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COTTON INVESTIGATIONS

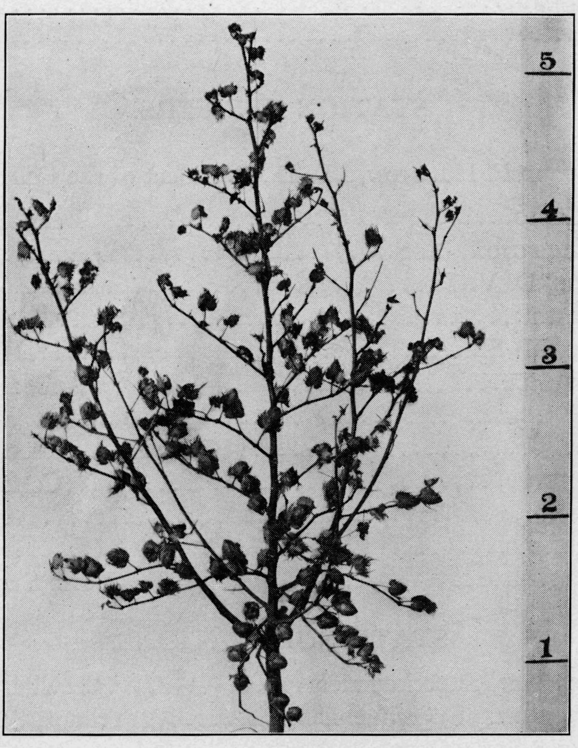
OF THE

BUREAU OF PLANT INDUSTRY, U. S. DEPARTMENT OF AGRICULTURE

AND THE

TEXAS EXPERIMENT STATION

EARLY COTTONS



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EARLY COTTONS.

By R. L. Bennett.

Investigations with different cottons planned by and in charge of the writer were begun this season at College Station, Texas, by the Bureau of Plant Industry, U. S. Department of Agriculture, through the Laboratory of Plant Breeding and the Texas Experiment Station, to secure information on the earliness of the cotton plant in the growth of fruit. The urgent need for such information is readily seen when it is understood, as Texas farmers understand it, that earliness is essential in making a successful crop where boll weevils destroy all late fruit as fast as it is formed. The presence of boll weevils means a shortened fruiting season.

While the work has been in progress only one season, and the results are to that extent immature, yet some features of certain nature are sufficiently conclusive to warrant a brief account of them at this time when growers are specially concerned with the qualities of earliness and productiveness in seed for planting their next crop. An advanced statement of these results for use in seed selection appeared in the Texas press September 10.

SOURCES OF SEED AND VARIETIES FOR THE INVESTIGATIONS.

For this work seed were obtained from originators and reliable seedmen of the earliest cottons and of some of the best late cottons; northern seed of good quality were obtained that had been grown for a long time in the northern edge of the cotton region, northeast Arkansas, and the Pan Handle of Texas; also common native seeds from south and central Texas, at LaGrange, College and Waxahachie. The intention was to study early and late varieties, and cotton from north and south edges of cotton region, and local seeds in their relations of growth and earliness. The varieties are listed herewith: King, Shine, Toole, Welborn, Herlong, Doughty, Drake, Boyd, Peerless, Peterkin, Hawkins Excelsior, Russell, Truitt, Allen, Berry Big Boll, Rowdan, Jones' Storm Proof, Bohemian, Jones' Little Boll, Owens, Meyer, and three Texas big boll cottons.

The earliness of certain varieties and the earliness of seed from different sources are important, since Texas farmers are importing largely of early varieties and of common seed from far northern sections in the hope of gaining in early fruiting.

The seeds of the several varieties and sources were planted April 9, twenty days later than they might have been planted but for the late arrival of some of the seed. Weevils appeared a few days after the cotton came above ground, and were so numerous as to stop all fruiting after July 20th; indeed they were so numerous that cotton planted June 8 did not grow an average count of one boll to the stalk, though the stalks grew from four to five feet high before they were stripped by caterpillars about September 25. The yield of the cottons planted April 9 was three-quarters of a bale per acre, with a few exceptions.

STRUCTURE OF THE COTTON PLANT IN ITS RELATION TO EARLINESS AND PRODUCTIVENESS.

The cotton plant is made up of a main stem, primary and fruit branches, and these are divided into joints, and at the joints in the axil of the leaves on the fruit branches, fruit or bolls are grown.

In studying the early and late cottons as they grew and developed, noting the rate of growth, rate and date of fruiting and measuring the final extent of growth and yield it was found:

First—That the early and late cottons differed in length of joint, i. e., space between successive leaves, or

Second—They differed in the presence or in the absence of fruit limbs at the first joints on the main stem.

The early cottons had short joints and began the growth of fruit limbs at the first joints on the main stem near the ground. See Fig. 1. The joints or spaces between successive leaves must be short, otherwise to produce the same number of bolls the plant would have to be larger than could be grown in a season. It was found that the late cottons had long joints or that fruit limbs were absent at the first joints on the main stem near the ground.

By beginning the growth of fruit limbs at the base of the plant and of fruit in the first leaf axil of the first fruit limb, plants matured this first fruit early in their fruiting season. This early setting of fruit was an additional advantage since such plants had a longer time in which to fruit before the weevils became so numerous as to destroy the later fruit as fast as it formed. Failure to grow fruit or fruit limbs at the base of the plant shortens the fruiting season, as well as makes the fruit late in appearing. See Figs. 3 and 4.

The length of fruit limbs and their number were found to be important in determining the earliness of fruit. Many growing points rapidly increase the number of joints at which the fruit or squares form. But the joints must be short in order that a fruit limb of reasonable length may accommodate several squares or bolls. Rapidity of fruiting or the formation of many squares in any given time was, therefore, found to be directly concerned with the length of joint, with the number of growing fruit limbs, and with the rate of growth.

The structure of the plant as regards the length of joints and fruit limbs is determined by forces inherent in the plant of normal growth, and when the desired structure is once found its continuation is a matter of seed selection. The rate of growth, however, is mainly dependent on cultural conditions and food and water supply. When a deficiency of food supply is remedied by fertilizers, the rate of growth is increased, and a rapid formation of joints and squares occurs. Thus the first or early formed fruit matures early in the fruiting season.

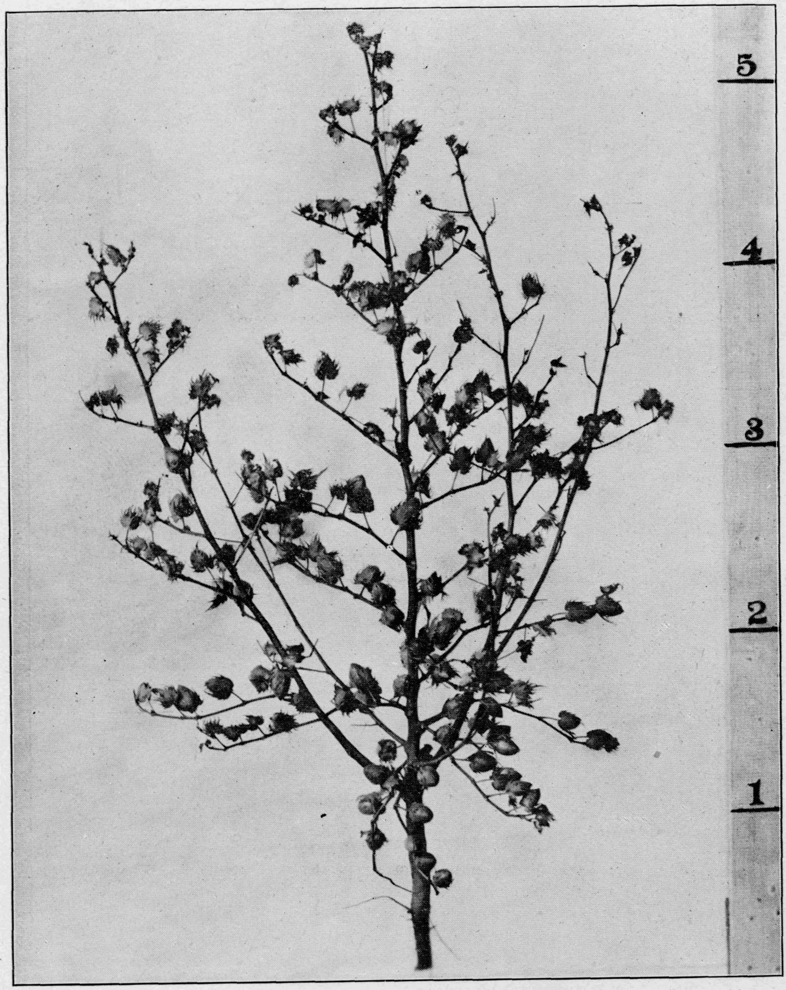


FIG. 1.—A short jointed, long fruit limb plant. An extremely early, productive cotton plant on which fruiting began near the ground at the first joints on the main stem. The short joints of the main stem and limbs are easily seen. There are only four primary limbs and the two older are well fruited. Age 120 days, height 5 ft., bolls 70, 2 open, in lower half circle 54 grown bolls. (Leaves removed)

MATURITY OF BOLLS ON EARLY AND LATE COTTONS, AND OF BOLLS ON LITTLE AND BIG BOLL COTTONS.

In noting the time from appearance of square in leaf axil to bloom and full grown boll, it was found that practically the same period is required in both the late and early cottons and also in both large and small boll cottons. In the large boll cottons, a few days longer is required for the bolls to dry out and open. At that stage of the bolls this extra time in opening is no disadvantage, since they escape the weevils as safely as do the small bolls on small boll cottons. Their

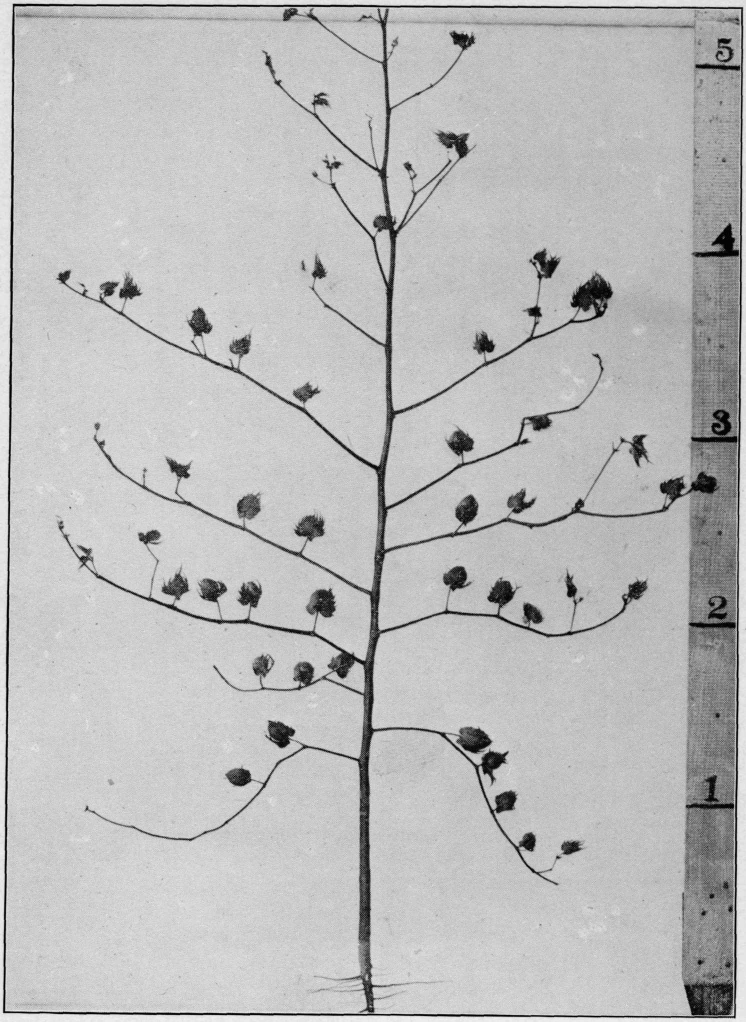


FIG. 2.—A stalk of extreme length of joints. Late fruiting and unproductive. Height 5½ ft., age 100 days, bolls mature 19. This type of stalk could only increase its fruit by growing many primary limbs, but such are late, and require much water.

equal escape is accounted for by the weevil's habit of not molesting bolls of any size until the squares are fed upon and destroyed. This is a fortunate habit of the weevil, since the larger boll cottons are more desirable for picking, are more storm proof, and because increasing the size of the bolls is one of the two ways of increasing the yield of the cotton plant—the other is by increasing the number of bolls. A few cottons have boll coverings of a nature that resists rapid drying out after maturity and therefore are later in opening after maturity. The College Entomological Department by actual count of bolls on over 1000 stalks of three big boll cottons and small boll King cotton, growing

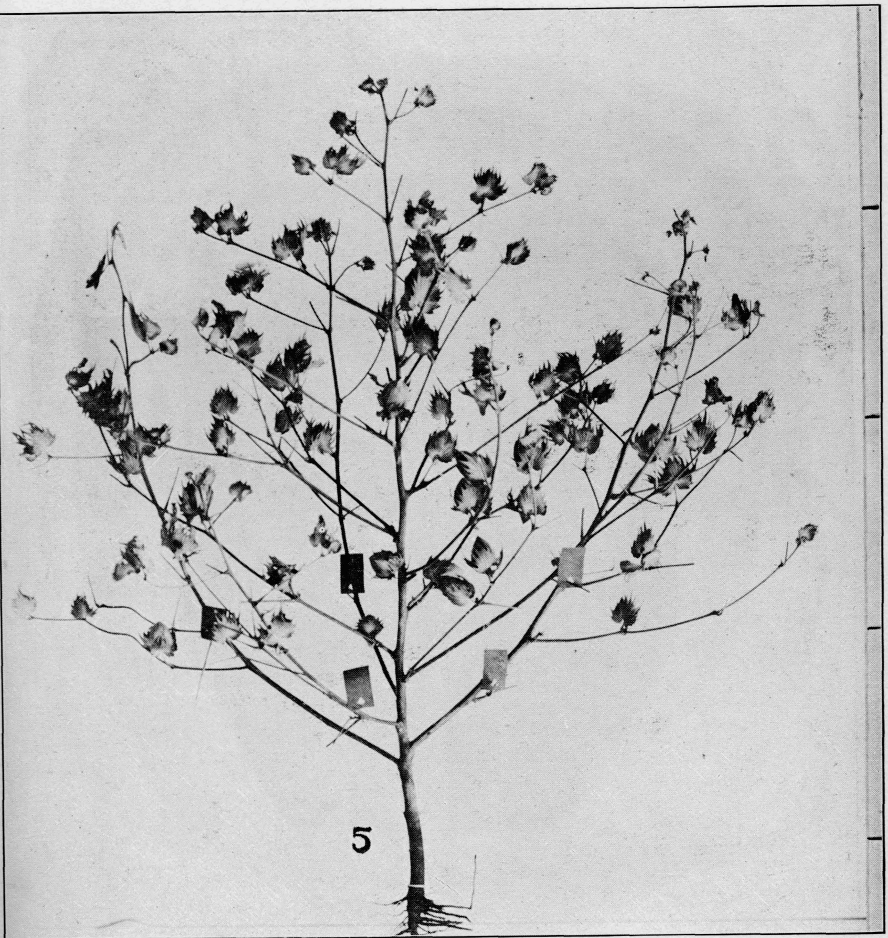


FIG. 3.—Late fruiting and unproductive stalk. The long joints are easily seen. The late fruiting primary limbs are marked with cards. Age 105 days, height 3½ ft., mature bolls 20, in lower half circle 9 bolls. A longer time would be required to mature the upper fruit than is afforded in boll weevil sections.

side by side, found a few more weevil-injured bolls on the small boll cotton.

If the time from appearance of square from terminal bud to mature boll, not open boll, were less in some cottons, there would be little, if any, advantage gained to the later formed squares on such cottons in escaping the weevils. In order for a shorter period of maturity of bolls to be of any advantage the joints would have to be shorter and the rate of growth would have to be greater than other cottons whose bolls require a longer time to mature. See bolls Fig 5.

RATE OF GROWTH.

If there is any practical difference in rate of growth of the several cottons it was not observable, but as rate of growth is important for earli-

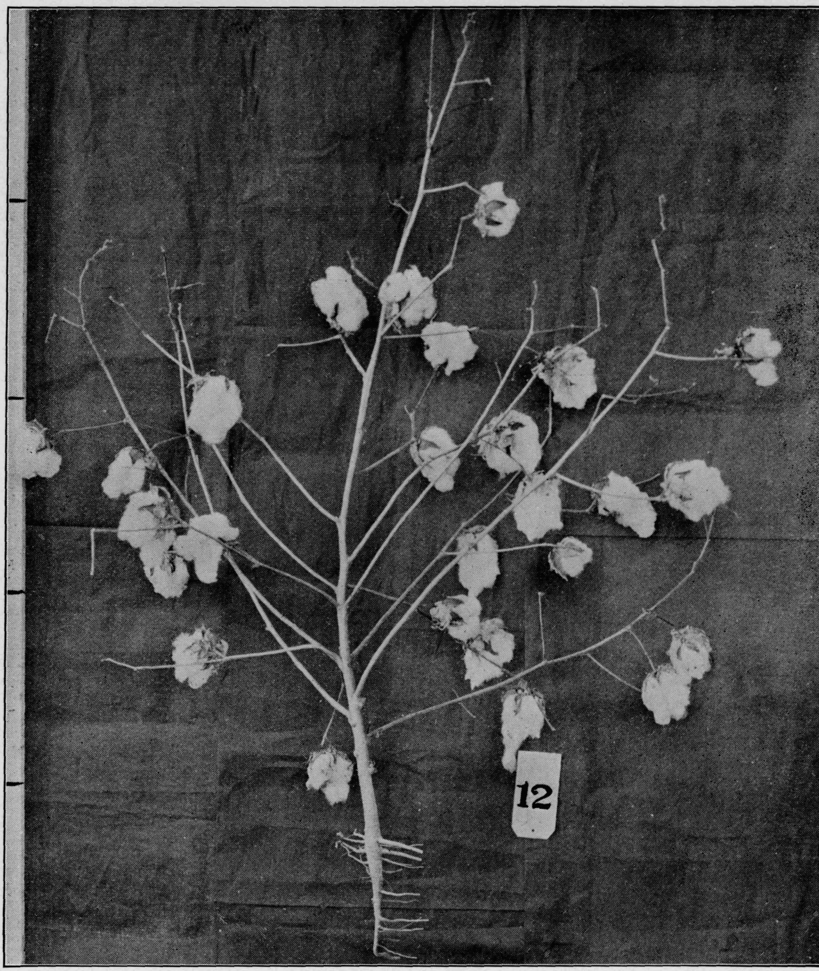


FIG. 4.—A mature cotton plant that was late in fruiting. The joints are long and the bolls are far out from the center and base of the stalk. The limbs have few joints and few bolls. Height of plant 3 ft., bolls 26, 10 in lower half circle. A late unproductive plant.

ness and as the rate differs in individual plants, it is desirable to secure in seed the quality of rapid growth and this is done when seed are selected from the largest stalks of the desired type.

WHAT IS AN EARLY COTTON.

From the observations of the cottons in this investigation, an early mature cotton plant would seem to be defined as having a short jointed main stem, with short jointed long fruit limbs (not wood limbs) at each joint on the main stem; the relative length of fruit limbs decreasing with age from base of stalk upward; the first fruit limbs should be at the first joints on the main stem; the first fruit in the first leaf axil or joint of the first fruit limb and successively at each joint on all fruit limbs to the close of the season. The larger the bolls, the greater will be the yield. Such a plant fruits earliest, most rapidly, is earliest in maturing fruit and is most productive. The highest development of such a plant is a matter of seed selection, and with the type defined, stalks nearest approaching the type can be recognized in a field when picking without previously watching and marking those that happen to open the first boll. See Fig. 1.

VARIETIES.

There are some traditional inaccuracies in the information regarding varieties of cotton and the cotton plant that need correcting in order that seed selection and breeding of earlier and better cottons may be accurately done.

It is held that early cottons necessarily have small bolls, and that the fiber is consequently short. Regarding the question that small boll cottons have short staple as a consequence of the smallness of the boll—such a conclusion is incorrect. More varieties of long staple have small bolls than otherwise. The Alabama Experiment Station has weighed and made public the weight of bolls of many long and short staple cottons, and a few of the weights of some of the most important long staple cottons and of one short staple cotton are given herewith:

King cotton, short staple, bolls required to pound seed cotton......	81
Moon cotton, long staple, bolls required to pound seed cotton......	83
Allen Hybrid, long staple, bolls required to pound seed cotton......	86
Sea Island, long staple, bolls required to pound seed cotton........	130

To the question that early cottons necessarily have small bolls—such a necessity does not exist. And if there were no early big boll cottons in cultivation at the present time, some could be made early by seed selection. By selection, big boll cottons could be made to grow fruit limbs at the first joints on main stem and to grow short joints, and to grow fruit in first leaf axil of first fruit limbs. Such a plant would be early in the same way that other cottons are early.

From the observations that have been published at some experiment stations on appearance of bloom and opening of bolls, it does not follow that a long staple boll requires any greater time to mature than a short staple boll.

Likewise, the ancient opinion is passed that long staple can be grown only on low, moist land. It can and is grown equally well on upland.

Long staple upland cottons have been bred up by selection and the breeders have given most thought and attention to length of staple, and little or no attention to earliness. As a result the long staple varieties are mainly late. Doubtless, from this fact the opinion had its beginning—that long staple cottons are necessarily late.

If there is any dependent relation of long staple on long joint and boll stem it would appear that short staples would hardly remain short on long jointed stalks—but there are many of them.

There must be a frame structure of stalk that will contain the most cotton or the most bolls and meet economic demands for earliness of the full crop of bolls, ease of picking, etc. The short

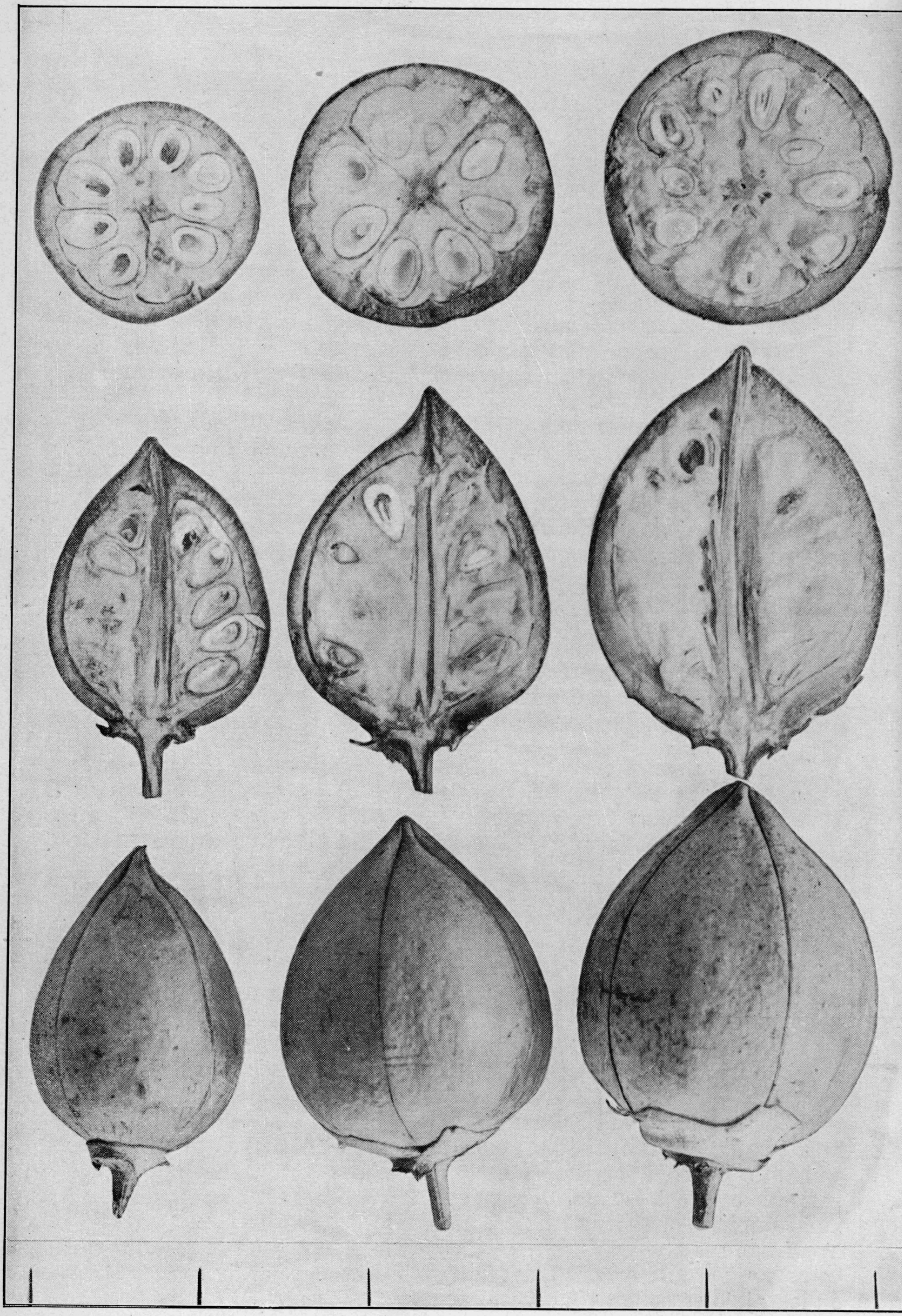


FIG. 5.—Cotton bolls vary in size and yield with different varieties. The large bolls are more desirable for picking, for retention of cotton in open burrs and for greater yield. Illustration one-sixteenth less than natural size. Spaces on scale equal one inch.

fruit limb and cluster style or type of stalk structure, growers contend do not meet those demands.

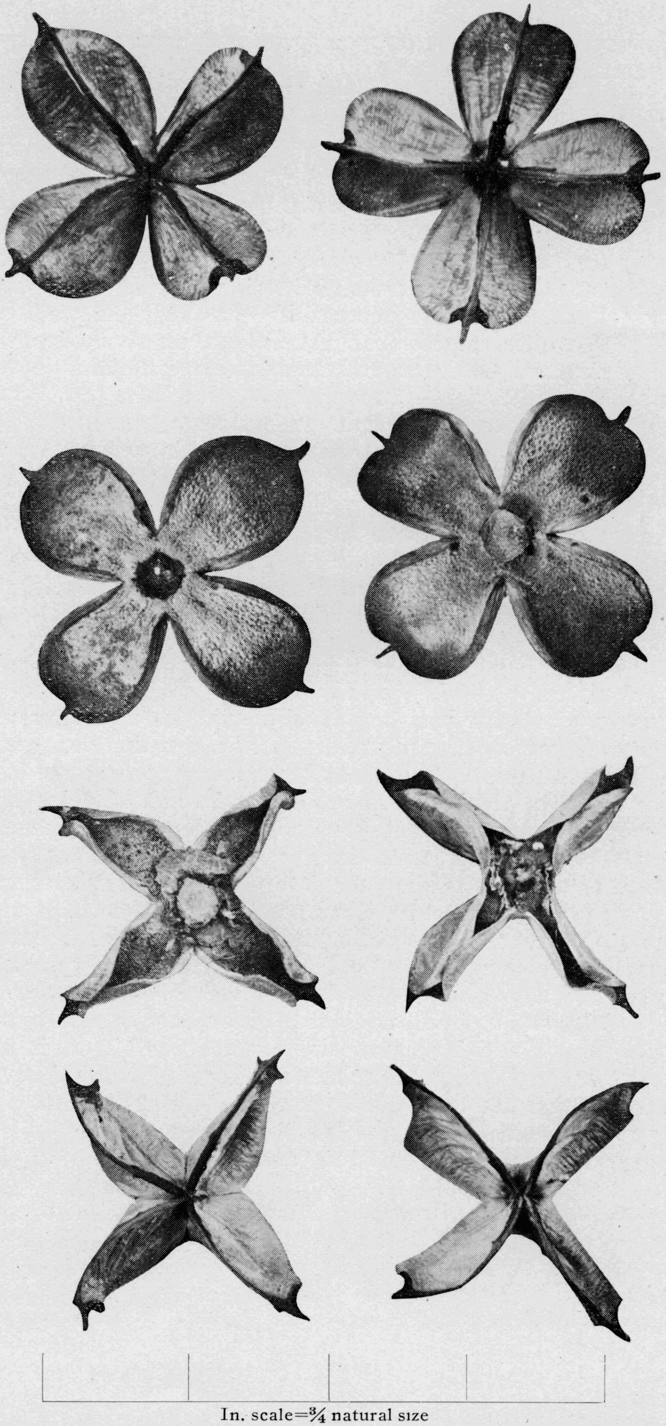
On soils where the water supply is too free the tendency is for the joints to become longer, but this tendency can be overcome by seed selection, and if seed are not selected the plants in time become long jointed, late and unproductive in a short fruiting season. For this reason moist bottom lands are not desirable for growing planting seed. Productive or fertilized dry upland soils grow the best seed.

In our tests of seeds and varieties this season at College on sandy loam land, at Waxahachie on high black waxy land, at San Angelo on sandy loam, there was some difference in yield and extent of growth of the different cottons. At College on sandy loam soil and weevils present, all varieties and seeds, with exceptions noted, made practically the same yield—three-quarters of a bale. At Waxahachie, the big boll Texas common seeds made more cotton in the same time than several of the varieties and were exceeded by selected seed of three or four eastern cottons which are not considered early. Similar yields were made at San Angelo.

Growers are advised, where they are unable to find satisfactory early cotton on the market, to select seed for earliness and productiveness from a cotton that they have known for a long time as having been uniformly productive and satisfactory in their locality.

SEED SELECTION.

A cotton plant that has the desirable qualities of earliness and productiveness requires careful seed selection for the maintenance and improvement of those qualities. The grower's constant desire is to increase the yield of his cotton, and the only way of doing that in the plant—not outside, culturally—lies in two directions: increasing the number of bolls and increasing the size. With the fruiting season made short by weevils, it is evident that the plant must begin fruiting early in its growth as near the ground as possible, and then with short joints the greatest number of bolls can be made in the shortened season. Having found and defined the type of plant or stalk for greatest earliness and productiveness, resort must be had to seed selection to maintain these qualities and to improve them. If seed are annually taken from the most perfect and largest of the above defined type, it fixes these important features in a greater intensity in all plants and improves the features at the same time. With such a developed plant the grower has only to provide the best cultural conditions and food, if that is necessary, for maximum earliness and productiveness of the cotton plant.



In. scale=¾ natural size

FIG. 6.—Cotton burrs, front and rear, showing difference in structure. The small, thin burrs open flat and twist backward removing all support to the locks and they fall out. Big tough burrs do not fold back and leave the locks unsupported.

IMPORTED SMALL BOLL SHORT STAPLE CAROLINA SEED.

Selected pure seed of such cottons when brought to Texas yield fairly well on some soils when rainfall is sufficient, though the bolls are very small and the staple short. There is only enough, however, of selected pure seed of these cottons any year to plant a small area, and to bring the common seed of such cotton in lieu of pure seed is inadvisable. There is every reason why Texas growers should look at home for better cottons, and through seed selection, rather than to remote regions, since they have no cottons better adapted to Texas than seed selected for earliness from the native Texas big boll good staple cottons.

EARLINESS OF NORTHERN SEED.

The extreme northern seed used in these investigations had been grown in extreme north Arkansas and the Panhandle of Texas so long that the original sources of the cottons and their original names were forgotten. From this we concluded that the seed had been grown north for a sufficient length of time to have become earlier, if any such influence were exerted on cotton by northern latitude. The structure of the plant and rate of growth and maturity of fruit of these seeds did not differ to any observable extent from plants from other seed. In referring to the structure of the upland cotton plant for differences that determine earliness, it is evident that plants from these northern seed, in order to be earlier, should either have fruited nearer the base of the stalk, or have had shorter joints, or have grown faster than those from some other seeds. Ordinarily, one season's experiments or tests of one lot of seed are not conclusive, but the structure of the stalks and the rate of growth in relation to earliness are conclusive that northern latitude has not yet exerted any practical, if any appreciable, influence on the earliness of the cotton plant.

Selection of seed from stalks of proper structure grown on the proper kind of soil must be the means for securing earliness, and not northern latitudes.

STORM-PROOF COTTONS.

From these investigations the qualities that make some cottons more resistant to storms were found and described. The large tough boll cottons lose less cotton from "falling out" and from winds and rains than small, thin boll cottons. Such bolls do not open so widely nor does the burr behind the locks twist back and leave the locks unsupported. Retention of cotton in burrs gives the grower more time to pick with a limited force and saves loss and damage to the cotton. Big boll native cottons were more storm-proof than any imported cottons. See Fig. 6.

FERTILIZING COTTON FOR EARLINESS.

By R. L. Bennett.

The extensive use of commercial fertilizers on cotton in the South has not been to hurry the growth of the plant that it might make a full crop in a short time, but it has been to increase the yield on more or less exhausted soils. In Texas, where the soils are fresher and where the growing and fruiting season has been long, from frost to frost, a fair crop on all soils has been made without the use of fertilizers, and were not the length of the fruiting season interfered with now by the boll weevil, fair crops could still be continued for some years. Texas growers, however, are now facing a sudden decreased yield, not from soil exhaustion, but from a shortened fruiting season, due to the boll weevil becoming so numerous in the latter part of the fruiting season of each year as to stop all fruiting. In the early part of the season they do damage, but perhaps the squares destroyed then simply lessen the number that would later fall off or shed. With the shortened fruiting season the plant must be made to grow so fast that it will make in the shorter time as much, if not more, than it formerly did while growing slower and through a long season. When cultural methods are good a rapid growth can be induced by feeding or fertilizing. Fertilizing increases yield on soils more or less exhausted and has been studied for a long time and is well understood in a practical way. But the question of fertilizing for rapid growth in a short season is somewhat new; though the practice is, however, the same as that of fertilizing for making better yields on exhausted soils. With the boll weevil shortening the fruiting season, fertilizing is almost as necessary for making profitable crops on the thinner uplands of the State as it is on the exhausted soils of the southeastern States.

Fertilizing cotton may be briefly defined as being nothing more than feeding the plant digestible plant food on soils not possessed of a sufficiency of such foods.

Investigations were undertaken this year by the Bureau of Plant Industry, U. S. Department of Agriculture, and the Texas Experiment Station.

First, to get information as to the effect of the three fertilizing elements on the earliness of the cotton plant.

Second, to get some data as to the relative yield of cotton in a short fruiting season when fertilized and not fertilized.

Third, to learn the way that fertilizers cause an early maturity of the cotton crop.

The investigation was begun in March, 1904, at College Station, and in duplicate at Waxahachie, Ellis County, and in the Brazos bottoms. The soil at College Station is what is locally known as poor soil. It is rather level, of a loamy nature, underlaid from six to twelve inches with tough hard clay, and originally grew scrub post oak. About two-fifths bale per acre was said to be the average yield under the treatment given before weevils appeared. This soil grew sorghum the previous year, and in December the sorghum stubble was turned under, and in early March the ground was run off in rows with a broad shovel, and into these furrows the fertilizers were distributed by hand and then bedded on. The seed of an early variety of cotton was planted April 9, twenty days later than it should have been planted or than adjacent cotton was planted. The delay in arrival of seed delayed planting, and shortened the fruiting season twenty days, and shortened the yield an unknown amount. Phosphoric acid, nitrogen and potash, the elements of plant food applied to soils, were used in this work as acid phosphate, sulphate of ammonia and kainit. Each was applied in small, medium and excessive amounts, and also the three were mixed in like amounts, as follows:

Acid phosphate 100, 200 and 500 pounds per acre.
Potash or kainit, 100, 200 and 500 pounds per acre.
Nitrogen or sulphate of ammonia, 250 and 500 pounds per acre.

The mixture was made of 1 part kainit, 1½ parts cotton meal for nitrogen and 2 parts of acid phosphate. This combination was applied at the rate of 225 and 600 pounds per acre.

Kainit contained 12 per cent potash; acid phosphate, 14 per cent available phosphoric acid; sulphate of ammonia contained 20½ per cent of nitrogen—as analyzed by Dr. Fraps of the College. Nitrate of soda was used in place of sulphate of ammonia in the Brazos bottoms and at Waxahachie.

EFFECT OF EACH ELEMENT OF PLANT FOOD OR FERTILIZER ON THE COTTON PLANT IN YIELD OF COTTON.

Of the effects of these three elements, it has been held that nitrogen would hasten growth but would delay maturity; that potash would delay maturity; and that phosphoric acid would hasten fruiting and maturity. If either of these elements exist in the soil in too small quantity the plant makes a poor growth, but if all are present in abundance and in an available form, the plant grows rapidly when water and heat are favorable. I was unable to observe any difference in the cottons in the way suggested above as effecting maturity, either at College, Waxahachie or in the Brazos bottoms. Potash apparently did not affect the plant either harmfully or beneficially, neither did the nitrogen. But acid phosphate at College made an astonishingly rapid growth and greatly increased the yield, its yield practically equalling cotton fed with all three elements combined. Unquestionably, if there is an appreciable influence to hurry or to delay maturity by any particular element of plant food, it is of no practical consequence, but there is a most decided increase of yield due to rapid growth when one or more of these three elements are added to a soil that is deficient in them. *The important thing to know is which one or more the soil is deficient in, then by adding to the soil the deficients,* the cotton can get the needed food and can make a rapid growth in a given time. It is immaterial which is absent, for by supplying the deficiency the plant is enabled to grow rapidly. Fertilizing, then, increases earliness and yield in a given time by supplying abundant food to the plant, and rapid growth is a result.

Height or growth at College of the fertilized and nonfertilized cotton in a given time is exhibited herewith:

Treatment	Planted	Measured	Age	Height	Squares to Stalk
Acid phosphate	April 9	June 13	65 days	18 inches	8 to 16
Nitrogen	April 9	June 13	65 days	6 to 9 inches	0 to 4
Potash	April 9	June 13	65 days	6 to 9 inches	0 to 4
Non-fertilized	April 9	June 13	65 days	6 to 9 inches	0 to 4

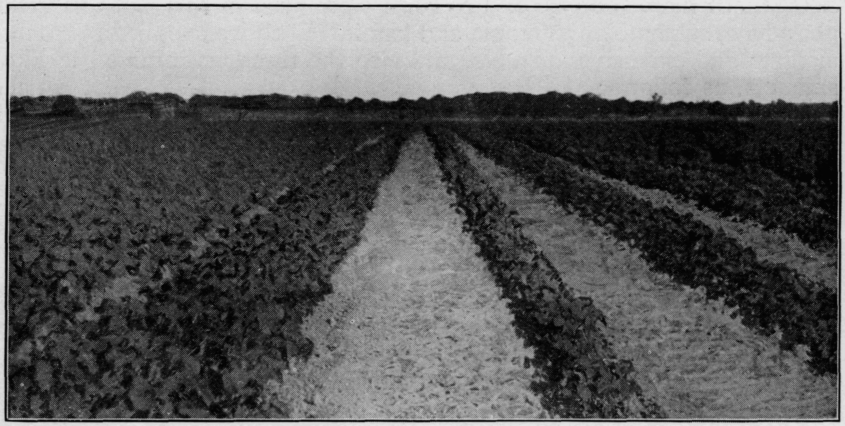


FIG. 7.—Fertilized and nonfertilized cotton. The acid phosphate fertilized is the large cotton on the left. The center of the view is down the middle between the two cottons. The photograph was made ten days after taking the height, amount of fruit and age in the above table. The width between rows is same in both cottons.

EFFECT OF FERTILIZERS ON YIELDS.

The data above given shows the greater amount of growth that was made by cotton fertilized with phosphoric acid, an element of which the soil was deficient or at least was needed by the plant. The mixed or combined fertilizer showed no greater growth at that date than the acid phosphate alone. The final yields were in proportion to the rate or extent of growth at the time weevils stopped all fruiting, which was about July 20.

Treatment	Yield 1st Picking Aug. 22, 1904	Yield 2d and Last Picking	Total
100 pounds acid phosphate	600	300	900
200 pounds acid phosphate	680	330	1010
500 pounds acid phosphate	770	330	1100
No fertilizer	360	390	750
No fertilizer	330	440	770
No fertilizer	340	380	720
100 pounds kainit	380	320	700
200 pounds kainit	390	410	800
500 pounds kainit	191	360	551
250 pounds sulphate of ammonia	230	410	640
500 pounds sulphate of ammonia	160	340	500
225 pounds mixture	730	400	1130
600 pounds mixture	710	370	1080

Excessive amounts of each element, 500 pounds per acre, was used in order to determine the effect on the plant. No such amounts would ever be used in practice, not by half—and such excessive amounts might, in themselves, and very probably would have a harmful effect. Part of the decrease of the plants where nitrogen and potash were used is perhaps due to that cause, that is to the very large amounts put directly under the plants. Part of the decrease is due to soil or plot variation and is too small to be otherwise taken into account.

The rapid growth due to phosphoric acid is strikingly shown in the yields of the first pickings as compared with the other plots and confirms the extent of growth exhibited in the above table and photograph. Unquestionably if this cotton could have been planted 20 days earlier, when it ought to have been planted, the acid phosphate would have made proportionately greater yields. It would have had twenty days longer to fruit, and the profit from the use of these amounts would have been greater. The increase from the use of 100 and 200 pounds acid phosphate is 150 and 260 pounds seed cotton. But the cotton did not use all of the 200 pounds, and perhaps 150 pounds would be about the correct amount for the College soil. Profit from the use of acid phosphate, though late planted, was $3.50 and $5.80 per acre on an estimate of $1.00 per hundred for phosphate put in the soil and 3 cents for the seed cotton.

The non-fertilized cotton made more than the average stated yield of the soil, and is accounted for in the better preparation of seed bed and earlier planting and better cultivation than was given the soil before weevils appeared; then, too, it is said that the season was extra favorable. But the soil needs deep breaking, because of hardpan beneath, if the yield is to be increased to the fullest extent by the use of fertilizers.

Two other tracts of King cotton were fertilized with a mixture of the three elements and were purposely planted later than the foregoing, and the yields are exhibited here to show the importance of early planting in order to get as long a fruiting period as possible before weevils stop all fruiting, and if the season is too short, fertilization can not do any good. At College Station the growing and fruiting season is about 120 days, which is sufficient time to make on upland by good culture, fertilization and good seed, a bale or more per acre.

Date planted, May 20; yields seed cotton, 340 per acre; fruiting period extends to July 20.

Date planted, June 8; yields seed cotton, nothing per acre; fruiting period extends to July 20.

The cotton of these two plantings grew from four to five feet by the last of September, when caterpillars destroyed all foliage.

HOW FERTILIZERS CAUSE INCREASED YIELDS IN A GIVEN TIME, OR CAUSE EARLY MATURITY.

The information obtained on this question has been partially stated above. Fertilizers cause a rapid growth or extension of the plant, and consequently the rapid formation of new joints on its main stem, and the sending out at these joints of new fruit branches and the rapid formation of new joints therein, where the squares or bolls grow.

Under the stimulus of abundant food, the plant makes a very much greater number of joints and consequently bolls in a given time than plants not so abundantly supplied with food. It should be understood that if the soil water supply or rainfall is very deficient, fertilized cotton may grow but little faster than non-fertilized cotton, since without the water the food can not enter the plant.

THE USE OF FERTILIZERS ON COTTON.

As already stated in this report, there is no difference in fertilizing cotton for earliness and in fertilizing for increased yields on exhausted soils. The latter practice is, however, so well known that an elaborate discussion is unnecessary, but a statement of the important features of the practice is necessary for growers in Texas who find it profitable to use fertilizers either for a poor soil or for a short fruiting season, shortened by weevils. There is, however, as between the two practices, a difference in degree in fertilizing for the two purposes. The quantity of fertilizer that plants can use in a short fruiting season is a little less than can be used on exhausted soil in a long fruiting season. Furthermore, when weevils shorten the fruiting season, plants can not grow fruit to the tips as they did in a long fruiting season, and for this reason the distance both ways between plants should not be greater than the distance that was found to be best before the fruiting season was shortened by the boll weevil.

WHAT KIND OF FERTILIZERS TO USE.

Potash, nitrogen and phosphoric acid are the forms of plant food found profitable to apply to soils to increase the growth and yields. The most common form in which they are offered for sale is kainit, cotton meal and acid phosphate. There is also the so-called complete fertilizers containing these three things or elements mixed together in different proportions for different crops. But there are perhaps few soils in Texas that need potash for cotton; and therefore to buy it in a complete fertilizer for all soils is a useless expense. Some soils, especially the worn sandy soils of east Texas and elsewhere may be found to need nitrogen, and perhaps occasionally potash, and the cheapest form to apply nitrogen is cotton meal, which also contains a little phosphoric acid and potash. The use of cotton meal may be at the rate of 100 to 150 pounds per acre as an approximately correct amount. Perhaps most of the upland soils of the State, unless it is some of the black waxy soils, will greatly increase the yield of cotton when acid phosphate is used at the rate of 100 to 200 pounds as the approximately correct amount. Soils may be tested, as was done in this investigation, and the two smaller amounts of each fertilizer may be used singly and in combination, and the weights of the seed cotton yielded by each will show the kind and amount of each fertilizer element that is most needed and that will be profitable. Plots of soil for such a test may be of any size from one-tenth of an acre up, though the area stated will be found most convenient for uniformity of soil throughout the several plots. Acid phosphate that contains not less than 14 or 15 per cent of available phosphoric acid should be used, and it will cost in Houston or other common railroad points about $18 or $19 per ton. It is important to know the per centage available in a purchase.

WHEN AND HOW TO APPLY FERTILIZERS TO SOIL.

The land should be flat broken in winter, December or earlier, or if cotton stubble it may be bedded in the old middles. About the last of January, or a sufficient period before planting for the seed bed to become firm, furrows for rows are run off on the flat broken land and fertilizers distributed in these furrows. On the re-bedded cotton stubble land, the fertilizers may be applied in the middle furrow, which was the old row before breaking. The fertilizers in the furrow are bedded on and the cotton planted in the usual manner. The cotton seed should be planted directly over the fertilizer and not in the furrow with the fertilizer, or at least not in contact, as their vitality may be destroyed.

Fertilizers may be distributed in a furrow by seed planters, or by one-horse fertilizer distributors, or by hand. If they are distributed by hand, a tin bugle or horn is necessary to prevent the wind interfering. This device is made of tin with a diameter of about two inches and of about three feet in length, with an enlarged funnel-like shape at the top, and to one side of the top a handle is soldered. The laborer takes the fertilizer in a sack on his right side and holds the bugle in his left hand with the lower end of the bugle in the furrow, and while walking rapidly along works the fingers of his right hand for an even distribution of the fertilizer. After a few hours' practice, a good man can put it down uniformly and at a rapid walk.

SOILS OF THE STATE.

The profitable way for growers to increase their crop of cotton is by fertilizing to increase or double the yield per acre and not by increasing the acreage. The cost of making one-third of a bale per acre is as great as the cost of making a bale, except the cost of fertilizer. Then fertilized upland cotton is surer to make a crop every year, since it makes in a shorter time and escapes the weather vicissitudes of a long season. Planted as early as possible, the soil water and a little rainfall and fertilizers and prompt culture will make three-quarters of a bale to a bale in 100 to 120 days, whether weevils infest or not.

All the sandy or loamy soils of the State of Texas can very probably use fertilizers to good advantage, especially acid phosphate. River bottoms may not respond profitably to fertilizers unless they be quite worn from long culture. The black waxy lands through the middle of Texas, north and south, as represented in Ellis County this year, did not respond to any of the fertilizers singly or combined in duplication of those at College, yet the soil non-fertilized produced only one-half a bale per acre. That small yield shows that something is or was wrong, otherwise if the soil needs no plant food, that is to say, is rich enough, it should have made more than it did. But the yield remaining the same whether fertilized or not shows that the soil needs study. I would suggest deep breaking, or at the very least, deep breaking under the beds, notwithstanding this might be readily objected to on the supposition that "cotton will not fruit until it strikes hard ground," or because "deep breaking has already been tried." The deep breaking should be done in sufficient time before planting for the seed bed to become firmed by rains. Something is unquestionably wrong or something is at least needed by the soil since it makes a small yield and does not respond to liberal fertilizing. I would therefore try deep breaking to make a better seed bed and a better water supply. The small yield was not due to excessive rainfall nor to a deficiency. This cotton had all the "hard ground to cause fruiting" that this theory might require, since the seeds were planted on hard unbroken soil at the bottom of a shallow furrow made in the two or three inches of broken surface soil. The hard ground which the cotton roots struck as soon as the seed germinated did not cause the cotton to fruit as much as it should have fruited on a soil so rich in plant food that an addition would cause no increased yield. This land would have been broken deeper for this work had time permitted. Black waxy soil, especially where rainfall is of irregular occurrence, must be kept well stirred or mulched to prevent it drying out "as deep as broken."

By using fertilizers on any soil where they will increase the yield, large crops can be made on less land and more corn and cowpeas can be grown to rotate the cotton land. The cowpea adds humus and nitrogen to the soil; then when cotton follows it, acid phosphate would in all probability be the only fertilizer needed for an increased yield of cotton.