an extent that very low yields were obtained. Only a few were at all promising. These results are so fully substantiated by tests conducted elsewhere that it would seem a waste of time and money to grow any but these varieties, except in an experimental way.

Home-grown seed or seed raised under conditions similar to those in this region should be used, as only in this way will the best results be obtained.

PREPARATION OF SEED.

The seed should be carefully cleaned and graded to remove all dirt, weed seeds, and small shrunken kernels. If smut is present the seed should be treated, as there is great loss from this parasite in seasons favorable for its development. One method is that of wetting the grain with a solution consisting of 1 pound of formalin to 40 or 50 gallons of water and then covering with a blanket or tarpaulin. The grain is allowed to remain covered for about two hours and is then spread out and occasionally stirred until dry, when it may be stored in a bin or in sacks free from smut. By this method, however, the smut balls are left in the grain and may break in the sacks in hauling or in the drill and thus infect the grain to some extent. If the grain is steeped in barrels or vats, or a good smut machine is used, the smut balls can be skimmed off and all infection prevented. The grain is sometimes sown without drying, in which case it is necessary to seed at a little heavier rate because of the swelling of the grain when wet.

TIME OF SEEDING.

The general belief is that winter wheat must be sown early in this section to obtain a good yield, the time usually considered best being from about August 15 to September 1. However, the results so far obtained at the Bellefourche Experiment Farm do not support this view.

In the fall of 1907 five plats of Turkey winter wheat were sown at intervals of about two weeks, beginning September 1. The highest yield (25.5 bushels per acre) was obtained from the plat seeded November 1. The plats sown October 1 and October 15 yielded nearly as much, but the one seeded September 15 yielded only 20.3 bushels per acre and that seeded September 1, 23 bushels. These plats were sown on new land broken during June, 1907, backset in August, and worked with a disk and harrow until a good seed bed was obtained. The test was continued in the same manner in the seasons of 1908–9 and 1909–10, except that the first plat was sown August 15 and the land was prepared by summer-fallowing. In 1909 the best yield (43 bushels per acre) was obtained from the seeding of October 1. The plats seeded August 15 and November 1, which were the earliest and latest seedings, respectively, yielded 5 bushels less, which was the lowest yield obtained.

In 1909 two plats were sown on each date at intervals of two weeks from August 15 to November 1. Those sown October 1 failed to come up because of cold weather soon after seeding, and some of the plats were injured by blowing. Of those harvested, the best average yields (19.3 bushels per acre in each case) were obtained from the plats seeded August 15 and September 15. The plat sown September 1 produced the lowest yield (8.3 bushels per acre), this low yield being due to the poor germination.

The above results show that a uniform rule can hardly be laid down as to the best date for seeding.

In every case a good stand in the fall has been followed by a good yield, except in one or two instances when the plats were injured by blowing. For this reason, it seems that the main effort should be directed toward obtaining a good stand rather than toward seeding at a certain date.

If a good seed bed is prepared and there is sufficient moisture present to germinate the grain and keep it growing vigorously, early seeding is advisable, as the temperature at an earlier date is likely to be more favorable to germination and rapid growth. It is not advisable, however, to seed on poorly prepared soil simply for the sake of seeding early, when a few days' delay would permit the preparation of a good seed bed. On the other hand, it is not well to put off seeding until very late, as there is grave danger that the seed will never come up.

It appears that to obtain a good yield a good stand is necessary, and a good stand depends upon the presence of certain conditions of moisture, temperature, and soil. These will vary in different seasons and in different localities, so that no rule that will apply in all cases can be given. Each farmer must study his own conditions and decide for himself what course to follow.

METHOD OF SEEDING.

It is essential that the seed be placed in close contact with soil containing moisture. To insure this it is best to seed with a drill, as by so doing the seed can be placed at the desired depth and the soil packed around it. By drilling, a more uniform stand is obtained and a smaller quantity of seed is required than by seeding broadcast.

RATE OF SEEDING.

The exceptional stooling of winter wheat makes it unnecessary and inadvisable to seed this grain as heavily as spring wheat. The usual rate recommended for semiarid conditions is about 3 pecks per acre, a less quantity sometimes being advocated. With a well-prepared seed bed this amount is probably sufficient for western South Dakota conditions. Unless damaged by winterkilling or other causes, winter wheat is more likely to be too thick than too thin at harvest time. While a very thick stand may slightly increase the yield in a favorable year, it may greatly decrease it in an unfavorable one.

TREATMENT AFTER SEEDING.

It is usually considered advisable to harrow winter grain lightly soon after it starts growth in the spring, for the purpose of conserving the moisture. Whether the difference in yield will pay for the labor involved is an open question. More experimental data are required before it can definitely be stated when and under what conditions harrowing will be found beneficial. It will probably be of most value on soils likely to crust and in seasons when a heavy precipitation in the winter and early spring is followed by drought. On soils likely to blow, harrowing should not be done until this danger is past.

Where a field is badly damaged by winterkilling, good judgment should be exercised in deciding whether the crop should remain or the field be disked for spring grain. Undoubtedly many fields have been reseeded that would have made good yields had they been left in winter wheat. The ability of the Kharkof and Turkey wheats to recover is great, and, because of stooling, a uniform, thin stand in the spring will usually result in a good stand by harvest. The slowness of winter wheat to start growth in the spring after a hard winter is likely to mislead the farmer. In this connection it may be noted that clean land, free from weeds, is essential. Otherwise, after a severe winter the weeds may get the start of the wheat and greatly reduce the yield.

SUMMARY.

Where successfully grown, winter wheat possesses many advantages over spring wheat, such as better distribution of labor, earlier maturity, greater drought resistance, and larger yields. There is apparently no reason why it should not be grown successfully in western South Dakota.

The principal difficulties likely to be encountered are winterkilling and the blowing of the soil. The loss from winterkilling can be greatly reduced by growing the best varieties and by proper preparation of the seed and soil. Much damage from blowing can be prevented by selecting fields for winter wheat which, because of their location, are more or less protected from the wind. Implements which fine the soil more than necessary should not be used.

From the small amount of data available, it seems that summer-fallowing is probably the best method of preparing the soil for winter wheat. When other methods are used, the germination and growth of the wheat are uncertain because of the low average autumn rainfall. In seasons when the precipitation in the summer and early fall is heavy it may be advisable to increase the winter-wheat acreage by seeding on corn ground or on early fall plowing.

The general belief that winter wheat must be sown early is not supported by the results obtained at the Bellefourche Experiment Farm. It seems of much more importance to prepare a good seed bed, to use good varieties, and to sow when moisture, temperature, and soil conditions are best than to seed at any specified time. Early seeding is

advisable if a good seed bed is provided and there is sufficient moisture in the soil to germinate the grain and maintain it in good condition until spring.

Success with winter wheat depends very much upon the varieties grown. As far as known, the Kharkof and Turkey varieties are best for this region. Thin seeding is advisable. Three pecks of good seed per acre are probably sufficient.

Winter wheat should be sown with a drill, as in this way a better and more uniform stand is secured.

The Turkey and Kharkof varieties have great ability to recover after a hard winter. When damaged, good judgment should be exercised before reseeding to spring grain.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *May 9, 1911.*

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Issued September 28, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 80.

B. T. GALLOWAY, Chief of Bureau.

FORAGE CROPS FOR THE SAND-HILL SECTION OF NEBRASKA.

BY

H. N. VINALL,

Assistant Agrostologist, Forage-Crop Investigations.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1911

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BUREAU OF PLANT INDUSTRY.

[Cir. 80]

B. P. I.—673.

FORAGE CROPS FOR THE SAND-HILL SECTION OF NEBRASKA.

INTRODUCTION.

The passage of the Kinkaid homestead law[1] caused a considerable influx of settlers into the sand-hill section of Nebraska. Many of those who filed claims on tracts of 640 acres of this land were entirely unacquainted with agricultural practices and, besides, lacked the funds properly to stock and equip their farms. The result has been that a number were forced to abandon their homesteads before obtaining title, while a great many others stayed only long enough to secure a deed to the land so they could sell it; then they, too, gave up the struggle. Not only were the settlers themselves unacquainted with the agricultural conditions in the sand hills, but there was practically no source from which information was available.

It was with a view of obtaining a basis for recommendations in connection with the growing of forage crops that investigations consisting of cooperative experiments and a study of the practices of the more successful farmers were inaugurated. In the spring of 1908 a series of tests of forage crops was started in cooperation with farmers located under various conditions that were typical of the sand-hill section. These experiments were arranged not only to determine the comparative adaptability and value of various crops, but also to determine the best methods of culture. In the dry-valley region alfalfa (including several varieties), sweet clover, awnless brome-grass, slender wheat-grass, western wheat-grass, orchard grass, tall oat-grass, millet, and sorghum were tested extensively. Alfalfa, sweet clover, red clover, alsike clover, awnless brome-grass, timothy,

[1] This law, known as the Kinkaid Act, amended the Federal homestead laws, making it possible throughout the region indicated on the map (fig. 1) for settlers to file claims on 640 acres of land instead of 160. There were excluded from this act only such lands in the indicated district as the Secretary of the Interior might deem reasonably practicable to irrigate. It was also provided that settlers who had previously filed on a homestead in the region affected should have, for 90 days after the passage of the act, preferential right to make entry on sufficient additional land to increase their holdings to 640 acres, the stipulation in regard to final proof being that the entryman must prove affirmatively that he has placed upon the lands entered permanent improvements of the value of not less than $1.25 for each acre included in his entry.

redtop, Italian rye-grass, and perennial rye-grass were among the most important crops tested in the wet-valley region.

In the years 1909 and 1910 the tests were continued, in many cases with the same cooperators, but on a larger scale than in 1908. The plats varied from one-fourth of an acre to an acre in area, except where reseeding experiments were conducted, in which case they were usually much larger. The tests were inspected during the growing season each year, so that the behavior of the various crops was studied at the most favorable time for determining their value.

The results of these experiments, together with the data obtained from the most successful farmers, have made it possible to make some suggestions of a rather specific nature regarding the best methods of improving forage-crop conditions in the sand-hill section. While the suggestions and recommendations contained in this circular must in a measure be considered as tentative on account of

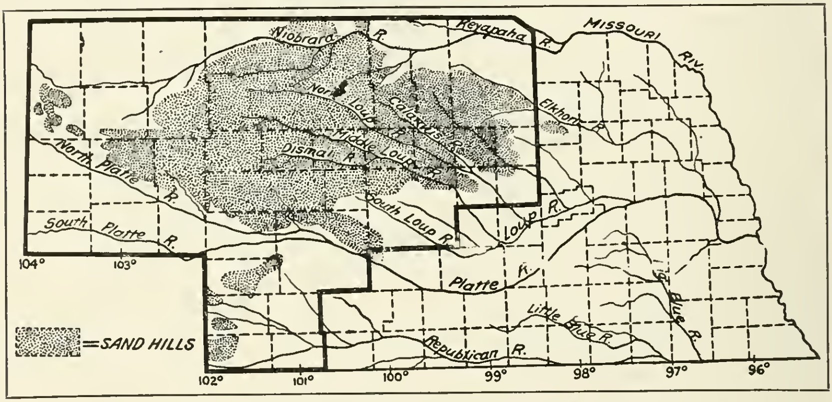

FIG. 1.—Map of Nebraska, showing the sand-hill section as indicated by Prof. Erwin Hinckley Barbour in his geological map of that State. The space inclosed by the heavy line shows the district affected by the Kinkaid homestead law.

the newness of the problems, it is hoped that they will be of considerable benefit to the farmers already in the sand hills and also to prospective settlers.

LOCATION OF THE SAND HILLS.

The sand-hill section of Nebraska, as shown in the geological map prepared by Prof. Erwin Hinckley Barbour, lies between 98° and 103° west longitude, and is bounded on the north by the Niobrara River and on the southwest by the North Platte River. (Fig. 1.) It includes practically all of the counties of Cherry, Garfield, Loup, Blaine, Thomas, Hooker, Grant, McPherson, and Garden; about half of Sheridan, Wheeler, Brown, Rock, and Logan; and considerable areas in Holt, Greeley, Valley, Custer, Lincoln, Keith, Morrill, Sioux, Perkins, Chase, and Dundy Counties. The space designated covers nearly 20,000 square miles, or about one-fourth the total area of the State.

TOPOGRAPHY OF THE SAND-HILL AREA.

The northern and western parts of this sand-hill area, lying in the counties of Holt, Rock, Brown, Cherry, Sheridan, Morrill, Garden, and Grant, are characterized as the "wet-valley region." In this region the valleys follow a general east-and-west direction and are usually quite broad and flat at the eastern or lowest end, which in most cases contains a shallow lake of varying dimensions, the largest of these being Dad's Lake, which is 4 to 6 miles long and 1 to 2 miles broad. In wet seasons the lakes increase in size and in dry seasons the smaller ones disappear entirely. Although in periods of extreme drought, like that of 1894, very few of the large lakes dry up completely, their varying size renders the area of the hay meadows which surround them inconstant.

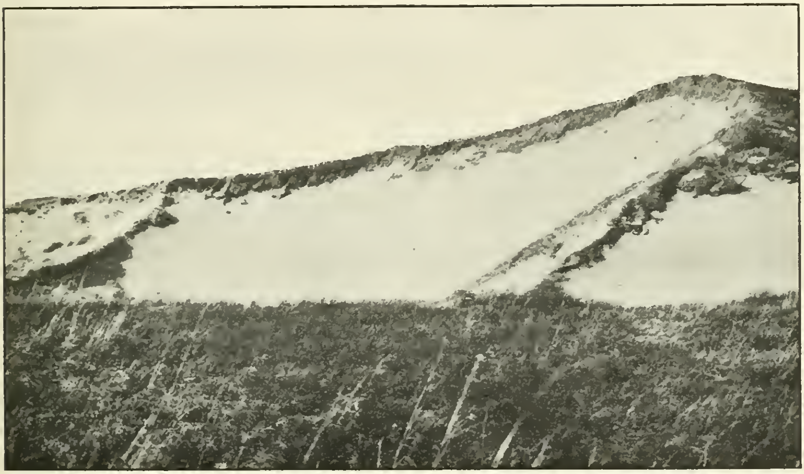

FIG. 2.—A blow-out near Alliance, Nebr.

The dry-valley region occupies most of the sand-hill section outside of the counties just named. It lies south of the former, and its distinguishing characteristic is its more abrupt and narrower valleys interspersed with ridges of sand hills. These valleys also are inclined in a general east-and-west direction, contain some fairly good soil in the bottoms, and have underground drainage sufficient to remove the surplus water. This dry-valley region grades insensibly into more irregular and choppy sand hills, which have no well-defined valleys between them and which contain little or no soil suitable for agricultural purposes. These choppy sand hills are found south of Thedford and Halsey in Thomas County, between the Middle Loup and Dismal Rivers. They are entirely useless for agricultural purposes other than grazing. On the tops of many of the hills are irregular conical depressions in the loose, shifting sand, locally known as "blow-outs." These depressions, swept out and kept clear of vegetation through the action of the wind, vary in depth from 15 to 50 feet and present the most difficult problem to deal with in the improvement of the sand hills. (Fig. 2.)

CLIMATE OF THE SAND-HILL AREA.

The forty-second parallel of latitude passes through about the middle of the sand-hill district. The temperatures in the hills are about the same as those along this parallel in eastern Nebraska and Iowa, except that the rapid radiation of heat at night from the sandy soil and the higher altitude make the nights cooler and bring the fall frosts somewhat earlier. In the western portion of the sand hills the climate is also more variable and the changes in temperature more sudden. The rainfall varies from 23 inches in the eastern part

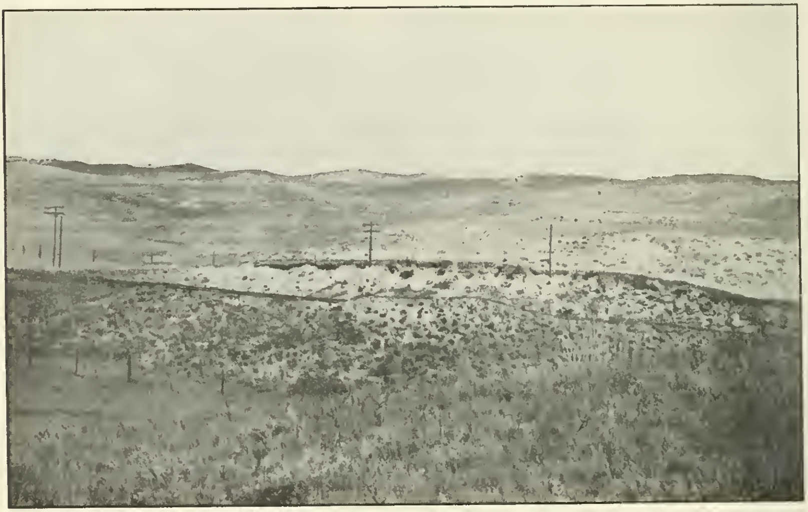

Fig. 3.—View between Seneca and Mullen, Nebr., showing the character of the native vegetation.

of Holt County to 16 inches in Sheridan and Morrill Counties. As a rule this rain comes at a seasonable time, being most abundant during the growing season of crops, from the middle of April to the first of August.

NATIVE VEGETATION.

The entire sand-hill district is fairly well covered at the present time with grasses. (Fig. 3.) Among the most common species[1] are the following:

On the tops and sides of the sand-hill ridges: Long-leafed reed-grass (*Calamovilfa longifolia*), redfieldia (*Redfieldia flexuosa*),

[1] Rydberg, P. A. Flora of the Sand Hills of Nebraska. Contributions from the United States National Herbarium, vol. 3, pp. 139–143. Also Pound, Roscoe, and Clements, F. E. The Phytogeography of Nebraska, vol. 1, pp. 345–347 and 352–368.

prairie muhlenbergia (*Muhlenbergia pungens*), Hall's beard-grass (*Andropogon hallii*), little bluestem (*Andropogon scoparius*), western stipa (*Stipa comata*), hairlike eragrostis (*Eragrostis trichoides*), and *Oryzopsis hymenoides*. These are common on the ridges of both the wet-valley and the dry-valley regions. Besides these grasses two species of Psoralea and two of Euphorbia are common. The sand cherry (*Prunus besseyi*) is also widely distributed and is a prominent feature of the sand-hill flora.

In the hay meadows of the wet-valley region the most valuable grasses are the following: Big bluestem (*Andropogon furcatus*), switch-grass (*Panicum virgatum*), western wheat-grass (*Agropyron smithii*), Indian grass (*Sorghastrum nutans*), wild timothy (*Muhlenbergia racemosa*), slender wheat-grass (*Agropyron tenerum*), porcupine grass (*Stipa spartea*), and nodding wild rye (*Elymus canadensis*).

In the moist soils adjacent to the lakes these better grasses are mixed with or superseded by sedges (*Carex* spp.) and rushes (*Juncus* spp.), several species of each being prominent. Where the ground is marshy in such situations, the tall marsh-grass (*Spartina cynosuroides*) and several species of Equisetum are also abundant. In the better soils of the dry valleys are found, besides a great many of the hay grasses named, patches of the side oats and blue gramas (*Bouteloua curtipendula* and *Bouteloua oligostachya*) and sometimes buffalo grass (*Bulbilis dactyloides*).

The sand-hill vegetation is very rich in species of grasses, and no attempt will be made to enumerate them further. During the spring and summer months these grasses are quite succulent and are efficient in producing both beef and milk, but in the fall and winter, with the exception of the buffalo and grama grasses, they are killed by frost and are not equal to the pasturage on the hard soils farther south, where the percentage of the last-named grasses is larger.

The hay secured in the wet-valley region is abundant and if cured properly makes a good roughage for cattle and horses, but it lacks the protein element necessary to sustain strength and produce growth when fed without grain.

CROP LIMITATIONS.

The extremely sandy character of the soil precludes any extensive system of small-grain or corn farming, such as is carried on in the eastern and southern parts of the State. This region is, therefore, and doubtless will remain essentially a stock-growing section. Prospective settlers should understand this point and make their plans accordingly.

Where a settler can obtain a large body of land, including some hay flats, he may profitably engage in the production of beef cattle or of horses and mules. If he has only a limited area, like 640 acres, and is in reach of a shipping point, he had better substitute for the beef cattle a dairy herd.

IMPORTANCE OF A LEGUMINOUS FORAGE CROP.

None of these sandy lands should be farmed more than two years successively to corn or any other intertilled crop. The stockman must have grain or some substitute for it to feed his animals during the winter in order to maintain their strength and enable the females to enter the spring season strong enough to produce and care for their young. A feed is desirable which will also prevent the usual shrinkage during the winter of the young cattle. To supplement the native hay with grain shipped in and hauled long distances over sandy roads would be too expensive. This feed must be grown on the ranch. What crop will fill this need? Obviously it must be one that can be grown without clean cultivation and which in itself does not markedly deplete the fertility of the soil. For such a crop we must look among the legumes.

COMPARISON OF BROADCASTED AND CULTIVATED CROPS.

Continuous clean cultivation of a sandy soil destroys the vegetable matter remaining in it from the grass roots, and in a short time, generally three years, the soil begins to blow. Soon, if such methods are continued, a large percentage of the crop will be cut off by the drifting sand each year just as it is coming up, and when the field is abandoned the wind will continue to remove the soil until the surface is lowered to a depth of 6 or 7 feet and the land becomes practically worthless, even for grazing purposes. Such experiences as these have induced the sand-hill farmer to look about for some crop which does not need cultivation, and preferably a perennial one for which the soil does not need to be plowed each year.

PRESENT CROPPING SYSTEM.

Most farmers are depending at the present time on growing corn and rye with a small acreage of oats and supplementing this with large quantities of native hay. This hay, if cut at the right time and cured properly, would be fairly efficient in carrying stock through the winter, but most of it is put up under contract and little care is used either to cut it at the proper time or to get it baled or stacked while it is bright and sweet smelling. On account of the scarcity of grain, this indifferently handled hay becomes the principal reliance of the ranchman for his cattle during the winter. Feeding it as the sole diet usually results in the cattle going on the grass in a very weak condition in the spring. If there are many bad storms, great numbers will be lost; and even if the older ones succeed in weathering the storms, a large percentage of calves will be lost on account of the weak condition of their mothers.

A small quantity of grain fed with the native hay daily would improve conditions a great deal, but the planting of most of the farm land to corn for a few years would be ruinous. Even sorghum, which would be some improvement on the native hay, presents the same difficulty on account of the necessity for its cultivation. Sorghum is a slightly stronger feed than native hay, but there is the same objection to its culture that there is to corn when planted in rows and cultivated on truly sandy soils. On the harder soil at the edge of the sand-hill region sorghum can be utilized profitably on account of its drought resistance. Settlers will find it useful on the newly turned sod in the sand hills, but it can not be utilized as a permanent crop on account of its effect on the soil.

IMPROVEMENT OF GRAZING CONDITIONS ON THE SAND RIDGES.

In the spring of 1908 tests with various grasses, including brome-grass, orchard grass, tall oat-grass, slender wheat-grass, and western wheat-grass, were conducted to determine whether a cultivated grass more palatable than native vegetation might be found that could be grown more successfully on the tops and sides of the sand ridges. Brome-grass proved more promising than any of the other grasses under such conditions, but it does not flourish in the loose sand. Most of the seedings, except those on land heavily manured, have been failures so far as practical results are concerned. No suggestions for the improvement of these grazing conditions can be made at the present time except that the blow-outs may be remedied somewhat by seeding them to sweet clover or brome-grass and then scattering manure or straw over the loose sand to prevent it from blowing. (Fig. 4.) It is hoped that in time a grass may be found which will prove sufficiently aggressive to thrive on the loose, sandy ridges.

USE OF CLOVER IN THE WET-VALLEY REGION.

As nearly every farmer knows, clover hay carries a high percentage of protein, and for putting on flesh and inducing growth it is much better than even timothy hay. One of the ways, then, of filling the need for protein is to mix a good percentage of clover with the native hay. It is strongly urged that this be done, as all the clovers grow naturally on the moist lands of the hay flats. In fact, no part of the United States seems able to produce clover with less care or attention than this wet-valley region, and its use here is strongly urged. Red clover seeded in 1895 near Chambers, Nebr., in meadow sod, without plowing or other cultivation, has reseeded itself from year to year in haying and is to-day in better condition and shows a better stand than ever before.

Where the meadow is inclined to be wet, alsike clover is best, but in all other locations common red clover is preferable. It is better than alsike clover on account of its larger growth, and especially its larger leaves, and better than mammoth because it is earlier and will make two cuttings in one season.

The advisability of seeding white clover under any circumstances is questioned. It grows readily, but does not make a hay crop, and in pastures where it is too abundant it induces the "slobbers" in horses.

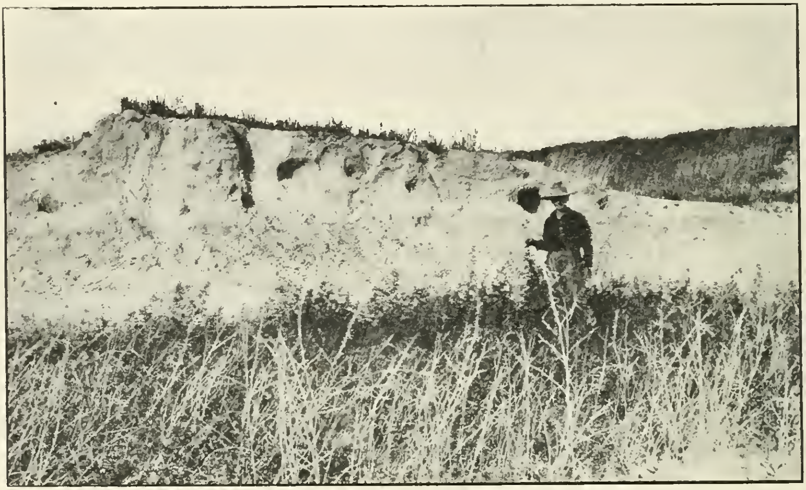

Fig. 4.—Field showing sweet clover seeded in a blow-out near Ainsworth, Nebr.

TIME OF SEEDING.

In the tests previously mentioned, good results were obtained from both fall and spring seeding of clover, but as yet there are not sufficient data to warrant definite recommendations. On account of the severity of the winter, however, spring seeding would seem to have the advantage. When seeding on uncultivated land, the earlier it can be done the better, as the clover will then start at a time when the grass is not growing rapidly. On cultivated land it can be sown with a grain crop, such as oats or barley. A better stand is usually secured, however, where no nurse crop is used.

RATE OF SEEDING.

It is advisable to use sufficient seed to insure a stand even when sowing on meadowland. Many disappointments have arisen from a half-hearted scattering of a few pounds of clover seed over a 40-acre meadow. Twelve pounds of red clover to the acre or 8 pounds of alsike are usually the quantities recommended and are sufficient to give a complete stand when proper methods of seeding are used. It is better to have a good stand of clover over 5 acres of the meadow, where one can see exactly how beneficial it is, than to have a spot here and there over 80 or 100 acres. Some reckon that if only a bunch here and there is started in a meadow the seed will gradually be scattered by the sweep rake in haying and will cover the entire meadow. It will do so if the clover is allowed to get fairly ripe before the haying is done, but it will take years. The farmer might have been cutting good clover crops from it much sooner if a smaller area had been given the proper quantity of seed and a field kept on cultivated ground to furnish the seed necessary for a gradual extension of his meadow. A field of pure clover on cultivated land is of great service for this purpose, as that produced in the meadows is so mixed with grass leaves that it is difficult to thrash. If the farmer has some source of seed on his own farm he will ordinarily use a larger quantity than if forced to purchase it.

METHOD OF SEEDING.

Many scatter clover seed on the surface of the ground and count on the rains covering it. When sown with oats on cultivated ground the soil should be plowed and thoroughly prepared with disk and harrow before seeding. Then the clover can be seeded at the same time as the oats and harrowed in with a drag harrow if no drill is available, or the oats can be disked or drilled in first and then the clover seed scattered on and harrowed in lightly. On these light soils it is always better to cover the seed in some way.

Where clover is sown without a grain crop, land that was in corn the previous year is preferable, because it is firm and solid. If the corn was cut for fodder, it only remains to sow the seed broadcast and harrow or drill it in the following spring. The field should be one which was kept free from weeds the preceding year, otherwise the young clover plants are likely to be choked out.

Most of this paper has been written with the present equipment of the sand-hill farmer in mind. As soon as possible every farmer should supply himself with a drill which will sow clover and alfalfa seed. A disk drill having a press attachment which is removable will pay for itself in one season in the saving of seed if any considerable area of land is seeded. The press wheels are very essential on cultivated ground, since it is always loose and needs to be compacted after the seed is sown. When seeding clover on meadowland these wheels can be removed and the seed left in the little furrows made by the disks. Succeeding rains will pack the soil sufficiently to insure an even germination, and the slight loosening of the turf will give the young clover plants a better chance.

Where this method of seeding has been followed the meadow takes on the appearance of a clover field. (Fig. 5.) The resultant stand is so certain when clover is seeded on meadowland with a disk drill that a few trials would convince the most skeptical that wonderful possibilities exist in the improvement of a native moist meadow by seeding it to red clover.

RESEEDING CLOVER FIELDS.

Clover seeded on cultivated fields and regularly harvested for seed will, of course, need reseeding every other year, but the clover stand

FIG. 5.—Field showing common red clover seeded with a disk drill in the native meadow grass.

in native meadows can be preserved indefinitely without putting on any additional seed if handled properly.

A remarkable point noticeable in clover production in this region is that the first cutting of clover can be depended upon to produce seed, usually a full crop. In the East the first cutting very seldom produces seed. The presence of seed in the first cutting is of immense advantage to the man who has it in his meadows, as it comes on early in the spring, and by the time the native grass is ready to cut much of the clover has matured seed. During the haying operation a great deal of this seed is shattered out by the rakes, and thus the ground is reseeded without any additional trouble, and a good crop of new clover is assured each succeeding year. The second cutting comes on more uniformly and can be cut when it is in better condition for hay.

Alsike is handled in very much the same way and seeds as freely as the red clover. In the meadows, however, it of course is not so important that the alsike mature seed, since it is a perennial and does not need to be reseeded often.

CLOVER SEED PRODUCTION.

Since clover seeds so freely in this region, an exceedingly profitable system of farming is opened up to the sand-hill settler who owns a tract of moist meadowland. There is always a ready market for prime red or alsike clover seed at from $4 to $6 a bushel, and there seems little doubt that with proper treatment a good field of clover should return in this region 4 bushels per acre. Yields much exceeding this have been reported. The seed is not bulky, and the farmer could therefore afford to haul it a considerable distance to a shipping point. If properly developed, this region should become one of the principal sections of the United States for producing clover seed.

USE OF REDTOP AND TIMOTHY IN HAY FLATS.

Both redtop and timothy will endure considerable moisture and thrive well when seeded on the hay flats. Timothy is no doubt a considerable improvement over the native grasses, and tests show that a more extensive use of it is justifiable. When one seeds redtop on his meadowland, however, it scatters quickly over adjoining territory, and in a few years the meadow has the appearance of a field of redtop. This is due to some extent to the fact that the redtop comes on early and produces seed before the regular haying season of the native grasses has arrived. Thus, like the clover, it is spread broadcast over the entire meadow.

Redtop is not much of an improvement in quality over the native grass for hay, although if cut early, before it is too nearly mature, it makes first-class hay. It lacks the vitalizing, strength-giving quality of the clover, however, and should be used only on land too wet for either alsike or red clover, and there are few places too wet for alsike clover. Most farmers regret having redtop on their farms.

WEED PESTS IN MEADOWS.

Until recently the hay meadows of this region have been remarkably free from weeds. Sedges and rushes occupy much of the very wet land, but the presence of these in the hay is not considered sufficient cause for its refusal; in fact, a considerable percentage of the hay from some points is made up of these two plants.

There has appeared, however, the squirrel-tail grass (*Hordeum jubatum*), which has proved such a nuisance in the hay meadows of

Wyoming, Montana, and other Western States. It has spread rapidly, and unless radical measures are taken to check it there will soon be little first-class hay shipped from this region. The farmers and stockmen should understand that its presence in hay not only means the refusal of the hay by buyers, but also makes it dangerous to feed at home. The lodging of numerous beards, or awns, in the animal's mouth makes it unable to eat. Much good can be accomplished by cutting this grass off before it produces seed. It is considered an annual, and although some of the roots may live over winter, a few years of conscientious clipping will do much to rid the meadows of this dangerous pest. The time to act is now, before it secures too extensive a foothold. The farmer in a case of this kind is too apt to plead lack of time, but the man who desires to succeed will find time for such work and do it at the right time.

SWEET CLOVER.

The value of sweet clover (*Melilotus alba*), a much maligned plant, for forage and soil improvement in the sand hills is emphasized by the results of tests and also by finding it in use and giving complete satisfaction in several localities. Not only do stock eat it readily when accustomed to it, but it grows freely and inoculates naturally in situations where no other cultivated legume yet found, unless it be vetch, will thrive. As a means of preparing a field for the seeding of alfalfa it has no equal. The bacteria that produce nodules on the roots of sweet clover are effective in producing inoculation on alfalfa, which ordinarily is slow to become inoculated in the poorer sandy soils. Fields which have grown sweet clover for two years will usually be abundantly supplied with the needed bacteria. A much wider use of this plant as a forage crop is therefore advised.

FEEDING VALUE.

Tests in feeding sweet clover to sheep were conducted at the Wyoming Agricultural Experiment Station,[1] and in both quality of meat and amount of gain it proved to be nearly equal to alfalfa and much superior to native hay. Even though a poor grade of sweet clover hay was used in the test, "the lambs exhibited a steady appetite for it."

Numerous farmers report it as of equal value to alfalfa in feeding dairy cows, which means that it is as good as the best. For pasture it is available for cattle, horses, and hogs while the plants are small and not bitter, but live stock usually refuse to eat it after it becomes more mature and attains its characteristic bitter taste. Animals unused to sweet clover are apt to refuse even to taste it, probably on account of the odor, but once they are induced to eat a small quan-

[1] Bulletins 78 and 79, Wyoming Agricultural Experiment Station.

tity there is no further trouble. They seem to relish it afterwards and will select it in preference to native and even tame grass hay.

SEEDING.

Although numerous tests have been conducted with sweet clover, there has not been sufficient experience with it as yet to warrant definite recommendations in regard to the proper time for seeding. So far the best results have been obtained by sowing it early in the spring on a well-prepared seed bed, which should be firmed as in the case of clover and alfalfa. In other sections, seeding it in grain, either oats, barley, or spring wheat, has been successful and perhaps could be followed out in this region wherever the moisture is fairly abundant. Usually it is simply sown broadcast on the field after the grain has been drilled in, and it is then allowed to be covered by the weather. On sandy land, however, it is preferable to give the soil a light harrowing after sowing the sweet clover so that the seed will be covered. On the drier soils it is best to seed it without a grain crop.

Most sweet clover seed germinates very poorly; hence it is advisable to sow 25 pounds per acre. This low germination is not caused entirely by poor seed, but also by the large quantity of "hard seed" usually present in commercial sweet clover seed. In some cases the proportion of hard seed has run as high as 90 per cent, and this means that a large part of the quantity sown will lie dormant in the soil and germinate the following year.

A tabulation of the results obtained by the Seed Laboratory of the Bureau of Plant Industry in germination tests of sweet clover seed was made in order to determine whether the source of the seed has any effect on the germination or on the percentage of the hard seed it contains. This tabulation showed that in 22 samples of seed from the southern United States the average germination was 14.3 per cent and the average percentage of hard seed, 60.13. In 22 samples of seed from the northern United States, the average germination was 36.6 per cent and the average percentage of hard seed was 43.22. In the 28 samples of imported seed the average germination was 56.48 per cent and the average percentage of hard seed, 12.33. This would seem to indicate that the imported sweet clover seed is the most reliable, and that seed from the southern United States is likely to contain more hard seed and germinate less than that from any other section. These results confirm the observations which have been made on field tests of these samples.

TIME TO CUT FOR HAY.

Sweet clover should be cut for hay early, before its stems have become large and woody. The proper time to cut seems to be just as the blossom buds are forming on the ends of the shoots. This will give about the maximum growth of leaf and stem. There will be at this time a large percentage of water in the green matter and considerable time will be necessary to cure it properly, but the hay when cured will be more palatable than if it had been allowed to reach full bloom.

TREATMENT OF SWEET CLOVER FIELDS.

If a good, strong germination of the seed is obtained early in May, sufficient growth should be made by August 1 to give a cutting of hay. The following year the growth will start very early and another good cutting can usually be secured between June 1 and 15. The second growth should then be allowed to go to seed, if it is desired to continue sweet clover on the field. There is usually no necessity of harrowing or disking the field after it has seeded, but such treatment would probably assist in getting an even germination.

Where the soil is poor the plowing under of a crop of sweet clover greatly benefits it; and even where the clover is cut for hay the decay of the roots, which in a good growth has been estimated at 20 tons green weight per acre, will add large quantities of humus to the soil.

ALFALFA.

DIFFICULTY OF CULTIVATION.

The crop which will eventually be of the most importance in both the wet and dry valley regions is undoubtedly alfalfa, and it is hoped that a more consistent effort to establish it will follow the publication of this circular. A great deal of it has already been sown throughout this territory and many discouragements encountered. Most of these have arisen from a lack of understanding regarding the requirements of this crop.

In the wet-valley region much of the alfalfa was sown where the water was near the surface, and during a wet time the crop was drowned out. In other cases, both in the wet and the dry valley regions, fields were sown with insufficient preparation of the ground. They lacked inoculation and on account of the poor character of the soil failed to secure it, and so, after making an indifferent growth for a number of years, the alfalfa was crowded out by weeds and grasses. In nearly all such fields a few plants became inoculated and are still fighting with the grasses, ever-present evidence of the hardy character and adaptability of the alfalfa plant.

Successful fields of alfalfa are to be found on sandy soils at Whitman, Hyannis, Seneca, Halsey, Anselmo, Chambers, Atkinson, Stuart, Bassett, and Ainsworth. (Fig. 6.) This wide distribution of successful fields growing under nearly every condition of moisture and in widely varying situations is sufficient evidence that alfalfa can and will be grown in practically every part of this region. There are sure to be numerous failures in seeding alfalfa on account of the uncertainty of the climate, and it is advised that discretion be used in limiting expenditures on the first trials. Success will be more general as the people become better acquainted with the crop and as hardier strains, suited to this locality, are developed.

FIG. 6.—Alfalfa field near Atkinson, Nebr.

SEED STRAINS ADAPTED TO SAND-HILL CONDITIONS.

NATIVE DRY-LAND STRAINS.

Seed of native dry-land strains of alfalfa is secured from nonirrigated fields in the semiarid sections of the West. It is usually ordinary alfalfa which has been grown for years under dry-land conditions. In this way the drought-resistant plants alone have survived, and such seed is preferable if it can be obtained.[1]

TURKESTAN ALFALFA.

Turkestan alfalfa was secured originally from Turkestan and has been found, as a rule, more drought resistant than the ordinary alfalfa. It is not recommended, however, under irrigation, or in sections with sufficient rainfall for full crops of ordinary alfalfa. In the sand-hill region ordinary alfalfa usually gives a better yield.[2]

[1] Westgate, J. M. Alfalfa. Farmers' Bulletin 339, U. S. Dept. of Agriculture, 1908, p. 38.
[2] Westgate, J. M. Op. cit., p. 37.

SAND LUCERN.

Sand lucern is a hardy, drought-resistant strain which originated from a cross between ordinary alfalfa and the yellow-flowered species, *Medicago falcata*. It is adapted to a wider range of soil types than ordinary alfalfa and is proving equal or superior to many of the strains now being grown for drought and cold resistance.[1]

GRIMM ALFALFA.

Grimm alfalfa[2] is a local strain developed in Minnesota, which on account of its superior hardiness is well adapted to localities where trying conditions are to be met.[3]

LOCATING THE FIELD.

The best soil obtainable should be chosen for the alfalfa field. Except in the wet-valley region, the best location will invariably be in the bottom of the valley, where the soil contains the most humus and the moisture supply is the most constant. In the wet valleys the prospective alfalfa field should be located where the water table will be at least 4 feet under the surface of the ground. There have been successful fields where the distance to water was less in wet seasons, but the chances are very much against such a field. A well-drained piece of land with the water 8 to 12 feet beneath the surface is best. Too much water is as ruinous to alfalfa as too little.

TIME OF SEEDING.

Numerous tests of alfalfa have been conducted in this region. The results of these tests demonstrate quite thoroughly that the best time for seeding is about the middle of June. There are several reasons for this: (1) The winds, which are likely to be quite frequent and rather destructive through March, April, and the early part of May, usually cease by the first of June. (2) It gives the weed seeds which may have remained in the ground from the year before a chance to germinate and be destroyed by cultivation before the alfalfa is sown. (3) The ground is warm, the rains are more abundant at this time, and the alfalfa has time to make a good growth before frost, so that it can withstand the winter. With all these points of advantage, however, judgment will have to be exercised in seeding, as this date might happen to be just the wrong time to seed. If no rains have fallen for some time and the surface soil is dry to a depth of 3 or 4 inches, it is best to retain the seed until it does rain or, in case the

[1] Westgate, J. M. Variegated Alfalfa. Bulletin 169, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1910.

[2] Brand, Charles J. Grimm Alfalfa and Its Utilization in the Northwest. Bulletin 209, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1911.

[3] Brand, C. J., and Waldron, L. R. Cold Resistance of Alfalfa and Some Factors Influencing It. Bulletin 185, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1910.

drought continues until after the middle of July, to carry the seed over until the following year. It avails little to put the seed in the ground at any time of the year when conditions are not favorable for its germination and continued growth.

Should the spring come on early and conditions be such at the middle of May as usually obtain at the middle of June, then it is well to sow the seed at that time, securing a stronger root system and larger top growth for protection during the winter.

RATE OF SEEDING.

The mortality among the young plants on sandy soil is very high, owing to the fact that the surface of the soil becomes extremely hot and many plants are wilted and burned off before the third leaf is formed. Such wholesale destruction of the young seedlings means that an oversupply of seed must be used. From 9 to 12 pounds of good seed should be ample, but on account of the conditions just mentioned it is usually best to sow 16 to 20 pounds per acre. If conditions are favorable and too thick a stand is secured, it can be thinned out much easier than a poor stand can be patched up. If the ground is too fully occupied by the young plants, a good harrowing or a light disking when the plants are only 3 or 4 inches high will not only reduce the number of plants but will leave the surface of the soil in good condition to retain the moisture.

PREPARATION OF SEED BED.

Wherever possible, ground that has been cropped to corn or potatoes the preceding year should be used for alfalfa. Such ground is best on account of its freedom from weeds and the firm seed bed it affords the alfalfa. The addition of manure to the soil several years in advance of its use for alfalfa is very beneficial, but manure should never be plowed under at the time of seeding, as it cuts off capillary action from below and generally leaves the upper soil loose and very dry, the rain water passing through rapidly but never returning past the layer of manure to benefit the young plants.

If corn or potato ground is used, it should be disked in the spring as soon as the first crop of weeds starts, then allowed to lie in a rough condition until a second crop germinates, when this can be killed by another disking or harrowing. It is advisable to kill out the weeds thoroughly before seeding, and this may require the third disking. If the soil is inclined to blow after such treatment, it may be better to give but one working. It will be found, though, that if the ground is disked crosswise to the direction of the prevailing winds the trouble from blowing will be less than if the ground were allowed to lie smooth and hard.

Where grain stubble is used it can be plowed in the spring after the first crop of weeds has started, left rough until the second crop germinates, and the latter killed by harrowing with a drag harrow or by disking.

Every effort should be made to get the seed bed as solid as possible, either by repeated harrowings, if the ground has been spring-plowed, or by the use of a roller. The frequency of the cultivations in the spring, especially with the harrow, must be determined to a great extent by the judgment of the man on the ground. Experience will show how much it is safe to work the soil with this implement. It must be remembered, however, that the weeds must be removed from the soil.

INOCULATION.

Throughout central and eastern Nebraska no trouble is experienced in getting a field of alfalfa inoculated. In the sand-hill country, however, many fields were noted which seemed to lack this very essential aid to growth. Numerous cases of winter injury would have been avoided if the field had been inoculated promptly and the growth during the late summer and fall had been more vigorous.

Lack of inoculation is shown by weak, spindling plants of a yellowish-green color in the field. The addition of barnyard manure or vegetable matter of any kind always assists greatly in procuring inoculation. It is well, however, to take other precautions besides the addition of manure. Ordinary sweet clover, which is very plentiful farther east in the State, and is found growing in many localities throughout the sand hills, is inoculated with bacteria usually understood to be the same as those which produce nodules on the roots of alfalfa. It is known that if a crop of sweet clover is grown on the soil prior to the seeding of alfalfa, the ground will be thoroughly inoculated. Sweet clover is more adaptable to different soil and climatic conditions than alfalfa and not only supplies the ground with bacteria but also adds a large quantity of vegetable matter in the shape of roots which decay very promptly when the plant dies. It would therefore be advisable to use sweet clover as an aid to the establishment of alfalfa fields throughout the sand hills.

When beginning a field on ground which has not been inoculated by the method just described, it is highly important and usually very profitable to secure soil from an old alfalfa field which is already inoculated, or from a patch of sweet clover, and scatter this soil at the rate of 500 pounds per acre over the ground which is to be sown to alfalfa.

The soil is best applied through a fertilizer drill, but as very few farmers in the sand hills possess a drill of this kind the application must generally be made by broadcasting the soil with the hands and then covering it immediately with a disk or ordinary spike-toothed harrow, as bright sunlight is very quickly fatal to the bacteria.

When this inoculated soil can not be obtained near at hand, it is best to go to the trouble of shipping it even from considerable distances rather than sow the seed without inoculation. In this event 200 or 300 pounds of the inoculated soil may be mixed with an equal quantity of loose soil or sand in order to facilitate the scattering of it evenly over the field.

METHOD OF SEEDING.

Before seeding, it is always profitable to spend sufficient time and money on the preparation of the ground to get it in perfect condition. Alfalfa seed is quite expensive, and a poor stand of alfalfa means that weeds will enter the field in the vacant spaces and in time ruin the field entirely.

When the ground has been thoroughly prepared, as previously indicated, the best results should come from seeding with a press drill, but extreme care must be taken to prevent the seed from being covered too deeply, as the press wheels sink in the loose soil to a considerable depth and the wind later fills these furrows. One can also broadcast the seed, but the germination is never as good when the seed is broadcasted and harrowed in as when it is put in the ground with a press drill. This arises largely from the fact that the soil is pressed down on the seed in the drill track and capillary action supplies the germinating seed with moisture, even though no rain falls for some time after the seed is sown.

In the case of broadcasted seed where it lies in the loose soil, the seed is very apt to suffer from lack of moisture directly after it has germinated. It is better to seed half the required quantity of seed one way and then cross-seed with the remaining half than to sow it all one way, as a more even stand is usually secured in this manner.

If the press drill is not available one can obtain about the same condition of soil by rolling the ground after it is seeded and then following the roller with a light harrowing. If the soil is unusually sandy and liable to blow badly, it is necessary to do something to keep the moving sand from cutting the young plants off as they appear above the surface of the ground. Some growers accomplish this by using a light dressing of barnyard manure. If such manure is free from weed seed it will not only keep the sand from blowing badly, but will supply the ground with additional plant food.

The following is one of the best ways noted in which to hold the sand and give the alfalfa a chance to start: After the alfalfa has been seeded, a very light dressing of native hay taken from old stack bottoms is scattered over the field. This dressing of hay should be quite thin and evenly distributed. The next process is to go on the field with a disk set very nearly straight and weighted, so that while it does not tear up the ground it will cut the hay into the soil and leave it standing over the field somewhat like stubble. (Fig. 7.) Splendid results have followed this method of seeding.

SUBSEQUENT TREATMENT.

If it should ever seem advisable to make a cutting the first season, care should be taken to set the cutter bar of the mower high. If cut low, the plants are slow to recover from the shock of cutting, and sufficient growth is not left on the field to protect the roots of the alfalfa through the winter. Present data indicate that clipping is warranted only as a protection against weeds, and that the common

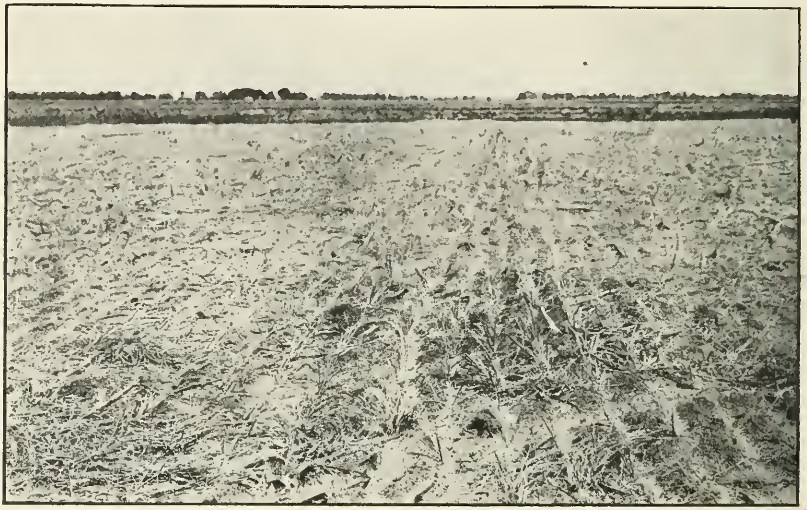

Fig. 7.—Field showing the method used for preventing the movement of sand by the use of old hay from stack bottoms.

practice of clipping new fields of alfalfa retards rather than strengthens the root growth.

When the stand of alfalfa is weedy it has been found advisable to disk the field each spring, and in some cases, where the moisture supply is adequate, after each cutting. The disk should be followed by a drag harrow to level off the soil for the mower. Even in fields which are not weedy it is best to disk each spring unless the ground is extremely dry, as it loosens up the surface soil and induces a heavier growth.

Ordinarily it is safe to cut three crops of hay each year, especially if the cutting is done at the proper season, when about one-tenth of the plants are in bloom. If the second crop is allowed to go to seed, the third growth had better be pastured back, since the cutting would necessarily be late, and in that case the field would be left without winter protection, which often means disaster.

SUMMARY.

The sand-hill section of Nebraska comprises nearly 20,000 square miles, or about one-fourth the total area of the State.

Stock raising is, and doubtless will continue to be, the main industry of this section.

Native hay is at present the chief dependence of the stockmen for their winter feed.

No tame grass has been found which appears more valuable on the loose, sandy ridges than the native vegetation.

Crops which require clean cultivation should be discontinued as far as possible.

The most dependable source of livelihood for the small landowner is dairying.

The clovers are well suited to the wet-valley region, and this division of the sand hills should become in time one of the important clover-producing sections of the United States.

The improvement of the native, moist meadowlands by the introduction of timothy is advised, but the use of redtop for this purpose should be discouraged.

The growing of sweet clover as a forage crop and in preparing land for alfalfa is recommended.

The most dangerous weed of the wet-valley region is the squirreltail grass (*Hordeum jubatum*), now quite common.

Alfalfa promises to become the most valuable cultivated crop of the sand hills.

The use of a hardy strain, good judgment in locating the field, inoculation of the soil, and careful attention to the details of seeding are necessary for success with alfalfa.

Approved:

James Wilson,

Secretary of Agriculture.

Washington, D. C., *June 27, 1911.*

[Cir. 80].

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Issued June 5, 1911.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF PLANT INDUSTRY—Circular No. 81.

B. T. GALLOWAY, Chief of Bureau.

THE SHRINKAGE OF CORN IN STORAGE.

BY

J. W. T. DUVEL,

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AND

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Assistant in Charge of the Baltimore Grain Standardization Laboratory.

93318°—Cir. 81—11

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1911

BUREAU OF PLANT INDUSTRY.

Chief of Bureau, BEVERLY T. GALLOWAY.
Assistant Chief of Bureau, WILLIAM A. TAYLOR.
Editor, J. E. ROCKWELL.
Chief Clerk, JAMES E. JONES.

[Cir. 81]

THE SHRINKAGE OF CORN IN STORAGE.

INTRODUCTION.

As the question of the natural shrinkage of shelled corn while in storage and in transit is of considerable importance to those engaged in the handling of grain, a series of special investigations was begun at Baltimore, Md., in order to determine the amount of shrinkage or loss in weight occurring in shelled corn containing various percentages of moisture while in storage in elevators or during transit in cars.

The experiment described in this circular, the first of the series on shrinkage, was made with 500 bushels of shelled corn stored on a 30,000-pound scale and was carried on in cooperation with the Baltimore & Ohio Railroad Co. and the Baltimore Chamber of Commerce.

EXPERIMENT WITH CORN STORED ON A SCALE IN A GRAIN ELEVATOR.

On January 5, 1910, 500 bushels (28,000 pounds) of shelled corn having an average moisture content of 18.8 per cent were placed in the wooden hopper of a 30,000-pound scale in Elevator B of the Baltimore & Ohio Railroad Co. at Locust Point (Baltimore), Md. The scale was tested prior to the beginning of the experiment, and after being filled with grain the hopper of the scale was covered with cloth to prevent an excessive quantity of dust from settling on the corn, and at the same time to permit a fairly free circulation of air over the top of the grain.

The corn used in this test was taken from the regular car receipts and was left in the hopper of the scale without handling from January 5 until May 14, a period of 129 days. It was then run out of the hopper and elevated three times to the same scale, the weight of the grain being taken after each elevation. After the third elevation the corn was held on the scale for an additional period of 18 days, or until June 1, at which time the experiment was terminated, making a total storage period of 147 days.

Figure 1 is a sectional view through the middle of the hopper of the scale, showing the position of the four electrical-resistance thermometers which were placed in the corn at the top of the first, second, fourth, and fifth 100-bushel drafts, respectively, in order that the temperature of the corn could be ascertained at any time throughout the course of the experiment.

The average condition and quality of the 500 bushels of corn at the beginning of the experiment, as represented by the results of the analyses of samples taken from the various drafts at the time the hopper of the scale was being filled, are shown in Table I.

TABLE I.—*Factors indicating the condition and quality of the corn tested when placed on the scale on January 5, 1910.*

Location of sample on scale.	Moisture content.	Weight per bushel.	Sound corn.	Germination of whole kernels.
	Per cent.	*Pounds.*	*Per cent.*	*Per cent.*
First 100 bushels	18.7	54.8	98.2	87.5
Second 100 bushels	18.8	54.8	97.6	91.0
Third 100 bushels	19.0	54.5	96.2	87.5
Fourth 100 bushels	18.5	54.8	97.3	91.5
Fifth 100 bushels	19.0	54.5	96.1	90.5
Average	18.8	54.7	97.1	89.6

As will be seen in Table I, the moisture content of the corn when placed on the scale on January 5 varied from 18.5 per cent in the fourth draft to 19 per cent in the third and fifth drafts, with an average of 18.8 per cent for the entire 500 bushels. The weight per bushel was 54.5 pounds in the third and fifth drafts and 54.8 pounds in the first, second, and fourth drafts, the average for the entire lot being 54.7 pounds. The average percentage of sound corn was 97.1 per cent and the average percentage of germination was 89.6 per cent.

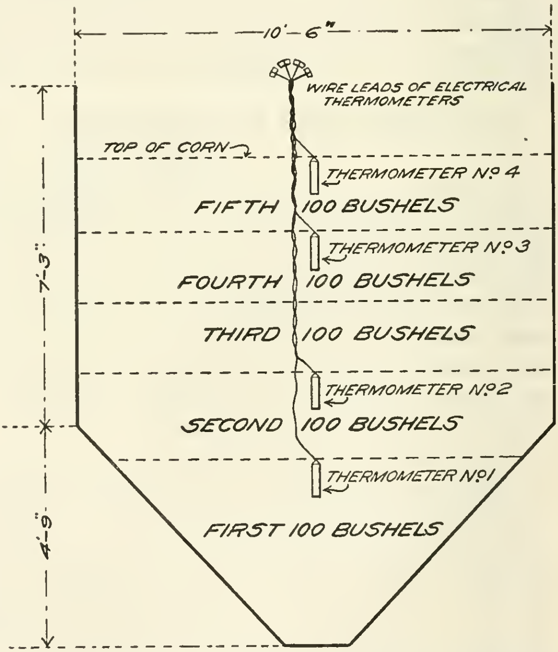

FIG. 1.—Diagram giving a sectional view through the center of the wooden hopper of the scale, showing the position of the four electrical-resistance thermometers in the stored corn.

SHRINKAGE IN THE WEIGHT OF THE STORED CORN.

Weighings and temperature records were made of the corn at frequent intervals throughout the experiment, during which time consideration was also given to the temperature and relative humidity of the atmosphere and to general weather conditions. The results of these records and observations are shown diagrammatically in figures 2 and 3. Figure 2 shows the shrinkage in the weight of the corn, the average temperature of the corn, the average of the daily mean air temperatures for the periods between weighings, the mean daily relative humidity of the atmosphere, and the weather record from January 5 to April 21, after which time the rate of deterioration in the corn was such that the relative humidity of the atmosphere and the general weather conditions exerted no apparent influence on the amount of shrinkage. Figure 3 shows only the shrinkage in the weight of the corn, the average temperature of the corn as indicated by the four electrical-resistance thermometers at the time the weighings were made, and the average of the daily mean air temperatures for the periods between the dates of the weighings from the beginning of the experiment, January 5, until June 1, at which time the test was terminated.

Immediately after the corn was placed in the hopper of the scale the average temperature of the corn, as indicated by the four electrical-resistance thermometers, the positions of which are shown in figure 1, was 20° F., the same as the temperature of the air. From figures 2 and 3 it will be seen that the shrinkage in weight from January 5 to February 24, 50 days, was 30 pounds, or slightly more than one-tenth of 1 per cent. The temperature of the corn at this time, as shown by the average of the readings of the four thermometers, was 32.5° F., an increase of 12.5 degrees over the average temperature of the corn when it was placed on the scale. The average of the daily mean air temperatures for one week prior to February 24 was 33° F., or 13 degrees above the temperature of the air at the beginning of the experiment. From February 24 to April 8, 43 days, the loss in weight amounted to an additional 30 pounds, making a shrinkage of 60 pounds, or approximately two-tenths of 1 per cent, for the first 93 days of the test. The increase in the average temperature of the corn during this period of 93 days from the beginning of the test was 26.3 degrees.

On April 21 the average temperature of the corn was 69.5° F., an increase of 23.2 degrees for the 13 days from April 8 to April 21, during which period there was a further loss in weight of 47.5 pounds, or nearly two-tenths of 1 per cent, and for the whole period, January 5 to April 21, 106 days, the shrinkage amounted to 107.5 pounds, or approximately four-tenths of 1 per cent. The highest temperature at any point in the corn at this time was 87° F., as was shown by thermometers Nos. 3 and 4 in the upper part of the grain, while thermometers Nos. 1 and 2 showed a temperature of only 51° and 53° F., respectively. At this time the corn in the scale showed the first distinct signs of going out of condition, and this deterioration

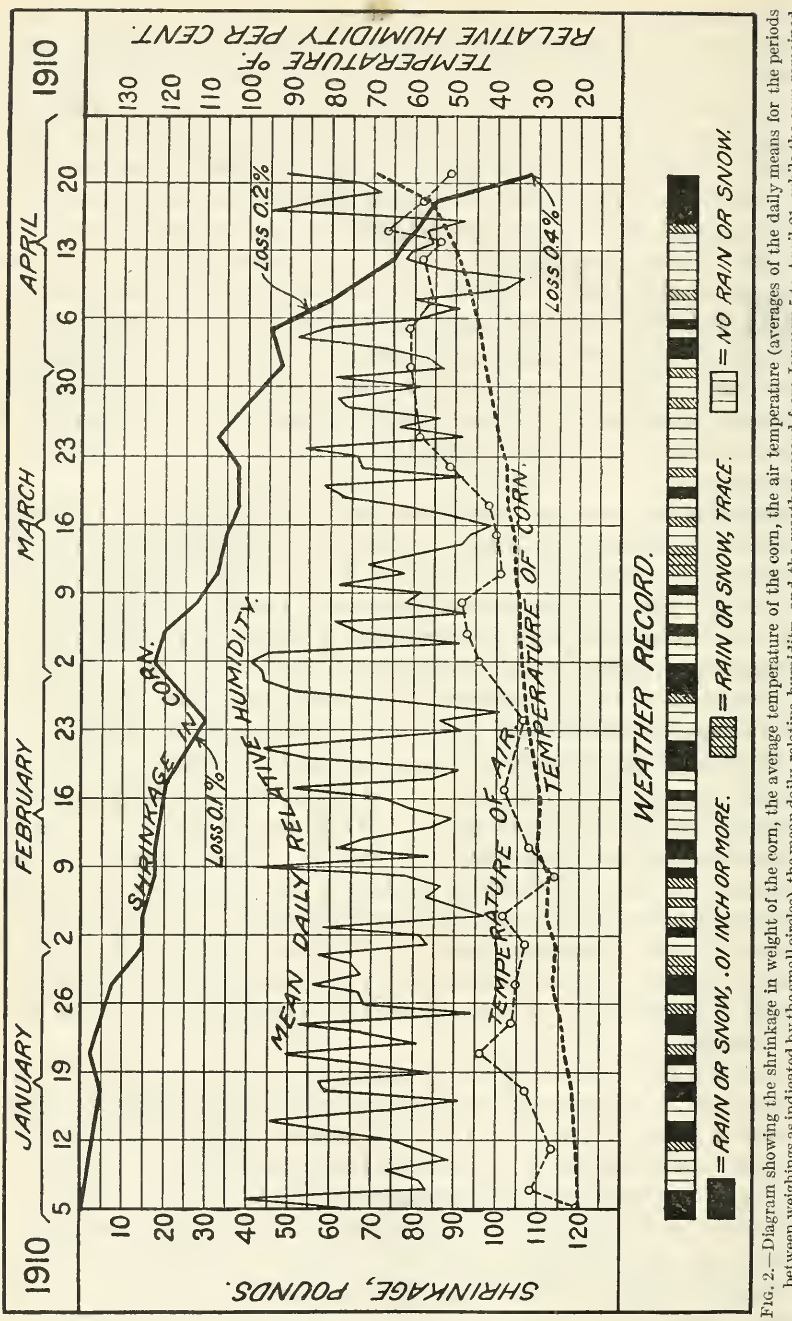

FIG. 2.—Diagram showing the shrinkage in weight of the corn, the average temperature of the corn, the air temperature (averages of the daily means for the periods between weighings as indicated by the small circles), the mean daily relative humidity, and the weather record from January 5 to April 21, while the corn remained in good condition.

was accompanied by a rapid rise in the temperature of the corn and a very marked increase in the rate of shrinkage, as illustrated in figure 3.

During the eight days from April 21 until April 29 the loss in weight was five-tenths of 1 per cent, or one-tenth of 1 per cent more than the loss from January 5 to April 21, the period of 106 days in which the corn remained in good condition. The increase in the average temperature of the corn from April 21 to April 29 was from 69.5° F. to 108° F., or 38.5° degrees. The maximum temperature recorded on April 29 was 130° F. at the top of the fourth 100 bushels, as compared with a maximum of 87° F. on April 21.

During the 15 days immediately following, April 29 to May 14, the shrinkage amounted to slightly more than 2 per cent. The average temperature of the corn on May 14 was 111.3° F. The maximum temperature of the corn on May 14 was 119° F. around thermometer No. 3, as compared with a maximum of 133° F. two days previous. The decrease in the temperature of the corn at this time was due to a reduction in the biochemical changes and to the decreased activities of the organisms responsible for the deterioration, influenced in a measure, perhaps, by the sudden drop in the air temperature.

The total shrinkage in the corn from January 5 to May 14 was 815 pounds, or approximately 3 per cent. The maximum average temperature of the corn for any given date, as shown by the four electrical-resistance thermometers, was 127° F. on May 5. The highest temperature recorded was 138° F. on May 2 around thermometer No. 3 at the top of the fourth 100 bushels, as compared with an average temperature of 20° F. at the beginning of the test.

On May 14 the corn, after it had remained in the hopper of the scale for 129 days without handling, was "run out" and elevated three times to the same scale. On the first elevation the loss was 205 pounds, or approximately eight-tenths of 1 per cent; on the second elevation the loss was 170 pounds, or approximately six-tenths of 1 per cent; and on the third elevation the loss was 73 pounds, or approximately three-tenths of 1 per cent. The total loss during the three elevations was therefore 448 pounds, or 1.6 per cent, on the basis of the original 28,000 pounds, or 1.65 per cent on the basis of the actual weight of corn in the hopper of the scale just previous to "handling."

The average moisture content of the samples drawn from the corn immediately prior to the third elevation was 16.5 per cent, as compared with an average moisture content of 18.8 per cent when the corn was first placed in the hopper of the scale, while the percentage of sound corn had decreased from 97.1 per cent to 7.6 per cent within the same period of storage.

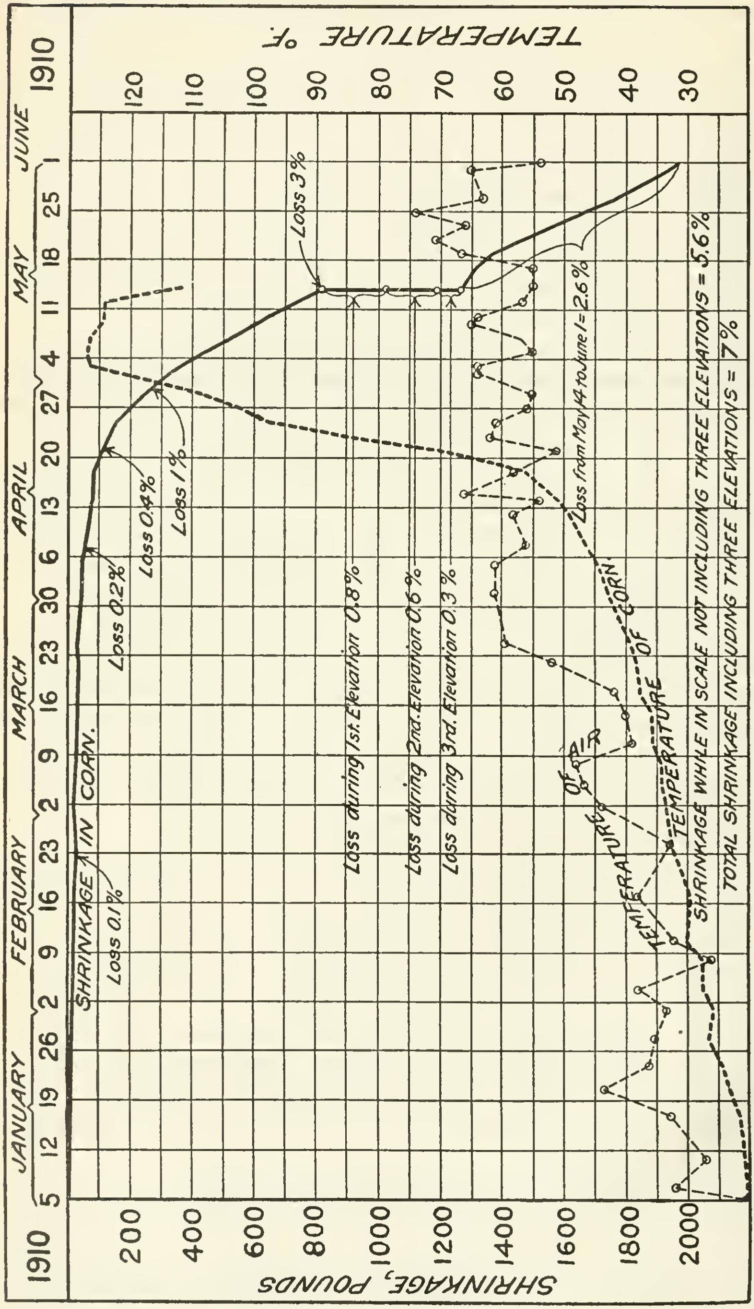

FIG. 3.—Diagram showing the shrinkage in weight of the corn while on the scale and during elevation, the average temperature of the corn, and the temperature of the air (averages of the daily means for the periods between the weighings as indicated by the small circles).

When the corn was returned to the scale on May 14, after the third elevation, the temperature of the corn was practically the same as the temperature of the air at the time the corn was handled, which was slightly less than 55° F. The corn was then held on the scale until June 1, when the corn was again hot. At this time the experiment terminated. During this final period of 18 days the additional loss in weight amounted to 707 pounds, or 2.6 per cent.

On the basis of the original weight, after deducting the weight of the samples drawn for analyses, the total shrinkage during the whole storage period of 147 days, not including the loss during the three elevations, was 1,522 pounds, or approximately 5.6 per cent. The total shrinkage, including the shrinkage of 448 pounds during the three elevations, was 1,970 pounds, or slightly more than 7 per cent. On June 1, at the termination of the experiment, the average moisture content of the corn was 14.7 per cent, or 4.1 per cent less than the same corn contained at the beginning of the test on January 5. During the same period there was likewise a marked change in the quality of the corn, showing that there had been a partial decomposition of the reserve food products during the course of the test resulting in a shrinkage in weight far in excess of the reduction in the percentage of moisture. The weight per bushel of the corn had decreased from 54.7 pounds to 50 pounds; the sound corn from 97.1 to 1.1 per cent, and the kernels which were capable of germination from 89.6 to 1 per cent.

EFFECT OF ATMOSPHERIC CONDITIONS ON THE SHRINKAGE OF CORN.

It was found that the shrinkage was not constant, but that during certain periods there was a retardation in the rate of shrinkage or even a temporary increase in weight due to the absorption of moisture from the atmosphere. In this connection it must be borne in mind that the hopper of the scale, being of wooden construction, undoubtedly absorbed moisture from the atmosphere on damp and rainy days the same as the corn.

Figure 2 shows that whenever there was an increase in weight or a retardation in the shrinkage the relative humidity of the atmosphere was very high between weighings, and in most cases a heavy rainfall occurred just before such weighings were made. The reverse, however, is not true in all cases; that is, all periods of high relative humidity do not show in the diagram a corresponding increase in weight, because the weighings were made only at irregular intervals while the relative humidity records are daily.

On January 21 there was an increase over the previous weighing, January 17, of 2.5 pounds. The relative humidity on January 17 was 81.5 per cent, and on January 21 it was 90.5 per cent. The average relative humidity during this period was 74.5 per cent. On March 2 there was an increase in weight of 12.5 pounds over the previous weighing, February 24. The average relative humidity during this period was 81.4 per cent. On February 28 and March 1 and 2 the relative humidity was 96, 97, and 99 per cent, respectively. On February 28 the precipitation amounted to 0.71 of 1 inch, followed by 0.12 of 1 inch on March 1 and 0.03 of 1 inch on March 2. From this time on until March 22 the amount of precipitation was very small and the average relative humidity was low. During this period the shrinkage was quite rapid. On March 24 the relative humidity was 86 per cent, and when the corn was weighed on March 25 there was an increase of 5 pounds over the previous weighing on March 22. The weighing made on April 5 showed a gain in weight of 2.5 pounds as compared with the weight on April 1. Here again the relative humidity was high, being 87.5 per cent on April 4 and 81 per cent on April 5. There was also 0.24 of 1 inch of rainfall during this period. After April 5 the relative humidity was comparatively low until April 17, when it reached 95 per cent, and on April 21 the relative humidity was 90.5 per cent. At this time the corn showed signs of heating and therefore the influence of the relative humidity and general atmospheric conditions was lost in the increased amount of shrinkage which accompanied the comparatively rapid deterioration of the corn.

SUMMARY.

(1) The shrinkage test described in this circular was made with 500 bushels of shelled corn stored in the hopper of a scale in a grain elevator, and extended over a period of 147 days, January 5 to June 1, 1910, during which time the corn was not "handled" except on May 14.

(2) At the beginning of the test the average moisture content of the corn was 18.8 per cent. The average temperature of the corn and the temperature of the air was 20° F.

(3) The shrinkage in weight from January 5 to April 21, while the corn remained in good condition, was approximately four-tenths of 1 per cent.

(4) The shrinkage in weight from April 21 to May 14 was approximately 2.6 per cent, during which time the corn went "out of condition," becoming sour and hot, with a maximum temperature of 138° F. on May 2.

(5) The shrinkage during the three elevations on May 14 was 448 pounds, or 1.65 per cent, on the basis of the actual weight of corn in the hopper of the scale just previous to "handling."

(6) The shrinkage during storage from May 14 to June 1, after the corn was cooled to 55° F. by handling, was 2.6 per cent.

(7) The total shrinkage during the test was 1,970 pounds, or slightly more than 7 per cent, while the natural shrinkage exclusive of the loss during the three elevations was 1,522 pounds, or approximately 5.6 per cent, calculated on the actual weight after making deductions for samples drawn for analyses.

(8) The rate of shrinkage while the corn remained in good condition was largely influenced by the weather conditions and by the relative humidity and temperature of the atmosphere.

Approved:

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *April 24, 1911.*

[Cir. 81]

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NOTE THE FIVE KINDS OF PAPER UPON WHICH THIS CIRCULAR IS PRINTED.

Issued August 31, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 82.

B. T. GALLOWAY, Chief of Bureau.

CROP PLANTS FOR PAPER MAKING.

BY

CHARLES J. BRAND,

Physiologist in Charge of Paper-Plant Investigations,
Office of Agricultural Technology.

101981°—Cir. 82—11——1

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1911

[This circular is printed on paper made wholly or in part from crop wastes and by-products from corn, broom corn, rice, and cotton.]

BUREAU OF PLANT INDUSTRY.

Chief of Bureau, BEVERLY T. GALLOWAY.
Assistant Chief of Bureau, WILLIAM A. TAYLOR.
Editor, J. E. ROCKWELL.
Chief Clerk, JAMES E. JONES.

☞*The paper upon which this page is printed was made from cornstalks and cotton hulls.* *See page 3.*

CROP PLANTS FOR PAPER MAKING.[1]

INTRODUCTION.

Continued advances in the prices of spruce and poplar wood and the rapid diminution of visible supplies have drawn marked attention to the problem of finding new sources of raw material for paper making. Not only is the price rising with the diminishing supply, but the consumption of both pulp and paper products is rapidly increasing. The statistics of the Bureau of the Census indicate that an increase of at least 5 per cent each year may be expected in the quantity of wood used, although the increase from 1899 to 1904 was more than 53 per cent—from 1,986,310 to 3,043,459 cords. In 1909, 4,002,000 cords were used. While old uses of pulped fiber are being extended and important new ones are being discovered, many promising methods of utilizing pulp and paper remain wholly unexploited. These will claim large additional quantities of raw material in their development.

The inadequacy of the supply of materials now in use to meet these requirements is an accepted fact. Two sources of new material offer themselves: The first, and, so far as the immediate future is concerned, perhaps the more promising, is the large number of coniferous and broad-leaved trees that hitherto for various reasons have not been used. These are under investigation by the Forest Products

[1] The greater part of the paper here presented was published in the Yearbook of the Department of Agriculture for 1910, pages 329 to 340. In order to secure a practical test of some of the papers that have been produced under Mr. Brand's supervision in the experiments of the Bureau of Plant Industry, it is thought advisable to issue a circular printed on papers made wholly or in part from crop wastes and by-products. This will furnish a practical test of the durability of paper produced from crop plants.

Each sheet of four pages is printed upon a different lot of paper, making a total of five kinds of paper in the circular. A statement as to the kinds of material used and the proportion of each is appended.—Wm. A. Taylor, *Acting Chief of Bureau.*

EXPLANATORY STATEMENT.

The first or cover folio (pp. 1, 2, 19, and 20) is printed on paper made from shredded cornstalks (80 per cent) and cotton-hull fiber (20 per cent). The raw materials were cooked together in a stationary digester by the soda process. The pith cells of the corn were partly removed by passing the pulp once over a wet separator.

The second folio (pp. 3, 4, 17, and 18) was made from shredded broom-corn stalks (100 per cent) treated by the soda process. The pith cells were partly removed; long fiber cells from the fibrovascular bundles and from the outside layer of the stalks predominate.

The third folio (pp. 5, 6, 15, and 16) contains rice-straw soda pulp (77 per cent) and sulphite pulp from spruce (23 per cent). The rice straw was cooked alone, while the bleached sulphite was added at the beating engine.

The fourth folio (pp. 7, 8, 13, and 14) contains broom-corn soda pulp (50 per cent) and soda pulp from poplar wood (50 per cent) cooked separately and mixed at the beating engine. None of the pith was removed from the broom-corn pulp.

The fifth or middle folio (pp. 9, 10, 11, and 12) is made from comparatively pure, long fiber pulp of cornstalks. Most of the pith cells were removed and no other fiber was added. The variety of corn used in this case was Reid's Yellow Dent.

Laboratory of the Forest Service. The second possible source is among plants other than trees. These are being investigated by the Bureau of Plant Industry, assisted in the chemical phases of the work by the Bureau of Chemistry. So many extravagant statements have been current from time to time that it seems wise, in the interest of conservatism, to say that the investigators of the Bureau of Plant Industry hope only to find a partial substitute for wood and that there in no expectation of "throwing a life line" to the pulp and paper industry which will afford instant and permanent relief from the persistently rising cost of wood.

ALL PARTS OF PLANTS AND PLANT TISSUES ARE NOT OF EQUAL VALUE IN PRODUCING PAPER FIBER.

While paper of some kind can be made from almost every plant, there is wide diversity in the quality and quantity of fiber produced. Plants, as is well known, are made up of complex tissues containing various kinds of cells. Paper pulp is made by liberating the individual cells comprising these tissues. This is accomplished by mechanical means in the case of certain trees, and by chemical resolution, commonly called digesting, in the case of nearly all other plants. The pulpy residue of chemical treatment is in large part cellulose. It is this substance that furnishes the basis of all papers. Cotton staple is an almost pure form of cellulose, and the only one occurring in so free a condition; that is, so completely disassociated from other tissue. Cellulose wherever it occurs is an unusually stable compound, and as chemical treatment of plant materials progresses it is the last to be attacked by acid or alkali solvents.

The quantity of cellulose-producing tissue varies greatly in different plants; hence, they are not of equal value for paper making. Furthermore, there are differences in the kinds of cellulose produced by different plants, and these kinds vary in value according to the durability of the paper produced from them.

CROP MATERIALS AVAILABLE FOR PRODUCING FIBER.

Outside of trees there are three classes of plant materials which may be utilized in the production of paper pulp. These are: (1) The wastes or by-products of cultivated crops, such as the stalks of corn, broom corn, and sorghum, the straws of rice, flax, and the common grains, hemp waste, cotton stalks, cotton-hull fiber, and bagasse; (2) certain plants that may possibly be cultivated with profit for paper-making purposes, such as hemp, esparto, jute, *Eulalia japonica*, okra, and some of the well-known Japanese paper plants; (3) wild plants, including certain grasses, rushes, sedges, canes, weeds, and wild fiber-furnishing plants like the yuccas, sotols, and agaves.

☞ *The paper upon which this page is printed was made from broom-corn stalks, long fiber.* *See page 3.*

Crop plants to be profitably available for paper pulp must comply with somewhat rigorous requirements: (1) They must exist in large quantities; (2) they must be available throughout the year; (3) they must yield a relatively high percentage of cellulose; (4) the fiber cells or cellulose must be of a highly resistant character and must have length, strength, and good felting qualities; and (5) the plant must be of such a nature that the cost of obtaining the fiber will not be prohibitive. No one crop plant now known satisfies these conditions completely, though it has not thus far been practicable in the experimental work of the Department of Agriculture to investigate all of them. Certain plants of representative character have been selected in order that the results with these might be applied as far as possible to other plants in the eligible list. The work has been confined largely to the stalks of corn and broom corn, rice and flax straw, and cotton-hull fiber used incidentally with certain of the other materials. In connection with the search for new materials, at least two present sources deserve much fuller development, namely, old papers and rags. Only a very small proportion of the available supply of these wastes is collected at present.

PAST ATTEMPTS TO UTILIZE CROP MATERIALS.

The present efforts to devise means for profitably utilizing some of the crop wastes in paper making do not by any means represent the first attempts in this direction. As long ago as the seventeenth century a small paper mill at Rimini, in Italy, produced paper from the husks of corn. Again, in the eighteenth century, there was greatly renewed interest in cornstalks and some other materials, and Schaeffer, in Germany, produced paper from the husks, leaves, and stalks separately, and from the combined materials of the whole stalk. He published a paper giving the results of his experiments and showing sample pages of the papers he produced. Cobbett, in England, early in the nineteenth century, had similar experiments made, and printed the title page of his Treatise on Corn upon paper produced from this material. Since the beginning of the nineteenth century a large number of experiments have been made with a view to utilizing most of the crop wastes, and many patents have been granted to experimenters covering processes and machines employed in the various phases of the work. It should be added that with the exception of straw, the use of which, in this country, is confined almost wholly to the manufacture of straw and box board, wrapping paper, and certain specialties, the attempts to utilize crop materials have resulted in failure.

☞ *The paper upon which this page is printed was made from rice straw and spruce wood. See page 3.*

THE OUTLOOK FOR UTILIZATION UNDER PRESENT-DAY CONDITIONS.

About half a century ago the supply of rags became so low and the price as a consequence so high that paper manufacturers were forced to find new materials as a basis of the further development of their industry. In this extremity esparto grass and certain woods, notably spruce and poplar, were found to produce excellent paper fiber. The enormous expansion in the use of paper since that time has now brought us face to face with a dearth of suitable wood. The price of spruce at the mill has risen from a few dollars a cord to $6 to $11, and in some cases even to $12 a cord, according to location and cost of delivery. Poplar, likewise, has risen from a comparatively low price until now it is perhaps worth on an average $7.50 per cord, delivered. Practically all the trees producing the highest class of materials have been cut, so that the present harvest is from less desirable and more scattered stands, which means reduced yields of fiber in raw material and an increased cost in securing the wood. While the price of wood has continually advanced as the supplies grew smaller, the supply of crop by-products has gone on increasing with practically no increase in price, and with but little likelihood of any considerable increase in the future. In course of time this disparity will become even more pronounced; hence attempts at the utilization of waste materials are now made under conditions far more favorable than were similar efforts made as recently as 10 or 15 years ago. In other words, the rising cost of materials is rapidly bringing us to a time when the question of producing paper from crop wastes and other plants may be considered from a new point of view.

METHODS USED IN OBTAINING PAPER STOCK FROM PLANTS.

With the exception of cotton, all raw vegetable fibers that enter into the manufacture of paper pulp are obtained by the mechanical or chemical separation of complex plant tissues. As a preliminary to the discussion that follows, a short description of the methods by which paper fiber is secured from trees and other plants may not be out of place.

The simplest method, that of mechanical grinding, is applicable only to certain woods, which are ground into a pulp by means of grindstones over which a continuous stream of water flows. The pulp secured in this way is the poorest of all, as it contains numerous substances which rapidly deteriorate in contact with light and air. This sort of pulp, known as mechanical wood pulp, mixed with a fair proportion of higher grade fiber, is the chief constituent of news and other cheap printing papers. It is also used largely in the

☞ *The paper upon which this page is printed was made from rice straw and spruce wood. See page 3.*

manufacture of pressed-fiber utensils, such as washtubs, trays, pails, and many other products.

The second means of securing pulp from raw materials has a far wider application than the mechanical process. It consists in separating the tissue cells from one another through the action of chemicals which attack the gums, resins, and other cementing substances which hold the parts of the plant together. Two classes of chemicals are used, namely, acids and alkalis. A good example of a pulp produced by the acid method is the well-known sulphite fiber produced so largely from spruce, and in less measure from other coniferous trees. In this case sulphurous acid is the solvent. The alkali method of digestion is suitable for a wider range of materials than the acid method. In this case the chemical solvent generally used is caustic soda. Practically all experiments with the wastes or by-products of crop plants and with wild plants other than trees are conducted by the soda process and a variation of it known as the sulphate process. In commercial practice the greater part of the soda pulp of commerce is produced from poplar and certain other broad-leaved trees, and from esparto, a grass that grows wild in the circum-Mediterranean region. Chemical pulp, produced either by the sulphite or soda process, and pulp from rags are the bases of nearly all of the better grades of printing, writing, and wrapping papers.

REVIEW OF RECENT EXPERIMENTS.[1]

During the past 10 years many crop materials have been subjected to pulping experiments by some of the more progressive paper manufacturers and by private individuals. In most cases a satisfactory quality of paper has been made, but in the end nothing practical has come of the work. The whole situation might be summarized by the statement that it has been found possible to make paper out of many crop wastes, but it has been found impossible to make money out of more than one or two.

Congress, in making appropriations for the Department of Agriculture for 1908–9, provided the sum of $10,000 to be used in testing "such plants as may require tests to ascertain if they be suitable for paper making." One half of this fund was assigned to the Forest Service for studies of unused woods, the other half to the Bureau of Plant Industry for the investigation of crop and wild

[1] The writer is indebted to Messrs. F. P. Veitch and J. L. Merrill, of the Bureau of Chemistry, and to Mr. E. M. Muncey, of the Office of Agricultural Technology, of this Bureau, for all chemical determinations; to Dr. H. S. Bristol and Mr. Edwin Sutermeister, of the Forest Service, for assistance in much of the earlier work, and to the Bureau of Standards, Department of Commerce and Labor, for testing the papers produced in the many commercial and semicommercial runs at the paper mill. The Bureau of Animal Industry, through Dr. E. C. Schroeder and his assistant, Mr. W. E. Cotton, aided the work by conducting a preliminary feeding test of the extract obtained from cornstalks.

plants. Work was taken up in the summer of 1908 on the following: Cornstalks, flax and rice straw, cotton stalks, bagasse, and tules. Since that time broom-corn and hemp stalks, hemp wastes, cotton-hull fiber, stalks of saccharine and nonsaccharine sorghums, *Epicampes macroura* (a southwestern grass whose tops are a by-product of the root-brush industry), Arundo, Arundinaria, Eulalia, and several other plants have been added to the list. During the past year special attention has been given to practical tests in a large book-paper mill.

CORNSTALKS.

Cornstalks were taken up first for several reasons: (1) They represent an enormous supply of raw material—the greatest unused crop by-product. Over 100,000,000 acres are now devoted annually to Indian corn in the United States. Taking 1 ton as the yield of stalks per acre, which is a very conservative estimate, there are produced at least 100.000,000 tons of stalks each year. Certainly not more than one-third of this vast quantity is put to paying uses in present farm practice. Ignoring another third, which may be produced in scattered localities, thus adding a factor to the considerable expense that would be involved in assembling it, there remain fully 30,000,000 tons of cornstalks grown in the area known as the "corn belt." A great addition to farm wealth would result if some of this supply of material could be made into paper and pulp products at a reasonable profit. (2) Results obtained with cornstalks would be applicable in a considerable measure to all grasses, rushes, and sedges which have a similar structure, and in less measure to dissimilar plants having some of the same cellular elements. (3) Considerable pioneering work had been done with cornstalks, the results of which were accessible to the Department.

While the cornstalk experiments have been encouraging, they have not yet produced results that justify a definite pronouncement. Paper of excellent quality has been made from 8 or 10 varieties of corn during the past season, but it remains to be determined whether the profit to the manufacturer will enable him to give the farmer enough for his stalks to pay for harvesting, shredding, baling, and delivering the same. All parts of the corn plant except the ears and roots are used. Under present plans it is expected that cornstalks will yield three products:

(1) Long fiber, which, on account of its strength and its good felting and other desirable qualities, is suitable for book, writing, and other papers of the better class. Bone-dry stalks will yield from 12 to 18 per cent of long fiber, varying with the variety, conditions of growth, and chemical treatment.

☞ *The paper upon which this page is printed was made from broom-corn stalks and poplar wood. See page 3.*

(2) Pith pulp, suitable for pulp and paper specialties, such as insulating material, grease-proof wrappers, pie plates, fiber boxes, and possibly bottles. The yield of pith will range from 15 to 30 per cent of moisture-free stalks. The usefulness of pith pulp for standard products is not as great as that of the long fiber, but it is a plastic material that should serve many useful purposes. The character of the fiber and pith cells is shown in figure 1.

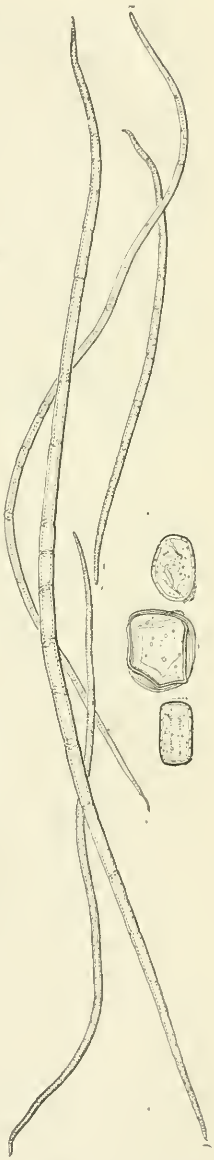

FIG. 1.—Long fiber and pith cells of Indian corn.[1] (Enlarged 71 diameters.)

(3) Cornstalk extract, the soluble solids of the stalks, obtained by water extraction or by saturation under pressure and subsequent expression. The method most commonly employed in obtaining this extract is to place the shredded stalks in the digester with a quantity of water and boil for an hour under a steam pressure of from 50 to 70 pounds. The liquid containing the soluble solids is then drained off and evaporated to the desired consistency, while the extracted stalks remain in the digester ready for cooking with caustic soda.

A ton of cornstalks will yield from 200 to 300 pounds of soluble solids containing the greater part of the food value of the stalks. When made under the best conditions from 8 to 12 per cent of the extract is protein, about 25 per cent is invert and cane sugar, and about 25 per cent more is sugars of the pentose and pentosan class.

About 25 gallons of extract of molasseslike consistency were produced at a paper mill during the summer of 1910, and a month's preliminary feeding test of two animals was made in cooperation with the Bureau of Animal Industry of the Department of Agriculture. All of the food mixed with dry matter was eaten and no injurious effects were observed. It remains to make a conclusive test with a larger number and a greater variety of animals before the nutritive value of the material can be determined or whether it is injurious if fed for a long time. As broom-corn and sorghum stalks and rice straw yield a similar extract, the possibility of reclaiming the food elements will very likely be

[1] The illustrations used in this circular were drawn by Mr. W. E. Chambers, of the Office of Agricultural Technology.

one of the factors in determining whether or not the wastes of crop plants can be put to practical use in paper making. If cornstalk extract proves valuable and the water-soluble solids can be returned to the farm, mixed with roughage, and fed, an important step in conservation will have been gained, as the removal of the raw material from the farm need not then represent a serious attack upon the soil resources. The extraction of the soluble solids from the stalks is beneficial, because it leaves the stalks in an improved and advanced condition for chemical treatment and lessens the cost by reducing the quantity of chemicals required.

Cost estimates are incomplete, but it appears that the farmer could not afford to handle the raw material for less than $5 a ton, air dry. If the extract has any value it is probable that the manufacturer could afford to pay this, though these are matters upon which more accurate data must be secured and which must necessarily be finally decided in actual practice.

BROOM CORN.

Both the corn and broom-corn stalks used in the Department's experiments were grown at specially selected places, and a careful record has been kept of the yield, the cost of production, the space required for storage, and the keeping quality of the materials. On the whole, the collaborators [1] who grew broom corn had better success in the production of stalks than those who grew corn. As a consequence, broom-corn stalks have been investigated more thoroughly than other materials. As a large number of digestions or "cooks" of Indian corn were made first, much experience was gained which was of decided advantage in the tests of broom corn.

Broom corn throughout its cultural history has been selected for the production of a greater quantity and better quality of fiber in its "brush." It would be only natural if the production of fiber in one portion of the plant should be correlated to the higher fiber value of the plant as a whole. This appears actually to be the case. At any rate, broom-corn stalks contain a higher percentage of long fiber than do cornstalks. As a result of the experiments that have been made with broom-corn stalks it may be conservatively stated that this crop by-product is suitable, so far as the quality and yield of its pulp are concerned, for immediate use in paper making. Like cornstalks, it reduces readily to pulp with a comparatively low consumption of chemicals and steam. The time required for pulping

[1] The following farmers have assisted the Department by producing corn and broom-corn stalks for the experimental work: Ovid Fields, Lyons, Ind.; Eugene D. Funk, Shirley, Ill.; L. W. Edmundson, Balbec, Ind.; I. C. Murphy, Sterling, Kans.; H. Z. O'Hair, Bushton, Ill.; J. E. Matheny, Miami, Mo.; J. T. Hancock, Corydon, Ky.; and W. A. Hook, Packwood, Iowa.

is from 3 to 4 hours, as compared with 8 to 12 hours for wood. In addition, preliminary tests indicate that there will be no great difficulty in recovering the caustic soda used in digestion.

In tests on a laboratory and semicommercial basis, yields of 32 to 40 per cent of fiber were obtained. Later, a cook of 3½ tons was made in the largest sized rotary digester in common use for wood, on which a yield of practically 42 per cent was obtained.[1] It appears from this that it will be safe to expect this percentage of fiber in actual practice. It was found that the proportion of pith in broom-corn pulp is so low that it could be made directly into a fair quality of white paper, which, however, would probably be too brittle for most purposes. Experiments were also made to test the effect of combining broom-corn pulp with certain proportions of soda pulp from poplar and sulphite pulp from spruce. It was found that a combination of 50 per cent of unseparated broom-corn pulp, pith, and long fiber, together with 50 per cent of poplar, produced what was pronounced by practical paper men as a merchantable quality of book paper. In combination with sulphite fiber from spruce a stronger though somewhat harsher sheet resulted.

The results that have been secured with broom-corn stalks indicate that this material is suitable for immediate use in paper making, on the basis of both quality of fiber produced and yield of fiber secured. Broom-corn stalks have one serious disadvantage, namely, the limited production of raw material. The figures for the recent census are not yet available, but according to the returns of the Twelfth Census 178,584 acres were devoted to broom corn in 1899. The yield of stalks to the acre will probably approximate very nearly 3 tons; hence, the quantity produced will probably be in the neighborhood of 450,000 tons. Many States grow small acreages of broom corn, but Illinois, Kansas, Oklahoma, and Missouri probably produce fully two-thirds of the total crop. It is possible that in these States there may be localities where the acreage cultivated near one central point is so large that pulp could be produced economically.

The harvesting of the stalks for pulp making does not interfere with the harvesting of the brush for brooms, nor would it in any way reduce the quality of the brush produced.

Broom-corn stalks, like cornstalks, yield a product under water extraction containing practically the whole food value of the raw material. In the case of broom corn it seems likely that the stalks could be pulped at a profit without taking into account the possible value of the food extract.

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[1] Acknowledgment is here made for much assistance and information furnished by S. D. Warren & Co., Cumberland Mills, Me. The writer is especially indebted to Mr. John E. Warren, the resident agent of the company, for many helpful suggestions and hearty cooperation.

RICE STRAW.

Rice straw may be regarded as one of the most promising crop materials available for paper making at the present time. In China and Japan this material has been employed for many years. There has been considerable discussion about its use in the United States, but up to the present time no commercial plant has been constructed for the purpose. Private experimenters have produced excellent qualities of book and writing papers from it, more particularly in combination with sulphite pulp and cotton-hull fiber. In the experiments of the Department, yields running approximately from 32 to 40 per cent have been secured. Not less than 35 to 36 per cent could be expected in practice. The character of the long fiber of this straw is shown in figure 2. Pith cells are also present in rice straw, but not in such proportion as in cornstalks. Indeed, it has been found perfectly feasible to produce paper without attempting to remove the pith cells, but merely combining the straw pulp with a suitable quantity of sulphite, soda, or cotton-hull fiber.

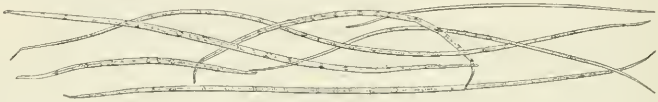

FIG. 2.—Rice-straw fibers. Though comparatively short, these are strong and felt well. (Enlarged 71 diameters.)

Rice straw also yields a food extract which in the analyses thus far made runs rather high in protein; nevertheless, it does not seem necessary in the case of this waste to depend upon the extract in order to make the material as a whole utilizable. The chief problem arises from the low recovery of soda from the spent liquors of the cooking process, due to the presence of a high percentage of silica in the straw.

Rice straw has a distinct advantage over cornstalks in that it is assembled at one place for thrashing and can be baled at once without extra cost for hauling in from the field and shredding. Although it does not promise to give as high a yield of fiber as broom-corn stalks, it has a distinct advantage over these because of the greater acreage grown. It has a further advantage over both corn and broom corn in that it is grown rather compactly in restricted areas, so that a pulp or paper mill located in any good rice-growing section could secure its supply of raw material within a comparatively small distance from the mill. Texas, Louisiana, Arkansas, and South Carolina are the great rice-producing States. At present these States have a total of only four paper mills, none of which use this material.

The number of acres of rice harvested in the United States in 1909 was 720,000. Growers state that the yield of straw will run from 2 to 2½ tons an acre. Using the lower yield, in the neighborhood of

☞ *The paper upon which this page is printed was made from cornstalks. See page 3.*

1,500,000 tons of rice straw are produced annually. At the present time this is largely a waste product, though a small part is fed to stock. It is also baled to some extent and shipped to the larger cities for stable bedding, bringing about $4 to $4.50 a ton. If the price of wood continues to advance, rice straw should be one of the first crop materials put to practical use.

COTTON-HULL FIBER.

Cotton-hull fiber is the lint that remains adhering to the hulls after the long fiber has been removed by the gin and the shorter fiber by the reginning machines. The hulls are a by-product of the cottonseed-oil industry.

The fiber is used to some extent as a source of cellulose in the manufacture of guncotton; also as a stuffing material for pads and horse collars, and in upholstering. It may be removed from the seed before crushing or from the broken hulls after the seed has been crushed and the kernels extracted. The fiber obtained before crushing has not been tested in the writer's experiments. That obtained from the broken hulls contains a high percentage of the hull material, which is removed with some difficulty. As the particles of the hull do not digest or bleach as readily as the fiber, they frequently show up in the pulp or finished paper as small brown specks, which would seriously interfere with the salability of the product.

There is some diversity of opinion among producers as to the quantity of cotton-hull fiber that could be made available. It would probably be rather small. It is not suitable for paper making in a pure state, as it is somewhat deficient in strength, and, furthermore, it will probably command a higher price for other purposes than paper manufacturers can afford to pay. Cooked in the same digester with corn, broom corn, or rice straw, cotton-hull fiber has been found to facilitate greatly the draining of the pulp and also to add softness to the paper. It is possible that its beneficial effect in this respect might make a market for a limited quantity of this material in connection with the others mentioned. A further possibility is that this fiber, treated by special processes, may prove suitable for particular grades of paper that command unusually high prices. At present, cotton hulls with the short lint adhering are sold for fertilizer and command $5 to $8 per ton at the point of production. The hulls are also mixed with the ground oil cake after expression of the oil and made into stock foods of various grades. When used as a component of stock food it is desirable to remove the short lint. Cotton-hull fiber will probably never be used extensively in paper making, and it is only mentioned here because it may prove a valuable adjunct in the working up of other crop by-products.

☞ *The paper upon which this page is printed was made from broom-corn stalks and poplar wood. See page 3.*

COTTON STALKS.

Cotton stalks tested in cooperation with the Forest Service of this Department were among the first crop wastes reduced to pulp. The aggregate quantity of these stalks produced in the United States is large. Those who have given attention to the matter estimate it at 10,000,000 tons. The yield per acre of stalks is much lower than that of any of the raw plant materials thus far discussed, and probably does not exceed 1,000 pounds. Cornstalks will average more than twice this quantity; rice straw, four times as much; and broom corn, six times this total. Numerous inventors have been attracted to cotton stalks by the large quantity grown, and much has been claimed for paper said to be made from them. At the present time no paper mill is using the material.

In the experiments thus far conducted by this Department cotton stalks have been found to require harsh chemical treatment, using about 30 per cent of caustic soda, which is 5 per cent more than poplar wood requires. They required from six to nine hours, with steam pressures of from 90 to 110 pounds, for cooking. The yield of fiber ranged from 35 to 43 per cent in various tests, but the fiber was found to be short and inferior in strength. With this yield and the low production of 1,000 pounds per acre it would require 5 acres of stalks to make a single ton of pulp. Difficulties were also encountered in connection with bleaching. The dark outer bark proved very refractory, necessitating the use of a large quantity of bleaching powder. All samples of paper made from this material which the writer has examined contain so much unbleached material as to render them unsuitable for anything except wrapping purposes. It is possible that methods may be devised which will produce a pulp sufficiently white and a fiber sufficiently strong to make cotton stalks a promising material, but the results obtained to date are not encouraging.

BAGASSE.

Bagasse is the refuse of the sugar cane after the juice has been expressed. It is susceptible to the treatment given to the stalks of corn and broom corn and some of the other materials that have been discussed. When treated by the caustic-soda process in the ordinary manner the yield of pulp has been comparatively low. The individual fibers, while rather short, are slender, so that a moderately strong sheet of paper can be produced. The pulp bleaches easily, especially if it has first been extracted by the method described for cornstalks. A large percentage of pith is present, which, in practice, would have to be dealt with as in the case of corn. Several small plants have been built with a view to making various forms of pulpboard and the rougher grades of paper from bagasse, but so far as

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☞ *The paper upon which this page is printed was made from broom-corn stalks and poplar wood. See page 3.*

the writer knows none of these has been permanently successful. The fact that the material is all assembled at the sugar mill and thoroughly broken up in the process of crushing should favor the utilization of this waste. On the other hand, the fuel value of bagasse must be carefully considered in any plan to utilize the material. The sugar industry, as now organized, counts on the refuse to furnish a very large proportion of the fuel required for the boilers. Its value for this purpose has been variously estimated at from $1.50 to $3 per ton. Both figures are probably too high.

FLAX STRAW.

In the United States flax is grown almost exclusively for seed, the annual production amounting to something more than 25,000,000 bushels. The number of acres harvested is about 2,500,000. On an average, between 2,000 and 2,500 pounds of straw are produced to the acre. At the present time not more than 250,000 or 300,000 tons of the total product of approximately 3,000,000 tons are used.

Recent years have seen considerable development in the use of flax straw, but much remains to be desired, considering the generally promising nature of the material. Many extravagant claims have been made and much promoting has been done, some of it of an extremely questionable character, on the basis of the supposed value of the straw of seed flax for textile and other purposes. At the present time its profitable use is confined almost wholly to the manufacture of binding twine, upholstery tow, and insulating material for refrigerator cars and cold-storage houses. The waste straw of the flaxseed industry is a totally different product from the carefully handled and prepared fiber from which linen fabrics are made. Even for twine-making purposes the straw must be harvested and thrashed in a particular way in order to produce a satisfactorily smooth quality of twine.

When cooked by the caustic-soda process the straw produces a material decidedly strong and in many respects promising. The yield of pulp has not run much over 30 per cent of the raw material. Much private capital has been spent in attempts to make paper from flax straw, but as yet there is no mill in the United States that uses the material. Recently private agencies have conducted extensive experiments with a view to producing paper suitable for cement bags and the like. The requirement is an extremely difficult one, as paper for such purposes must have extraordinary strength. Some of the papers produced came up to the requirement, and the results as a whole were encouraging. In these tests tow was used and not the flax straw as it comes from the thrashing machine. If this method were followed in practice there would be a considerable addition to

☞ *The paper upon which this page is printed was made from rice straw and spruce wood.* *See page 3.*

the expense for raw material. It requires from 3 to 4 tons of straw to make 1 ton of tow, and medium tow is worth over $20 per ton at the tow mills. Flax straw must be regarded as one of the most promising materials, but extreme caution should be used in its exploitation. Straw from different sources differs in strength and quantity of fiber; climatic conditions appear to have a profound effect upon its fiber value.

MISCELLANEOUS CROP MATERIALS.

In addition to the crop by-products that have been discussed there are other materials that may prove of value. Among these are the common grain straws, the wastes of hemp, jute, flax, manila, and other fiber crops, and the stalks of the grain sorghums which are now being cultivated in considerable areas and whose culture is being extended rapidly. *Epicampes macroura*, a southwestern grass, which is especially plentiful in Mexico, may prove useful, as it has an excellent fiber. This plant, which is known as "zacaton," furnishes the so-called "rice roots" so extensively used in the making of brushes. In the brush industry only the roots are used, and the tall-growing stems and leaves with their fine fiber are a waste product.

Two points should be borne in mind in all attempts to make pulp from crop wastes: That not all materials are suitable for making expensive products and that it not infrequently happens that there is as much profit, because of lessened cost of production and greater demand, in making cheaper products for which the material may be better adapted as in making the higher priced articles.

PLANTS THAT MAY BE GROWN AS PAPER CROPS.

In addition to the waste materials that are available, evidence has been gathered that certain crops can probably be grown at a profit to both the grower and manufacturer, solely for paper-making purposes. One of the most promising of these is hemp. Hemp grows well in most parts of the country and produces very high yields of raw material. The average production of "hay-dry" hemp stalks per acre will reach very nearly 5 tons. Of retted stalks, an average of from 2½ to 3 tons can be expected. When dew retted, as is the common practice, the tax on the soil of growing the crop is very light—an exceedingly important point in farm economics. According to careful estimates by Prof. L. H. Dewey, hemp can be grown through the retting stage at a cost of about $14 an acre. With an average yield of 2½ to 3 tons of retted stalks, it seems very likely that hemp can be grown profitably solely for paper stock.

Hemp produces a paper of great durability and great strength in thin sheets. The retted stalks will yield from 40 to 45 per cent of cellulose. The fiber (fig. 3) is of such a nature and length as to fit

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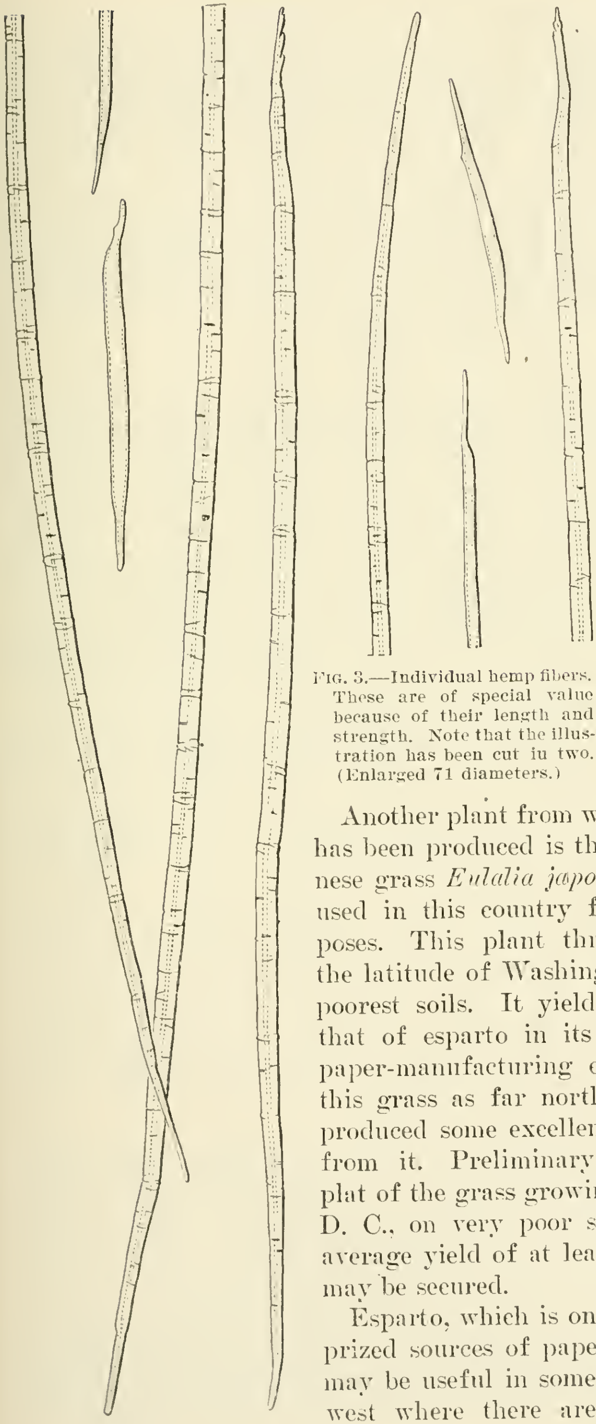

FIG. 3.—Individual hemp fibers. These are of special value because of their length and strength. Note that the illustration has been cut in two. (Enlarged 71 diameters.)

it for the manufacture of numerous special papers that will command better prices than the ordinary grades. Should retted hemp come into use as a paper-making material it will effect a considerable saving in certain years to the hemp-fiber industry, as it frequently happens that hundreds of tons of hemp stalks are over-retted, making them unfit for textile use. These could be worked into paper to advantage.

Another plant from which excellent paper has been produced is the well-known Japanese grass *Eulalia japonica*, which is much used in this country for ornamental purposes. This plant thrives luxuriantly in the latitude of Washington on some of the poorest soils. It yields a fiber similar to that of esparto in its behavior. A large paper-manufacturing company has grown this grass as far north as Maine and has produced some excellent varieties of paper from it. Preliminary observations on a plat of the grass growing near Washington, D. C., on very poor soil indicate that an average yield of at least 2 tons to the acre may be secured.

Esparto, which is one of the most highly prized sources of paper in the Old World, may be useful in some parts of the Southwest where there are extensive areas of unused dry land. The grass is one of the important sources of paper in Europe. The present supply is obtained from the dry regions of Algeria, Tunis, Tripoli, and Spain, where it grows wild and is harvested by hand. It seems likely, furthermore, that the application of methods of selective breeding might produce strains of esparto of superior value.

Okra and jute have received some attention as paper crops, but no conclusive results have been obtained with them. Samples of paper from okra that have been examined are rather deficient in strength. This, however, might readily be due to overtreatment with chemicals.

CONCLUSION

There are numerous crop materials now going to waste that deserve utilization for the making of paper. Hitherto the price of wood has been so low that they could not enter into competition with it. This condition appears to be changing, and a point may soon be reached where crop by-products can be made into pulp and paper at a profit to both the farmer and the manufacturer. There does not seem to be any reasonable hope at the present time of producing paper stock from crop wastes that will be cheap enough to use for printing newspapers. This is due chiefly to two causes—the low cost at which such paper can be produced from ground wood and the striking adaptability of ground-wood pulp to the newspaper-printing industry.

Not only is the grinding process the cheapest method of obtaining print paper of any character, but this process also produces the highest proportion of pulp to raw material. While the two chemical processes which have been discussed produce on an average only about 1,000 pounds of pulp per cord of wood, the yield of ground-wood pulp per cord is considerably over 2,000 pounds. Although lacking in durability, ground-wood fiber, with the addition of a small proportion of stronger and better chemical fibers, answers its intended purpose admirably. It is light, reducing freight cost on the unprinted paper and postage on the printed. It is opaque, printing readily on both sides of moderately thin sheets, and, finally, it has excellent ink-absorbing qualities, fitting it unusually well for use on the high-speed presses of the present day.

Wood will probably be used for making news paper long after other materials have acquired importance in many branches of the chemical pulp industry. It should be added that chemical pulp papers, such as books and magazines are printed upon, consume over 1,000,000 cords more of wood each year than the ground-wood industry.

There is some skepticism as to the failure of the pulp-wood supplies, but this is certainly poorly grounded. During 1909 the quantity of

☞ *The paper upon which this page is printed was made from broom-corn stalks, long fiber. See page 3.*

spruce used was less by 40,000 cords than in 1907, but the cost was $2,000,000 greater. Present efforts in connection with the reforestation of spruce and poplar are not extensive enough to produce any noteworthy effect upon the available supply within a generation. At the present rate of increase in consumption, it will require between 15,000,000 and 20,000,000 cords of wood to satisfy the demand for pulp and paper fiber in 1950. It will certainly be impossible to furnish this from the forests. If every acre cut over each year were reforested it would be twenty-five or thirty years, or possibly even longer, before the trees could attain sufficient size to warrant cutting. The forests can not recover from the overdrafts continually being made upon them; hence it is only a question of a limited number of years until paper fiber must be grown as a crop, as are practically all other plant materials entering into the economy of man. While the conservation of only a few of the by-products of the farms yielding paper fiber can be accomplished profitably in the near future and only a few plants promise to be money-makers immediately if grown solely for paper production, it seems very probable that raw products now scarcely considered may in a few years play an important part in the paper and pulp industry.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *June 14, 1911.*

☞ *The paper upon which this page is printed was made from cornstalks and cotton hulls. See page 8.*

The paper upon which this line is printed was made from cornstalks and cotton hulls. See page 3.

Issued July 21, 1911.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF PLANT INDUSTRY—Circular No. 83.

B. T. GALLOWAY, Chief of Bureau.

SUGGESTIONS TO SETTLERS ON THE BELLE FOURCHE IRRIGATION PROJECT.

BY

BEYER AUNE,

Farm Superintendent, Office of Western Agricultural Extension.

100242°—Cir. 83—11

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1911

BUREAU OF PLANT INDUSTRY.

Chief of Bureau, Beverly T. Galloway.
Assistant Chief of Bureau, William A. Taylor.
Editor, J. E. Rockwell.
Chief Clerk, James E. Jones.

B. P. I.—685.

SUGGESTIONS TO SETTLERS ON THE BELLE FOURCHE IRRIGATION PROJECT.[1]

DESCRIPTION OF THE REGION.

The Belle Fourche Irrigation Project is located in the southwestern part of Butte County, S. Dak., and draws its water supply principally from the Belle Fourche and Red Water Rivers, which are diverted into a reservoir from which two large canals carry the water to the land. The topography of the area covered by the project is gently rolling, with occasional flat areas of some extent. The project will irrigate something over 90,000 acres of land, but owing to the rolling character of the ground, much of which lies above the level of the ditch, the area included between the main canals considerably exceeds this acreage. This feature will enable many farmers to have both dry land and irrigated land in their farm units, and the Reclamation Service has so subdivided the land into units that each farmer will have as nearly 80 acres of each as the local topography will permit. The irrigated portion of each farm unit will usually vary from about 60 to 100 acres. The territory surrounding the project is an open cattle range, the land being covered with a sod composed of western wheat-grass, buffalo grass, grama grass, and some wire-grass and small sedges. The soil, which has been formed principally through the weathering of cretaceous shale, is generally a heavy clay, though along the streams it is considerably lighter.

TREATMENT OF SOD LAND.

Where sod land is to be brought under cultivation, either above or below the level of the ditch, it is advisable to break the land rather late in the spring after the grass has started, especially on the heavy clay soils, but whether it is advisable to try to obtain a crop the first summer will depend somewhat upon the location of the land. Sod land on the lower lying creek and river bottoms or where there is no tendency to rapid surface drainage can probably be advantageously

[1] This circular is a revision, with some additions, of an unnumbered circular, entitled "Hints to Settlers on the Belle Fourche Project, South Dakota," prepared by Mr. Charles A. Jensen and issued March 17, 1909.

used for corn or flax on spring breaking. But if the land is on the high-lying prairie (especially if north of the Belle Fourche River) it is practically useless to try to obtain a crop the first season without irrigation, and irrigation would be difficult on sod land the first season. If corn is planted on the sod some fodder may be obtained, but certainly very little grain, if any, will be produced, and it is doubtful whether the fodder harvested will repay the labor involved. It should be kept in mind that this refers to the prairie uplands north of the Belle Fourche River rather than to the area south of it.

It is an observed fact that more rain occurs south than north of the river, probably because the south side is benefited by the rains occurring in the Black Hills, which are more frequent than those northward on the prairies. For instance, during the summer months (April to September, inclusive) of the years 1908, 1909, and 1910, Vale, a town on the Belle Fourche River, received an average of 4.11 inches more rain than was recorded at the experiment station 10 miles to the north during the same periods, the records for each year being as follows: For 1908, Vale, 13.84 inches, experiment farm, 8.84 inches, a difference in favor of Vale of 5 inches; for 1909, Vale, 16.77 inches, experiment farm, 14.37 inches, a difference of 2.40 inches in favor of Vale; for 1910, Vale, 12.64 inches, experiment farm, 7.71 inches, a difference of 4.93 inches in favor of Vale.

For the new settler on the north side who comes on his land in the spring it is a question whether it will not pay him better to break what land he can in the spring, disk it enough to close up the coarse air spaces so it will retain moisture during the summer, and then obtain work somewhere on the project for the remainder of the summer. There is a fairly good demand for labor in connection with the work of the Reclamation Service and also on the farms already started. During the summer the land that has been broken should be kept in good condition by an occasional disking or harrowing, so that the sod will rot and be ready for backsetting in the fall. If the backsetting is not too deep (that is, not more than 4 or 5 inches) the soil can easily be worked into condition for winter wheat, which succeeds very well in the area. This procedure will probably prove better for the new settler than to stay on the farm the first summer with but small prospect of getting any returns from the land. If the new spring breaking is planted to a crop and the crop harvested without irrigation, the land will probably be too dry in the fall to be put into winter wheat.

PREPARATION OF THE SEED BED.

On land that has been previously broken, the seed bed for spring planting should be prepared as early as practicable. The plowing should, when possible, be done the previous autumn, so that the soil surface may be in condition to catch the early spring rains, thus preventing their running off the surface. This is particularly applicable to the heavy gumbo soils, which, if left in a compact condition over winter, shed water very effectually. If the land is plowed in the spring it is not advisable to plow deep, especially in the gumbo soils, as the subsoil turned up will not be in good condition for plant growth. It is important to harrow the land immediately after plowing, as this helps to establish a mulch which prevents undue loss of soil moisture and tends to firm down the soil, thereby establishing good germinating conditions. The packing of the soil by harrowing will also prevent the wind from gaining free entrance to the plowed layer. The loss of moisture caused by the high winds which are prevalent in the spring is greater than the loss occasioned by the high summer temperature: hence the importance of the harrowing. If the land has been fall-plowed it should be gone over with a disk or harrow in the spring as soon as possible after the frost is out of the ground and the surface dry enough, in order to prevent the loss of moisture, to keep the surface from crusting, and to break up the clods.

EARLY PLANTING IMPORTANT.

The growing season at Belle Fourche is relatively short, and spring crops should be started as early as conditions will permit. Such crops as wheat, oats, rye, and Canada peas will stand some spring frost without serious injury, and these crops can ordinarily be seeded with safety from the first to the middle of April. In 1909 wheat, oats, and barley were sown on the experiment farm from April 6 to 8, and corn was planted May 10. In 1910 wheat was sown April 2, oats, April 5, barley, April 8, and corn was planted May 18.

In 1908 the last frost occurred May 20; in 1909, May 17; and in 1910, May 23. During these years the first autumn frosts occurred September 26, September 23, and August 25, respectively.

While early planting does not result in a rapid early growth of top, it enables the roots to become well established in the soil, and the deep rooting gives the plants an advantage when later in the spring the temperature gets high enough for more rapid growth above ground. This advantage is important in the dry-land soils. Of course, seeding should not be done so early that the cold, wet ground will cause the seeds to rot, but the spring climatic conditions in the area are usually such that seeding may safely be done quite early. Seeding should, when possible, be done with a grain drill, as the seed can not be properly buried and surrounded firmly with moist soil by broadcasting followed by harrowing or disking. As the seed bed in the heavy gumbo soil is likely to be somewhat rough, seeding should be deep. Wheat, oats, barley, rye, and peas should be put in about 3 inches deep, and a press-wheel attachment on the grain drill should be used to pack the soil around the seeds, insuring an even germination and stand.

CROP VARIETIES.

The varieties of grain best adapted to the region have not yet been as definitely determined as is desirable, but a few varieties have shown themselves sufficiently well adapted to be recommended. The Kubanka variety of durum (macaroni) wheat is well suited to the dry lands. Fife and Bluestem wheats also do well as spring wheats and should have the preference over the durum varieties on the irrigated land. Three varieties of oats, Kherson, Sixty-Day, and Swedish Select, are among the best so far known. For dry-land areas the preference seems to be in favor of Kherson or Sixty-Day oats, but the Swedish Select variety would probably be better for irrigated land, though, as it produces considerable straw, irrigation should be used rather sparingly. Among the winter wheats, Turkey Red and Kharkof, are the best for the area. If soil conditions are right, fall seeding can be done from the first part of September to the middle or even the latter part of October.

Among the various barleys grown, Hanna No. 24 has proved a good two-rowed variety. Of corn varieties so far tested, Minnesota No. 13 has been the best. For land which for any reason can not be seeded in early spring, proso is a good, quick-maturing catch crop which may be planted as late as June 5 to 15.

Potatoes should be given a place on every farm. A number of varieties are now grown on the project. Among them the Early Rose, the Early Ohio, and the Blue-Pitted varieties seem to be among the best. The quality of potatoes raised on the project is good and the crop should be given considerable emphasis.

ALFALFA AND GRASS CROPS.

In favorable situations on the project hay can be made from the native grasses, but as the land is settled the supply from this source will decrease and the increased demand for hay will need to be met by cultivated hay crops. Of the possible hay crops alfalfa appears to be the most promising. Very little has yet been done on the project in the way of alfalfa production. It has been shown, however, that alfalfa is a success on the lighter soil types under irrigation. It is doubtful if it would succeed on the heavy upland gumbo without irrigation, or even with irrigation unless the subsoil is somewhat open. Alfalfa is a deep-rooted plant, and on much of the heavier Belle Fourche land the subsoil is undecomposed shale, which often contains enough alkali to prevent the growth of alfalfa. It seems likely that western wheat-grass is better adapted to the heavy soils, especially in the lower places that receive the run-off from the surrounding slopes. These low-lying lands are not well suited to alfalfa, while wheat-grass does well on them. Some of this grass is being tried at the experiment farm, but it is yet too soon to know how it will succeed under artificial seeding.

SPECIAL POINTS ON ALFALFA GROWING.

It would not be advisable for the new farmer without previous experience to seed a large area of alfalfa. It should be planted on land that has been under cultivation for a year or two at least. When young, alfalfa is delicate and requires very favorable conditions, though when once well established it becomes very hardy. It should be seeded during May, at the rate of about 8 to 10 pounds of seed per acre, without a nurse crop, and the moisture in the soil up to the time of seeding should be conserved by thorough tillage. Alfalfa should be seeded with a grain drill, if possible, to a depth of 1 to $1\frac{1}{2}$ inches, and it can be harrowed lightly after it is several inches high if the conditions of rainfall and soil require it. Under irrigation it can be seeded more heavily—12 to 15 pounds of seed to the acre—and, if desired, with a nurse crop of wheat or oats.

Some alfalfa seed is raised in the area, and if this is clean and sound it will pay to use it in preference to any other. If no local seed is available, care should be used to get seed of hardy northern-grown strains. Alfalfa fields may be greatly improved by surface cultivation in the spring, which not only hastens the early growth but postpones the time when the first irrigation is necessary. It may even be possible, if the season is favorable, to delay irrigation until just before the first crop is ready to cut. It is important that alfalfa be irrigated just before cutting rather than soon after. Alfalfa fields are often badly injured by scalding when irrigated just after a crop is removed, and much moisture is also unnecessarily lost before the plants become tall enough to shade the ground. When irrigated before cutting, the young shoots will begin growth while the crop is being removed and the second crop will make a quicker growth.

TREE PLANTING FOR WINDBREAKS.

Tree planting should be one of the first things undertaken by the plains farmer, so that windbreaks may be established as soon as possible. The proper preparation of the land for this purpose is an important requirement. An attempt to start trees by breaking a few furrows of sod and giving no subsequent cultivation is likely to prove unsatisfactory. Under this treatment some of the trees may start, but more of them are bound to die for want of moisture. If the land to be planted to trees has previously been under cultivation it should be plowed as deeply as possible in the fall and left rough until spring, when it should be thoroughly disked and harrowed before planting. New land should be broken in the early summer, replowed deep after the spring rains, and then disked and harrowed until the sod is in good tilth. Harrowing should be continued during the remainder of the summer to provide a good dust mulch.

Some of the best trees to use for windbreaks are green ash, cottonwood, white elm, white willow, Russian golden willow, Russian oleaster, honey locust, Scotch pine, Black Hills spruce, and red cedar. The willows, the cottonwood, and the Black Hills spruce should be planted in moist situations.

If weather conditions are favorable, planting should be done during April and the first part of May. The rows should be at least 24 feet apart. On dry land 30 feet would be better, while on irrigated land the rows may be as close as 16 feet. The trees should be planted 6 to 8 feet apart in the rows and in such manner as to allow cross cultivation. Cultivation is an absolute necessity, and as soon as the trees are set out the cultivator or drag should be started and a deep dust mulch maintained during the summer months. On heavy gumbo soil deep cultivation must be practiced so as to keep the ground from crusting beneath the mulch. An absolutely clean fallow must be maintained all summer until the trees shade the ground enough to keep out the weeds and grass.

APPLES.

Some of the hardier varieties of apples will do very well in this region. To start an orchard, the land must be well prepared and the trees given plenty of room—not closer than 33 feet each way. Deep and absolutely clean cultivation should be maintained all summer. Yearling and 2-year-old trees are the best to plant. The following varieties are suggested as being likely to do well: Yellow Transparent, Oldenburg, Wealthy, Pewaukee, Peerless, Milwaukee, and Malinda. Crab apples: Florence and Whitney.

SMALL FRUITS.

Small fruits can be readily grown in this section. The land must be well prepared before and thoroughly cultivated after planting. For currants, gooseberries, and raspberries the rows should be 6 feet apart and the plants 3 to 4 feet apart in the row. For strawberries the rows should be 4 feet apart and the plants 18 to 24 inches apart in the row.

The following varieties are suggested as being adapted to the region:

Gooseberries. Downing and Houghton; raspberries, Sunbeam (red) and Cumberland (black); strawberries, Dunlap and Warfield; currants, Fay and Wilder.

During the winter currants, gooseberries, and raspberries should be laid down and covered for better protection from extreme cold.

GARDENING.

All vegetables of the northern latitudes can be grown successfully on the project. Where irrigation is used, water should be applied in the fall and the land plowed deep and left rough during the winter. In the spring it should be double-disked and harrowed until in the best of tilth. On dry land it is best to have the garden follow summer fallow. While this, of course, requires twice as much land, it will be found to pay in the long run. The land to be summer-fallowed might be plowed in the spring or fall before, but it must be given clean cultivation all summer so as to save all available moisture for the next year's garden. It will be found much easier to take care of a garden if the rows are planted 3½ to 4 feet apart, so that the horse cultivator may be used. As in all other cases, deep and clean cultivation must be practiced.

CONTROLLING THE SOIL MOISTURE.

One of the most important physical factors in agriculture and one which is to some extent within the farmer's control is the soil moisture. Its proper use and conservation should always be kept in mind whether the land is to be dry-farmed or irrigated. Irrigation insures moisture at the time it is needed, but irrigation is often seriously overdone. At least one irrigation can often be dispensed with to the very great advantage of the crop by proper tillage in the spring to hold the moisture already in the ground at the time of seeding. Grain after it is well up can safely be harrowed with an ordinary steel harrow with the teeth slanting well back. Harrowing of grain after a rain loosens the soil surface, checks evaporation, and hastens the warming of the soil, which is necessary to plant growth.

By proper tillage both before and after seeding it seems highly probable that grain can be matured ordinarily with but one irrigation during the season. If grain has been planted deep with a grain drill it can be harrowed, even when 5 to 6 inches high, without serious injury. It is always inadvisable to irrigate grain crops early in the season unless it is absolutely necessary, and there will generally be enough moisture in the ground to give the plants a good start if the spring moisture is properly conserved. Early irrigation, especially if carried on by the flooding system, will leave the surface of the ground in a hard, crusted condition, which permits the rapid escape of moisture from the ground and keeps the soil cold.

METHODS OF IRRIGATION.

The Reclamation Service expects to deliver, if required, about 24 acre-inches of water during the season, but it would be harmful both to crops and to soil should the farmers actually apply so much water to their crops in addition to the rainfall. A wheat-grass meadow might tolerate that quantity, but no other crop excepting possibly alfalfa with good underground drainage should be given so much water. Lands susceptible to the accumulation of alkali would be seriously damaged by the excessive use of water.

It is probable that for some time the flood method of irrigation will be more generally used in the area than any other. Owing, however, to the close texture and heaviness of so much of the soil, the furrow method would undoubtedly be the better one to use so far as the effect on the soil surface is concerned. If the land surface is fairly smooth the field can be furrowed at a reasonably small expense.

A satisfactory furrowing implement can be made by fastening together several pieces of 4 by 6 inch or 6 by 6 inch timbers, parallel to each other, about 18 or 24 inches apart, with the sharp corners down. When drawn over the field this will leave small V-shaped furrows several inches deep in which the water will flow quite readily for some distance. This method of irrigation has the advantage of the flooding method in that it leaves the soil surface between the furrows comparatively dry, and this dry surface acts as a mulch, preventing the rapid loss of the moisture which would follow flooding. Land thus furrowed can be irrigated more quickly and less water is necessary than when the flood method is used. As the work of applying water to the land is the most expensive item in irrigation the most economical method should be used.

Wherever possible, land should be thoroughly irrigated in the fall to insure a good supply of soil moisture for the growth of the crop the following spring. Where this is done there should be no difficulty in getting the crop far advanced the next season before irrigation is necessary. While newly broken sod land can not be put into good condition for irrigation the first summer, it might nevertheless be irrigated after midsummer and seeded to winter wheat.

MANURING.

An important factor which should be kept in mind by the farmer who has heavy soil, such as gumbo, is the need of getting organic matter into the soil. All available barnyard manure should be used on heavy land, even though the land is new. The plowing under of green crops will also loosen up the soil, making it more congenial to plants and easier to cultivate. In general, the best time to apply manure is in the fall, and when practicable it should be plowed under at that time.

THE BELLE FOURCHE EXPERIMENT FARM.

An experiment farm has been established on the project, about 2 miles northwest of Newell, S. Dak., where experiments are carried on for the solution of problems pertaining to the area. Part of it will be under irrigation when water is available, and part of it is now being used for experiments in dry-land agriculture. Any information which can be supplied by the station will be cheerfully furnished.

PUBLICATIONS OF VALUE TO FARMERS ON THE BELLE FOURCHE PROJECT.

The following publications of the Department of Agriculture and of the South Dakota Agricultural Experiment Station will prove of value to settlers on the Belle Fourche Irrigation Project.

UNITED STATES DEPARTMENT OF AGRICULTURE.

The publications of the Department of Agriculture may be obtained without cost upon application to the Secretary of Agriculture, Washington, D. C. The editions of some of these publications are necessarily limited, and when the supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, who has them for sale at nominal prices.

In ordering give the classification under which the bulletin appears, as well as the number and title; thus, Farmers' Bulletin 138, "Irrigation in Field and Garden."

BULLETINS, BUREAU OF PLANT INDUSTRY.

No. 130. Dry-Land Agriculture.
182. Ten Years' Experience with the Swedish Select Oat.
187. A Study of Cultivation Methods and Crop Rotation for the Great Plains Area.
188. Dry Farming in Relation to Rainfall and Evaporation.
196. Breeding Drought-Resistant Forage Plants for the Great Plains Area.
203. The Importance and Improvement of the Grain Sorghums.

CIRCULARS, BUREAU OF PLANT INDUSTRY.

5. Barley Culture in the Northern Great Plains.
12. Dry-Land Grains.
24. Alfalfa in Cultivated Rows for Seed Production in Semiarid Regions.
59. Dry-Land Grains for Western North and South Dakota.

REPRINTS FROM YEARBOOK.

No. 195. Successful Wheat Growing in Semiarid Districts.
393. The Relation of Irrigation to Dry Farming.
458. The Use of Small Water Supplies for Irrigation.
461. Dry-Land Farming in the Great Plains Area.
495. Soil Mulches for Checking Evaporation.
505. The Problems of an Irrigation Farmer.

FARMERS' BULLETINS.

138. Irrigation in Field and Garden.
139. Emmer: A Grain for the Semiarid Regions.
158. How to Build Small Irrigation Ditches.
263. Practical Information for Beginners in Irrigation.
322. Milo as a Dry-Land Grain Crop.
371. Drainage of Irrigated Lands.
373. Irrigation of Alfalfa.
382. The Adulteration of Forage-Plant Seeds.
386. Potato Culture on Irrigated Farms of the West.
395. Sixty-Day and Kherson Oats.
399. Irrigation of Grain.
404. Irrigation of Orchards.
448. Better Grain-Sorghum Crops.

SOUTH DAKOTA AGRICULTURAL EXPERIMENT STATION BULLETINS.

The bulletins of the South Dakota Agricultural Experiment Station may be obtained by writing to the Director at Brookings, S. Dak.

No. 101. Forage Plants.
102. Evergreens for South Dakota.
104. Raspberries, Blackberries, and Dewberries.
110. Progress in Variety Test of Oats.
112. The Killing of Mustard and Other Noxious Weeds in Grain Fields by the Use of Iron Sulphate.
118. Corn.
119. Fattening Lambs.
120. Progress of Variety Test of Alfalfa.
121. Sugar Beets in South Dakota.
122. Creamery Butter.

SUMMARY.

The Belle Fourche Irrigation Project comprises about 90,000 acres in the southwestern part of Butte County, S. Dak. The rolling nature of the ground permits both dry and irrigated farming.

The territory surrounding the project is an open cattle range covered with a sod of native grasses. The soil is generally heavy.

Sod land should be broken late in the spring after the grass has started. Land along the bottoms may be used to advantage for corn and flax on spring breaking, but on the higher lying prairie it is useless to attempt a crop the first year without irrigation.

The growing season is comparatively short. Such crops as wheat, oats, rye, and Canada peas will stand some spring frosts and may be planted from the first to the middle of April.

A few varieties of grains have shown themselves sufficiently well adapted to be recommended. The Kubanka durum wheat is well suited to the dry lands, while Fife and Bluestem should have the preference on irrigated land. Kherson, Sixty-Day, and Swedish Select oats are the best known so far. Among winter wheats, Turkey Red and Kharkof are the best.

Fall seeding can be done from the first of September to the middle or last of October.

Among barleys, Hanna No. 24 has proved a good two-rowed variety. Of corn varieties tested, Minnesota No. 13 has been the best. Proso is a quick-maturing catch crop that may be planted as late as June 5 to 15.

A number of varieties of potatoes are grown, and this crop should have a place on every farm.

Little has been done on the project in the way of alfalfa production, but it has been shown that it is the most promising hay crop. Western wheat-grass probably is better adapted to the heavy soils. Alfalfa should be seeded during May. It is not advisable without previous experience to seed a large area of alfalfa. Alfalfa should be planted on land that has been under cultivation for a year or two, and care should be taken to obtain seed of hardy northern-grown strains.

For windbreaks the best trees are the green ash, cottonwood, white elm, white willow, Russian oleaster, honey locust, Russian golden willow, Scotch pine, Black Hills spruce, and red cedar. Cultivation of young trees is an absolute necessity.

Some of the hardier varieties of apples, such as Yellow Transparent, Oldenburg, Wealthy, Pewaukee, Peerless, Milwaukee, and Malinda, are likely to do well; of crab apples, the Florence and the Whitney are suggested.

Small fruits can be readily grown in this section, as can also all vegetables of the northern latitudes.

Soil moisture is an important physical factor within the control of the farmer. Irrigation is often overdone. At least one irrigation can often be dispensed with to great advantage. By proper tillage before and after seeding it is probable that grain may be matured with but one irrigation. Whenever possible, land should be irrigated thoroughly in the fall.

The heavy soils need organic matter, and all barnyard manure should be used. Manure should be applied in the fall and plowed under at the same time. The plowing under of green crops will also loosen up the soil.

An experiment farm has been established on the project for the purpose of carrying on experiments with problems pertaining to the area, and information that can be supplied will be cheerfully furnished.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *June 12, 1911.*

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 84.

B. T. GALLOWAY, Chief of Bureau.

SUGGESTED CROPPING SYSTEMS FOR THE BLACK LANDS OF TEXAS.

BY

B. YOUNGBLOOD,

Assistant Agriculturist, Office of Farm Management.

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BUREAU OF PLANT INDUSTRY.

B. P. I.–688.

SUGGESTED CROPPING SYSTEMS FOR THE BLACK LANDS OF TEXAS

INTRODUCTION.

The black-land region of Texas is one of the most productive and best developed agricultural sections of the Southwest, yet it presents some of the most difficult problems to be found in this country. The older portions have passed through a period of exploitive farming, during which cotton and grain were grown to the exclusion of crops which might have exerted a beneficial effect upon the soil. As in all rich, new sections, no effort was put forth to maintain fertility, because it was thought that the productiveness of the black heavy soils was practically inexhaustible. Eventually a marked decline was noted in the yields of all crops, and as land values rose [1]—owing to the increase in population—the conditions became such that only the most skillfully operated farms could be made to pay reasonable wages for labor performed and interest on the investment in land and equipment.

The main problem, therefore, and the one deserving immediate attention, is that of improving the soils and maintaining the farms in a high state of productiveness. This is made difficult by the prevalence of the disease known as root-rot (*Ozonium omniverum*), which attacks and materially injures crops, especially cotton and the legumes.

Cotton, the chief source of income, is damaged by this fungus to the extent of several millions of dollars annually.

The legumes have been grown only to a very limited extent, as there was not the same incentive during this period of exploitation to cultivate them against the attacks of the root-rot that there was in the case of cotton. Consequently, a system of farming developed on most farms in which legumes had no part. On the few farms where legumes are found, cowpeas and alfalfa are the most common. Cowpeas, however, are nearly always badly damaged by root-rot, while alfalfa is usually attacked the second or third year,[2] making

[1] During the last 40 years the price of black land has gradually risen from a few dollars to from \$50 to \$200 per acre, depending upon its desirability for farming purposes and its location.

[2] On the uplands southwest of Williamson County it is doubtful whether alfalfa should be included at all on account of the severe effects of root-rot; but on the alluvial bottom lands it is grown with profit. Its cultivation west of San Antonio depends largely on irrigation, a subject not discussed in this bulletin.

it necessary to plow up the field and plant to some crop not affected by this disease.

The general knowledge of the beneficial effect of leguminous crops on the land, strengthened by the local experience of increased yields resulting from turning under alfalfa, led to investigations which had for their object the control or extermination of root-rot, so that it might be possible to grow the legumes and establish types of farming which would restore the productiveness of the soil.

The first of these investigations, which have been continued to the present time, was undertaken about nine years ago by Dr. C. L. Shear, of this Bureau, and his assistant, Mr. George F. Miles. Though they tried every available means of eliminating root-rot without

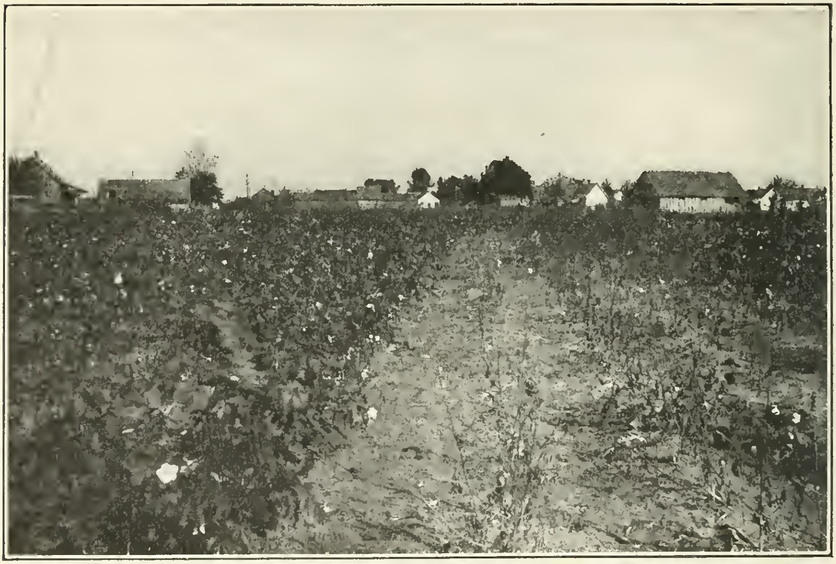

FIG. 1.—Experimental plats of cotton at Petty, Tex., showing the results of deep fall plowing. Plat A, at the left, was plowed 7 to 9 inches deep on November 12, 1906. Only 26.79 per cent of those plants were dead on November 11, 1907, and most of these had matured their crop. Plat B, at the right, received ordinary spring plowing. Of these plants, 69.54 per cent were dead on November 11, 1907, and these had died so early that they matured but a small part of their crop.

success, they found that deep fall plowing (fig. 1), applications of barnyard manure, and the rotation of grain crops with cotton in a large measure controlled the disease.

These facts, together with knowledge of certain farm practices which developed of necessity under root-rot conditions, furnish a basis for the establishment of rotations in which the well-known crops of this region follow each other naturally. For example, being compelled to plow up his alfalfa, the farmer follows it with grain, usually corn or wheat. He knows from experience that cotton would not succeed, for the reason that it is just as susceptible to root-rot as alfalfa. This fact suggests at once a rotation of alfalfa, grain crops, and cotton, so arranged as to alternate susceptible crops with those which appear to be immune.

This work has also shown the need of a greater variety of legumes which may be used under root-rot conditions. For this reason an extensive test of varieties is being made in cooperation with farmers in the black-land region.

DESCRIPTION OF THE BLACK-LAND REGION.

The black-land region comprises two parallel belts and numerous isolated areas of level to rolling prairie, aggregating between 13,000,000

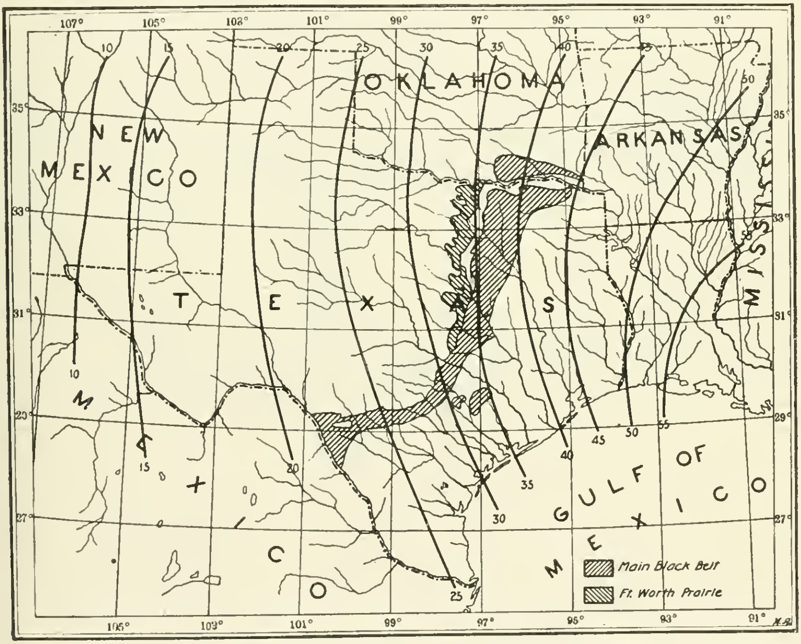

FIG. 2.—Location of the black lands, showing the average annual distribution of rainfall in the Southwest (based upon records of the United States Weather Bureau covering the period from 1871 to 1908, inclusive).

and 14,000,000 acres. The main black-land belt extends from the southern part of Oklahoma in a southwesterly direction across Texas. (Fig. 2.) It is about 550 miles long and varies in width from about 65 miles in northern Texas to about 25 miles in southwestern Texas. West of the main belt lies the Fort Worth prairie, an irregularly shaped, narrow belt extending from Red River to the vicinity of Round Rock, Tex. It is about 240 miles long and varies from 5 to 25 miles in width. The two belts are separated from Red River to the vicinity of Waco, Tex., by a narrow strip of sandy timbered country known as the east, or lower, cross timbers. Southwest of Waco the two areas lie contiguous and dovetail into each other.

Isolated areas, varying from a few acres to many sections in extent, are found west of the Fort Worth prairie in Somervell, Erath, Bosque, Comanche, Brown, Hamilton, Mills, Coryell, Lampasas, Bell, Burnet, Llano, and other western counties.

CLIMATE.

The climate is typically southern. The summers are long and hot, while the winters are mild, with the exception of a few "northers," which, because of their sudden appearance, are rather severe. The

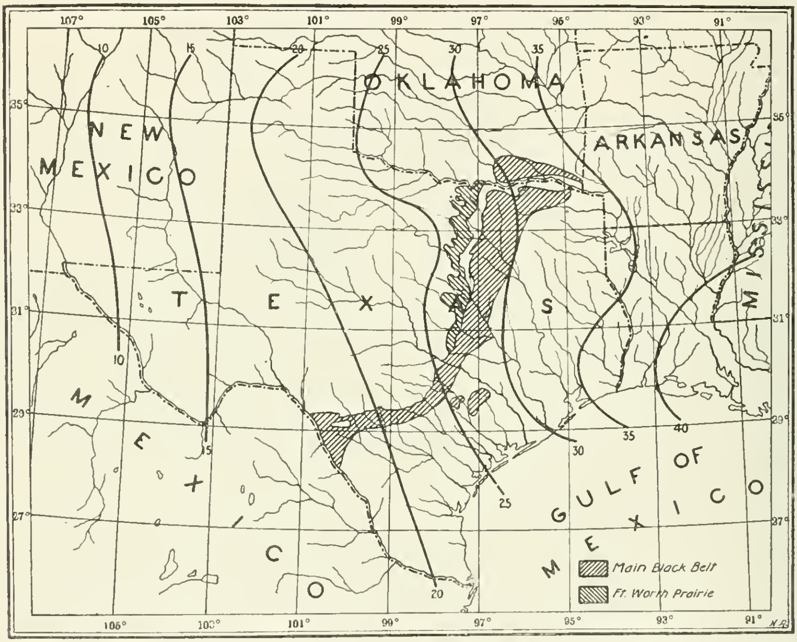

FIG. 3.—Location of the black lands, showing the precipitation during the crop-growing season (based upon records of the United States Weather Bureau covering the period from 1871 to 1908, inclusive).

belt extends from the humid region of northeastern Texas to the arid region in old Mexico. Wind velocities increase from an annual hourly velocity of 7 or 8 miles in the northeastern to 10 or 12 miles per hour at the southwestern end of the belt. The mean annual temperature at Paris, in the northeast, is 64° F.; at San Antonio, in the southwest, 69° F.

The usual crop-growing season extends from about February 1 to October 31, depending upon the latitude.

A close study of figures 2, 3, and 4 will greatly facilitate an understanding of farm problems in various parts of the black-land belt. It must be kept in mind, however, that a given amount of rainfall in the Southwest is not as efficient in crop production as the same amount in the Central West or in the Eastern States, owing to the greater evaporation in the Southwest.

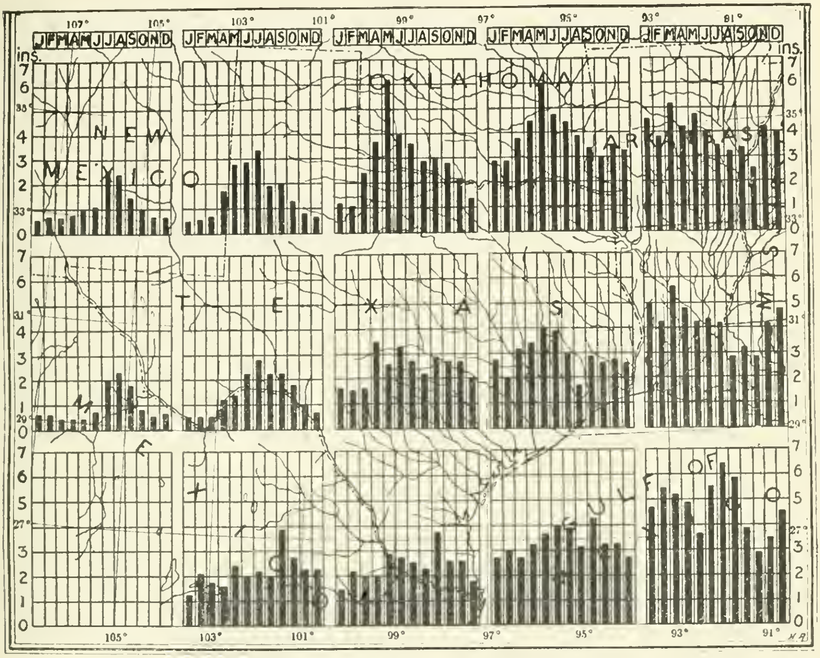

FIG. 4.—Graphical representation of the distribution of the average precipitation during the several months of the year in the Southwest at selected areas extending westward from the eastern to the western limits of the black-land region. The line of diagrams at the top of the figure shows the distribution over the territory extending west from the vicinity of Memphis, Tenn., through Little Rock, Ark., the vicinity of Oklahoma City, Okla., Amarillo, Tex., to Santa Fe, N. Mex. The middle line of diagrams shows the distribution over the territory extending west from the vicinity of Vicksburg, Miss., through Shreveport, La., and Fort Worth, Blanco, and El Paso, Tex. The bottom line of diagrams shows the distribution over the territory along the Gulf coast extending from the vicinity of New Orleans, La., through Galveston and Corpus Christi to Brownsville, Tex. (Data compiled by the United States Weather Bureau.)

The following dates showing the extreme and average occurrence of killing frosts (first in autumn and last in spring) in this region are compiled from the records of the United States Weather Bureau:

TABLE I.—*Extreme and average dates of killing frosts in the black-land region of Texas.*

Station and relative location in the region.	Average date.		Extreme date.	
	First in autumn.	Last in spring.	First in autumn.	Last in spring.
Paris (northern part)	Nov. 15	Mar. 28	Nov. 3	Apr. 12
Dallas (farther southwest)	...do.....	Mar. 26	...do.....	May 1
Waco (central part)	Nov. 10	Mar. 16	...do.....	Apr. 5
San Antonio (southwestern part)	Nov. 30	Feb. 25	Nov. 9	Mar. 19

SOILS.

The types of soil of the main black belt are derived from the underlying soft, chalky, or marly limestones, while those of the Fort Worth prairie and the more western isolated areas are derived from a harder and more impervious limestone which obviously is nearer the surface and more to be reckoned with in crop production than the soft limestone, which is more or less penetrable by water and the roots of plants. These soils are referred to as "black land," "black wax," "black waxy," "tallow ridge," "black prairie," "limestone," or "black sticky."

In their virgin state the black-land soils usually contain ample quantities of nitrogen, phosphoric acid, potash, lime, and organic matter, but after a few years of cultivation to grain and cotton the humus content becomes deficient and the soil assumes a poor physical condition, favoring the development of cotton root-rot and causing crops to suffer quickly from drought. The phosphoric-acid content becomes low in the loamy types of soil and the potash low in the stiff, black clays. Yet attempts to replenish these elements by the use of commercial fertilizers have resulted unsatisfactorily. The best results have been obtained from the use of barnyard manure and the plowing under of cowpeas and alfalfa. These experiences suggest that the immediate need of the black lands is organic matter. Formerly an abundance of lime was present in these soils, but now, owing to the cropping systems used, it has been found that applications of lime may profitably be made as a means of improving the physical condition of the heavier soils.

That the black-land soils are durable is very evident. The writer has visited a number of fields which have been cultivated continuously for 40 to 60 years and found them still producing fair crops of small grain, corn, and cotton. Compared with newer fields, however, a decline in the yields of these crops is perceptible. Abandoned farms in this region are rare.

HISTORICAL SKETCH OF THE BLACK-LAND REGION.

The occupation of Texas by white men began in 1820; but the black lands were utilized chiefly for hunting until along in the thirties. Farming began along the streams and in the sandy timbered region of east Texas, and the black lands were devoted chiefly to grazing until railroads were built and modern implements and barbed wire came into use. Their fertility, however, was recognized by some as early as the forties, and here and there a farm was opened upon which crops of corn, wheat, rye, and oats were grown. On the loams near the timber and on the alluvial soils along the streams crops of Irish and sweet potatoes were grown.

Though some cotton was produced in the black-land counties in the forties and fifties, it did not become an important crop until along in the sixties. Since then it has been the chief money crop, and the acreage has steadily increased. While it is more susceptible to root-rot than legumes, it has been successfully grown by shifting it from place to place on the farm. It is planted either in uninfested fields or after such crops as corn, wheat, or oats, which have been shown by experience to be immune to this disease. One farm was found upon which a definite 3-year mixed rotation, including wheat, oats, milo, corn, sorghum, and cotton, has been maintained for a third of a century. During this time no material loss has been sustained from root-rot, though it is present in all the fields.

Legumes have been grown to only a limited extent on the black soils. Census statistics show that though cowpeas have been grown to a limited extent in the black-land counties no material increase in their acreage has occurred since 1849. The acreage devoted to alfalfa is not large, because it does not have the permanency as a meadow that it assumes in other sections. It thrives usually from two to five years, then begins to die out in spots as a result of root-rot, and soon becomes unprofitable. Cowpeas and alfalfa being practically the only leguminous crops with which the farmers were familiar, they came to the erroneous conclusion that this class of crops could not be profitably grown, with the result that the legumes are by no means as extensively grown as their well-known value for grazing, hay, and soil-improvement purposes in other sections would seem to justify.

ROOT-ROT IN THE BLACK-LAND REGION.

The Texas root-rot is a fungous disease which attacks the roots of cotton, fruit trees, sweet and white potatoes, and, so far as known, all leguminous crops and many other cultivated plants. The grains and grasses are not affected by it. Apparently, its most favorable habitat is the heavy, black, waxy soils, especially those in poor physical condition. It is most conspicuous in fields that have been planted to cotton continuously or devoted to alfalfa for some time. It apparently becomes more destructive in its effects as the arid region is approached. That not all fields are infested with it is evident from the fact that here and there we find cotton fields and alfalfa meadows which show no signs of the disease. An alfalfa meadow on the stiff black upland, near Howe, Tex., said to be 11 years old, is still in perfect condition.

The disease is seldom found established in all the fields of any given farm. Usually it does not affect a cotton crop planted in a field which has been devoted to grain for two or three years immediately preceding, but there is always the possibility of its reappearing at any time. How it spreads is not well known, but it is thought that it is carried from infested fields by winds, water, and farm implements.

Though there is no known method of exterminating this disease, its evil effects may be practically overcome by a proper rotation of crops, deep fall plowing, and the incorporation of organic matter into the soil, all of which are highly desirable practices for any black-land farm.[1]

SUITABLE ROTATIONS.

Few, if any, satisfactory rotations are practiced in the black lands of Texas. The uncertainty of the rainfall is a factor which often forces the farmer planning to practice a given rotation to quickly change his plans—as, for instance, when the land is prepared for alfalfa which, for lack of moisture, can not be sown. The farmer can not afford to let the land lie idle, so he substitutes some other crop which can be planted later in the season. Another reason why rotations are not more generally followed is the prevalence of root-rot.

The fact, however, that the farmer can not follow a rotation with the regularity of clockwork does not necessarily imply that he should not follow any rotation. On the contrary, he should plan a rotation that will improve the fertility of his soil, reduce root-rot, and otherwise satisfy his needs; but he should make it so flexible that it may be modified from time to time, as the conditions warrant, without detracting from the purposes which it is intended to accomplish.

THE BURNS ROTATION.

The most notable example that has come under the observation of the writer, illustrating how the agriculture of this region has developed without legumes, is found in the cropping system practiced by Mr. James Burns, of San Saba, Tex.

A definite rotation in which there is a total absence of legumes is rather unusual, if not altogether unique, in the history of southwestern agriculture. It becomes still more exceptional if it has been followed systematically for a long series of years; yet such a rotation has been practiced on one of the black-land farms whose history the writer has studied.

Thirty-two years ago this farm was divided into three equal fields (fig. 5) and the following 3-year mixed rotation was established, which has been maintained with consistency to the present time:

[1] Shear, C. L., and Miles, G. F. Texas Root-Rot of Cotton: Field Experiments in 1907. Circular 9, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1908.

TABLE 11.—*The 3-year mixed rotation in use on the Burns farm.*

30-acre tracts.	1908.	1909.	1910.
Field 1	Wheat 20 acres. Oats 10 acres.	Cotton 30 acres.	Corn 10 acres. Milo 10 acres. Sorghum 10 acres.
Field 2	Cotton 30 acres.	Corn 10 acres. Milo 10 acres. Sorghum 10 acres.	Wheat 20 acres. Oats 10 acres.
Field 3	Corn 10 acres. Milo 10 acres. Sorghum 10 acres.	Wheat 20 acres. Oats 10 acres.	Cotton 30 acres.

On this farm are kept 30 to 40 head of high-grade Shorthorn cattle, 10 to 15 Duroc-Jersey hogs, and 100 to 200 chickens. As soon as the crops are harvested the stock are turned in to glean the fields. The wheat and oats are grazed until about March 1, when

FIG. 5.—Bird's-eye view of the three fields on the Burns farm, where a 3-year mixed rotation has been in operation for 32 years.

the stock are taken off and the grain allowed to mature. In this manner everything produced is saved and sufficient manure has been added to the soil to maintain its fertility.

Owing to the limited rainfall, everything possible is done to conserve moisture.[1] After being broken as early as practicable in fall and winter the ground is kept stirred until planting time by the use of a disk and a steel-toothed harrow. All crops except wheat and oats are planted in rows and at rates of seeding which give stands about three-fourths as thick on the ground as is customary

[1] The records of the weather station located on this farm show that the annual rainfall for the period from 1901 to 1910, inclusive, has averaged 24.6 inches.

in a humid climate. Shallow cultivation (2 to 4 inches) is given as often as is necessary to maintain a mulch and keep down the grass and weeds throughout the growing period of the crops.

This rotation has enabled the owner to produce cotton with practically no loss from root-rot (though it is present in all his fields) and to produce sufficient crops from year to year, regardless of droughts, to meet his needs. He has so managed that it has not been necessary to buy hay, grain, lard, or bacon, and his cash income has been sufficient to meet all obligations incident to providing for and educating a family of 18 children.

The chief defect in his rotation is the absence of legumes. None have been used because in his early experience the owner was unsuccessful in growing cowpeas and other legumes which are commonly found in rotations, and he decided that it was useless to make further attempts. However, in contrast to most black-land farms, the need for legumes was met by a rigid rotation, including forage crops and the maintenance of enough stock to convert the roughage produced into manure, which was returned to the land. In this way the productiveness of the soil was maintained, while under the prevailing types of farming it gradually falls. In a later paragraph it will be shown that the owner of this farm is now testing several legumes which he plans to use in improving his cropping system.

ALFALFA IN SHORT ROTATION.[1]

The fact that alfalfa is naturally adapted to the black soils when unaffected by root-rot and that even when root-rot is present it remains one of the most profitable crops of the region for two or more years (fig. 6) led up to the idea that alfalfa could be grown profitably in short rotations with other crops. This was actually being done in a rather indifferent way by farmers who had been forced to plow up their alfalfa and follow with grain. In thus compelling farmers to plow up their meadows in two to five years root-rot in one respect has served a useful purpose. After the alfalfa has yielded hay in abundance for three or four years, they have followed it with corn, cotton, wheat, and oats and secured increased yields varying from 50 to more than 200 per cent.

On similar soils in the black belt of Alabama, William Munford planted alfalfa on land that produced an average of not over 18 bushels of corn per acre. When the meadow was two years old he plowed up and planted a part of it to corn, which yielded 45 bushels per acre, an increase of 150 per cent. Another portion of the same field was allowed to remain in alfalfa three years and then planted

[1] It should be noted that alfalfa to be successful, here as elsewhere, must be planted on land that is fairly rich in humus. The most successful farmers either give the land a good dressing of stable manure before planting or turn under a green crop of some kind.

to corn, which yielded 55 bushels per acre, an increase of 205.5 per cent.[1]

Many of the farmers visited know from experience that the fertility of the soil is better conserved if a new meadow is planted in another field whenever it becomes necessary to plow up the old one because of root-rot, but there was some confusion as to how to plan a rotation including alfalfa.

In order to make it perfectly plain to everyone, a suggested plan, based on successful practice in use on various black-land farms, is outlined in figure 7, showing how a 160-acre farm, 120 acres of

FIG. 6.—Cows grazing on an alfalfa meadow 5 years old near Cleburne, Tex. Root-rot is gradually reducing the size of the meadow.

which are in cultivation and divided into four 30-acre fields, would appear each year for a period of 12 years. This plan may be modified for any given farm as conditions justify without lessening its value.

It will be observed that the alfalfa remains 3 years [2] in each of the 4-year periods, and in the meantime a 3-year rotation of cotton or wheat, corn, and oats is in operation on the other three fields. For convenience wheat or oats occupy each field the year previous to its being planted to alfalfa or, if the soil is poor, cowpeas may be used in preference to either wheat or oats. In this rotation ample opportunity is afforded for controlling root-rot, as resistant crops occupy the land from two to three years between the alfalfa and the cotton.

[1] See "A Successful Alabama Diversification Farm," Farmers' Bulletin 310, U. S. Dept. of Agriculture, 1907.

[2] In cases where alfalfa is destroyed before the third year a short rotation of alfalfa, corn, cotton, and small grain may be used.

Where root-rot is exceptionally destructive, leguminous catch crops such as cowpeas and soy beans should be left out of the rotation until the disease is checked, but where it appears only on a plant here

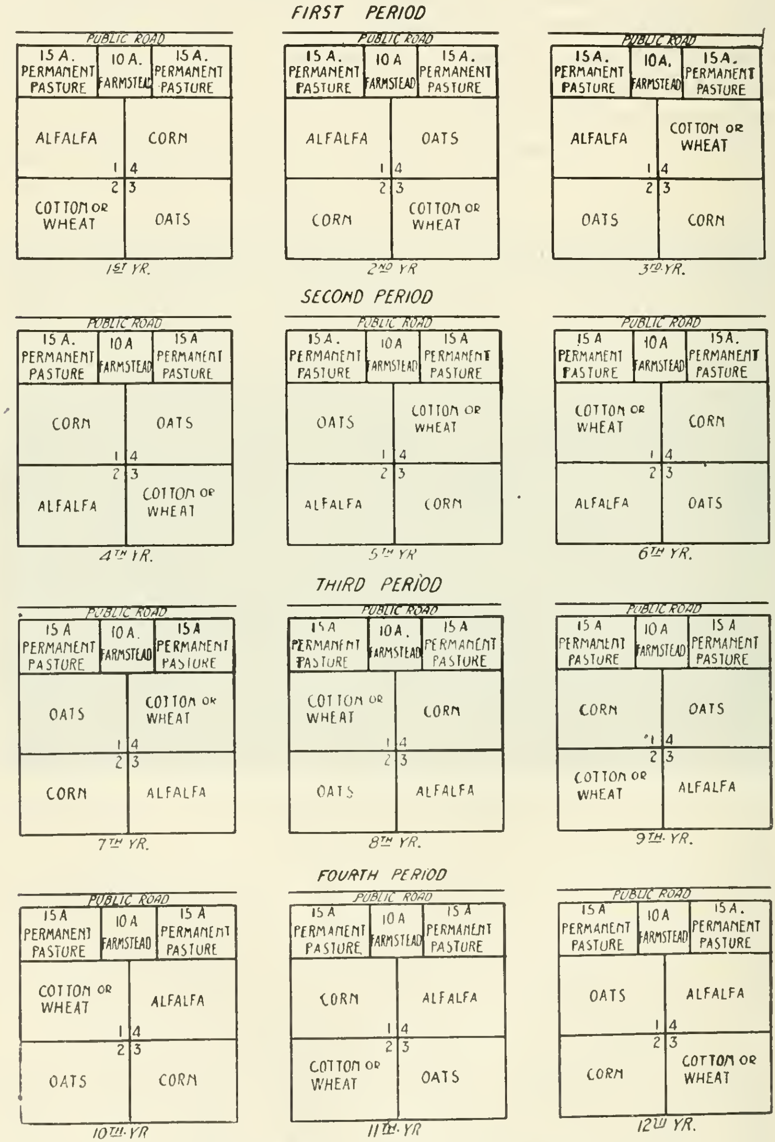

FIG. 7.—Appearance each year for 12 years of a 160-acre farm, 120 acres of which are devoted to four crops of 30 acres each, in rotation, viz, alfalfa, cotton or wheat, oats, and corn.

and there its effects will be more than compensated for by the benefits derived from these crops.

LEGUMES NOW BEING TESTED.

In 1909, owing to the general interest manifested in the establishment of better cropping systems, it was determined to find if possible whether or not legumes other than those heretofore tested could be used for the production of hay and green manure in rotation with the crops already established.

As up to this time Whippoorwill cowpeas were the only crop of this kind that had been tried to any considerable extent, it was thought that possibly some suitable varieties might be found among the many already in use in other sections or among those that had been introduced from other countries. To determine this question, the cooperation of the Office of Forage-Crop Investigations was enlisted, and a test of all available varieties of annual legumes was begun in the spring of 1910. Public-spirited farmers in various parts of the area entered heartily into the scheme and freely gave the use of their land and services to help solve this problem. Seed of about 25 varieties was obtained and distributed to 16 farmers to be planted and grown under the immediate direction of the writer.

From the beginning the farmers maintained an eager interest in the work, and so pleased were they with the results of last season's experiments that they have determined to incorporate some of the most promising varieties into their regular cropping systems. Though none of the legumes proved to be immune to root-rot, some of them were so slightly affected by it that their value for forage and as soil builders was hardly impaired.[1] Among these were certain varieties of soy beans and cowpeas. Sweet clover, Florida beggarweed, and guar[2] were also used. (Figs. 8, 9, 10, 11, 12, and 13.)

It has been found difficult to obtain a stand of sweet clover in most sections; its introduction should therefore be attended with some caution. Florida beggarweed is a new crop in this region; its introduction should also be attended with some caution.

The results of one season's work are by no means conclusive, but since the tests were made after many years of observation, study, and experience in growing cowpeas and alfalfa on a black-land farm, enough has been learned to show that under ordinary conditions alfalfa and other legumes may be grown for forage and soil-improvement purposes, if they are included in a properly planned rotation.

The tests will be continued until definite conclusions can be drawn as to which of the newly introduced varieties are the most satisfactory, and the conclusions will be published later by the Office of Forage-Crop Investigations. The results already attained indicate quite con-

[1] A single exception to this statement was on J. M. Campbell's farm near Richardson, Tex., where Iron and Brabham cowpeas and Mammoth soy beans were purposely planted on an old alfalfa meadow which had been destroyed by root-rot, the continued presence of the disease in the soil being well known. By the time the crops were ready to be cut for hay, about half of each variety had been destroyed by the disease.

[2] The value of this legume is as yet problematical, and further experiments will be necessary to determine its utility as a green manure or forage crop for this region.

clusively that there are several varieties which can be used in relieving the situation which has so far prevailed in the black-land region.

USE OF LEGUMES IN THE ROTATION.

As an example of how the annual legumes may be used in the cropping systems already established, let us refer again to the rotation in use on the Burns farm. The originator of this rotation was one of the first to begin a test of all available legumes under our direction.

FIG. 8.—Groit cowpeas grown in 1910 near Richardson, Tex., on heavy black-waxy soil. Root-rot was present, but the damage done was very slight.

Finding several that were very promising in so dry a season as 1910, he is giving them field trials in 1911 so that in 1912 he may select for his use those which suit him best and thereafter modify his rotation somewhat, as in Table III.

TABLE III.—*Proposed rotations, showing possible use of legumes in a cropping system.*

Tract.	1912.	1913.	1914.	1915.
Field 1.	Wheat..... 15 acres. Oats...... 7½ acres.	Legumes... 22½ acres.	Corn...... 10 acres. Milo....... 10 acres. Sorghum... 2½ acres.	Cotton...... 22½ acres.
Field 2.	Legumes... 22½ acres.	Corn....... 10 acres. Milo...... 10 acres. Sorghum... 2½ acres.	Cotton..... 22½ acres.	Wheat...... 15 acres. Oats........ 7½ acres.
Field 3.	Corn....... 10 acres. Milo....... 10 acres. Sorghum... 2½ acres.	Cotton..... 22½ acres.	Wheat..... 15 acres. Oats........ 7½ acres.	Legumes.... 22½ acres.
Field 4.	Cotton..... 22½ acres.	Wheat..... 15 acres. Oats....... 7½ acres.	Legumes... 22½ acres.	Corn........ 10 acres. Milo.... ... 10 acres. Sorghum.... 2½ acres.

These changes are expected to produce the money crops—wheat and cotton—on a smaller area, and the increased productiveness of

FIG. 9.—Brabham cowpeas grown near Hutchins, Tex., in 1910, on black land infested with root-rot.

FIG. 10.—Mammoth soy beans grown on black land near Cleburne, Tex., in 1910. They were sown in rows 3 feet apart and cultivated. They received practically no rain from planting to maturity. Root-rot was present, but did little damage.

the soils which it is thought will follow is depended upon to keep a larger number of live stock and thus materially enlarge the income.

In addition to having one field in legumes, as shown in the diagram, it is planned to grow cowpeas and soy beans in alternating rows with

FIG. 11.—Guar 3 to 5 feet high, grown in 1910 near San Saba, Tex., with practically no rain from planting, April 22, to maturity.

FIG. 12.—Sweet clover growing along a railway near Sherman, Tex. It is found growing wild in many places in the black lands between Red River and Temple, Tex.

corn, milo, and sorghum and to plant sweet clover with oats, cutting both for hay in case the clover is large enough when the oats are ready; but in case the sweet clover is too small, the oat crop will be allowed to mature. In either event the sweet clover is expected to grow again and make either a crop of hay or some grazing before fall. After the wheat, such legumes as cowpeas, soy beans, beggarweed, and guar[1] will be planted in rows $2\frac{1}{2}$ to 3 feet apart and so cultivated as to conserve moisture. The rainfall is so limited and uncertain that satisfactory results are seldom obtained from planting broadcast after grain or between the corn rows at the last cultivation.

MODIFICATION OF A ROTATION COMMON IN THE SOUTH.

A rotation tending to maintain fertility, in use in the more humid sections, is (1) corn with cowpeas planted between the rows at the last cultivation, (2) cotton,[2] and (3) oats followed by cowpeas sown broadcast. This rotation, omitting the cowpeas and often with the oats left out, is the one that has prevailed in the black lands from the beginning and that has brought about the decline in the productiveness of the soils. In fact, those who realized the advisability of including legumes in the rotation failed in their efforts to grow them because of the limited and uncertain rainfall more than from any other cause.

FIG. 13.—Florida beggarweed grown on the black land near Hutchins, Tex., in 1910. The plant shown in this figure was more than 7 feet tall. The beggarweed was planted in rows 3 feet apart and cultivated. The plat could have been cut twice for hay. A good crop of seed was produced.

In the last few years, however, many farmers have learned that they can grow cowpeas quite successfully by planting them in alternate rows with corn, or in rows after oats, and cultivating them as frequently as they would corn. Those who have tried this plan are well pleased with the results. They have not only produced a crop of cowpeas, but by planting the corn twice as thick in the row as ordinarily they have secured as good and in most instances better yields of corn than from similar areas of the same type of soil upon which

[1] Guar is mentioned on account of its promise as a soil builder. Its value as a forage crop in this country is doubtful.

[2] In many localities this rotation is modified by transposing the cotton and corn crops.

the corn was planted in the usual manner. Furthermore, in every instance a better quality of corn than the average was reported. With these modifications the rotation, corn and cowpeas, cotton, and oats followed by cowpeas, becomes applicable over the greater part of the black-land region.

SUMMARY.

(1) The farmers of the black-land region of Texas are seeking information relative to cropping systems which will increase and maintain soil fertility and make their farms more profitable.

(2) The price of black land has increased during the last 40 years from a very low price to prices ranging from $50 to $200 per acre.

(3) The original productiveness of much of the soil has been greatly lessened by (1) the presence of a plant disease known as root-rot, which is especially injurious to cotton and legumes, and (2) the consequent absence of legumes from the rotations.

(4) Though no practical remedy for Texas root-rot has yet been discovered, its evil effects may be largely overcome (1) by deep fall plowing, (2) by the rotation of resistant with nonresistant crops, and (3) by the incorporation of organic matter into the soil.

(5) Legumes generally are not as much affected by root-rot as is cotton. In a properly arranged rotation alfalfa and a number of varieties of cowpeas can be grown to great advantage. Tests under way indicate that several other legumes will prove to be of great service to the farmers either as hay or as soil improvers, notably certain varieties of soy beans.

(6) Alfalfa is killed by root-rot in two to five years, causing many farmers to decide that it is not a suitable crop for black lands. Experience, however, has proved that in many sections it pays to grow alfalfa in a short rotation with grain, allowing it to remain on a field about three years, or until destroyed by root-rot, and then plowing up the meadow and reseeding another, to remain a similar length of time.

(7) The yields of wheat, corn, oats, and cotton following alfalfa in rotation are materially increased.

(8) In a desirable cropping system for a black-land farm the Texas root-rot is overcome, legumes are grown, the fertility of the soil is increased and maintained, and the acreages of crops grown are so arranged that ample crops of each may be produced from year to year for the needs of the farm.

(9) The rotation should be planned in such a manner that it can be modified from time to time to meet changes in the weather and other unexpected conditions without detracting from its value.

(10) On most black-land farms a mixed rotation similar to the one used by James Burns is most satisfactory, as it enables one easily to adjust acreages of various crops.

(11) Cowpeas may be grown successfully on the black lands in the ordinary rotation of cotton, corn, and oats by planting them in alternate rows with the corn, or after the oats in rows, and cultivating them two or three times.

(12) The work thus far accomplished is but preliminary to a more extensive and detailed study of farm-management problems in the black-land belt. The legume tests will be continued as long as may be necessary in order to arrive at definite conclusions.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *August 15, 1911.*

[Cir. 84]

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B. P. I.—690. Issued June 20, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 85.

B. T. GALLOWAY, Chief of Bureau.

CROWN-GALL AND SARCOMA.

By Erwin F. Smith,

Pathologist in Charge of Laboratory of Plant Pathology.

INTRODUCTION.

In a recent bulletin of the Bureau of Plant Industry of the United States Department of Agriculture[1] the writer pointed out resemblances in crown-gall of plants to malignant animal tumors and especially to sarcoma. Since the publication of this bulletin further study has revealed several very interesting facts. Our observations show that in method of development this disease is strikingly like that of certain malignant neoplasms in man, especially those in which a distinct strand of tumor tissue has been traced from the primary tumor to the secondary tumor.

There is perhaps no metastasis, in the strict sense of the term, but so far as regards the mechanism of tumor development it is a matter of minor importance whether the migrating tumor cells separate themselves entirely from the parent mass or remain connected with it by means of a tumor strand. The plant body favors the latter method of development, whereas the rapidly circulating blood stream in animals favors the former, i. e., the dislodgment and distribution of cells. The matter of chief importance is the method of action of the parasite on the cells of the host.

QUESTIONS UNSOLVED.

In the bulletin mentioned the following subjects were either not touched upon or left in an inconclusive state:

(1) The question of the presence or absence of the bacteria in the secondary tumors.

[1] Bulletin 213, Bureau of Plant Industry, U. S. Dept. of Agriculture, entitled "Crown-Gall of Plants: Its Cause and Remedy." The edition of this bulletin is exhausted at the Department of Agriculture. It may be obtained, however, from the superintendent of documents, Government Printing Office, Washington, D. C. Price 40 cents.

(2) The relation of the origin of the secondary tumors to the primary tumor, i. e., whether the new growths result from the independent migration of bacteria from the primary tumor to the site of the secondary tumor or whether the tumor cell itself is the migrant. That the latter was believed to be the case may be seen from the second paragraph on page 164.

(3) A comparison of the cell structure of the secondary tumor with that of the primary tumor.

NEW FACTS.

Having obtained much favorable material for study from inoculations made on the daisy in January of this year, using for inoculation pure cultures of the schizomycete plated from tumors on the daisy, the answers to these questions are at hand and are confirmatory of the hypothesis made in the bulletin, viz, that the study of crown-gall is calculated to throw some light on the origin of malignant animal tumors.

This study has yielded the following results.

BACTERIA IN SECONDARY TUMORS.

The bacterium causing the primary tumor occurs also in the secondary tumors. It is not plentiful, but, so far as we have plated, occurs in about the same numbers as in the primary tumor. Numerous poured-plate isolations and several successful reinoculations have put beyond question its normal occurrence in these secondary tumors. It occurs also sparingly in the tissue between tumors. In other words, we do not have in this disease a cell stimulus begun in the primary tumors by a parasite and then able to propagate itself independently of the inciting organism. On the contrary, the bacteria and the tumor cells occur together both in the primary tumor and in the secondary tumor *and the one inside the other.* Owing to our inability thus far to stain the causal organism inside the cells without at the same time staining many confusing granules or to see it therein under the microscope so as to determine its presence in unstained sections with certainty, the evidence for this last statement is indirect, but none the less conclusive. This evidence is twofold: (a) By the poured-plate method, from the interior of tumor tissue after surface sterilization we obtain the tumor-producing schizomycete, and, therefore, it occurs in these tissues; (b) when such tissues are sectioned and studied under the microscope the vessels and the intercellular spaces, so far as we have been able to observe, are free of bacteria. Numerous observations made during the last three months confirm many earlier ones. If bacteria were commonly present in the vessels or spaces between the cells (as happens in many other plant diseases) they ought to be readily visible either stained or unstained, for, quite unlike the cells, these spaces are free of all confusing granular matters. By the doctrine of exclusion, therefore, the bacteria must be within the cells. The discovery of them in place is complicated by the fact that they are not very numerous, are not acid fast, are probably often in the form of involution cells or in some other form difficult to identify, and are mixed in with numerous minute crystals, crystalloids, and other granules of the host protoplasm, which itself takes bacterial stains readily.

TUMOR STRANDS.

In many instances (we can not yet affirm in all) the secondary tumors are connected with the primary tumor by a deep-seated strand or pedicel of tumor tissue. This strand wedges its way through the interior of stems and leaves, *after the manner of a foreign body*, until in some suitable place, often at a considerable distance from the primary tumor, it gives rise to a deep secondary tumor, which subsequently ruptures through to the surface of the plant. This offshoot from the primary tumor occurs deep in the wood, at the junction of wood and pith, and may sometimes be seen with the naked eye, owing to the fact that the chloroplasts in its cells become more numerous than elsewhere and give to the strand a deep-green color and because being under great pressure it wells out on cross section of the stem, something like a cut muscle; at other times the strand is restricted to a few cells and can be made out with difficulty even under the microscope, but wherever it occurs in any quantity it is seen to be totally distinct in its structure from the normal tissues surrounding it, conforming to the tumor tissue in its histology, and can be traced in the one direction to the primary tumor and in the other to the secondary, and frequently in the course of its progress from the primary to the secondary tumor we have observed island-like enlargements, and comparison of these in various stages of development show that they are the beginnings of other tumors. Sometimes these enlargements of the green strand have progressed far enough to push up the normal tissues and show as a swelling on the outside of the stem; at other times not. Finally, from this strand we have cultivated out *Bacterium tumefaciens*, and reproduced the disease with the cultures. Frequently the wood in this part of the stem takes on an increased growth.

SECONDARY TUMORS HAVE THE STRUCTURE OF THE PARENT TUMOR.

As might be expected from statements under the previous heading, "Tumor strands," when the primary tumor occurs on the stem and secondary tumors subsequently appear in the leaves the structure of the leaf tumors is approximately that of the stem. We have, then, in place of the leaf traces and loose cellular structure of the ordinary dorsiventral petiole or midrib, a firm structure consisting of a greenish pseudopith (of tumor tissue), surrounded by a cylinder of wood, beyond which is a cambium and then a bark covered with cork. This stem structure is sometimes very perfect, although less woody than a normal stem—i. e., of a looser structure—at other times, incomplete on one side, only a partial cylinder of wood being formed. This stem structure may develop either in the central leaf trace or in one or more of the side leaf traces, according as one or the other is penetrated by the advancing strand of tumor tissue. All stages of this conversion have been seen, from petioles which still present their external form and show only a slight disturbance in one of the leaf traces to those in which all resemblance to an ordinary leaf has disappeared, the petiole being displaced by a thick, firm, stemlike growth more or less circular in cross section and totally unlike the dorsiventral structure of a leaf. Even in such cases traces of the unchanged wings of the petiole may be seen sometimes as marginal appendages of the secondary tumor.

Full details will be given in another bulletin as soon as the illustrations can be prepared.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *June 17, 1911.*

[Cir. 85.]

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Issued August 15, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 86.

B. T. GALLOWAY, Chief of Bureau.

PRELIMINARY REPORT ON THE KLAMATH MARSH EXPERIMENT FARM.

BY

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AND

LYMAN J. BRIGGS,
Physicist, in Charge of Physical Investigations.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1911

SCOPE OF THE INVESTIGATIONS.

In view of the similarity in appearance between the Lower Klamath Marsh and the so-called tule lands in the delta of the Sacramento and San Joaquin Rivers in California it was deemed advisable to follow the same agricultural practices that have proved most

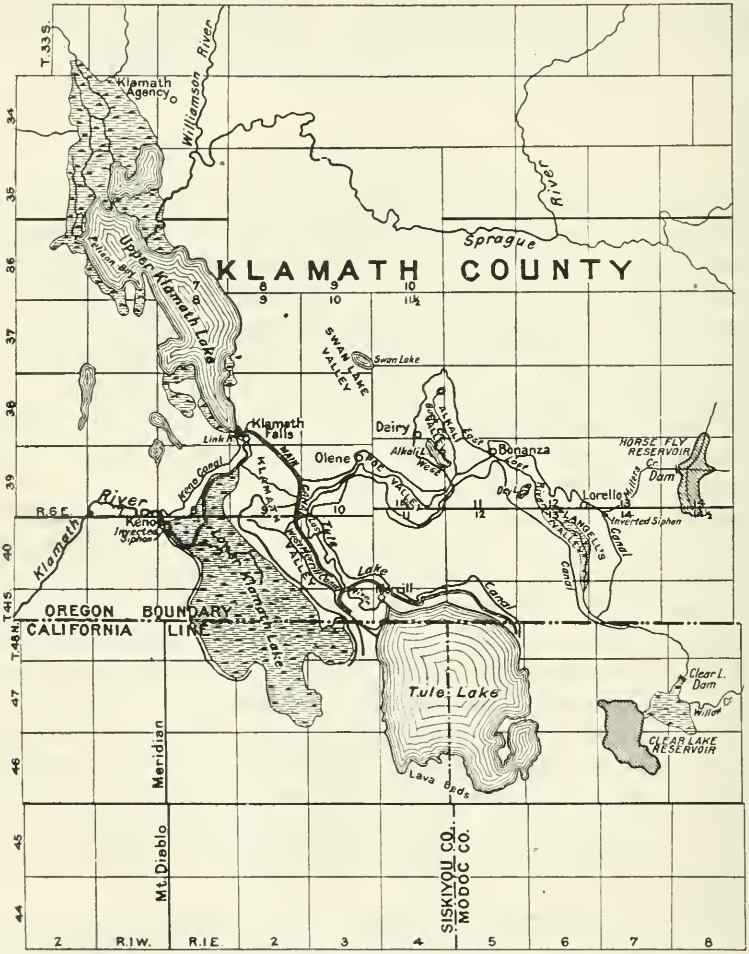

FIG. 1.—Map showing the location of Lower Klamath Lake and Marsh formed by lateral overflow from Klamath River, which flows through the northern edge of the marsh. Klamath River drains Upper Klamath Lake over a basaltic rock barrier at Klamath Falls.

suitable in the subjugation of these lands and to try some of the crops that have been the basis for that highly profitable agriculture.

Such temperature records as were available indicated that the Klamath marshlands were subject to low minimum temperatures during the summer months, with the liability of a killing frost even in summer. Preliminary examinations of the drained marshland showed the presence of considerable quantities of alkaline salts, chiefly carbonates of sodium, magnesium, and calcium. It was believed at first that these salts could be washed out without difficulty in the ordinary processes of irrigation, and the first efforts were directed toward getting the raw tule mat into good tilth. Arrangements were made for bringing to the reclaimed land a supply of irrigation water from the channel which leads into the swamp from the Klamath River.

The drainage of the experimental tract had been accomplished by cutting through it open ditches about 5 feet deep and 2 feet wide. Three of these ditches were run parallel, about 200 feet apart, connecting with a head ditch at either end and supplemented by a dredger cut along one side of the tract. This arrangement of ditches, together with a wooden flume by which the irrigation water was brought to the tract, made it possible to try both surface flooding and lateral subirrigation, the latter being accomplished by keeping one ditch full of irrigation water and the adjacent parallel ditch empty.

It was found that the raw tule mat was very tough and hard to reduce quickly into good tilth. It was successfully plowed by using a very sharp plow. In order to have at least a small piece of land in good tilth, the furrow slice was removed from about 1 acre. After this was done it was found possible to work up the next layer into very good tilth for a seed bed.

In the spring of 1910, when the irrigation system had been installed, a number of grain and grass crops, together with a series of vegetable crops, were planted; a considerable number of the crops being planted both on the land from which the furrow slice had been removed and on the land that had not been plowed the previous season, but instead had been thoroughly cut to pieces with a heavy disk. It was found impracticable to plant crops on the land which had been plowed but from which the furrow slice had not been removed. When this plowed land had been cut to pieces with the disk and irrigation water was applied in an endeavor to moisten the seed bed, most of the pulverized furrow slice was floated up and washed about by the irrigation stream, so as to make a uniform wetting impossible. Spring planting on this land was not attempted.

When the drainage of the experimental tract was first undertaken a large number of curbed open wells were dug for the purpose of observing the rate of recession of the ground water.

With the beginning of the crop season of 1910 observations were begun as to the depth of the water in these open wells, and samples of the water were tested from time to time with the electrolytic bridge to determine the salt content. The necessary instruments were also installed to observe the air temperature, wind velocity, and the temperature of the seed bed. Samples of the irrigation water were tested with the electrolytic bridge and composite samples were collected for chemical analysis. The same was done with the drainage water removed from the tract. All of these observations were continued throughout the crop season of 1910, and notes were made as to the growth and behavior of the crops planted. As a precautionary measure, samples of all the seed used in planting were tested to ascertain their normal germination.

LIST OF CROPS TRIED.

The land which had not been plowed, but which had been thoroughly cut to pieces with the disk in the fall of 1909 was planted to the following crops on April 29: Turkey wheat, barley, Crimean wheat, oats, meadow fescue, alsike, redtop, sand lucern, timothy, white clover, and bluegrass.

The land from which the furrow slice had been removed was planted to the following crops on April 29: Onion sets, onion seed, radish, lettuce, turnips, cowhorn turnips, mangels, sugar beets, chick-peas, and Canada peas.

On May 7 on this same plat were planted three varieties of potatoes.

On May 11 two varieties of wheat, one of barley, and one of oats were planted on the land from which the furrow slice had been removed, and on May 21 on this same plat were planted kafir corn, sweet corn, and thousand-headed kale.

On May 25 flax and hemp were planted on the same plat.

After a severe frost on June 20 and 21 the following crops were planted on the land from which the furrow slice had been removed: Mangels, sugar beets, rutabagas, red beets, radish, kale, Canada peas, chick-peas, sand lucern, wheat, barley, and oats.

On July 8 there was also planted on the land from which the furrow slice had been removed one drill row of each of the following: Meadow fescue, alsike, redtop, sand lucern, timothy, and white clover.

RESULTS OF THE CROP EXPERIMENTS.

The major portion of all the crops planted came up and commenced growth in a fairly satisfactory manner, although the seedling growth was slow in nearly every case. Irrigation water was used freely on most of the land in an effort to reduce the salt content by leaching. After passing the seedling stage most of the plants began to show symptoms of distress, manifested by arrested growth and yellowing. This was particularly true on the land from which the furrow slice had been removed. On the land where the tule mat had been cut with the disk and where heavy irrigation was used the plants, particularly the cereals, made a slightly better growth, but even there the growth was abnormally slow and weak. A critical examination of the plants at the time when the arrested growth had become conspicuous (about the middle of June) showed that the roots were confined to the superficial layer, and that in the few cases where they had penetrated much beyond the first 3 inches they were dead and badly corroded. On the nights of June 20 and 21 severe frosts occurred, with the result that all of the tender crops were killed to the ground and nearly all of the others were severely injured. Immediately after this frost a second planting of the tender crops was made. The crops from the second planting came up promptly, but after having exhausted the food supply stored in the seed these too began to suffer and die, although temperature and moisture conditions were favorable to growth.

The wheat, oats, barley, alsike, clover, alfalfa, and redtop remained alive throughout the season on the disked land, but none of these crops made anything like a normal growth, even under the most favorable conditions it was found possible to provide. A few plants of both sugar beets and blood beets, as well as some of the potatoes, survived the season on the land from which the furrow slice had been removed, this survival occurring chiefly in a few places where excess quantities of irrigation water were used, but even under these conditions growth was abnormally weak.

It became apparent from these experiments that thorough leaching of the land would be a necessary preliminary to the production of any of the ordinary crop plants. Indeed, none of the crops in the foregoing list gave any indication of ability to thrive under the conditions of the experiment.

EXPERIMENTS IN LEACHING THE LAND.

The land planted to crops was irrigated by surface flooding or by furrows. It was found that on the disked but unplowed land the water moved readily through the porous superficial layer to the depth of 4 or 5 inches and drained off into the open ditches on either side, but there was little evidence of any considerable penetration below this layer. On the land from which the furrow slice had been removed the water was absorbed so slowly that after heavy flooding it was necessary to draw off the water from the check after each irrigation, even though the ditches on either side of the flooded tract were kept empty. In other words, the downward and lateral movement of water into the land was so slow as to make very doubtful the possibility of reclaiming the land by leaching out the excess of alkaline salts.

Early in the season one of the three parallel open ditches was blocked up at either end and kept filled with irrigation water, while the adjacent ditch 200 feet away was kept empty. This condition was maintained with but few interruptions throughout the season from May to October, with the object of leaching out the excess salts in the land between these two ditches.

Water samples were collected each week from the open wells in this tract, and the salt content was determined with the electrolytic bridge, check samples being collected from time to time for chemical analysis.

At the end of the season samples of water collected at depths of 2, 4, and 6 feet at various points in the subirrigated tract showed conclusively that there had been no material leaching of the salt except in the upper foot.

In the latter part of the season an effort was made to leach out the salt by protracted surface flooding of the land from which the furrow slice had been removed. Borders were thrown around two checks, each containing one-eighth of an acre, and each of these two checks was bordered on two sides by an open ditch nearly 5 feet deep. One of these checks was kept continuously flooded for two weeks and then allowed to dry out for two weeks, while the other was flooded. This flooding process was repeated on each check so that each was flooded twice for two weeks at a time with an intervening period of two weeks without flooding. Samples of the subsurface water were secured at depths of 2, 4, and 6 feet in each of the checks after each period of flooding and, although an aggregate of 5 feet in depth of water was applied to each of these checks during two weeks of flooding, it was found that no appreciable lessening of the salt content had occurred at the depth of 2 feet or below. All of the water applied to these checks that had not evaporated had apparently seeped out laterally through the more porous surface layer.

In view of the very light texture of the tule mat and underlying material, none of which weighs over 40 pounds per cubic foot when dry, it seems difficult to understand the cause of its relatively high impenetrability. When saturated this material holds a large proportion of water, it being not uncommon to find samples containing 5 or 6 parts of water to 1 part of dry material. In other words, when approaching the saturation point this soil contains 500 or 600 per cent of water. Chemical analyses of this subsurface water and of the tule mat itself show the presence of large quantities of soluble salts, chiefly carbonates of sodium, calcium, and magnesium; in other words, lime and black alkali. The tule mat when moist gives a pronounced alkaline reaction to litmus, and the subsurface water on boiling gives an alkaline reaction to phenolphthalein. In this re-

-pect the Lower Klamath Marsh differs markedly from the tule lands of the delta of the Sacramento and San Joaquin Rivers, which are either neutral or slightly acid; particularly in the lower depths.

COMPARISON WITH OTHER TULE LANDS.

Owing to the rank growth of the tule on the Lower Klamath Marsh it has been assumed that these lands have the same potential value as the tule lands in the delta of the San Joaquin and Sacramento Rivers. There are two fundamental differences, however, between these two tracts:

(1) The lands of Lower Klamath Marsh are formed almost entirely from organic matter and the siliceous remains of diatoms. Draining the tract and exposing this soil to the air will result in the rapid oxidation and disappearance of the organic matter, accompanied by a marked lowering of the surface. The residual material will eventually be largely siliceous and will contain little plant food. The delta tule lands, on the other hand, contain a large proportion of silt deposited by floods and do not undergo any marked changes as the result of drainage, while the silt provides the necessary mineral plant food.

(2) The delta tule lands are either neutral or slightly acid in their reaction, particularly in the lower depths, while the lands of Lower Klamath Marsh are markedly alkaline. This condition is due to the presence in the latter case of black alkali (sodium carbonate), the most injurious of the alkali salts. This salt combines chemically with the disintegrated organic matter, which is one of the reasons why it is so difficult to remove by leaching. A second reason is that the compounds thus formed are colloidal in character and greatly retard the movement of water through the soil, behaving in this respect like particles of colloidal clay.

Black alkali is least harmful under the conditions found in the undrained marshland: that is, in the presence of submerged organic matter. A part of the alkali combines directly with the organic matter, and the remainder is largely converted into sodium bicarbonate, which is much less harmful to plant growth. It is under such aquatic conditions that the tule makes its growth in the Lower Klamath Marsh, but as soon as the land is drained these favorable conditions are gone. The sodium bicarbonate is converted into the harmful carbonate, and as the organic matter oxidizes, all the alkali with which it was combined is set free. Thus conditions grow steadily worse in the zone into which the plant roots should penetrate, while in the drainage zone below the soil remains as impervious as before.

CONCLUSIONS.

(1) The Klamath marshlands on the Lower Klamath Lake have been formed through the disintegration of aquatic vegetation and without the deposition of any considerable quantity of rock sediment or silt. They are therefore lacking in essential elements of fertility.

(2) These swamp lands contain a sufficient quantity of alkaline salts, chiefly carbonate of sodium (black alkali), to render them unfit for crop production until these salts are leached out.

(3) On account of the highly impervious character of the marshland, the leaching out of these alkaline salts is rendered very difficult and appears to be impracticable by any methods at present known. The expense would exceed the prospective value of the land.

(4) The air-drainage conditions on the Klamath marshlands are such that low temperatures and killing frosts are likely to occur every month in the year, thus limiting the possible agriculture to the hardier species of crop plants.

Approved:

James Wilson,
Secretary of Agriculture.

Washington, D. C., *July 22, 1911.*

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Issued September 9, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 87.

B. T. GALLOWAY, Chief of Bureau.

DESCRIPTION OF THE COMPREHENSIVE CATALOGUE OF BOTANICAL LITERATURE IN THE LIBRARIES OF WASHINGTON.

BY

ALICE C. ATWOOD,

Bibliographical Assistant, Office of Taxonomic and Range Investigations.

4847°—Cir. 87—11

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BUREAU OF PLANT INDUSTRY.

Chief of Bureau, Beverly T. Galloway.
Assistant Chief of Bureau, William A. Taylor.
Editor, J. E. Rockwell.
Chief Clerk, James E. Jones.

B. P. I.—673.

DESCRIPTION OF THE COMPREHENSIVE CATALOGUE OF BOTANICAL LITERATURE IN THE LIBRARIES OF WASHINGTON.

INTRODUCTION.

Two catalogues stand in the Bureau of Plant Industry library, one designated the Plant-Industry Catalogue and the other the Botany Catalogue. To give some idea of the scope of the latter and of the special features which it presents, in order that its use by botanical workers may be still further increased and extended, is the purpose of the present circular.

The "Botany Catalogue," as it is called for want of a better name, has been developed under the supervision of Mr. Frederick V. Coville and originated in an attempt, for which he was chiefly responsible, to enlarge and coordinate the collections of botanical literature in the libraries of Washington. The nucleus of the present catalogue was the botanical part of the catalogue of the Department of Agriculture library, to which it forms an extensive adjunct, especially in regard to literature not included in the Department collections.

The examination of titles with reference to the cooperative purchase of books among the different libraries necessitated some kind of a check list showing what books were already available and where they were located. Starting as a mere author list, chiefly used for the assistance of the Department library in cooperative book buying, it came to be generally consulted by workers in botanical lines, and as it grew it became necessary to enlarge its scope in many ways and to develop a subject catalogue along with it.

THE AUTHOR CATALOGUE.

The author catalogue now consists of about 50,000 entries, including botanical works contained in the Library of Congress, the libraries of the Department of Agriculture, National Museum, Smithsonian Institution, Geological Survey, Surgeon General's Office, and the private libraries of Dr. Edward Lee Greene and Capt. John Donnell Smith. The latter library is at present in Baltimore, but it is available to workers in Washington and will eventually form a part of the Smithsonian library.

Proof sheets are received daily from the Library of Congress, from which printed cards are ordered, comprising additions to the Library of Congress and the libraries of the Department of Agriculture and the Geological Survey, while a large number of typewritten and handwritten cards are added covering additions to the various libraries for which printed cards can not be obtained and also a large number of analytical and index entries. From July, 1910, to July, 1911, about 7,000 cards were added to the author catalogue and serial list, and as many more have gone into the subject catalogue.

INDEX ENTRIES.

While indexing has not been engaged in to any large extent, the index cards for American botany, issued by the Torrey Botanical Club, have been added to the catalogue, and a number of scientific serials, principally those published before 1800, have been completely indexed. In addition, much incidental indexing has been done upon subjects of special interest.

SCOPE.

The subject matter represented by the catalogue is much wider in scope than would be justified by a strict use of the term "botanical." The allied subjects of horticulture, tropical agriculture, fibers, gums and resins, pharmacology, special crops (cacao, cotton, rubber, etc.), seed adulteration and control, etc., have found their place in the catalogue, as well as voyages and explorations which touch upon the botany of a country, or which publish scientific results.

The biographical and bibliographical sides have not been neglected. The catalogue is unusually rich in biographies and bibliographies of botanists, gathered often from sources not generally consulted. Bibliographical notes on special works and articles dealing with dates of publication of works issued in parts also form a valuable part of the material in the catalogue.

DESIDERATA.

In accordance with the original intention, the catalogue has been used as a basis of comparison in the purchase of botanical literature, and a list of desiderata has been formed both for works entirely lacking and for volumes lacking in sets. These desiderata have been entered on yellow slips designed especially for the purpose and filed in the author catalogue, so that the author catalogue not only represents botanical works available in Washington, but also gives information as to those not available and desirable for purchase by the Department or other libraries interested in the cooperative purchase of books.

SERIAL LIST.

Many important botanical articles appear in scientific serials or society publications, and even when a reprint is available it is important to have access to the original place of publication. At first, a few entries for scientific serials or society publications, as they chanced to be referred to, were added to the author catalogue, but during the last year the matter has been taken up systematically, and a separate serial list has been made giving information as to the location of the sets in the larger libraries of Washington. The serial list consists of an alphabetical list, with full cross references, of general scientific serials and society publications, followed by a roughly classified list of serials under the headings "Botanical," "Horticultural," "Microscopical," and "Pharmaceutical." Serials dealing with plant pathology, pomology, and tropical agriculture are included under the heading "Horticultural."

The serial list will be further enlarged and compared with other libraries in the city and promises to be a valuable adjunct to the catalogue.

ARRANGEMENT.

The author catalogue is arranged alphabetically as a dictionary catalogue, but editions and translations are arranged chronologically after the original edition, the original title being penciled at the top of the card in the case of a translation or edition with change of title. Cross references are made from differing titles to the original. In the case of voyages and explorations of which there have been a great number of editions or translations, cards for the earliest edition with the English translation and possibly some other important editions are filed in the catalogue, and a card giving in brief additional editions and translations available in the Library of Congress is filed with them. Authors treated as subjects (biography and bibliography) are found in the author catalogue, not in the subject catalogue; the same is true of institutions, botanical gardens, etc.

THE SUBJECT CATALOGUE.

The subject catalogue has grown very rapidly since its inception, and it is the intention to make it as complete as possible. It represents a few subjects for which no cards appear in the author catalogue, such as atlases and general bibliographies of countries, entries which are of use only on the subject side; on the other hand, only a portion of the Torrey Club index cards have as yet had subject entries made for them.

ARRANGEMENT.

The subject catalogue is a semiclassed catalogue, divisions and subdivisions of large subjects being made within the alphabetical arrangement. Names of genera are arranged under the family, the family names appearing in their regular alphabetical place. Small geographical divisions are arranged under the country to which they belong, as, for example, under "Germany" will be found "Germany—Bavaria," "Germany—Munich," "Germany—Prussia," "Germany—Rhine Valley." The United States is arranged first under the United States as a whole, then under large divisions, as "New England," "Southern States," "Rocky Mountain Region," etc., and then under the individual States. Towns, cities, counties, etc., appear under their respective States, as in the case of Germany. In the same manner as the United States are arranged Great Britain, Canada, West Indies, Chinese Empire, Australia, and other similar divisions.

Some of the other large subjects are also subdivided, as "Materia medica," by countries; "Plant names," by languages; "Plant anatomy" and "Plant morphology," by names of families; "Plant nutrition," by names of plant foods used; "Alkaloids in plants," by names of the individual alkaloids. Examples might be multiplied indefinitely.

GUIDES.

To facilitate the use of the subject catalogue a special system of guide cards has been adopted. Blue guide cards are used for main subjects standing in regular alphabetical order and buff guide cards for subdivisions of subjects. It will, of course, be understood that guides are not supplied for every subject, only the more important being so indicated. The systematic headings can be readily distinguished, as all names of genera are in red, while all other headings are in black.

EDITIONS AND TRANSLATIONS.

Cards are not multiplied for editions and translations in the subject catalogue. A card for the original or earliest edition is inserted, with a note referring to the author catalogue for other editions and translations. The only exception to this rule is in cases where the recent edition is the most important, as is the case with textbooks and reference books. In such an instance the card for the latest edition is filed, with a note referring to the author catalogue for earlier editions.

RELATION OF THE BOTANY CATALOGUE TO THE PLANT-INDUSTRY CATALOGUE.

When the Botany Catalogue was installed in the Bureau of Plant Industry library it soon became evident that there was some unnecessary duplication in the subject catalogues of the Plant-Industry Catalogue and the Botany Catalogue. It was then decided to cut out of the Botany Catalogue the subject of plant pathology with its allied subjects, which is so fully and carefully treated in the Plant-Industry Catalogue; in the same manner were treated such subjects as sugar cane, sugar beet, sugar-producing plants, and nitrification. The Plant-Industry Catalogue turned over to the Botany Catalogue all subjects dealing with systematic botany, plant life history, general horticulture, and such special crops as the Botany Catalogue had already treated more or less fully. Cross references in the subject catalogue refer to the headings used in the Plant-Industry Catalogue. The line of demarcation between the Plant-Industry Subject Catalogue and the Botany Subject Catalogue may not seem to have been drawn very logically, but it is the result of the varying use of the two catalogues, and appears to be practical if not in accordance with theory.

The catalogue is only a tool for the use of the worker in botanical literature, and the desire is to make it as complete and workable a tool as is possible. The daily use of the catalogue constantly suggests improvements in both plan and execution, so that its present usefulness is limited only by the amount of time and labor that can be devoted to it.

Approved:
JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *July 24, 1911.*

[Cir. 87]

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 88.

B. T. GALLOWAY, Chief of Bureau.

THE PICKING AND HANDLING OF PEANUTS.

BY

W. R. BEATTIE,
Assistant Horticulturist.

9122 °—Cir. 88—11

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1911

BUREAU OF PLANT INDUSTRY.

THE PICKING AND HANDLING OF PEANUTS.

INTRODUCTION.

The growth of the peanut industry in the United States during the last 15 or 20 years has been so great that few people realize its present importance. During this period of expansion few changes in the methods of handling have been made and there is now need for improvement all along the line, from the producer to the consumer. The problem which confronts the cleaner and dealer is to place upon the market peanuts that are clean and free from insect or other injury. Under the pure-food laws peanuts that are weevil-cut or improperly cleaned are subject to seizure if offered for interstate trade. In the future, buyers of peanuts will discriminate against goods that are badly broken or otherwise damaged.

While the primary trouble lies in the methods employed in picking peanuts from the vines, there is need for general improvement both on the farm and in the cleaner's establishment. Farmers are not exercising proper care in the harvesting and curing of the crop; this results in placing upon the market too great a percentage of mildewed and damaged nuts. As peanuts come from the farms they too often contain dirt, stems, cotton stubble, and rubbish of all kinds, rendering necessary a system of docking of weight which leads to general dissatisfaction. The machines used for picking peanuts from the vines break many of the pods, rendering the kernels or "peas" subject to the ravages of insects during the summer. It is a well-known fact that if the shell of a peanut is not broken or cracked the peas will keep almost indefinitely. The present situation does not present any serious difficulties, but merely shows the need of a general improvement in all branches of the industry in order to place the work entirely above reproach.

Many of the growers of peanuts hold their crop through the winter months and on into the summer as a speculation. Very often the farmer does not have a suitable place to store his peanuts and heavy losses result from this practice. The first step in improvement will be to provide machinery that will not break or injure the peanuts and then to secure better methods of storage and handling. It is a fact to be deplored that cars and warehouses used for the transportation and storage of peanuts are often not as clean as they should be, and in the past very little attention has been given to the matter of preventing injury from insects, rats, and mice.

HARVESTING AND CURING PEANUTS.

In the sections where the bunch peanuts are grown the work of stacking and curing is as a rule quite well done and very few are damaged. The greatest injury is found where the runner pea is grown, and this is due primarily to the heavy growth of vine, with the pods borne all along the stems, rendering it difficult to stack the vines without a part of the peas being exposed to the weather. This exposure causes the mildewing of the pods and frequently the molding of the peas, which may be avoided by more careful stacking and proper capping of the stacks with peanut vines or hay. In some sections the farmers pick the peas from the vines before they are properly cured, causing them to mold in the bags or in the storage bins.

PICKING PEANUTS FROM THE VINES.

So long as the bulk of the peanut crop was picked from the vines by hand very little trouble was experienced with the breakage of the pods. The scarcity of labor has compelled the adoption of machinery for picking peanuts, and many of the machines have proved far from satisfactory in that they break the shells.

Peanut-picking machines are of two classes: (1) Cylinder machines similar to the ordinary grain thrasher and (2) picking machines which remove the peas from the vines by means of a woven-wire screen. The cylinder machines break a large number of pods when run at a high rate of speed, and since the work of picking is paid for by the bag there is a tendency on the part of the owner of the machine to run through as many as possible. If the machines are not overfed and the cylinder is run at a speed not exceeding 370 revolutions per minute the damage will not be great.

The picker type of machine does not break any appreciable number of pods and its work is almost equal to that done by hand. The fault of all these machines is that they do not properly clean the peanuts; the manufacturers, however, are now providing a more complete cleaning process.

Every farmer who hires his peanut crop picked should see that the machine does proper work, that the pods are not broken, and that the peas are well cleaned. The most successful operators of thrashers and picking machines do not crowd the work and are content with turning out 60 to 75 bags a day. It should be borne in mind that peanut-picking machinery is still more or less in the experimental stage and that many improvements remain to be made. For the present the demand is for quality of work, although there is no reason why the capacity of these machines should not be increased. Considerable breakage of the pods comes from trampling upon them around the thrasher, and this can largely be avoided by keeping the loose and shattered pods well cleaned up while the work is going on.

STORAGE OF PEANUTS ON THE FARM.

The farmer's safeguard in the matter of the prices obtained for his peanuts lies largely in his ability to hold at least a portion of his crop through the winter or even until the new crop is partly grown. Farmers should be prepared to hold their crop for a time, rather than place it all upon the market during the autumn months when prices are generally at their lowest. In order to do this suitable storage facilities are necessary.

Frequently the bags of peanuts are simply piled in an open shed or in the barn, where they are not properly protected. Occasionally the bags are simply stacked upon the ground in the field without even the protection of a canvas cover. A building for the storage of peanuts need not be expensive, but may be constructed of rough boards with an iron roof and the whole raised a little above the ground for dryness. All openings for ventilation should be screened to keep out mice and rats; insect injury will not prove serious provided the peanuts have not become broken in picking or handling.

In many cases it has been found most convenient to store peanuts in bags. In no case should the bags be piled too high—that is, more than seven courses—and alleyways should be left every third or fourth row. Some growers follow the practice of storing in cribs or bins, where the peanuts are piled loosely until they are wanted for the market, at which time they are bagged. The method of storage on the farm matters very little provided the surrounding conditions are suitable. The less the peas are handled the better on account of the breakage.

STORAGE OF PEANUTS IN LARGE WAREHOUSES.

It has been the custom for a few cleaners and warehousemen to buy up peanuts during the autumn and to store them in warehouses holding from 20,000 to 100,000 bags each. Many of these warehouses are cheap frame structures. Recently some very fine storage houses have been built for this purpose. The type of building which seems to be best adapted to the storage of peanuts is four or five stories in height, with heavy brick walls and either concrete or mill construction floors. For best results the distance between floors should be but 10 or 11 feet. It has been found most economical not to pile the bags so high that two men can not handle them without climbing upon the bags that are already placed. Walking over the bags is sure to break a large number of the pods, and even the piling of the bags to a great height will crush the shells in the lower bags. It is recommended that occasional alleyways be left between the rows of bags instead of the solid method of piling now practiced. It is customary to have an elevator near the entrance to the warehouse, and the openings between floors should be provided with iron doors to prevent the spread of fire.

Provision should be made for the fumigation of these peanut warehouses at least twice during the summer. With this end in view the windows should be so arranged that they may be opened from the outside; ventilators in the roof should be provided with means of closing them during fumigation, and then for opening them to air out the house afterwards.

TRANSPORTATION OF PEANUTS.

There can be no doubt that many peanuts are broken and injured by careless handling. Catching hold of the corners of the bags for handling may break the pods. Jamming the bags with trucks or carts also causes considerable breakage.

A practice which no doubt will be discouraged in the future is the mixing of old goods with new in shipping. Many farmers hold over a few bags from one year to another and frequently these are sold for the current season's crop by simply placing a bag here and there in a car of new peanuts. These old goods are often damaged and should at least be kept separate from the new stock. The branding of every bag with the name of the grower and the year that the peanuts were grown would solve this difficulty, especially if required by law. The mixing of old and new goods is not always traceable to the farm, but more often to the merchant's storehouse where peanuts from a large number of farms have been brought together.

THE CLEANING OF PEANUTS IN FACTORIES.

As the cars arrive at the factory the bags of peanuts are weighed and placed in storage until wanted for cleaning. As a rule no precautions are taken to guard against broken or "weevil-cut" goods. It would be feasible to provide a tight room near the entrance to the warehouse into which the peanuts could be run as they come from the car and given a fumigation before being placed in storage or cleaned. This would apply especially to peanuts shipped during the summer months, after "weevil" damage has begun. It would not be practicable to separate the broken peanuts from the perfect ones as they come from the cars except in cases where the breakage is very great. All badly broken stock should be manufactured early in the season before there is any danger of injury.

It is highly important that warehouses and cleaning establishments be kept clean and free from everything that will harbor "weevils." Screenings and other refuse, commonly sold for hog feed, should be removed to a building located some distance from the warehouses and factory. Old bags should not be piled in the factory but should be kept in a separate building.

CARE OF SHELLED GOODS.

It is customary for the cleaners to stack the bags of shelled peanuts in a corner of the factory, where they are exposed to the dust. By this method the shelled peanuts are liable to attack by insects coming from infested stock in the factory. The finished goods should be stored either in a specially constructed building or in a room tightly built to keep out dust. By this method it would also be possible to give these goods a fumigation before shipment.

Shelled peanuts are subject to injury from moisture or from extreme heating. The storage room should be dry and should be so located that the heat from the engines or boilers will not affect it. This storage room for shelled goods should be arranged for convenience both in handling the bags from the filling machines and in loading them into the cars.

CLEAN CARS.

It is customary to reload cars that have been emptied of farmers' stock peanuts with cleaned goods ready for the market. Very often the cleaning of these cars is left to laborers and the work is not properly done. More care should be taken to sweep these cars properly and if they are infested with insects they should be fumigated.

SUMMARY.

The difficulties which now confront the dealers and handlers of peanuts are due largely to careless methods on the farms. The trouble results mainly from the improper methods of curing the crop and the breakage of the shells in thrashing. Greater attention should be given to the housing and care of peanuts after their removal from the vines. This applies both to storage on the farm and in warehouses. More careful attention should be given to the condition of cars used for the shipment of cleaned and shelled peanuts. There are no serious problems involved, but a general improvement in the methods of curing and subsequent handling of the crop is needed.

Approved:

James Wilson,

Secretary of Agriculture.

Washington, D. C., *August 24, 1911.*

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 89.

B. T. GALLOWAY, Chief of Bureau.

AN IMPROVED METHOD OF ARTIFICIAL POLLINATION IN CORN.

BY

G. N. COLLINS and J. H. KEMPTON.

17217—12

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BUREAU OF PLANT INDUSTRY.

Chief of Bureau, Beverly T. Galloway.
Assistant Chief of Bureau, William A. Taylor.
Editor, J. E. Rockwell.
Chief Clerk, James E. Jones.

B. P. I.—709.

AN IMPROVED METHOD OF ARTIFICIAL POLLINATION IN CORN.[1]

INTRODUCTION.

In the breeding of corn, if accurate records regarding parentage are to be kept, all pollinations must be done by hand. In the methods of study now popular many pollinations are self-pollinations; that is, it is necessary to place the pollen of a plant on the silks of the same plant and protect the silks from all other pollen. By the methods usually employed it is impossible to be certain that all foreign pollen is excluded. This uncertainty prevents the placing of confidence in the ancestry of plants that exhibit unexpected characters.

From what is known of reversions and mutations the appearance of characters assumed to be absent from the parents, though of rare occurrence, must still be considered. A technique so faulty that the evidence on this point can not be relied upon removes all hope of touching some of the most vital problems in heredity and renders all data regarding the absolute purity of the germ cells valueless. It is believed that the method here described makes it possible to place the same confidence in the self-pollination of corn as in plants which are not wind-pollinated.

METHODS USUALLY EMPLOYED.

The usual method of making self-pollinations is to inclose the tassels and young ears in strong paper bags. When pollen has accumulated in the bag surrounding the tassel and the silks have emerged from the young ear, the bag containing the pollen is removed. The ear is then uncovered, the pollen dusted over the silks, and the bag replaced on the ear. During the operation the silks are necessarily exposed for a short time to any pollen that may be floating in the air. A number of refinements have been devised by different operators

[1] For the original suggestion of the method here described, the writers are indebted to Dr. L. J. Briggs, of the Bureau of Plant Industry.

to reduce the chances of the silks receiving foreign pollen. The most effective is that proposed by Roberts.[1] In his experimental field the tassels are all bagged before they begin shedding pollen; there is thus no pollen free in the air of the field, except the small quantity that escapes while making the hand pollinations. The quantity of free pollen is further reduced by an ingenious method of applying the pollen by means of an insect-powder "gun" or spring blower. By this method the pollen is distributed so perfectly that but a small part of the amount usually required is sufficient. Another precaution used by careful operators is to wash their hands in alcohol after each pollination in order to destroy the vitality of any pollen that might remain on the hands.

EXTENT OF CONTAMINATION.

Regarding the amount of foreign pollen that gains access to ears pollinated in the ordinary way, East states that in 53 ears bagged and the bags not removed 14 seeds developed and in 25 ears manipulated as in pollinating but to which no pollen was applied 20 seeds were formed.[2] These figures are not very different from results obtained by the writers in using the same method. When 106 ears were bagged and the bags allowed to remain, 10 seeds were produced on 5 ears. The operation of pollination applied to 23 ears, but without the application of pollen, produced in all 1 seed. Our somewhat more favorable results are probably the result of bagging the ears at an earlier date.

DESCRIPTION OF THE NEW METHOD.

The method here proposed involves the use of strong paper tubes about 4 inches in diameter and 40 inches long. Longer tubes are sometimes necessary for very tall plants, and for short plants a piece may need to be torn off. To apply the tubes, one end is pushed over the tassel and wired firmly at a point just below the upper end of the last leaf sheath. The other end of the tube is then brought down and passed over the young ear and securely wired. (Fig. 1.) In pulling the tube down to the ear the tassel will be bent to one side in such a way that as soon as the anthers open the pollen falls down the tube and comes in contact with the silks. To protect against any foreign pollen which may be present on the tassel or ear when bagged, the tubes should be put in place four or five days before the silks are expected to appear. The greatest difficulty in applying the tubes is

[1] Roberts, H. F. A New Method of Corn Pollination. American Breeders' Magazine, vol. 2, no. 1, 1911, p. 55.

[2] East, E. M., and Hayes, H. K. Inheritance in Maize. Bulletin 167, Connecticut Agricultural Experiment Station, 1911, pp. 30–31.

to allow for the elongation of the stalk above the ear. Unless guarded against, this elongation will break the stalk at the base of the tassel and then push through the paper, making an opening where foreign pollen can enter. To prevent this breaking of the tube, two extra

FIG. 1.—Corn plant, showing method of using paper tube to insure self-pollination.

folds are taken where the paper is cemented, making a strip an inch or so wide composed of four thicknesses of paper. In adjusting the tubes this strip is placed on the upper side, causing the tube to form an even curve instead of bending sharply at one point.

Since the tubes remain in place until all danger from foreign pollen is past, provision must be made for the increasing size of the ear. This can be done by using a coiled instead of a straight wire to fasten the tube to the ear. The coiled wires are easily made by wrapping the wire around any small cone-shaped object, like the point of a lead pencil. The advantage of the cone-shaped coil over a cylindrical coil is that the tension necessary to straighten the coil is nicely graduated when a cone-shaped coil is used. (Fig. 2.)

Some experience is necessary to apply the tubes properly, and the exact manner has to be varied slightly for the different types of corn. When the ears are well exserted before silking it has been found best to bring the leaf just below the ear up against the outside of the tube and pass the wire around it: otherwise, it is difficult to keep the tube from slipping off the ear as the stalk elongates. The most difficult cases are those where the exsertion of the ear at silking is small. In such cases it is necessary to pass the wire around the stalk as well as around the leaf. With varieties that have large husk leaves it is well to remove them by cutting off the tips of the husks at a point beyond the tip of the young ear; otherwise, the silks become entangled in the mass of leaves and the pollen fails to gain access to all.

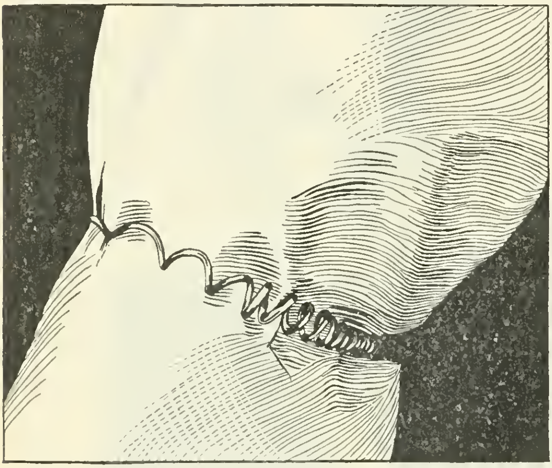

Fig. 2.—Coiled wire used in attaching the paper to the ear.

While this method can be generally applied only to ears that are to be self-pollinated, it works equally well for artificially crossing two plants that are adjacent in the same or neighboring rows. In testing Mendelian ratios it will be found convenient to arrange the planting with the hybrids between the parents. It will thus be possible to apply the method to self-pollinations and crosses between the hybrid and the parents.

Where the tubes are used it would seem that the only possible source of contamination would be from pollen on the tip of the ear or husk leaves at the time the tube was applied. To test this possibility, the tassels were removed from four plants and tubes applied in the customary way. Before applying the tube a quantity of fresh pollen was placed on the tip of the ear. No seed was formed on any of these ears, the time that had elapsed before the silks emerged having been sufficient for the pollen to lose its vitality.

In work with bagged plants the writers have been greatly annoyed by the frequency with which the ear grows through the bag during moist weather. This annoyance is entirely avoided by the use of tubes. A further source of error when bags are used, unless the wiring is carefully done, is the possibility of the silks becoming exposed by growing down along the husks and coming out between the wire and the ear. When tubes are used, the small diameter of the tubes and the fact that the elongation of the ear is unobstructed causes the silks to grow straight up the tube.

Regarding the time necessary to apply the tubes, it was found that with practice 30 tubes could be applied in an hour. Since all the work is completed in the one operation, the saving of time as compared with the system of bagging is very considerable.

Approved:

James Wilson,

Secretary of Agriculture.

Washington, D. C., *November 10, 1911.*

Issued February 6, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 90.

B. T. GALLOWAY, Chief of Bureau.

SUGGESTIONS TO POTATO GROWERS ON IRRIGATED LANDS.

BY

L. C. CORBETT,
Horticulturist.

21974°—Cir. 90—12 WASHINGTON : GOVERNMENT PRINTING OFFICE : 1912

BUREAU OF PLANT INDUSTRY.

B. P. I.—714.

SUGGESTIONS TO POTATO GROWERS ON IRRIGATED LANDS.

INTRODUCTION.

Considering the difficulties which have confronted potato growers on the irrigated lands of western Nebraska and northeastern Colorado during the last year, it would seem wise to pay special attention to such questions as the preparation of land, the time and manner of irrigation, the seed supply, and the rotation of crops on lands designed for potato culture.

PREPARATION OF LAND.

Since the potato is a deep-rooted crop and forms its tubers beneath the soil, it stands to reason that it requires a much deeper seed bed than will be necessary for cereal crops. In fact, the preparation for potatoes should be as deep and as thorough as for sugar beets, whether in the irrigated or in the humid region. If a preparatory crop such as alfalfa or clover is to be turned under for potatoes, it is advisable to plow this crop under in the fall and to compact the soil sufficiently to make it a good retainer for water, but not so smooth that it will blow. Before planting in the spring the land should be made fine to a depth sufficient to admit of planting and cultivation. If unusually dry the land should be irrigated before the crop is planted. If the normal precipitation has occurred during the winter and spring months, the crop may be planted without irrigation. It is not advisable, however, to plant the crop in dry, hot earth and to immediately irrigate it. Irrigation should precede rather than follow the planting. If the crop does not grow rapidly after planting, irrigation should be provided from time to time as the appearance of the crop and the condition of the soil would indicate; a dark-green or blackish color shows a lack of moisture on the part of the plants, while light-green or yellowish tints indicate the presence of too much moisture. The plant should be kept growing at the maximum rate from the time it appears above the ground until it has completed its season's work, and cultivation supplemented by irrigation must be relied upon to keep the plant working.

METHOD OF IRRIGATION.

The water for irrigating potatoes is best applied in every other furrow, the furrows being narrow and deep and the water so applied that the ground will not be saturated above the point where the tubers are formed. This will induce the formation of a deep instead of a superficial root system. In order to accomplish this the rows must be sufficiently wide apart to admit of throwing up broad high ridges, with narrow deep furrows between, in which the water can be led in a small stream for a long period rather than by means of a large stream flowing only for a short time. The successive irrigations should be carried on in alternate rows; the second irrigation should be in the rows not used by the first, and the third in the rows used during the first. Cultivation should follow irrigation as quickly as the condition of the soil will permit, but as soon as the tubers have made their growth, usually about September 1, water should be withheld so that the soil will dry and the crop ripen in proper condition for harvesting.

After the crop has been harvested it is wise to rake and burn all refuse matter. Vines allowed to decay upon the land tend to perpetuate any disease that may have been present upon the crop during the growing season. There is little fertility in the vines, and the danger of contaminating the following season's crop by harboring disease is greater than the value of the vines for manurial purposes.

A good winter treatment would be to plow the land deeply and allow it to remain in a rough condition during the winter in order that it may hold all the snow which may fall and rapidly absorb the rains. Rough earth will not blow as badly as that which is smooth.

SEED.

As a rule, seed from a distance does not do so well the first year in any given locality as home-grown seed. For this reason it is advisable each year to bring in sufficient seed to grow a seed patch large enough to supply all of the tubers necessary for planting the next year's crop. By this method new seed will be available, and it will have had the advantage of one year's growth in the home locality and will not have the disadvantages that arise from repeated reproduction on lands frequently used for potato culture.

ROTATION OF CROPS FOR POTATO CULTURE.

Throughout the eastern United States and upon the irrigated lands of the West it has been the prevailing practice to grow potatoes upon lands which have previously grown a leguminous crop, such as clover or alfalfa. These crops supply organic matter in abundance and at the same time provide the necessary amount of nitrogen for the potato crop.

After careful observations of the behavior of the crop on irrigated soils, particularly on those of a retentive nature, it is believed that more satisfactory results will be obtained by following a somewhat modified rotation in which the leguminous crop is plowed under for a cereal crop, such as corn, which is given clean cultivation, and the cereal crop is followed by the potato crop. If corn is not grown in sufficient quantity to bear this relation to the rotation, oat or wheat stubble might be used instead. The decaying organic matter produced by plowing under alfalfa or clover would then be removed far enough from the potato crop to allow complete decomposition of the organic matter and a slight withdrawal of nitrogen by the cereal crop.

On some of the lands where the alfalfa-potato rotation has been carried on for a number of years, the growers say that it is necessary to raise a crop of sugar beets from time to time when the land gets too rich for potatoes. It is believed that this observation is very pertinent to the success of the potato industry in the irrigated section and, although alfalfa must always form the main crop of any rotation system in this region, a greater use of cereals, particularly corn, would prove an advantage in connection with potato culture.

UNFAVORABLE CONDITIONS IN 1911.

The conditions which have prevailed in western Nebraska and northeastern Colorado during the last crop season have been such as to induce very extraordinary behavior on the part of the potato plant. The hot, dry weather which occurred early in the season tended to weaken the potato plants and make them backward in the production of tubers. The delay in irrigation until the plants showed signs of decided need of water produced a check in the plants. When the water was applied it brought about conditions unfavorable for the growth of the potatoes, but very favorable to the development of disease. Diseases which are usually present, but which only manifest themselves later in the season, were during the present year moved forward to such an extent that instead of lessening the crop to a very slight extent, as is the usual occurrence, they came early enough to practically prevent the development of the crop.

If normal conditions obtain next season, it is not likely that there will be a recurrence of the troubles which have caused so much loss during the present year. It is believed, however, that should the season of 1912 prove to be a repetition of that of 1911 the above precautionary suggestions, if carefully followed, will in a great measure serve to overcome losses.

SUMMARY.

Cultivate the soil deeply, making a deep seed bed. Watch carefully the needs of the plants and irrigate as often as necessary, using a minimum quantity of water and a maximum amount of cultivation. Provide deep furrows for irrigation, so as to stimulate the development of a deep rather than a shallow root system in the plants. Use clean seed. Clear the fields of diseased vines and rubbish at the close of the harvest season and use every device known to induce a rapid, continuous, healthy growth in the plants from the time they appear above the ground until the crop is made.

Approved:

James Wilson,

Secretary of Agriculture.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 91.

B. T. GALLOWAY, Chief of Bureau.

THE NEMATODE GALLWORM ON POTATOES AND OTHER CROP PLANTS IN NEVADA.

BY

C. S. SCOFIELD,

Agriculturist, Western Agricultural Extension.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1912

BUREAU OF PLANT INDUSTRY.

Chief of Bureau, BEVERLY T. GALLOWAY.
Assistant Chief of Bureau, WILLIAM A. TAYLOR.
Editor, J. E. ROCKWELL.
Chief Clerk, JAMES E. JONES.

B. P. I.—729.

THE NEMATODE GALLWORM ON POTATOES AND OTHER CROP PLANTS IN NEVADA.[1]

INTRODUCTION.

During the seasons of 1910 and 1911 there occurred in certain irrigated potato-growing districts of Nevada an outbreak of a potato disease known locally as the eelworm. Particular attention was attracted to the ravages of this disease because several carloads of potatoes shipped from Nevada into California during the winter of 1910–11 were condemned by certain county horticultural commissioners of California and were returned to Nevada to be disposed of elsewhere. A recurrence of the disease in the season of 1911 and the shipment of infected potatoes into California resulted in the issuance by the State Commissioner of Horticulture of California of an order establishing a quarantine against all potatoes shipped into that State from the counties of Lyon, Churchill, and Washoe, in the State of Nevada.[2]

Since California markets have afforded the chief outlet for the potatoes grown in Nevada in excess of local needs and since potatoes have been a very profitable crop in certain irrigated districts in Nevada, the closing of California markets to their potatoes has been severely felt by Nevada potato growers. The outbreak of the so-called eelworm disease or nematode gallworm disease in these Nevada potato fields has been so severe and the results so disastrous as to warrant bringing together the available information concerning this disease as it affects potatoes and other crop plants, for the assistance of the affected districts in Nevada. Some of this information may be applicable also to other sections of the country,

[1] Owing to a severe outbreak of a potato disease in certain irrigated districts in Nevada, caused by the nematode *Heterodera radicicola*, there has been an urgent demand for information as to the cause of the disease, the probable extent of its spread, and the possible remedies. In order to meet this demand for information a committee was appointed, consisting of Dr. N. A. Cobb, Technologist, Prof. L. C. Corbett, Horticulturist, Dr. W. A. Orton, Pathologist, and Mr. C. S. Scofield, Agriculturist, all of the Bureau of Plant Industry, to bring together such available information as would be most useful to the potato growers and others concerned. While the present interest in this nematode is due to its attacks on potatoes, it should be clearly understood (1) that the same nematode is parasitic on many other important crop plants, where it may cause damage, and (2) that this is but one of a number of species of parasitic nematodes. It is important to keep these facts in mind to avoid serious mistakes in dealing with the present problem in Nevada and similar problems that may occur elsewhere.—B. T. GALLOWAY, *Chief of Bureau.*

[2] For further details in reference to this quarantine order, see Monthly Bulletin of the State Commissioner of Horticulture of California, vol. 1, December, 1911, pp. 26–30; and also the same publication for January, 1912, in which a modification of this order was published.

for the same nematode which has caused the potato disease in Nevada is widely distributed throughout the United States and is causing every year much more damage than is generally understood.

It is the purpose of the present publication to give some information concerning the parasite which is the cause of this potato disease, briefly describe its life history, indicate some of the sources of infection and methods of transferring the parasite from one place to another, and suggest remedial measures for combating the disease in Nevada.

It is of the utmost importance to those concerned to act intelligently in dealing with the present situation in Nevada. The potato crop is one of the most profitable crops at present produced on the irrigated lands of Nevada. When not injured by the gallworm the potatoes are of very high quality and usually command a higher price in California markets than potatoes from any other section. It is important, therefore, to prevent the further spread of this parasite in the potato-growing sections of the State and so to reduce its numbers where it now occurs that it will cease to be a serious pest. This can be accomplished through first locating all of the infested fields and then devoting these fields to the production of crops upon which the nematode can not live. This location of infested areas will require very thorough inspection of all the fields which have been used for potatoes within recent years. Such an inspection to be thorough must be made by examining the roots of plants that are susceptible to the attacks of this species of nematode. The inspection should go still farther and include a critical examination of all fields on which it is proposed to plant potatoes. The nematode gallworm is parasitic on so many plants that it may easily live in the soil for many years if plants which it can attack are present.

A critical inspection of the irrigated lands of Nevada will probably show that the nematode gallworm occurs only in small and restricted areas. If these infested areas are definitely located and precautions are taken to avoid carrying the worm to other fields where it does not now occur, and if at the same time these infested fields are devoted exclusively to crops which can not harbor the parasite, it should be possible in a few years to reduce its numbers to a point where it will cease to be a factor of importance.

CAUSES OF THE POTATO DISEASE.

The so-called eelworm or gallworm disease (also called "root-knot") is caused by a minute nematode worm (*Heterodera radicicola* (Greef.) Müll.). Figures 1 and 2 show the two sexes of this worm enlarged to illustrate various features which are so small as to be almost invisible to the naked eye. The mature female is nearly pear shaped, as shown in figure 1, being less than a millimeter in length, more often about three-fourths of a millimeter long, the body cavity being occupied by eggs and larvæ. The male is a slender, thread-like worm, from 1 to 1.5 millimeters in length (see fig. 2). The development of the female takes place within the underground tissues of the host plant and its presence in these tissues is indicated by enlargements or malformations. Figure 3 shows a potato which is badly infected with gallworms. The skin is roughened and broken in patches. Not all infected potatoes show the same symptoms. Often the gallworm is found in potatoes of which the skin is nearly smooth, and in such cases the presence of the parasite can be detected only by cutting the potato. In the infected tubers there is usually a ring of darkened tissue just under the skin, and a microscopical examination of this tissue will reveal the presence of the mature females and the young larvæ. In figure 4 are shown the larvæ and the eggs of the gallworm as seen through the microscope from a preparation made from a diseased potato. One of the eggs seen in figure 4 is shown still further enlarged in figure 5.

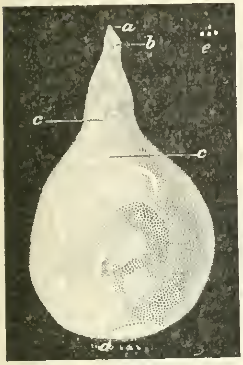

FIG. 1.—Female of the nematode gallworm (*Heterodera radicicola*) magnified 85 diameters: *a*, Mouth; *b*, spherical sucking bulb; *c*, *c*, ovaries, as seen through the body wall; *d*, anus; *e*, small white spots showing approximately the natural size of these worms. They are usually white. It is generally not difficult to isolate them in water by breaking open the galls containing them. (After N. A. Cobb.)

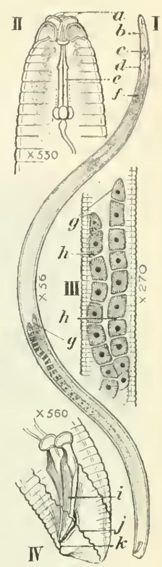

FIG 2.—The adult male of *Heterodera radicicola*, or gallworm: *I*, Worm in profile view; *II*, head of the same, more highly magnified; *III*, middle region of the worm showing blind ends of the sexual organs; *IV*, posterior extremity. The drawings were prepared from stained specimens, examined in carbolic-acid solution.

a, Lips; *b*, œsophageal tube; *c*, median bulb; *d*, exeretory pore; *e*, spear; *f*, intestine; *g*, blind ends of testicles; *h*, testicles; *i*, spicula; *j*, rudimentary bursa; *k*, anus. (After N. A. Cobb.)

LIFE HISTORY OF THE GALLWORM.

The larvæ of the gallworm upon hatching from the egg, which hatching sometimes occurs within the body of the parent, ultimately escape from the host plant and live for a period in the surrounding soil. These larvæ, although very active, have but little power of progressive locomotion, and the spread of infection from place to place must depend upon the transportation of infested soil or infected plants. Soon after emerging from the parent and the tissue of the host plant these larvæ seek other roots and bore their way into the plant tissues by means of a spear-like structure, which is protruded from the mouth. They feed upon the cell sap of the host plants.

After fertilization takes place the females begin reproduction by forming eggs within the body. These eggs are laid at the rate of from 10 to 15 a day, and it is estimated that one female may lay as many as 500 eggs. After completing the egg-laying process the female dies, the male having died soon after fertilizing the female.

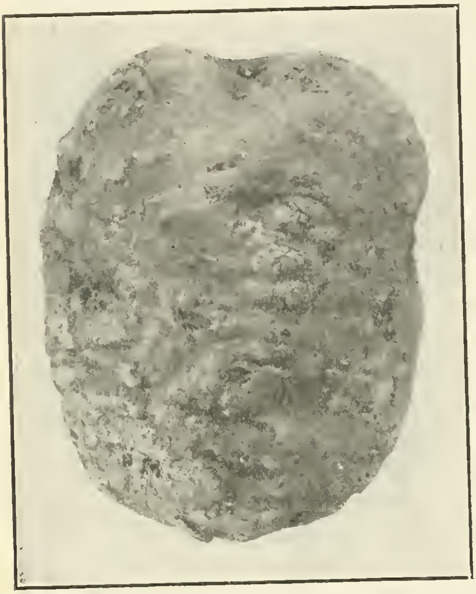

Fig. 3.—Potato infected with the gallworm. This shows the rough character of the surface, which indicates the presence of these worms. The knobs, or warts, are often much more strongly developed than in the above. Gallworms in seed potatoes are particularly dangerous, for if infected potatoes are used for seed the land will be inoculated. If infected potatoes are used as food, the refuse parts should be cooked or destroyed. Otherwise they may spread the disease. (After F. B. Headley.)

The worm lives from one season to the next, either in the egg stage or in the larval stage within the host plant. The life of the individual worm is short (only a few weeks), when temperature and moisture conditions are such as to favor growth.[1] It is possible, therefore, to greatly reduce the numbers, if not to exterminate the worm entirely, by keeping the infested land free from plants upon which the worm can feed.

SOURCES OF INFESTATION.

The gallworm discussed in this paper is one of a large number of species of nematode worms. This particular species occurs very generally throughout the southern United States. In many sections it is found in such large numbers as to be a serious pest to many crop plants, such as the peach, the fig, cowpeas, cotton, and many vegetables. It may be transported from place to place on any of these plants which it infests or in soil from infested fields. Probably the most common method of transporting the worm is through the shipment of nursery stock and of potatoes. The distribution of the worm

[1] Additional information concerning the life history of this parasite, with a list of susceptible plants and details of experiments in controlling the nematode in the southeastern United States, may be found in Bulletin 217 of the Bureau of Plant Industry, entitled "Root-Knot and Its Control," by Dr. Ernst A. Bessey, issued November 21, 1911.

from field to field in any particular district may be accomplished by carrying soil on agricultural implements, on the feet of animals or men, or by transplanting plants from one field to another. In fact, there are so many ways in which infestation can be accomplished that the greatest precautions should be used to prevent the distribution of infested earth or plants into uninfested areas. The careless disposal of garbage containing infected potato peelings or the spreading of manure from yards where infected roots or tubers have been used as stock feed may transport the worm and develop serious infestation.

FIG. 4.—Microphotograph of the eggs of the gallworm and the young worms just hatched, taken from a potato. This appearance is often seen in microscopic preparations made from infested areas of roots. (After F. B. Headley.)

All classes of nursery stock, including strawberry plants, tomato plants, and small fruits, should be examined with great care if they are to be set in fields which it is desired to keep free from this parasite.

UNINFECTED SEED POTATOES ABSOLUTELY ESSENTIAL.

In attempting to control this disease it is, of course, absolutely essential to plant uninfected potatoes as seed. It is not enough to be sure that the potatoes planted do not show superficial evidences of the disease; it should be determined beyond doubt that there is absolutely no infection present. This can best be assured by securing clean and healthy seed from fields where a critical inspection shows that the disease has not been present.

All culled potatoes from the field should be examined, for even when disease is present the bulk of the crop may be unaffected. The gallworm does not occur in the potato-growing districts of the Northern States, particularly North Dakota, Minnesota, Wisconsin, and Maine. Seed obtained originally from these States and grown on fields that are free from the gallworm should be safe to use in planting other uninfested fields. Too much stress can not be laid upon the importance of securing for planting potatoes which are uninfected and in planting them on uninfested land.

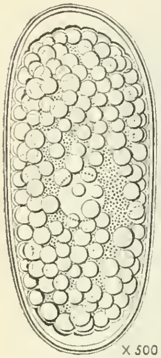

FIG. 5.—Newly deposited egg of the gallworm. These eggs are distinctive features of the nematode disease. They occur in large numbers, as shown in figure 4. (After N. A. Cobb.)

LOCALIZATION OF INFESTED AREAS.

The practical problem which confronts the potato growers of Nevada is the location of all fields which are infested with this parasitic nematode. The present indications are that the nematode infestation is by no means general in irrigated land. The nematode has probably existed in some of the older irrigated lands of the State for many years, but there is much new land being put under irrigation in Nevada, which it seems probable is entirely free from this worm. If all of the infested areas can be located by a critical inspection, it will be possible to produce potatoes in large quantities on uninfested land and devote the infested land to crops which are resistant to the parasite. There are probably some fields in the State which have been devoted to potatoes during the last year or two on which the parasite does not occur, and from these uninfested fields seed might be secured. It would be much safer, however, to obtain seed from the Northern States, such as Minnesota, Wisconsin, or North Dakota, with which to plant new land, rather than to risk the infestation of the new land with local seed. But it will be impossible to proceed intelligently in combating the ravages of the gallworm until the infested areas have been located, so that the danger of infestation, not only by means of potatoes but in many other ways, can be fully ascertained.

SUSCEPTIBILITY OF OTHER PLANTS.

In view of the fact that the gallworm is parasitic on many plants other than potatoes, it is important not to foster the parasite by the culture of plants which are subject to its attacks. The following is a list of some of the plants which are readily and seriously attacked by the gallworm and which should never be grown on infested fields or transplanted into uninfested land from any land that may possibly be infested:

Beets, carrots, celery, cucumbers, eggplant, lettuce, muskmelon, pumpkins, potatoes, salsify, squash, tomato, watermelon, clover, cowpeas, rape, soy beans, catalpa, cherry, elm, peach.

The following are subject to attack by nematodes and, although these plants are not themselves liable to serious injury, they should not be planted on infested soil for fear of keeping the gallworm alive:

Alfalfa, vetch, sweet clover, asparagus, cabbage, cauliflower, garden peas, horseradish, strawberries, kale, Lima beans, onions, radish, spinach, sweet potatoes.

FIG. 6.—Roots of peach, showing enlargements caused by the gallworm. Dr. Neal, investigating this disease in 1888, expressed the opinion that large numbers of peach trees in the southern United States had been killed by the gallworm. In short, agriculturists, seedsmen, nurserymen, and general merchants should be specially cautioned against rearing, buying, or selling trees, plants, or tubers which show any swelling on the roots except such as are well known to be natural to them. (After J. C. Neal.)

FIG. 7.—Roots of grape (Black Hamburg), showing enlargements caused by the gallworm. The total damage to various crops wrought by the gallworm amounts annually to an enormous sum of money. (After J. C. Neal.)

FIG. 8.—Roots of weeping willow, showing enlargements caused by the gallworm. The worm thrives in the moist sandy soils favorable to the growth of most willows. (After J. C. Neal.)

The following plants are, so far as known, seldom or never affected by the gallworm and may be used on infested land with the expectation of greatly reducing the numbers of the worms, particularly if the land is at the same time kept free from weeds and other plants which may be attacked:

Barley, oats, wheat, rye, corn, sorghum, milo, kafir, timothy, and redtop.

In view of the importance of recognizing promptly the presence of this nematode, the accompanying text figures are presented to show some of the malformations on the roots of different plants resulting from nematode attacks.

In figures 6, 7, 8, 9, and 10 are shown the results of gallworm injury on the peach, the grape, the willow, the fig, and cotton. These plants are all distinctly susceptible to gallworm injury and may serve to indicate the presence of this worm if it occurs abundantly in the soil. Figure 11 shows the enlargements on the roots of a cowpea caused by the nematode. These enlargements are characteristic and need not be confused with the nodules caused by the nitrogen-gathering bacteria which inhabit the roots of this plant. The nodules caused by the nitrogen-fixing bacteria are small and spherical and are attached to the side of the rootlets, while the nematode causes the swelling of the root itself. Figures 12 and 13 show the effect of the attack of the gallworm on red clover and also the worm as it is found in the roots. In figure 12 the enlargements on the roots are shown, while in figure 13 the sections of the root show the presence of the gallworm larvæ. Figure 14 shows the enlargement caused by the gallworm on the roots

FIG. 9.—Roots of the fig, showing enlargements caused by the nematode gallworm. The fig is very susceptible to the attacks of this parasite and, though when the roots are severely infested the tops may continue to grow when conditions are favorable, in times of drought or in cold weather the diseased plants suffer severely. (After J. C. Neal.)

FIG. 10.—Roots of cotton, showing enlargements caused by the gallworm. Owing to the wide prevalence of this worm in the southeastern United States, the aggregate annual damage which it causes on cotton is very large, though not generally appreciated. (After George F. Atkinson.)

FIG. 11.—Roots of the cowpea, showing enlargements caused by the gallworm. With the exception of one variety (the Iron cowpea) this plant is very susceptible to the gallworm, and the use of susceptible varieties as green-manure crops in peach orchards and in rotations just preceding cotton in the South is to be avoided. (After J. C. Neal.)

of sugar cane. Many plants of the grass family are practically immune to this parasite, as has already been indicated. Figure 15 shows the distortion and enlargement of the roots of the tomato caused by the gallworm. One of the dangerous sources of infestation of new land is through the transplanting of tomato plants grown in hotbeds, where conditions favor the development of the gallworm, and a careful inspection should be made of all tomato plants set in uninfested soil. Figure 16 shows the enlargement of the roots of the radish caused by the gallworm. This quick-growing vegetable may be used to advantage as an indicator to determine whether or not the

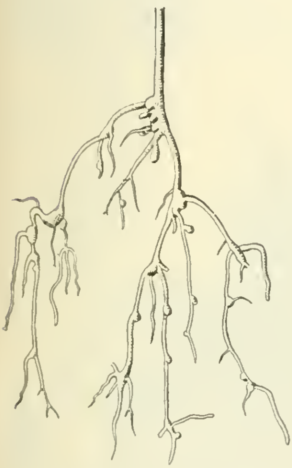

FIG. 12.—Root system of a young red-clover plant, with swellings caused by the gallworm. These enlargements should not be confused with the beneficial root nodules caused by nitrogen bacteria nor with the disease known as crown-gall. (After B. Frank.)

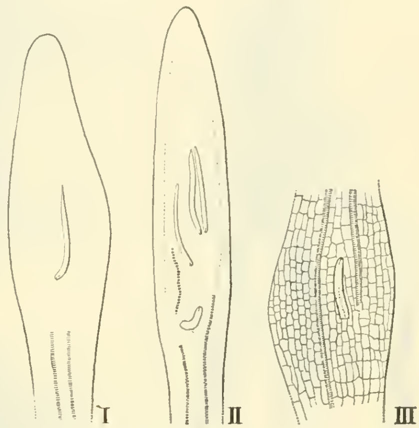

FIG. 13.—*I.* Longitudinal section of root tip of red-clover plant, showing a young gallworm (*Heterodera radicicola*) embedded in the tissues. (After B. Frank.) *II.* Longitudinal section of root tip of red-clover plant, showing four young gallworms (*Heterodera radicicola*) in the tissues. (After B. Frank.) *III.* Longitudinal section of root of red-clover plant, near the tip, showing enlargement caused by the gallworm (*Heterodera radicicola*) and a portion of the young worm. (After B. Frank.)

nematode occurs in any particular soil, though it would be unsafe to assume that a soil was free from nematodes if these enlargements were not conspicuous on the roots of the radish. Figure 17 shows a distortion of the parsnip caused by the gallworm, while figure 18 shows the same condition on salsify. Figures 19, 20, and 21 show the effects of the gallworm on the roots of the okra, cucumber, and lettuce.

POSSIBILITY OF ERADICATION.

So far as known there are no effective means of completely eradicating the gallworm from infested fields. It has been found practicable to eradicate it from the soil of greenhouses, hotbeds, and cold frames by methods of sterilization with steam or chemicals; but such methods are too expensive for field application. Where the gallworm occurs in fields, its subjugation can be accomplished only by slower methods. In some cases it may be possible to flood land with irrigation water and keep it submerged for a period of several months, and thus destroy the living nematodes and the eggs; but in view of the fact that nematodes are usually more abundant on light sandy soils than on heavy soils such protracted flooding is not often practicable. It may also be possible in some cases to keep the infested field in clean fallow long enough to starve out all the nematodes; but this is hardly practicable in any region where the soil is light and subject to wind erosion.

FIG. 14.—Roots of sugar cane, showing enlargements caused by the gallworm. This worm is common and destructive in the Tropics. Many plants of the grass family resist the disease. (After N. A. Cobb.)

FIG. 15.—Roots of tomato, showing enlargements caused by the gallworm. Tomatoes sometimes suffer severely from this disease. (After George F. Atkinson.)

CROPS SUGGESTED FOR INFESTED AREAS.

Probably the best means of combating the nematode is by planting crops which are not subject to its attacks. Such crops as corn, sorghum, wheat, rye, oats, and barley are among the most promising for this purpose. Corn and sorghum are particularly desirable, because they permit clean tillage, and thus all weeds and other plants on which the nematodes might live may be kept out. It should be particularly noted that the sugar beet is susceptible to the nematode and should not be planted on fields known to be infested.

SUMMARY.

During the seasons of 1910 and 1911 there has been a serious infestation of certain potato fields in Nevada caused by a nematode gallworm known as *Heterodera radicicola.* This has resulted in hindering the marketing of Nevada potatoes in California, where the crop has been sold heretofore.

FIG. 16.—Radish showing root enlargements caused by the gallworm. Care should be taken not to confuse these enlargements with those of clubroot, a disease occurring on cabbage, turnips, and related plants. (After J. C. Neal.)

FIG. 17.—Parsnip attacked and deformed by the gallworm. This disease attacks the roots of hundreds of other kinds of plants. If such roots are used for food the refuse should be cooked or destroyed. Such material can not be introduced into New South Wales and other progressive States. (After N. A. Cobb.)

FIG. 18.—Roots of salsify, showing enlargements caused by the gallworm. A number of foreign countries have legislated against the introduction of plants and farm produce infested with this disease. (After George F. Atkinson.)

The parasite causing the disease is a very small unsegmented worm which invades the roots of many different plants, causing malformations and often seriously hindering the growth of the plants. The nematode multiplies very rapidly under favorable conditions. The life cycle may be completed within a few weeks and each female may lay as many as 500 eggs.

The nematode may be carried from place to place in the roots of living plants, in potatoes, on soil on the roots of nursery stock, or with potted plants. It may also be carried from one field to another in earth on farm implements or in irrigation water. Manure from yards where diseased roots or tubers have been fed may carry the

FIG. 19.—Roots of okra, showing the enlargements caused by the gallworm. The nematodes producing this disease are to be found in the root enlargements. (After J. C. Neal.)

worm, and garbage containing peelings of diseased potatoes is also a prolific source of infestation.

The use as seed of any infected potatoes is to be strongly condemned. No effort should be spared to locate all infested fields in a district where the nematode is known to occur, and seed potatoes should be secured from fields known to be uninfested or, better still, from a region where, because of adverse climatic conditions, the nematode is unknown.

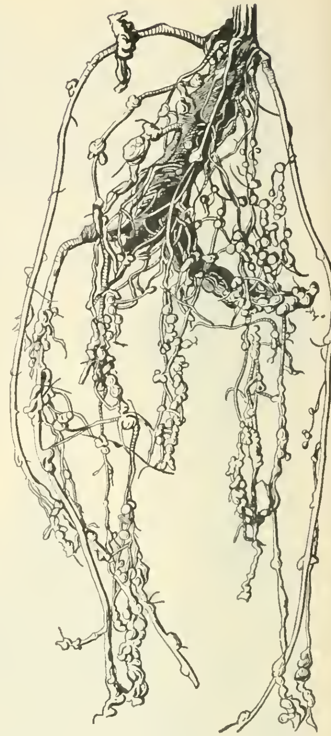

FIG. 20.—Roots of cucumber, showing enlargements caused by the gallworm. Nearly all other common garden plants are similarly attacked. There are many thousands of the worms in the nodules upon such a root system. (After Kati Marcinowski.)

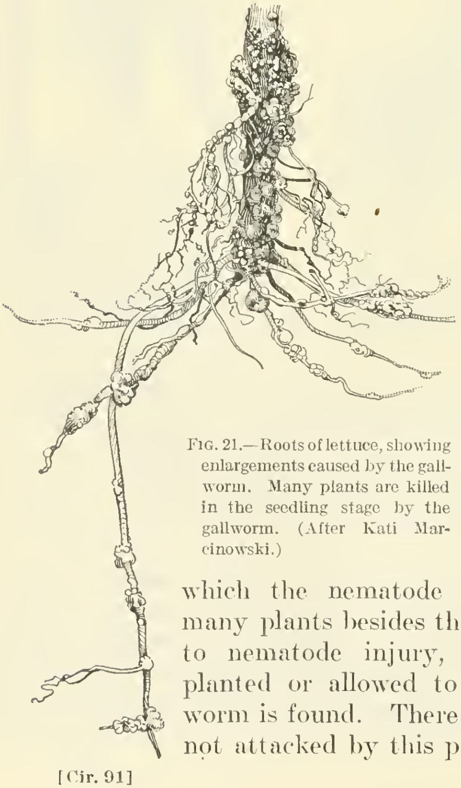

FIG. 21.—Roots of lettuce, showing enlargements caused by the gallworm. Many plants are killed in the seedling stage by the gallworm. (After Kati Marcinowski.)

A thorough inspection should be made of all fields in each district where the nematode is suspected to occur, and all infested fields should be devoted to crops which the nematode does not attack. There are many plants besides the potato which are susceptible to nematode injury, and these should never be planted or allowed to grow in fields where the gallworm is found. There are a number of crops that are not attacked by this parasite, and these only should be grown on infested fields until the nematode is practically starved out.

It is very difficult to eradicate the nematode completely when it is once well established in a field, but its numbers may be so reduced by the use of immune crops that susceptible crops may be grown again without serious injury.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *February 10, 1912.*

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B. T. GALLOWAY, Chief of Bureau.

THE CONTROL OF COTTON WILT AND ROOT-KNOT.

BY

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THE CONTROL OF COTTON WILT AND ROOT-KNOT.

INTRODUCTION.

General attention should be called to the spread of two diseases which seriously injure cotton, particularly on sandy land. These are cotton wilt, or "black-root," and root-knot. They already occur in scattered localities from North Carolina to Texas and are estimated to cause an annual loss exceeding $10,000,000. There are thousands of acres of land already so infested that ordinary varieties of cotton can not be grown, and the area enlarges each year.

In addition to the loss of crops this land has depreciated in market value; it costs more to cultivate on account of the weeds and grass that spring up after the cotton dies, and the farmer must often use it for crops less profitable than cotton.

This situation is the more unfortunate because it is unnecessary. These diseases may be controlled by the means pointed out in this circular.

Fig. 1.—A young cotton plant dying from wilt.

HOW TO RECOGNIZE COTTON WILT.

When plants wilt suddenly or the leaves yellow and fall without apparent reason, the wilt is to be suspected. (Fig. 1.) If a freshly wilted plant is pulled and the inner wood of the stem or root is found blackened (fig. 2), the disease is almost certainly wilt.

The trouble begins in May and June and continues to develop throughout the season. Its first appearance in a field is likely to be in small spots, which enlarge each season until considerable areas are affected. Beyond the places where the cotton is killed, dwarfed or stunted plants occur. Some plants remain alive in the worst areas, and by selection from such individuals resistant varieties have been developed.

Cotton wilt is more fully described in Farmers' Bulletin 333, entitled "Cotton Wilt," which will be sent free upon application to a

FIG. 2.—Cross sections of cotton stem, showing browning of wood caused by the wilt fungus. (Natural size.)

FIG. 3.—Roots of cotton, showing enlargements caused by the gallworm. Owing to the wide prevalence of this worm in the southeastern United States, the aggregate annual damage which it causes on cotton is very large, though not generally appreciated. (After George F. Atkinson.)

FIG. 4.—Roots of okra, showing the enlargements caused by the gallworm. The nematodes producing this disease are to be found in the root enlargements. (After J. C. Neal.)

Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture.

HOW TO RECOGNIZE ROOT-KNOT.

Where root-knot occurs with wilt the injury from the latter is greatly increased. Root-knot itself does not show on the aboveground parts of the plant except through its indirect injury, and hence is frequently overlooked.

It is desirable that the farmer know with certainty whether there is root-knot in his land. As a test, okra, tomatoes, or cantaloupes may be planted and the roots dug up after midsummer and examined for swellings or galls. If these are found, a rotation of plants immune to root-knot should be started to get rid of the pest. (See p. 7.)

Root-knot causes a knotlike enlargement of the roots, varying in size from a pinhead to a hen's egg. The galls on cotton are small,

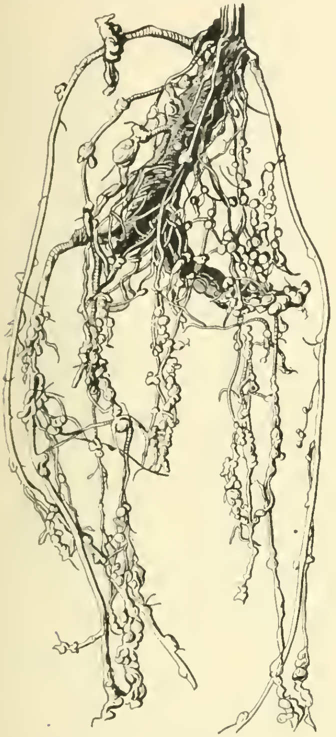

FIG. 5.—Roots of cucumber, showing enlargements caused by the gallworm. Nearly all other common garden plants are similarly attacked. There are many thousands of the worms in the nodules upon such a root system. (After Kati Marcinowski.)

FIG. 7.—Roots of the cowpea, showing enlargements caused by the gallworm. With the exception of one variety (the Iron cowpea) this plant is very susceptible to the gallworm, and the use of susceptible varieties as green-manure crops in peach orchards and in rotations just preceding cotton in the South is to be avoided. (After J. C. Neal.)

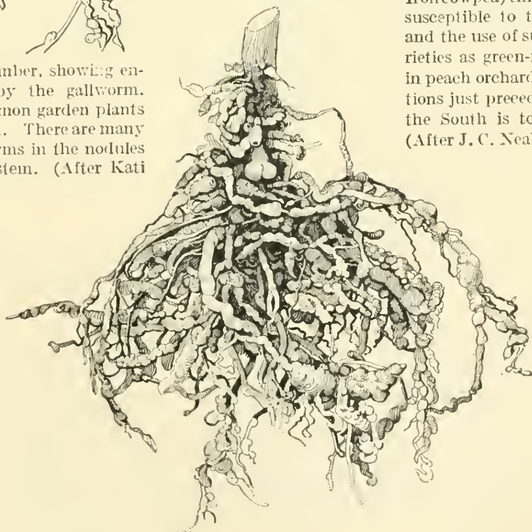

FIG. 6.—Roots of tomato, showing enlargements caused by the gallworm. Tomatoes sometimes suffer severely from this disease. (After George F. Atkinson.)

on okra larger, and on cucumbers and tomatoes frequently of great size, as shown in figures 3, 4, 5, and 6. Ordinary cowpeas are very much subject to root-knot (fig. 7), and experience has shown that when a farmer has observed that his cotton wilts worse after a cowpea crop the cause is almost always root-knot.

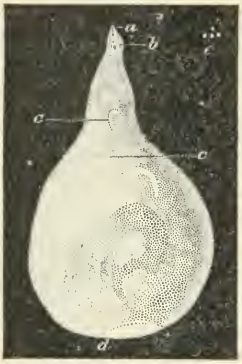

FIG. 8.—Female of the nematode gallworm (*Heterodera radicicola*) magnified 85 diameters: *a*, Mouth; *b*, spherical sucking bulb; *c*, *c*, ovaries, as seen through the body wall; *d*, anus; *e*, small white spots showing approximately the natural size of these worms. They are usually white. It is generally not difficult to isolate them in water by breaking open the galls containing them. (After N. A. Cobb.)

For a complete discussion of root-knot, its cause and control, see Bulletin 217 of the Bureau of Plant Industry, entitled "Root-Knot and Its Control."

IMPORTANT FACTS CONCERNING WILT AND ROOT-KNOT.

Cause.—Wilt is caused by a parasitic fungus, a minute threadlike organism, which enters the roots from the soil and plugs the water-carrying vessels of the root and stem.

Root-knot is caused by minute eelworms, or nematodes, which bore into the roots. (See figs. 8 and 9.) The irritation caused by these worms results in enlarged growths of the root at the point of attack.

Plants attacked.—The cotton-wilt fungus attacks only cotton and okra. There are very similar wilt diseases of the cowpea, watermelon, tomato, and other crops, but they are not communicable to cotton.

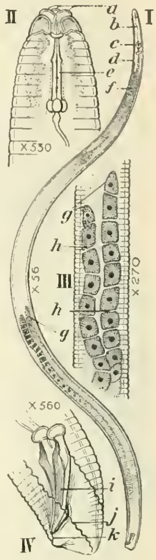

FIG. 9.—The adult male of *Heterodera radicicola*, or gallworm: *I*, Worm in profile view; *II*, head of the same, more highly magnified; *III*, middle region of the worm showing blind ends of the sexual organs; *IV*, posterior extremity. The drawings were prepared from stained specimens, examined in carbolic-acid solution.

a, Lips; *b*, œsophageal tube; *c*, median bulb; *d*, excretory pore; *e*, spear; *f*, intestine; *g*, blind ends of testicles; *h*, testicles; *i*, spicula; *j*, rudimentary bursa; *k*, anus. (After N. A. Cobb.)

The root-knot nematode attacks a very large number of plants and spreads freely from one to another. A few plants are immune; see list on page 7.

Duration of infection.—The wilt fungus lives many years in the soil. Rotation of crops affords only slight relief.

The root-knot nematode may be starved out by two to four year rotations of crops on which it can not live.

Fertilizers and fungicides ineffective.—Neither cotton wilt nor root-knot can be prevented by the use of kainit, salt, phosphate, or other fertilizers; nor by sulphur, lime, or other fungicides applied to the soil. Stable manure in some cases affords a degree of temporary relief from wilt.

Relation to soil.—Both wilt and root-knot are mainly confined to sandy or light loam soils. Clay soils are but seldom infected.

Means of distribution.—Wilt is spread by direct growth through the soil, by cultivation, by drainage water, by cattle, by manure, and in other ways not always explainable. No attempt to check it has ever succeeded.

Root-knot is generally brought to a farm on figs, peaches, or other plants purchased, and after its introduction it is propagated chiefly by growing ordinary cowpeas, which are quite susceptible.

Varietal resistance.—Varieties of cotton resistant to wilt have developed. The only successful method of control appears to lie along this line. Resistance to root-knot may be secured by future breeding, but at present this disease must be controlled by proper rotations.

Wilt and root-knot generally occur together. Most cases of "black-root" consist of such mixed infections and require a rotation to be practiced before resistant varieties will give their best results.

THE CONTROL OF ROOT-KNOT BY CROP ROTATION.

The principles on which rotations for the control of root-knot are based are the use of crops immune from attack and, as far as possible, those which return a profit, the building up of the fertility of the soil, and, furthermore, the eradication of all weeds subject to root-knot. Rotation and diversification of crops are of fundamental importance to southern agriculture everywhere and become absolutely necessary where the root-knot nematode is present.

The rotations necessary are of a special character, as indicated below:

CROPS IMMUNE TO ROOT-KNOT.

Barley.
Beggarweed.
Brabham cowpea.
Corn.
Crab-grass.
Iron cowpea.
Peanut.
Rye.
Velvet bean.
Wheat.
Winter oats.

CROPS SUSCEPTIBLE TO ROOT-KNOT.

Alfalfa.
Asparagus.
Beans.
Cantaloupe.
Celery.
Clover.
Cotton.
Cowpeas (all except Iron and Brabham).
Cucumbers.
Figs.
Mulberries.
Okra.
Peaches.
Soy beans.
Sugar cane.
Sweet potato.
Tobacco.
Tomatoes.
Vetch.
Watermelon.

WEEDS ATTACKED BY ROOT-KNOT AND THEREFORE TO BE ERADICATED.

Balloon vine (*Cardiospermum halicacabum* L.).
Indian potato (*Ipomoea* sp.).
Maypop or passion flower. (*Passiflora incarnata* L.).
Mayweed (*Anthemis cotula* L.).
Papaya or melon pawpaw (*Carica papaya* L.).
Pigweed (*Amaranthus hybridus* L.).
Purslane (*Portulacca oleracea* L.).
Sawbrier (*Smilax glauca*, Walt.).
Sweet fennel (*Foeniculum vulgare* Hill).

The following rotations are suggested for fields infected with both wilt and root-knot: Beginning in the fall, sow winter oats if they can be gotten in early enough to make a fairly good growth before it is necessary to plow the land for the next crop. Plow the oats under for green manure and plant corn with Iron or Brabham cowpeas between the rows, putting the corn in at the usual time, about March 15 to 20 for middle Georgia and South Carolina. In the fall sow a winter grain; this can be cut for hay the next May or allowed to ripen. Cowpeas, either the Brabham or the Iron variety, may then be sown broadcast, or, better, in 2-foot drills, where they can be cultivated once or twice. Cut the cowpeas for hay and follow with another crop of winter grain. This should be plowed under in the spring in time to plant a wilt-resistant variety of cotton the third year. If it is desired to make a 4-year instead of a 3-year rotation, the last-mentioned crop of winter grain may be harvested for hay or allowed to ripen, a second crop of Iron or Brabham cowpeas broadcasted for hay, and this followed by oats to be plowed in for green manure. A wilt-resistant variety of cotton should then be planted. Wheat, rye, or barley may be substituted for oats as a winter grain crop and velvet beans for the Iron or Brabham cowpea in the more southern districts.

THE CONTROL OF WILT BY THE USE OF RESISTANT VARIETIES.

The experiments of the Bureau of Plant Industry, which have now been carried on for 12 consecutive years, have shown that the only practicable solution of the wilt problem is through the use of resistant varieties developed by special breeding. Such varieties have been produced and grown successfully for the past six years in a large number of localities until no doubt remains as to the possibility and practicability of controlling wilt in this manner. During this time these cottons have been further improved by selection for better yield, greater resistance, higher percentage of lint, and other desirable characters.

The first wilt-resistant Upland cotton produced was the Dillon, a limbless, cluster variety derived from the old Jackson Limbless. The Dillon cotton is highly resistant to wilt and is a productive variety. It has produced a bale and a half per acre where other varieties were a complete failure. The yield of lint is from 37 to 38 per cent. This variety has been quite widely grown for several years with uniformly good results.

The second wilt-resistant variety bred was the Dixie. This has the branched pyramidal habit characteristic of the Peterkin group of varieties and is on this account more popular than the Dillon with those who object to a cluster cotton. It has medium-sized bolls and yields about 35 per cent of lint. More detailed descriptions of these varieties are given in Farmers' Bulletin 333.

A third promising variety, the Modella, also of the Peterkin type, is being introduced in Georgia by Mr. A. C. Lewis, of the Georgia State Board of Entomology.

The real problem at present is to bring these results within the reach of every farmer who needs them. The wilt exists on thousands of farms and each year is spreading very rapidly. The Government can not put into the hands of every farmer a supply of resistant seed, and, even if it could, experience has shown that this would not permanently relieve the situation, for special care is needed to prevent the resistant varieties from deteriorating through crossing with nonresistant cotton in neighboring fields, through the lack of careful selection, and through the mixing of seed at the gin. A careful man can maintain the quality of this cotton for an indefinite period, but when neglected it has to be replaced by fresh seed in three or four years. Consequently there is likely to be a permanent annual demand for some thousands of bushels of carefully bred wilt-resistant seed in every county. It is furthermore apparent that this should be supplied from within the home county, for locally bred seed is adapted to local conditions and gives better results than seed brought from a distance. An excellent opportunity exists for progressive men to engage with profit in the growing of this seed. The methods found most successful in this work require accuracy and care and instruction at the start. There is also need for educational work among the farmers that they may understand the methods of wilt control and the need for root-knot rotations in connection with the use of resistant varieties.

THE ORGANIZATION OF A COOPERATIVE CAMPAIGN.

The needs mentioned have led to the development of a cooperative arrangement between the three organizations that have been charged with one phase or another of the work, namely, the Office of Cotton and Truck Disease and the Office of Farmers' Cooperative Demonstration Work in the Bureau of Plant Industry and their respective State agencies, the agricultural experiment station at Clemson College for South Carolina, and the State Board of Entomology at Atlanta for Georgia.

Since the plan seeks to utilize all existing agencies and to put the great problem of wilt control on a self-supporting basis, the details will be of interest to all concerned. The Office of Cotton and Truck Disease has been engaged in the scientific questions involved—the study of the nature and cause of wilt, its control, the breeding of resistant varieties, the nature of disease resistance, etc. The pathological problems have been nearly solved. This office is now working on the relationship and parasitism of the wilt fungi. The breeding problems are also well on the way to solution. There remain to be completed studies on the inheritance of disease resistance and a new line of breeding made necessary by the eastward migration of the boll weevil, namely, the production of wilt-resistant varieties that are early, large bolled, and adapted to boll-weevil conditions. This work has been under way for four years. It has given results of promise and will be carried on to completion.

The part of this office in the cooperative work will be to outline methods of control, provide stocks of the resistant varieties bred, and furnish all needed aid and information to the other workers. The work will be done through its representatives in the field who are at the same time the employees of the South Carolina Agricultural Experiment Station and the Georgia State Board of Entomology. The work in Washington is in charge of Mr. W. A. Orton, assisted by Mr. W. W. Gilbert. The office is represented in South Carolina by Prof. H. W. Barre, of Clemson College, assisted by Mr. L. O. Watson, and in Georgia by Mr. E. L. Worsham and Mr. A. C. Lewis, of the State Board of Entomology at Atlanta.

The Farmers' Cooperative Demonstration Work, in charge of Mr. Bradford Knapp, has for its general object the improvement of agricultural methods and conditions in the regions invaded or about to be invaded by the boll weevil. It has built up for this purpose a large organization, reaching from State agents through county and local agents to thousands of farmers who are trying new methods. It is through these agents and demonstrators and through the extension department of the States that the men on the farm can be helped most directly. The part taken by this office in the cooperation consists in the dissemination of information, in bringing effective rotations for the control of root-knot into general practice through demonstrations by farmers, and in the introduction and trial of wilt-resistant varieties of cotton and cowpeas.

The agents of the Farmers' Cooperative Demonstration Work will meet the pathologists as frequently as possible and secure their help in identifying plant diseases and their advice regarding methods of control.

The officers of the experiment station in South Carolina and the Board of Entomology in Georgia cooperate in this campaign in several ways. Their pathologists are the official representatives of the Bureau of Plant Industry to the end that the efforts of all workers may be united and duplication of effort and expense avoided.

Two distinct lines of work are under way. The first is the dissemination of information on wilt and root-knot and their control. The second seeks to provide for the local production of an adequate supply of the resistant varieties of both cotton and cowpeas, the permanent maintenance of their quality, and the production of still better strains. This is to be accomplished by cooperation with progressive farmers in the wilt-infected territory.

THE COOPERATIVE BREEDING PLAN.

Experience has shown that most farmers lack the time or opportunity to do careful seed breeding and that consequently there is a large and steady demand for improved seed. It will be especially so with the resistant varieties, and it is believed that the production of such seed will constitute a specialized business in which a limited number of farmers will find it profitable to engage.

To assist in the development of such a line of work, and to insure the production of a supply of high-bred wilt-resistant seed of known origin, a plan of cooperation between the United States Department of Agriculture, the State agricultural officials, and the farmers who desire to make a specialty of such breeding work has been formulated and 20 or 30 men in each State (Georgia and South Carolina) have already become interested in the work. The farmers sign agreements with the Department and State representatives, promising to secure proper seed, to follow the breeding methods outlined, to exercise the necessary care to maintain the purity of their seed, and to offer it for sale at a reasonable price, not to exceed an amount previously agreed upon. They also agree that they will not sell seed not grown by them unless so stated. The Department and State representatives provide the cooperative breeders with small quantities of select planting seed or refer them to farmers from whom select seed can be purchased at a reasonable price, not to exceed $1.50 a bushel. They visit the breeders during the season to advise them regarding the best methods of breeding and to inspect their crops.

Two grades of selected seed will be recognized: "Registered seed" and "improved seed." Such men as attain the highest standard in their breeding by carefully following the individual-selection and progeny-row methods recommended and whose seed is of high grade will be granted a diploma and allowed to sell their crop as "registered seed." Other breeders who are found to be maintaining the standard of their varieties in wilt resistance, yield, and purity, but who are not yet following the required breeding methods in detail or doing progressive breeding will be given a certificate of recognition of quality and their seed will be designated "improved seed." These diplomas and certificates will be given only after thorough inspection of the growing crops by experts and after an official test of the seed placed on sale by the breeder in comparison with standard resistant strains.

HOW TO SECURE INFORMATION.

The farmer who has had trouble with wilt or root-knot may secure help from the nearest agent of the Farmers' Cooperative Demonstration Work or by addressing Prof. H. W. Barre, Clemson College, S. C., or Mr. A. C. Lewis, Capitol Building, Atlanta, Ga., who will advise him with regard to the diseases and the best methods of control·

HOW TO SECURE RESISTANT SEED.

As a result of the cooperative breeding work that has been carried on during the past season, a considerable supply of wilt-resistant cotton seed of the Dixie and Dillon varieties has been produced by cooperating farmers under the supervision of our representatives in Georgia and South Carolina. This seed is now for sale by them at a price not to exceed $1.50 a bushel. Parties desiring to secure any of this seed for planting should write immediately to Prof. Barre or to Mr. Lewis, stating how much seed is desired. An order on the cooperative breeder nearest them for the desired quantity of seed will then be sent them, together with the price to be paid. This order, accompanied by the necessary money, must be sent by the purchasing farmer to the breeder, who will immediately ship the seed. Shipment by freight or express should be specified, all charges to be paid by the purchaser.

THE PRINCIPLES OF BREEDING.

To maintain the quality of an established cotton variety it has generally been believed that it is only necessary to grow the cotton in a field as far separated from other cotton fields as circumstances permit, to pull out all plants of undesirable character (the process of "roguing" in the language of seed growers), and to exercise care at the gin to avoid mixture with other cotton. All this is indeed imperative, but it has been found that one step farther is necessary to accomplish the best results and that step is to practice the progeny-row method of breeding.

This method depends on the simple fact that plants differ not only in their visible characters but also in their ability to transmit these characters to their offspring. Cotton should be very uniform in length and quality, but the greatest variation exists in an unselected field. Some plants taken from each field produce variable offspring, while others produce uniform offspring, give a larger yield, a higher lint percentage, and a better staple.

BREEDING METHODS.

The progeny-row method consists in the selection of the best plants to be found, in planting the seed from each in a separate row, and in the final choice that autumn of the best row or rows, the seed from which is increased as rapidly as possible the following years. The details of this method as now practiced and recommended for the breeder are as follows:

Preparation of land.—Assuming that, to start his breeding work, the prospective breeder has obtained from the Department of Agriculture or elsewhere a few individual plant selections made the previous year, he should first select a piece of land badly infected with wilt, separated as far as possible from any other cotton field to avoid cross-pollination; often a plat may conveniently be located in a cornfield or in a field of the same variety being grown for seed. Care should be taken that the land is not infected with root-knot. The plat should be prepared and fertilized as for other cotton and the rows laid off in a block, side by side (see figs. 10, 11, and 12), 4 to 4½ feet apart and 200 to 250 feet long, thus providing for 100 hills 2 to 2½ feet apart in each progeny row. Plenty of space is necessary to permit the normal development of the individual plants.

Diagrams illustrating methods of seed selection.

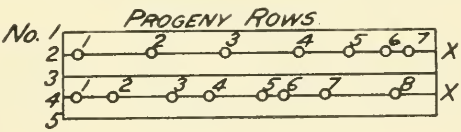

FIG. 10.—(*First Year.*) Five selections, made from individual plants of the Dixie variety, are planted in 100 hill rows. This plat is isolated or placed in a cornfield or in a field of Dixie cotton to prevent crossing with other cotton. All wilted and inferior plants are pulled out during the season. At the end of the season the rows are carefully inspected, Nos. 2 and 4 selected as the most wilt resistant and productive, and Nos. 1, 3, and 5 discarded. From these selected progeny rows, indicated by "x," 15 individual selections are made, indicated by circles and numbers. These are ginned and 8 discarded because of too low lint percentage or other undesirable characters, leaving the 7 best plants for use next season. All the remaining plants in the 2 selected progeny rows are picked into 2 lots for planting increase plats the following year.

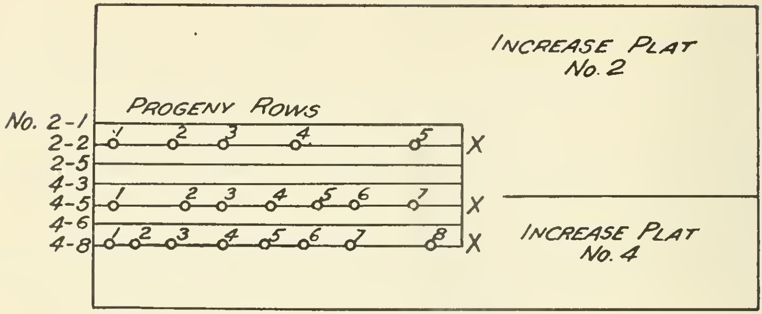

FIG. 11.—(*Second Year.*) Two increase plats, Nos. 2 and 4, are planted from seed saved the first year. The 7 individual selections are planted in a block surrounded by the increased plats, as indicated. The roguing of the increase plats and progeny rows is done the same as the first year. After careful inspection in the fall, 3 progeny rows are selected (indicated by "x"), and from these, 20 individual selections are made, as indicated. The remainder of the selected progeny rows are picked by themselves, ginned, and compared for wilt resistance, yield, and lint percentage, with the result that 2 are saved for the next year's increase plats, namely Nos. 2-2 and 4-8. In the same manner the 20 individual selections are ginned and compared, and 10 finally saved for further work.

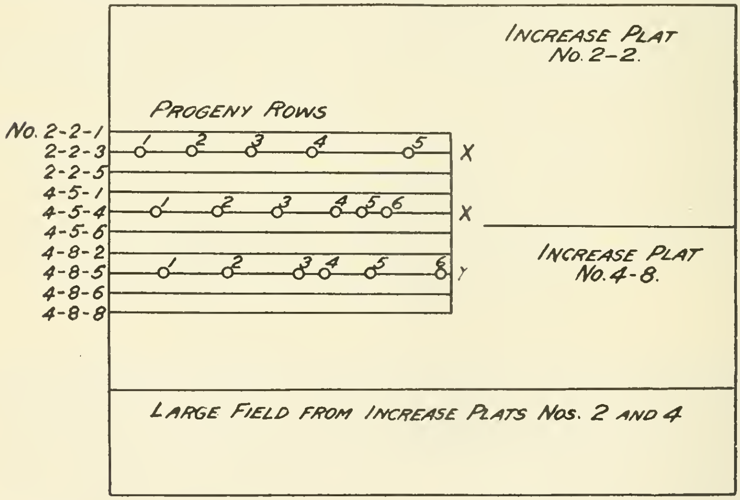

FIG. 12.—(*Third Year.*) The seed from progeny rows Nos. 2-2 and 4-8 of the second year are planted in 2 increased plats and at one end of these, as indicated, are planted the 10 individual selections finally saved. The seed from the 2 increase plats is used to plant a large adjacent field for seed purposes. These seed are designated "registered seed." The same methods of roguing and individual selection are continued in this and subsequent years.

Planting.—The individual selections should be planted by hand in these progeny rows. A small bull-tongue or wooden V attached to a plowstock may be used to open a shallow trench in the beds. The seeds are dropped in this trench at the proper intervals and covered about an inch deep with the foot and the soil is very slightly compacted. Four or five seeds to the hill should be used and the remainder saved for possible replanting. Each row should be marked by a stake at the end, bearing the number of the individual selection. This should be driven down so that the whiffletrees will not hit it during cultivation. Stakes should be at least ½ by 2½ by 18 inches long and planed on one side so that the numbers can be written on them with a heavy pencil. For convenience in field labeling and in keeping breeding records, each selection grown by an individual farmer is given a number, as 1, 2, etc.; and each individual selection made from these has another number added to the first with a dash between, as 2–1, 2–2.

Thinning, wilt counts, and roguing.—All progeny rows should be gone over about the middle or last of May, the exact time depending on the date of planting, and all hills thinned to one plant, leaving the healthiest plants. A record of the number of hills should be made to form a basis for the determination of wilt resistance. Counts of the wilted plants in each row should be made about June 20, August 1, and September 15. The total number of wilted plants compared with the figures of the original stand will give the percentage of wilted plants. Wilt resistance should be the first and most important consideration in the selection of the best progeny rows, only those being taken which are highly resistant. After each wilt count the diseased plants should be pulled or rogued out to prevent their crossing on other plants or being picked by mistake with the healthy plants.

The year following, when an increase plat is grown from the progeny-row seed, a similar method of roguing, involving the pulling out of all wilted and nontypical plants, is practiced to maintain the purity and wilt resistance of the strain.

Selection and note taking.—After the last wilt counts in September have been made, the progeny plat should be gone over carefully and all rows discarded that show much wilt. Records should be made of the principal characters of the progeny rows, such as earliness, uniformity, size, etc., on note blanks provided by the Department of Agriculture. In the books in which these blanks are bound, detailed directions for taking notes are printed and the time required for the work is very largely reduced by the use of a series of symbols to indicate the degrees of the characters present which are listed on the note blanks.

Note blank prepared by the Department of Agriculture.

COTTON NOTES.

No.................................... Year....................

Locality............................ Farm of............................ Notes by....................

PROGENY NOTES.		GENERAL NOTES.
	No. off Type..........	
	Earliness..........	
Date Planted..........	Uniformity..........	....
No. Hills..........	Productiveness..........	....
Germination..........	Shedding..........	....
Date Replanted..........	Height..........	....
No. Living..........	Shape..........	....
No. Wilted..........	No. Selections..........	....

INDIVIDUAL NOTES.	1	2	3	4	5
Earliness					
Productiveness					
Shedding					
Shape					
Height					
Joints—long or short					
Basil branches—number					
Length					
Productiveness					
Leaves—Size					
Persistence					
Bolls—No					
Shape					
No. mature on					
No. locks					
Weight seed cotton in..........bolls					
Ease of picking					
Seed—Size (weight per hundred)					
Color					
Fuzz					
Lint—Length					
Strength					
Lint index					
Per cent lint					

After what appear to be the best progeny rows have been picked out, a number of the best individual plants should be selected from them.

The person who does the selecting should have in mind a clear picture of the type toward which he wishes to select and take only those plants that conform as closely as possible to that type. This is an all-important point, since if the type selected for each year is different progress is impossible. Only by continuous selection toward a certain ideal type can that type be attained or even approximated.

For convenience in finding the plants for picking, a white or light-colored piece of cloth should be tied to the top of the selections. A tag should also be attached, bearing the number of the progeny row plus the number of the individual selection made from that row, as 2–2 or 4–3–1. Selections should be made at the time of the first picking, which is best delayed until at least half the cotton is open, as one can more easily judge of the plant's performance at that time than earlier. After the necessary notes have been taken on the note blanks provided, the individual selections should be picked separately into cloth bags or strong paper bags and plainly marked with the number of the plant. The rows should then be picked, a record being made of the exact number of plants picked in each row. The second picking should be made when most of the cotton has opened, but before frost has caused the premature opening of late bolls. For comparing the yields the cotton from all the progeny rows, including the first and second pickings, should be weighed separately and the yield per hundred plants calculated.

Ginning.—The ginning of the individual selections and progeny rows should be left until winter, when the rush of fall work is over.

For ginning individual plants a small hand gin is essential. Three types of hand gins are on the market: (1) A small saw gin, very similar in appearance to the ordinary commercial saw gin, but having only 10 saws and furnished with a handle by means of which it is operated; (2) a small-sized roller gin of the type generally used to gin Sea Island cotton and also operated by a handle; and (3) a gin somewhat similar to the roller gin but having a series of fingers instead of beaters to break the lint from the seed. The price of these gins is from $50 to $75. It is often possible for several farmers to club together to bear the expense of such an outfit. Progeny rows, as well as individual plants, can best be ginned on a hand gin. In ginning different individual plants or progeny rows, great care should be exercised that the gin be thoroughly cleaned out after each operation, so that not a single seed will be left to mix with the succeeding lots or to render the results of both lots less accurate.

Lint percentage.—Before being ginned the seed cotton of each plant should be carefully weighed on a pair of scales that will weigh in grams. Before weighing the cotton all burrs or trash should be picked out and any sand present knocked out by beating the cotton over a wire screen. After ginning, the seed should be weighed and the weight of lint determined by the difference between the weight of the seed and the seed cotton. The weight of the lint divided by the weight of the seed cotton equals the percentage of lint. In the final selection of the best individuals for future breeding, preference should be given to those having a high lint percentage, other things being equal, and selections having less than 35 per cent of lint should be discarded.

Length of lint.—The length of the lint of individual selections should be roughly noted in the field when selections are made and no plants with a distinctly short lint should be saved. If more accurate data are desired they can be obtained by a more careful study of the cotton at the time of ginning. The best way is to comb out the lint on a few seeds with a very fine comb and measure with a ruler. Selections having a staple less than three-fourths to seven-eighths of an inch should not be saved.

Lint index.—"Lint index" is a term used to designate the quantity of lint on 100 seeds and is held by some [1] to be a more accurate method of estimating the value of a strain of cotton than the lint percentage. It is obtained by multiplying the weight of 100 seeds by the percentage of lint previously determined and dividing by the percentage of seed, viz, 100 minus the percentage of lint.

Size of seed.—If the size of seed of different selections is desired for comparison, the weight in grams of 100 seeds is determined. These data are necessary if the lint index is to be calculated.

Increase plats.—When the progeny rows that were saved have been weighed, ginned, and the lint percentage determined, the one or more that are to be used for the increase plats the next season for the production of planting seed should be selected, choosing the ones that have the greatest wilt resistance, the largest yield per hundred plants, and the highest lint percentage. These seeds should be planted on wilt-infected land in the same field with the smaller plats. (See figs. 10, 11, and 12.) If the quantity of seed is small it may be made to go farther by careful hand planting. Enough seed should be reserved with which to replant if necessary, and under no circumstances should seed of another variety be used for replanting. Any missing hills may well be planted to cowpeas for seed purposes. The field should be thinned, so as to allow plenty of space for the proper development of each plant. During the season the field should be gone over several times and all wilted or nontypical plants pulled out. This is extremely important, as only by removing the inferior plants can crossing with them be prevented and deterioration of the cotton thereby avoided. The cotton should be carefully picked by itself and every precaution taken to prevent mixing with any other cotton.

For ginning it is best to wait until late in the season, when the rush is over. It is then possible to have the work done more carefully, as more time is available. If possible, a farmer who runs a single gin should do the ginning. The roll should be taken out of the gin and every seed of other cotton removed from any place where it is liable to become mixed with that to be ginned. If taken to a public gin the cotton should not be run through the cotton feeding device or the seed through the screw seed ejector. The gin should be fed by hand and the seed caught on the floor or on a piece of burlap spread down for the purpose.

[1] Cook, O. F. Danger in Judging Cotton Varieties by Lint Percentages. Circular 11, Bureau of Plant Industry. 1908.

This selected seed is to be used in planting a larger area the succeeding year for seed purposes. (See figs. 10, 11, and 12.) This seed field should be given the same care as the increase plat. Careful personal supervision of the details of this work is essential to the maintenance of the best grade of seed.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *February 23, 1912.*

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BUREAU OF PLANT INDUSTRY—Circular No. 93.

B. T. GALLOWAY, Chief of Bureau.

THE DANGER OF USING FOREIGN POTATOES FOR SEED.

BY

WILLIAM STUART, *Expert*,

AND

W. A. ORTON, *Pathologist*.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1912

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TWO SERIOUS DISEASES.

The most dreaded of these is the wart disease, concerning which so much has been written in England and in this country. Potato wart, or "black-scab," is a disease of the tubers which forms large, irregular excrescences, at first greenish or white and later black. These begin near the eyes, but in advanced cases involve the whole tuber, which is converted into an unrecognizable and useless mass. There are no conspicuous evidences of this malady in the foliage of affected plants. The more severe cases exhibit the disease at the surface of the ground, where the worst affected tubers protrude above the soil. Other tubers have small warts, but are usable for culinary purposes, and some may be so slightly affected as to pass as healthy. It is a disease difficult to detect by inspection in its early stages, and there is nothing to prevent its distribution in the United States on imported potatoes. This danger is the greater since the badly infected districts of England lie near Liverpool, from whence many shipments are made. This disease has been more fully described in two publications of the Department of Agriculture, Circular No. 52 of the Bureau of Plant Industry and Farmers' Bulletin 489, both of which may be had free of charge upon application to the Secretary of Agriculture or to a Senator, Representative, or Delegate in Congress.

Such dangers as the present emphasize the need for a national quarantine law to enable the Secretary of Agriculture to exclude diseased or insect-infested plant products or imports from localities known to have these pests. Such a bill has been pending before Congress for several years, but as yet no action has been taken.

The potato wart is not the only disease likely to be imported. There is another tuber trouble, known as Spongospora scab (*Spongospora subterranea* (Wallroth) Johns.), which would be an undesirable addition to our already long list of diseases brought from foreign sources. This scab causes small spots or even tumor-like growths of small size. It does not destroy the potato, as may the wart, but lessens its market value. Spongospora scab is quite prevalent in Ireland. Large quantities of potatoes are now being imported from that island.

A third trouble which may be introduced on imported potatoes is the black-leg, a bacterial disease which can rarely be detected in the tubers, as the infection is always internal. It manifests itself in the field after the potatoes are half grown. The tops yellow and curl up, the stem blackens and decays at the base, and the hill dies. This disease has already been introduced into many of our States, probably from England by way of Canada. The danger is no less in importations from Germany, as the disease exists there as well as in England.

The wart disease also exists in Germany, but there is less danger of its importation from that country, as it is not yet common in the principal potato-producing sections there. German potatoes may, however, be affected by "leaf-curl," a peculiar disease of doubtful nature very widely prevalent in that country. This disease causes a curling of the leaves and reduces the yield or cuts it off altogether. It is transmitted in the seed tubers, but is not to be detected by any kind of inspection.

The danger from these diseases is not limited to a single season, as soils once infected remain unfit for potato culture for many years.

These facts, together with those previously presented concerning European varieties of potatoes, should become generally known in time to prevent the planting of such foreign seed.

Any diseased or doubtful specimens discovered should be sent to the Department of Agriculture for identification.

SUMMARY.

(1) Foreign-grown potatoes should under no circumstances be used for seed purposes.

(2) Such potatoes are not adapted to our soils and climate and will not return profitable yields.

(3) Several serious diseases not now prevalent in this country are almost certain to be introduced if such stock is used for seed.

Approved:

James Wilson,

Secretary of Agriculture.

Washington, D. C., *March 11, 1912.*

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 94.

B. T. GALLOWAY, Chief of Bureau.

THE MANGUM TERRACE IN ITS RELATION TO EFFICIENT FARM MANAGEMENT.

BY

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THE MANGUM TERRACE IN ITS RELATION TO EFFICIENT FARM MANAGEMENT.

INTRODUCTION.

The terrace problem is an extremely important one in the Southern States. Where there is any considerable slope it is necessary to have some sort of ditch or terrace system to carry off the water in such a way as to prevent erosion of the soil. Many of the systems now in vogue are entirely satisfactory with reference to the removal of surplus water without erosion, but frequently fail to meet the needs of a commercial system of agriculture where it is essential to use modern machinery. The Mangum terrace, as worked out by P. H. Mangum, of Wake Forest, N. C., many years ago, admirably meets the requirements of the farm for modern machinery equipment. Since this is one of the factors of vital importance in efficient farm management in the South, it is believed that a description of it may have wide interest at this time.

UNDESIRABLE FEATURES OF CERTAIN TERRACE SYSTEMS.

Among the undesirable features of many of the terrace systems commonly used in the South at the present time may be mentioned: (1) The waste of land occupied by terrace banks; (2) the increased labor cost by plowing the land in small stretches and by cultivating on contour lines with frequent short rows [1] (it has been shown that in one case a saving in cost of 70 per cent in hoeing and 20 per cent in cultivating was effected by abolishing the old contour system); and (3) the large crop of weeds and grass seeds produced on the old-style terrace bank and also the insects harbored, particularly in boll-weevil sections. (Fig. 1.)

Where 1-horse implements are mainly used and the farms are of such size as not to warrant the use of a more extensive type of machinery, the fact that the terrace bank is not to be plowed across or that the whole field must be worked in contours, necessitating short rows between the terraces, may not be such a very serious hindrance: but where gang plows, section harrows, and riding cultivators

[1] See Farmers' Bulletin 310, U. S. Dept. of Agriculture, entitled "A Successful Alabama Diversification Farm," p. 24.

are to be used, a system of terracing whereby it is possible to plow across fields of medium slope regardless of terrace banks is highly desirable. This point can not be too strongly emphasized, and its importance to southern farms can hardly be exaggerated. The Mangum terrace system permits cultivation of the entire field. With this system in more general use, millions of acres could be cultivated with 2-row cultivators where under many of the systems of terracing at present it is possible to use only a 1-horse outfit, and even then do unsatisfactory work.

ADAPTATION OF MANGUM SYSTEM TO SOUTHERN CONDITIONS.

As before noted, the system of terracing here described was originated and has been in use on the Mangum farm at Wake Forest,

FIG. 1.—The old-style terrace system—land wasting, labor wasting, and pest breeding.

N. C., for about 30 years, during which period it has given entire satisfaction. It is now found in use from the upper Coastal Plain in North Carolina far into the mountain region in the western part of the State. It is not, however, universally practiced between these points.

The Mangum terrace is simple in construction, permanent in character, and lends itself easily to the use of modern labor-saving machinery. The system has been sufficiently tried to thoroughly demonstrate its merits and practicability under a wide range of conditions. It is a system which should be known and practiced not only throughout much of North Carolina but in regions of similar topography and climatic conditions in the other Southern States. The use of the Mangum terrace becomes all the more a matter of general interest when it is recalled that the future use of labor-saving machinery is in a great measure dependent upon the cultivation of southern lands in larger and less irregular bodies. In this system, where the land has only a medium slope, it is perfectly feasible to cultivate directly over the terrace on a line with the greatest level of the field. This one feature saves a very large amount of labor.

HOW TO LAY OFF AND CONSTRUCT THE MANGUM TERRACE.

The terrace as developed and recommended by Mr. Mangum is laid off on a uniform grade of $1\frac{1}{2}$ inches to 14 feet. This is a slightly higher grade than is usually given a terrace. In many hundreds of actual tests, however, it has been found to give entire satisfaction. The reasons why a grade higher than usual may be permitted are (1) that the water is spread over a broad flat surface instead of confined to a narrow channel and (2) that as the whole area is cultivated the soil is kept roughened, which impedes the velocity of the water. On some soils, however, even a higher grade may be used, while on very light, sandy soils probably a lower grade would be more satisfactory.

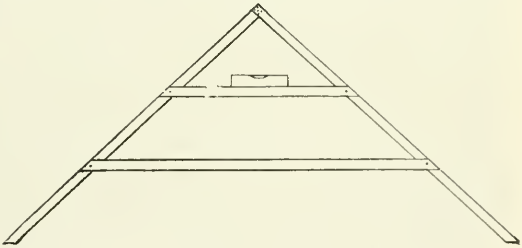

FIG. 2.—A-shaped frame level for laying off the terrace line.

A level for laying off these lines can be constructed on any farm. Make a big letter **A**, 14 feet across the base. (See fig. 2.) On the bar across the apex of the letter **A**, one end of which bar is fastened with one nail, place an ordinary farm spirit level. Set up on an absolutely level surface. Get a little block, $1\frac{1}{2}$ inches high, and put it under one of the feet of the **A**-frame. Adjust the loose end of the crosspiece until the level-bubble remains in the center; then fasten the loose end of the crossbar upon which the level rests.

Now, get a bundle of broom-sedge straw or other material suitable for use in marking out the line of the terrace and start across the field to lay out a line with the desired fall. In going up the grade always keep to the front the end of the letter **A** which rested on the block. Stick a broom straw as a marker where you start at the side of the field and adjust the front end of the **A**-frame by moving it from side to side until the bubble is in the middle of the level. Put the rear end then where the front end was, and continue the process across the field, sticking a broom straw at each point. This marks out the grade line.

When the line is laid out, the terrace can be constructed in any one of several ways. In many cases the most convenient way is shown in figure 3. This figure shows the first steps taken toward constructing the terrace after a line has been laid out. With a 2-horse plow, a backfurrow strip about 15 feet wide, centering on this line of broom straws, has been thrown up. When the ground has settled after a rain the backfurrowing process is repeated. If there is not sufficient time to wait for a rain, the upper side of the ridge can be thrown across on the lower side with shovels. In this way

FIG. 3.—The first steps in constructing a Mangum terrace. A backfurrowing area centers along the grade line.

the terrace is constructed. It should be carefully watched the first year, for it takes several years to build up a thoroughly strong and reliable terrace bank. The next year the terrace is backfurrowed again, and this is continued from year to year until the desired height is reached. The proper height will depend upon the slope of the land, the steeper slopes requiring higher banks.

These terrace lines are usually laid off at intervals of about 6 feet of fall in the slopes of the land. This would make them come on very steep land sometimes 20 to 30 steps apart and on very slightly sloping land 50 to 75 steps apart.

OTHER METHODS OF CONSTRUCTING THE TERRACE.

Figure 4 shows a terrace bank thrown up with a road scraper. This should be gone over with the plow and smoothed down so that the upper side of the terrace will present a broad, flat surface instead of a sharp depression in the ground, bearing in mind that the purpose of the Mangum terrace is to conduct the water off in a wide stream so as to prevent erosion.

Fig. 4.—Terrace bank thrown up with a road scraper. The sharp depression on the upper side will be eliminated when the area is plowed over, and the water will then spread over a broader surface.

Figure 5 shows the first steps in constructing a terrace with a road scraper by simply scraping the dirt down hill. This is to be gone over next with a plow, making the lower side of the present bank the center of backfurrowing.

Figures 6 and 7 show fields in which the rows run directly over the terrace.

Figure 8 shows a cultivator crossing the terrace.

Figure 9 shows the adaptability of the Mangum terrace to permanent pasture lands.

FIG. 5.—The first step in making a terrace with a road scraper when only the upper side is scraped. The lower side will be made the center of the backfurrowing area, 15 or 20 feet wide.

FIG. 6.—View of the completed terrace system in a field near Raleigh, N. C. The gently sloping land makes necessary only small terrace banks. The rows run across the field in line of greatest level, regardless of the terrace.

FIG. 7.—A large field of considerable slope in Wake County, N. C., where the rows cross the terrace bank.

FIG. 8.—One of the original terraces on the Mangum farm in Wake County, N. C.

CARE OF THE TERRACE.

On breaking land which has been terraced in this manner, the terrace can be entirely disregarded in fields of ordinary slope. On such fields, where the terrace is plowed across in breaking, care must be taken to fill up all dead furrows which may cut the terrace bank. This bank should also be made the center of a backfurrow strip of plowing before a crop is planted.

On extremely steep lands the plowing is done in contours, and the area included from the crest of one terrace to the crest of the next is plowed as one body.

FIG. 9.—The Mangum terrace on steep pasture land. When covered with sod this terrace will last indefinitely with little or no attention.

SUMMARY.

The Mangum terrace is a broad bank of earth contouring the field at a grade of approximately 1½ inches to 14 feet. It can be constructed in several ways. Under ordinary farm conditions the most practical way is by backfurrowing along the grade line.

This system of terracing is adapted to all types of soil and is especially applicable on moderately rolling lands. On slightly to medium rolling lands the rows can be run on the line of greatest level of the field, cutting across the terrace bank. Extensive cultivation machinery can be used with perfect satisfaction where this system of terracing is practiced. By its adoption considerable labor will be saved, even though 1-horse implements only be used.

In this system of terracing there is no waste of land. Like all other terrace systems, care must be taken to preserve the terrace when once constructed. Do not break the bank with a turning plow without carefully filling up the furrow afterwards. Fill up all dead furrows that cut the bank.

It takes several years to build up a thoroughly satisfactory terrace bank. With reasonable care the terrace should last for many generations.

Approved:

JAMES WILSON,

Secretary of Agriculture.

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BUREAU OF PLANT INDUSTRY—Circular No. 95.

B. T. GALLOWAY, Chief of Bureau.

THE SEED-CORN SITUATION.

BY

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BUREAU OF PLANT INDUSTRY.

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THE SEED-CORN SITUATION.

INTRODUCTION.

With about the same regularity that corn-planting time arrives it is found that in some portion or portions of the United States the corn that must be used for seed will not germinate well and that good yields can not be expected, because good seed of adapted strains does not exist.

With the assistance of the various State agricultural experiment stations a general survey was made of the seed-corn situation in the spring of 1912. This situation was found somewhat more serious than usual because it was more general and because it affected large portions of many of the leading corn-producing States. Aside from the lack of proper precaution in selecting and saving seed corn, which is the principal cause, the bad situation can be attributed to summer drought, frequent and prolonged fall rains, and unusually cold weather in November. Some sections endured all these unfavorable conditions.

In general, the southeastern portion of the United States produced in 1911 a much better corn crop than the average, and sufficient corn that will grow is available for spring planting in that section.

New York, Pennsylvania, Ohio, Indiana, Michigan, Wisconsin, Minnesota, and North Dakota produced a better corn crop than the average, but in these States there is very little corn fit to plant except that which was gathered early and well cared for. This seed was gathered and dried in September and is in almost perfect condition, but is very limited in quantity in comparison with the supply needed.

In the leading corn-producing States of Illinois, Iowa, and Missouri summer droughts caused the crop to be below the average and the fall rains and November freezes injured or destroyed for seed purposes all corn that was not gathered and dried early. As in the Northern States, the seed which was gathered and dried early bids fair to produce a good crop, but is entirely insufficient to plant the usual corn acreage of these States.

The drought was especially severe in the Great Plains, and all of the States from South Dakota south produced much less than a normal corn crop. In large portions of these States no corn was produced and no acclimated and well-adapted seed exists except very insufficient quantities held over from the previous season.

GENERAL SEED-CORN SITUATION IN THE SPRING OF 1912.

A very serious situation arises when, at planting time, farmers find that their corn will not germinate well—that it is unfit for seed. In the spring of 1912 the farmers throughout the greater portion of several of the leading corn States found themselves in this costly predicament, which is exceedingly critical, because it prevails over such large areas of the principal corn-producing States.

In 1911 summer droughts were quite general throughout the United States, though small areas were relieved by local rains. The drought was broken late in the summer by frequent rains. In many sections frequent fall rains kept the corn green and sappy till severe freezes came. In portions of certain Central and South Central States there was no seed corn, because the corn crop was entirely destroyed by drought. In many Central States good seed was scarce because the crop was poor. In many Northern States the corn crop was better than the average, but good seed was unusually scarce at planting time.

GENERAL SITUATION CRITICAL, BUT NOT UNUSUAL.

The seed-corn situation in the spring of 1912 furnishes a most valuable lesson to farmers of all parts of the United States. In certain localities, where little trouble is ordinarily experienced in obtaining seed corn that will germinate well, none was obtainable at planting time, while in other localities, where conditions unfavorable to seed corn are frequent and where farmers exercise more precautions, good seed corn existed.

Unquestionably the acre yield for 1912 will be reduced in many States, owing to the planting of poorly preserved or poorly adapted seed corn. In the aggregate the loss will be immense, but much of it will never be attributed to this factor, because well-adapted, well-preserved seed was not available for demonstrating its value in comparison with that planted. The cause of corn being unfit for seed is commonly attributed to exceptional weather conditions. Such conditions may sometimes be the cause, especially in the North, but delay in selecting seed or the growing of varieties maturing too late is usually the true cause. Exceptional weather conditions occur every year, sometimes in one locality and sometimes in another. It is because many autumns are long and dry that the habit is formed of waiting till October to select seed corn.

The writer's experience in Nebraska will illustrate this point. In assisting in addressing farmers on corn trains in 1905, emphasis was placed upon seed-corn preservation and experimental results were given to show that good preservation sometimes increases productiveness by 18 bushels per acre. The experiments were conducted in the East and the general opinion prevailed among the Nebraska speakers, as well as among Nebraska farmers, that seed preservation was of little importance in Nebraska. Frequent statements were made that the autumns were long and dry and seed corn needed no special care. In contrast to this, corn trains, operated throughout the State of Nebraska in the spring of 1912, carried the following news to farmers:

There are very few localities in the State where more than half of the ears will grow, and in many places not more than 1 ear out of 10 will grow. A very hard freeze the first week in November killed or greatly weakened a large majority of the corn which was not of an early variety or which had not been picked and properly cared for before that time. With the facts before us it becomes quite a problem to know just where the seed will come from for planting the Nebraska cornfields. For the entire State a decreased yield of 5 bushels per acre, due to a poor stand, would result in a total decreased harvest of 32,500,000 bushels of corn. At 50 cents a bushel this amounts to a loss of $16,250,000.

The farmers who gathered their seed in September or early October and had it dried out before the freezes came are the ones who have good seed. These are the only farmers in so far as the station has been able to learn who have seed that they can depend upon.

MEANS OF PREVENTING SUCH SITUATIONS.

When advice is given it should be the best advice possible. The usual advice given for meeting poor seed-corn situations is to test separately the germination of each ear. The objection to this advice is the likelihood that the practice will become a yearly habit, being recommended by good authorities as the best possible procedure. Why not gather and dry the seed early and thus prevent the deplorable situation? This will not only make the testing unnecessary but will retain full productiveness—productiveness which the germination test can not restore or even reveal. Spring carefulness, no matter how great, can not make up for fall neglect. The situation is due to a lost opportunity. The way to meet properly these oft-recurring losses is to begin at the beginning and prevent them. Ten times more advice has been given regarding germination tests and methods of getting out of bad seed-corn situations than has been given regarding methods of keeping out of them. Such conditions are easily prevented in the fall, but can not possibly be rectified in the spring. Twelve years' experience in selecting seed of hundreds of varieties of corn and testing its germination teaches that seed that matures properly and is well preserved will germinate well. And what is of much more importance, it will yield well if the variety is a good-yielding acclimated variety.

The planting of poor seed corn is an exceedingly costly and unnecessary yearly occurrence.

Exceedingly costly? Yes. Each acre of the hundred million acres grown annually would produce several bushels more if planted with early-selected well-preserved seed. The loss from the planting of neglected seed corn amounts to millions of dollars each year.

Unnecessary? Absolutely. This loss is easily prevented by (1) the use of acclimated and adapted varieties, (2) earlier selection, and (3) good care of seed corn.

By the application of these three principles the writer has seen a number of farmers double the profits from their corn crops.

USE OF ACCLIMATED AND WELL-ADAPTED STRAINS.

The advice to meet these poor seed-corn situations by preventing them is given with the knowledge that they can under all conditions be prevented. It is the only sound advice that can be given as applicable to all conditions. Farmers in localities that have no seed corn because last year the season was too dry or too short can prevent the recurrence of this condition by saving early each fall a supply of seed corn sufficient for two or three years' planting. Good seed corn well cared for will retain good germination and high productivity for three or four years.

If there has been a failure of the corn crop in a locality for several years in succession, it is good evidence that poorly adapted varieties are being grown and that great loss is being sustained in not growing crops from better adapted seed. Most farmers have observed the superiority of well-adapted varieties. This is well demonstrated when good home-grown seed is planted in comparison with seed imported from a distance. In sections having no home-grown seed because of the entire failure of crops, imported seed is planted and the decreased yield is not noticed because there is no possibility of planting home-grown seed for comparison.

Splendid opportunities for observing the value of home-grown seed were brought out in two series of 5-year tests conducted by the Office of Corn Investigations in cooperation with 28 State experiment stations. Equivalent lots of seed were grown each year at all the stations. The point of value from the five years' work is that a variety stood high or low in rank according to its adaptation or lack of adaptation to the locality in which the test was made. Varieties producing best at home often produced poorest when tested under other environments, notwithstanding the same seed of all varieties was used in all the tests.

A variety, a native of Sabina, Ohio, was taken 50 miles north and grown for five years at Sunbury, Ohio. Equivalent lots of Sabina-grown seed and Sunbury-grown seed were then tested at both points. At Sabina the Sabina-grown seed produced better by 47 per cent. At Sunbury the Sunbury-grown seed produced better by 11 per cent. Acclimatization and adaptation alone can account for these differences, and in this case the acclimatization and adaptation to Sunbury conditions had been brought about in five years. By being grown five years at Sunbury the variety had become adapted to Sunbury conditions and at the same time had lost its adaptation to Sabina conditions. The same variety constantly grown under Sabina conditions retained its adaptation to Sabina conditions.

To make certain of always obtaining the greater productiveness of adapted varieties it is necessary to save sufficient seed for two or three years' planting. In localities where extreme weather conditions may make the corn crop an entire failure this practice is of the utmost importance. It is plainly impossible to acclimate and adapt varieties if all seed is destroyed occasionally, making new importations of seed necessary. There are occasional instances in which imported seed produces better than home-grown seed. Such cases are experienced especially in the Southern States, where dry summers permit early-maturing northern-grown varieties to escape the summer drought. For this reason northern-grown seed is preferred in some sections. A better practice would be to select and acclimatize an earlier maturing variety. It would then escape the summer droughts and by becoming acclimated and adapted would produce better than imported seed.

RETENTION OF SUFFICIENT SEED FOR TWO OR THREE YEARS' PLANTING.

Even in sections where the corn crop is not likely to be an entire failure it is advisable during good corn seasons to retain sufficient seed for two or three years' planting. Careful tests have shown that seed that grew under favorable conditions is more productive than seed of exactly the same strain grown under unfavorable conditions. The greatest hindrance to corn breeding in some localities is the dissimilarity of seasons. The corn plant is exceedingly adaptive, but occasional wet seasons prevent a strain from adapting itself to droughty conditions and occasional dry seasons prevent acclimatization and adaptation to humid conditions. If the corn is poor in quality because of an unusually dry or an unusually wet season, no seed should be saved and that grown during a more normal season should be planted.

A mistaken idea prevails regarding the "running out" of corn because it has been grown too long in a locality. A strain of corn may run out, but the cause is with the farmer and is not because the corn has been grown too long in the same locality. The longer a corn is grown in the same locality the better adapted it becomes to the conditions of that locality, provided seed is saved each normal season from the best-producing individuals.

EARLIER SELECTION OF SEED CORN.

Great progress has been made in recent years in a more general adoption of fall selection instead of spring selection of seed corn, but there is room for still greater progress. Nearly all farmers should select their seed corn three or four weeks earlier than they do. In the South seed corn should be selected and dried during August, in the North early in September, and no prudent corn farmer anywhere in the United States will allow October 15 to pass without having sufficient seed for at least one year's planting stored where it can not be injured by unfavorable or unexpected weather conditions. Where a seed patch is not maintained and seed must be selected from the general field it should be selected before the corn is cut and shocked. Where corn is husked from the standing stalk the seed should be selected several weeks before the corn is dry enough to husk and crib.

It is doubtful whether the governor of each of the corn-producing States could issue a more valuable proclamation each year than one proclaiming a suitable week for all farmers of the State to gather and dry seed corn.

As an excuse for not having good seed it is customary to state that the season was exceptional. Such seasons will continue to occur, and the only way to escape loss is by being prepared each year for an exceptional year. Last year was a very adverse season in South Dakota, Nebraska, and some other corn States; consequently this spring it is necessary to import seed corn into these sections. Nevertheless, well-acclimated and unquestionably higher yielding seed could have been selected last September from fields in these same States. This statement is made with full knowledge of the facts, because at that time such seed was selected and dried in those very sections and is now practically perfect and germinates 100 per cent. Having personally assisted in the gathering and drying of seed corn in these sections in September, the writer knows that large quantities of seed could have been saved at that time from the same and many other fields. Unfortunately, however, most farmers postponed the selection until freezing weather, with the consequence that the seed they selected will not yield well and most of it will not even germinate well. It is not the season so much as the man.

Mr. Edgar Brown, in charge of the Seed Laboratory of the United States Department of Agriculture, has reported an average germination of 81 per cent for 1,708 samples of corn intended for seed in the spring of 1912 and obtained from farmers of various States, as shown in Table I.

TABLE I.—*Results of germination tests of seed corn intended for use in the spring of 1912.*

State.	Number of samples.	Lowest germination.	Average germination.
		Per cent.	*Per cent.*
Virginia	113	5	90.3
Kentucky	69	26	89.8
Missouri	151	2	88.7
Maryland	41	30	87.1
Iowa	141	20	85.4
Pennsylvania	144	0	84.2
West Virginia	55	8	82.5
Kansas	66	0	82.0
Ohio	189	10	80.7
Illinois	175	0	79.8
Indiana	108	0	79.0
Minnesota	106	0	76.1
Michigan	86	1	75.0
Wisconsin	88	0	73.9
Nebraska	100	30	73.1
South Dakota	57	1	64.6
North Dakota	19	0	56.8
Total	1,708		81.0

The Seed Laboratory also tested the seed gathered and dried early by men of the Office of Corn Investigations. From the States mentioned 73 samples gave an average germination of 98 per cent. (See Table II.)

TABLE II.—*Results of germination tests of seed corn gathered by men of the Office of Corn Investigations.*

State.	Number of samples.	Lowest germination.	Average germination.
		Per cent.	*Per cent.*
Virginia	29	95	98.5
Maryland (including the District of Columbia)	26	93	98.3
Kansas	1	97	97.0
Ohio	4	93	94.8
Wisconsin	2	97.6	98.8
South Dakota	1	96	96.0
South Carolina	9	96	98.0
California	1	100	100.0
Total	73		98.1

There are usually a few days between the time the corn stops growing and the coming of heavy frosts, especially if an acclimated corn is grown. We would have better corn yields and make better progress in originating and acclimatizing higher yielding strains of corn for different localities if seed corn were as readily killed by frosts as are sweet-potato vines. If seed corn would not stand so much abuse and if it were killed outright by the first freeze, farmers would dry their seed corn before they dig their potatoes and the next year's crop would be better.

The blame can not be justly shifted upon the season. It is the farmer who fails to do his part. Corn has been transported from a land of perpetual summer, where the returning wet season permitted the seed to germinate without having endured winter conditions. It has been introduced into northern localities where the winters are severe. It has shown a remarkable ability to adapt itself to short summers, but is dependent upon man to care for its seed during the winter. Without this care the corn crop would not perpetuate itself in the United States. Our first duty in giving the crop opportunity to yield well is early selection and good preservation of the seed.

GOOD CARE OF SEED CORN.

Good methods of caring for seed corn are described in Farmers' Bulletin 415, entitled "Seed Corn." It has been demonstrated that the early-fall use of seed-corn racks such as are illustrated in that

FIG. 1. Exterior view of a building constructed solely for the good preservation of seed corn. It has a concrete basement and flue. Warm air passes from the basement through openings in the floor, ascends through the corn, and escapes through ventilators.

bulletin will increase the acre yield of corn by several bushels on practically all farms. The initial cost is very slight, and the racks will last a lifetime and are easily put out of the way when not in use. Fortunately, with care good seed can be dried and stored at very little expense. But it must not be supposed that the returns will not warrant an expense, for it is doubtful whether another investment can be made that will bring as great a profit as an investment in caring for seed corn. A community seed-corn house could be operated to great advantage. However, what is everybody's business is apt to be attended to by nobody in particular. The sure way for a farmer to avoid using his land and labor in planting seed of reduced productiveness is by selecting his seed early and caring for it well. It is not the cost price of good seed that makes this care necessary. Five dollars a bushel is a good investment for acclimated and well-preserved seed corn, but usually at planting time such seed can not be purchased at any price. Some few localities have conscientious, careful seed-corn men. They are of great value to their communities and fortunately their number is increasing.

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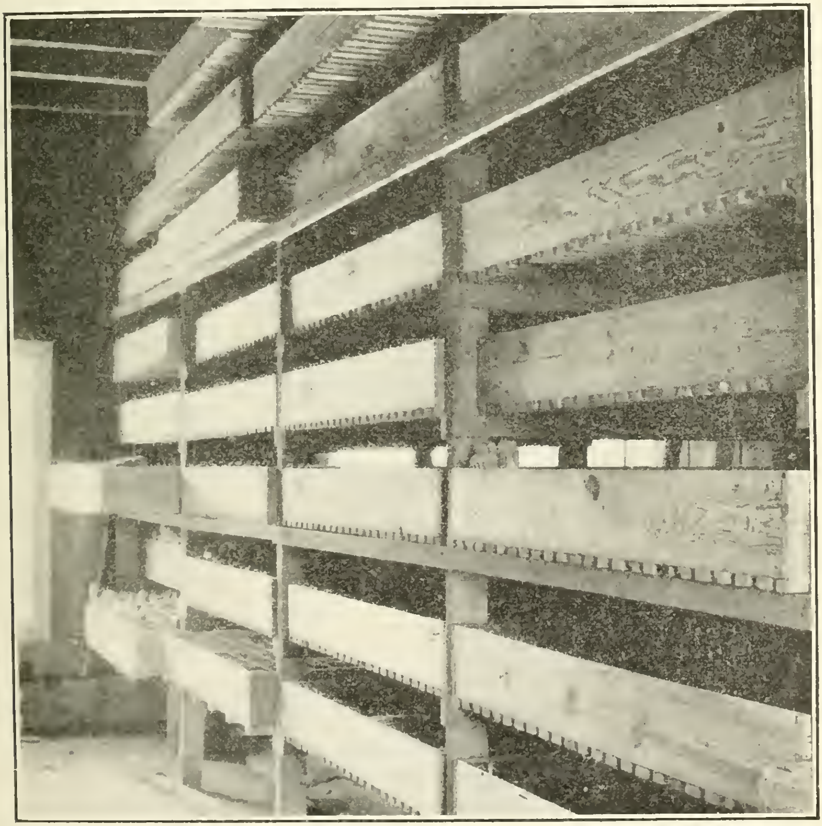

FIG. 2.—Interior view of the seed-corn dry house shown in figure 1.

tion of seed corn have been put to practical, accurate, and extensive tests. In figures 1 and 2 are shown exterior and interior views of a seed-corn dry house constructed at a cost of $500. In 1910 this seed-corn house returned to the farm $1,500 in profit, due to a 5-bushel increased acre yield on 740 acres planted with seed corn dried and stored in it. These figures were obtained as the result of 17 separate tests, practically all of which told the same story. The tests conducted by the Office of Corn Investigations were intensive and accurate. Hand planting and thinning were practiced in order to reduce all rows to exactly the same number of stalks. The results show practically a 5-bushel increase per acre due to good seed preservation. Like many farmers the owner of the farm was not fully satisfied with small plat work. He therefore made more extensive tests. At corn-gathering time in November he selected 2 bushels of seed, placing 1 bushel in a crib and the other bushel in the seed-corn dry house. In the spring with a 2-row planter he planted four rows 1,280 feet long and $3\frac{1}{4}$ feet apart with the seed kept in the dry house; then four rows with the seed kept in the crib. This he repeated seven times, making eight tests in all in which four rows planted with one lot of seed were compared with the adjoining four rows planted with the other lot of seed. At harvest time four rows yielded a wagon load of ears, which constituted a weighing. The result is shown in Table III.

TABLE III.—*Comparison of the yield of seed corn stored in a dry house with that in a crib.*

Corn-row number.	Ears produced— From seed kept in dry house.	Ears produced— From seed kept in crib.
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29, 30, 31, 32		1,845
33, 34, 35, 36	2,025	
37, 38, 39, 40		1,765
41, 42, 43, 44	1,930	
45, 46, 47, 48		1,730
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53, 54, 55, 56		1,855
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Total	16,255	15,265

These results are the same as in the tests where the rows were thinned to the same stand of stalks. The point of importance is that the seed kept in the dry house did not germinate any better than the seed kept in the crib, but produced 5 bushels more per acre.

The prevailing idea that the thing of most importance is to obtain a good stand of stalks must be discarded. Farmers must consider the productiveness of the stalks of more importance than the number. Full stands can be obtained by the heavy planting of weak seed. Good yields can not be obtained in this way. The most expensive seed to plant is that from which a stand of stalks can be obtained but from which a good yield can not be obtained. The stand of stalks bears the same relation to the grain yield as the number of trees in an orchard bears to the amount of fruit produced. Productivity as well as quantity must be considered.

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Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *April 10, 1912.*

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 95.

B. T. GALLOWAY, Chief of Bureau.

THE SEED-CORN SITUATION.

BY

C. P. HARTLEY,

Physiologist in Charge of Corn Investigations.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1912

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BUREAU OF PLANT INDUSTRY.

Chief of Bureau, Beverly T. Galloway.
Assistant Chief of Bureau, William A. Taylor.
Editor, J. E. Rockwell.
Chief Clerk, James E. Jones.

B. P. I.—743.

THE SEED-CORN SITUATION.

INTRODUCTION.

With about the same regularity that corn-planting time arrives it is found that in some portion or portions of the United States the corn that must be used for seed will not germinate well and that good yields can not be expected, because good seed of adapted strains does not exist.

With the assistance of the various State agricultural experiment stations a general survey was made of the seed-corn situation in the spring of 1912. This situation was found somewhat more serious than usual because it was more general and because it affected large portions of many of the leading corn-producing States. Aside from the lack of proper precaution in selecting and saving seed corn, which is the principal cause, the bad situation can be attributed to summer drought, frequent and prolonged fall rains, and unusually cold weather in November. Some sections endured all these unfavorable conditions.

In general, the southeastern portion of the United States produced in 1911 a much better corn crop than the average, and sufficient corn that will grow is available for spring planting in that section.

New York, Pennsylvania, Ohio, Indiana, Michigan, Wisconsin, Minnesota, and North Dakota produced a better corn crop than the average, but in these States there is very little corn fit to plant except that which was gathered early and well cared for. This seed was gathered and dried in September and is in almost perfect condition, but is very limited in quantity in comparison with the supply needed.

In the leading corn-producing States of Illinois, Iowa, and Missouri summer droughts caused the crop to be below the average and the fall rains and November freezes injured or destroyed for seed purposes all corn that was not gathered and dried early. As in the Northern States, the seed which was gathered and dried early bids fair to produce a good crop, but is entirely insufficient to plant the usual corn acreage of these States.

The drought was especially severe in the Great Plains, and all of the States from South Dakota south produced much less than a normal corn crop. In large portions of these States no corn was produced and no acclimated and well-adapted seed exists except very insufficient quantities held over from the previous season.

GENERAL SEED-CORN SITUATION IN THE SPRING OF 1912.

A very serious situation arises when, at planting time, farmers find that their corn will not germinate well—that it is unfit for seed. In the spring of 1912 the farmers throughout the greater portion of several of the leading corn States found themselves in this costly predicament, which is exceedingly critical, because it prevails over such large areas of the principal corn-producing States.

In 1911 summer droughts were quite general throughout the United States, though small areas were relieved by local rains. The drought was broken late in the summer by frequent rains. In many sections frequent fall rains kept the corn green and sappy till severe freezes came. In portions of certain Central and South Central States there was no seed corn, because the corn crop was entirely destroyed by drought. In many Central States good seed was scarce because the crop was poor. In many Northern States the corn crop was better than the average, but good seed was unusually scarce at planting time.

GENERAL SITUATION CRITICAL, BUT NOT UNUSUAL.

The seed-corn situation in the spring of 1912 furnishes a most valuable lesson to farmers of all parts of the United States. In certain localities, where little trouble is ordinarily experienced in obtaining seed corn that will germinate well, none was obtainable at planting time, while in other localities, where conditions unfavorable to seed corn are frequent and where farmers exercise more precautions, good seed corn existed.

Unquestionably the acre yield for 1912 will be reduced in many States, owing to the planting of poorly preserved or poorly adapted seed corn. In the aggregate the loss will be immense, but much of it will never be attributed to this factor, because well-adapted, well-preserved seed was not available for demonstrating its value in comparison with that planted. The cause of corn being unfit for seed is commonly attributed to exceptional weather conditions. Such conditions may sometimes be the cause, especially in the North, but delay in selecting seed or the growing of varieties maturing too late is usually the true cause. Exceptional weather conditions occur every year, sometimes in one locality and sometimes in another. It is because many autumns are long and dry that the habit is formed of waiting till October to select seed corn.

The writer's experience in Nebraska will illustrate this point. In assisting in addressing farmers on corn trains in 1905 emphasis was placed upon seed-corn preservation, and experimental results were given to show that good preservation sometimes increases productiveness by 18 bushels per acre. The experiments were conducted in the East, and the general opinion prevailed among the Nebraska speakers, as well as among Nebraska farmers, that seed preservation was of little importance in Nebraska. Frequent statements were made that the autumns were long and dry and seed corn needed no special care. In contrast to this, corn trains, operated throughout the State of Nebraska in the spring of 1912, carried the following news to farmers:

> There are very few localities in the State where more than half of the ears will grow, and in many places not more than 1 ear out of 10 will grow. A very hard freeze the first week in November killed or greatly weakened a large majority of the corn which was not of an early variety or which had not been picked and properly cared for before that time. With the facts before us it becomes quite a problem to know just where the seed will come from for planting the Nebraska cornfields. For the entire State a decreased yield of 5 bushels per acre, due to a poor stand, would result in a total decreased harvest of 32,500,000 bushels of corn. At 50 cents a bushel this amounts to a loss of $16,250,000.
>
> The farmers who gathered their seed in September or early October and had it dried out before the freezes came are the ones who have good seed. These are the only farmers in so far as the station has been able to learn who have seed that they can depend upon.

MEANS OF PREVENTING SUCH SITUATIONS.

When advice is given it should be the best advice possible. The usual advice given for meeting poor seed-corn situations is to test separately the germination of each ear. The objection to this advice is the likelihood that the practice will become a yearly habit, being recommended by good authorities as the best possible procedure. Why not gather and dry the seed early and thus prevent the deplorable situation? This will not only make the testing unnecessary but will retain full productiveness—productiveness which the germination test can not restore or even reveal. Spring carefulness, no matter how great, can not make up for fall neglect. The situation is due to a lost opportunity. The way to meet properly these oft-recurring losses is to begin at the beginning and prevent them. Ten times more advice has been given regarding germination tests and methods of getting out of bad seed-corn situations than has been given regarding methods of keeping out of them. Such conditions are easily prevented in the fall, but can not possibly be rectified in the spring. Twelve years' experience in selecting seed of hundreds of varieties of corn and testing its germination teaches that seed that matures properly and is well preserved will germinate well. And what is of much more importance, it will yield well if the variety is a good-yielding acclimated variety.

The planting of poor seed corn is an exceedingly costly and unnecessary yearly occurrence.

Exceedingly costly? Yes. Each acre of the hundred million acres grown annually would produce several bushels more if planted with early selected well-preserved seed. The loss from the planting of neglected seed corn amounts to millions of dollars each year.

Unnecessary? Absolutely. This loss is easily prevented by (1) the use of acclimated and adapted varieties, (2) earlier selection, and (3) good care of seed corn.

By the application of these three principles the writer has seen a number of farmers double the profits from their corn crops.

USE OF ACCLIMATED AND WELL-ADAPTED STRAINS.

The advice to meet these poor seed-corn situations by preventing them is given with the knowledge that they can under all conditions be prevented. It is the only sound advice that can be given as applicable to all conditions. Farmers in localities that have no seed corn because last year the season was too dry or too short can prevent the recurrence of this condition by saving early each fall a supply of seed corn sufficient for two or three years' planting. Good seed corn well cared for will retain good germination and high productivity for three or four years.

If there has been a failure of the corn crop in a locality for several years in succession, it is good evidence that poorly adapted varieties are being grown and that great loss is being sustained in not growing crops from better adapted seed. Most farmers have observed the superiority of well-adapted varieties. This is well demonstrated when good home-grown seed is planted in comparison with seed imported from a distance. In sections having no home-grown seed because of the entire failure of crops, imported seed is planted and the decreased yield is not noticed because there is no possibility of planting home-grown seed for comparison.

Splendid opportunities for observing the value of home-grown seed were brought out in two series of 5-year tests conducted by the Office of Corn Investigations in cooperation with 28 State experiment stations. Equivalent lots of seed were grown each year at all the stations. The point of value from the five years' work is that a variety stood high or low in rank according to its adaptation or lack of adaptation to the locality in which the test was made. Varieties producing best at home often produced poorest when tested under other environments, notwithstanding the same seed of all varieties was used in all the tests.

THE SEED-CORN SITUATION.

A variety, a native of Sabina, Ohio, was taken 50 miles north and grown for five years at Sunbury, Ohio. Equivalent lots of Sabina-grown seed and Sunbury-grown seed were then tested at both points. At Sabina the Sabina-grown seed produced better by 47 per cent. At Sunbury the Sunbury-grown seed produced better by 11 per cent. Acclimatization and adaptation alone can account for these differences, and in this case the acclimatization and adaptation to Sunbury conditions had been brought about in five years. By being grown five years at Sunbury the variety had become adapted to Sunbury conditions and at the same time had lost its adaptation to Sabina conditions. The same variety constantly grown under Sabina conditions retained its adaptation to Sabina conditions.

To make certain of always obtaining the greater productiveness of adapted varieties it is necessary to save sufficient seed for two or three years' planting. In localities where extreme weather conditions may make the corn crop an entire failure this practice is of the utmost importance. It is plainly impossible to acclimate and adapt varieties if all seed is destroyed occasionally, making new importations of seed necessary. There are occasional instances in which imported seed produces better than home-grown seed. Such cases are experienced especially in the Southern States, where dry summers permit early-maturing northern-grown varieties to escape the summer drought. For this reason northern-grown seed is preferred in some sections. A better practice would be to select and acclimatize an earlier maturing variety. It would then escape the summer droughts and by becoming acclimated and adapted would produce better than imported seed.

RETENTION OF SUFFICIENT SEED FOR TWO OR THREE YEARS' PLANTING.

Even in sections where the corn crop is not likely to be an entire failure it is advisable during good corn seasons to retain sufficient seed for two or three years' planting. Careful tests have shown that seed that grew under favorable conditions is more productive than seed of exactly the same strain grown under unfavorable conditions. The greatest hindrance to corn breeding in some localities is the dissimilarity of seasons. The corn plant is exceedingly adaptive, but occasional wet seasons prevent a strain from adapting itself to droughty conditions and occasional dry seasons prevent acclimatization and adaptation to humid conditions. If the corn is poor in quality because of an unusually dry or an unusually wet season, no seed should be saved and that grown during a more normal season should be planted.

A mistaken idea prevails regarding the "running out" of corn because it has been grown too long in a locality. A strain of corn may run out, but the cause is with the farmer and is not because the corn has been grown too long in the same locality. The longer a corn is grown in the same locality the better adapted it becomes to the conditions of that locality, provided seed is saved each normal season from the best-producing individuals.

EARLIER SELECTION OF SEED CORN.

Great progress has been made in recent years in a more general adoption of fall selection instead of spring selection of seed corn, but there is room for still greater progress. Nearly all farmers should select their seed corn three or four weeks earlier than they do. In the South seed corn should be selected and dried during August, in the North early in September, and no prudent corn farmer anywhere in the United States will allow October 15 to pass without having sufficient seed for at least one year's planting stored where it can not be injured by unfavorable or unexpected weather conditions. Where a seed patch is not maintained and seed must be selected from the general field it should be selected before the corn is cut and shocked. Where corn is husked from the standing stalk the seed should be selected several weeks before the corn is dry enough to husk and crib.

It is doubtful whether the governor of each of the corn-producing States could issue a more valuable proclamation each year than one proclaiming a suitable week for all farmers of the State to gather and dry seed corn.

As an excuse for not having good seed it is customary to state that the season was exceptional. Such seasons will continue to occur, and the only way to escape loss is by being prepared each year for an exceptional year. Last year was a very adverse season in South Dakota, Nebraska, and some other corn States; consequently this spring it is necessary to import seed corn into these sections. Nevertheless, well-acclimated and unquestionably higher yielding seed could have been selected last September from fields in these same States. This statement is made with full knowledge of the facts, because at that time such seed was selected and dried in those very sections and is now practically perfect and germinates 100 per cent. Having personally assisted in the gathering and drying of seed corn in these sections in September, the writer knows that large quantities of seed could have been saved at that time from the same and many other fields. Unfortunately, however, most farmers postponed the selection until freezing weather, with the consequence that the seed they selected will not yield well and most of it will not even germinate well. It is not the season so much as the man.

Mr. Edgar Brown, in charge of the Seed Laboratory of the United States Department of Agriculture, has reported an average germination of 81 per cent for 1,708 samples of corn intended for seed in the spring of 1912 and obtained from farmers of various States, as shown in Table I.

TABLE I.—*Results of germination tests of seed corn intended for use in the spring of 1912.*

State.	Number of samples.	Lowest germination.	Average germination.
		Per cent.	*Per cent.*
Virginia	113	5	90.3
Kentucky	69	26	89.8
Missouri	151	2	88.7
Maryland	41	30	87.1
Iowa	141	20	85.4
Pennsylvania	144	0	84.2
West Virginia	55	8	82.5
Kansas	66	0	82.0
Ohio	189	10	80.7
Illinois	175	0	79.8
Indiana	108	0	79.0
Minnesota	106	0	76.1
Michigan	86	1	75.0
Wisconsin	88	0	73.9
Nebraska	100	30	73.1
South Dakota	57	1	64.6
North Dakota	19	0	56.8
Total	1,708		81.0

The Seed Laboratory also tested the seed gathered and dried early by men of the Office of Corn Investigations. From the States mentioned 73 samples gave an average germination of 98 per cent. (See Table II.)

TABLE II.—*Results of germination tests of seed corn gathered by men of the Office of Corn Investigations.*

State.	Number of samples.	Lowest germination.	Average germination.
		Per cent.	*Per cent.*
Virginia	29	95	98.5
Maryland (including the District of Columbia)	26	93	98.3
Kansas	1	97	97.0
Ohio	4	93	94.8
Wisconsin	2	97.6	98.8
South Dakota	1	96	96.0
South Carolina	9	96	98.0
California	1	100	100.0
Total	73		98.1

There are usually a few days between the time the corn stops growing and the coming of heavy frosts, especially if an acclimated corn is grown. We would have better corn yields and make better progress in originating and acclimatizing higher yielding strains of corn for different localities if seed corn were as readily killed by frosts as are sweet-potato vines. If seed corn would not stand so much abuse and if it were killed outright by the first freeze, farmers would dry their seed corn before they dig their potatoes and the next year's crop would be better.

The blame can not be justly shifted upon the season. It is the farmer who fails to do his part. Corn has been transported from a land of perpetual summer, where the returning wet season permitted the seed to germinate without having endured winter conditions. It has been introduced into northern localities where the winters are severe. It has shown a remarkable ability to adapt itself to short summers, but is dependent upon man to care for its seed during the winter. Without this care the corn crop would not perpetuate itself in the United States. Our first duty in giving the crop opportunity to yield well is early selection and good preservation of the seed.

GOOD CARE OF SEED CORN

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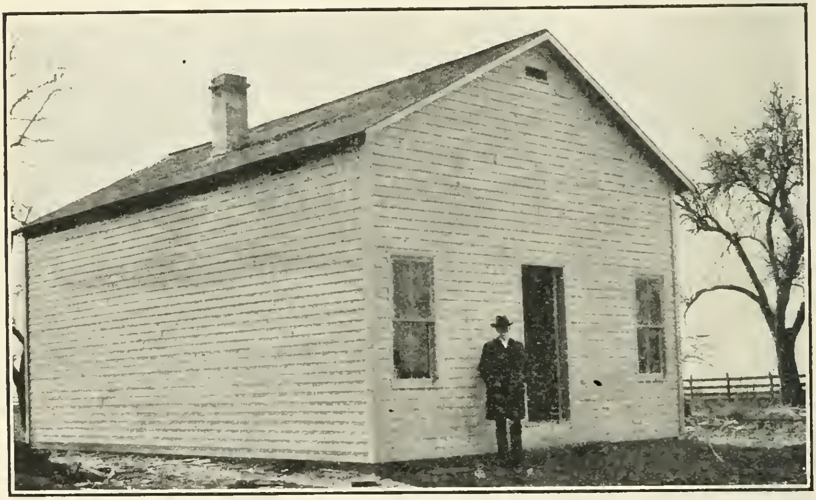

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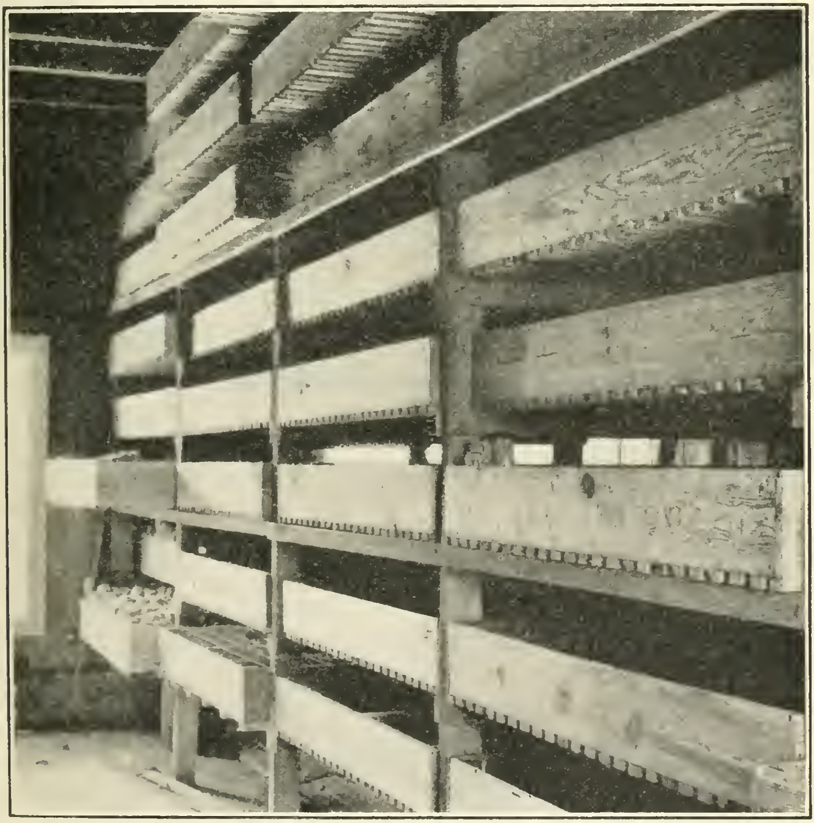

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Approved:

James Wilson,

Secretary of Agriculture.

Washington, D. C., *April 10, 1912.*

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 96.

B. T. GALLOWAY, Chief of Bureau.

RESULTS OF COTTON EXPERIMENTS IN 1911.

BY

O. F. COOK.

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 1912

BUREAU OF PLANT INDUSTRY.

Chief of Bureau, BEVERLY T. GALLOWAY.
Assistant Chief of Bureau, WILLIAM A. TAYLOR.
Editor, J. E. ROCKWELL.
Chief Clerk, JAMES E. JONES.

B. P. I.—745.

RESULTS OF COTTON EXPERIMENTS IN 1911.

INTRODUCTION.

Even with an annual plant like cotton most experiments have to be continued for several years before the completed results are ready to be reported. But when the work leads to the recognition of new factors that affect the crop or suggests new methods of agricultural improvement there should be no loss of time in making the results available for the information of the public or for the use of other investigators of similar problems. These purposes can be served by a brief summary of the principal conclusions that have been reached, especially those that affect general problems of breeding and crop production.

The present statement is to be considered as supplementary to that contained in the Annual Report of the Chief of the Bureau of Plant Industry for 1911. The subjects that have been treated in more detailed publications are also omitted unless further conclusions have been reached. The following subjects have received attention in recent publications of the Bureau of Plant Industry:

Suppressed and Intensified Characters in Cotton Hybrids, Bulletin 147.
A Study of Diversity in Egyptian Cotton, Bulletin 156.
Local Adjustment of Cotton Varieties, Bulletin 159.
Origin of the Hindi Cotton, Circular 42.
Mutative Reversions in Cotton, Circular 53.
Cotton Selection on the Farm by the Characters of the Stalks, Leaves, and Bolls, Circular 66.
Dimorphic Branches in Tropical Crop Plants: Cotton, Coffee, Cacao, the Central American Rubber Tree, and the Banana, Bulletin 198.
Hindi Cotton in Egypt, Bulletin 210.
Relation of Drought to Weevil Resistance in Cotton, Bulletin 220.
Dimorphic Leaves of Cotton and Allied Plants in Relation to Heredity, Bulletin 221.
Arrangement of Parts in the Cotton Plant, Bulletin 222.

BREEDING NEW VARIETIES OF AMERICAN UPLAND COTTON.

Several of the varieties that have been originated by this Department and sent out through the Office of Congressional Seed Distribution are gaining in popular appreciation and agricultural utility. The distribution of seed is being continued in order to permit more thorough testing and more general adoption of the varieties as far as they prove superior to other sorts.

The Columbia cotton, an early long-staple type originated several years ago in South Carolina by Dr. H. J. Webber, proves to be well adapted to large areas in the eastern part of the cotton belt. The advance of the boll weevil has reduced the production of long-staple Upland cotton in Mississippi and Louisiana, resulting in an acute commercial demand for this type of fiber. The action of State quarantine laws against the importation of cotton from sections infested with the cotton boll weevil and the high prices realized by eastern growers of the Columbia variety have stimulated interest in this variety to the extent that all the available supplies of good seed have been exhausted for some time. Special efforts are being made to preserve the uniformity of this variety by growing new supplies of seed under conditions of isolation from other cotton and by more effective cooperation in the work of selection.

Other long-staple varieties have been developed by Mr. D. A. Saunders in Texas and Louisiana, with the object of replacing the late varieties of long-staple cotton formerly grown extensively in the Mississippi and Red River valleys. The Foster variety, of which a limited distribution was made in 1910, has given excellent results in some localities, but is too susceptible to differences in external conditions to be recommended for general planting. The variety was originated from a hybrid between two distinct types, the long-staple Upland and the Texas big-boll, which doubtless explains the tendency to variation.

Tests are also being made of two other varieties with long lint originated by Mr. Saunders by the selection of individual variations from the Texas big-boll type. One of these has much the same habits of growth as the well-known Triumph variety, but has still larger bolls and leaves of a somewhat paler green. The lint has a length of about $1\frac{1}{8}$ or $1\frac{3}{16}$ inches.

The Lone Star variety, another selection from the Texas big-boll type, is receiving wide distribution in Texas and other weevil-infested States and is giving very satisfactory results. If adequate provision can be made for maintaining the uniformity of the stock by selection the variety is likely to become as important as the now famous Triumph cotton, or perhaps even more so. The two varieties are quite similar, and under some conditions are not easily distinguishable. In other places the Lone Star shows distinct elements of superiority in the larger bolls, longer lint, and especially in the greater ability of the plants to maintain an erect position instead of becoming prostrate, as the Triumph cotton often does when it makes a luxuriant growth and fruits abundantly. The Lone Star also has less tendency than the Triumph to shorten the lower fruiting branches.

Another short-staple variety called Trice was bred by Prof. S. M. Bain, of the Tennessee Agricultural Experiment Station, in cooperation with the Bureau of Plant Industry. The Trice cotton is becoming popular in western Tennessee and the demand is also spreading in the adjacent regions of northern Mississippi, Arkansas, and Missouri. This variety was obtained by selection from a local stock known as Tennessee Green Seed. The Trice is an extra-early variety, more prolific than King, with larger bolls and better lint. It is much superior to the unselected stocks that are being grown in western Tennessee and is preferable to King and other eastern short-staple varieties that have been carried west as a means of securing protection against the boll weevil. But the Columbia and other long-staple varieties of cotton are also giving good results in western Tennessee, where the conditions seem to favor the production of fiber of good quality.

ACCLIMATIZATION OF TROPICAL VARIETIES OF UPLAND COTTON.

As a result of agricultural explorations made several years ago in weevil-infested regions of Mexico and Central America several new types of Upland cotton were introduced to test the possibility of their acclimatization in the United States. Some of the introduced varieties behaved in a very abnormal manner when first planted in the United States, becoming very much overgrown and unproductive and showing great diversity, but they have now returned to their normal characteristics as early and prolific members of the Upland series. Uniform strains are being bred from individual plants selected as the best representatives of their types. Four of the imported types, Kekchi, Durango, Acala, and Tuxtla, prove to have important points of superiority over any of our United States varieties of Upland cotton.

In addition to certain specialized characters that afford some protection against the boll weevil, the new sorts have very abundant lint of excellent quality and of good length, ranging from 1 to $1\frac{1}{4}$ inches. The bolls are larger than in American Upland varieties that produce as long a fiber. Two of the new types, Durango and Acala, seem to be specially adapted to conditions of dry farming and irrigation in the Southwestern States. These types have been grown in field plantings with excellent results. Still larger plantings are to be made in the coming season to test the behavior of the varieties under different conditions and to secure seed for more general distribution. The Acala type promises to become useful for general purposes and is apparently superior to the Texas big-boll varieties now in general cultivation, while the Durango seems likely to take a prominent place among long-staple Upland varieties.

The Durango cotton has been derived from a Mexican stock, supposed to have come from the State of that name. The seeds used for the first planting were from a few bolls obtained by Mr. F. L. Lewton from an exhibit made by the Mexican Government at the St. Louis Exposition. After several years of acclimatization and selection in southern Texas a superior strain was separated, from which the present Durango variety has been developed. The Acala and Tuxtla varieties were obtained in the State of Chiapas, in southern Mexico, during an agricultural exploration of that region by Messrs. G. N. Collins and C. B. Doyle in the winter of 1906 and 1907. The existence of a big-bolled long-staple type of Upland cotton in southern Mexico had been ascertained during an expedition made by the writer in the previous summer, but seed could not be obtained at that time. The origin and peculiar characteristics of the Kekchi cotton have been described in some detail in previous publications, especially in Bulletin 88, Weevil-Resisting Adaptations of the Cotton Plant, Bureau of Plant Industry, United States Department of Agriculture, 1906.

CHARACTERISTICS OF THE DURANGO COTTON.

In cultural characters the Durango cotton is distinctly superior to the old long-staple varieties usually referred to as "Peeler" cotton, especially for irrigated districts in Texas and other Southwestern States. It is very early and prolific, flowers rapidly, and produces larger bolls than Allen, Sunflower, or other Peeler varieties. The lint is not as long as in some of the Peeler varieties, but it is much more abundant and more uniform in length—about 1¼ inches under favorable conditions. The bolls ripen early and open promptly, so that a large part of the crop can be gathered at a single picking. The plants have an open, upright habit, which gives them an advantage under boll-weevil conditions, facilitates picking, and lessens the danger of discoloration by moisture.

Another desirable characteristic of the Durango cotton is that the involucral bracts are unusually small, and hence less likely to be broken off and mixed with the fiber at the time of picking. Broken bracts furnish most of the "trash" that now figures so largely in the commercial grading of cotton. The small size of the bracts and the upright, open growth of the plants may be expected to render this variety unusually well suited to the application of cotton-picking machines, if any of these can be developed to the point of practical utility.

The most objectionable tendency observed in this variety is toward a premature ripening of the bolls, before the seeds at the ends of the locks are fully matured. Were it not for this tendency the Durango cotton could be recommended for general planting in competition with Triumph or any other short-staple sort; but other long-staple varieties show the tendency to premature opening in a greater degree than the Durango. In comparison with other long-staple types, the Durango cotton must be considered as distinctly drought resistant.

Growers of long-staple cotton are familiar with the fact that the length and strength of the fiber are likely to be diminished if the plants are checked by drought or other unfavorable conditions while the crop is being produced. The Durango cotton, being less susceptible to such unfavorable conditions, has produced good crops in localities where other types of long-staple cotton could not be grown to the same advantage. In numerous experiments in Texas and southern California the new variety has shown itself superior to all of the United States Upland long-staple varieties with which it has been compared.

The importance of the factor of local adjustment is well shown by differences in the behavior of the Columbia cotton when grown in comparison with the Durango. In South Carolina, where the Columbia cotton was bred, it is an excellent variety, with a long, strong, and uniform staple. But when grown in Texas and southern California the Columbia cotton is markedly inferior. Many plants produce only short, weak lint that would not be considered as premium cotton, and there are other departures from the normal characters of the variety in the habits of growth, leaves, and bracts. Continued selection of the more normal plants under the western conditions would doubtless improve the behavior of the variety, but in view of the superior adaptation of the new Durango type it seems hardly worth while to attempt to adjust the Columbia cotton to the western conditions.

LONG-STAPLE COTTON AS AN IRRIGATED CROP.

The possibilities of producing long-staple cotton are worthy of a careful consideration in all of the irrigated districts of the Southwest. The popular idea has been that the production of a long, strong fiber was necessarily limited to regions with a humid atmosphere, like the Sea Islands of South Carolina or the Delta region of the Mississippi Valley. In reality, however, the production of fiber of high quality does not depend upon atmospheric conditions, at least to any such extent as has been supposed.

As long as the soil affords an adequate and readily available supply of moisture, a high degree of atmospheric humidity is not necessary. A dry atmosphere is injurious, of course, if it renders the supply of moisture in the soil inadequate and thus reduces the plants to a condition of drought. But with soil of the right texture and a supply of moisture that can be replenished by irrigation it is possible to maintain equable conditions and produce cotton of very high quality. This has been conclusively shown in experiments with Egyptian cotton in Arizona and southern California, and with the Durango cotton in southern Texas.

The general tendency in irrigated districts is to use too much water, the ability of the cotton plant to resist drought being underestimated. The crop is easily injured by the excessive use of water, especially in the earlier part of the growing season. In localities where the natural rainfall assisted by dry-farming methods provides enough moisture for the germination of the seed, it is better to use irrigation only to protect the maturing crop against injury by too severe drought.

To raise short-staple Upland cotton on irrigated lands where Egyptian or long-staple Upland cotton can be grown must be considered as a waste of agricultural resources. It is true that short-staple cotton can be produced and marketed with less difficulty and by more careless methods. This may justify the planting of short-staple cotton by inexperienced farmers or in new settlements, but as soon as communities become better organized an increased production of long-staple cotton is to be expected from the irrigated regions of the Southwest.

Though many irrigation enterprises have been undertaken in the hope of producing high-priced truck and fruit crops, cotton seems likely to become the chief product of irrigated lands in Texas, as well as of those that are cultivated by dry-farming methods. Promoters of irrigation enterprises often fail to appreciate or to call attention to this prospect, perhaps for the reason that short-staple cotton would not appear as a profitable crop for lands enhanced in value by the cost of irrigation works and water rents. Indeed, it is still very difficult to understand how any crops now in sight will justify the high prices that are expected for some of the irrigated lands. In regions where alfalfa does not thrive, as in some parts of Texas, cotton is all the more likely to become the chief dependence of irrigation farming.

EXTENSION OF COTTON CULTURE IN THE SOUTHWEST.

A gradual extension of cotton culture into the drier region of Texas and other Southwestern States is one of the agricultural movements now in progress. The boll weevil can do less damage in a dry climate. The injured buds fall off and dry up more promptly and this destroys the weevil larvæ. Cotton resists drought better than most other crops and seems likely to be the chief product of large tracts of country in southern and western Texas that are now being occupied by farming communities. This movement is going forward rapidly, and hundreds of settlements are being opened. Many of the more extensive cattle ranges of former years are being plowed and planted, not merely because the land has become valuable for agricultural purposes, but because the rapid extension of mesquite and other woody vegetation has restricted the supply of grass and greatly reduced the value of the land for grazing purposes.[1]

There is no apparent reason why this extension of the cotton belt to the westward should not make good the losses caused by the boll weevil in the more humid regions of the East. On the other hand, the greater diversification of farming in the regions where cotton is becoming a more precarious crop tends to compensate for the restriction of range facilities in the West. The former cattle country is producing cotton and the cotton country is showing renewed activity in the production of cattle. The boll-weevil invasion has stimulated activity in the extermination of the cattle tick.

The higher cost of labor and transportation in the Southwest is largely compensated by protection from weevils and favorable weather in the long picking season. There is seldom any rain to damage the cotton by beating it down to the ground or to discolor or rot the fiber in the bolls, as often happens during periods of wet weather in the more humid Eastern States. This is particularly important, of course, in connection with the production of the high-grade long-staple cottons that are likely to be grown in irrigated districts.[2]

COTTON IMPROVEMENT ON A COMMUNITY BASIS.

A general study of this subject shows that many factors of improvement could be much more effectively utilized if cotton-growing communities were organized to grow a single variety of cotton and maintain its uniformity by selection. The present multiplicity and

[1] Change of Vegetation on the South Texas Prairies. Circular 14, Bureau of Plant Industry, U. S. Dept., of Agriculture, 1908.

[2] One well-known investigator of the weevil problem has gone so far as to suggest an ultimate transfer of the entire cotton industry of the country into the dry Southwestern States:

"The time will no doubt come when cotton production will be abandoned in the humid area of the Southern States, and the area of production of this crop transferred to the warm arid region just mentioned. When the boll weevil has become distributed throughout the present cotton area of the United States, the annual loss from its effects, in spite of all methods and agencies that can be brought to bear against it, will probably exceed $50,000,000. Why should this loss continue to be incurred and carried year after year, when a new cotton region which will produce a far higher grade of fiber worth a higher price awaits exploitation?

"Let the Southern States raise other crops that are better suited to their conditions, and move the area of cotton production to the Southwest, where it belongs. The boll weevil will not trouble it there. Such action will not be realized for several decades, it is safe to say, and I will no doubt be set down as a foolish theorist for making the suggestion. However this may be, I rely upon my firm conviction that the change will come eventually and that time will prove the soundness of the suggestion." See Townsend, C. H. T., "The Cotton Square-Weevil of Peru and Its Bearing on the Boll-Weevil Problem in North America," Journal of Economic Entomology, vol. 4, 1911, p. 248.

mixing of varieties is a serious obstacle to the improvement of the industry.

In a community that planted only one kind of cotton the crossing of varieties in adjacent fields and the mixing of seed in gins would be avoided, selection could be made more effective, and the production of a larger quantity of uniform fiber would enable growers to obtain higher prices. The danger of weevil injury would be diminished if communities could also agree upon dates of planting and make a combined effort to have the fields cleared of stalks early in the fall. Special attention should be given to establishing improved varieties and methods of selection in communities organized for the production of a single type of cotton.[1]

METHODS OF DISTRIBUTING SUPERIOR VARIETIES.

A study has been made of the results of sending out seed of improved varieties of cotton through the Office of Congressional Seed Distribution to see whether the usefulness of the system could be increased. The custom has been to send the seed out in 1-peck packages, with the idea of enabling the farmer to plant the new variety on a field basis by the second or third year. But there are several reasons why much of the seed is wasted, or at least fails to serve the intended purpose.

Many of the packages are not used for planting, being sent to people who are not growing cotton. Some of them go to farmers who do not "bother" with such a small quantity of seed. Many farmers plant the improved seed by the side of other cotton, or even mix it with their local variety before planting, with an idea that the whole stock can be improved in this way. Very few farmers observe the precautions necessary to avoid crossing with other varieties in the field or mixing the seed at the gin. To avoid admixture of seed the gin has to be thoroughly cleaned out. This means extra time and trouble that many farmers are unwilling to take. The purity of the new stock is usually destroyed in the first season.

After the cotton is grown other difficulties appear in the separate picking, ginning, and marketing of a single bale or a part of a bale of a different kind of fiber, especially if the new variety is one that produces a longer staple than the local sorts. Mixed bales, containing two kinds of cotton, are refused by buyers. These difficulties are often avoided by selling the small stock of improved cotton in the seed, so that the variety is lost to the farmer. Only a small part of the seed that is sent out through the general distribution is really made use of for introducing the new variety into cultivation.

[1] A more extensive statement of the advantages to be secured by the organization of cotton-growing communities may be found in the Yearbook of the Department of Agriculture for 1911, pp. 453–466.

Thus it is seen that the packages sent out in the past have been too large for some purposes and too small for others. The crop raised from a peck of seed can hardly be discarded as a mere casual experiment, but is usually too small to receive separate treatment in ginning and marketing. Unless the first planting of a new variety is isolated from other cotton, the seed should be discarded and another beginning made, preferably with seed enough to plant at least a small isolated field and produce at least one full bale of the improved fiber.

It has become evident that two or three distributions of a few superior varieties are likely to be of much more use than single distributions of a larger number of varieties. The chief object of such distributions is not to increase the number of varieties, which is already too large, but to secure the widest utilization of the best varieties. To accomplish this purpose it is necessary not only to breed new varieties, but to maintain the select stocks for a period of years, at least long enough for the public to become acquainted with the variety and for local breeders and seedsmen to develop supplies of good seed.

The problem of distribution is obviously to get more of the select seed into the hands of men who are sufficiently interested to make use of it as a means of establishing the culture of the new variety in their local community. To avoid the present waste of seed in the general distribution it has been recommended that the packages of seed used for this purpose be reduced to 1 quart. This smaller amount will serve the general purpose of affording the farmer an opportunity to become acquainted with the new variety and to decide whether he cares to adopt it.

The seed saved by reducing the size of the packages in the general distribution is to be used for a special distribution of larger amounts of seed to a limited number of farmers who report the best results from the first small package and who are ready to give special attention to the new variety in order to keep the seed pure and market the improved crop separately. In the distribution of the larger packages preference should be given to districts or communities that are favorably situated and well organized, so that they can devote themselves to the production of a single superior variety. In addition to the reports that are furnished regarding the results of the first planting, farmers are to be asked to send small samples of the cotton they have raised. This method will secure more definite information regarding the behavior of varieties in different parts of the cotton belt and make it possible to place the special distributions to the best advantage. Well-organized communities are also to be encouraged as far as possible by expert advice and assistance in growing, selecting, and marketing the improved varieties.

PRESERVATION OF SUPERIOR VARIETIES BY SELECTION.

One of the chief factors in the improvement of all agricultural industries, the utilization of better varieties, is largely nullified by the failure of the cotton-growing public to understand and observe the precautions that are needed to preserve the uniformity of improved stocks. The breeding of a superior variety of cotton represents an improvement of the industry only to the extent that the stock is preserved and continued in cultivation. With selection neglected, the uniformity of a strain is soon lost, usually before its agricultural value can be realized and even before it is brought into general cultivation. Selection is quite as necessary for the preservation of old varieties as for the development of new ones. Such selection is quite distinct, both in object and method, from that employed by a breeder in developing a new variety or in finding superior individuals and comparing their progenies. The modern school of biologists may be right in supposing that little or nothing can be obtained in the way of further improvement after a definite varietal type has been separated. But this has nothing to do with the fact that continued selection is a necessity to keep any select stock from losing its uniformity by crossing with degenerate mutations that continue to appear, even in pure strains, from self-pollinated plants.[1]

Though it is of the highest importance with cotton to use select seed in order to secure good yields and uniform fiber, the present system of seed production is altogether inadequate and entails annual losses of enormous proportions. To say that the average yield could be increased 10 per cent and the quality improved to a similar extent by the use of better seed are conservative estimates amply justified by many experiments in different parts of the cotton belt. Yet if these factors of improvement could be applied to the whole cotton industry of the United States their annual value would reach a very large figure.

Owing to the relatively small number of seeds produced by the individual plant and the relatively large number that have to be planted, there is no prospect that the production of high-grade seed can be centralized in the hands of commercial seed growers or dealers, as with other crops. The great bulk of the crop will continue in the future, as in the past, to be grown from seed raised on the same farm or at least in the same community. Moreover, all the experiments indicate that properly selected home-grown seed is likely to give better results than any newly imported stock, even of a superior variety. The production of local supplies of high-grade seed is one of the fundamental objects of community organization.

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[1] Bain, S. M. A Cotton Variation with a Self-Fertilized Ancestry. American Breeders' Magazine, vol. 2, No. 4, 1911, p. 272.

IMPORTANCE OF BREEDING VARIETIES WITH DISTINCTIVE CHARACTERS.

Since the value of a superior variety depends very largely upon the preservation of uniformity after it has been introduced into cultivation, means of maintaining uniformity must be taken into account in breeding. Varieties with distinctive peculiarities, especially in the vegetative parts of the plants, are more valuable because it is easier to detect and remove undesirable individual variations that would otherwise destroy the uniformity of the stock. Preference is being given to the breeding of new varieties that have readily distinguishable characteristics, and the distinctive characters of existing varieties are being determined in order to give a better basis for selection.

The big-boll long-staple selection bred by Mr. Saunders in Texas, as already stated, has foliage of a slightly paler green than other varieties of Upland cotton. Plants with darker foliage are always found to depart from the type in other respects, having smaller bolls and shorter and less abundant lint. The difference in color makes it easier to recognize and remove from fields or breeding plats such variations of this pale-leaved strain.

Seedlings of numerous varieties of Egyptian and Upland cotton have been compared with a view to the development of methods for detecting undesirable variations in the early stages of growth. It has been found that the Hindi variations of Egyptian cotton can be recognized immediately after germination by differences of the cotyledons or seed leaves. Those of the Hindi cotton are larger and smoother, are marked with red along the veins, and have a reddish callus at the base. Differences in the forms of the first series of true leaves also permit some of the varieties to be distinguished in the early stages of growth. Egyptian varieties usually have five or six simple leaves at the base of the stalk before the lobed leaves begin to appear. Upland varieties have fewer simple leaves and some show lobed leaves from the first. The involucral bracts that inclose the flower buds afford another series of characters of use in distinguishing varieties.

JUVENILE LEAF-CURL OF COTTON.

Malformation of the leaves is a widespread disorder of young cotton seedlings. Many of the seedlings with malformed leaves also lose the terminal bud. This disorder forces the development of vegetative branches from the axils of the cotyledons and from other joints at the base of the stalk. Though such plants always recover, in the sense that they afterwards produce normal leaves, flowers, and bolls, they are more or less misshapen, mature later than uninjured plants, and produce a smaller crop. Retarded and irregular growth is particularly undesirable in weevil-infested regions, where a prompt development of the crop is of the utmost importance in avoiding weevil injury.

Though generally confused with a distortion of the leaves caused by plant lice, the juvenile leaf-curl is quite independent of the presence of these insects. Both kinds of malformation are often to be found on the same plant, but they are not of the same character. The juvenile leaf-curl may be distinguished by the fact that it is usually accompanied by irregular holes or incisions in the leaves that do not occur when plant lice alone are involved. Nothing has been found to indicate that the juvenile leaf-curl is due either to insects or to parasitic fungi or bacteria. All the damage is done, apparently, while the leaves are still in very early stages of development. The parts that remain uninjured appear to be entirely normal.

The underlying cause of the juvenile leaf-curl is still obscure, but it is evident that the malformations result from the death of some of the cells of the leaves during the early stages of growth. If only a few cells die, the result is a simple puncture of the leaf surface. The loss of larger groups of cells results in more serious malformations and even in the abortion of the whole terminal bud. Thus the distorted leaves and the aborted terminal buds may be considered as merely different symptoms of the same form of injury to cells of the seedlings. The petioles of the leaves show another injury in the form of long narrow gashes, as though cut lengthwise with a knife. It is to be expected that corresponding malformations will be found in young plants of other species. Mr. G. N. Collins has called the writer's attention to a peculiar lobing of the leaves of Indian corn, which may be of the same nature.

That the injuries begin at very early stages in the development of the leaves is shown by the fact that wounds are often healed, or some of the lost parts may be regenerated from adjacent tissues. As a result of healing the wounds, the leaves often have a peculiar broken-and-mended appearance. A similar condition is sometimes found in the leaves of abnormal hybrids and mutations, but in these cases the abnormality continues through the whole life of the plants. This analogy might be taken as a confirmation of the idea that the cause of the malformation is to be found in the injury or death of some of the cells at very early stages of the development in the bud, while it is still possible for new cells to be formed by proliferation.

The popular belief that the leaf-curl is much more severe during periods of cold weather may mean that some of the cells are killed by cold. Or it may be that cold has the effect of delaying division or other cytological processes that normally occur at night. Such a delay would render the cells more susceptible to injury from sudden exposure to heat or sunlight in the morning. It has been noticed that plants less exposed to the sun show less of the leaf-curl, while those that are well shaded or grow in diffuse light, as in a greenhouse, are not affected. If too much exposure of the young plants to the sun is the cause of the injury it may be possible to secure protection by later planting or more gradual thinning. It is to be considered that the growing tissues of the young seedlings are probably exposed to greater extremes of heat and dryness than those of more mature plants, because they are closer to the heated surface of the soil. After a cold night the young plants often appear badly wilted in the morning, an hour or two after sunrise, perhaps because the leaves are heated before the roots are warm enough to absorb water rapidly. Injuries due to sudden exposure in the morning are often ascribed to frost. Cotton seedlings may be killed in this way although the night temperatures remain above the frost line. This fact was shown some years ago in experiments with cotton in Guatemala.

METHODS OF UTILIZING FIRST-GENERATION HYBRIDS.

It has long been known that hybrids between Upland and Egyptian cotton produce lint of superior quality. The hybrids are also more vigorous and productive than pure-bred varieties, and better able to withstand unfavorable conditions. Many attempts have been made to breed superior hybrid varieties, but the later generations always prove inferior to the first, or to the parent varieties. Many of the plants have short or sparse lint or are weak and infertile.

Accepting the fact that the superiority of the hybrids is limited to the first generation, other possibilities of utilization are being investigated in southern California. Experiments have been made by Mr. Argyle McLachlan with two methods of producing hybrid seed, hand pollination and natural crossing by bees. The former process would be rather expensive, but the methods have been so simplified that the cost would not be prohibitive.

The production of hybrid seed through natural crossing by insects is facilitated by planting the parent varieties in alternate rows. As only a part of the seed will produce hybrid plants, the feasibility of this method depends on the possibility of recognizing the hybrids in the early stages of development and pulling out the remainder of the plants. Studies of the characters of young seedlings have shown that the hybrids can be distinguished in the early stages of growth. The proportion of hybrids in any particular lot of seed would depend, of course, on the number and activity of the bees or other cross-fertilizing insects at the time of flowering, and this varies greatly in different localities and in different parts of the season.

The utility of the hybrids would be increased if two or more crops of cotton could be obtained from the same plants. The winters of southern California are not cold enough to kill the roots, and the

Egyptian cotton has the habit of forming subterranean shoots when the stalks are frozen to the surface of the ground below the level of the original seed leaves. The new shoots appear in the form of irregular nodules, with a superficial resemblance to crown galls. They probably represent the development of dormant root primordia, for they always arise from the four grooves where the lateral roots come out from the taproot, never from other parts of the surface. The first leaves of these regenerated shoots are very irregular in shape, but the normal form is soon attained and the new stalk makes an entirely normal development.[1]

The readiness of the Egyptian cotton in forming these subterranean buds on the overwintered roots suggested the idea that cuttings would callous and root readily under the same conditions and thus open up a third possibility of utilizing hybrids by propagation from cuttings. The first attempt of this kind was made by Mr. McLachlan in May, 1911, with cuttings of new-wood branches that had developed on overwintered plants. Notwithstanding the lateness of the season and the absence of any special care or precaution to induce the rooting of the cuttings, about 10 per cent survived and grew into very vigorous and productive plants. The possibility of carrying such cuttings through the winter by different methods of protection and handling is being tested at Bard, Cal.

CONTROLLING THE FORMATION OF BRANCHES IN EGYPTIAN COTTON.

Previous experiments having demonstrated the possibility of producing Egyptian cotton of high quality in the irrigated districts of Arizona and southern California, it becomes necessary to understand the cultural peculiarities of this type of cotton. The most obvious cultural difference between the Egyptian and Upland types of cotton is the greater vegetative vigor or luxuriance of the Egyptian. Though the Upland cotton is similarly affected by combinations of fertile soil, moisture, and heat, the Egyptian cotton is much more susceptible and often grows two or three times as tall as Upland cotton planted in adjacent rows.

In addition to the greater height of the plants, the Egyptian cotton also produces a much larger number of large "wood limbs" or vegetative branches. Under field conditions these branches grow in an upright or ascending position, forming so dense a mass of foliage that no normal fruiting branches can develop on the lower part of the plant. The result is that fruiting is largely confined to the top of the plant, making the crop very late in comparison with Upland cotton.

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[1] Arrangement of Parts in the Cotton Plant. Bulletin 222, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1911, p. 23.

The large size of the plants increases the labor of picking, and much of the crop is lost by the breaking down of the branches between the rows. These are the most serious difficulties in the development of an Egyptian cotton industry in the irrigated districts of Arizona and southern California.

When the Egyptian cotton is grown under conditions that do not induce luxuriant growth the behavior is much like that of Upland cotton. The plants are low and spreading, with open foliage, and the bolls develop about as rapidly as those of Upland cotton. This Uplandlike behavior has been observed when the Egyptian cotton was grown in cool climates, as in the vicinity of Washington, D. C., and near Los Angeles, Cal. This is also the normal behavior of the plant in the lower part of the Nile Valley, where most of the Egyptian cotton is raised. The temperatures are kept low by the north winds that regularly blow in from the Mediterranean.

Early planting has been advised in California as a means of restricting the development of the vegetative branches, because fewer branches are produced during the cooler weather of early spring. But the advantage that may be gained in this way is easily lost, for a sudden access of warm weather is likely to throw the plants into luxuriant growth and induce the development of vegetative branches from all of the lower joints of the stalk.

Apart from the influence of cold weather in keeping the plants from becoming too luxuriant, experiments have shown that there are two other factors, moisture and exposure to sunlight, that govern the development of vegetative branches. Plants that grow from the outset in dry soil, even though standing alone and fully exposed to high temperatures and to full sunlight, often fail to develop any vegetative branches, but begin to produce fruiting branches only a few inches from the ground. When cotton is grown under irrigation it is possible to restrict the production of vegetative branches by withholding water in the early part of the season until the fruiting stage is reached.

The development of vegetative branches is also restricted when the plants stand close together so as to shade the lower joints of the main stalk, which produce most of the vegetative branches. If the plants are thinned too early, so that the lower joints are exposed before there is enough foliage to keep them shaded, vegetative branches are likely to be put forth at each joint and even from the axils of the cotyledons or seed leaves. But if the plants are allowed to stand closer together or are thinned gradually they may not produce any vegetative branches.

There are obvious limitations, of course, in the use of dryness and shading to prevent the development of vegetative branches. If the plants are kept too dry they make only a slow growth. If allowed to stand too close together they remain weak and spindling. The practical problem is to use the two factors in proper combination, so as to suppress the vegetative branches without interfering with the growth of the main stalk and the fruiting branches. Further experiments are to be made in this direction.

If the plants can be kept from developing any vegetative branches it will be possible to let them stand only 12 or 15 inches apart in the rows instead of 3 or 4 feet apart, as has been considered necessary, and the rows will not need to be more than 3 or 4 feet apart instead of 5 or 6 feet. This control of the branching may enable the yield to be increased, and at the same time cultivation and picking will be greatly facilitated.

A control of the branching would also enable the crop season to be shortened, since one of the chief reasons for early planting would be removed. It would become much more feasible to alternate Egyptian cotton with winter crops. Cold weather, juvenile leaf-curl, and plant lice usually conspire to make the growth of the plants very slow during the spring months. There is nothing to show that later planting would lessen the crop or even delay maturity if there were other ways of controlling the formation of the branches.

EGYPTIAN COTTON LESS SUSCEPTIBLE TO SHEDDING.

In another cultural character the Egyptian cotton compares more favorably with the Upland type. This character is the greater freedom from shedding or abortion of the buds and young bolls. Perhaps on account of its deeper root system the Egyptian cotton is often able to retain its buds and young bolls under conditions that cause extensive shedding in adjacent rows of Upland cotton. Shedding occurs in the Egyptian cotton when the vegetative branches grow up and shade the lower fruiting branches, but there is no such general shedding of buds and young bolls as usually results from a sudden checking or forcing of growth in Upland cotton.

Losses from shedding are often quite serious in irrigated regions, each application of water causing many buds to fall. The effect is much the same as when the boll weevil is present. The plants grow large and luxuriant, but have only a few bolls. This was noticed especially in an experimental field of Columbia cotton raised at El Centro, in the Imperial Valley of California, in 1911. An adjacent planting of Durango cotton, though it had suffered in the same way, produced a much larger crop. While it may be possible to avoid such losses by working out better methods of culture and irrigation, the general fact that the Egyptian type of cotton is less susceptible to shedding than the Upland type is an important consideration.

EGYPTIAN COTTON AS A FAMILY CROP.

The Egyptian cotton is also superior to the Upland type from the standpoint of what may be called domestic or household production; that is, by the work of the settler and his own family. It is much lighter work to pick Egyptian cotton than to pick a short-staple crop of equal value. This is because the actual weight is less with the Egyptian cotton and because more careful methods of picking must be used. The Egyptian plants are taller and more erect, so that the picker stands in an upright position. This makes the work easier and lessens the exposure to the sun. There is also more shade in the Egyptian fields, on account of the larger size of the plants. With the small or prostrate Upland plants most of the work must be done with the body in a stooping position or while kneeling on the ground, with the back exposed to the sun. At the same time the movements of the body are impeded by a large picking sack, which pickers of Upland have to drag through the field. Large sacks will not be used with the Egyptian cotton because they admit too much "trash" or broken leaves.

It takes longer to pick the Egyptian cotton because of the smaller size of the bolls and the need of greater care to keep the fiber clean. The greater care takes more time, of course, but lightens the physical exertion. Indeed, it would be difficult to mention any other form of outdoor work in which women and children can assist to better advantage.

Another feature that adapts Egyptian cotton to household production is that it is easier to pick the cotton clean in the morning and afternoon when the bracts and dead leaves are not so brittle as in the middle of the day. With hired labor it is scarcely feasible to interrupt picking for several hours in the middle of the day, but this is an advantage if the housewife and children are to do a share of the work. The prejudice against outdoor work for women and children is giving way before a realization of the superior healthfulness of activity in the open air. Children make better educational progress when they are allowed a share in the activities of their parents. Town children spend most of their waking hours with other school children of their own age and have only slight contacts with parents or with practical affairs of life. For children to help their parents with such farm operations as picking cotton is also entirely different from having them work in gangs or in factories.

Unlike perishable fruits and truck crops, the cotton does not spoil if picking has to be interrupted for a day or even for a week, nor does it have to be packed and shipped as soon as gathered. Many families could pick two or three bales of Egyptian cotton without serious difficulty, for the harvest season is very long, three months or more. Even a single bale of Egyptian cotton, worth about $100, would be a welcome addition to the income of many a pioneer family. The money return, at present prices, would be as great as for twice as much short-staple cotton and with a much smaller amount of heavy labor.

If each settler were to plant 2, 3, or 5 acres of Egyptian cotton to supplement the poultry yard, the kitchen garden, or the small fruit orchard, a considerable production would be possible, quite independent of the possibilities of utilizing hired labor by farmers who operate on a more extensive scale. But this resource is necessarily limited to communities that grow enough cotton to provide facilities for ginning and marketing.

EGYPTIAN COTTON NOT ADVISED FOR TEXAS.

As yet there is no reason to believe that the success obtained with Egyptian cotton in Arizona and southern California can be duplicated in Texas. There have been numerous experiments with Egyptian cotton in Texas and some have appeared quite successful, but the results as a whole do not warrant the idea that Egyptian cotton is a promising crop for Texas.

There are two principal differences between Texas and the more western States—the presence of the boll weevil and the hotter weather of the spring season. The warmer weather of the spring months in southern Texas is detrimental to the Egyptian cotton because it brings the plants into a condition of luxuriant growth at a stage too early in their development. The result is to induce the production of a large number of vegetative branches. The plants soon require more moisture than is usually available under the Texas conditions and are seldom able to set a crop. With hot weather and plenty of moisture the Egyptian cotton grows to enormous size and matures very late, and this increases the danger of injury by the boll weevil.

There is an untried possibility that the breeding of earlier varieties of Egyptian cotton or the discovery of improved cultural methods for controlling the growth of the plants may make it feasible to grow Egyptian cotton in some of the irrigated districts of southern Texas. Egyptian fiber of excellent quality was produced under irrigation at San Antonio in 1911, the season being so dry that the weevils did very little damage. But if a commercial culture were to be maintained it would be necessary to confine the Egyptian cotton to isolated communities where no Upland cotton would be planted. Isolation would be necessary to prevent the contamination of the Egyptian cotton by cross-pollination with the Upland and also to avoid the boll weevils that breed on the Upland cotton earlier in the season.

CONCLUSIONS.

Improved varieties of American Upland cotton bred by the Department of Agriculture and sent out through the Congressional Seed Distribution are being utilized for the improvement of the cotton industry.

New types of Upland cotton, introduced from weevil-infested regions of Mexico and Central America, have been acclimatized in the United States and have given excellent results in Texas and other Southwestern States.

One of the new varieties from Mexico, called Durango, is the most promising Upland long-staple cotton for irrigated districts. Long-staple cotton is likely to become one of the most important crops in the irrigated regions of Texas and other Southwestern States.

Cotton-growing communities have much to gain by cooperative organization for the production and marketing of a single superior variety of cotton.

An improved method of distributing select varieties has been devised to avoid waste and encourage the production of superior fiber on a community basis.

The necessity of continued selection to preserve superior varieties has been demonstrated and improved methods of selection have been devised. The value of distinctive characters that enable the plants to be recognized in the field is being taken into account in the breeding of varieties.

Cultural methods are suggested for avoiding malformations of young seedlings, which often delay the development of the plants and reduce the yield.

Several methods of utilizing superior first-generation hybrids between Egyptian and Upland varieties of cotton are being tested, including the propagation of such hybrids from cuttings.

Experiments have shown the possibility of controlling the development of vegetative branches by thinning the plants gradually and restricting the supply of water in the early stages of growth.

The Egyptian type of cotton proves to be less susceptible to the shedding of the buds and young bolls than the Upland cotton, which is an additional element of security for the crop.

Differences in habits of growth and methods of picking render the Egyptian cotton superior to the Upland type as a family crop.

The successful production of Egyptian cotton in Arizona and southern California does not justify expectations of similar results in Texas, where the conditions are essentially different. The Durango variety is preferable for irrigated districts in Texas.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *April 16, 1912.*

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B. T. GALLOWAY, Chief of Bureau.

A PRELIMINARY REPORT ON RICE GROWING IN THE SACRAMENTO VALLEY.

BY

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A PRELIMINARY REPORT ON RICE GROWING IN THE SACRAMENTO VALLEY.

INTRODUCTION.

In the Sacramento Valley of California there are large tracts of land that 30 years ago produced profitable crops of wheat and barley which are now not yielding crops of either grain in paying quantities. These tracts were first used for grazing cattle, but were afterwards converted into extensive grain ranches, which to-day might be as remunerative in yield as in the earlier days if maintenance of soil fertility had been valued as an asset. Under improved methods of farming, however, a large part of this area, depleted as it is in plant food, will still produce grain in quantity and of good quality at a profit. While crop rotation, diversified farming, and intensive culture will play conspicuous parts in the improvement of the agriculture of this valley, irrigation will play a more important part in the development of its agricultural possibilities, for through the intelligent use of water it is possible to obtain the full capacity of the crops now grown and also profitable returns from crops which are not now cultivated in this valley.

Among the crops requiring water rice is worthy of a trial, but its successful cultivation is so dependent upon water that it should never be planted where the supply is not sufficient to submerge the land to the depth of at least 3 inches from the middle of June to the middle of September. If there is water enough during this period for a continuous submergence, the greatest obstacle to the production of the crop is removed. There is no crop grown in California at present that requires as much water as rice.

CONDITIONS UNDER WHICH VARIETY TESTS OF RICES WERE MADE.

In the spring of 1909 the Office of Grain Investigations of the Bureau of Plant Industry inaugurated tests to determine the adaptability of rice to the climate and soil of the Sacramento Valley. These tests were made on the black adobe soil lying on the east side of Butte Creek, approximately 9 miles west of Biggs, Cal. (Pl. I, fig. 1.) This soil is of a close, compact structure. When wet it has an exceedingly tenacious and puttylike consistency. During the dry season it breaks at the surface into blocks with deep fissures between them. These blocks upon long exposure are divided and subdivided by smaller fissures until the surface may become a loose, shallow mass of small pieces of the size of peas. In this condition the soil absorbs water readily, which is given up slowly under evaporation. The subsoil, which lies at a depth of approximately 3 feet, is very impervious, though water penetrated it to a depth of 6 inches before the plats were drained. The surface of the plats was nearly level, with just enough slope for good drainage into the narrow sloughs, which are features of the topography of this area of black adobe that may be used for conveying water for both drainage and irrigation.

Grain had been grown exclusively upon this land, though it was not under cultivation during the year preceding the tests. The land was plowed in the autumn. The rains of the winter months reduced the clods and left the surface of the soil in a condition that required less work and expense to secure a good seed bed than would have been possible if the entire preparation for planting had been postponed until spring.

The seed of each variety was planted with a drill to the depth of $1\frac{1}{2}$ to 2 inches at the rate of 80 pounds per acre. On account of a lack of moisture in the soil at the time of planting, it became necessary to apply water to germinate the seed. This irrigation is not likely to be required when the planting is done immediately after the late spring rains or before the end of the rainy season. It would not be advisable to plant early except on well-drained land that had been plowed in the autumn.

In the first irrigation the water was retained long enough to wet the surface of the soil thoroughly. The second application of water was made when the plants were approximately 3 inches high, which was sooner than would have been necessary if the soil had not become too compact on the surface when the plats were drained. From this period water was applied every 7 to 10 days to keep the soil moist. After the plants had tillered well the land was submerged to a depth of 3 to 5 inches. This submergence was continuous until the grain reached the hard-dough stage. At this stage of maturity the plats were drained for harvest. All varieties were allowed at least 10 days in the shock before they were thrashed.

From the date of planting until October 1 there was less than 1 inch of rain. During the same period the average daily range of temperature varied from 29° in May to 38° in August, with the greatest range occurring in July, August, and September.

FIG. 1.—A GENERAL VIEW OF THE RICE PLATS ON BLACK ADOBE SOIL IN THE SACRAMENTO VALLEY OF CALIFORNIA.

FIG. 2.—A PLAT OF THE LENCINO VARIETY OF RICE (G. I. NO. 1583) IN FLOWER. DURING THIS PERIOD THE LAND IS SUBMERGED.

FIG. 1.—A PLAT OF THE WATARIBUNE VARIETY OF RICE (G. I. NO. 1561) IN "BOOT." DURING THIS PERIOD THE LAND IS SUBMERGED.

FIG. 2.—A PLAT OF THE HONDURAS VARIETY OF RICE (G. I. NO. 1643) AT FULL MATURITY.

TABLE I.—*Results of variety tests of rices[1] grown upon one-tenth acre plats on black adobe soil in the Sacramento Valley of California in 1910.*

G. I. No.	Date planted.	Date land was submerged.	Date of maturity.	Days to maturity.	Height of plant, including head.	Length of heads.	Heads per plant.	Yield per acre.[2]
					Inches.	*Inches.*		*Bushels.*
1533	Apr. 12	June 25	Oct. 22	193	38	7.0	6–12	71.5
1561[3]	Apr. 13	...do.....	...do.....	192	36	7.5	7–21	154.0
1562	...do.....	...do.....	Oct. 1	171	40	7.5	7–10	131.3
1563	...do.....	...do.....	Sept. 29	165	40	7.0	6–14	122.4
1582	...do.....	...do.....	Sept. 2	142	31	7.0	8–22	42.8
1583[3]	...do.....	...do.....	...do.....	142	33	7.0	8–15	47.1
1585	...do.....	...do.....	...do.....	142	31	6.5	8–22	58.0
1597	Apr. 12	...do.....	Sept. 7	148	28	6.5	5–14	71.3
1599	Apr. 13	...do.....	Sept. 2	142	33	7.0	8–15	23.1
1600	...do.....	...do.....	Sept. 30	170	38	7.0	6–11	94.6
1602	...do.....	...do.....	Sept. 25	165	36	7.0	9–20	77.7
1642[3]	Apr. 12	...do.....	Oct. 22	193	29	7.0	10–27	124.0
1643[3]	...do.....	...do.....	...do.....	193	38	7.5	6–12	63.3

[1] These rices, on account of the quality of their grain, were selected for planting in 1910 from 300 varieties which were grown here in 1909 on plats consisting of only 4 rows a rod each in length and 7 inches apart. The yields from the rices in 1909 were relatively much higher than in 1910, when the plantings were made on a larger scale. Estimated upon the actual yield from plats one-half acre in size, the Wataribune (G. I. No. 1561) and Shinriki (G. I. No. 1642) varieties in 1910 yielded 113.7 and 137.2 bushels per acre, respectively.

[2] Estimated upon the actual yields from one-tenth acre plats.

[3] See illustrations.

In this valley these rices require a longer time to mature and they produce smaller plants than when grown on the plains of the Gulf coast, but they exhibit a greater capacity for tillering, with resultant larger yields.

The short-grain rices appear to be better suited to this climate than the long-grain varieties. (Pl. I, fig. 2.) They ripen more uniformly, though slowly, tend to shatter less, and produce larger yields. There is less sun-cracking of the grain in these varieties after ripening than in the long-grain rices, which will result, of course, in a larger percentage of head rice when milled.

The number of days for maturing the crop may be greatly lessened by stimulating the growth at the time the plants begin to "boot" by increasing the depth of water (Pl. II, fig. 1), with a gradual lowering of it during this period, and by giving another impetus to growth by suddenly increasing the depth of water just as the heads appear. This last depth of water should be maintained until the heads begin to turn down, when the land should be drained for harvest. A shorter season and earlier planting seem desirable in order that the crop may escape the effect of the increasing humidity in September and October, which appears to lengthen the period of ripening.

The Honduras (Pl. II, fig. 2) and Shinriki (Pl. III) varieties (G. I. Nos. 1643 and 1642) are the leading commercial rices of the United States. In this test these varieties have exceeded the maximum yields produced on experimental plats in Louisiana and Texas. Of the two rices, the Shinriki, which is a small-grain variety, is better adapted to the Sacramento Valley.

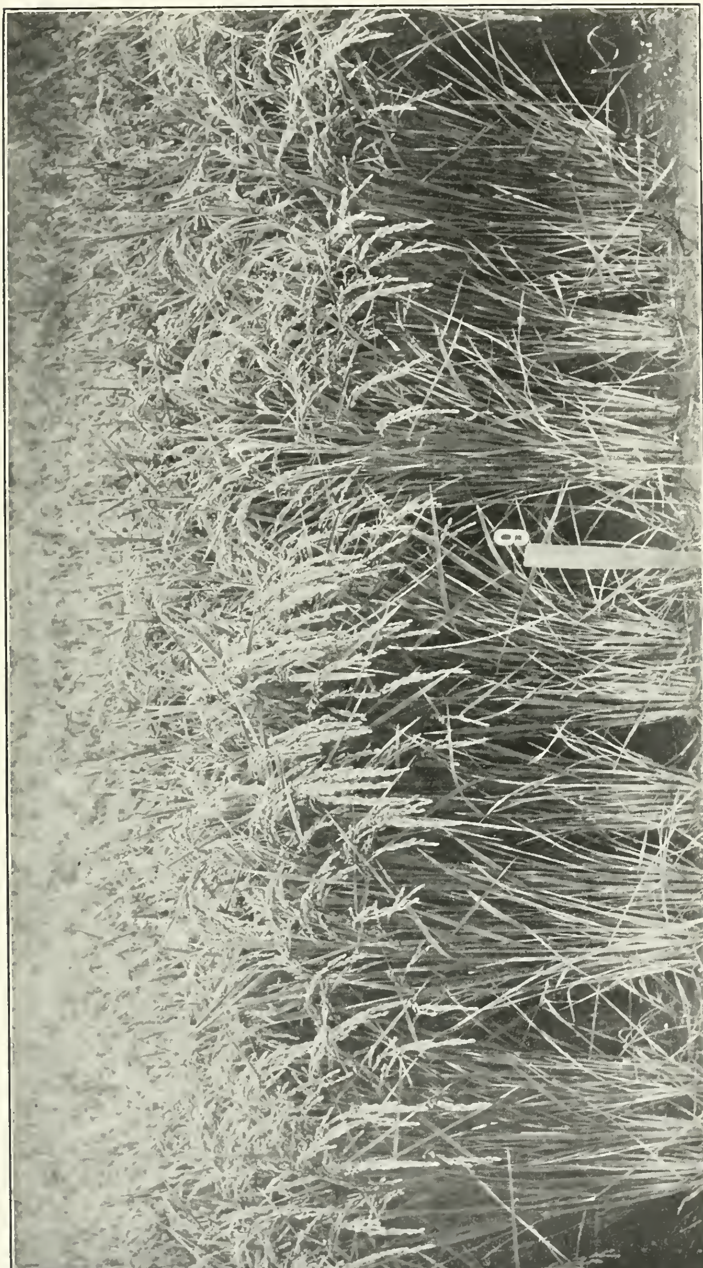
The Wataribune (G. I. No. 1561) (Pl. IV), the Oiran (G. I. No. 1562), and the Shinriki (G. I. No. 1642) varieties produce good yields, but on account of the long period which they require for maturity they may never become the leading rices of this valley, because the late planting of them might result in the loss of a crop. For this reason early-maturing varieties of good quality, though producing less per acre, might be more remunerative. The other varieties included in Table I are introductions from foreign countries that will be described and discussed in a later publication.

SUGGESTIONS AS TO METHODS OF CULTURE.

In selecting land for rice it is very important to know whether the subsoil possesses the mechanical characters for retaining water, for in the irrigation of this crop a continuous submergence of the land for several weeks is required. Such a condition is not possible unless the subsoil is sufficiently impervious to water, or unless, by tidal irrigation, the depth of water upon the land may be maintained continuously when needed, regardless of the nature of the underlying stratum of soil. On land that can not be flowed by the tides the cost of submergence and the time required in the submergence depend upon the depth of the soil. A soil with a depth of 20 inches is preferable to a deeper one, because less water will be used and less time consumed in flowing the land. However, heavy clay soils of great depth that can be well prepared and drained may be used advantageously for the crop, but comparatively shallow soils must be underlain by an impervious subsoil or so located as to be subject to tidal overflow. These details of irrigation, an item of great expense in the production of rice, must be considered to secure maximum returns.

Soil of a compact nature seems well adapted to rice. Clays, for this reason, if they are not too deficient in organic matter and can be effectively drained, are preferred to other soils, because they dry out more readily at the surface and become solid after the removal of the water, making the fields accessible at harvest much sooner than would be possible on the more open soils. The culture of rice, however, is not confined to clay soils, for wherever water can be economically handled by irrigation and drainage loamy and even sandy soils will produce good crops.

When not contrary to good farm management and the nature of the soil will permit it, land for rice should be plowed in the late autumn and well drained. With good drainage at this time the alkali which has accumulated just below the surface will be washed out by the winter rains. Furthermore, the action of the weather during the dormant period will have the effect of pulverizing the



A Plat of the Shinriki Variety of Rice (G. I. No. 1642) at Full Maturity. This Variety Requires a Long Season and Should Not Be Planted Later than April 15 in the Sacramento Valley.

A TENTH-ACRE PLAT OF THE WATARIBUNE VARIETY OF RICE (G. I. NO. 1561) DRAINED FOR HARVEST. THIS VARIETY REQUIRES A LONG SEASON AND SHOULD NOT BE PLANTED LATER THAN APRIL 15 IN THE SACRAMENTO VALLEY.

soil and making possible a good seed bed at a minimum cost. If plowing is postponed until spring, the land should not be left in furrow, but should be harrowed at once and not allowed to dry out before planting. High germination and vigorous growth of the young plants are dependent upon a good seed bed. The importance of its preparation can not be emphasized too strongly.

The seed may be drilled or broadcasted. Large, heavy, flinty seed, uniform in size and free from sun cracks, should be used. The cracking of the grain by the sun occurs when the plants are allowed to stand too long after ripening or when the heads of rice are exposed in the shock. In thrashing and in cleaning by a fanning mill, grains are often cracked, but this may be easily prevented by the proper adjustment of the machinery. This imperfection in the seed is not easily detected, because the husk which envelops the kernel remains attached when the grain is thrashed. Sun-cracked and machine-cracked seed will not produce vigorous plants.

The seed should not be sown deeper than $1\frac{1}{2}$ inches. In a well-prepared seed bed a less depth is desirable if the proper conditions of moisture exist. On a cloddy seed bed greater depth is required in order that all seed may be covered. A drill should be used to get a uniform depth and distribution of seed, for these conditions insure an even stand, which is an advantage in controlling weeds. In broadcasting seed there is always danger of getting a very uneven stand, due to difficulties in covering. Poor seeding reveals itself again at harvest when the rice does not ripen uniformly, which always means a loss, whether the field is cut when ripe or when portions of it are immature. This loss may come from the shattering of grain from the mature plants or from the low marketable product caused by small and poorly formed kernels.

The rate of seeding will vary according to the variety of rice, the vitality of the seed, the character of the seed bed, and the method of seeding. With the small-grain rices, which, as a rule, tiller heavily, the quantity of seed that should be sown per acre should be less than with the large-grain rices that do not tiller so strongly. Too thin seeding, however, induces excessive tillering, which invariably results in irregular ripening and low-grade rice. The sowing of seed of good vitality in a well-prepared seed bed will always give better results than the sowing of seed of low vitality in a poorly prepared seed bed. A smaller quantity of seed is used when drilled than when broadcasted.

Rice should be sown late enough to escape the extreme cold weather of spring, but early enough to mature before the autumnal rains. Sowing in April usually will be safe, as the crop will seldom be exposed to low temperatures.

Level tracts of land with sufficient slope for effective drainage, if they possess the required characters of soil and subsoil, are admirably suited for rice. In the use of such lands for this crop the field should be inclosed by strong embankments and so subdivided that each subfield shall have a surface level enough to hold the irrigation water at a rather uniform depth and yet with the necessary slope for good drainage. These conditions are obtainable by constructing the field levees on contour lines at distances which during submergence will hold the water at a depth of approximately 5 inches on the lower side and 3 inches on the upper side of each subfield. These levees should be just high enough to prevent the water from overflowing into the subfields below and broad enough to allow all kinds of machinery used in the cultivation of rice to pass over them easily and without damage to them. The planting of the field levees, which is made possible by their construction, will leave no uncultivated strips of land in the field for the growth of weeds, and though the rice upon them may not be equal in every respect to the main crop, the results obtained in the control of weeds alone will justify the practice. Such levees are permanent, and with little money and time can be kept in excellent condition.

The successful cultivation of rice is dependent upon an abundant and always available supply of water. This does not mean, however, that the land upon which the crop is grown must be submerged during the entire season. Under the favorable conditions of a good seed bed, water need not be applied for germination. However, the soil should never be allowed to dry out. This will require frequent irrigation.

After the plants have tillered well, the land should be submerged for a week to as great a depth as the levees will allow. At the end of this time the water may be lowered in the subfields to approximately 1½ inches and kept at this stage until the plants begin to "boot," when the water should be applied again to the maximum depth for a few days. (Pl. II, fig. 1.) After most of the heads have appeared, the water should be applied for a third time to its maximum depth and maintained without fluctuation until the heads are well turned down. (Pl. III.) At this stage of growth the fields should be rapidly drained.

With effective drainage (Pl. IV) the ground will be dry and firm enough within two weeks to support the weight of the harvesting machinery. Rapid drainage of the fields at this time is imperative if the crop is to be harvested at the least expense in labor and loss of grain. It can be easily obtained through open ditches, varying in depth from 2 to 4 feet, if properly located and kept free of weeds and other obstructions. Even with increased power the self-binder can not do efficient work on wet ground, and the delay in harvesting on account of a boggy field invariably results in reduced yields from the shattering of the grain. Besides facilitating the field operations at harvest, thorough drainage is needed for other purposes. With a crop that requires water so constantly and abundantly as rice there is always danger of the soil becoming water-logged unless provisions are made for removing the surplus water. A well-aerated soil is just as essential for rice as for any other crop if maximum yields are to be maintained. To prevent alkali from accumulating in dangerous quantities and for the control of aquatic weeds a good drainage system is a necessity and makes possible the rotation of crops, which must be practiced if the fertility of the soil is to be conserved.

The rice crop is valued not so much for the yield in bushels as for the yield in pounds of head rice, or whole grains, which it will produce when milled. It is therefore important that all parts of the field should mature simultaneously and that there should be no delay in harvesting, for a lack of uniformity in ripening produces too many chalky grains that do not mill well, and the long exposure of ripe grains to the sun produces cracked kernels that break readily in the process of milling.

The milling quality of rice is further increased by prompt and careful shocking. As soon as the grain is harvested the sheaves should be put into round shocks. These shocks must be strongly built to withstand the wind and well capped to protect the grain from rain and sun. During dry weather the process of curing requires at least two weeks. This period is considerably prolonged during rainy weather. Under no circumstances should the grain be thrashed until the kernel is hard and the straw thoroughly dry. After thrashing, the quality of the grain may be seriously affected by exposure to rain and sun. For this reason thrashed rice should be stored at once under a good cover.

SUMMARY.

Clay soil with an impervious subsoil, if it lies in level tracts and can be well drained, is well adapted to rice.

Shallow soils are preferable to deep soils, because less water will be required to submerge them.

For rice there should be an abundant and always available supply of water.

To prepare a good seed bed on black adobe soil it is better to plow in autumn than in spring.

Sow with a drill.

Plant in April if the land is dry and firm enough to support teams and implements.

Do not allow the soil to bake.

Keep the necessary moisture in the soil by frequent irrigation.

Keep the land submerged from the time the plants have tillered well until the heads turn down.

Provide for thorough drainage.

Build shocks to protect the grain from sun and rain.

Keep the rice in shocks at least 10 days before thrashing it.

CONCLUSIONS.

The results from a two-year test of 300 varieties of rices on black adobe soil near Biggs, Cal., indicate the possibility of rice culture in the Sacramento Valley. The successful introduction of this crop is dependent upon an abundant supply of water, which must always be available during the growing season. The soil area adapted to rice in this valley is sufficiently large to produce many times the 55,000,000 pounds of cleaned rice which are consumed each year on the Pacific coast. How much of this area has sufficient available water for proper irrigation is uncertain, though for a good portion of it there is apparently an abundant supply. Increase in the rice acreage should therefore be made with care.

Approved:

James Wilson,

Secretary of Agriculture.

Washington, D. C., *May 1, 1912.*

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B. T. GALLOWAY, Chief of Bureau.

PEANUT BUTTER.

BY

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PEANUT BUTTER.

INTRODUCTION.

The growing popularity of peanut butter as a food has led to many inquiries regarding the methods employed in its manufacture. Peanut butter is in reality a very simple preparation, consisting merely of fresh-roasted peanuts ground finely and salted to suit the taste. Several large factories and a large number of smaller ones are now devoted to the manufacture of this product with which to supply the rapidly increasing demand. Some of the larger factories are almost models in their construction, equipment, and management, while many of the smaller establishments, which have no elaborate equipment, are turning out an excellent product.

Peanut butter was first manufactured and offered for sale as a food for invalids, but the article was soon adopted by many persons who for one reason or another, such as a preference for vegetable foods only, objected to the use of ordinary dairy butter. It soon outgrew this condition of limited use, and its development on a commercial scale has been as a general food product. It was never intended that this product should be used as a substitute for or a competitor of butter, but as a luncheon delicacy and to add variety to the diet. Peanut butter is a wholesome and nutritious food product and has become a popular article upon our markets. Last year one manufacturer used over 130 cars of shelled peanuts in the production of 6,000,000 small jars of this food. Other manufacturers used large quantities, the total consumption of peanuts for the manufacture of peanut butter alone amounting during the year 1911 to approximately 1,000 cars of shelled goods, or 1,000,000 bushels.

In order to produce high-class peanut butter the manufacturer must employ the best of materials. On the other hand, the use of the best stock obtainable will be of little avail unless the work of converting it into a salable product is conducted in a sanitary manner.

The peanut-butter factory should be arranged and conducted along the same general lines of cleanliness as any model food-packing plant. Peanut butter should never be prepared in a room or building attached or adjacent to a peanut-cleaning establishment, as the

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dust incident to the cleaning of peanuts injures the butter. For this reason it is not practicable for the peanut cleaners to manufacture peanut butter, or for the peanut-butter makers to operate cleaning establishments in the same building. Should both lines of business be handled by the same firms, the factories should be sufficiently separated to insure absolute cleanliness in the butter plant.

THE STOCK.

As the peanuts come from the farms they contain considerable dirt, stones, and trash. Before they are ready for the market they must be cleaned and graded and the shelling stock separated from that sold in the shell. There are two distinct types of peanut grown in this country, the Virginia, or Jumbo, type, including the varieties known as Virginia Bunch, Virginia Runner, and North Carolina (or Wilmington), and the Spanish type, including the true Spanish, Georgia Red, Tennessee Red, and Valencia. Three grades of Virginia and Spanish shelled goods are produced, these being known as No. 1, No. 2, and No. 3. In each case the No. 1 grade consists of the unbroken or whole kernels, the No. 2 of the split kernels, and the No. 3 of the finely broken and badly shriveled kernels commonly spoken of as "pegs."

The Valencia is a comparatively new variety in the American trade, but it seems to be well adapted for use in the manufacture of peanut butter. As a rule the red varieties are not considered desirable for peanut-butter stock and if used must be blanched very thoroughly in order to get a clear product free from particles of the red skins.

Among the Virginia, or Jumbo, peanuts there is always a small percentage of the pods that have become damaged in the field by the weather. Usually this mildewing or discoloring of the pods does not affect the kernels, and this class, together with the pods that become broken in handling, is used for shelling purposes. In the case of the Spanish and Valencia varieties the greater portion is shelled. By this method the best grade of the Spanish and Valencia and the cheaper grades of the Virginia type of peanuts are commonly employed for the production of peanut butter.

In the manufacture of high-grade peanut butter only the No. 1 and No. 2 grades of each class are employed. An inferior-grade butter is made from third-grade goods, also from screenings, but the product is unfit for human food and its manufacture should be discontinued.

Peanut butter having the proper consistency contains about 41 or 42 per cent of fat, this being the natural oil of the peanut. The Virginia, or Jumbo, type contains about the proper proportion of fat, but several manufacturers are adding some Spanish peanuts to give the product the desired smoothness. Peanut butter made entirely of Spanish peanuts is very smooth but contains too much oil. It is possible by the use of an oil press to remove 8 or 10 per cent of the oil from the cleaned Spanish meats before grinding them, thus reducing the oil content to about the proper proportion.

The shelled goods as received from the cleaning factory require considerable hand picking and additional cleaning to render the peanuts fit for grinding.

FACTORY AND EQUIPMENT.

The model peanut-butter factory consists of a four or five story building equipped with elevators, light, and power, with a railroad siding located at the rear of the factory for convenience and economy in handling materials. In the smaller factories the entire equipment is often placed on one floor. Here, however, a greater portion of the work must be done by hand, and it is impossible to take advantage of a gravity system of delivering the goods from one machine to another.

The equipment of a peanut-butter factory consists of roasters, blanchers, picking tables, grinders, bottle-filling, capping, and labeling machines, together with suitable facilities for the storage of raw materials and for packing and shipping the finished product.

The arrangement of the equipment of the various factories differs, but the ideal would have the roasters and stock of raw materials located on the top floor, the blanchers and picking tables on the third floor, the grinders and bottling machinery on the second floor, and the packing and shipping departments on the ground floor.

ROASTING.

The roasting machinery is built especially for the purpose, but is similar to that used for the roasting of coffee, cocoa, and products of that class. The same equipment may be used for roasting both shelled and unshelled peanuts. As an accessory to the roaster it is desirable to have a carrier or truck, the hopper of which has a perforated bottom for receiving and cooling the roasted nuts. Figure 1 shows the roasting and cooling plant in one of the leading peanut-butter factories.

In some factories artificial gas or natural gas is employed for heating the roasters. In others a hard coal or coke fire is employed. The temperature of the roasters will vary with the class of goods that is being handled. For shelled goods this should be about 320° F. For peanuts in the shell the temperature may be carried considerably higher without danger of scorching. As a rule about 30 or 35 minutes are required to roast a batch. The stage of roasting, however, must be determined by the judgment and experience of the operator.

In the model factories the peanuts are elevated to a hopper over the roasting machine and are fed by gravity through a chute into the end of the roasting drum. When the roasting is completed the drum is dumped directly into the portable cooler having a perforated bottom. This is then wheeled to an opening in a suction blast pipe, and cold air is pulled downward through the roasted peanuts in order to cool them quickly.

The quality and flavor of peanut butter depend largely upon the care exercised in roasting. Some markets prefer a "high" roast,

FIG. 1.—A roasting and cooling equipment in a model peanut-butter factory.

while others want a very "mild" roast. If the roasting process is carried too far the butter will have a dark-brown color and a burned or bitter taste due to the carbonizing of the fats and cell tissue.

Where peanuts are grown large quantities are eaten raw. While no careful digestion experiments have been reported with raw and roasted nuts, there is a belief, borne out by data collected by the Department of Agriculture in its nutrition studies, that the raw and medium roasted nuts are less likely to cause digestive disturbance than those that are parched or overroasted. However, as with other foods, individuals will be found who can digest the raw product without trouble and to whom the roasted ones are not so wholesome, and vice versa. Peanuts that are given a mild roast seem to be generally considered more palatable and wholesome than those that are overroasted. On the other hand, if the roasting is too light the peanut butter is lacking in flavor and color and does not have good keeping qualities.

After roasting and cooling, the peanuts are ready for blanching and are dumped directly from the cooler into a chute, from which they are fed into the blanching machine on the floor below.

BLANCHING.

The term "blanching" is applied to the process of removing the outer red skins and the germs, or hearts, of the nuts. This is accom-

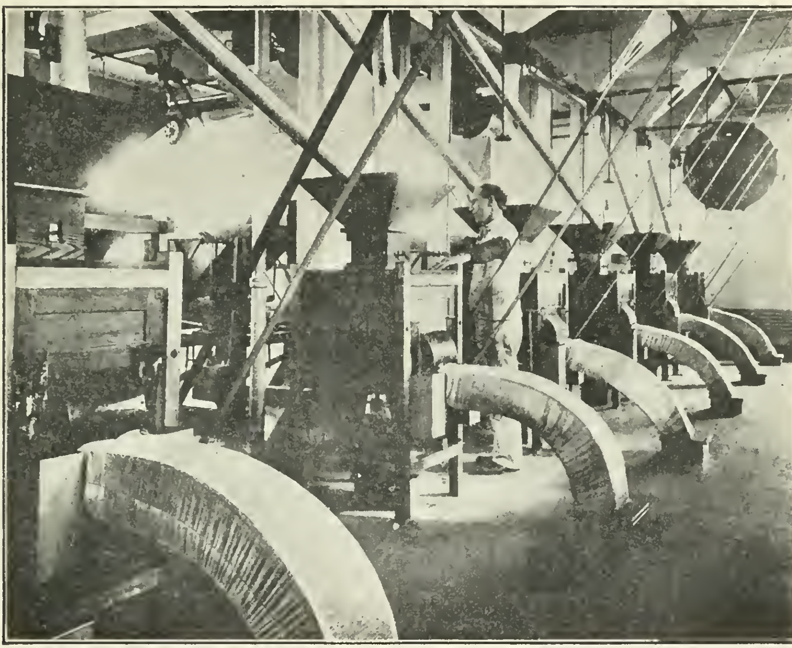

Fig. 2.—A type of blanching machine in common use.

plished by means of blanching machines consisting of a set of brushes revolving against a corrugated plate. The peanuts, after passing between the brushes and the plate, are carried over screens and in front of a fan in order to separate the skins and germs from the clean meats. Figure 2 shows the type of blanching machine in common use.

The work of hand picking the stock is usually done after the roasting and blanching. This makes possible the removal of any meats that are discolored or in any way inferior. The tables for hand picking the peanuts are similar to those employed in the bean-cleaning factories and consist either of a broad canvas belt, as illustrated in figure 3, or of a long and narrow belt, such as is used in the regular peanut-cleaning factories.

In some factories a mechanical stoner is employed to take out any small pebbles or bits of flint rock that may have escaped the process in the cleaning factory. These stoning devices all work upon the gravity principle; the peanuts, being lighter than the stones, are blown upward, and the stones fall into a receptacle. (Fig. 4.)

The shrinkage or loss in manufacture varies with the season and with the quality of the raw materials. This is sometimes as low as 13

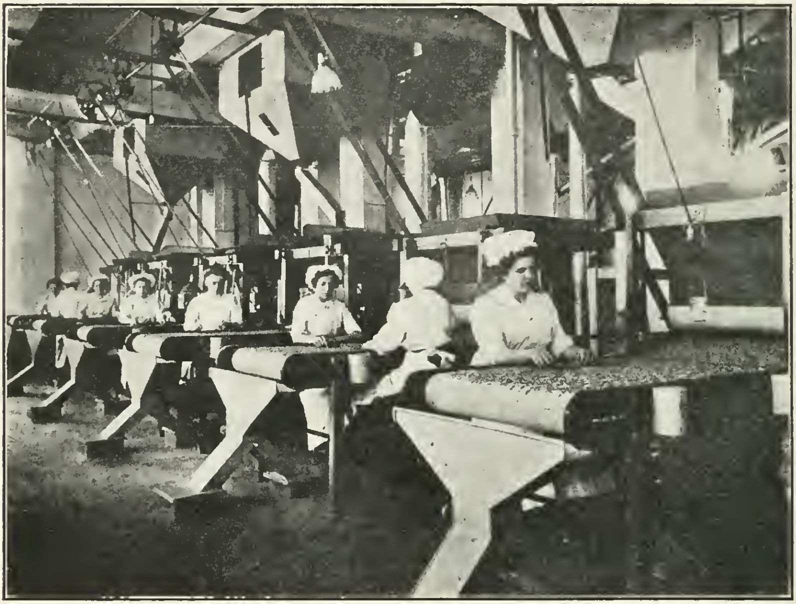

FIG. 3.—Picking tables in a model peanut-butter factory.

or as high as 18 per cent, averaging about 15 per cent of the original weight of the goods. Taking 100 pounds of No. 1 shelled peanuts, the loss in roasting will be about 5 pounds, in blanching about 9 pounds, and in hand picking 1 pound to 1½ pounds. At seasons of the year when the moisture content of the meats is high the loss in roasting may be as great as 8 pounds.

The working cost also varies with factory equipment and the quality of the goods, the main difference being in the hand picking. The larger and more perfectly equipped factories can be operated more economically than the smaller plants. The working cost can be safely estimated at 2 cents a pound, exclusive of bottles or other containers.

BLENDING.

From the stoner the peanuts are carried by an elevator or fed through a chute to the supply hoppers above the grinders. In case two grades or kinds of peanuts are used, the blending usually is done as the peanuts are fed into the hopper above the grinder. In

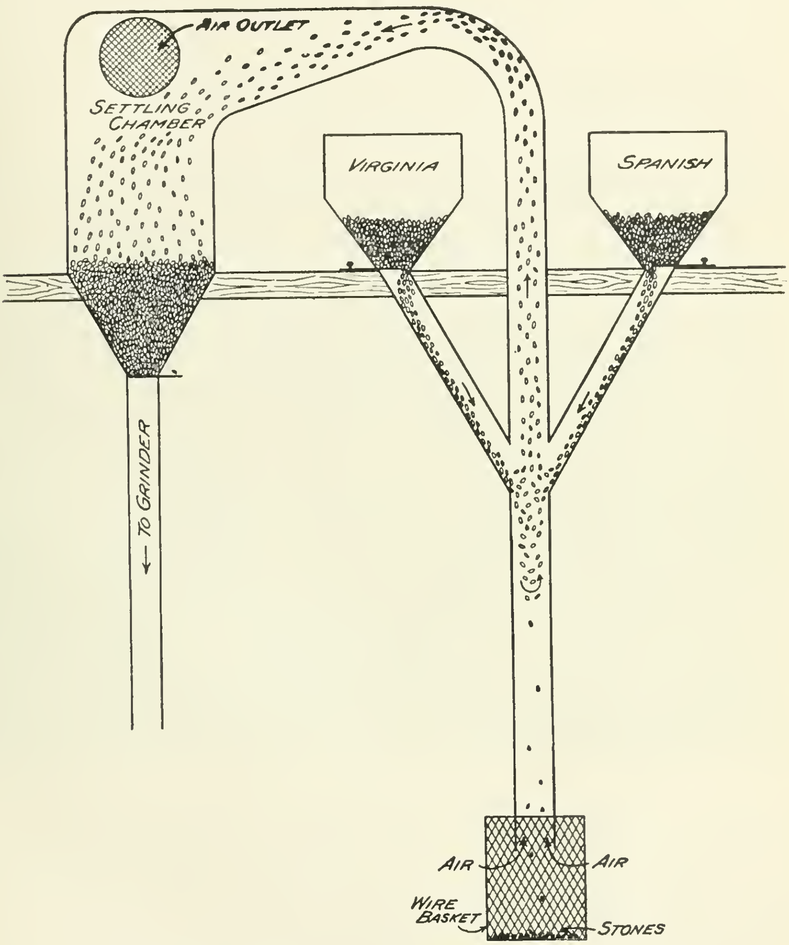

FIG. 4.—Sketch showing device for removing stones from peanut meats.

one or two factories, however, this is accomplished in the stoning device, two streams being fed side by side and blended by the air blast which lifts the peanuts away from the small stones. A common method is to blend Spanish and Virginia peanuts in equal quantities, and the uniformity of the product depends largely upon the completeness of the blend.

The manufacturers who are producing the finest grades of peanut butter are employing more than one variety in its composition. When made entirely of Virginia peanuts, the product is lacking in smoothness, and the addition of some Spanish stock greatly improves its consistency. Peanut butter composed entirely of Spanish peanuts is very smooth, but does not possess as fine a flavor as that made from a blend of equal parts of the Virginia and Spanish varieties.

A variety of peanut known as "Java" is frequently imported and is used to a limited extent for the manufacture of peanut butter. This variety makes a very smooth product, but as the nuts have a tendency to become strong and rancid they can be used only when strictly fresh.

GRINDING.

The manufacture of peanut butter in quantities requires the use of special grinding machinery. While peanut butter can be made for home use with the aid of an ordinary meat grinder, machines of this class do not grind finely enough for commercial work. Peanut butter requires to be ground to a fine granular form rather than to a pasty consistency. The oil in the meats is contained in minute capsules or cells, and it is desirable to have these cells broken apart rather than crushed and the oil liberated. For this reason worn or smooth grinding plates do not give good results when run closely together, owing to the rubbing or smoothing of the pulp between them. When ground to a paste it lacks proper consistency and does not hold up well.

The grinding produces considerable heat, and care is necessary to prevent scorching. One or two factories are equipped with grinders in which the working parts are surrounded by a water jacket similar to that around the cylinder of a gasoline engine. By this means a circulation of water through the jacket controls the temperature of the burrs. By connecting the jacket to both hot and cold water pipes and with the use of a thermometer similar to those employed in heating systems, the operator, by means of conveniently arranged valves, can absolutely control the temperature of the grinder.

Figure 5 shows a large motor-driven grinder which is equipped with a cooling device. This grinder requires a 30-horsepower motor to operate it and will grind 21 pounds of meats a minute. Most factories are, however, equipped with smaller grinders of the type shown in figure 6. The smaller machines do not have so great a tendency to become overheated as do the larger ones, but in all cases where some method of cooling is not provided it will be necessary to run the machines at a moderate speed or allow them to cool occasionally.

Before grinding the peanut meats, from $1\frac{1}{2}$ to 3 per cent in weight of the best grade of dairy salt is added. Frequently this salt is weighed and mixed with the peanuts before they are placed in the hopper of the grinder. Most of the larger grinders are fitted with a small auxiliary hopper, from which the salt is fed into the grinder with the peanuts by means of a worm or gear. The greatest difficulty lies in securing a uniform distribution of the salt particles through the butter.

Many persons prefer peanut butter without the addition of salt. For this reason some of the manufacturers are putting their product upon the market either without the addition of salt or only slightly

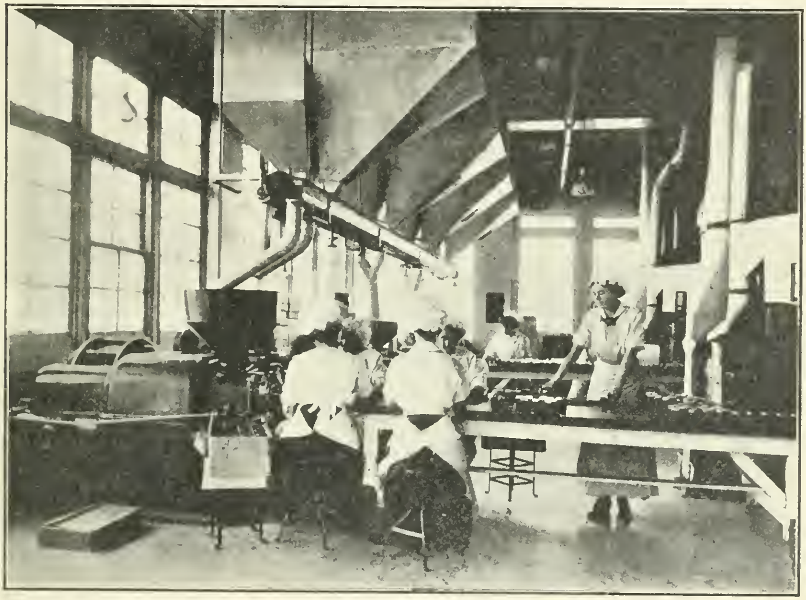

Fig. 5.—A grinding and bottling outfit.

salted. The matter of salting is one to be determined entirely by market requirements, although the addition of a small quantity of salt increases the keeping qualities. In order to complete the mixing process the product is sometimes run through a set of rolls or through a mixing machine after grinding.

BOTTLING AND PACKING.

The bottles or other containers are filled either directly from a spout on the grinding machine or from a separate filling machine. The transfer from the grinder to the filling machine should be by means of a closed conveyer, rather than by open pails or tubs.

Another method would be to have the grinder upon a raised platform, discharging directly into the filling machine. The separate filling machine has the advantage of mixing the mass more thoroughly than when the filling is done directly from the grinder. In either case the containers, especially those of the smaller sizes, should be filled from a spout, the bottle being placed over the spout and filled from the bottom, thus avoiding the formation of air bubbles.

Peanut butter is placed upon the market in several styles of small containers, including bottles, glass jars, and tin cans, and in pails, tubs, and barrels, from which it may be sold by the pound. The three sizes of small glass jars in most common use contain 6 ounces, 10 ounces, or 1 pound each. The usual retail prices of these are 10, 15, and 25 cents, respectively. Bulk goods which are packed in pails, tubs, or barrels are sold at prices ranging from 10 to 20 cents a pound.

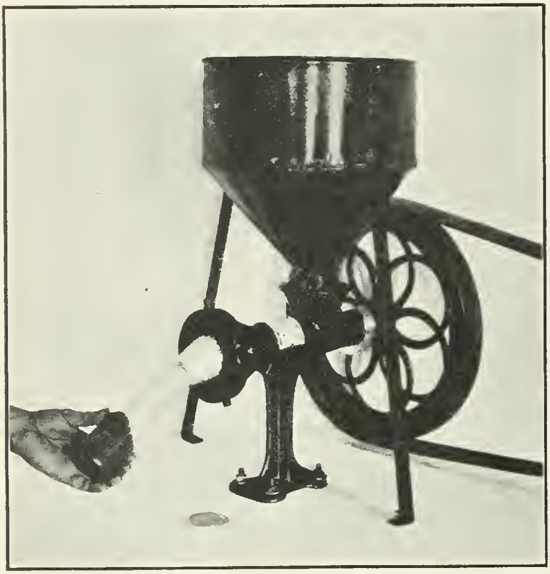

Fig. 6.—A small grinder commonly used in peanut-butter factories.

It should be borne in mind that a rubber packing is not suited to the sealing of jars containing peanut butter, as the oil present will dissolve some of the rubber. Either a ring of paper or a thread of rubberlike compound spun upon the inside of the cap forms a better seal than rubber. The vacuum process of extracting the residual air from the jars is now in common use in packing establishments.

The pails and tubs used for handling peanut butter in bulk are provided with either metal or wooden covers, and these are fastened on with wire, strips of metal, or by nailing, no attempt being made to make the majority of these receptacles air-tight.

Where peanut butter is packed in small glass jars, these are inclosed in boxes or pasteboard cartons, usually two dozen bottles to a package. The sealed package glass jar is undoubtedly the most satisfactory and cleanly method of handling the butter. It is important that the glass jars used be clear and white, in order that they may present an attractive appearance when placed upon the market. The use of jars that are composed of glass of a greenish tint will give the best peanut butter an inferior appearance. Bulk goods are generally handled by dealers who sell large quantities, and a pail or tub is quickly emptied. The principal objection to the sale of bulk goods is the fact that the pails or tubs are frequently left uncovered in the stores and the contents exposed to dust. Manufacturers of bulk goods should provide suitable tight-fitting covers having a knob or handhold upon the top of the cover. The type of tin can with an inside-fitting cover shown in figure 7 is especially adapted for the handling of peanut butter in bulk.

Dealers who handle peanut butter in tubs or pails should also bear in mind that the oil in the butter has a tendency to rise to the top and the heavier particles to settle to the bottom. In order that the product may be uniform throughout, it is desirable to use a wooden paddle and to stir it frequently from the bottom of the pail or tub. Dealers and consumers frequently complain of the oil that rises to the top of peanut butter in the small jars. If this happens it is only necessary, upon opening the jar, to mix the oil thoroughly with the remainder of the contents in order to restore it to the original consistency.

FIG. 7.—A type of tin can suited for handling peanut butter in bulk.

SUMMARY.

Peanut butter is rapidly growing in popularity as a wholesome and nutritious food.

While large and well-equipped factories are being used for the manufacture of this butter, a clean and wholesome product can also be made on a small scale, provided good materials are employed and the work is conducted in a sanitary manner.

A peanut-butter factory should not be conducted in conjunction with a peanut-cleaning establishment because of the dust resulting from the cleaning process.

Only the better grades of shelled peanuts should be employed. The use of screenings and other low-grade materials in the manufacture of peanut butter should be prohibited.

The small glass jar is the most desirable type of package for the sale of peanut butter. When the butter is handled in bulk and sold by the pound, great care should be taken to keep the containers covered in order to protect the contents from dust.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *May 11, 1912.*

[Cir. 98]

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Issued August 23, 1912.

U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—Circular No. 99.
B. T. GALLOWAY, Chief of Bureau.

A METHOD FOR THE DETERMINATION OF THE SPECIFIC GRAVITY OF WHEAT AND OTHER CEREALS.

BY

C. H. BAILEY AND L. M. THOMAS,
Assistants in Grain Standardization.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1912

BUREAU OF PLANT INDUSTRY.

Chief of Bureau, BEVERLY T. GALLOWAY.
Assistant Chief of Bureau, WILLIAM A. TAYLOR.
Editor, J. E. ROCKWELL.
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B. P. I.—759.

A METHOD FOR THE DETERMINATION OF THE SPECIFIC GRAVITY OF WHEAT AND OTHER CEREALS.[1]

INTRODUCTION.

In buying and selling wheat great importance is placed on the density of the wheat kernels, the various degrees of which affect to a considerable extent the commercial grading and the price that the wheat will command.

Believing that the specific gravity of wheat might in a measure indicate milling quality, a study of the relationship of specific gravity to milling yield was undertaken. Of a large number of liquids tried in these experiments for specific-gravity determinations, toluene was found to possess more nearly the required properties. Toluene (known commercially as toluol), $C_6H_5CH_3$, possesses the desired properties in that it has (1) relatively low specific gravity; (2) a low surface tension, enabling it to flow smoothly in thin sheets; (3) a fairly high boiling point, insuring not too high volatility; (4) physical constants, including specific gravity, viscosity, etc., that will not change materially on exposure to the atmosphere; and (5) a nonsolvent action on the constituents of the kernel. It is likewise immiscible with water and practically nonexplosive. Toluene was therefore employed with the results set forth in the following pages.

By employing a liquid medium of this character it is possible to use a specific-gravity bottle, or picnometer. A picnometer of the size and style shown in figure 1 was found to be the most satisfactory. The ground-in thermometer is of decided advantage in making all determinations at the same temperature (20° centigrade). The capillary side tube serves as a convenient overflow for the excess toluene when the bottle is filled at temperatures below 20° C. The small cap is used to cover the side tube when the thermometer registers 20° C. and to hold that which passes up this tube as the contents of the bottle reach the room temperature.

[1] Since the preparation of this paper one of the writers, Mr. C. H. Bailey, has accepted a position at the University of Minnesota and is now in charge of the cereal and flour laboratory of the Minnesota Agricultural Experiment Station.—J. W. T. DUVEL, *Crop Technologist in Charge of Grain Standardization Investigations.*

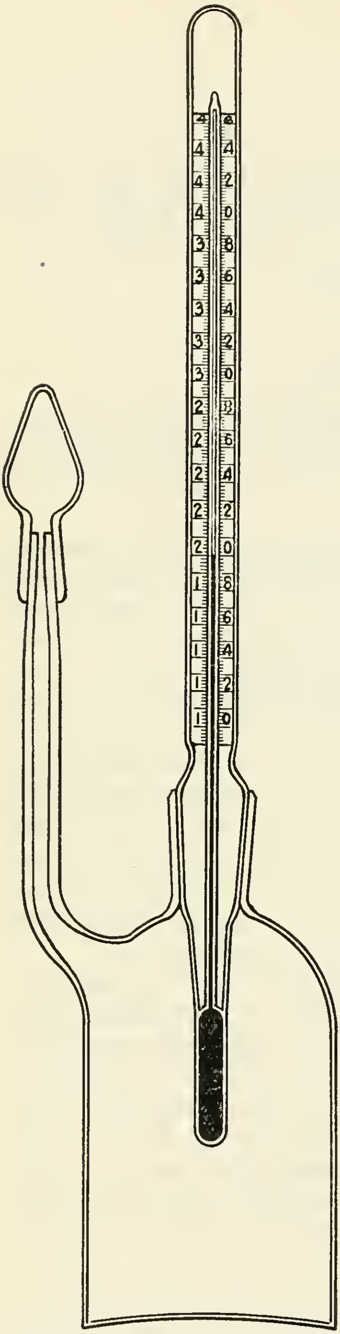

FIG. 1.—Picnometer used in specific-gravity determinations.

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HOW TO MAKE THE SPECIFIC-GRAVITY TEST.

In addition to the picnometer, or specific-gravity bottle, used in making the determinations, it is necessary to have a good analytical balance and an aspirator, or filter pump. If it is desired to purify the toluene used in previous tests, gas burners or some other form of heating appliance and condensers will be required in addition to the apparatus mentioned.

After the capacity of the picnometer has been ascertained by weighing it when empty and likewise when filled with distilled water at 20° C., the specific gravity of the toluene is determined in the usual way by comparing the weight of toluene which the bottle holds with the weight of the distilled water at the same temperature:

Weight of water : weight of toluene :: 1.0000 : x,

x equaling the specific gravity of the toluene. Each lot of toluene must be tested, as there may be a slight variation in its specific gravity.

Ten grams of the cleaned wheat sample (the exact weight being recorded) are placed in the picnometer, and a sufficient quantity of cooled toluene is added to a little more than cover the wheat. The cap is placed on the capillary tube, the neck of the picnometer connected with the filter pump, or aspirator, and the air gradually exhausted. This promotes the escape of the air from the mass and particularly that held under the surface hairs and in the creases of the kernels. When the air bubbles cease to be given off, the vacuum is released for a moment and the bottle is then reexhausted. When no more bubbles rise, the picnometer is disconnected from the pump and completely filled with toluene cooled to about 18° C. The thermometer is then placed tightly in the neck of the bottle and the temperature of bottle and contents allowed to rise gradually to exactly 20° C. The last drop on the end of the capillary tube is removed with a piece of filter paper, the overflow cap set firmly in place, and the picnometer and contents weighed on a good analytical balance.

The specific gravity of the sample is calculated according to the following formula:

$$\text{Specific gravity of the wheat} = \frac{\text{Specific gravity of the toluene} \times \text{weight of the wheat.}}{\text{Weight of the toluene displaced by the wheat.}}$$

For example, if the weight of the picnometer containing toluene and the 10 grams of wheat is 87.2697 grams and the weight of the picnometer containing toluene alone is 83.4461 grams, then by subtracting the latter figure from the former we have 3.8236 grams, and this subtracted from 10 gives 6.1764, which is the weight in grams of the toluene displaced by 10 grams of wheat. Substituting in the formula given above, we have $\frac{0.8667 \times 10}{6.1764} = 1.4032$, the specific gravity of the wheat.

ADVANTAGE OF USING TOLUENE.

Toluene has been found most satisfactory for specific-gravity determinations, there being little tendency for this substance to soak into the kernels, as is the case with water and alcohol. After standing several hours in toluene no appreciable change in the results of the test was found, showing that the toluene did not enter the kernels to any extent. Toluene apparently does not dissolve out any great amount of fats and oils from the kernels, as is evidenced by the fact that, if filtered after using, its specific gravity is found not to have changed materially. Commercial toluol, costing from 35 to 40 cents a pound, can be used instead of the more expensive chemically pure toluol. This commercial product has a specific gravity of about 0.8667 and will not change materially if kept in a cool place in a tight can or bottle.

Alcohol, when tried, exhibited a tendency to soak into the kernels when suction was applied. Alcohol also changes in its specific gravity, through evaporation of alcohol and the consequent increase in the relative proportion of water, to an extent that renders the results of little value. On the other hand, the results obtained without applying suction when toluene was used were not correct, as was evidenced by the way in which air bubbles were given off when the bottle was connected to the aspirator.

NECESSITY FOR EXHAUSTING THE AIR.

That it is necessary to exhaust the air from the picnometer containing the wheat covered with toluene in order to free the wheat from mechanically held air is shown in Table I, in which are given the results of specific-gravity determinations made with and without the use of the aspirator. This table further shows that the volume of air so held is not the same in all cases. The specific gravity of a number of samples determined without aspiration will therefore not necessarily run parallel to the true specific gravity of the same samples.

Table I.—*Specific-gravity determinations made with and without the use of the aspirator.*

No. of sample.	Specific gravity.			Volume of air removed by aspirator.
	Without aspirator.	With aspirator.	Difference.	
				C. c.
576	1.4055	1.4242	0.0187	0.120
577	1.4067	1.4299	.0224	.129
578	1.3945	1.4235	.0290	.165
589	1.3216	1.3798	.0582	.335
596	1.4246	1.4427	.0181	.110
607	1.3710	1.4306	.0596	.258
611	1.4199	1.4341	.0142	.108
612	1.3964	1.4175	.0211	.101
621	1.3920	1.4398	.0478	.240
Maximum	1.4246	1.4427	.0596	.335
Minimum	1.3216	1.3798	.0142	.101
Average	1.3925	1.4247	.0321	.174

UNIFORMITY IN DUPLICATE TESTS.

Table II shows the results of duplicate specific-gravity determinations of 13 wheat samples, representing both hard and soft wheats. The maximum variation from the average of the two determinations amounted to 0.0039, the average variation being 0.0009. Considering the difficulty of securing two samples of 10 grams each which are exactly alike from any given lot of wheat, this variation is very slight and indicates a small unavoidable error in sampling rather than an inaccuracy in the test.

Table II.—*Specific-gravity determinations showing uniformity in results of duplicate tests.*

No. of sample.	Duplicate determinations.			Variation from average.
	First.	Second.	Average.	
596	1.4418	1.4436	1.4427	0.0009
621	1.4393	1.4402	1.4398	.0005
611	1.4349	1.4333	1.4341	.0008
607	1.4297	1.4315	1.4306	.0009
577	1.4274	1.4307	1.4291	.0016
576	1.4247	1.4236	1.4242	.0006
612	1.4169	1.4181	1.4175	.0006
351	1.4133	1.4133	1.4133	.0000
353	1.4134	1.4106	1.4120	.0014
352	1.3986	1.3978	1.3982	.0004
590	1.3922	1.3856	1.3895	.0039
589	1.3804	1.3789	1.3798	.0008
243	1.3616	1.3615	1.3616	.0001

Maximum variation from average, 0.0039. Average variation from average, 0.0009.

CONCLUSIONS.

The method described in this paper for determining the specific gravity of wheat gives very uniform results and is entirely satisfactory.

Since this method was devised the correlation of specific gravity with the quality of wheat has been undertaken. It appears very probable from the work so far that this test, with others, will prove of value in indicating kernel structure, milling quality, and flour yield of wheat.

Approved:

JAMES WILSON,

Secretary.

WASHINGTON, D. C., *May 31, 1912.*

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 100.

B. T. GALLOWAY, Chief of Bureau.

DISTRIBUTION OF SEEDS AND PLANTS BY THE DEPARTMENT OF AGRICULTURE.

BY

B. T. GALLOWAY,

Chief, Bureau of Plant Industry.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1912

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BUREAU OF PLANT INDUSTRY.

B. P. I.—762.

DISTRIBUTION OF SEEDS AND PLANTS BY THE DEPARTMENT OF AGRICULTURE.

INTRODUCTION.

The purchase and distribution of seeds and plants by the Government may be said to date back to colonial days. As early as 1743 the British Parliament granted $600,000 to promote the cultivation of indigo and other crops in the American Colonies, and the assemblies of various Colonies appropriated small sums from time to time to encourage the cultivation of plants new to the country, such as hops in Virginia, mulberry trees for silk culture in Georgia, and vineyards for the establishment of an American wine industry.

Franklin, while in England as agent for Pennsylvania, sent home silkworm eggs and mulberry cuttings. Thomas Jefferson during the five years he represented this country as minister to France (1784–1789) forwarded numerous seed samples of grasses, rice, peppers, and olives to correspondents at home, especially to the Society for the Improvement of Agriculture at Charleston, S. C. It was to this society that he sent samples of rice seed, from which some of the best rice in the world was raised in the Carolinas. Other representatives of our Government in the early days of its history followed the example of Franklin and Jefferson, until during the administration of John Quincy Adams instructions were given to all United States consuls to forward rare plants and seeds to Washington for distribution. A botanical garden was later established at Washington, in which were grown many of the rare and interesting plants imported from foreign countries, and considerable quantities of such seeds and plants were distributed by the Commissioner of Patents.

Notwithstanding these efforts to introduce new seeds and plants, many varieties of fruits and vegetables with which we are familiar were scarce or unknown in the early part of the nineteenth century. There were but few seed farms, nurseries, or seedsmen, and the illustrated seed catalogues of our day were unknown. Seeds were mostly grown by the farmers themselves and there was no improvement from year to year. Interest in better seeds and in securing new seeds and plants resulted largely from the agricultural fairs inaugurated by the various societies for "promoting agriculture" which were organized at Charleston (1784), New York (1785), Philadelphia (1791), Boston (1792), and Washington (1809).

In 1839, through the efforts of Hon. Henry L. Ellsworth, Commissioner of Patents, an appropriation of $1,000 was made for the purpose of collecting and distributing seeds, prosecuting agricultural investigations, and procuring agricultural statistics, with which 30,000 packages of seeds were purchased and distributed. This appropriation marks the beginning of our present Department of Agriculture. Similar appropriations continued to be made, increasing in amount from year to year as the importance and value of the work came to be recognized, but prior to 1865 the appropriations were always for the combined purposes of purchasing seeds and collecting statistics, so that the actual amount expended for seeds alone can not be determined. From 1839 to 1862 the work was handled by a small force of clerks in the Patent Office, but in 1862 it was transferred to the newly created Department of Agriculture. For 40 years thereafter the work was carried on by a group of employees known as the "Seed Division," until 1901–2, when various affiliated but hitherto independent branches of the Department were brought together to form the present Bureau of Plant Industry. During the period of 72 years from 1839, when the first appropriation of $1,000 was made, to 1911, when $289,680 was appropriated, the quantity of seed distributed has steadily increased and the methods of handling it have undergone many changes.

OBJECT OF THE DISTRIBUTION.

The law under which the Department of Agriculture was organized provides—

> There shall be at the seat of Government a Department of Agriculture, the general design and duties of which shall be to acquire and diffuse among the people of the United States useful information on subjects connected with agriculture in the most general and comprehensive sense of that word and to *procure propagate, and distribute among the people new and valuable seeds and plants.* (Sec. 520, R. S.)

There can be no doubt that the purpose of the earlier legislation for the purchase and distribution of seeds was to introduce into this country new and improved varieties of vegetables, fruits, flowering plants, and new crops in order to increase the horticultural and agricultural products of the United States, and for many years attempts were made to confine the distribution to new varieties of vegetables, grains, sorghums, and fruits. The distribution of such seeds has undoubtedly left a decided impression upon the agriculture of this country. As the demand for the new seeds and plants introduced by the Department increased, however, such demand very naturally found expression in requests made to Senators, Representatives, and

Delegates in Congress, and the number of these requests soon became so great that it was impracticable to fill them with strictly new varieties of seeds. The practice of sending out larger and larger quantities of vegetable seeds thus developed. These seeds, while in no wise new, were useful in the new communities to which they were largely sent.

During the years from 1889 to 1893 practically the entire seed appropriation was expended for standard varieties of vegetable and flower seeds. In 1894 a change was advocated and action was taken to discontinue the customary distribution. This action was not approved by Congress, which in the act approved April 25, 1896, changed the wording of the previous acts, which for many years had read "for the purchase, propagation, and distribution, as required by law, of valuable seeds," etc., to read as follows:

> For the purchase, propagation, and distribution of valuable seeds, bulbs, trees, shrubs, vines, cuttings, and plants, and expense of labor, transportation, paper, twine, gum, printing, postal cards, and all necessary material and repairs for putting up and distributing the same, and to be distributed in the localities adapted to their culture, one hundred and fifty thousand dollars. *And the Secretary of Agriculture is hereby authorized, empowered, directed, and required to expend the said sum in the purchase, propagation, and distribution of such valuable seeds*, trees, shrubs, vines, cuttings, and plants, *and is authorized, empowered, directed, and required to expend not less than the sum of one hundred and thirty thousand dollars* in the purchase at public or private sale of valuable seeds, the best he can obtain, and such as shall be suitable for the respective localities to which same are to be apportioned and in which the same are to be distributed as hereinafter stated, and *such seeds* so purchased *shall include varieties of vegetable and flower seeds suitable for planting and culture in the various sections of the United States.*

Under the wording of this act the Attorney General, to whom the question was submitted for decision, held that the purchase and distribution of seeds, including vegetable and flower seeds, were mandatory and left the Secretary of Agriculture without discretion.

THE CONGRESSIONAL DISTRIBUTION.

Because the purchase and distribution of seeds and plants by the Department of Agriculture is specifically appropriated for by Congress, and because of the wording of the appropriation acts, which provide that "an equal proportion of five-sixths of all seeds, bulbs, shrubs, vines, cuttings, and plants shall, upon their request, after due notification by the Secretary of Agriculture that the allotment to their respective districts is ready for distribution, be supplied to Senators, Representatives, and Delegates in Congress for distribution among their constituents or mailed by the Department upon receipt of their addressed franks," the distribution of such seeds and plants is commonly designated as the "congressional seed distribution."

VEGETABLE AND FLOWER SEEDS.

The most prominent feature of this distribution for several years, in fact since 1896, has been the purchase and distribution of standard varieties of vegetable and flower seeds, which alone can be secured in sufficient quantities to meet the requirements of the law. The quota of each of the 487 Senators, Members, and Delegates in Congress for the past three years has been 20,000 packages of vegetable and 2,000 packages of flower seed, each package consisting of five packets containing different kinds of seed. The Secretary's quota for distribution direct to miscellaneous applicants, including State agricultural experiment stations, schools, hospitals, army posts, crop reporters, cooperators, and American citizens in foreign countries, was 1,000,000 packages of vegetable and 150,000 packages of flower seeds. Provision was also made whereby Members of Congress could exchange their vegetable seed for an equal number of flower-seed packets, or vice versa, to enable them to adjust their quotas to the demands of their constituents. The number of packets provided in the last distribution, which began December 2, 1911, and ended April 19, 1912, was 51,138,240 packets of vegetable seed and 12,226,315 packets of flower seed, or a total of 63,364,555 packets. The kinds and quantities of seed included in this distribution are shown in Table I.

TABLE I.—*Vegetable and flower seeds distributed in the year 1911–12.*

Vegetable seeds.			Flower seeds.	
Kind.	Number of varieties.	Quantity.	Kind.	Quantity.
		Pounds.		*Pounds.*
Bean (pole)	9	25,070	Ageratum	5
Beet	8	25,699	Antirrhinum	354
Brussels sprouts	3	3,740	Aster	168
Carrot	5	19,450	Balsam	378
Collards	1	7,495	Calendula	1,780
Corn	6	325,472	Candytuft	2,052
Cucumber	3	11,259	Castor bean	100
Endive	3	8,383	Celosia	8
Kale	1	4,008	Cosmos	1,181
Kohl-rabi	2	1,832	Dianthus	807
Lettuce	8	73,043	Eschscholtzia	580
Muskmelon	7	22,890	Kochia	1,427
Okra	3	9,094	Mignonette	1,798
Onion	4	20,512	Morning-glory, dwarf	447
Parsley	2	5,305	Morning-glory, tall	3,425
Parsnip	2	10,482	Nasturtium, tall	11,572
Pea	9	174,600	Pansy	124
Radish	12	132,336	Petunia	158
Squash	3	7,500	Poppy, double	1,407
Tomato	8	14,215	Poppy, single	1,172
Turnip	6	25,945	Portulaca	349
Watermelon	20	19,155	Sweet pea	17,000
			Zinnia	1,608

The total weight of the vegetable and flower seeds alone was 994,116 pounds, or over 497 tons, enough to fill 20 freight cars.

In planning a distribution the country is divided into sections, as shown in figure 1.

Nearly all varieties of flower seed included in the distribution and such vegetables as lettuce, raddish, onion, pea, bean, beet, carrot, parsnip, turnip, tomato, and cucumber will thrive at different seasons in all sections. Such vegetables as okra and collards are distributed only in section 1. On the other hand, sweet corn, which is in much demand in sections 3, 4, and a portion of section 5, is not distributed in section 1, because it is likely to be destroyed either by insects or fungous diseases. Such seeds as watermelon and muskmelon are not sent into the extreme North.

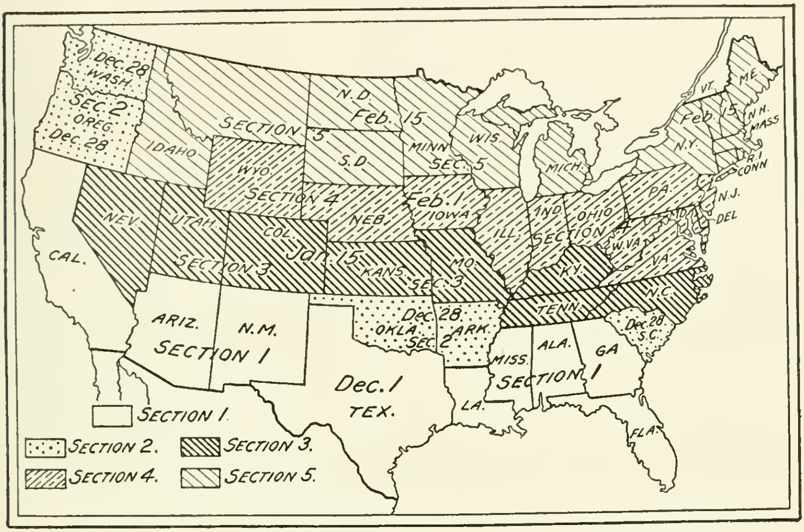

FIG. 1.—Sections into which the United States is divided for the distribution of vegetable seed.

HOW SEEDS ARE PURCHASED.

All seeds are purchased through competitive bids obtained in the spring from the principal seed growers and dealers in the country, about 200 being requested to submit quotations. The quotations are opened and listed in the presence of such bidders as care to attend by the Department board of awards, of which the chief clerk of the Department is the chairman, and referred to the Bureau of Plant Industry for the advice and recommendations of seed experts, in accordance with which recommendations purchases are made by the board. In awarding contracts the board disregards varieties unsuitable for distribution, as well as bids of growers or dealers who in the past have failed to carry out their contracts satisfactorily. When the lowest price is not accepted in any case the reasons therefor are stated in writing as a part of the permanent record. Approximately 25 per cent of the seeds are purchased from surplus stocks grown the previous year, and the remaining 75 per cent are grown under contract for the Department during the current season, thus insuring that the seeds shall be fresh and of strong vitality.

HOW SEEDS ARE TESTED.

All purchases are made subject to satisfactory appearance, viability (germination), and trueness to varietal name or type. The testing of samples of seed to ascertain its viability is done by experts in the Seed Laboratory of this Bureau, both before and after the shipment of the bulk seed. When a consignment of seed is received at the warehouse a small portion is taken from the middle and near the top and bottom of at least one-fourth of all bags and thoroughly mixed to make a composite sample, which is then sent to the seed laboratory. From the sample 100 or 200 seeds are counted out and placed between moist blotters in a germinating chamber, which is really an incubator fitted with automatic devices for keeping the blotters moist and for regulating the temperature to suit the requirements of different kinds of seed. At the end of a week or more, depending on the kind of seed, the blotters are examined and the number of seeds which have sprouted are counted to determine the percentage of germination. As the result of these tests many thousands of pounds of vegetable and flower seeds which fail to meet the requirements of the Department as to viability are rejected annually. Table II and III show the average percentage of germination of all vegetable the flower seeds purchased by the Department for distribution during the past 11 and 10 years, respectively, and the viability of so-called "commission" seeds[1] (vegetable[2]) purchased in the open market, during the past 4 years.

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[1] "Commission" seeds are usually put up in packets and sent out to dealers for sale by them on a commission basis, all seed not sold at the end of the season being returned to the seed-packing house.

[2] Purchase of "commission" seeds by agents of the Department have been confined to vegetables, so that no data for flower seeds of this class are available.

TABLE II.—*Germination tests of vegetable seeds purchased for congressional distribution compared with "commission" seeds purchased in the open market.*

Kind.	Congressional seeds for 11 years.		"Commission" seeds for 4 years.	
	Number of samples tested.	Average[1] germination.	Number of samples tested.	Average[1] germination.
		Per cent.		*Per cent.*
Bean, dwarf	171	95.8	565	77.8
Bean, pole	72	96.8	....	....
Bean, Lima	21	91.8	64	71.6
Beet	172	81.5	508	73.4
Brussels sprouts	20	84.5	....	....
Carrot	65	71.9	638	44.9
Collards	21	87.3	....	....
Corn	206	86.4	312	64.8
Cucumber	90	89	1,043	65.7
Endive	31	80.1	114	56
Kale	37	85.9	123	54.5
Kohl-rabi	19	88.7	100	52
Lettuce	228	95.2	1,185	74.9
Muskmelon	121	88.1	537	55.2
Okra	66	85.7	....	....
Onion	54	85.9	710	43.1
Parsley	68	68.3	118	32.6
Parsnip	56	75.7	294	22.6
Pea	115	93.2	526	60.1
Radish	271	95.5	1,371	72
Squash	121	92.2	785	52.3
Tomato	81	87.2	848	66.8
Turnip	55	94	852	67.3
Watermelon	210	86.3	652	60.5
	2,371	88.7	11,345	58.41

[1] Determined by multiplying the yearly germination by the number of samples and dividing the sum of the products by the total number of samples.

TABLE III.—*Germination tests of flower seeds purchased for congressional distribution.*

Kind.	Number of samples tested.	Average[1] germination for 10 years.	Kind.	Number of samples tested.	Average[1] germination for 10 years.
		Per cent.			*Per cent.*
Ageratum	21	57.5	Kochia	22	65.2
Antirrhinum	29	63.4	Morning-glory	55	71.8
Aster	26	64.4	Nasturtium	59	69
Balsam	30	94.3	Mignonette	40	63.2
Calendula	54	73.8	Pansy	14	55.2
Candytuft	58	75.4	Petunia	45	63.1
Castor bean	11	72.9	Poppy	83	66.2
Celosia	6	71	Portulaca	16	77.4
Cosmos	41	73.2	Sweet pea	26	89.4
Dianthus	44	87	Zinnia	45	81.6
Eschscholtzia	51	58.7			

[1] Determined by multiplying the yearly germination by the number of samples and dividing the sum of the products by the total number of samples.

The high average percentage of germination of Government seeds, as compared with "commission" seeds, is to be expected in view of the high standard maintained by the Department and the rigid tests to which all samples are subjected before acceptance.

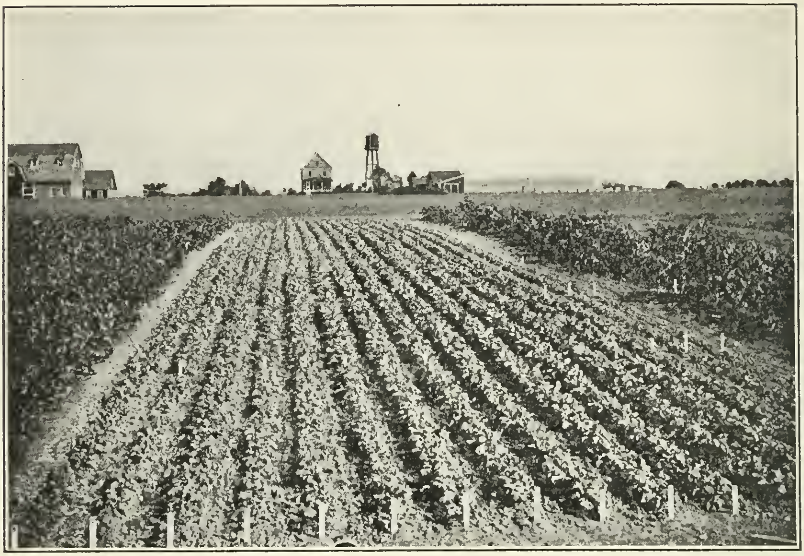

Fig. 2.—Testing vegetable and flower seeds at the trial grounds of the Arlington Experimental Farm, Va.

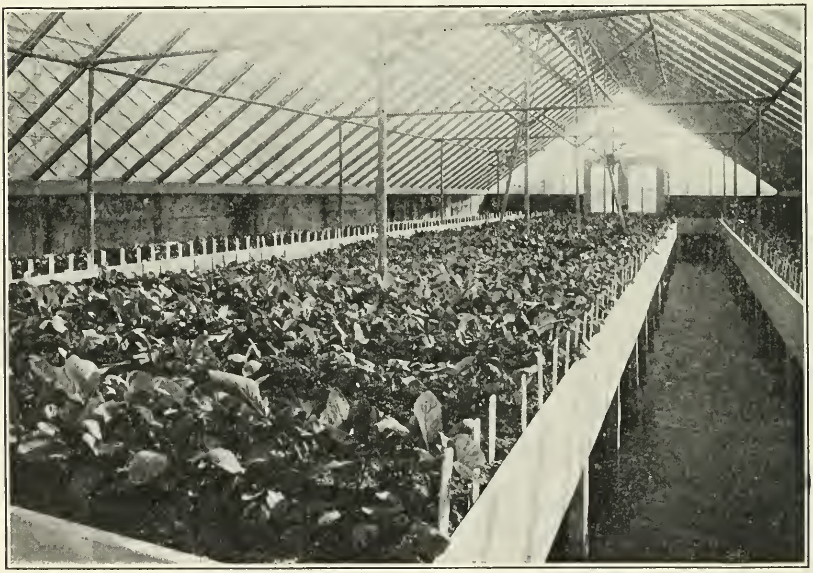

Fig. 3.—Testing vegetable seeds in the greenhouses at the Arlington Experimental Farm, Va.

In addition to the test for viability, samples of each lot of seed are tested by the horticulturist of the Bureau and his assistants on the trial ground of the Department at the Arlington Experimental Farm in Virginia. Here also is tested a more or less complete collection of varieties of vegetable and flower seeds, especially new strains or novelties offered by seedsmen in their spring catalogues. (See figs. 2 and 3.) In the case of seeds grown for the Department under contract, the seed fields are inspected at the proper season by experts and rogued (that is, plants not true to type are removed) if necessary, or if too badly mixed for roguing the contract is canceled. After harvest samples of the seed are tested the same as those from surplus stocks. It is the aim of the Bureau to have its seed experts visit all the principal seed-growing sections and keep well informed as to the quality and purity of stocks of the different growers throughout the country. If the stocks of any grower are found to have deteriorated or have become mixed, no purchases of such stocks are made thereafter.

WHERE SEEDS ARE GROWN.

Most vegetable seeds and many of the flower seeds are grown in this country, seed growing as a business having assumed large proportions within recent years. Formerly most of the seed produced in the United States was grown within 100 miles of New York City, that is, in Connecticut, on Long Island, in eastern Pennsylvania, and in New Jersey. In the last 50 years, however, the business has extended across the continent. Lettuce and radish, the two largest items in the congressional distribution, are grown in California, which leads the world in their production. (See figs. 4 and 5.) Notwithstanding the large quantities of flower seed produced in California, most of the American supply continues to be grown in Europe (especially in Germany and France) and northern Africa, where it can be produced at less expense than in this country. The principal vegetable and flower seed-growing districts of the United States are shown in figure 6. Varieties not indicated on the map are procured in Europe.

HOW SEEDS ARE PACKETED AND MAILED.

The vegetable and flower seed which is found satisfactory and accepted for distribution is shipped into Washington during the late fall and winter months, where it is packeted, assembled, and mailed by contract. This contract includes labor, printed packets and envelopes, filling packets and placing them in the envelopes, sealing, franking, and hauling to the post office or direct to the mail cars. The packeting is done by machines, which automatically measure the exact quantity of seed required for a packet, seal the packets, and drop them into hoppers which lead to bins on the floor below.

FIG. 4—A 20-acre seed field of sweet peas in the Santa Clara Valley, Cal.

FIG. 5.—A 250-acre lettuce seed field in the Santa Clara Valley, Cal.

Each of these machines will put up from 25,000 to 35,000 packets a day, and 20 machines are in use from December 15 to April 15, turning out steadily about 1,250 packets per minute. (See fig. 7.)

The five packets containing the different kinds of seed which go to make up a "combination" are then assembled in addressed en-

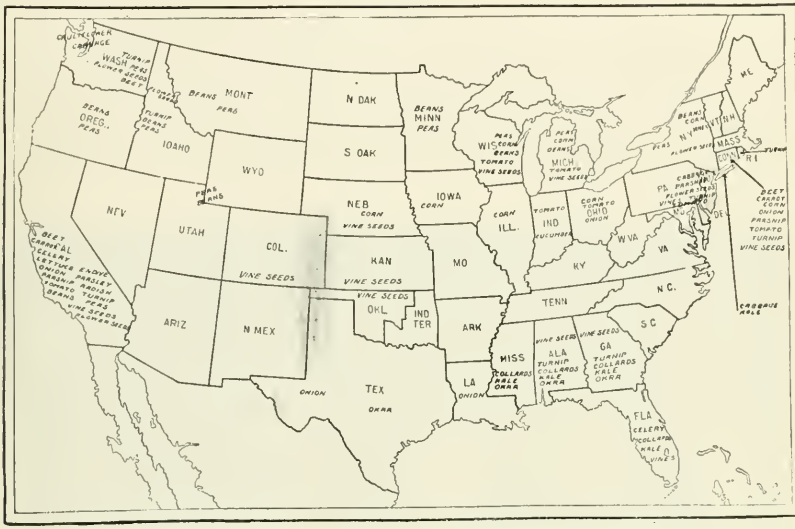

FIG. 6.—Map of the United States, showing the principal sections where vegetable and flower seeds are grown.

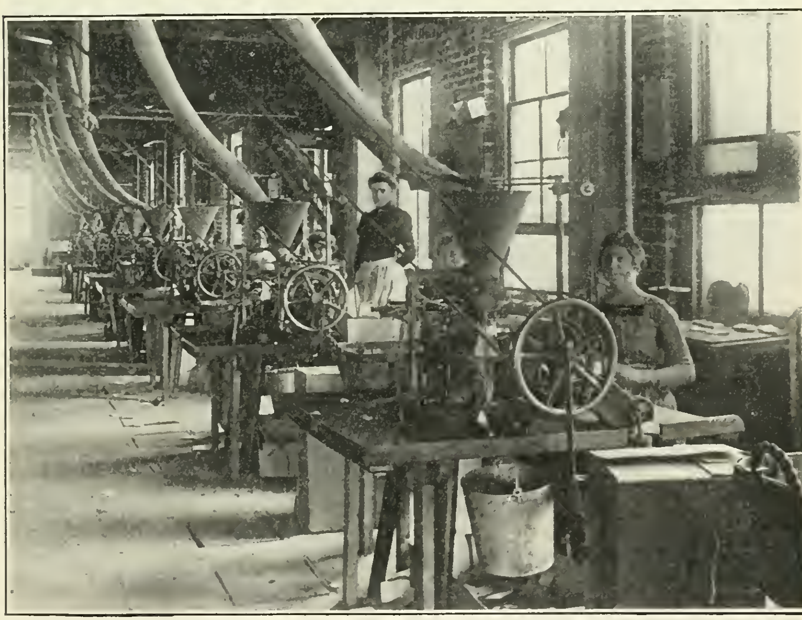

FIG. 7.—Automatic seed-packeting machines.

velopes (which are then called packages) by operators who sit before moving endless belts in front of the seed bins, each operator handling only one kind of seed. When the envelopes reach the end of the belt they pass through machines which automatically seal them at the rate of 30,000 a day. The seed warehouse is equipped with four of these belts and four sealing machines, and the daily output of 120,000 packages is mailed to the addresses furnished by Senators and Members of Congress at the rate of about 250 a minute. (See fig. 8.) In the old days, before the automatic packeting machines were developed, the seed was put into the packets with spoons by a large force of girls employed each winter.

FIG. 8.—Machines for automatically sealing envelopes containing seed packets.

MISCELLANEOUS SEEDS AND PLANTS.

About 90,000 strawberry plants of standard varieties are also distributed annually upon congressional requests.

Of grapevines about 6,000 are distributed in the Southern States, and about 18,000 are sent into the Middle and Northern States.

For the Southern States also from 3,000 to 4,000 citrange plants are provided annually. The citrange is a hybrid propagated from a cross between the Florida sweet orange and the Japanese *Citrus trifoliata*, which was effected by plant breeders of this Bureau several years ago with a view to originating a variety that would prove hardy and resistant to cold north of Florida. The Japanese *trifoliata* is a true orange and is hardy as far north as New York, but its fruit is not edible. The citrange resulting from this cross is hardy as far north as North Carolina on the east and Washington on the Pacific coast. Its fruit resembles an orange in appearance, but the juice is like that of a lemon.

For many years Dutch bulbs (hyacinths and tulips) and narcissuses have been included in the congressional distribution. As it is believed that these bulbs can be grown in this country equal to those imported by commercial dealers at a cost of more than $500,000 annually, a propagating garden was established by the Department in 1908 near Bellingham, Wash., where conditions are especially favorable. This garden was established not only for the purpose of supplying bulbs for distribution but of securing accurate information regarding their propagation and culture and if possible demonstrating that they can be grown successfully and profitably on a commercial scale. While the results so far secured are very encouraging, it is entirely too soon for the Department to attempt to supply information regarding methods and cost of growing them. The bulbs which are grown at the garden are not for sale or distribution but will be retained for further propagation until such time as the natural increase is sufficient to supply the quantity required for the regular distribution.

Trial sets of different varieties of imported bulbs, Virginia-grown bulbs, and bulbs from the Bellingham garden are tested each spring on the grounds of the Department for comparison. These tests indicate that the American-grown bulbs not only give more vigorous plants and better blossoms, but are from a week to 10 days earlier than imported bulbs of the same varieties.

Perhaps one of the most valuable features of the distribution is the sending out of seed of improved varieties of cotton, many of them developed during the past 10 or 12 years by the cotton specialists of this Bureau. From 12,000 to 16,000 packages are sent out annually on congressional requests. Prior to 1909, 6 to 12 varieties were distributed annually, but since that year the distribution has been confined to 4 or 5 of the purest strains of improved types. The distribution last spring included the Columbia Long Staple, the Hartsville, and the Dixie Wilt-Resistant for the cotton-growing States east of the Mississippi and in the boll-weevil territory to the west, the Lone Star, a variety which has proved especially well adapted to Texas and Oklahoma.

Seed of 24 varieties of tobacco, grown from plants selected by the tobacco specialists of the Bureau and suitable for the various tobacco-growing sections of each State, have been distributed for several years. The distribution of these improved types has undoubtedly been of much benefit to this great industry.

Another and very popular feature of the distribution is the sending out annually of about 20,000 packages of lawn grass seed mixture of the best quality obtainable, composed of Kentucky bluegrass, 80 per cent; redtop, 15 per cent, and white clover, 5 per cent by weight.

The growing importance of the beet-sugar industry in this country and the dependence of the farmers and factories upon Europe for their supply of seed led the Department a few years ago to include several thousand pounds of improved strains of sugar-beet seed in the congressional distribution and to make careful tests of the seed of the different varieties in sections where it seemed probable that beet seed could be produced successfully, with a view not only of obtaining American-grown seed for the distribution but of encouraging the establishment of a new and profitable industry.

For many years, also, large quantities of grass seeds, alfalfas, vetches, clovers, sorghums, cowpeas, soy beans, and other valuable field and forage crop and miscellaneous seeds have been tested by careful growers in the field and distributed upon congressional requests and to collaborators of the department. The distribution of these seeds has undoubtedly led to their cultivation in communities where before they were practically unknown; has tended to encourage the diversification of crops, especially in the South and West; and has greatly extended the area in which such crops form a part of the regular farming system.

The miscellaneous field seeds are tested for purity and viability in the Seed Laboratory and for trueness to varietal type and adaptation on the trial grounds of the Department and in the field, the same as vegetable seed. In connection with this class of seeds, special equipment is maintained for fanning, cleaning, and fumigating whenever necessary.

The principal sections in the United States where the field seeds mentioned in the preceding paragraph are grown are shown in figure 9.

INTRODUCTION OF RARE SEEDS AND PLANTS.

As already pointed out, when the seed distribution was first established it was mainly with the idea of securing new and rare seeds and plants from foreign countries for introduction and distribution in this country. The original intent of the law was never lost sight of, notwithstanding the great increase in the quantity of standard, well-known varieties required to meet the demand. Seeds and plants of many valuable crops and fruits were introduced from abroad which were rare, new, or little known in the United States. Among these may be mentioned new varieties of sorghum, Kafir corn, rice, oats, barley, wheat, and other cereals and forage crops, peaches, pears, plums, grapes, and small fruit, as well as subtropical fruits, among which the Washington Navel orange is deserving of special note. Most of this material was purchased from foreign dealers and correspondents or obtained through American consuls in different parts of the world. Prior to 1898 the introduction of rare or new seeds and plants was conducted as a part of the regular work of the Seed Division.

Soon after the inauguration of his administration Secretary Wilson saw the importance of building up the home plant industries through explorations in foreign countries and the introduction of new crops here. He succeeded in 1898 in getting $20,000 of the regular seed appropriation set aside for the introduction work, and has been active ever since in pushing this work through the Office of

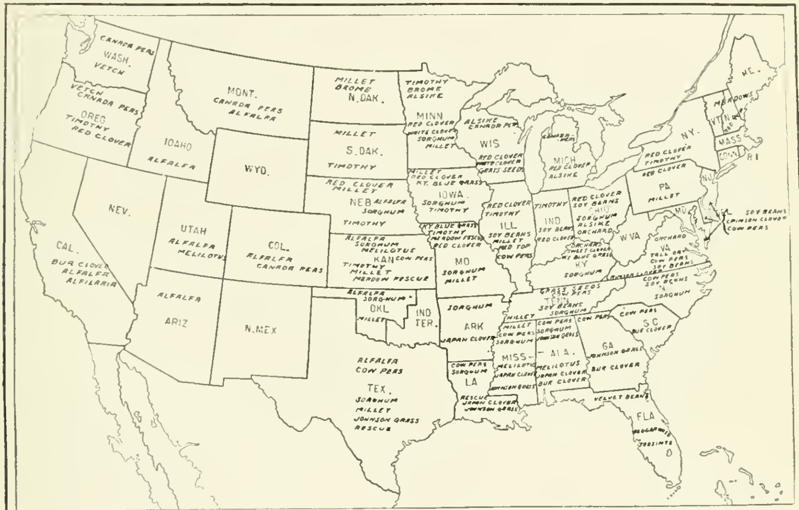

Fig. 9.—Map of the United States, showing the principal sections where grass and forage seeds are grown.

Foreign Seed and Plant Introduction of the Bureau of Plant Industry. This office is now spending about $52,000 annually.

In addition to securing rare plants and seeds through correspondents and American consuls abroad, it has been the practice of the Department since the establishment of the above-mentioned office to send out trained agricultural explorers into almost every region of the globe where plants of value to American agriculture are likely to be found. Among the successful explorers and expeditions may be mentioned the following:

Mr. David Fairchild has traveled extensively in Europe, Asia, Africa, Australia, and South America, secured seeds and plants of many valuable fruits, grains, vegetables, forage grasses, and ornamentals, and put the office in touch with the best foreign agricultural institutions in all the countries through which he traveled.

Prof. N. E. Hansen has made four trips to Russia, Siberia, and Turkestan, in the years 1897, 1906, 1908, and 1910, and obtained seed of drought and cold resistant alfalfas, clovers, and vetches for introduction into the Northwest.

The late Dr. S. A. Knapp visited Japan in 1898 and again in 1901 and procured quantities of the short-kerneled native rice, the cultivation of which has since grown into an industry in Louisiana.

Mr. M. A. Carleton, former cerealist of this bureau, was sent to Russia in 1898, and again in 1900, in search of a rust-resistant wheat and brought back large quantities of the drought-resistant durum and other varieties of wheats, oats, and other cereals.

Dr. Ernst A. Bessey in 1902 and 1903 visited Turkestan, the Caucasus, and parts of Russia, where he secured large quantities of Turkestan alfalfa and other seeds.

Mr. Walter T. Swingle was sent to Smyrna, where he studied the Smyrna fig industry in the year 1898, and in 1899 and 1900 to North Africa, where he discovered valuable forage plants and where he procured (in Algeria) the large number of palms which started the date plantations of the Southwest.

Mr. T. H. Kearney, in the winter and spring of 1902–3 and again in 1904–5, explored portions of North Africa and procured large numbers of date palms and considerable quantities of valuable forage-crop seeds for introduction.

Mr. O. F. Cook, who explored portions of Mexico and Central America in 1904 and 1905 in search of a boll-weevil-resistant cotton, procured for introduction seeds of native cottons and corns which formed the basis of his most valuable researches in cotton and corn breeding.

Mr. Frank N. Meyer spent the three years from 1905 to 1908 in China and Manchuria exploring portions of the country never before seen by white men and sending home many hundred selected species or varieties of seeds and cuttings of rare plants and fruits. Among the valuable things secured on this expedition were the Chinese seedless Tamopan persimmons, some remarkable hardy varieties of yellow roses, a new dry-land stock for stone fruits, and the Chinese tsaos, or jujubes. Mr. Meyer has just returned from an exploration of nearly three years of the dry and cold regions of central Asia, including the little-known Chinese Turkestan. He went in search of plants for the cold dry Northwest and sent back, among the several hundred living plants he collected, some remarkable dry-land poplars, new and valuable shipping varieties of table grapes, hardy wild apples and apricots, a remarkable hardy olive, and a most valuable collection of the wild forage legumes of the Siberian steppes, some of which have already been incorporated into new varieties for field trial. (See fig. 10.)

TESTING, PROPAGATION, AND DISTRIBUTION.

The material which comes in from these expeditions and from correspondents all over the world at the rate of 10 shipments a day is either sent to the plant introduction gardens of the office, turned over to the specialists of the Department, or distributed to carefully selected expert growers, who are in a position to give them a fair trial and report the results. (See fig. 11.)

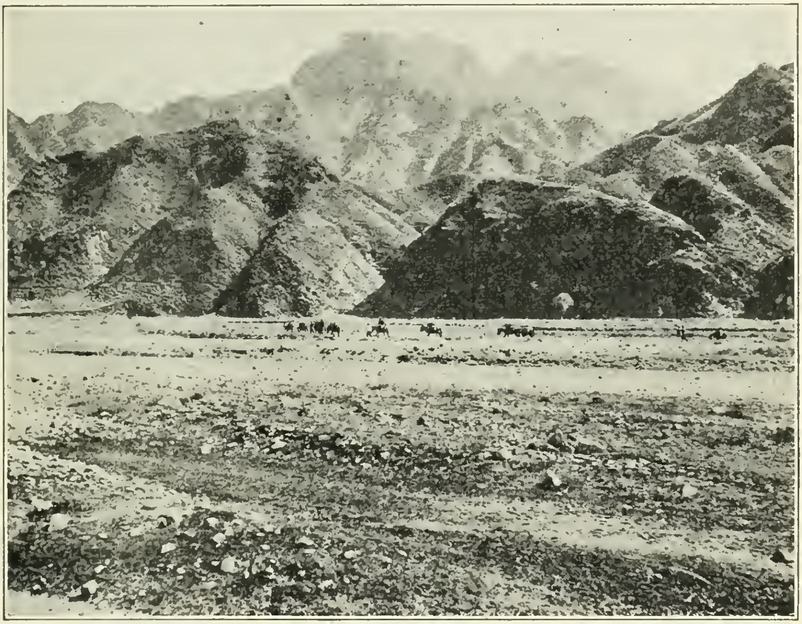

FIG. 10.—Caravan of Mr. Frank N. Meyer, agricultural explorer, on his way to the cold semidesert region of the Wutaishan in North China.

The plant introduction gardens, maintained for purposes of the propagation and preliminary testing of material, comprise the garden at Miami, Fla., for plants which thrive only below the frost line; the garden near Brooksville, Fla., for the bamboo and other oriental plants in particular and for plants which will withstand some frost; the garden at Chico, Cal., for the propagation of a wide range of material from all over the world on a large scale; and the upper Mississippi Valley garden at Ames, Iowa, for specially cold-resistant plants. (See fig. 12.)

Mention should also be made of the date-introduction gardens at Phoenix, Tempe, and Yuma, Ariz., and at Mecca and Indio, Cal., which were inaugurated by the Office of Foreign Seed and Plant Introduction and where are growing the date palms introduced from the Old World by Messrs. Swingle, Fairchild, and Kearney. These gardens have now the most complete collection of date varieties in the

FIG. 11.—A shipment of date offshoots as it arrived from Bagdad, Arabia. These are now growing in southern California and Arizona.

FIG. 12.—An orchard of stone fruits at the Plant Introduction Garden, Chico, Cal., grafted on the wild Chinese peach.

world. These orchards are coming into bearing, and it is only a question of a few years when American-grown dates will be sold on our markets.

SOME RESULTS OF THE INTRODUCTION OF NEW SEEDS AND PLANTS.

Among the hundreds of new varieties of seeds and plants introduced from foreign countries since the organization of the Office of Foreign Seed and Plant Introduction, as well as before that systematic work was begun in 1898, some have proved of great economic importance and of enormous value to the country. Within the limits of this circular it would be impracticable to mention more than a few of the most striking examples.

Sorghum.—Introduced from China and France in 1864 at a cost of about $2,000. Sorghum is now grown throughout the United States, and the annual value of the crop is estimated at $40,000,000.

Kafir corn.—Introduced at a cost of not more than $5,000. Largely grown in the semiarid Southwest, where but few other crops are successful. Estimated value of the crop per annum about $15,000,000.

Durum wheat.—Cost of introduction probably less than $30,000. Its cultivation has extended rapidly throughout the semiarid Northwest, and the annual value of the crop probably exceeds $40,000,000.

Japanese short-kerneled rices.—Introduced at a cost of less than $20,000. Assisted materially in the phenomenal growth of the rice industry in Texas and Louisiana. Estimated value of annual increase in the product, $3,000,000.

Swedish Select oats.—Cost about $5,000 to introduce. Estimated increase in annual value of this variety in Wisconsin alone, $1,000,000.

Excelsior White Schoenen oats.—Introduced in 1868 at a cost of not more than $1,000. Value of estimated annual increase, $15,000,000.

Chevalier barley.—Distributed by the Department in 1871. Cost probably not in excess of $1,000. For many years one of the standard varieties in the United States, the crop of which is worth many millions of dollars.

Fultz wheat.—Introduced by the Department in 1871 at small cost. Became one of the standard varieties in the East, and the annual value of the crop amounts to millions of dollars.

Washington Navel orange.—Original cost of this introduction not on record, but probably insignificant. Value of the California crop alone in excess of $10,000,000 annually.

While, naturally, it is quite impossible to estimate accurately the actual value of these various introductions, they have the positive value which a better yielding variety always has—a permanent increase in the wealth of the country—and it is not too much to state that they have already increased the wealth of the country since their introduction by many times what they have cost the Government to introduce.

SUMMARY.

(1) The purchase and distribution of seeds by the Government, which began in 1839, laid the foundation for the establishment of the present Department of Agriculture.

(2) One of the two fundamental duties of the Department of Agriculture, as prescribed in the organic law (sec. 520, R. S.), is to "procure, propagate, and distribute among the people new and valuable seeds and plants."

(3) The Department of Agriculture soon found that it was impracticable to procure sufficient *new* seeds and plants to carry on the distribution authorized annually by Congress and was compelled to purchase increasing quantities of standard varieties of well-known value in order to meet the demand.

(4) In 1896 the law requiring the purchase and distribution of seeds, including vegetable and flower seeds, and the expenditure of not less than a specified sum for that purpose was made mandatory, and in 1898 a specified sum was expressly set aside for procuring rare and valuable seeds from foreign countries, legislation which has been periodically reenacted to the present day.

(5) Prior to 1898 the procuring of new and rare seeds and plants from foreign countries was carried on in a desultory manner, but resulted, nevertheless, in the introduction of a few crops and fruits of great economic importance, crops the value of whose yearly harvest exceeds the entire cost of the congressional seed distribution from its origin to the present time.

(6) Beginning with 1898, the work of introducing, testing, propagating, and distributing new and valuable seeds and plants from foreign countries was systematized and regular exploring expeditions have been organized and sent out to several of the promising fields in different parts of the globe.

(7) The value of the congressional seed distribution consists in the wide distribution, through Senators and Members of Congress, to applicants in all parts of the country of standard varieties of garden seeds of known value and of the best quality; also seed of improved varieties of cotton, tobacco, alfalfa, clover, sorghum, the grasses, cowpeas, fruits, and miscellaneous plants; and further in encouraging the production in this country of seeds, bulbs, and plants largely or wholly obtained from abroad, by contracting with American growers to furnish such seeds and plants for congressional distribution.

(8) The value of foreign seed and plant introduction work consists in procuring, introducing, testing, propagating, and distributing new, rare, or little-known seeds and plants from foreign countries,

in determining their adaptability and value in different sections of the country, in establishing new plant industries, and above all in finding among the thousands of new plants introduced annually one or more which may add enormously to the wealth, comfort, and happiness of the people.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *June 5, 1912.*

[Cir. 100]

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BUREAU OF PLANT INDUSTRY—Circular No. 101.
B. T. GALLOWAY, Chief of Bureau.

THE GERMINATION OF PACKETED VEGETABLE SEEDS.

BY

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AND

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BUREAU OF PLANT INDUSTRY.

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B. P. I.—766.

THE GERMINATION OF PACKETED VEGETABLE SEEDS.[1]

INTRODUCTION.

There is probably no subject relating to the cultivation of the soil in which so many persons are interested as in the home vegetable garden, since suburban and country residents generally depend on their gardens for a supply of vegetables throughout the major portion of the year. The garden is a place of interest to all the family, and here children with a small plat to call their own frequently get their first real acquaintance with plant life.

From both the educational and the practical standpoint it is important that the home garden should be planted with seeds which germinate well. The market gardener who uses large quantities of seeds can test them or have them tested for germination before planting and regulate the rate of seeding according to their vitality, but this is not practicable with the small packets used in planting the home garden. Most of the seeds used in planting such gardens are bought in packets either from local stores where box seeds are offered for sale, or they are ordered by mail after consulting the catalogue of a favorite seedsman.

Box seeds are put up in showy packets, lithographed in colors, and packed in boxes containing collections of all the common kinds and varieties of vegetables. These are sold outright to local stores or are sent to them to be sold on commission.

SEEDS TESTED FOR GERMINATION.

During the years 1907, 1908, 1909, and 1910 box seeds were purchased and tested for germination, and in 1911 seeds were bought from firms whose principal business is filling mail orders from catalogues. A summary of the results is shown in Table I.

[1] During the past five years a series of tests has been carried on to determine the vitality of packeted vegetable seeds. Germination tests have been made of 18,571 packets, about one-third of them having been purchased from mail-order houses in 1911, and the other two-thirds bought at local stores where box seeds were sold, in 1907, 1908, 1909, and 1910. The germination of the mail-order and box seeds was 77.5 and 60.5 per cent, respectively. The seeds purchased from different mail-order houses were more nearly uniform in quality than the box seeds. The average germination of box seeds put up by one firm for four years was less than one-half that of those put up by another firm. The low vitality of many of the seeds tested is the best evidence that such seeds should be sold with a guaranty as to the percentage of germination.—B. T. Galloway, *Chief of Bureau.*

TABLE I.—*General summary of germination tests of vegetable seeds made in 1907, 1908, 1909, 1910, and 1911.*

Tests by years.	Number of—			Average germination.	Germination 10 per cent and less.		Failed to germinate.	
	Different firms packeting.	Kinds of seed.	Packets.		Firms packeting.	Packets.	Firms packeting.	Packets.
Box seeds for 4 years:				*Per cent.*				
1907	27	19	2,567	63.5	12	106	8	42
1908	39	19	3,760	62.9	21	145	17	90
1909	33	19	2,863	59.1	18	158	17	119
1910	24	19	3,264	55.6	26	249	14	156
Total or average	60	19	12,454	60.5	....	658	....	407
Mail-order seeds in 1911	20	19	6,117	77.5	18	74	13	51

In these five years 18,571 packets of vegetable seeds were tested for germination. The box seeds were put up by 60 firms and the mail-order seeds were purchased from 20 firms. The average germination of all the packets of box seeds was 60.5 per cent, and the average germination of the mail-order seeds was 77.5 per cent. Of the 12,454 packets of box seeds, 658, or approximately 5 per cent, germinated 10 per cent or less, and 407, or approximately 3.5 per cent, failed to germinate. Of the 6,117 packets of mail-order seeds, 74, or approximately 1.2 per cent, germinated 10 per cent or less, and 51, or approximately 0.85 per cent, failed to germinate. While the vitality of much of this seed was low and in many instances the seed was worthless, under the present custom in the seed trade the purchaser has no information as to the quality of the seeds he is sowing, and when they fail to grow it is impossible to tell whether the failure is due to the use of poor seeds or to some unfavorable condition of soil or climate.

COMPARISON OF BOX AND MAIL-ORDER SEEDS, BY FIRMS.

Figure 1 shows the average germination, by firms, of the packets of box seeds put up by each of the 11 dealers whose seeds were purchased in four successive years, together with the average germination, by firms, of the mail-order seeds purchased in 1911. It will be noted that the average germination of the seeds from all but 3 of the mail-order houses was higher than the highest average for any of the 11 firms putting up box seeds.

GERMINATION OF BOX SEEDS, BY FIRMS.

Table II shows, by firms and years, the average germination of the box seeds purchased in each of the four years, together with the average germination for the whole period.

The difference in average germination for different firms is marked, the highest being 81.5 per cent and the lowest 36.5 per cent. Comparing the firms whose seeds were tested in each of four years, the

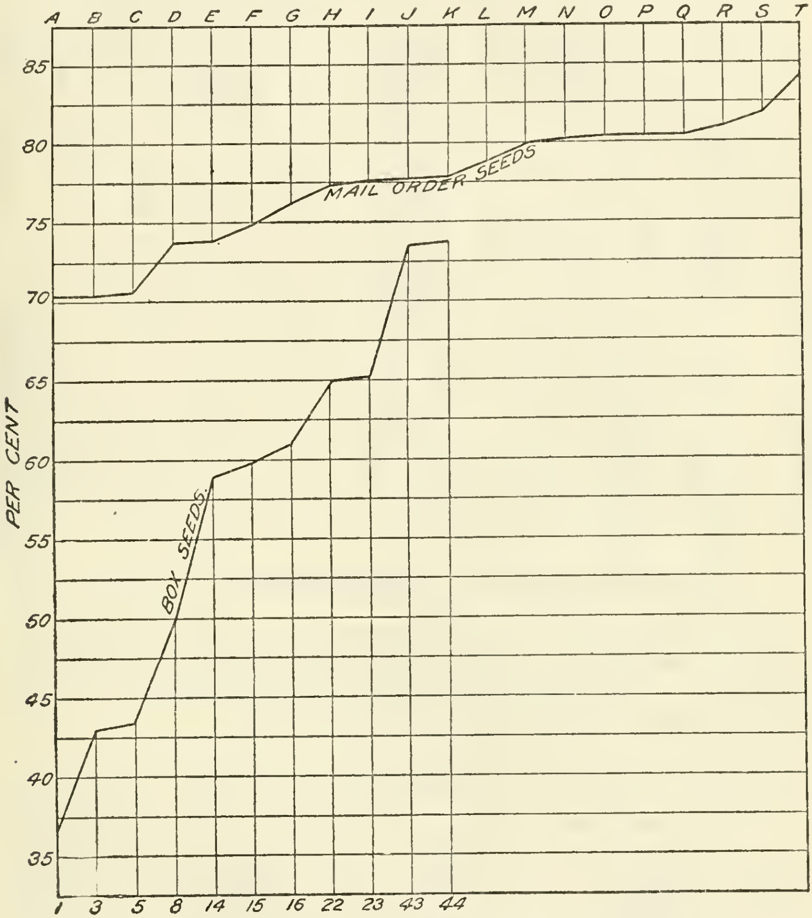

FIG. 1.—Curves showing average germination of box vegetable seeds put up by 11 firms in four successive years, and of mail-order seeds bought of 20 firms in one year. The letters at the top represent firms from whom mail-order seeds were purchased, and the figures at the bottom represent firms putting up box seeds.

highest is 73.7 per cent and the lowest is 36.5 per cent, the highest average being more than double the lowest average.

TABLE II.—*Average germination of box vegetable seeds put up by 60 firms in four years.*

Firm No.	1907	1908	1909	1910	Average.	Firm No.	1907	1908	1909	1910	Average.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1	39.5	37.1	37.0	30.4	36.5	33		69.8			69.8
2			25.1	51.7	41.4	34		81.9		66.1	69.9
3	41.9	43.6	40.8	42.1	42.8	35			70.6		70.6
4			43.0		43.0	36		70.9			70.9
5	51.4	42.2	49.1	35.8	43.4	37		71.1			71.1
6			45.8		45.8	38		62.8	82.0		71.8
7	48.6			41.2	46.3	39			73.1		73.1
8	53.8	52.2	48.3	44.8	49.8	40	74.0	77.1		62.6	73.2
9	57.9	49.2			51.6	41	72.8			73.4	73.2
10	56.9	49.6			52.6	42	74.4	70.7	74.9		73.3
11			53.1		53.1	43	76.6	80.2	88.1	58.8	73.5
12	80.6	14.0			54.6	44	75.3	74.6	72.2	72.7	73.7
13	46.7	68.8	60.2		58.4	45		73.8			73.8
14	59.6	61.8	56.8	51.2	58.9	46			77.8	69.8	74.2
15	57.8	66.6	46.9	60.3	59.8	47	74.5				74.5
16	60.5	61.6	64.8	57.2	61.2	48			74.9		74.9
17	66.1	47.1			61.5	49		75.4			75.4
18			61.6		61.6	50		75.7			75.7
19			63.2		63.2	51	73.5	76.1	79.4		75.8
20		64.2	76.1	59.6	63.8	52	77.7		74.6		76.3
21			61.4		64.4	53	76.8				76.8
22	68.5	62.7	66.6	61.1	64.8	54		77.1			77.1
23	65.7	75.9	69.4	62.2	65.2	55		80.5		74.6	77.3
24		65.6			65.6	56	79.1				79.1
25		66.2			66.2	57			79.5		79.5
26		66.6			66.6	58		81.3		79.0	79.6
27		67.2			67.2	59	82.6	74.2		78.5	79.9
28		63.4	67.5	70.9	67.4	60			81.5		81.5
29	70.9	68.2		64.3	68.5						
30			72.3	66.3	68.9						
31		69.1			69.1	Average	63.5	62.9	59.1	55.6	60.5
32			69.8		69.8						

GERMINATION OF MAIL-ORDER SEEDS, BY FIRMS.

Table III shows, by firms, the average germination of mail-order seeds purchased in 1911. The difference in average germination of seeds sent out by these firms is comparatively small, the highest being 81.8 per cent and the lowest 70.3 per cent.

TABLE III.—*Average germination of packeted vegetable seeds bought from 20 mail-order houses in 1911.*

Firm.	Average germination.	Firm.	Average germination.	Firm.	Average germination.	Firm.	Average germination.
	Per cent.		*Per cent.*		*Per cent.*		*Per cent.*
A	70.3	G	76.2	M	79.9	S	81.8
B	70.4	H	77.3	N	80.2	T	84.1
C	70.6	I	77.6	O	80.3		
D	73.7	J	77.7	P	80.4	General average	77.5
E	73.8	K	77.8	Q	80.4		
F	74.8	L	78.8	R	81.0		

COMPARISON OF BOX AND MAIL-ORDER SEEDS, BY KINDS.

Table IV shows, by kinds, the average germination of box seeds for each year, the average for the four years, and the average of the mail-order seeds for 1911. A comparison of the last two columns in this table shows the relative germination of the box and mail-order seeds, the average germination of box seeds for four years being lower for every kind than the average germination of mail-order seeds in 1911. The difference in germination between box and mail-order seeds of the same variety varies from 2.3 per cent for parsnip and 3.3 per cent for spinach to 28.5 per cent for cabbage and 29.5 per cent for onion.

TABLE IV.—*Average germination, by kinds, of vegetable seeds tested, 1907 to 1911.*

Kind of seed.	Box seeds.					Mail-order seeds.
	1907	1908	1909	1910	Average.	1911
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Bean	84.5	83.0	76.4	71.4	77.8	86.7
Lima bean	91.5	70.0	57.1	69.6	71.6	76.3
Cabbage	50.9	53.3	44.1	41.8	47.4	75.9
Carrot	46.1	44.4	46.7	42.7	44.9	55.0
Cauliflower	58.5	62.4	50.8	51.1	56.4	76.8
Sweet corn	72.6	64.9	59.6	62.4	64.8	83.1
Cucumber	69.3	69.3	66.5	55.5	65.7	76.7
Lettuce	73.7	75.3	75.0	72.7	74.9	87.9
Muskmelon	60.3	59.0	47.0	54.5	55.2	77.6
Onion	46.4	46.2	43.1	34.7	43.1	72.6
Parsnip	20.8	24.8	30.2	12.1	22.6	24.9
Garden pea	75.4	63.4	74.6	47.3	60.1	79.6
Pumpkin	65.1	62.3	58.6	59.3	61.2	73.4
Radish	70.8	76.1	67.7	72.7	72.0	79.9
Spinach	62.5	62.2	51.4	52.1	57.5	60.8
Squash	60.0	51.6	54.5	44.5	52.3	64.8
Tomato	68.9	66.9	66.5	65.0	66.8	79.4
Turnip	69.8	73.5	67.1	58.0	67.3	75.2
Watermelon	63.6	62.0	58.7	57.7	60.5	74.4
Average	63.5	62.9	59.1	55.6	60.5	77.5

BOX SEEDS OF HIGH AND LOW VITALITY.

Figure 2 shows by kinds the average germination for four years of box seeds put up by the two firms whose seed was most commonly found for sale. The average germination of the seeds put up by one of these firms was 73.7 per cent, while the average germination for the other firm was 42.8 per cent, a difference of 30.9 per cent. The average germination of the seeds put out by each of them was nearly uniform from year to year, the greatest difference between any two years for one firm being 3.1 per cent and for the other 2.8 per cent. While the quality of the seeds sold by the two firms is so different, each has its own standard of vitality and adheres to it closely.

VARIATION IN GERMINATION OF LETTUCE SEED.

Table V gives a comparison of the highest and lowest percentages of germination of lettuce seeds packeted by several firms putting up box seeds. It shows a wide difference in the germination of packets of the same kind of seed put out by the same firm in a given year.

TABLE V.—*Comparison of the highest and lowest percentages of germination of box lettuce seed packeted by eight firms.*

Firm No.	Germination.											
	1907			1908			1909			1910		
	Highest.	Lowest.	Difference.	Highest.	Lowest.	Difference.	Highest.	Lowest.	Difference.	Highest.	Lowest.	Difference.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	89	0	89	......	......	......	......	......	......	57	16	41
3	95	5	90	99	1	98	98	0	98	98	0	98
5	99	2	97	99	0	99	99	0	99	98	0	98
8	99	0	99	100	11	89	100	0	100	99	0	99
13	......	......	......	100	20	80	100	2	98	......	......	......
14	100	19	81	97	0	97	99	35	64	99	3	96
15	100	2	98	99	0	99	98	0	98	99	0	99
16	100	17	83	100	6	94	......	......	......	......	......	......

Table VI shows the highest and lowest percentages of germination for mail-order lettuce seed purchased from 10 firms in 1911. It is

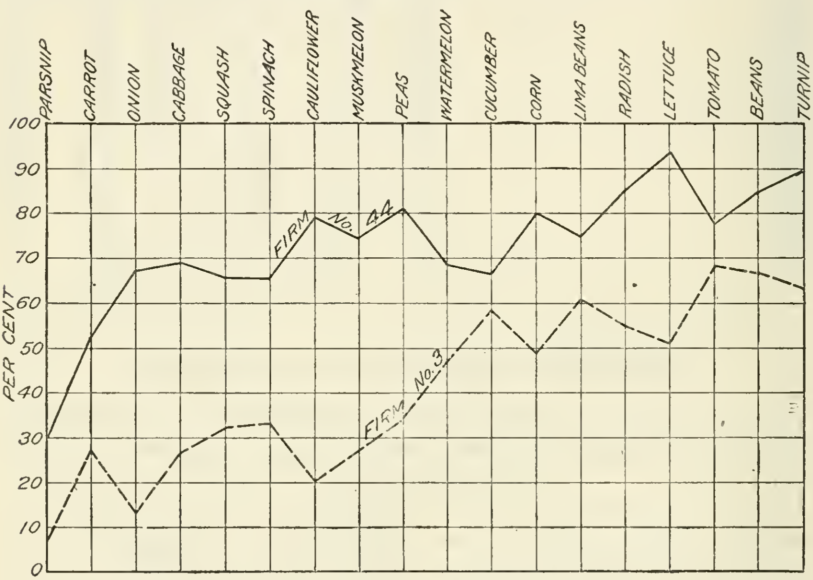

FIG. 2.—Curves showing average germination of box vegetable seeds by kinds in four years for two firms whose seeds were most commonly found for sale.

evident that the same firm in a given year sells different lots of the same kind of seed, some lots being very high and others very low in vitality.

TABLE VI.—*Comparison of the highest and lowest percentages of germination of lettuce seed purchased from 10 mail-order houses.*

Firm.	Germination (per cent).			Firm.	Germination (per cent).		
	Highest.	Lowest.	Difference.		Highest.	Lowest.	Difference.
B	100	0	100	H	100	10	90
C	98	0	98	I	100	0	100
D	100	0	100	J	100	0	100
E	100	11	89	M	99	18	81
F	100	0	100	N	100	0	100

SEEDSMEN'S STATEMENTS SOMETIMES MISLEADING.

One firm in its catalogue makes a statement to the effect that, having carefully tested the seeds sold, it intends to sell only seeds of the best quality, but for self-protection against fraud on the part of purchasers all seeds are sold subject to the usual clause by which the dealer disclaims any warranty and all liability and responsibility for damage resulting from failure through the use of his seeds.

The average germination of the box seeds put up by this firm and tested for four years was 42.8 per cent, the highest average during that period being 43.6 per cent.

It would thus appear that such firms either do not test their seeds accurately or else disregard the results of such tests to the extent of including lots showing unsatisfactory germination in their output of packeted seeds for the box trade.

WHY MAIL-ORDER SEEDS GERMINATE BETTER THAN BOX SEEDS.

There is doubtless an economic reason for the higher average quality of the seeds sold by mail-order houses as compared with the seeds sent out by many of the houses selling box seeds. It is possible for a new firm or one without reputation to purchase a large quantity of seeds, put them up in showy packets and boxes, and by means of attractive prices dispose of them to local merchants either on commission or by sale outright. Mail-order houses, on the other hand, are dependent for their trade on proportionately few new customers each year, their business being based largely on the satisfactory quality of their seeds which purchasers have used in previous years.

GERMINATION OF SEEDS SHOULD BE GUARANTEED.

The sale of packeted vegetable seeds will not be on a proper basis until each packet is labeled with the percentage of live seed which it contains. This practice would do away with the trade in seeds of low vitality and at the same time give the purchaser the information to which he is entitled and without which he can not use to the best advantage the seeds he buys.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *July 5, 1912.*

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Issued October 16, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 102.

B. T. GALLOWAY, Chief of Bureau.

THE PRODUCTION OF HAIRY VETCH SEED.

BY

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AND

EDGAR BROWN,

Botanist in Charge of Seed Laboratory.

57971—12

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BUREAU OF PLANT INDUSTRY.

B. P. I.—773.

THE PRODUCTION OF HAIRY VETCH SEED.

INTRODUCTION.

During the past seven years the culture of hairy vetch has increased in the United States at least tenfold. The crop is constantly growing in favor in the Southern States for winter cover and hay. In the North it is being used more and more on sandy lands and also on other soils where red clover no longer gives satisfactory returns. This rapid increase has been in spite of the fact that the seed has been relatively costly, the farmer rarely purchasing it as low as $5 a bushel, while in the last three years the seed has commanded $6 to $9 a bushel. This increase in price seems to be due mainly to the increased American demand, as the actual supply grown in Europe is not large and thus far but little has been produced in the United States. The higher prices will doubtless tend to stimulate the growing of this seed in Europe, but it can be profitably produced in many parts of this country. Undoubtedly it will be economical for American farmers to grow the hairy vetch seed needed locally, and any surplus can always be sold at good prices. In good vetch-seed sections a crop of 5 bushels of hairy vetch and 20 bushels of rye to the acre can reasonably be expected, and under favorable conditions 10 to 12 bushels of hairy vetch seed to the acre can be grown. Even at $3 or $4 a bushel such crops are very profitable, and at this price the demand for the seed would certainly increase enormously. In view of this increasing demand, American farmers are urged to grow seed of this crop, at least for their local use, and also where the conditions prove very favorable to supply the general market. Satisfactory machines are now available to separate hairy vetch seed from rye.

SOURCES OF SEED.

At present practically all the seed used in this country is imported from Russia and Germany. Table I, showing the quantity of seed imported each fiscal year ended June 30 since 1905, together with the import prices, is based on the record of customhouse samples. It will be noted that the quantity of seed imported has increased very rapidly, especially since 1908.

TABLE I.—*Hairy vetch seed importations.*

Fiscal year.	Quantity (pounds).	Average price per pound.	Fiscal year.	Quantity (pounds).	Average price per pound.
1905	73,245	$0.046	1909	294,896	$0.039
1906	68,354	.055	1910	542,948	.041
1907	208,100	.048	1911	954,025	.059
1908	242,332	.042	1912	635,470	.087

The average price is considerably lower than the average price for a good quality of seed; because in these lots are included many which are low in quality, both on account of adulteration and low vitality.

EUROPEAN METHODS OF GROWING HAIRY VETCH SEED.

In the Baltic Provinces of Russia hairy vetch occurs as a more or less persistent weed in grain fields, and practically all of the supply of the seed from that region is secured by separation from the rye seed.

In Prussia, especially in the provinces of East and West Prussia and Pomerania, there is extensive production for seed, but in Germany generally more hairy vetch is raised with rye for green fodder than for seed. The rate of seeding used in Germany is considerably heavier than that which has been found advisable for seed purposes in this country. The German Agricultural Society recommends sowing 53 pounds of hairy vetch and 72 pounds of rye to the acre, but the average rate of seeding is somewhat less, though the crop is usually grown on light, sandy soil, where a comparatively heavy seeding is needed. Hairy vetch seed is universally sown with winter rye and usually with the variety known as Johannesroggen, or St. John's rye. This variety of rye is peculiar in that it can be sown as early as June and at any time thereafter until the latter part of September. It is a very free-stooling variety and makes a large leaf growth close to the ground. This rye supplies excellent pasturage in the fall, and the date of maturity is 10 to 15 days later than common rye.

SEPARATION OF HAIRY VETCH SEED FROM RYE.

As hairy vetch is usually sown in combination with rye it is not necessary to separate the mixed seed as harvested when about one-third of the mixture is vetch. Such mixed seed is far more economical to use than to pay the present high price for imported seed.

When a separation of the seeds is desirable it is easily and effectively accomplished by the use of a spiral separator, known in Europe as "Schneckentrieur." This apparatus is covered by United States Letters Patent No. 627970, dated July 4, 1899. It is also patented in Germany, Austria, and Hungary, and perhaps in other foreign countries. It is not known to be manufactured or for sale in the

United States, but it can be obtained in both Germany and Russia. The machines seen in Russia had a capacity of 50 to 75 bushels a day and required no power, being operated by gravity.

A satisfactory separation of vetch seed can also be made by use of a cloth-belt apparatus by means of which the rye or other cereal seed is carried up and away on a belt, while the vetch seed falls over the belt to the bottom. A number of forms of this machine are patented, designed especially for the separation of buckhorn from clover seed. A separation which is sufficiently good for preparing mixed rye and vetch seed for sale locally can be obtained by letting the mixed seed run over a series of inclined boards, each set at a given angle and a slight distance apart, so that the vetch seed will run from one board to another and the rye seed, which does not run so readily, will drop through between the boards. This can easily be made by anyone for home use and requires no power to run, as the seed is simply allowed to fall over a series of steps.

GROWING HAIRY VETCH FOR SEED.

Hairy vetch will produce a good crop of seed in most States. The largest crops have been grown on the Pacific coast, but those produced in the Northern States are but little smaller. In the Southern States the seed crop seems to vary greatly with the season, but good yields have been obtained.

Hairy vetch is a winter annual, behaving like winter wheat. If planted in the spring, it may produce a few blossoms the same season, but will make little or no seed until the following season. If planted in the fall, it ripens its seed crop the following July. Spring sowing is seldom advisable, and then only on the Pacific coast and in the arid regions. When spring sown, it is best to pasture the crop the first season. In the Eastern and Northern States spring seeding should never be practiced, as the plants seldom survive the humid heat of summer.

The seed may be sown from the middle of August till November, September being the best month. If sown alone, 40 pounds of good seed to the acre are sufficient, though 60 pounds are frequently used. As a general practice, however, it is better to sow it in conjunction with a small-grain crop—oats, winter wheat, or rye. Oats are often used in the South, but in the North wheat or rye must be used. Rye is the favorite, but if intended for hay the wheat combination is more nutritious. In growing such mixtures for seed, enough grain is used to make about two-thirds of a stand and 20 pounds of the vetch seed are added. Such a mixed crop is easily cut with a mower having a swather attachment, or even with a binder. If more vetch is used it is liable to lodge, especially in spots where the vetch is thick, and the mowing is therefore rendered more difficult.

Where hairy vetch is planted alone, it nearly always becomes more or less lodged, and should be mowed, if possible, against the direction in which most of it is lying. After cutting the first swath, it should be rolled upon the uncut vetch before cutting the second swath. The two swaths should then be rolled out clear from the uncut vetch. Sometimes three swaths are combined in this way. The cut vetch should not be handled more than is necessary in curing, and care should be taken in shocking to cover the pods as much as possible. Hay caps are very desirable for this purpose. In thrashing pure vetch it is sometimes desirable to have sharpened teeth on the concaves, as long vetch is inclined to wrap about the cylinder.

If hairy vetch is pastured rather late, the subsequent growth will not be tall, but often is heavily set with pods. The same result can be obtained by cutting the vetch early and feeding it green or putting it into a silo. Such a second crop is much more easily mowed than tall vetch, and in some instances excellent seed crops have been thus secured.

Some farmers obtain their own supply of seed by cutting hairy vetch for hay rather late, i. e., after some of the pods have ripened. Much of this seed will rattle to the bottom of the mow, especially if a little care is taken to shake each forkful as it is being used for feed. Such late cutting reduces slightly the value of the hay, but the seed obtained often justifies the practice.

Hairy vetch ripens its pods over a period of two or three weeks. The best crops are obtained when the first pods are fully ripe and the upper pods well filled. The latter ripen in the shocks, and if carefully handled comparatively few of the ripe pods shatter. It is best to cut the crop early in the morning or on a cloudy day. In any event the vetch, whether cut in bundles or otherwise, should be put into shocks at once and left thus till thrashed. The most important rule is to handle the cut crop rapidly and as little as possible.

An incidental advantage to the use of locally grown hairy vetch seed is its much better germinating quality. Old seed has a large percentage of hard seeds, which lie in the ground a long time without sprouting and which are practically valueless to the farmer. Fresh samples collected in Europe in 1911 gave a uniformly high germination, only one testing below 91.5 per cent. Imported seed, which is usually 1 year old, frequently shows a hard-seed content of 10 to 40 per cent.

EXPERIMENTS IN GROWING HAIRY VETCH SEED IN AMERICA.

While hairy vetch for hay or green manure has long been grown successfully in nearly all parts of the United States and Canada, there has been relatively little investigation made of its seed production. Table II is a compilation of published American data in seed production, together with unpublished results obtained by the Department and its cooperators.

TABLE II.—*Data showing the results of American experiments in growing hairy vetch seed.*

Place.	Year.	Area.	Seeding.	Acre rate of seeding.	Date of seeding.	Total yield.	Acre yield (bushels).	Source of information.
Wayne County, Ohio	1903	4 acres	Broadcast	30–45 pounds vetch 30 pounds rye	Middle to end of September.	13 bushels vetch 61 bushels rye	Vetch, 3.25 Rye, 15.25	Press Bulletin, Seed Laboratory, Bureau of Plant Industry, 'Growing Hairy Vetch for Seed," 1903.
St. Marys County, Md.[1]	1903	do				18 bushels vetch 8 bushels rye	Vetch, 4.5 Rye, 2	Do.
Agricultural College, Miss.	1899	Small plat	Drills $2\frac{1}{2}$ ft. apart.	83 pounds			5.57	Annual Report, Mississippi Agricultural Experiment Station, 1899, p. 12.
		do	Rows $2\frac{1}{2}$ ft. apart.	37 pounds			5.85	
		do	Broadcast	53 pounds			7.40	
Arkansas Valley, Colo.	1899	$\frac{6}{7}$ acre			Aug. 11	400 pounds	7.7	Bulletin 68, Colorado Agricultural College.
Pullman, Wash.	1898	2 acres		3 pecks			5.5	Bulletin 41, Washington Agricultural Experiment Station.
Do.	1899	$\frac{3}{4}$ acre					14.7	
James River Valley, S. Dak.	1898	Small plat (old seed).	Drilled	36 quarts			6.5	Bulletin 61, South Dakota Agricultural Experiment Station.
		Small plat (new seed).	do	do			6.5	
Guelph, Ont.	1901	Small plat			Autumn		8	Report, Ontario Agricultural College, 1901.
Do.	1903				do		10.8 [2]	Idem, 1903.
Do.	1905				do		8.6 [3]	Bulletin 140, Ontario Agricultural College, 1905.
Forest Grove, Oreg.	1906	2 acres	Sown with oats.			480 pounds vetch 900 pounds oats	Vetch, 4 Oats, 28	Cooperative experiment, Bureau of Plant Industry.
Pullman, Wash.	1908	$\frac{1}{16}$ acre				19.5 pounds	3.5	Forage-Crop Investigations, Bureau of Plant Industry.
Monmouth, Oreg.	1906	2 acres	Sown with oats.	50 pounds vetch 1 bushel oats	Fall		Vetch, 10 Oats, 20	Letter of William Riddell & Sons,[4] February 1, 1907.
Hale, Mich.	1911	26 acres	Sown with rye.			20 pounds vetch 230 pounds rye	Vetch, 7 Rye, 8.85	Cooperative experiment, Bureau of Plant Industry.
Marquette County, Wis.	1909	1 acre	do	30 pounds vetch 30 pounds rye	Aug. 20		Vetch, 3 Rye, 9	
Do.[5]	1910	do		30 pounds rye Volunteer vetch	Late summer or fall.	18 bushels of the mixture.	Vetch, 5.4 Rye, 12.6	
York County, Va.	1910	8 acres (poor sandy loam).	Sown with rye.		August	100 bushels; half rye, half vetch.	Vetch, 6.25 Rye, 6.25	J. A. Bechtel, York County, Va., in letter to the Southern Planter, July, 1912, p. 764.
Arlington Farm, Va.	1912	$1\frac{1}{6}$ acres	Broadcast	40 pounds vetch 30 pounds rye	Sept. 20	538 pounds vetch 4.8 bushels rye	Vetch, 7.5 Rye, 4	Seed Laboratory experiment.
Do.	1912	$3\frac{1}{2}$ acres	do	30 pounds vetch 45 pounds rye		677 pounds vetch 3,656 pounds rye	Vetch, 3.2 Rye, 17.4	

[1] This crop was much injured by storms and the yield considerably lessened.
[2] Average of 3 years.
[3] Average of 4 years.
[4] This firm also grew hairy vetch seed in 1907, 1908, and 1909, but the yields were not so good as in 1906. In 1910 the vetch yield was 3 bushels to the acre.
[5] Crop of 1910 was on the same ground as that of 1909; the only seed sown was 30 pounds of rye, a thick crop of the vetch appearing from the shattered seed.

These results show yields ranging from 3 to 15 bushels per acre, with an average of 6½ bushels for all the trials. Such a yield makes a decidedly profitable crop. Where vetch is grown alone the seed yields are heavier, but this is largely counterbalanced by the difficulty of harvesting, so that it is advisable as a rule to grow it in combination with rye.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *August 7, 1912.*

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 103.

B. T. GALLOWAY, Chief of Bureau.

RAMIE.

BY

LYSTER H. DEWEY,

Botanist in Charge of Fiber Investigations.

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BUREAU OF PLANT INDUSTRY.

Chief of Bureau, Beverly T. Galloway.
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B. P. I.—782.

RAMIE.

INTRODUCTION.

Ramie (*Boehmeria nivea*) has been an important fiber-producing plant in China for many centuries. Experiments in the cultivation of ramie have been carried on in this country since 1860. Although none of them thus far have led to a commercial industry, interest in the possibility of cultivating ramie continues. Ramie fiber, long, strong, durable, light, lustrous, and nonelastic, is in some respects the most attractive plant fiber of commerce. Several kinds of ramie goods are appearing in increasing quantities in our markets. Some mills are now engaged in the manufacture of these goods in the United States, and others are being equipped for the work. There are more inquiries for information about ramie than about any other fiber-producing plant.

THE PLANT.

The ramie plant (fig. 1) is a perennial belonging to the nettle family and is native in eastern Asia. Herbaceous stalks one-eighth to one-half of an inch in thickness and 2 to 6 feet in height, similar to those of the nettle, but without stinging hairs, grow up each year from the perennial rootstocks. When cut during the growing season, new shoots grow up. The leaves are broadly ovate, serrate, green above, and downy white on the under surface.

RANGE OF CULTURE.

Ramie is cultivated commercially in China, in Japan, including Taiwan (Formosa), in Chosen (Korea), and to a limited extent in India and Africa. It has never been cultivated on a commercial scale in this country, but experiments conducted by private individuals, State experiment stations, and by the United States Department of Agriculture have demonstrated that it can be grown on suitable soils from Maryland to Texas; also in California and in Porto Rico.

CLIMATE.

A warm, moist climate is essential for the successful cultivation of ramie. Cold checks it and severe drought kills it. It is cultivated in warm temperate climates rather than in the Tropics. Unless grown under irrigation or on moist bottom lands along rivers it requires at least 40 inches of well-distributed rainfall. Its roots are

FIG. 1.—Second growth of ramie, showing the crop ready for harvest two months after cutting the first crop.

injured where the ground freezes more than 3 inches. There should be a period of at least five months free from frosts. In the Tropics it grows throughout the year unless checked by drought, but its productiveness is not thereby very much increased.

SOIL.

Ramie requires a rich, deep, moist soil, well drained, yet not subject to drought. A dark, rich, sandy loam is best. Rich, alluvial bottom lands free from overflow are suitable for it. The plant will not grow in undrained swamps or on stiff clays, and its cultivation is not profitable on light sandy soils unless heavily fertilized.

FERTILIZER.

Ramie requires a fertile soil and, as its growth should be continued five years or more on the same land and heavy crops removed each year if it is to be a profitable crop, the fertility must be kept up by liberal applications of stable manure or commercial fertilizer. Table I, from Bulletin 94 of the California Agricultural Experiment Station, by Prof. E. W. Hilgard, indicates the elements removed from the soil by ramie.

TABLE I.—*Soil ingredients (in pounds) withdrawn from 1 acre by a crop of ramie.*

Soil ingredients.	Leaves (4.25 tons).	Stalks (7.25 tons).	Bark (2.75 tons).	Whole plant (14.25 tons).
Potash	68.13	155.99	27.86	251.98
Soda	8.99	33.63	7.52	50.14
Lime	566.91	71.77	19.14	657.82
Magnesia	114.58	43.68	10.01	168.27
Manganese oxid	1.92	1.45	0.20	3.57
Ferric oxid and alumina	38.56	12.16	0.71	51.43
Phosphoric acid	77.13	67.71	10.86	155.70
Sulphuric acid	30.86	14.53	3.17	48.56
Silica	692.71	7.06	4.48	704.25
Chlorin	41.56	2.50	7.79	51.85
Total ash constituents	1,641.35	410.48	91.74	2,133.57
Nitrogen	206.10	105.85	57.75	369.70

Table I shows that the leaves, constituting nearly one-third of the total weight of the plant, contain more than two-thirds of the total ash. The leaves and stalks should be left on the farm. The bark containing the fiber is the only portion having a market value. It is the only part that needs to be removed from the farm, and its proportion of fertilizing elements is relatively small. Ramie requires more potash than wheat, but less phosphoric acid. If the leaves and stalks after decortication are returned to the land they will aid in keeping up the supply of humus in the soil; otherwise, stable manure must be liberally applied, unless winter legumes, like crimson clover, can be grown, to be plowed under in the spring.

PROPAGATION.

Ramie is propagated by root cuttings or by seeds. The plants may be more abundantly multiplied from seeds, but they grow more quickly and with more certainty from root cuttings. Seeds must be sown on the surface of the ground in a well-prepared seed bed, which must be covered with cloth to keep a warm, saturated atmosphere until they germinate and take root (fig. 2). When 6 to 10 weeks old they may be transplanted to a nursery in the open ground, and two months later, when well rooted, they may be set out in the open field. The young plants or roots are set 20 to 30 inches apart in rows 3 to 4 feet apart. The land between the rows must be cultivated. If irrigated, the furrow system must be used to avoid covering the young plants with water.

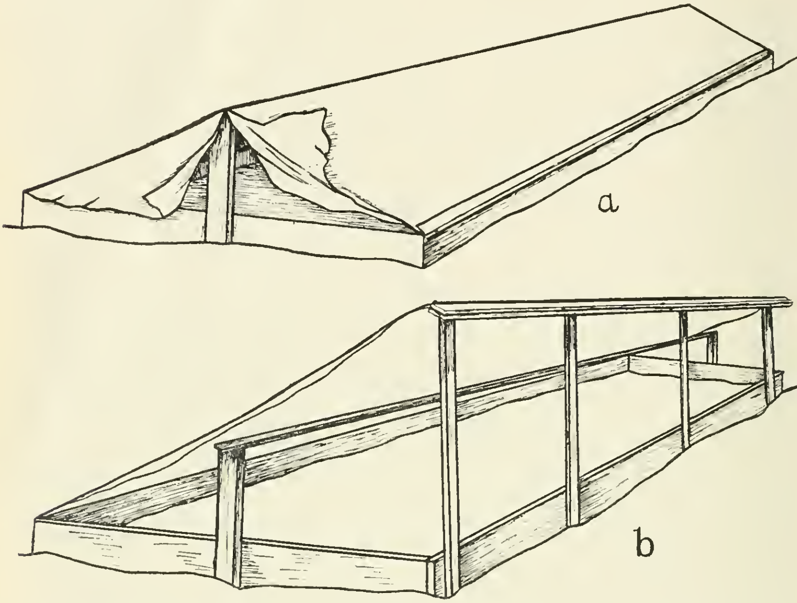

Fig. 2.—Ramie seed bed covered with cloth to retain heat and prevent evaporation: *a*, Cover to remain closed until seedlings are up; *b*, cover raised on one side to give ventilation with partial shade.

HARVESTING.

The first stalks of ramie are usually much branched and of no value. It is best to cut off the first shoots when they are 10 to 30 inches high, to induce a thicker and more uniform growth of shoots. Afterwards one to four, usually two, crops are cut each year. In Asia, where ramie is commercially cultivated, it is cut by hand. Each stalk is cut as it matures, leaving the younger stalks to grow. The harvest there is almost continuous in the small hand-tended patches. No special machinery has been devised for cutting ramie. It may be cut with self-rake reapers, such as are used for hemp, and must be kept straight. If to be decorticated green it must be gathered up immediately after cutting, but if to be decorticated when dry it should be cured in the swath or gavel like hemp, and care must be exercised to avoid heating or molding.

PREPARATION OF FIBER.

In Asia, the bark, including the fiber, is stripped from the stalk immediately after it is cut. The thin outer skin, which clings tenaciously, and the green pulp are scraped from the fiber by drawing the fresh green strips of bark between a bamboo thimble and a blunt knife held in the hand. The strips of bark with the fiber are called "ramie ribbons." This term has also been applied to the fiber decorticated by machines. The hand-cleaned fiber free from the bark and pulp is called "China grass," and in this form it is baled and exported.

DEGUMMING AND COMBING.

In order to be spun into fine yarns by machinery, ramie must be degummed and combed. The degumming is a chemical process, removing the gums and leaving the fiber soft. After being dried the degummed fiber is put through a series of drawing machines to separate and straighten the individual fibers and then through a combing machine to remove the short fibers or "noils," leaving the clean, straight, long fiber, or filasse (called "tops"). Both tops and noils are spun, the tops making the finest and strongest yarns. The degumming and combing processes are carried on at the mills and not by the grower or producer of the fiber.

YIELD.

The yield of ramie stalks and the percentage of fiber vary widely under different conditions. The yield of stalks usually increases up to the fourth year. The estimates shown in Table II, based on numerous experiments in France, are suggested as an aid in estimating the probable output under favorable conditions in this country.

TABLE II.—*Estimated yield per acre (in pounds) of ramie stalks and fiber.*

Years.	Green stalks.	Air-dry stalks.	Dry fiber.
First	6,000	1,500	300
Second	12,000	3,000	600
Third	18,400	4,600	900
Fourth	26,400	6,600	1,300

A series of statements of eight different authorities as to the yield of raw fiber from two annual cuttings in experimental plantings ranges from 500 to 2,800 pounds, with an average of 1,293 pounds. The yield of dry fiber is 3 to 5 per cent of the weight of the green stalks, or 15 to 20 per cent of the weight of the air-dry stalks. In Taiwan (Formosa), where three or four crops are harvested each year over about 5,000 acres, the average annual yield is about 700 pounds per acre. In Hunan and Hupeh, China, the annual yield is 400 to 600 pounds of China grass per acre from three crops.

MARKET.

China grass, which is ramie fiber cleaned by hand in China, can be delivered in San Francisco or New York at 6 to 10 cents per pound. If it is to be produced in this country it must compete in quality and price with that imported. It is not listed separately in the statistics of imported articles, so there are no exact figures available as to the quantities imported. It is roughly estimated that the importations of China grass now amount to nearly 1,000,000 pounds annually, besides considerable quantities of yarns and some degummed filasse prepared in Europe. No regular market for ramie fiber has been established in this country, and it is not listed with American quotations of other fibers. Ramie ribbons and China grass are both quoted in the London fiber market. Hongkong is the principal shipping port for the fiber, but it may be purchased in nearly all the ports of China and also in Taiwan (Formosa).

USES.

Ramie is used in this country principally in millinery goods, knit underwear, dress goods, for mixing with silk, and for shoe thread. It is suitable for dress goods, plushes, upholstery materials, portieres, table napery, incandescent gas mantles, and nearly all lines of goods now made from silk or linen yarns. It is distinctly different, however, from either silk or linen. It is especially suitable for goods in which strength, nonelasticity, absorbent properties, and luster are required.

DECORTICATING MACHINES.

The lack of satisfactory mechanical methods for separating the fiber from the woody inner portion of the stalk and from the thin outer bark has made it impossible to produce the fiber with profit outside of countries having cheap, skilled, hand labor. Many machines have been devised for decorticating ramie and some have been built, but very few have been actually used in the field. Most of the machines have lacked either efficiency in cleaning the fiber or capacity sufficient to enable them to compete with the work as it is done in China. At the present time three different companies in Europe are advertising machines for decorticating ramie fiber from the green stalks. Very promising work was done in trials in the fall of 1911 with a machine built in this country to decorticate ramie fiber from the dry stalks. If this machine does as well in actual commercial work as it has in the rather extensive trials, it may be regarded as satisfactory for decorticating the dry stalks. Fiber decorticated from green stalks is desired for most degumming processes, and machines are now being perfected for this work.

The outlook for the ramie industry in this country appears promising. At least five different companies are operating mills for degumming, combing, and spinning ramie. The manufactures of ramie yarns, shoe thread, dress goods, and incandescent gas mantles have become established industries. Increasing quantities of ramie goods are being offered under the name "ramie," so the purchasing public may soon learn to recognize the merits of this superior fiber. In some instances its reputation has been injured by goods made of badly degummed fiber wearing out quickly in the laundry, by goods made of noils sold to compete with the better grades made from tops, and, worst of all, by cheap jute goods sold under the name "ramie."

The importations of raw ramie fiber from China and of degummed fiber and ramie yarns from Europe, the established manufacture of ramie goods in this country, and the increasing demand for these goods indicate clearly that a market for the fiber is assured. The question remains for the American farmer, Can this raw fiber, the yield of which is scarcely more than 4 per cent of the weight of the green crop, or 800 to 2,500 pounds per acre, be produced at a cost permitting it to compete with the hand-cleaned ramie fiber from China?

Approved:

JAMES WILSON,

Secretary of Agriculture.

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BUREAU OF PLANT INDUSTRY—Circular No. 104.

B. T. GALLOWAY, Chief of Bureau.

SPECIAL CONTESTS FOR CORN-CLUB WORK.

BY

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61895°—12

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B. P. I.—784.

SPECIAL CONTESTS FOR CORN-CLUB WORK.[1]

INTRODUCTION.

It is a well-established fact that both play and contest interests perform a very important part in the processes of education and have much to do in creating efficiency for man in the equation of social and industrial life.

FIG. 1.—Two Iowa boys discussing the merits of seed ears.

The corn-club work is an important factor in the economy of the farm in directing rural boys to the business of farming as a profitable and noble profession. The way in which the club work takes hold of a boy is well shown in figure 1, and from this enthusiasm greater interest in farm life may develop.

[1] This circular is prepared for use in the Northern and Western States, where the boys' corn-club work is supervised by the Office of Farm Management of the Bureau of Plant Industry. This work in the Southern States is supervised by the Office of Farmers' Cooperative Demonstration Work of the Bureau of Plant Industry.

The rules and regulations governing the age, acreage, basis of award, methods of measurement, and general club requirements are the same in all States. The administration of the club work through these two offices is adapted by them in each case to local conditions.

We need the boys for the present efficiency of the farm, and we must have their work, their leadership, and their influence for the future if American agriculture and rural interests are to endure and contribute as they should to human comfort and prosperity.

The purpose of this circular is to suggest lines of interest and instruction in addition to the regular club work, which has to do with the acre yield at a reasonable cost of production. These club contests may well be taken up in connection with the rural and village schools; country, district, and State fairs; short courses, farmers' institutes, educational gatherings, etc., with a view to giving direction and interest as well as important training during the entire year. The club contests will enable both teacher and parent to win the boy for better things in needed education and efficient farm life. Much could be said about the influence of this kind of work upon actual production and land values.

Boys' corn-club work should be constructive and permanent, and in order that it may be so the following lines of contest work are suggested to the club membership. These contests should offer some relaxation from the main line of work and should be practical and recreative as well as instructive.

A FEW OBJECTS OF CLUB CONTESTS.

The following are a few of the objects of corn-club contests:

(1) To increase members' interest in corn in all of its important phases.

(2) To secure better seed corn and consequently better yields. (All seed should be returned to the exhibitors.)

(3) To give industrial activity and practice to club members for the entire year.

(4) To give members greater interest in club work through combined play and contest methods.

(5) To furnish profitable diversion to the boys during the otherwise idle hours of playtime and vacation periods. "An ounce of prevention is worth a pound of cure."

PREMIUM LIST SUITABLE FOR AWARDS IN CLUB CONTESTS.

To stimulate interest in the contests the following premiums are suggested:

(1) Free trips and expenses paid to district and State fairs, educational institutions, summer Chautauquas, etc.

(2) Top buggy, saddle, gold watch, automobile, etc.

(3) Clear title to one or more acres of land (to encourage land ownership).

(4) Farm implements, tools, equipment, etc.

(5) Thoroughbred pigs, cattle, horses, mules, pen of chickens.

(6) Club emblems, banners, and pennants.

(7) Manual-training workbench, set of tools, cameras, trunk, leather hand bag, writing desk, etc.

(8) Poultry equipment, such as incubators, watering and feeding troughs, brooders, fencing, and gates.

(9) Free tuition to short courses in agricultural and mechanical colleges and regular courses in colleges.

(10) Canvas tent, camp outfit, canoe, hunting equipment, baseball suit, and suit of clothes.

(11) Dictionary, encyclopedia, set of agricultural books, special club library, series of books of standard literature.

(12) Subscriptions to farm journals, magazines, and special periodicals for boys.

Every premium offered for contests and corn-club work should have for its main interest the promotion and encouragement of the regular club work. The premium should represent the greatest need and interest of the corn-club membership; it must teach the broad viewpoint of the club work and encourage both members and leaders to be progressive and constructive in their work, and it should serve to increase the club members' interest and respect for farm life.

Club leaders, county superintendents, teachers, and others interested in promoting agricultural and rural-home interests should lose no opportunity to have club exhibits and interests recognized effectively at county, district, and State fairs. County farmers' institutes, short courses, and teachers' associations are excellent mediums for promoting the club work, and an exhibit of club products, special contests, essays, and general discussions on phases of the work should occupy some place and time during the regular session. Do not wait for an invitation to submit club interests, but proceed at once to make and present your plans to the proper officials, such as the secretary, the president, and the various premium and program committees. Most of these will be glad to recognize the boys and girls in their club interests in every way possible.

Women's clubs, summer Chautauquas, and all business organizations can be easily interested in the local club work and upon tactful solicitation will gladly give moral support and oftentimes financial help.

WHERE TO HOLD THE CONTESTS.

No contest serves its highest purpose unless it is first local. Begin at the rural school, then go to the township, county, district, State, and finally to the national contest events. In this way you carry with you an increasing interest and enthusiasm in the work, and all the time the real producers at home are most conspicuous.

A number of contests are mentioned below, and the methods of conducting them are suggested in the short memorandum for each one. The basis of award may be used to determine the standing of contestants.

When possible, arrange to have a corn-club emblem given to each member who makes a creditable exhibit. These will cost only $12 a hundred.

FALL CORN CONTESTS.

Instructions in Seed-Corn Selection.

Bear in mind that upon your faithfulness in the selection of seed corn for vitality, quality, and high-yielding value depends much of your success in crop production for the next season. Your work will influence countless others in this most important phase of farm work and economy.

All seed corn should be selected early in the fall, just as soon as the corn is mature and dry enough for seed, and it must be done before the fall freezing begins. Select early matured ears from the carefully selected stalks; if possible, increase your yield by your selection from two-ear stalks. Select the best ear on this ideal mother stalk, or, if two are suitable for seed, select both. Of course, for a few years it will be quite impossible for the club member to secure enough seed corn which will meet the above standard. Have the ideal in mind, however, and select your best corn and get as near to this standard as possible.

Remember that you must have ideals in mind, first, of the mother stalk; second, of the perfect ear; third, of the perfect grain; and all this must conform to the standard which applies to your particular breed of corn.

Every farmer should have a seed-corn breeding plat at the head of his crops, just as he maintains a good male unit at the head of his hog and stock herds. As a club member you can do much to educate the people of our country as to the importance and absolute need of careful seed selection and a well-protected seed plat. Remember to select for vitality, quality, and high production. "Like begets like." The following will furnish you with a brief guide in the matter of selecting seed corn:

(1) Type of plant:

- (*a*) Stalk, without suckers, strong and thick at base; large and well-developed roots; ears about four feet from base.
- (*b*) Seed ear, large, sound, well shaped, good weight, strong shank, tip turned down. Select early-maturing ears with perfect husks.
- (*c*) The grains of corn on the ear should have a large, healthy germ, good color, deep grained, and wide at the apex.

(2) Storage: Store in a dry place of uniform temperature; test for vitality before planting. No seed of which less than 95 per cent is germinable should be used.

(3) Ideal ear for seed and exhibition:

- (*a*) Size and color determined by breed type.
- (*b*) Sound, mature, good-looking.
- (*c*) Cylindrical and must carry diameter well from butt to tip; should taper very slightly from butt to tip.
- (*d*) Rows should be straight and compact.
- (*e*) Butt and tip well filled; show shank and sign of cob tip.
- (*f*) Cob one-half diameter of ear.

CONTESTS IN THE SELECTION OF SEED CORN.

Give the first, second, third, fourth, and fifth premiums for each of the following:

(1) The best hand-picked bushel of seed corn (shown in bushel basket).
(2) The best 10-ear sample.
(3) The best single ear.
(4) The best hill of corn, showing stalks, ears, roots, etc.
(5) The best stalk of corn from which to select seed corn.

BUSHEL CONTEST.

BASIS OF AWARD.

(1) Trueness to breed type	25
(2) Vitality, maturity of corn, and market condition	25
(3) Appearance of corn, i. e., uniformity of butts, tips, color, size, etc., as it applies to the entire bushel	25
(4) Shelling percentage, shape, size, color, and quality of individual grains (apply "test" to the entire bushel)	25
Total score	100

TEN-EAR AND SINGLE-EAR SAMPLE CONTESTS.

BASIS OF AWARD.

The basis of award in the bushel contest can be used to advantage in scoring both the 10-ear and single-ear samples, or, better still, follow the score-card instructions submitted by your State college of agriculture and experiment station.

CORN-HILL CONTEST.

The hill must be entire and unbroken at the roots of the plant in order to be eligible.

BASIS OF AWARD.

(1) Number of stalks and ears of corn to the hill	25
(2) Condition of roots and stalks (see stalk standard below)	25
(3) Quality and breed type of corn	25
(4) High-production value of sample hill (based upon yield per acre and average weight of corn to hill)	25
Total score	100

SINGLE-STALK CONTEST.

The object of the single-stalk contest is to teach the primary source of good seed. The exhibit should include the entire plant, stalk, ears, and root system.

BASIS OF AWARD.

(1) General appearance and condition of the stalk, including roots, ears, and all of its parts	25
(2) Weight of corn on the stalk	25
(3) Quality and breed type of the corn	25
(4) High production; value of the sample stalk	25
Total score	100

Storing Seed Corn.

After selecting the seed corn it should be carefully stored in a place with uniform dryness and temperature. The storeroom should be well ventilated.

Do not allow seed corn to heat, freeze, or to be subject to sudden changes, such as from a dry to a wet or from a cold to a warm atmosphere.

There are a number of economical and efficient methods of storing seed corn, such as the single-twine method and the double-twine method, and by the use of various drying racks, etc. The method used will be selected with reference to its particular fitness to the quantity of seed and the available storage room; also with reference to

Fig. 2.—A seed-corn stringing contest with referee, timekeeper, and contestants on stage.

the kind of storeroom. For more information on this subject,[1] see Farmers' Bulletin 415, entitled "Seed Corn," by C. P. Hartley, and the special circulars on this subject issued by your State agricultural college and experiment station.

Seed-Corn Stringing Contest.

Arrange the contestants in pairs, with two members facing each other on the floor or platform. Have the member to the right handle the string, tie, operate, and hang in place, while the second member feeds the corn from the pile into the stringer. The second member

[1] See also Farmers' Bulletins 229, The Production of Good Seed Corn; 253, The Germination of Seed Corn; 313, Harvesting and Storing Corn; 408, School Exercises in Plant Production; 409, School Lessons on Corn; 414, Corn Cultivation; 415, Seed Corn; 428, Testing Farm Seeds in the Home and in the Rural School; and Circular 95, Bureau of Plant Industry, entitled, "The Seed-Corn Situation."

should take a position on his knees in front of the corn and the first boy, while the first boy stands erect and operates the string. A timekeeper and a referee or a set of three judges should be appointed. Figure 2 shows a seed-corn stringing contest, with contestants, timekeeper, and referee on the stage.

The boys or team who make the highest grade on the three following points are classed as winners:

BASIS OF AWARD.

(1) Stringing the largest number of ears in a given time	40
(2) Doing the work with the greatest ease and skill of hand, head, and body	30
(3) Having the best work; shown in the condition of the corn as hung in its place	30
Total score	100

Plowing Contest.

A field area should be provided so that each contestant can plow 10 furrows. The arrangement of plowing should be made convenient for the judges to do their work, so as to leave the plowed ground in shape for the owner to use.

BASIS OF AWARD.

(1) Skill in managing the team and plow	30
(2) Uniformity of depth, width, and condition of the soil	40
(3) General appearance of 10 furrows (exterior condition, such as smoothness, freeness from trash, etc.)	30
Total score	100

WINTER CONTESTS.

CORN-JUDGING CONTEST

The judging contest may apply to a 10-ear or single-ear sample, a bushel, a perfect hill, or a single stalk. The regulation score card should be used.

BASIS OF AWARD.

(1) Time required in judging	20
(2) Accuracy in the scoring work	30
(3) Neatness of score card	20
(4) One-half page description of an ideal sample	30
Total score	100

CORN BREED AND VARIETY NAMING CONTEST.

The principal object of the breed and variety contest is to have the club members become familiar with the characteristics of standard breeds of corn grown in the corn-club States. This is quite important in connection with the work in seed selection and in the corn-judging contests.

Place 12 or 20 ears of corn, representing as many varieties, on a table or a paper placed on the table. Each contestant is given a pencil and a sheet of paper, with numbers corresponding to the numbers of the ears and with blank spaces for the variety names. He is then permitted to pass by the corn and study it and to enter the number and name of each kind of corn on his paper.

BASIS OF AWARD.

(1) Time required to name the breed and variety	30
(2) Accuracy of names given	40
(3) Writing, spelling, and neatness of paper	30
Total score	100

CORN-RECIPE AND PRODUCTS-NAMING CONTEST.

BASIS OF AWARD.

(1) Greatest number written or stated in five minutes	30
(2) Accuracy of recipes and named products	40
(3) Spelling, writing, and neatness of paper	30
Total score	100

CORN-PROBLEMS CONTEST.

In like manner contests may be held in (1) proposing the best 10 original problems in arithmetic relating to corn and corn-club work and (2) in solving a set of 10 corn problems.

BASIS OF AWARD.

(1) Accuracy	40
(2) Composition	30
(3) Originality	30
Total score	100

MANUAL-TRAINING CONTESTS.

The following items can be made the subjects of manual-training contests: (1) Making a 10-ear corn tray; (2) a seed-test box; (3) a drying rack; (4) a reproduction in relief of a picture or of some other article made entirely from corn.

BASIS OF AWARD.

(1) Character of work and finish	30
(2) Faithfulness to plan (show plan or drawing)	30
(3) Originality in design	40
Total score	100

DRAWING CONTESTS.

A drawing of (1) a seed-test box; (2) a seed-drying rack; (3) an ideal corn crib; (4) a plan of an 80-acre farm, showing the location of the cornfield and the seed plat with relation to other crops, farm buildings, etc.; and (5) grains of corn, cross section of grains, etc.

BASIS OF AWARD.

(1) Accuracy, trueness to object	40
(2) Neatness	30
(3) Originality of design	30
Total score	100

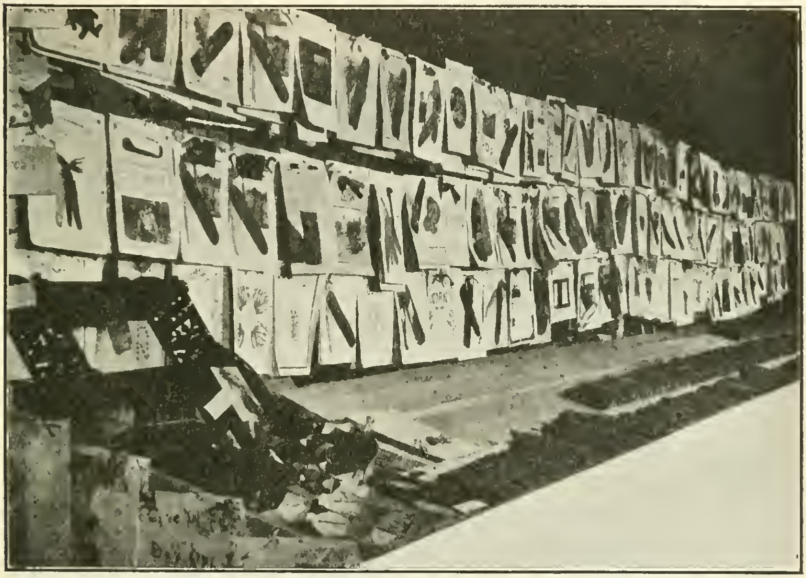

FIG. 3.—Exhibit of a seed-selection and a corn-club booklet contest.

LANGUAGE AND COMPOSITION CONTESTS.

Contests can be held for club members in language work, with a view to teaching them how to express themselves in simple and correct English. The essay should be from 500 to 800 words long and should be in booklet form, 9 by 11 inches, written and illustrated by the club member, as shown in figure 3.

BASIS OF AWARD.

(1) Composition and punctuation	30
(2) Subject matter	40
(*a*) complete treatment; (*b*) sequence.	
(3) Writing, spelling, and neatness	30
Total score	100

SUBJECTS.

(1) How I Made My Crop of Corn.
(2) Corn-Club Work as an Education.
(3) The Value of Careful Seed Selection.
(4) History of Corn.
(5) Importance of Testing Seed Corn.

ROPE-TYING CONTEST.

BASIS OF AWARD.

(1) Time of speed in rope tying (period of five minutes)	30
(2) Accuracy in tying and naming knots tied	40
(3) Skill in handling self and rope	30
Total score	100

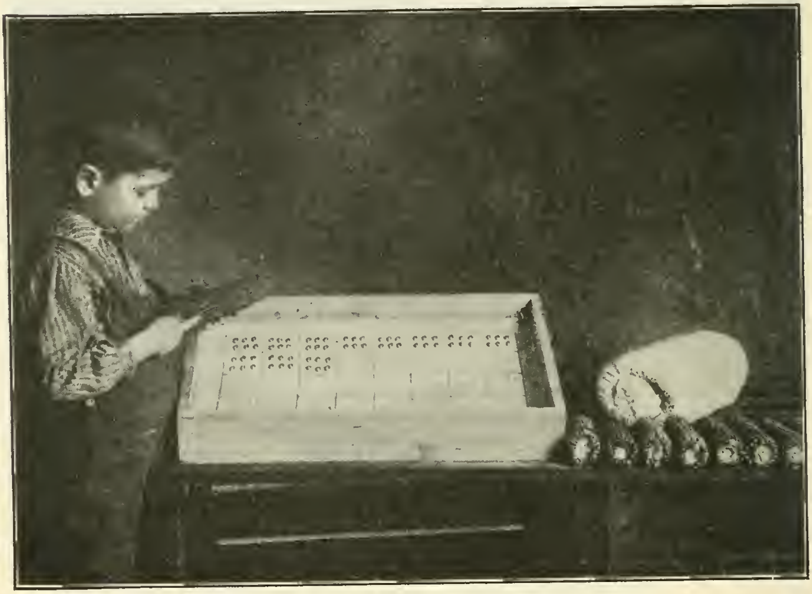

FIG. 4.—A Minnesota club member preparing his seed test.

In like manner hitching, horse-mounting, and soil-type naming contests may be planned and successfully carried out, with the idea of reenforcing the Boys' Corn-Club work with a series of practical and highly useful play contests.

SPRING CONTESTS.

SEED-CORN GERMINATION TEST.

Any one of the common methods and devices for seed testing will be a success if you do the work carefully and follow instructions which apply to the particular method or device. A club member preparing his seed test is shown in figure 4.

The methods approved by all of our leading corn experts are as follows:

(*a*) Homemade test-box method; (*b*) rag-baby tester; (*c*) commercial testers.

Consult your State experiment station circulars, Farmers' Bulletin 415, and Circular 95 of the Bureau of Plant Industry for further information as to how to make the test.

SEED-CORN TESTING CONTEST.

Premiums may be awarded to club members, rural-school pupils, or club teams who test the largest number of seed ears during the season or in a given time and submit a tabulated report of their tests showing the source of seed, with the percentages of strong, weak, and dead seeds. The award is to be made upon the three following points:

(1) Number of ears tested	40
(2) Condition and accuracy of the report of the test	30
(3) Drawing and explanation of the test box used	30
Total score	100

EXPERIMENT CONTESTS.

The experiment contest should be conducted so as to encourage the study of well-established facts as they apply to corn culture. The test is to see who can make the best experiment on one of the following subjects:

(1) Capillarity of soils.

(2) Germination of seed at different depths in glass.

(3) Use of corn as food.

(4) Effect of different fertilizing materials on the soil. (Use muddy clay water. Put lime into it to clarify.)

(5) Use of a dust mulch for moisture conservation.

BASIS OF AWARD.

(1) Accuracy of the experiment	40
(2) Skill in presenting the experiment	30
(3) Time required and equipment	30
Total score	100

In like manner contests correlated with physiology, spelling, and geography can be easily drawn from club interests.

CLUB CONTESTS IN STANDARDS OF FARM LABOR FOR ALL SEASONS.

The objects of the club contests in standards of farm labor are: (1) To suggest a means by which the child or club member may be taught the value of careful observation as it applies to the cost of different farm operations and what constitutes a day's work; (2) to furnish the club member and teacher with suggestions as to how records should be kept and what constitutes a complete record of a farm operation; (3) to give greater interest to the boy in his as well as his father's farming methods; and (4) to furnish authentic farm-labor reports to the United States Department of Agriculture. The following is a summary of the necessary records, and it also explains the contests:

RECORD FOR CONTESTS.[1]

Contest in keeping the best record of plowing the club acre or the father's field. Estimate on entire plat or field, but do not include disking, cultivating, fertilizing, etc.

(All records must be written with pen and ink.)

Suggestions for keeping plowing records:

(1) Size of club plat or field, length ______ rods; width ______ rods.

(2) Number of acres in plat or field ______.

(3) Number of horses used ______.

(4) Weight of horses ______ pounds.

(5) Kind of plow used ______; size or width of plow ______; condition of plow ______.

(6) Depth of plowing ______ inches; width of furrow ______ inches.

(7) Number of acres plowed per day ______.

(8) Total number of hours and minutes spent in plowing during the day (estimate on actual plowing only) ______.

(*a*) Give time of leaving barn with team in the morning ______.

(*b*) Give time of beginning actual work in plowing ______.

(*c*) Give time of stopping for noon __; time reaching barn __.

(*d*) Give time of starting for field in afternoon __; time begun plowing ______.

(*e*) Estimate total time lost during plowing due to repairs, accident, etc., __.

(*f*) Give time of leaving at night __; time of reaching barn __.

(9) Kind of soil, such as loam, clay, sandy, stony, etc., ______.

(10) Condition of soil—hard, friable, loamy, etc., ______.

(11) State whether the field was covered with stalks, sod, stubble, weeds, etc., ______.

(12) State the effect of last year's crops on the condition of the land ______.

(13) What crops were grown upon this field last year? ______.

(14) Draw a diagram of your club plat or the field upon which you have reported. (Give dimensions in rods.)

I hereby certify that the above is an accurate and complete report of the plowing operation, and I have answered every question to the best of my knowledge and ability.

Signed, ____
(Club member.)

Post-office address, ____

____
(State.)

[1] Record blanks will be furnished upon application to the Department of Agriculture.

BASIS OF AWARD TO DETERMINE STANDING OF CONTESTANTS.

(1) Accuracy of record	40
(2) Neatness of report	20
(3) Completeness of report	20
(4) Penmanship of report	20
Total score	100

OTHER FARM-MANAGEMENT CONTESTS.

In like manner contests should be held on the keeping of records or labor reports, on fertilizing, disking, the cultivation of corn, husking corn, seed selection, and in making a germination test. Assign different subjects to different pupils and in the right season for good work.

For additional instructions regarding contests in farm operations and for a supply of record blanks to be used in your contests, address the United States Department of Agriculture, Bureau of Plant Industry, Office of Farm Management, Washington, D. C., and the instructions and supplies of record blanks will be forwarded for your use in the schools.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *September 18, 1912.*

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