UNITED STATES DEPARTMENT OF AGRICULTURE

DEPARTMENT BULLETIN No. 1153

Washington, D. C. ▼ May 12, 1923

BOLL-WEEVIL COTTON IN TEXAS.

By O. F. Cook, *Bionomist in Charge, Office of Crop Acclimatization and Adaptation Investigations, Bureau of Plant Industry.*

CONTENTS.

NATURE OF BOLL-WEEVIL COTTON.

The expression " boll-weevil cotton " is used by farmers in Texas, who recognize the effects of weevil injury in altering the behavior of the plants by forcing them into rank growth, so that the damaged fields are different from normally productive cotton. In addition to the direct injuries inflicted by destroying flower buds and bolls, the insects are responsible indirectly for an abnormal luxuriance that changes the form and appearance of the plants. Texas has had more experience with weevil injury than other States, with varied conditions and seasons that bring out the contrasts between the normal behavior of the cotton crop and the abnormal behavior of " bad weevil years." The weevils entered southern Texas from Mexico in 1892, but did not reach Louisiana till 1903. Arkansas and Oklahoma were invaded in 1905, Alabama in 1909, Georgia in 1914, and North Carolina in 1919.

Cotton tends, of course, to grow rank in the rich Texas soils if moisture is abundant and the spring weather is warm, but such natural tendencies to luxuriance are greatly increased when the weevils are abundant and the floral buds are destroyed so that no fruit can be set. The spring generations of weevils are bred in the flower buds, and breeding begins as soon as the buds are large enough to furnish the partly developed pollen that is the principal food of the weevils. Most of the infested buds are blasted and drop to the ground in a few days.

31823—23——1

When the farmer sees the plants shooting up too fast and failing to blossom he knows that the weevils are at work and that only a small crop may be expected, if not a complete failure. Thus boll-weevil cotton is a cultural condition that needs to be recognized in order that it may be avoided as far as possible. The cultural factors of control for avoiding or restricting weevil injury are important, and especially those that add little or nothing to the expense of producing the crop. On this basis it may be considered that the boll-weevil problem in Texas has been solved, since there is no longer any question that production can be maintained or even increased if commercial conditions are not too adverse. But the period of readjustment and improvement of methods of production required by the boll weevil is not at an end even in Texas, though farther advanced than in other States.

Dry weather often restricts the size of cotton plants in Texas and also holds the weevils in check, so that the condition of boll-weevil cotton is not reached every year. Prevalence of dry weather explains why the production of cotton has been maintained in Texas and even greatly increased in many counties during the period of the weevil invasion, by making use of improved methods and varieties. How to get the most advantage from the favorable factor of dry weather is a distinct cultural problem in Texas. Some seasons, of course, are so dry that the cotton hardly reaches the fruiting stage, or bolls that have set may fail to develop, but there is an equal or greater danger of the plants growing too large when moisture is abundant. Large, spreading plants are undesirable, even where there are no boll weevils, on account of the late maturity of the crop. The larger the plant grows beyond a desirable medium size the greater the risk and exposure to injury by frost or other unfavorable conditions, as well as by the boll weevils.[1]

The season of 1921 afforded unusually striking examples of the development of boll-weevil cotton at the United States Experiment Farm near San Antonio, Tex., in a region where the activities of the weevils usually are restricted by drought. (Pl. I, Fig. 1.) Dry weather was not lacking in 1921 but came too late, after the plants had grown large and the weevils had so much shelter that they continued to breed in great numbers till the end of the season. The experiments were of interest as showing the extent to which the weevils are protected by the large growth of the plants and how necessary it is to avoid the condition of the overgrown boll-weevil cotton. It was plain that the failure of some fields to set any crop was due to the large plants that closed the lanes between the rows and gave full protection to the weevils. Restricting the size of the individual plants and keeping the lanes open between the rows of cotton are cultural requirements of first importance under weevil conditions.

DISTINCTIVE CHARACTERS OF BOLL-WEEVIL COTTON.

Fields of boll-weevil cotton, in addition to the larger growth of the plants, have a darker and more uniform green color that is easily recognized even from a distance. That flowers are very few or lacking entirely in the boll-weevil fields partly explains the differ-

[1] Cook, O. F. Relation of drought to weevil resistance in cotton. U. S. Dept. Agr., Bur. Plant Indus. Bul. 220, 30 p. 1911.

ence in color, but the foliage has the deeper shade of green that usually marks a state of vegetative vigor as distinguished from the more yellowish green of plants in the fruiting stage. An urban writer's account of the boll weevil, that "it bit the tops off of the cotton plant," is quite imaginary. There is no obvious external symptom except the abnormal growth of the plants.

One consequence of rank growth is the development of more numerous and larger vegetative branches, so that the lanes are closed between the rows and the ground shaded continuously. The shading of the ground is an important feature, making the conditions more favorable for the weevils as the season advances. Once the state of boll-weevil cotton is reached the weevils can breed without interruption and maintain themselves in such numbers that all of the buds are destroyed, so that no more flowers appear and no more bolls are set beyond the small number that usually escape the weevils early in the season. With sufficient moisture to support a continuous growth the fields become veritable thickets (Pl. I, Fig. 1) and show a wilderness of bare stalks in the fall after the leaves are killed by frost.

The rank growth of the plants may be considered a result of pruning away the floral buds and young bolls by the weevils. This apparently serves, like other pruning, to stimulate additional growth, which is shared by all parts of the plant. The fruiting branches have a continued succession of new joints, each with its small flower bud that the weevils destroy. The later joints of the fruiting branches are shorter and shorter, and many of the late-season flower buds are defective.

STERILE INVOLUCRES OF BOLL-WEEVIL COTTON.

That the late-season growth of boll-weevil cotton becomes distinctly abnormal was indicated in 1921 by the production of many defective involucres. (Pl. II.) The involucre of the cotton plant is a specialized organ that incloses the floral bud, replacing the function of the calyx, which in cotton is poorly developed. Instead of the three small leaves, or bracts, that form the normal cotton involucres, many involucres of the boll-weevil cotton have only one or two bracts and no other floral organs. Slender rudiments of a calyx were found in some of the 2-bracted involucres, but no petals, stamens, or pistils.

Reduced budless involucres of similar form have been observed on sterile hybrids and abnormal individual variations of Pima (Egyptian) cotton, as well as in upland sorts, but with no such regularity or frequency as in the boll-weevil cotton of 1921, both at San Antonio and at Greenville, Tex., representing the Lone Star and many other upland varieties. Failure to find any 2-bracted involucres that produced bolls in upland varieties is in contrast with the Egyption type of cotton, where normally developed bolls are often found with involucres of only two bracts. The tendency of upland cotton is to a larger number of bracts. Some of the upland varieties, as Tuxtla and Meade, show frequent variations to 4-bracted involucres, which seldom, if ever, occur in Egyptian cotton.

Reduced sterile involucres are to be reckoned, of course, as a form of abortion, but of a nature entirely distinct from the direct injuries that the weevils inflict by puncturing the flower buds to lay their eggs or to feed upon the pollen. The abnormal involucres, having no flower buds to be attacked by weevils or blasted by unfavorable conditions, are immune from shedding and remain on the plants to the end of the season. The shedding of normal buds after blasting involves a loss of the inclosing involucre as well as the supporting pedicel or stem of the bud, leaving only a rounded scar on the fruiting branch.

Some of the solitary bracts, representing reduced involucres, are not of the usual expanded form, but narrowly tubular or trumpet shaped. (Pl. III, Fig. 2.) To form these tubular bracts the margins must have been united or fused together at a very early stage of development, while the abortion of the other bracts and of the flower bud must have taken place at a still earlier stage in the formation of the involucre. The tubular bracts may be described as "ascidia," a name that has been applied to similar malformations of leaves in several other families of plants. The marginal teeth of the solitary bracts are reduced in number, especially those of the tubular bracts, or ascidia. Having lost their floral buds at the early stage of development, the reduced involucres can serve only as leaves, and they persist for the remainder of the season, as already stated. The stalks or pedicels of the reduced involucres are very short and slender, more like petioles of small leaves than like pedicels of normal buds or bolls.

Another peculiar feature of these reduced, budless (or ablastic) involucres is their general failure to develop a nectary or honey-secreting pit, which is located at the base of a normal bract. Suppression of the nectaries is a further indication of divergence from the normal course of development of the bracts at a very early stage. Hundreds of the reduced involucres were examined at San Antonio without finding any with normal functional nectaries, though the position of the nectary usually is indicated by a prominence of rounded form and reddish color. (Pl. II.)

The reduction or partial formation of the involucres with abortion of the flower buds is a peculiar phenomenon, pointing, no doubt, to some abnormal physiological state of the plants that may result from the persistent destruction of the floral buds by the boll weevil. Though the abnormal reduced involucres are not confined to boll-weevil cotton, but are of occasional occurrence outside the weevil belt and in many kinds of cotton, they have not attracted attention or been reported as a regular feature, as in the late-season growth of boll-weevil cotton.

WEEVILS SHELTERED BY LARGE PLANTS.

The size and form of the plants largely determine the condition of the fields in relation to the boll weevil. With the ground shaded by the heavy foliage of overgrown plants, conditions are favorable for the multiplication of the weevils. The lanes are closed between the rows of large plants, so that fields of boll-weevil cotton are covered with a complete canopy of foliage, giving protection to the weevil larvæ in the flower buds. The weevil-infested buds that have fallen

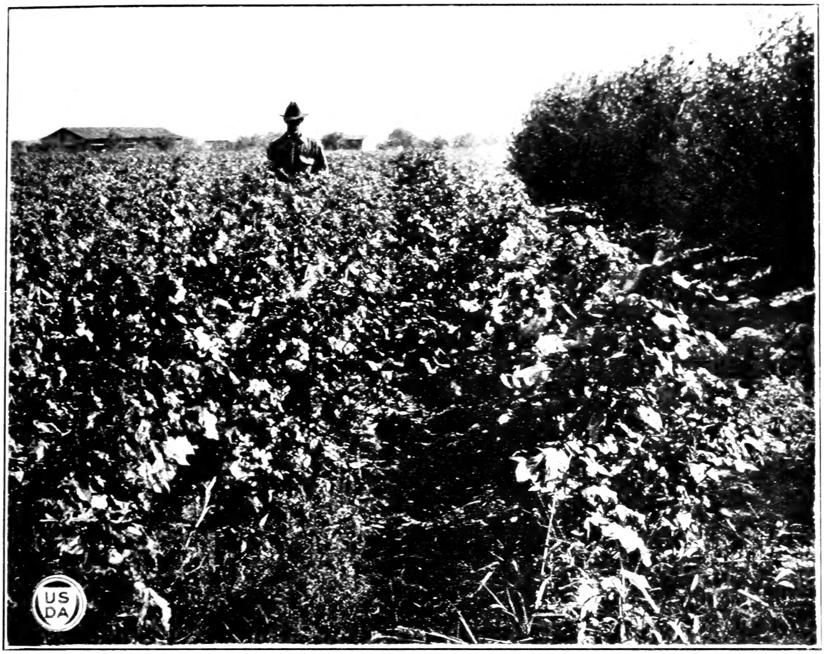

FIG. 1.—TYPICAL BOLL-WEEVIL COTTON.

Field at San Antonio, Tex., in 1921, with heavy and continuous foliage closing the lanes between the rows.

FIG. 2.—FIELD OF BOLL-WEEVIL COTTON AT SAN ANTONIO, TEX.

The smaller and more open rows next to the pomegranate orchard were much more productive than the remainder of the field.

ABNORMAL INVOLUCRES OF BOLL-WEEVIL COTTON.

Fruiting branches of boll-weevil cotton with buds and bolls replaced by abnormal sterile involucres.

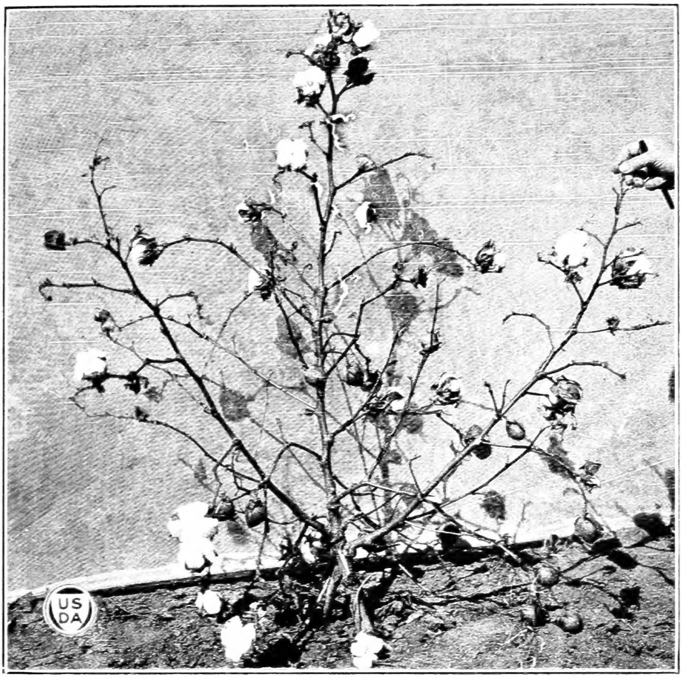

FIG. 1.—PRODUCTIVE COTTON PLANT.

This plant stood apart from but within a few feet of heavily infested boll-weevil cotton and continued to set bolls till the end of the season.

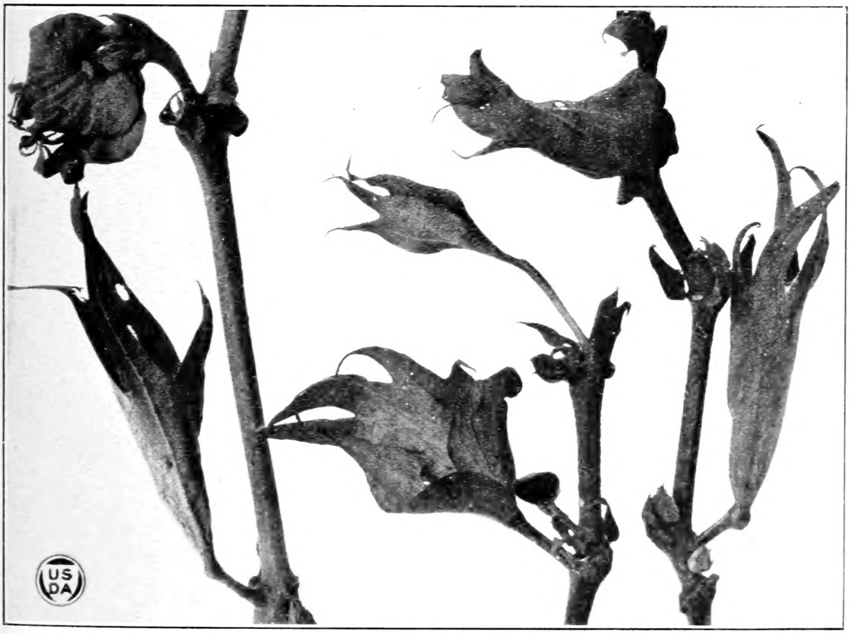

FIG. 2.—ABNORMAL INVOLUCRES OF BOLL-WEEVIL COTTON.

These forms include narrow funnel-shaped "ascidia." A normal late-season involucre is shown on a short secondary branch at the upper left-hand corner. (Natural size.)

COTTON AT COVINGTON, TENN., OCTOBER 17, 1921.

These rows are 2 feet apart with plants 3 to 4 inches apart in the rows, an extreme application of close spacing.

to the ground are not reached by the direct light and heat of the sun, nor is the ground heated sufficiently to dry the buds and kill the weevil larvæ inside.

Prompt shedding of the weevil-infested buds, followed by thorough drying and baking of the buds on the hot ground, explains the beneficial effect of the dry, hot weather of Texas in checking the reproduction of the weevils, so that it often is possible to set a crop of bolls during a period of dry weather in spite of many weevils surviving the winter and attacking the cotton early in the season. But with too much rain and warm weather in the spring, as in the season of 1921 at San Antonio, there is danger of the plants growing rank and becoming crowded in the field. The ground also is continuously shaded, and weevil larvæ in fallen buds are sheltered and protected from the sun to such extent that a later period of dry weather does not have its normal effect of stopping the propagation of the weevils and permitting a crop to be set. The advantage that dry weather brings to fields of smaller and more open plants may be lost entirely when the plants have grown too large before the dry weather comes, as happened at San Antonio in the season of 1921.

Thus the condition of overgrown, crowded fields needs to be recognized, even more clearly than in the past, as very unfavorable from the standpoint of production; indeed, as most unfavorable. Not only is there nothing more to expect in the way of setting more bolls in the same season, but even the next year's crop is jeopardized by allowing the fields of boll-weevil cotton to remain through the season as a breeding place for weevils.

Usually the fields are left until fall or until the plants are killed by frost,when the weevils are ready to go into winter quarters, so that a full quota of the insects is likely to be carried over to the next season. Earlier destruction of boll-weevil cotton is the obvious need, if improved cultural methods are not used, to avoid this hopeless condition. The longer the boll-weevil cotton stands in the fields the greater the danger of the injury being carried over to the next season.

WEEVIL DAMAGE ON EXPOSED PLANTS.

How closely the weevils are dependent in dry weather upon the shelter of the fields of overgrown boll-weevil cotton may be illustrated by facts observed at the United States Experiment Farm at San Antonio, Tex., in the season of 1921 and brought to the writer's attention by D. M. Simpson. The spring and early summer conditions favored a rather large growth of the plants, so that the condition of genuine boll-weevil cotton was generally attained. (Pl. I.) With the plants overgrown and crowded, meeting between the rows and completely shading the ground, the weevils bred abundantly, and a dense weevil population was maintained in spite of a rather long period of dry weather in the latter part of the season.

After the setting of a few bolls per plant in a short interval of dry weather in the early flowering period, before the plants were large enough to shade the ground completely, very few bolls escaped the weevils in any of the fields that attained the regular conditions of boll-weevil cotton. In later plantings the destruction was nearly complete, but it was noticed by Mr. Simpson that bolls continued to be set on isolated plants during the late-season period of dry weather, even on plants that stood only a few feet away from the heavily infested fields or experimental plats that had grown into boll-weevil cotton. (Pl. III, Fig. 1.) Some of the plants that had been isolated rather late in the season by root-rot killing their neighbors were still producing numerous young bolls in October, notwithstanding the large weevil population close at hand. These productive plants were in striking contrast to the barren boll-weevil cotton only a few feet away, where scarcely any late bolls were to be found except occasional bolls on drooping lower branches, which the weevils seem to neglect or fail to find.

A count of bolls on one of the isolated plants on October 19 gave a total of 44, including several that had opened recently and 18 that were still green. Thus there could be no doubt that regular fruiting had continued on this isolated plant, while other plants in the same field averaged less than five bolls apiece, often only one or two bolls, and most of these confined to lower branches and produced early in the season. On 12 plants that were nearest to this isolated individual with 44 bolls, the following numbers of bolls were counted: 7, 4, 7, 1, 4, 3, 3, 2, 6, 4, 9, 7. But some of these were end plants and their partial exposure may have given advantages over the regular run of plants in the rows.

A similar advantage from better exposure was apparent in the outside rows of a field that was bordered on the south side by an orchard of pomegranates (Pl. I, Fig. 2). This field was planted late and did not have the advantage of setting bolls during the short period of favorable conditions earlier in the season, when bolls had been set on earlier plantings. Thus, the late-planted field was an almost complete failure, yielding scarcely a boll per plant except on the rows along the pomegranate orchard. On account of the smaller size of the plants, which may be ascribed to competition with the pomegranates, these outside rows did not close the intervening lanes or shade the ground continuously and suffered notably less from the weevils than the remainder of the field, which grew into regular boll-weevil cotton. Late in the season the advantage was shown very definitely in the numerous green bolls that were still developing on the small, open rows, while no fruit was being set in other parts of the field. Although the outside row had the smallest plants, it yielded 8 pounds 15 ounces of seed cotton, or nearly twice as much as the next row, which produced 4 pounds 9 ounces, with other rows declining gradually to 2 pounds 6 ounces at the fifth row, which was about the average for the remainder of the field. That the open rows and outstanding individual plants escaped injury to such an extent seems to show that the insects required the shelter of the boll-weevil cotton and were unable or unwilling to come out and work in the open, even on plants only a few feet away.

OPEN LANES BETWEEN COTTON ROWS.

The facts already stated emphasize the need of cultural methods that will keep the plants upright and the lanes well open between the rows, avoiding as far as possible the spreading plants, heavy foliage, and continuously shaded ground that mark the condition of boll-weevil cotton. Cultural control of the form and branching of the plants is the more possible because the large plants do not differ merely in their greater size but in structure as well, by having two distinct kinds of branches, while the small single-stalk plants have only one kind of branches, those that bear the flowers and bolls. The strong spreading branches that come out near the base of large widely spaced plants are not the same as the fruiting branches of the single-stalk plants but are in the nature of secondary stalks, having the same structure and functions as the main stalk of the plant. The production of bolls by means of these secondary stalks, or vegetative branches as they have been called, requires a longer season than to produce bolls on the fruiting branches of primary stalks. Hence, narrow, upright plants with only the central upright stalk and none of the spreading secondary stalks are preferable for purposes of production, especially under weevil conditions.

There is a general cultural reason for keeping open lanes between cotton rows, in order to permit the lower fruiting branches to develop and bring the early bolls to maturity, as well as special reasons for having open lanes in weevil-infested regions. The conditions of temperature, light, and moisture at the surface of the ground are very different in open fields from the conditions that obtain in continuously shaded boll-weevil fields. The heating and drying of the surface of the soil not only kill the weevil larvæ in the fallen squares, or floral buds, but the greater exposure to sunlight in the open lanes tends also to restrict the activity of the adult weevils, so that bolls continue to be set on isolated plants and in open rows only a few feet away from immense numbers of weevils living in the shelter of the boll-weevil cotton. Thus, the keeping of the lanes open between the rows is to be reckoned as an essential of successful cultivation of cotton in southern Texas if full advantage is to be taken of the possibilities of setting a crop when the favorable conditions of dry weather occur. If the lanes are closed the effect of dry weather is lost, because the weevils are protected.

WIDER LANES AND CLOSER SPACING IN THE ROWS.

To grow large plants in wide rows is not a practical way to keep the lanes from closing and the ground from being shaded. Wider spacing of individual plants has been considered and sometimes advised as a way of securing more exposure and thus avoiding weevil injury, but the limitations of such a method are apparent when the behavior of the plants is taken into account. If plants are supposed to be of the same size, wider spacing would mean, of course, that the fields would be more open and give the weevils less protection, but the plants vary in size and generally grow larger and produce stronger and more spreading branches in proportion to the space allowed. Hence, crowding may not be avoided by wider spacing, even with plants 2 or 3 feet apart in the rows. If the conditions favor luxuriant growth the ground under the plants is shaded and the weevils are protected.

With large widely spaced plants recognized as unpractical, the feasibility of wider lanes will be seen to depend on keeping the plants smaller by leaving them closer together in the rows. Experiments at San Antonio in previous years with different seasonal conditions have suggested that wider lanes and closer spacing of plants in the rows might be a means of securing a safer and more regular production, if not the largest production, of cotton under the San Antonio conditions, taking account of the many dry seasons when lack of moisture instead of weevil damage is the limiting factor.

The danger in dry seasons is that the plants will not grow large enough to produce a crop, or that the crop may be lost if the plants are so severely checked by drought that the buds or young bolls are aborted. In dry seasons small plants in widely spaced rows have the best prospect of securing moisture enough to reach the fruiting stage, of avoiding serious checks, and of taking full advantage of any favorable conditions that may occur. No doubt the best or safest spacing might depend somewhat upon the nature and water-holding capacity of the soil, but tentative experiments in previous dry seasons at San Antonio indicated that about the same yield of cotton per acre may be obtained with rows as much as 5 or 6 feet apart as with rows 3 feet apart. The results were not consistent in other years, and a wider range of experiments will be necessary to determine the facts. Some of the experiments were made with 6-inch spacing, but the thinning was done later than would be advisable if the plants were to be left still closer together with the rows wider apart. Little or no thinning might be necessary if the stands were not too thick.

If favorable conditions could be assured in the early fruiting stage, close spacing of the rows as well as of the plants in the rows might give the largest yields, as some experiments show. But if weevils survived the winter in large numbers and destroyed the early buds, there could be little prospect of a crop later in the season, since with the rows close together the ground is soon covered and shaded, and the weevils may continue to breed even in dry weather.

Cutting out alternate rows would be a way to get more exposure, if early-season conditions proved unfavorable or the weevils were so numerous that an early crop could not be set. If late-season conditions, like those of 1921, could be assured, cutting out the alternate rows might be a practical measure, even with rows as far apart as 4 feet, but might give no advantage if wet weather continued late in the season.

At San Antonio the largest yields have been obtained in some seasons with rows only 3 feet apart, but it is recognized that this result would depend upon favorable early-season conditions, which are by no means assured in southern Texas. In some years the weevils are very abundant early in the season, and the setting of a crop has often depended very definitely upon a period of dry weather to hold the weevils in check. With the rows close together the condition of continuous shading of the ground would be reached earlier in the season, and there would be less chance of the weevils being checked by periods of dry weather. If the conditions of boll-weevil cotton can be avoided, the plants may be able to take advantage of favorable periods of dry weather to set a crop, even late in the season, as shown by the facts already stated. The results of a single season are not to be taken as an index of the best course to be followed as a general rule. An ideal system would make it possible to take full advantage of favorable conditions at any stage in a region of very variable weather like southern Texas.

FEASIBILITY OF WIDER LANES.

Since the results of 1921 showed that plants spaced at 6 inches might still grow into rather rank boll-weevil cotton, still closer spacing in the rows to 4 inches or less may prove desirable. One question to be determined is whether there is a practical advantage in chopping or pulling out any of the plants. Unless the stands are very thick and the plants likely to become very spindling or stunted for lack of moisture, no thinning may be necessary or give any advantage in yield.

In the dry wind-swept regions of the Southwest the young plants grow better in the spring if they stand close together in the rows. Very large yields as well as very early crops have been obtained from small plants only 3 or 4 inches apart and also from rows that have not been thinned. Some plants in these rows remain very small and bear only one or two bolls or none at all, but these presumably include the weaker plants that would have borne little if they had been left in the usual thinning. It usually is possible to find many unproductive or completely sterile plants in fields of cotton, even with wide spacing.

Rows thinned early to 3 or 4 inches should be compared with no thinning to learn the actual results under the Texas conditions and to determine definitely whether advantages are gained by thinning. If thinning can be omitted labor and expense will be saved, and there may be a distinct cultural advantage in avoiding the setback that the plants are likely to receive from injuries in the thinning operation and in the greater exposure to wind or other unfavorable conditions that often interrupt the growth of young cotton if thinned too early and spaced widely. The feasibility of wide lanes is not to be determined without a clear understanding of the effects of close spacing in the rows as an essential feature of an open-lane culture for avoiding boll-weevil cotton.

With complete loss of the crop as a frequent penalty enforced by the boll weevils if the lanes are not kept open, many farmers may be inclined to test for themselves the feasibility of wider lanes, such as 4½ or 5 feet, but in all such cases, to gain experience of practical value, the spacing of the plants in the rows should be taken into account.

FACTORS OF THE SPACING PROBLEM.

Careful consideration needs to be given to the spacing problem, because numerous factors are involved and wide variations of soil and seasonal conditions must be taken into account, especially in southern Texas. Questions of spacing may have a special importance in this region because it is less feasible to hold the weevils in check by poisoning. Regular use of poison is hardly to be expected in Texas in districts where the weather often is dry enough to suppress the weevils.

In some parts of Texas there is little or no dew to moisten the leaves and hold the poison, which is applied as a fine dust. Moreover, the use of poison is not considered economical on cotton that is not expected to yield more than half a bale per acre. Low yields are the general rule in the drier districts of Texas, even when the boll weevils do little or no damage. One of the compensating advantages, in addition to weevil protection, is that farmers of the drier districts are less troubled with weeds, so that costs of cultivation are lower than in humid regions.[2]

The spacing problem is complicated by the very wide range of seasonal conditions, the Texas climate being notoriously capricious. That any one method of spacing will assure the largest possible results under all conditions is too much to expect, but the method that is safest, in the sense of giving the best average of results under varied conditions and for a period of years, would be reckoned as the most practical. To develop such a method and to secure the evidence that would be necessary to establish it in popular recognition as the best must require many experiments and a wide range of practical experience as well as a great amount of interest and information in the hands of the farmers. Since it is not to be expected that farmers will make a practical and effective use of a cultural method that they do not understand, careful study and observation of the facts are a necessary preliminary to the practical use of better methods of spacing.

With differences of seasons, soils, and other variable factors to be taken into account, the weevils may be very irregularly distributed, and cultural experiments may miscarry or the results may be deceptive if the behavior of the weevils is not considered. One side or one corner of a field may be thoroughly infested before any damage is done in other parts of the same field. The factor of weevil infestation may interfere seriously with the testing of varieties or with cultural experiments by methods that for other purposes are considered most reliable.

Repeated side-by-side comparisons of two varieties or two cultural methods, as represented by small blocks or strips of cotton planted in alternation, give the most direct and convincing evidence when consistent results are secured. From 4 to 6 rows of the same kind of cotton or representing the same treatment are planted in each block, the blocks are repeated 3 or 4 times in alternation, and the cotton from each row is picked, weighed, and recorded separately. The last precaution, of records of individual rows, is important as affording the best evidence to show how uniform or how irregular the conditions of the experiment actually were and whether any differences were consistently shown in the repeated comparisons.

But such methods of testing may not give significant results if the weevils are very abundant. Differences that might be very important in separate fields of cotton may not be shown definitely in side-by-side plantings, or may even appear reversed if weevils are bred in larger numbers on an adjacent early variety, early planting, or early thinning, so that the cotton of later development suffers worse. Thus, the true advantage of closer spacing of plants in the rows may not be shown in some experiments if the weevil population is too large at the beginning of the experiment and is being increased rapidly by breeding more weevils in earlier flower buds of adjacent wide-spaced rows. In such cases there may be more weevils to attack the buds of the close-spaced rows than in a field planting not adjacent to other cotton or if whole communities planted their cotton

[2] Coad, B. R., and Cassidy, T. P. Cotton boll weevil control by the use of poison. U. S. Dept. Agr. Bul. 875, 31 p. 1920.

at the same time and used the same methods, which would be the ideal system of weevil control.

Comparisons of different dates of planting or of different spacing methods necessarily lose their significance when the weevils are so abundant that no crop can be set or when enough weevils are bred in the earlier plantings to destroy adjacent later plantings. A method or precaution may show a practical effect in avoiding weevil damage under the ordinary conditions when there is moderate or light infestation of weevils, but the same method may show no advantage in seasons when the weevils come through the winter in large numbers, as happens occasionally in southern Texas. Though the weevil population is relatively small in the spring, enough weevils may survive the winter to destroy all of the early buds, depending largely upon the weather conditions of the fall, winter, and spring seasons. Thus, in the fall of 1921 the frosts came very late, much of the cotton in northern Texas, as around Greenville, not being killed till the night of December 24, so that the survival of large numbers of weevils could be expected. It is easy to understand that in such years the normal and usual advantages of early fruiting are not realized and that everything may depend upon the opportune occurrence of a period of dry weather in June or July to check the reproduction of the weevils and allow some bolls to set.

Even the best methods of handling the crop may fail sometimes if conditions are too adverse or the weevils are abundant early in the season and are not checked by dry weather or by the use of poison. Though experience in Texas has shown that complete destruction of the crop by boll weevils is a rare and local occurrence if reasonable precautions are taken, the possibility of total destruction in exceptional years has to be recognized and unreasonable panic avoided, or frantic changes of varieties or methods, for worse instead of better. With other crops it is recognized that even the best varieties or the best methods may fail if conditions are too adverse, and cotton is no longer the "sure crop" of preweevil times. No kind of cotton is weevil proof, in the sense of having any complete protection from weevil attack, and no method of handling the crop can assure safety under all conditions, though striking advantages may be shown under ordinary circumstances.

Farmers in southern Texas who know how the seasonal conditions fluctuate will the more readily appreciate the difficulties that may be encountered in any particular test or demonstration of methods and the need of observing carefully the behavior of cotton and the extent of weevil injury under different conditions or of trying simple experiments with different spacings to see what can be gained by this means under their local conditions. Even when no effort is made to try a formal experiment, significant information may be obtained by careful observation of the behavior of different plantings if the different features and factors of the problem are kept in mind and conclusions not drawn prematurely on the basis of limited experience or the results of a single comparison.

EARLY CROPS FROM SMALL PLANTS.

On account of the longer season required and the later opening of the bolls of large plants, it is plain that the further solution of the problem of avoiding weevil damage does not lie in the direction of the wider spacing and larger size of the individual plants, but in the opposite direction, of spacing closer in the rows to restrict the size of the plants and bring them to maturity earlier in the season. Restricting the growth of the plants does not mean that they are to be checked or stunted, for time is lost in starting again when growth has been stopped by any serious setback to the crop. Large plants are more exposed to serious checking by drought or other unfavorable conditions than plants of the medium or small size that are produced by closer spacing.

Large plants require more time to set a crop and may fail to open their bolls before frost, while the smaller plants in the same fields may have opened all their bolls. The earlier opening of the bolls of small plants is a fact that most farmers know or can observe readily for themselves, and this is a very important fact in relation to the spacing problem. The damage that the frost does to the bolls of large plants is usually avoidable through cultural control of the size of the plants. Though many special features and local applications of the closer spacing methods remain to be worked out, the need of restricting the growth of the plants as a means of securing earlier and larger crops is widely recognized and frequently discussed in agricultural newspapers.

Since the weevils do not breed until there are flower buds to feed upon, the object of cultural expedients is to set a crop as quickly as possible after the flower buds begin to form but before the weevils have increased to such numbers that all of the buds are infested. Thus, earliness should be measured by the period between the formation of flower buds and the setting of a crop rather than by the date of the first flower or the total number produced. Relatively little damage usually is done to early bolls, as the weevils prefer to feed and lay their eggs in the floral buds, being by habit and preference bud weevils instead of boll weevils. The advantage of producing many flowers and setting many bolls in a short space of time does not lie with the large, widely spaced plants, but with the small or medium-sized plants, when adjacent rows of the different spacings are compared. The large plants may grow much faster, but do not on that account set a crop more rapidly or safely.

Even though small plants, standing close together, may not begin to flower quite as early as larger and more widely spaced plants, a distinct advantage of practical earliness may be shown by small plants in being able to set larger numbers of bolls in shorter periods of time and thus make full use of any favorable conditions that may occur. The general rule is that large plants require more time, both for setting and for maturing the crop. Thus, at San Antonio, Tex., in the season of 1914, when the fruiting period was very short, the yields of Acala cotton spaced to 4 inches in the row more than doubled the yields of rows with 2-foot spacing that produced large, spreading plants.

In comparisons of 6-inch and 12-inch spacings of Lone Star cotton at San Antonio in 1921, with rows 4 feet apart, even the 6-inch plants grew rather large and produced enough vegetative branches to close the lanes and shade the ground between the rows. The yields of the 6-inch and the 12-inch spacings, compared in alternate 4-row blocks, were nearly equal, although the 6-inch rows were thinned a little later than the 12-inch and no doubt were handicapped somewhat by their proximity to 12-inch rows. As already explained, the earlier thinned 12-inch rows, not being restricted like the 6-inch rows, could produce earlier buds and breed more weevils to attack the later thinned rows.

At Greenville, Tex., in 1921, unthinned rows with plants averaging about 3 inches apart gave the highest yields in a carefully conducted test. The next highest yields were from 6-inch rows, and the lowest yields from rows with 12-inch spacing. The 6-inch rows gave an average increase of 18 per cent and the 3-inch rows an average of 25 per cent over the 12-inch rows, as reported by Homer C. McNamara, who conducted the experiment. These results were from repeated comparisons of the different spacings, and all the blocks were thinned on the same day. Moreover, the results were consistently in favor of the closer spacings, whether the blocks were treated as wholes or as individual rows. It was noted also that plants with the very close spacing were more slender and erect and grew to a somewhat greater height than those in the 6-inch and 12-inch blocks and that the lanes appeared wider between the close-spaced rows. The season at Greenville was unusually dry and restricted the plants to a moderate growth.

Placing the rows farther apart should be considered as a measure of safety to avoid the condition of boll-weevil cotton rather than as a way of securing the largest possible yields under the most favorable conditions. But a general advantage could be claimed for a system that produced better crops under extreme conditions and did not fall seriously behind in ordinary seasons. As Mr. Simpson observes, in the San Antonio district many farmers in the drier parts have more land than they cultivate, so that the chief object in cultural methods is to produce a given quantity of cotton at the smallest labor cost rather than to secure the highest yield per acre, if this should require more labor. Reducing the number of rows might save labor in dry regions where the weed problem is less serious.

If a simplified method should enable larger areas to be handled at the same labor cost and larger yields secured in this way, the farmer would have an advantage, although the yields per acre might be less. Experiments were conducted at San Antonio in 1915, 1916, and 1917, with plants spaced to about 6 inches in rows 3, 4, 5, 6, and 7 feet apart. The yields of the rows gave very definite increases with the greater width of lanes. In 1915 the increased yields of the widely separated rows, including those that were 6 and 7 feet apart, were sufficient to equalize the yield per acre with the closer rows. In the two succeeding years the larger yields were with rows closer together, but the differences of labor cost were not reckoned.

Undoubtedly the possibilities of securing advantages from dry weather are greater in Texas than farther east, so that the spacing problems are different. Along the northern rim of the Cotton Belt, where the seasons are short and the weather seldom is dry enough to stop the multiplication of the weevils, no advantage would be expected from placing the rows farther apart. Very large yields, 2 bales or more per acre, are reported by W. C. Bailey at Covington, Tenn., with rows only 2 feet apart and the plants only 3 or 4 inches apart in the rows. Such a field was visited by Robert L. Taylor, of the Bureau of Plant Industry, and photographs were taken (Pl. IV).

In a 100-foot section of a row 312 plants were counted by Mr. Taylor, with a total of 752 bolls, or only two or three bolls per plant, on the average, but yielding at the rate of about 2,100 pounds of seed cotton per acre. Further tests must determine whether this extreme method of close spacing can be used to general advantage in Tennessee or elsewhere. But Mr. Bailey's experiment is of interest as showing the range of possibilities that must be taken into account to meet the requirements of different local and seasonal conditions.

Very high yields were obtained from a one-fourth-acre plat of Pima (Egyptian) cotton grown at Sacaton, Ariz., in 1918, with the rows 2½ feet apart and the plants spaced to about 4 inches; but repetition of this experiment in 1920 and 1921 gave different results. In 1920 there were no heavy summer rains, so that it was possible to control the growth of the plants by careful irrigation, while in 1921 such control was not possible, owing to heavy rainfall in July and August. With too much moisture and rank growth, the plants became tall and spindling, and the yield was reduced to a rate of 1,148 pounds per acre, in comparison with 2,113 pounds in 1920 and 3,136 pounds in 1918. Several of the wider spacings in 1921 yielded more than the very close rows; hence it would have been very unfortunate if the farmers had been advised to plant their cotton 2½ feet apart because this arrangement gave the highest yield in 1918.

LATE THINNING TO SUPPRESS VEGETATIVE BRANCHES.

For close spacing to be practicable the vegetative branches or secondary stalks should be suppressed, so that the plants have only the single main stalk. Injurious crowding results if many vegetative branches are produced on plants that stand close together. Even at 12, 15, or 18 inches apart the plants may be too crowded if there are many vegetative branches, more crowded, in fact, than single-stalk plants with 6-inch or 3-inch spacing. The development of vegetative branches is influenced, of course, by the weather and the soil conditions as well as by the spacing. With rich soil and hot weather there is danger of producing too many vegetative branches if the plants are thinned early and left more than 6 inches apart.

It has been supposed that cotton should be thinned as early as possible, to make the plants stocky and spreading, after the analogy of trees; but such plants are more likely to produce vegetative branches than to mature an early crop of bolls. Very early thinning of cotton is often detrimental on account of greater exposure of the young seedlings to dry winds, blowing sand, and cutworms or other pests, so that the stand may be lost or seriously reduced. Very late thinning is also distinctly detrimental when the plants are checked and made too spindling. Fruiting branches on the lower joints of the main stalk, as well as vegetative branches, may be suppressed if the stand is thick and thinning is deferred too long. Hence it is important not to thin too early or too late, but to adapt the time of thinning to the needs of the particular case as determined by the conditions of the plants and the width of spacing to be used, if that has been decided beforehand. Between the extremes of early and of late thinning an exercise of practical judgment is possible if the factors of the spacing problem are clearly understood.

The precaution of thinning rather late, when the plants are from 6 to 10 inches tall, is in order when conditions favor luxuriant growth and the farmer wishes to use rather wide spacing, 10 to 12 inches or more. This tends to suppress the vegetative branches and to reduce the risk of injurious crowding later in the season. If close spacing is to be used, 8 inches or less in the rows, or if two plants are left in a hill with 10-inch, 12-inch, or 15-inch spacings, there is no object to gain by deferred thinning, since the vegetative branches are not likely to be troublesome with such close spacings under normal conditions that do not force rank vegetative growth of the plants. The possibility of suppressing the vegetative branches and the importance of doing so were recognized first in Arizona, in connection with Egyptian cotton, which often grows too rank, so that the vegetative branches are recognized as a distinct menace to the crop, even to the extent that some farmers have considered it worth while to cut off the vegetative branches in order to keep the lanes open.

Close-spaced plants may grow too tall and become too spindling if the conditions are such that an excess of vegetative growth can not be avoided, but if single-stalk plants can not be grown to advantage the results are worse with large, spreading plants. Some lands are too rich and moist to raise cotton to the best advantage. Even though large crops may be produced in favorable seasons, there may be complete failures in other years, and the planting of cotton is not justified where failures are too frequent.

Since the use of deferred thinning is only to suppress the vegetative branches under conditions of too luxuriant growth, where the production of many vegetative branches is a danger to the crop, it is a mistake to extend this precaution to other conditions where no restriction of the growth of the plants is needed. Good understanding and practical judgment of spacing questions are not to be expected unless the vegetative branches are taken into account. If plants that are spaced, for example, at 12 inches develop many vegetative branches, they become too crowded, and the lanes are closed between the rows, so that the yield may be smaller than with plants of the same general size and number of vegetative branches but spaced farther apart. Though most of the experiments reported in former years show larger yields for 12 inches than for wider spacings, cases probably occurred where early-thinned plants produced vegetative branches and became too crowded at 12 inches, while the wider spacings with more room could produce bolls on secondary fruiting branches when the period of setting the crop was longer, before the boll weevils came. Such cases of larger yields secured occasionally from 16-inch or 18-inch spacings would explain why 12 inches was looked upon as the practical minimum of close spacing before the existence of the two distinct kinds of branches and the possibility of suppressing the vegetative branches were recognized.[3]

CLOSE SPACING NECESSARY WITH LATE THINNING.

Apart from the intentional use of late thinning to suppress vegetative branches under conditions that require this precaution, the

[3] Cook, O. F. Dimorphic branches in tropical crop plants: Cotton, coffee, cacao, the Central American rubber tree, and the banana. U. S. Dept. Agr., Bur. Plant Indus. Bul. 198, 64 p., 9 fig., 7 pl. 1911.

question of late thinning may be forced upon the farmer by bad weather or other accidents that not infrequently interfere with the work of thinning at the stage that he prefers. Too much rain, pressure of other farm work, or inability to obtain enough labor for chopping at the proper time may bring the farmer to the necessity of thinning his cotton late and still getting as large a crop as possible. In such cases it is important to know that wide spacing is not advisable and often is positively injurious to cotton that is thinned late.

Late-planted cotton often shoots up rapidly to a height of a foot or more before it can be chopped, and then a serious injury may be done if the plants are spaced more than a few inches apart. Many farmers suppose that such fields, because of the tendency to rank growth in late plantings, should have wider spacing than cotton that is planted and thinned early, but the practical need is to restrict the growth and get a crop of bolls set as early as possible, especially under weevil conditions. If the cotton is thinned late, so that the vegetative branches are suppressed, the plants need not be more than 6 inches apart in the rows, and the largest yields are likely to be secured from still closer spacing.

As a general principle or rule, the longer thinning is deferred the less thinning should be done. If the plants do not average less than 2 or 3 inches apart in the row, little or no advantage in yield should be expected from thinning. Farmers who consider this too unreasonable should at least try the experiment for themselves, since this can be done with no expense or trouble by the simple expedient of leaving some of their cotton without thinning when the stands are not too heavy.

Of course, good results are secured very often with early thinning and wide spacing under the conditions of moderate growth that are more likely to be encountered early in the season. Early planting is the more necessary to insure good results with wide spacing, while with late-planted cotton the precaution of closer spacing is the more necessary, to avoid the production of large late-maturing plants, which is the normal tendency of rank growth. If late cotton is spaced widely and allowed to grow large, the prospects always are poor, especially under weevil conditions, but the chances of a crop are greatly improved by leaving the plants closer together.

Late plantings are not advisable, of course, and usually suffer much worse from the weevils, especially if they are close to early plantings that breed weevils in advance. But late plantings may be the only chance of a crop if early plantings are destroyed by bad weather or other accidents, and an opportune period of dry weather, by checking the weevils at the right time and restricting the growth of the plants, may allow a late planting to set a good crop. In some cases early plantings have been outgrown and outyielded by later plantings in adjacent rows. This is explained by the checking and stunting of the young plants by exposure to long periods of cold weather or other unfavorable conditions early in the season, while the later plantings have more uniformly favorable conditions.

CONCLUSIONS.

The expression "boll-weevil cotton" is used in Texas to describe an abnormal luxuriance of the plants induced by the boll weevil. In years when the weevils are abundant early in the season and most of the flower buds are destroyed, the plants grow more vigorously, attain a larger size, and show a deeper green color than in normally productive fields. Large numbers of sterile, defective involucres, lacking the essential organs of normal cotton flowers, are produced on boll-weevil cotton in the latter part of the season.

As a result of the more luxuriant growth of boll-weevil cotton, the fields are soon covered with a dense mass of foliage, the lanes are closed between the rows, and the ground is shaded continuously. Under such conditions the weevils breed in large numbers and there is no prospect of producing a crop. Weevil larvæ in fallen buds are protected by the shade of the overgrown plants instead of being killed by exposure to heat and dryness.

Seasonal conditions at San Antonio, Tex., in 1921, afforded definite contrasts and illustrations of the limiting factors of cotton production in the presence of the boll weevil. The insects were so abundant that most of the flower buds were destroyed, though other conditions were favorable for the growth of the plants and the production of a large crop of cotton.

After the plants had grown large and reached the condition of boll-weevil cotton, the heavy foliage and continuous shading of the ground protected the weevils, even during dry weather. Thus, the normal advantages of dry weather in restricting weevil injury were completely lost in the fields of boll-weevil cotton, and very few bolls were produced. But many late-season bolls were matured on individual plants and open rows that stood apart, even for a few feet, from the boll-weevil cotton.

The behavior of well-fruited open plants, contrasting with that of sterile crowded plants, shows the necessity of avoiding the rank growth and dense shade conditions of the boll-weevil fields. The setting of many late bolls on exposed individual plants and open rows of cotton shows how strictly the insects, during periods of dry weather, are dependent upon the protection afforded by the boll-weevil cotton and teaches the necessity of avoiding the rank growth and continuous shading of the fields. The advantage of cultural methods that will keep the lanes open between the rows is clearly indicated.

Wider separation of the rows, combined with closer spacing of the plants in the row, is a way of restricting the size of the individual plants, keeping the lanes open between the rows, and avoiding the adverse condition of boll-weevil cotton. Experiments have shown that wider rows with closer spacing of plants in the rows is a practicable method of culture and likely to have advantages in dry seasons as well as in years of boll-weevil cotton.

Though further tests and experiments are needed to determine the best arrangements of rows under different local conditions, the indications are that the rows should not be less than 4 feet apart and the plants should not be more than 6 inches apart in the rows to give the best assurance of suppressing the secondary stalks, keeping the lanes open between the rows, and avoiding boll-weevil cotton. As an emergency measure, in the absence of other precautions in spacing, the cutting out of alternate rows might be advisable as a means of avoiding the condition of boll-weevil cotton, as shown by the higher yields of the open rows and exposed plants that continued to set bolls late in the season in the San Antonio experiments of 1921.

Where close spacing is used, 6 inches or less, the vegetative branches, or secondary stalks, are likely to be suppressed without the further precaution of deferred thinning that may be required with the wider spacing of the plants, to 10 or 12 inches. The use of deferred thinning is to suppress vegetative branches under conditions of very luxuriant growth, but under ordinary conditions thinning should be done when the plants are 5 or 6 inches high. Several experiments have been reported where the largest yields were from rows that were not thinned. If thinning is deferred longer than necessary some of the lower fruiting branches as well as the vegetative branches are likely to be suppressed. A special need of close spacing is to be recognized with cotton that is planted late or where thinning has been deferred till the plants are 10 inches or a foot high. No thinning may be necessary with open or scattering stands where plants do not average less than 2 or 3 inches apart in the row.

LIST OF PUBLICATIONS ON WEEVIL RESISTANCE AND CLOSE SPACING OF COTTON.

COOK, O. F.

1904. Evolution of weevil-resistance in cotton. *In* Science, n. s., v. 20, p. 666–670.

1906. Weevil-resisting adaptations of the cotton plant. U. S. Dept. Agr., Bur. Plant Indus. Bul. 88, 87 p., 10 pl.

———, McLachlan, Argyle, and Meade, Rowland M.

1909. A study of diversity in Egyptian cotton. U. S. Dept. Agr., Bur. Plant Indus. Bul. 156, 60 p., 6 pl.

COOK, O. F.

1909. Local adjustment of cotton varieties. U. S. Dept. Agr., Bur. Plant Indus. Bul. 159, 75 p.

1911. Dimorphic branches in tropical crop plants: Cotton, coffee, cacao, the Central American rubber tree, and the banana. U. S. Dept. Agr., Bur. Plant Indus. Bul. 198, 64 p., 9 fig., 7 pl.

1911. Relation of drought to weevil resistance in cotton. U. S. Dept. Agr., Bur. Plant Indus. Bul. 220, 30 p.

1912. Cotton improvement on a community basis. *In* U. S. Dept. Agr. Yearbook, 1911, p. 397–410.

1912. Results of cotton experiments in 1911. U. S. Dept. Agr., Bur. Plant Indus. Circ. 96, 21 p.

MCLACHLAN, ARGYLE.

1912. The branching habits of Egyptian cotton. U. S. Dept. Agr., Bur. Plant Indus. Bul. 249, 28 p., 1 fig., 3 pl.

COOK, O. F.

1912. Cotton improvement under weevil conditions. U. S. Dept. Agr., Farmers' Bul. 501, 22 p.

1913. Morphology of cotton branches. *In* U. S. Dept. Agr., Bur. Plant Indus. Circ. 109, p. 11–16.

1913. A new system of cotton culture. *In* U. S. Dept. Agr., Bur. Plant Indus. Circ. 115, p. 15–22.

1913. The abortion of fruiting branches in cotton. *In* U. S. Dept. Agr., Bur. Plant Indus. Circ. 118, p. 11–16

1913. Cotton problems in Louisiana. *In* U. S. Dept. Agr., Bur. Plant Indus. Circ. 130, p. 3–14.

1914. A new system of cotton culture and its application. U. S. Dept. Agr., Farmers' Bul. 601, 12 p., 2 figs.

1914. New factors in cotton culture. *In* Bul. Georgia State Col. Agr., v. 2, no. 12, p. 115–126, 3 fig.

1914. Single-stalk cotton culture. U. S. Dept. Agr., Bur. Plant Indus. Misc. Pub. 1130, 11 p., 12 fig.

MEADE, ROWLAND M.

1915. Single-stalk cotton culture at San Antonio. U. S. Dept. Agr., Bul. 279, 20 p., 3 fig., 6 pl.

CARDON, P. V.

1918. Experiments with single-stalk cotton culture in Louisiana, Arkansas, and North Carolina. U. S. Dept. Agr. Bul. 526, 31 p.

AYRES, W. E.
1919. Cultural experiments with cotton—1918. Ark. Agr. Exp. Sta. Bul. 161, 15 p., illus.

COOK, O. F.
1919. Experiments in spacing cotton. *In* Jour. Amer. Soc. Agron., v. 11, p. 299–303.

1920. Cotton a community crop. *In* Jour. Heredity, v. 11, p. 174–177.

WALKER, G. B., and AYRES, W. E.
1921. Cultural experiments with cotton. Miss. Agr. Exp. Sta. Circ. 35, 4 p.

ANONYMOUS.
1921. Shall we adopt thick spacing? Farmers give thick spacing a try out. *In* Progressive Farmer, Raleigh ed., v. 36, no. 14, p. 1, 7. Also in Ga.-Ala. ed., v. 36, no. 14, p. 1, 7.

1921. What distance between cotton plants? *In* Okla. Farmer, v. 31, no. 11, p. 5, 15.

ULM, AARON HARDY.
1921. Plant crowding defeats boll weevil. *In* Farming, v. 2, p. 41–44, illus.

CATES, J. SIDNEY.
1922. A revolution in cotton planting. *In* Country Gentleman, v. 87, no. 7, p. 6, 40, illus.

KNAPP, BRADFORD.
1922. Production of cotton under boll-weevil conditions. Col. Agr., Univ. Ark. Ext. Serv. Circ. 128, 12 p.

BRYAN, A. B.
1922. Thick spacing of cotton pays. *In* Progressive Farmer, Raleigh ed., v. 37, no. 15, p. 6.

BISHOP, GEORGE.
1922. Cotton thick in the row. *In* Okla. Farmer, v. 32, no. 8, p. 13.

BROWN, H. B.
1923. Cotton Spacing. Miss. Agr. Exp. Sta. Bul. 212.[4]

---

[4] This recent publication contains an interesting summary of experimental data on close spacing and emphasizes the importance of not going to extremes in late thinning, which is possible through a misunderstanding of the single-stalk system. The author concludes as follows:

"We believe that cotton plants should be thinned as early as it is safe to do so—that is, as soon as the danger of losing a stand from cold weather, damping-off fungi, etc., has passed and before the plants are stunted by undue crowding."

This is a good statement of the rule that should be followed, since it avoids the other extreme of thinning cotton too early, "as soon as it comes to a stand," which is frequently advised. The full advantage of the single-stalk system is not gained if the plants are allowed to become stunted or spindling, as happens with thick stands that are left too long before thinning. Specially delayed thinning is in order only where it is necessary to suppress vegetative branches.

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
5 CENTS PER COPY
SUBSCRIPTION PRICE, 80 CENTS PER YEAR

▽