Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 112.

B. T. GALLOWAY, Chief of Bureau.

MISCELLANEOUS PAPERS.

Issued February 8, 1913.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

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.

OPPORTUNITIES IN PECAN CULTURE.[1]

By C. A. Reed, *Scientific Assistant in Pomology.*

INTRODUCTION.

The demand for authentic information pertaining to pecan culture was never so great as at present. Much has been said in a speculative way regarding the commercial future of the industry, the suitability of various localities, the probable bearing age, the size of crops, their immunity or susceptibility to disease and insect pests, their relation to the weather, and many other matters, but with the industry still in an experimental stage such statements have been necessarily based largely upon limited experience and are therefore subject to revision on short notice.

The feature of the industry concerning which there is the greatest interest is its commercial future. This information can be gained only through a full knowledge of what it has cost to establish and maintain pecan orchards properly, what the crops of nuts have been, what prices have been realized, the influence of increased production upon future prices, and the possibility of increasing the market demand for the nuts.

DIFFICULTY OF OBTAINING ACCURATE DATA.

Although the planting of pecan trees was probably begun in the eighteenth century, or perhaps even earlier, their planting in orchard form is comparatively recent. Some pecan orchards are known to have been planted prior to 1880, but until about 1905 practically all consisted of seedling trees. In the planting of these early orchards little attention was paid to such matters as seed selection, the adaptability of locality and soil to the species, proper distances between trees, their cultivation, etc., the importance of which is now well understood. A few such seedling orchards when kept under cultivation have begun to bear crops of more or less importance at 15 to 25 years of age, but few orchards have made records as to bearing which would be of interest even if obtainable. The chief value of such orchards is in the opportunity they afford of quick transformation by top-working to named varieties.

The growing of named varieties—trees propagated by budding and grafting with scions from individual parent trees—began to be active about 1890. At that time comparatively few varieties were known,

[1] Issued Feb. 8, 1913.

and during the next decade less than a dozen were widely disseminated. Of these several proved unsatisfactory and have since been superseded. During the second decade of active interest in pecan orcharding a great many varieties were introduced, most of which are already disappearing. The dissemination of new varieties, many of which may later prove to be of little importance, is still going on and may be expected to continue. Many of the disseminated varieties have been disappointing in that they have not fruited as was expected, especially in localities other than those where they originated, while some have proved highly susceptible to fungous diseases.

By far the greater number of promising orchards of budded or grafted trees now existing are still too young to bear commercial crops. It is only here and there that orchards more than five or six years of age, of good varieties, well adapted to local conditions, and under a high state of cultivation are to be found. A number of orchards which might otherwise have been in bearing have been so heavily cut for bud wood that the chances of fruiting have been impaired for the time being.

Occasional individual tree records made under highly favorable conditions are frequently taken as a basis for estimates of what may be expected from orchards of the same varieties of the same age. The fallacy of taking these records as a basis for orchard estimates is apparent when it is realized that it is entirely impracticable to maintain in large orchards the garden conditions under which such records have usually been made. This has recently been emphasized by the record of an orchard of 200 trees in southwestern Georgia, the exact weight of the nuts from each tree for the last two seasons having been personally recorded by the writer during the harvest. In 1911, the seventh season from planting, the crop from these 200 trees, all of which are of one variety, of the same age, and under the same degree of cultivation, amounted to 1,137 pounds and ranged from a few nuts per tree, and occasionally none at all, to 17½ pounds in the case of one tree. The average for the entire orchard was 5.08 pounds per tree. In 1912 the total crop fell to 639 pounds, or an average of 3.19 pounds per tree, the range of individual trees being from no crop to 13½ pounds. If estimates of the probable yield of the entire orchard were to be based upon records of single trees in this orchard the figures of the total crop would show a range from no crop to 3,500 pounds during 1911 and 2,700 pounds during 1912, none of which would be correct.

THE COST OF ESTABLISHING AND MAINTAINING PECAN ORCHARDS.

A letter of inquiry regarding the most important items in the cost of establishing and maintaining pecan orchards was recently sent out from the Bureau of Plant Industry to a number of persons in the growing districts who have had experience in orchard culture. Replies were received from 17 growers in the States of Georgia, Florida, Mississippi, Louisiana, and Texas. The questions asked and the replies made were both limited in number and brief, but as they brought out the opinions of some of the most prominent and successful pecan growers, the questions and a summary of the replies are here presented.

(1) At about what price per acre can cleared land in your section suitable for pecan planting be purchased?

The estimates made were mostly from $20 to $40 per acre; one was $40 to $100, one $75, and one $200.

(2) At what price can uncleared land be obtained?

One estimate was $5 to $15 per acre. Most were from $10 to $30. One was from $20 to $50, and one $125.

(3) About what ought it to cost to put uncleared land into shape for planting?

In some instances the estimates made included the cost of removing stumps, stating that frequently the value of the standing timber was sufficient to pay for clearing. The estimate for clearing, removal of the stumps included, ranged from $18.21 to $28.21 per acre.

(4) About how much per acre has it annually cost you thus far for fertilizer in your pecan orchard?

The kind and quantity of fertilizer pecan trees should receive vary greatly, depending upon local conditions. Some orchardists use no commercial fertilizer, relying entirely upon leguminous crops and stable manure. Others feed the trees by fertilizing the crops grown between the rows, while some rent the land between the rows, reserving a strip along the row which they (the owners) cultivate and fertilize independent of the rest of the land. Estimates as to the actual cost of fertilizing the trees alone are very difficult to obtain. Some replies indicated that from $10 to $25 per acre was paid annually for fertilizer for the land, including both that given the trees and the intercrops. Others showed that to apply 2 pounds of fertilizer to each tree during the season of its planting and to increase this by 1 pound per tree each year thereafter had cost thus far from $1.50 to $2 per acre.

(5) Have you found the growing of other crops between the trees to be practicable; and, if so, about how much per acre have been the annual gross returns from such crops?

(6) What crops have you found to be most practicable for growing between pecan trees?

The invariable reply to these inquiries was in favor of growing intercrops. Cotton, corn, and leguminous crops were most commonly recommended, although a few from truck-growing districts reported much better returns from vegetable production. One or two reported very favorably on growing nursery stock. Some said that during the first five to seven years the land would be quite as valuable for cultivated crops as open land. It is obvious, however, that after the trees reach bearing age the value of the land between the rows for intercropping must depreciate rapidly.

(7) Have you kept any record of the cost of cultivation? If so, about how much has it been per acre each year, including both the cultivation of the trees and the crops between the rows?

With but one or two exceptions the replies to this inquiry were to the effect that no record had been kept. Such records as have been kept include the cost of cultivating the intercrops, and it was therefore impossible to determine the separate cost of cultivating the trees. One letter stated that the annual cost of cultivating the trees would not be more than $1 per acre; another, that this cost would not exceed $5 per acre.

The questions asked omitted a discussion of the price of the trees, the cost of planting, the salary of a supervisor, the cost of replanting dead trees, pruning, spraying, and harvesting the crop, and many other items which must be taken into account when a complete record of the cost of establishing and maintaining pecan orchards is undertaken. As it is customary to plant from 17 to 20 trees per acre, the cost of the trees can be quickly computed by consulting the nurserymen's price lists. The other factors are all either very variable or else few data are available.

YIELDS THAT MAY BE REASONABLY EXPECTED.

The gross returns which may be realized from an orchard at any given age depend upon the size of the crop and the price received. Considerable light upon the former may be obtained from a summary of yield records already made, and such records as it has been possible to obtain are here included. The price which has been realized in the past will, of course, have some bearing upon what may be expected in the future, but it can not be taken as a safe criterion. In the past pecans of named varieties have been grown in very small quantities and have been largely utilized by nurserymen as samples and by fancy confectioners, tourists, and land sellers. In this way a high price has been maintained. Ordinarily the producers have received from 30 to 50 or 75 cents a pound for nuts of the best varieties. The demand for the best pecans can not become general until prices settle to a uniform level within reach of the consumer of average means. The present extensive planting insures abundant production, and the need of a wide market is therefore self-evident. With the disappearance of fancy prices, the general demand will undoubtedly materially increase. Further, the prices which the producer will realize in the future will depend more largely than in the past upon the prices of wild nuts, with which the cultivated product must soon enter into competition. The present prevailing retail price for pecans from native trees is from 20 to 30 cents per pound, uncracked, and from 60 to 90 cents for half kernels.

Estimates of yields that may be expected must be based upon records of orchards of the same varieties and age when under substantially the same conditions of climate, soil fertility, moisture supply, and cultivation. The difficulty in obtaining records upon which to base such estimates has already been shown. The figures presented in Table I will serve for general guidance until more and better records are available.

TABLE I.—*Yield records of pecan orchards.*

Location and variety.	Winter planted.	Number of trees.	Average number of pounds per tree each season.								
			4th.	5th.	6th.	7th.	8th.	9th.	10th.	11th.	12th.
Southern Georgia:											
Jewett, Rome, Stuart, and Van Deman.	1899–1900.	250							0.40	0.90	0.68
Southern Mississippi: [1]											
Delmas	1901–2	[2] 321	[3] 0.44			0.81	5.23	12.15			
Stuart	1902–3										
Pabst	1904	70		(4)	(4)	1.43	3.28	7.71			
Russell	1904	70		(4)	.78	3.21	3.28	5.28			
Schley	1904	12		(4)	(4)	2.41		.50			
Stuart	1904	70		(4)		3.97		16.42			
Van Deman	1904	70		(4)	.21	[5] 1.55		[6] 3.21			
Total		292			.50	2.53	3.28	7.84			
Mixed, Stuart, Schley, Delmas, and others.		[7] 209									
Southwestern Georgia:											
Frotscher	1904–5	200		0.92	1.05	5.08	3.19				
Frotscher	1904–5	270					3.23				
Teche	1904–5	2					.20				
Nelson	1904–5	1					.12				
Clark	1904–5	1					.00				
Stuart	1904–5	26					.81				
Total		300		.08	.12	.66	3.13				
Frotscher	1905–6	1,265			.23						
Delmas	1905–6	68			.73						
Schley	1905–6	413			.09						
Stuart	1905–6	348			.14						
Van Deman	1905–6	330			.06						
Total		2,424			.23						
Northern Florida:											
Mixed, Frotscher, Eggshell, Schley, Moneymaker, and others.	1904–5	120			.48	.45					

[1] In southern Mississippi two Stuart trees planted in the winter of 1889–90 bore 250 pounds each in 1911; in 1912 the crop from these two trees fell materially.
[2] This orchard was reported as having 300 young trees set in the spring seasons of 1902 and 1903 and about 7 old trees top-worked in 1902 and 1904. The old trees annually bear about three times as much as the same number of young trees. In order to get an average per tree of the trees of one age, the top-worked trees are counted as being equivalent to three times as many, or 21 young trees. The date of planting the 300 trees is taken as having been 1903.
[3] Owing to a very hard storm in the fall of 1906 there was no crop in 1907 or 1908, the fifth and sixth seasons from planting.
[4] A few nuts.
[5] Schley and Stuart not included.
[6] Schley, Stuart, and Van Deman not included.
[7] Mature trees 25 to 30 years old; averaged 38.49 pounds in 1911 and 9.57 pounds in 1912.

The figures shown in Table I, with the exception of those regarding the orchard of 200 trees previously mentioned, the yields of which were recorded by the writer, have been made by careful orchard owners, who furnished the data to the Department of Agriculture.

Another record, which has been submitted in different form from middle Georgia, is as follows:

Stuart	Few nuts fourth year; increase yearly to ninth year 2½ to 3 pounds.
Mobile	Few nuts third year; increase yearly to ninth year 5 to 15 pounds.
Teche and Frotscher	Few nuts fifth year; increase yearly to ninth year 2 to 5 pounds.
Rome	Few nuts eighth and ninth years.
Capitol	Few nuts fifth year; increase yearly to ninth year 2 to 3 pounds.
Senator, Atlanta, Centennial	"No good."

CONCLUSIONS.

Pecan orchards demand the same intelligent management as other orchards. It is sometimes held that being a native of the forest the tree not only needs no cultivation but will do better without it. This theory might be applied with equal reason to any fruit tree, and in answer it is only necessary to suggest a comparison between wild and cultivated apples, pears, oranges, or other fruits. The impression that the pecan tree has no enemies in the way of insect pests or fungous diseases, that it is not subject to damage from drought, wet weather, or freezing temperatures, and that the nuts are in unlimited demand at a dollar or more a pound is at variance with the facts. The pecan is often subject to serious injury by numerous insects and diseases, and it is also much affected by unfavorable weather. Warm spells in winter followed by sharp freezes not infrequently result in the death of young trees; rains occasionally interfere with pollination; prolonged dry weather causes the nuts to be small and perhaps to drop prematurely; and warm, wet weather may cause the nuts to become moldy or to germinate while still in the hulls. Although in the past choice pecans have frequently brought two, three, or more cents a nut when sold by the pound, it is evident that when sold on their merit in competition with wild pecans and when the orchards now being planted reach bearing age the prices will fall materially below the figures now often cited by enthusiastic exploiters.

The prospective pecan grower should, of course, bear in mind that no horticultural product is free from its troubles, and while the pecan has its full share its culture probably has no more drawbacks than other similar industries. Ordinarily, commercial returns are not to be expected until the trees are 10 to 12 years old. The length of time trees will continue to bear is a matter of conjecture. Commonly, old seedling trees are moderate bearers, the heavy bearers being fairly young or of middle age. The indications are that the most productive trees of the forest are not long lived, and as the varieties selected and propagated for planting in orchards are usually heavy bearers it is not improbable that the shorter lived varieties are unconsciously selected at the same time. It is therefore not unlikely that the life of bearing pecan trees in orchard form will be much shorter than that of the average pecan tree of the forest.

76060°—Cir. 112—13——2

THE JONATHAN FRUIT-SPOT.[1]

By W. M. Scott, *Formerly Pathologist*, and John W. Roberts, *Assistant Pathologist, Fruit-Disease Investigations.*

INTRODUCTION.

In February, 1911, the senior writer[2] published a preliminary report on "A new fruit-spot of apple,"[3] in which he stated that the cause of the disease was unknown, but that there was a strong suspicion of injury produced by arsenate of lead used in spraying. It was also stated that the fungi *Cylindrosporium pomi* Brooks and *Alternaria* sp. were isolated from a few of the spots, indicating a possible connection of one or both of these organisms with the disease.

The results of spraying experiments and further laboratory studies conducted by the writers show that the spots are not due to arsenate of lead injury and probably are not caused by any vegetable organism.

THE NATURE AND IMPORTANCE OF THE DISEASE.

The spots, though seldom more than skin deep, detract greatly from the appearance of the apple and afford a place of entrance for decay fungi. They are dark brown in color, more or less circular in outline, at first scarcely depressed, later becoming considerably sunken, and vary from one-eighth to three-fourths of an inch in diameter. (Figs. 1 and 2.) They resemble very young bitter-rot spots and are not easily distinguished from the advanced stage of the New Hampshire fruit-spot (*Cylindrosporium pomi* Brooks). As many as 25 spots often occur on one apple, and a lenticel usually forms the center of each spot. Since the spots are entirely superficial, the intrinsic value of the fruit is not seriously affected, but its market value is greatly reduced.

The disease occurs only on fully matured fruit and usually develops after the crop is picked. If left on the trees long after maturing, the fruit of susceptible varieties may become affected before being picked. This was observed on the Jonathan variety in Virginia

---

[1] Issued Feb. 8, 1913.

[2] The work covered by this paper was done previous to the resignation of Mr. Scott, which occurred in February, 1912.

[3] Phytopathology, vol. 1, no. 1, p. 32-34.

and West Virginia during the fall of 1911. According to numerous observations made by the writers, fruit picked at the proper time, or rather early, and rushed into cold storage with only two or three days' delay, and consumed within a few days after removal from storage, will not develop the disease to any serious extent. Fruit of susceptible varieties kept in common storage or delayed in reaching cold storage usually becomes affected. The disease has been particularly annoying to fruit growers who have attempted to keep prize specimens of the Jonathan in cellar storage for exhibition purposes. The growers of Esopus (*Spitzenberg*) in Oregon and Washington

FIG. 1.—Esopus (*Spitzenberg*) apple showing early stages of the Jonathan fruit-spot.

have perhaps suffered most from this trouble, the spots often developing on the fruit en route to the eastern markets. The writers have observed large quantities of affected fruit from the Northwest in the markets of Washington and New York.

The Jonathan is the most susceptible variety grown in the east, and its commercial standing is greatly impaired on account of this weakness. The disease is now rather commonly known among apple growers as the "Jonathan spot," and for that reason the writers have adopted the name "Jonathan fruit-spot." The Esopus is almost, if not quite, as susceptible to the disease as the Jonathan, and the Yellow Newton apparently ranks third in degree of susceptibility. It has also been observed to a very slight extent on the Grimes, Arkansas Black, and a few other varieties of less importance.

Dry weather during the summer is apparently favorable to the development of the Jonathan fruit-spot. It was very bad in 1910 and 1911, both of which were dry seasons, while in 1912, a comparatively wet season, it was not common on eastern-grown fruit. In the fall of 1911 the spotting was particularly serious on the Jonathan, specimens having been received from practically every section of the country where that variety is grown.

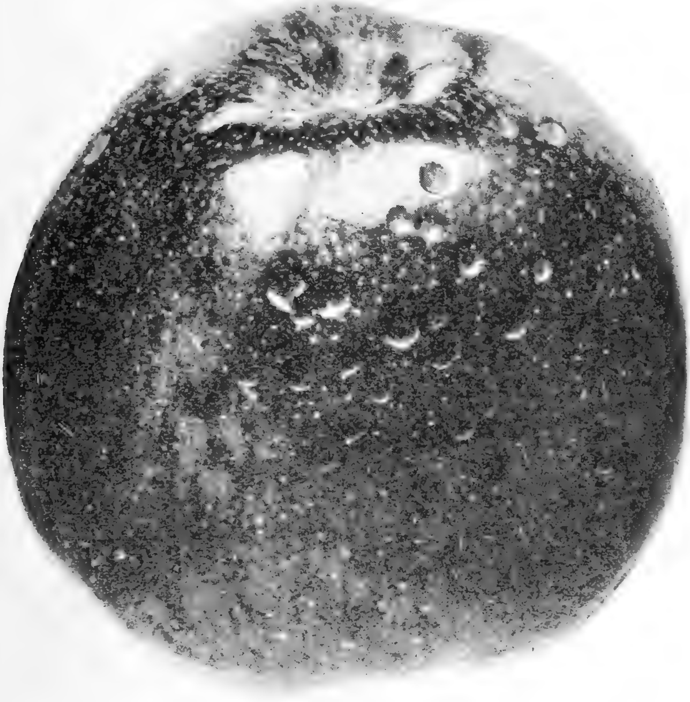

FIG. 2.—Esopus (*Spitzenberg*) apple showing older stages of the Jonathan fruit-spot.

SPRAYING AND STORING EXPERIMENTS.

In order to test the supposition that the Jonathan fruit-spot might be due to arsenical injury, spraying experiments were conducted in the orchard of Mr. S. H. Derby, at Woodside, Del., during 1911. A block of Jonathan apple trees about 15 years old was divided into 5 plats of 6 trees each and treated as follows:

Commercial lime-sulphur solution at the rate of $1\frac{1}{4}$ gallons to each 50 gallons of water was used in connection with arsenate of lead on all of the sprayed plats. The amount of arsenate of lead was varied from one-half pound to 5 pounds in each 50 gallons of spray. Plat I was sprayed with one-half pound, Plat II with 1 pound, Plat III with 2 pounds, and Plat IV with 5 pounds of arsenate of lead to each 50 gallons of the diluted lime-sulphur solution. Three applications were made in accordance with the usual directions for the control of the codling moth, i. e., (1) as soon as the petals fell, (2) three weeks later, and (3) ten weeks after the petals fell. The trees were thoroughly sprayed each time, so that the fruit remained coated with the arsenate of lead well on toward picking time. Plat V was left unsprayed as a check.

The crop was picked on September 12 and found to be practically free from insects and diseases. No spotting was discernible at this time. Two boxes of fruit from each plat were immediately shipped to Washington, reaching the laboratory on September 15, three days after picking. On this date a careful examination revealed no indication of the disease on any of the fruit, sprayed or unsprayed. One box from each of the five plats was then placed in cold storage, while the remaining five boxes were stored in a moderately cool basement.

The basement-stored apples were examined on September 30 with the following results: The fruit from Plat I showed 41 per cent affected with the Jonathan fruit-spot, Plat II 52 per cent, Plat III 36 per cent, Plat IV 36 per cent, and Plat V (check) 46 per cent. A reexamination of the same apples on October 23 showed Plat I to have 56 per cent of the fruit affected, Plat II 70 per cent, Plat III 52 per cent, Plat IV 42 per cent, and Plat V (check) 64 per cent. Many of these apples were seriously injured, being literally covered with spots measuring from 5 mm. to 1 cm. in diameter. These results show that unsprayed fruit may become quite as badly affected with the Jonathan fruit-spot as fruit sprayed with arsenate of lead. An unusually heavy dose of the poison, as shown in the results from Plat IV, which was sprayed with 5 pounds of arsenate of lead to 50 gallons of water, did not increase the amount of affected fruit.

The fruit which was placed in cold storage was examined on November 10 and all of it found to be free from the disease. Finally, on December 18 these apples were removed from cold storage and examined with the following results: Plat I had 5 per cent of its fruit spotted, Plat II 10 per cent, Plat III 20 per cent, Plat IV 14 per cent, and Plat V (check) 33 per cent. In most cases the spots were small, inconspicuous, and few to an apple, being in these respects in great contrast to those appearing on the basement-stored fruit. The cold storage prevented the spotting for at least two months, and at the end of nearly three months this fruit was not nearly so much affected as the cellar-stored fruit was at the end of six weeks.

On September 25, 1911, one bushel of unsprayed and one bushel of sprayed Jonathan apples were received from Watervliet, Mich. These were sent in by Mr. E. W. Scott, of the Bureau of Entomology; they were taken from an orchard in which that bureau was conducting spraying experiments. The plat from which the sprayed fruit was taken had received the three usual codling-moth applications, arsenate of lead at the rate of 2 pounds to each 50 gallons of water having been used. Upon arrival an examination of this fruit failed to disclose any of the spot disease in either lot. Both lots were covered over in baskets and left in the laboratory at room temperature and reexamined on September 29. At this time characteristic spots averaging 5 mm. in diameter and from 1 to 25 to each apple were found on 9 per cent of the unsprayed and on 18 per cent of the sprayed fruit. On October 23, 65 per cent of the unsprayed fruit was found to be spotted and 66 per cent of the sprayed fruit was similarly affected.

One can only conclude from the results of these experiments that spraying with arsenate of lead is not in any way responsible for the Jonathan fruit-spot. The spots develop on unsprayed fruit as readily as on that which has been thoroughly sprayed with arsenate of lead. It is evident that this poison neither favors nor retards the development of the disease.

LABORATORY STUDIES.

Nearly 400 cultures of the diseased spots have been made in various ways and on various media, but no organism has been isolated with any degree of consistency. A species of Alternaria often occurred in cultures from fruit grown in the eastern part of the country, but cultures from northwestern-grown fruit were almost entirely barren. A few apparently successful inoculations were made by spraying Alternaria spores on Jonathans kept in moist chambers and the fungus reisolated, but both the Jonathan and Esopus (*Spitzenberg*) are so susceptible to the disease that they are apt to become spotted under any conditions outside of cold storage. In some cases both the inoculated fruit and the controls contracted the disease at about the same time. Spores of this fungus inserted through needle punctures failed to produce the disease. As Alternaria is very commonly associated with the rotting of apples, especially when the fruit is placed in cellar or basement storage, the possibility of its being the cause of this disease becomes very remote.

The fungus *Cylindrosporium pomi* Brooks occurred in a few of the cultures, but this was probably accidental. It is not unlikely that the Brooks spot and the Jonathan fruit-spot occurred together on some of the apples from which cultures were made, and for this reason the fungus causing the former might easily have found its way into a few of the cultures, particularly since the two spots are somewhat similar in appearance. Cultures from the true Brooks spot produced the fungus readily, while those from the Jonathan fruit-spot were, with few exceptions, barren. Moreover, spraying with a fungicide prevents the former disease, but has no effect upon the latter. It seems evident, therefore, that these two diseases are distinct.

Microscopic examinations of the affected tissues failed to reveal the presence of any organism to which the disease could be attributed. The cells involved resemble similarly located cells in cases of "bitter-pit," or "Baldwin spot," in which that disease extends to the surface of the apple. Bitter-pit differs from this disease, however, in that it is essentially a disease of the fleshy portion of the fruit, often reaching to the core without affecting the skin, while the "Jonathan spot" is usually little more than skin deep. The writers consider the disease a physiological one, but as in the case of the bitter-pit the cause is at present obscure.

SUMMARY OF CONCLUSIONS.

The investigations conducted by the writers seem to warrant the following conclusions:

(1) The Jonathan fruit-spot of the apple is due neither to spraying with arsenate of lead nor to a specific organism.

(2) It is probably a physiological trouble, falling in the same category as the bitter-pit or Baldwin spot.

(3) Early picking, prompt cold storage, and immediate consumption of the fruit after removal from storage, will largely obviate losses from the disease.

EGYPTIAN COTTON AS AFFECTED BY SOIL VARIATIONS.[1]

By Thomas H. Kearney, *Physiologist in Charge of Alkali and Drought Resistant Plant Investigations.*

INTRODUCTION.

Observation of the growth of Egyptian cotton in irrigated soils of the southwestern United States for several years past has shown that this plant is decidedly sensitive to variations in its physical environment. Differences in the texture, and consequently in the moisture-holding capacity of the soil, are easily detected from the accompanying differences in the size, appearance, and fruitfulness of the plants, in the size of the bolls, and in the quality of the fiber. The presence of alkali salts in the soil also induces marked differences in the growth and behavior of the cotton plants. It is evident that in order to obtain the largest yields and, what is of the utmost importance, the greatest possible uniformity in the staple, strength, and other qualities of the fiber, Egyptian cotton must be grown in soils that do not vary greatly in texture and salt content.

MOISTURE CAPACITY OF THE SOIL.

In many plantings of Egyptian cotton which have been made on recently cleared land the fields have appeared more or less spotted, the plants in some places being smaller, more erect, and lighter colored, with fewer and smaller bolls and shorter, often weaker, fiber than in other places. Marked differences of this kind frequently appear within distances of a few feet. A field of the Yuma variety on the United States Experiment Farm at Bard, Cal., in 1911 showed conspicuous local differences in the growth and appearance of the plants. Soil samples were therefore collected at a number of different points corresponding to various stages in the size and condition of the plants.

Upon making the borings it was at once evident that the variations in growth of the plants were closely correlated with variations in the depth of the blanket of silt loam which overlaid a subsoil of coarse, light-colored sand. The depth of the silty layer varied from 5 to 18 inches in different parts of the field. Where it was thinnest the plants were poorest, and vice versa.

The moisture-holding capacity of these two soils was widely different, that of the silt loam being high, as indicated by a moisture

[1] Issued Feb. 8, 1913.

equivalent,[1] in samples from different parts of the field of 24.4 to 31.4 per cent, corresponding to a wilting coefficient of 13.3 to 17 per cent. The coarse sand had a moisture equivalent of only 2.8 per cent (wilting coefficient, 1.5 per cent). The salt content of the soil in the different samples was investigated by means of the electrolytic bridge and was found to be nowhere sufficiently high to indicate that alkali was a factor in bringing about these differences of growth. The case was clearly one of the presence or absence of a sufficient depth of soil having a high enough water-holding capacity to prevent the plants from suffering as a result of drought between irrigations. It is rather surprising, in view of the very low water capacity of the underlying sand, that a depth of the silty layer of only 14 or 15 inches should have been sufficient to enable the plants to make a strong growth and produce numerous large bolls.

The results of this investigation are summed up in Table I.

TABLE I.—*Relations between the depth of silt and the growth of Egyptian cotton at Bard, Cal., in 1911.*

Boring No.	Depth of silt loam overlying coarse sand.[1]	Condition of the plants.
	Inches.	
6	[2] 18	Rank growing, dark green, very fruitful, bolls large; growth here is heaviest in field.
1	17	Good sized, dark green, fruitful.
5	14 to 15	Similar to those at boring No. 6.
2	12	Smaller, lighter green, and less fruitful than at boring No. 1.
4	11	Small, erect, light colored, with few small bolls and inferior fiber.
3	9	Similar to those at boring No. 4.
7	[3] 7 to 8	Similar to those at borings Nos. 3 and 4.
8	5	Poorest in the field, only 3½ feet high, erect, light colored; bolls very few and very small, fiber very inferior.

[1] Unless otherwise specified, the silt rested directly upon the rather coarse, light-colored sand. This sand extended to a depth of at least 4 feet at every boring which was carried to that depth (Nos. 1, 3, 5, and 6).

[2] Here the silt was underlain by 15 inches of a fine, reddish-colored sand (moisture equivalent, 7.6 per cent), which in turn rested upon the above-described coarse sand.

[3] Here the surface silt was of lighter texture than elsewhere in the field (moisture equivalent, 24.4 per cent). It rested upon 6 to 7 inches of very fine sand, which was in turn underlain by the coarser sand above described.

In 1912 similar observations were made on the same farm. A series of soil samples were taken midway between two rows of Egyptian cotton, in one of which the plants had been thinned to a distance of 6 inches and in the other to a distance of 18 inches.[2] Borings were made at three points: (1) Where the plants were tall, luxuriant, and dark green in color; (2) where the plants were smaller and of a light yellowish green color; and (3) where the plants were

[1] The term "moisture equivalent" is defined and the value of this factor as a measure of the moisture-holding capacity of the soil is pointed out by Briggs and McLane in Bulletin 45 of the Bureau of Soils (1907). The moisture equivalent of a given soil being known, the wilting coefficient for plants growing in that soil can be calculated by means of the formula given by Briggs and Shantz in Bulletin 230 of the Bureau of Plant Industry, p. 58 (1912).

All determinations of moisture equivalent referred to in this paper were made by Mr. J. W. McLane, of the Biophysical Laboratory, Bureau of Plant Industry.

[2] The field had been planted under the direction of Mr. O. F. Cook in order to study the effect of different thicknesses of stands upon the development of the vegetative branches.

small and yellowish green. Each of the three samples consisted of three cores taken about 1 foot apart and to a depth of 4 feet. The soil from all three cores at each successive 1-foot depth was thoroughly mixed together to represent that depth of the boring in question, and upon each of the 12 samples as thus prepared four determinations of moisture equivalent were made.

The electrical resistance of saturated soil from each sample was measured in order to ascertain whether there were significant differences in the salt content of the soil. The high resistances observed in every case made it evident that the effects noted could not be attributed to alkali. On the other hand, the fact that the resistances were much lower at all depths of boring No. 1 than of borings Nos. 2 and 3 indicated that a deficiency of nutrient salts at the two latter borings may have been a factor in the poor growth of the plants.

On several plants in the neighborhood of each boring counts were made of the number of the node on the axis at which the first fruiting branch was retained and of the number of set bolls to the plant.[1]

Table II gives for each of the three borings the wilting coefficient (calculated from the moisture equivalent) and the electrical resistance of the soil at successive depths, as well as the average height of the plants, the mean of the numbers of the node bearing the first fruiting branch, and the mean number of bolls per plant.

TABLE II.—*Relations between the wilting coefficient of the soil and the growth and fruitfulness of Egyptian cotton plants at Bard, Cal., in 1912.*

Boring No.	Soil.			Plants.					
	Depth.	Willing coefficient calculated from the moisture equivalent.[2]	Electrical resistance of the saturated soil.	Spacing.	Number of plants on which counts were made.	Color of foliage.	Height.	Mean number of node of first fruiting branch.	Mean number of bolls per plant.
	Feet.	*Per cent.*	*Ohms.*	*Inches.*			*Feet.*		
1	1	11.7	427	6	7	Dark green....	8	15.1	65.4
	2	8.2	271						
	3	4.5	460	18	4	Dark green....	8	17.2	78.0
	4	1.6	968						
2	1	2.8	1,370	6	11	Light green...	4.5	18.5	21.2
	2	2.0	1,318						
	3	1.5	2,108	18	5	Light green...	4.5	17.0	38.0
	4	1.2	2,403						
3	1	1.8	1,353	6	7	Light green...	2.5	15.4	10.6
	2	1.2	2,164						
	3	1.3	2,043	18	5	Light green...	2.5	15.2	15.0
	4	1.2	2,164						

[1] The counting was done by Mr. Rowland M. Meade. The importance of retention of the fruiting branches at low nodes on the axis as an indication of fruitfulness is pointed out by Mr. Argyle McLachlan in Bulletin 249, Bureau of Plant Industry, 1912, entitled "The branching habits of Egyptian cotton."

[2] Based upon thoroughly mixed samples of each 1-foot depth, regardless of variations of texture within that depth. The variations are indicated by the following notes:

Boring No. 1. Soil silty from the surface to a depth of 14 to 20 inches (varying in the several cores), then fine sand, with some admixture of silt at a depth of 24 to 30 inches, then coarse sand from the depth of 30 to 48 inches.

Boring No. 2. First 12 inches much sandier than at boring No. 1. Coarse sand began at a depth of 20 to 24 inches and continued to the bottom of the boring (48 inches).

Boring No. 3. Soil sandy to the surface. Coarse sand began at a depth of about 18 inches and continued to the bottom of the boring.

These results confirm those of the previous year as to the effect of differences of soil texture upon the size and vigor of the plants, and also give a more definite expression of the effect upon the fruitfulness (number of bolls). There was apparently no consistent effect upon the height of the first fruiting branch.

It is evident, therefore, that in the absence of appreciable quantities of alkali salts, the size, vigor, and fruitfulness of Egyptian cotton plants in alluvial soils along the Colorado River is largely determined by the depth of the layer of silt with its relatively high moisture capacity and its doubtless greater supply of plant food.

The very sandy soils have so low a moisture capacity that they hold very little water even immediately after an irrigation and with the customary intervals between irrigations they soon become so dry that much of the time the plants are without available water. This frequent condition of virtual drought seriously impairs the yield and quantity of fiber produced in such soils.

ALKALI CONTENT OF THE SOIL.

In a previous publication[1] the results of observations on the growth of Egyptian cotton plants in alkali soil at Sacaton, on the Gila River, in southern Arizona, were summed up as follows:

> No plants grew at Sacaton in places where the average amount of alkali in the first 3 feet of soil was as high as 1.7 per cent. While resistant individual plants can produce a small amount of fairly good fiber in the presence of from one-half to 1 per cent of alkali, it is probable that land containing considerably less than one-half of 1 per cent must be selected in order to obtain anything like a full stand and the best quality of fiber. The actual limit of safety remains to be determined.

Since this statement was written, further observations upon the alkali resistance of this plant were made at Sacaton, Ariz., in 1910, and at Bard, Cal., in 1911. Even with these additional data the quantity of alkali of a given composition which limits the successful growing of Egyptian cotton can be stated only approximately.[2]

In a general way, however, the more recent observations confirm the conclusion previously reached that Egyptian cotton is superior to many other crop plants in its ability to endure an excess of salts in the soil.

OBSERVATIONS AT SACATON, ARIZ.[3]

A portion of one of the fields planted to the Yuma variety of Egyptian cotton was located where the soil contained more or less salts and where as a consequence the stand was very irregular. The

---

[1] Circular 29, Bureau of Plant Industry, entitled "Experiments with Egyptian cotton in 1908," 1909, p. 18.

[2] A discussion of the varying factors which make it difficult to determine in the field the limits for the growth of a particular plant in the presence of alkali will be found in Farmers' Bulletin 446, entitled "The choice of crops for alkali land," 1911, pp. 8 to 12.

[3] These were made in October, 1910, at a time when the cotton had begun to ripen in most parts of the field.

cotton rows in this field began in good soil where the growth of the plants was normal and where the yield and character of the fiber were as good as could be expected considering the late date of planting (April 12). Toward the ends of the rows where the soil contained gradually increasing quantities of alkali salts the plants were small, produced few bolls, and ripened very late. Finally no plants remained where the quantity of alkali was excessive.

In two of these rows the soil was sampled to the depth of 3 feet at the base of every tenth plant from the good end of the row until the region was reached where the stand was much interrupted. There samples were taken at more frequent intervals and finally alongside each remaining plant.

The soil from each 3-foot boring was thoroughly mixed and its electrical resistance when saturated was determined by means of the electrical bridge, the standard container of which has a capacity of about 50 cubic centimeters.[1] From the resistances, the percentage of total salts to dry weight of soil were computed by means of a special correlation curve for the Sacaton type of alkali. This curve was based upon determinations of the electrical resistance and of the total water-soluble salts in 48 samples of soil which had been collected two years previously on the experiment farm at Sacaton. Analysis of these samples in the chemical laboratory of the Bureau of Soils showed the average composition of the Sacaton alkali to be as follows:[2]

	Per cent.		Per cent.
Ca	1.0	Cl	24.4
Mg	.3	SO_4	16.4
K	1.0	HCO_3	22.1
Na	31.9	CO_3	5.0

Notes were made on the condition of each plant where a soil sample was taken and the seed cotton was collected for examination in the laboratory. Mr. Argyle McLachlan made a series of diagrams for each of these plants, showing graphically the number and position of the fruiting branches and the number of developed and aborted bolls on each branch. Comparison of these diagrams indicated that

[1] The bridge is described and figured and directions are given for its use in determining the salt content of soils in Bureau of Soils Bulletins 15 (by L. J. Briggs) and 61 (by R. O. E. Davis and H. Bryan). In the latter publication tables are given for temperature correction (pp. 22 to 24) and for computing from the resistance the percentage of total salts to dry weight of the soil (pp. 14 to 16).

[2] This composition of the alkali, and especially the presence of carbonates and of large quantities of bicarbonates, probably explains the fact that the Sacaton curve does not agree with that on which is based Table III, p. 14, in Bulletin 61 of the Bureau of Soils. The latter applies to alkali consisting of one-half chlorids and one-half sulphates. For resistances below 40 ohms it indicates higher percentages of total salts and for resistances above 40 ohms it indicates lower percentages than does the Sacaton curve. The disparity increases until a resistance of 170 ohms indicates twice as much total salts on the Sacaton curve as on the chlorid-sulphate curve. On the other hand, the curve for carbonates ("black alkali") on which is based Table VI, on p. 16, Bulletin 61 of the Bureau of Soils, indicates much higher percentages of total salts for given resistances than on either of the other curves until a resistance of 170 ohms is reached, from which point the Sacaton curve agrees very closely with the carbonate curve.

there was a tendency for the plants growing in soil relatively free from alkali to retain the first fruiting branch at a lower node on the axis than in the case of plants in the stronger alkali soils, although the correlation between the height of the first fruiting branch and the alkali content of the soil was not a close one.

At most of the borings the resistance of the saturated soil ranged from 200 to 400 ohms. Where it exceeded 200 ohms no differences which were not well within the limits of individual fluctuation could be detected in the plants. Table III summarizes the notes made chiefly upon plants growing where the soil gave resistances lower than 200 ohms.

TABLE III.—*Electrical resistance of saturated soil, indicated percentage of total salts, and character of the plants and fiber of Egyptian cotton at Sacaton, Ariz., in 1910.*

Soil (averages for the 4-foot column).		Plants.			
Electrical resistance in ohms.	Indicated percentage of total salts (Sacaton curve).	Size, earliness, and fruitfulness.	Number of the node on axis where the first retained fruiting branch occurs.	Bolls.	Fiber.
+200	−0.34	Normal	10 to 16	Normal	Normal.
200	.34	...do	12 to 17	...do	Do.
185	.36	Ripening somewhat retarded, otherwise normal.	13 to 15	...do	Do.
155	.41	Smaller and later ripening	16 to 17	Normal or rather small.	Rather short, otherwise normal.
140	.43	Smaller, less fruitful	12	Small or medium	Good in length, strength, and quality.
110	.48	Late ripening, fairly productive.	18	Small	Normal.
100	.51	Small, late ripening, with few bolls.	16	...do	Short, but strong and fine.
90	.54	...do	17	Very small	Normal.
70	.63	Small, fairly fruitful	18	Fair sized	None matured.

The data given in Table III indicate that with alkali of the Sacaton type, where the salt content of the soil exceeds 0.4 per cent of its dry weight (electrical resistance 150 ohms or lower), the fruitfulness of the plants is likely to be impaired and the ripening of the bolls seriously retarded. This would seem to be about the limit for profitable production of this crop in the presence of alkali of the Sacaton type, although it is evident that the quality of the fiber does not necessarily suffer in the presence of 0.55 per cent of salts (electrical resistance of 90 ohms).

OBSERVATIONS AT BARD, CAL.

A small field of Egyptian cotton grown in the vicinity of Bard in 1911 was located on a sandy soil containing in spots so much alkali that the resulting stand of cotton was very uneven. There were several areas of greater or less size where the plants either had failed to appear or had subsequently died. The electrical resistance of the soil was determined in different parts of this field on October 23, and notes were made upon the character of the plants where the respective soil samples were taken. The results of these observations are summarized in Table IV. The percentages of total salts indicated by the electrical resistances as given in this table are computed from Table III, page 14, Bulletin 61 of the Bureau of Soils, which applies to a type of alkali consisting of one-half chlorids and one-half sulphates.

TABLE IV.—*Electrical resistance of the saturated soil, indicated percentage of total salts, and condition of Egyptian cotton plants, at Bard, Cal., in 1911.*

Boring No.	Depth.	Character of soil.	Electrical resistance.	Indicated total salts in percentage of dry weight soil.	Condition of plants.
	Feet.		*Ohms.*		
1	1	Sandy loam	45	0.75	No plants; boring in center of a small bare spot.
	2	do	63	.53	
	3	do	113	.29	
	4	Fine sandy loam.	117	.28	
	Average.			.46	
2	1	Sandy loam	33	1.12	Between two good-sized, healthy, fruitful plants bearing abundant fiber of excellent quality, strong, 1⅜ inches long.
	2	do	63	.53	
3	1	Sandy loam	63	.53	Among small scattered plants (less than half normal height) mostly dead. Plants shallow-rooted here.
	2	do	91	.37	
	3	Fine sandy loam.	62	.53	
	4	do	59	.56	
	Average.			.50	
4	1	Sandy loam	55	.60	Between two good-sized, healthy, fruitful plants bearing strong, abundant, silky fiber. Root system comparatively shallow.
	2	do	50	.67	
	3	Sand	69	.48	
	4	do	85	.39	
	Average.			.53	
5	1	Sandy loam	55	.60	Beside a dying plant at edge of spot in center of which boring No. 3 was made. This plant bore a few open bolls, the fiber in which was coarse and weak.
	2	do	81	.41	
	3	do	75	.45	
	4	Sand	97	.34	
	Average.			.45	

Inspection of this table shows no close relation between the salt content of the soil and the growth of the cotton plants. Thus, at boring No. 2, located midway between two plants which were about as good as any in the field, the first foot of the soil contained considerably more soluble salts than the first foot of borings Nos. 1, 3, and 5, where there were either no plants at all or the plants were evidently suffering.[1]

[1] Much of this alkali had doubtless accumulated in the upper soil after the cotton was planted, the ground water table in this field having reached the surface of the soil during the high-water stage of the Colorado River in June. It had lowered by the date when these borings were made, saturated soil having been encountered at a depth of about 4½ feet in the neighborhood of boring No. 3.

The only conclusion that may safely be drawn from the foregoing data is that when other conditions are favorable plants of Egyptian cotton can remain in good condition and produce numerous bolls and strong, abundant fiber of good length and quality where the soil to a depth of 4 feet contains as much as one-half of 1 per cent of water-soluble salts of this composition.

The apparent ability of Egyptian cotton plants to withstand more alkali at Bard than at Sacaton is perhaps partly to be ascribed to accumulation of the alkali in the upper soil at the former locality after the plants had reached an advanced stage of growth. The different composition of the salts at the two localities is doubtless also partly responsible for the difference.

The average composition of the alkali on the experiment farm at Sacaton is given on page 21. The alkali in the field at Bard where the above-described observations were made had the following average composition:

	Per cent.		Per cent.
Ca	8.4	Cl	33.0
Mg	4.0	SO_4	21.0
K (included with Na).		HCO_3	15.6
Na	37.1	CO_3	None.

At Bard, none of the very injurious free carbonates ("black alkali") was detected, while considerable quantities were present in some of the Sacaton samples. Moreover, there was a much higher proportion of lime (Ca) in the Bard samples, and this substance, as is well known, is very effective in neutralizing the poisonous effects of the sodium salts which form the bulk of the alkali at both localities.

CONCLUSIONS.

The moisture capacity of the soil is an important factor in determining the size, vigor, and fruitfulness of Egyptian cotton plants. A larger supply of nutrient salts in the heavier soils is probably also a factor. With irrigation as ordinarily practiced in the Southwest, very sandy soils, having a low moisture capacity, are unsuited to this crop, since the plants are exposed to virtual drought during much of the period between irrigations. Recurring deficiencies of available water in the soil are very unfavorable to the yield and quality of the fiber. New land as a rule should be avoided in growing Egyptian cotton, as the soil commonly varies greatly in moisture capacity and the crop produced will be correspondingly lacking in uniformity.

The alkali resistance of Egyptian cotton is relatively high when other conditions are favorable. It would appear that fair yields of fiber of good commercial quality can be obtained where nearly one-half of 1 per cent of the total dry weight of the soil consists of readily soluble alkali salts, provided that carbonates ("black alkali") are absent or form only an inconsiderable proportion of the total alkali.

RELATION OF STAND TO YIELD IN HOPS.[1]

By W. W. STOCKBERGER, *Physiologist*, and JAMES THOMPSON, *Scientific Assistant, Office of Drug-Plant, Poisonous-Plant, Physiological, and Fermentation Investigations.*

INTRODUCTION.

Among many hop growers the impression prevails that the average yield of hops per acre is annually growing less and that the productivity of a large proportion of the hop soils is decreasing. The statistical data on this point, however, are so meager that it seems unwise to draw from this source very definite conclusions regarding the increase or decrease in yield per acre. From the records of the United States Census the average yield per acre of hops can be determined only at 10-year intervals throughout a period of 30 years, and since the figures for any given year will vary widely, depending on whether a light or a heavy crop is produced, it is manifestly unsafe to assume that the averages for the census years necessarily represent actual conditions for the intervening years. If records of the average yield were available for each one of the 30 years the evidence of the figures might be accepted as a fair indication of the general trend of the yield of this crop.

The average yield per acre is materially influenced by a number of factors, prominent among which are seasonal conditions, soil type, and cultural methods. In case large areas are under consideration, such as a county or State, extensive changes in acreage or a shifting of the area of production may also materially affect the average yield. When such modifications take place, changes in the average yield reported for the given area have little bearing on the question of diminishing crop yields. Nevertheless, the statistical data on the average yield per acre in the several hop-growing States and in the chief hop-producing counties therein are worthy of careful consideration by every grower of hops, but it is of far greater importance that he should be fully informed as to the successive yields of his own fields.

On certain types of soil not so well adapted to hops as the richer alluvial soils there is ample evidence of a declining yield, due fundamentally to soil conditions. This decline is most noticeable in hopyards located on uplands where beneath the shallow surface soil

[1] Issued Feb. 8, 1913.

there is a layer of hardpan and clay. On the other hand, it is far from clear that the diminished output per acre reported for some of the rich, deep alluvial soils is due to their decreased productiveness, especially if such soils are overflowed in winter and thereby receive a deposit of sediment. The fact that the application of commercial fertilizers to some of these soils has as a rule yielded negative results seems to indicate that they are not lacking in available plant food, and a study of the other factors concerned will probably reveal the most important causes of the decline in yield, if such is actually taking place.

It is the purpose of the present publication to direct attention to the often unappreciated extent of the losses due to imperfect stand and to offer certain suggestions which, if followed, should result in an increased yield without materially increasing the cost of production.

CAUSES OF IMPERFECT STANDS.

In newly planted yards a small percentage of missing hills may normally be expected, owing to the failure of some of the cuttings to strike root. In most cases, after a yard has come into full bearing the stand tends to become poorer and poorer through the dying out of the plants from causes at present imperfectly understood. This dying out occurs in all the hop-growing sections of the United States, but it is far more prevalent in some districts than in others. Many ingenious explanations have been offered to account for this trouble, but a satisfactory one yet remains to be found. From extensive observations made in the hop fields of the United States and of Europe the writers have reached the tentative conclusion that a primary cause lies in too severe or faulty pruning, in the bruising of the roots in plowing, and in the crushing of the crown of the plant by the feet of horses and the wheels of wagons when teams are driven over the fields.

Hills often die out because of weakness or disease induced either by the rough treatment received when they are uncovered at pruning time or by the injuries inflicted by the plow or other implements used in cultivation. When the roots are bruised or torn they heal slowly and imperfectly and are almost certain to become infected by some of the destructive organisms widely distributed in the soil.

In most hopyards some attention is given each year to replanting the missing hills, but, since the trouble is rarely taken to make certain that the cuttings are sound and vigorous and that they come from hills selected for their thriftiness and high yield, many replants either die outright the first year or maintain a struggling and unprofitable existence. The vigor of the cuttings is often impaired through the lack of precaution to keep them from drying out before they are set, or the replanting is deferred until the soil has become so dry that it does not afford the conditions essential to proper growth. Replants usually make a poor growth unless the site of the missing hill which they are intended to replace is excavated, the dead crown and roots removed, and the soil replaced by fresh earth taken from midway between the rows.

The stand may become imperfect through numerous other causes, but the ones here described should receive first consideration, since it is within the power of the hop grower to minimize in great measure their effect.

VARIATION IN THE PERCENTAGE OF PERFECT STAND.

The percentage of perfect stand varies widely and is to a large extent dependent upon the local conditions affecting a given hop field and upon the knowledge, skill, and industry of the hop grower. In some yards which have come under the writers' observation a careful count of the missing hills showed the stand to be 99.3 per cent, while in other yards the stand was found to be as low as 75 per cent. These, of course, represent extreme cases and are far less numerous than those in which the stand ranges from 90 to 95 per cent for individual fields. The percentage of stand for any given yard will be found to fluctuate from year to year, according to the rate at which the hills are dying out and the care and attention given to replanting.

The estimate by inspection of the number of missing hills and the percentage of stand have been found to be very misleading. In every case in which a grower's estimate of the percentage of stand has been verified by an actual count of the missing hills, his estimate has proved too high, and it is believed that growers often deceive themselves as to the extent of the loss suffered through an imperfect stand. An estimate of the percentage of stand that is based on a count of the missing hills in every fifth or tenth row, although less accurate than a full count, is much to be preferred to one based on inspection alone.

VARIATION IN STAND ON A SINGLE ACRE.

An exact record of the stand on an acre for 4 consecutive years shows some striking variations which are believed to be fairly representative of the conditions existing in many hopyards. This acre was laid off at one side of a large field which had been under hops continuously for 10 years, and during the 4 years it was under observation it received the same attention and culture treatment as the remainder of the field of which it forms a part. At harvest time each year a record was made of the condition of each hill, and the position of each hill that was missing or which had vines bearing no hops was noted on a chart. From this chart the data in Table I were compiled.

TABLE I.—*Comparison of the stand of hop plants on 1 acre for the years 1909 to 1912, inclusive.*

Factors of variation.	1909	1910	1911	1912
Productive hills	853	865	887	790
Missing hills	56	66	24	113
Hills having vines with no hops	43	21	50	58
Hills having "bastard" vines	5	10	....	....
Hills having male vines	10	5	6	6
Total	967	967	967	967
Stand ......per cent	94.2	93.1	97.5	88.3
Productive stand ......do	89.1	89.9	92.2	82.2

With a perfect stand, under the system of planting followed on this acre, there would be living plants in each of the 967 hills. Owing to the prevalence of missing hills, however, the stand has been more or less imperfect each year, as shown by the percentages given in Table I. Aside from the missing hills the crop is further influenced by the constant occurrence of unproductive plants. Of these, there are three classes: The male plants, of which a small number is considered essential by American hop growers; the "bastard," or mongrel, plants, the frequent occurrence of which is restricted to certain localities; and the normal female plants which from one of several causes are nonproductive. When yield is considered, the nonproductive as well as the missing hills must be taken into account, since the yield per acre is directly proportional to the number of productive hills. The percentage of productive stand, by which is meant the percentage of bearing hills, is an important index of productiveness, and on the acre in question this figure shows, as may be seen from Table I, that each year about one-tenth of the hills are wholly unproductive.

The records of the individual hills show some of the important reasons for the variation from year to year in the number of missing hills. The two chief causes of this variation are the more or less successful yearly replanting and the annual occurrence of new missing hills. The variation in these factors is numerically expressed in Table II.

TABLE II.—*Annual variation in the number of replanted and missing hills of hops on 1 acre.*

Factors of variation.	1909	1910	1911	1912
Hills successfully replanted	No record.	12	57	21
Hills previously missing and not successfully replanted	...do......	44	9	3
New missing hills	...do......	22	15	110
Total number of hills missing	56	66	24	113

The importance of replanting and the success with which it has been carried out on the acre under observation may readily be judged from Table II. In 1910 less attention was bestowed upon the replanting than in the two succeeding years, with very obvious results. Were it not for the continuous dying out of the hills an almost perfect stand could readily be attained. It is important to note that each year there was added to the list of missing hills a number that previously had been productive. In fact, it frequently occurs that a hill which has been producing heavily for several years suddenly becomes "missing." Of the 110 new missing hills recorded in 1912 the average yield for the previous year was 10.2 pounds green weight, and 56 of these hills had each given a high yield in the years 1909 to 1911, inclusive.

Out of the entire number of hills on this acre only 1 has been missing for the whole period of four years, 4 have been missing for three consecutive years, and 45 for two years in succession. Of the 56 hills missing in 1909 only 6 were still missing in 1912. Altogether, 193 different hills have been missing on this acre during the past four years, which would have necessitated the replanting of more than 20 per cent of the entire number of hills if a perfect stand were to be maintained. The fact that new missing hills occur each year, many of which have previously been highly productive for several years, strongly suggests that the average length of life of the cultivated hop plant may be less than is popularly supposed. Cases are known where it is claimed that individual plants have given a fair yield each year for 30 years, but many growers agree that, with a newly planted yard, after three or four crops have been harvested the hills begin to die out to a greater or less extent. Positive conclusions on this point, however, can not be drawn from the data in hand, since the period covered by the observations is entirely too short to be more than suggestive.

VARIATION IN PRODUCTIVE STAND.

A large part of the variation in productive stand is caused by the occurrence of hills having vines producing no hops. Such hills present a greater problem than those which are missing, since many of them if left undisturbed produce a good crop the following year and digging them out and setting new plants might result in loss rather than gain. Each year a few of the replants fail to bear hops; others of the hills are probably unproductive through loss of vigor, since a number are dead the following year, and some vigorous and normally productive hills through some accident fail to yield a crop. How these various classes among the hills having vines but no hops are distributed from year to year is shown in Table III.

TABLE III.—*Record of the hills on 1 acre having vines but producing no hops, for the years 1909 to 1912, inclusive.*

Year.	Total hills.	Replanted hills.	Productive hills.		Nonproductive hills.		Hills dead the following year.
			Previous year.	Following year.	Previous year.	Following year.	
1909	43	(1)	(1)	36	(1)	1	6
1910	21	2	17	18	2	1	2
1911	[2] 50	19	25	37	6	5	8
1912	58	3	51	(1)	4	(1)	(1)

[1] No record.
[2] The crop on 24 of these hills was lost through defective supports, which allowed the vines to fall to the ground.

This table shows that the relation existing between the newly replanted hills and those having vines but no hops is less close than is generally supposed, since the number of the latter which were replants is small both in comparison with the total number of hills having vines producing no hops and with the number of hills successfully replanted, as shown in Table II. The figures in columns 4 and 5 of Table III indicate that of the hills having vines but no hops in any given year the greater number were productive in the previous year as well as in the one immediately following. Similarly, the figures in columns 6 and 7 show that very few of these hills were nonproductive in either the previous or the following year. Finally, from the last column it appears that relatively few of the hills having vines but producing no hops are numbered with the dead the following year.

In view of the facts here presented there seems no escape from the conclusion that a large number of the cases of hills having vines but no hops arise through neglect or carelessness in cultivating or caring for the plants up to harvest time.

LOSS IN YIELD DUE TO DEFECTIVE STAND.

Everyone recognizes that, as a rule, a poor stand means a diminished yield, but it frequently happens that the extent of this loss is not fully appreciated. This is particularly true when the number of missing or nonproductive hills is small, for then the grower often feels that the saving would not be large enough to warrant his giving the time and attention necessary to maintain a full productive stand. This impression is likely to persist unless some relative numerical expression is found that will approximately represent the extent of the loss. A fairly satisfactory method of estimating loss is to determine the percentage of productive stand and the actual yield, say on 1 acre, and from these figures to calculate what the yield would be on the basis of a productive stand of 100 per cent. The difference between the estimated yield and the actual yield will then represent the loss. Applying this method to the records of the acre discussed in the previous paragraphs the results set forth in Table IV were obtained.

TABLE IV.—*Estimated loss and comparison of actual with estimated yield on 1 acre of hops.*

Year.	Productive stand.	Actual yield, dry weight.	Estimated yield with full productive stand.	Estimated loss due to lack of stand.[1]	
				Quantity.	Value.
	Per cent.	*Pounds.*	*Pounds.*	*Pounds.*	
1909	89.1	1,487	1,668	181	$29.32
1910	89.9	1,443	1,605	162	15.87
1911	92.2	2,353	2,552	199	64.27
1912	82.2	1,828	2,223	395	50.56

[1] The estimate of value is on the basis of the farm value of hops in cents per pound, less 6 cents per pound for harvest costs. These farm values are officially estimated by the Bureau of Statistics, U. S. Dept. of Agriculture, as follows: 1909, 22.2 cents; 1910, 15.8 cents; 1911, 38.3 cents; 1912, 18.8 cents.

When the effect on yield of missing and unproductive hills is thus translated into terms of dollars and cents per acre, the results of inattention to proper cultural methods become very clear. The average loss on this acre for the four years 1909 to 1912 was $40, a sum certainly well in excess of that required to pay for the labor and supervision necessary to maintain a maximum percentage of productive stand.

SUGGESTED PROCEDURE FOR MAINTAINING A GOOD STAND.

Although some growers succeed in maintaining a practically perfect stand, others may fail to do so owing to causes clearly beyond their control. However, strict attention to the suggestions which follow will eliminate nearly all of those cases of missing or nonproductive hills which are due to carelessness or neglect. Such cases, as is shown on previous pages, are responsible for the greater part of the loss due to defective stand.

PRACTICAL SUGGESTIONS.

(1) Just before harvest time mark by means of stakes driven well into the ground all missing, "bastard," and excess male hills. After harvest dig out these hills and leave an open excavation at least 3 feet across and 2 feet deep.

(2) At pruning time dig out all hills that have died during the winter; then, before replanting, fill the site of all excavated hills with fresh soil mixed with manure.

(3) If possible, replant early while the soil contains an abundance of moisture to support the growth of the cuttings; cuttings planted in dry soil or sand should be well watered when they are set out.

(4) In replanting use only sound, vigorous cuttings taken from high-yielding hills and see that the cuttings are not allowed to dry out before planting.

(5) After the plants are well started inspect the hills carefully and replace all weak or dead plants with vigorous reserve plants from the nursery.

(6) Personally supervise the work of replanting, especially when it is done under contract or when immigrant labor is employed.

(7) In pruning, carefully distinguish (a) normal, well-developed stocks, which may be cut back either quite close to the crown or so as to leave only the first set of eyes on the stumps of the vines of the previous year, and (b) small, weak stocks, which should be so cut that two or even three sets of eyes will be left on the stumps of the vines.

(8) See that the vines are properly tied up, so that they will not be caught and broken or torn down by the implements used in cultivating or spraying.

(9) Keep a constant oversight of the fields and whenever a vine is torn down or falls to the ground see that it is immediately replaced on its proper support.

ADDITIONAL COPIES of this publication may be procured from the SUPERINTENDENT OF DOCUMENTS, Government Printing Office, Washington, D. C., at 5 cents per copy