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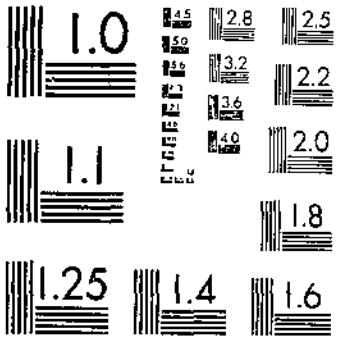

MICROCOPY RESOLUTION TEST CHART
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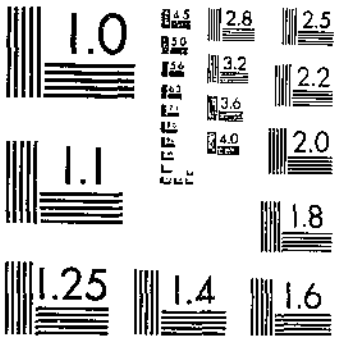

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TECHNICAL BULLETIN No. 277 JANUARY, 1932

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

THE SHEDDING OF 4-LOCK AND 5-LOCK BOLLS IN UPLAND COTTON

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INTRODUCTION

In cotton culture the loss of floral buds and young bolls by shedding is of great agricultural importance, and little is known regarding its causes or methods of control. Shedding follows the abortion or blasting of squares and young bolls, either from external injuries, as by pests and diseases, or from any physiological disturbances that may inhibit development. There is a widespread opinion among growers that shedding, when not caused by recognized pests or diseases, is a natural result of an overproduction of flowers rather than an abnormality of the plant. Another opinion is that shedding is itself a disease, for which remedies should be sought.

Eaton,[1] in some of his studies of factors associated with the shedding of floral buds and immature bolls of cotton in the Southwest, reports that "A very intimate relationship exists between the fruitfulness of the plants and the factors which influence the rate of photosynthesis." He also explains that "The nutritional relationships of the cotton plant in these regions are responsible for a considerable part of the boll shedding, which occurs every year," and that "The amount of fruit which is already carried by a cotton plant greatly influences the further growth which the plant can make, the number of flowers to appear and the number of bolls to be retained."

Data on shedding recorded at various locations in the Cotton Belt of the United States have shown wide variations in the amount

[1] EATON, F. M., DEFRUITING AS AN AID IN COTTON BREEDING. Jour. Heredity 18: 457-460, illus. 1927.

of shedding under different conditions of growth. Contrasting differences have also been observed in the amount of shedding by different kinds of cotton grown in side-by-side comparisons. Cook,[2] in discussing causes of shedding, points out that "Egyptian cotton may retain nearly all of its buds and young bolls while upland varieties in adjacent rows are shedding nearly all of their buds."

During the last few years many data on the shedding of cotton bolls have been published, but none of the reports reviewed have considered a relation between the number of locks per boll and the rate of shedding. Studies of the amount of pollen required to develop a boll and experiments with different methods of pollination, conducted by Meade,[3] indicate that some of the shedding of young bolls is due to imperfect fertilization. Since each lock in a boll is represented by a lobe of the stigma and contains ovules to be fertilized, the possibility of imperfect fertilization increases with each additional lock.

It now is indicated that types of cotton characterized by small bolls with few locks also have less tendency to shed. Most of the primitive upland types of cotton have fewer locks per boll than do the cultivated types, and the increase in the number of locks per boll in the cultivated varieties may be largely due to selection and to improved cultural conditions. Evidence has been obtained at Greenville, Tex., and at Bard, Calif., showing that 5-lock bolls may have a greater tendency to abort than have 4-lock bolls.

Selection of 5-lock bolls in the upland type of cotton has been in progress for many years, and the results obtained represent the combined efforts of many plant breeders. The efforts to establish the 5-lock boll as a constant character in the Texas big-boll varieties have been based upon the supposition that a cotton with 5-lock bolls would be more productive and would require less labor to pick, but there seems to be no scientific evidence to support the popular opinion that a variety of cotton producing 5-lock bolls exclusively would be superior in all respects to a variety with some 4-lock bolls.

Since the trend in cotton breeding is to select for 5-lock bolls, the need of more information regarding this character is obvious, and more work needs to be done to determine the feasibility of establishing such a character.

METHODS AND MATERIALS

The data presented in this bulletin were collected at the United States Cotton Breeding Field Station, Greenville, Tex., in 1925, and at the United States Acclimatization Garden, Bard, Calif., in 1926 and 1927.

The Lone Star variety was chosen for the experiments conducted at Greenville, Tex., as being typical of the Texas big-boll group of varieties. It was developed by the United States Department of Agriculture from a single plant, selected in a field of Jackson cotton in 1905, and is grown extensively in Texas and adjacent States.

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[2] COOK, O. F. CAUSES OF SHEDDING IN COTTON. Jour. Heredity 12: 199–204, illus. 1921.

[3] MEADE, R. M. BEE KEEPING MAY INCREASE THE COTTON CROP. Jour. Heredity 9: 282–285, illus. 1918.

The Acala variety was chosen for all experiments in California, since it has proved to be superior to other big-boll varieties in the irrigated valleys of the Southwest and has been adopted as the standard variety in California under the State laws of community production. This variety was introduced from Mexico by the United States Department of Agriculture in 1906.

The use of two varieties in these studies limits the comparability of the data collected, as direct comparisons can not be made in all cases. However, since the results obtained under similar conditions coincide, varietal differences that may exist are not of great importance in this discussion.

In these studies the number of locks per boll was determined during the flowering stage by counting the number of lobes of the stigma. These lobes are well defined so that the number of locks can be determined readily and accurately. Flowers with 4-lobed stigmas were recorded as 4-lock flowers, and those with 5-lobed stigmas were recorded as 5-lock flowers. The date of flowering was recorded as the initial date in the production of the boll. These records were kept on small tags placed on the pedicels of the flowers, each tag bearing the date of flowering and the number of lobes of the stigmas or locks in the boll.

Daily collections of the fallen tags from young bolls that had been shed were made, and the date of shedding was recorded. At Greenville, Tex., an examination was made of each aborted boll to determine whether the shedding was due to injury by insects or to some other external cause. This precaution was taken because of the presence of the boll weevil in Texas, and was not considered essential to the experiments conducted in California.

Additional records were kept of the number and kind of flowers tagged on each date, and of the number and kind of bolls that fell. From these records the number of 4-lock and 5-lock bolls remaining on the plants could be determined for any given date. As the bolls that developed reached maturity the tags were taken off and marked with the date of opening, each boll being examined to see that the number of locks in the boll checked with the number recorded on the tag. Then at the end of the season the bolls that reached maturity and the bolls that fell were checked against the flowers tagged, in order to guard against errors in field work.

EXPERIMENTS AT GREENVILLE, TEX.

COMPARATIVE RATE OF SHEDDING

In the first series of observations, conducted at Greenville, Tex., in 1925, five comparisons of the rate of shedding of 4-lock and 5-lock bolls were made at weekly intervals from June 30 to July 28. For each of these comparisons 100 flowers with four locks and 100 flowers with five locks were tagged, except in the last comparison, when only 50 flowers with four locks were available. The records of these comparisons in each case show a higher percentage of shedding in the 5-lock bolls than in the 4-lock bolls.

For the June 30 comparison 38 per cent of the 4-lock bolls fell, as compared with 46 per cent of the 5-lock bolls, and for July 7 comparison 48 per cent of the 4-lock bolls fell, as compared with 56

per cent of the 5-lock bolls. As the season advanced, the amount of shedding of both 4-lock and 5-lock bolls increased greatly, but a slightly higher percentage of 5-lock bolls continued to be shed throughout the period in which data were recorded. For the comparisons of July 14, 21, and 28, the rate of shedding of 4-lock bolls was 80, 95, and 90 per cent, respectively, as compared with 84, 96, and 95 per cent of the 5-lock bolls. The high rate of late-season shedding greatly reduced the apparent differences in the rate of shedding of the 4-lock and 5-lock bolls, expressed in percentages of the total.

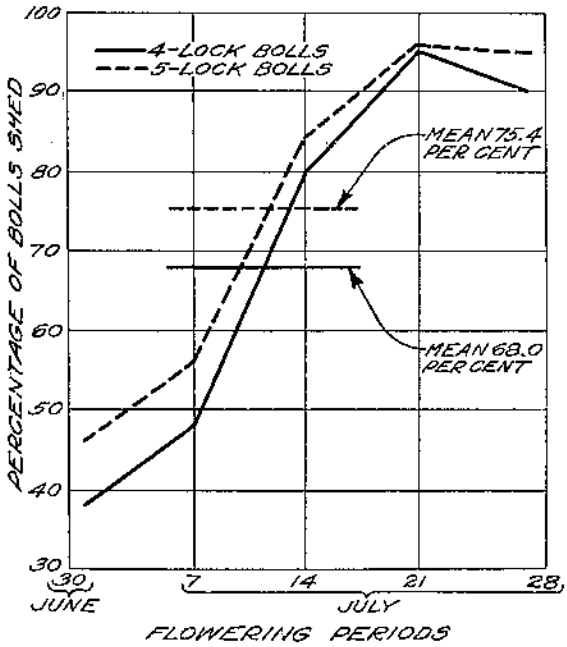

FIGURE 1.—Percentages of 4-lock and 5-lock bolls shed from flowers opened June 30 and July 7, 14, 21, and 28, 1925, on Lone Star cotton at Greenville, Tex.

Of a total of 450 flowers with four locks that were tagged, 144 bolls, or 32 per cent, reached maturity, whereas of 500 bolls with five locks, only 123 bolls, or 24.6 per cent, matured. These differences, though small, are in favor of the 4-lock boll in each comparison, and during the early flowering period, when the rate of shedding was not so great, significant differences are shown. The date and number of flowers tagged for each comparison, the number of 4-lock and 5-lock bolls shed, and the total number and percentages of 4-lock and 5-lock bolls shed are shown in Table 1. The percentages of 4-lock and 5-lock bolls shed for each date are shown graphically in Figure 1.

TABLE 1.—*Flowers tagged each week from June 30 to July 28 and bolls shed from each group of 4-lock and 5-lock bolls on Lone Star cotton at Greenville, Tex., 1925 percentages of totals*

Date	4-lock—		5-lock—	
	Flowers tagged	Bolls shed	Flowers tagged	Bolls shed
	Number	*Number*	*Number*	*Number*
June 30	100	38	100	46
July 7	100	48	100	56
14	100	80	100	84
21	100	95	100	96
28	50	45	100	95
Total	450	306	500	377
Per cent		68		75

EARLY AND LATE FLOWERING PERIODS

In the second series of observations conducted at Greenville, Tex., in 1925, a complete record was kept of the flowers produced and the bolls aborted on 25 consecutive plants selected from each of four adjacent rows. These plants produced flowers in two distinct periods—an early flowering period from July 4 to August 14, and a late flowering period from September 17 to October 21. This break in the flowering period is of common occurrence in many regions, the late-season bolls usually being referred to as the top crop.

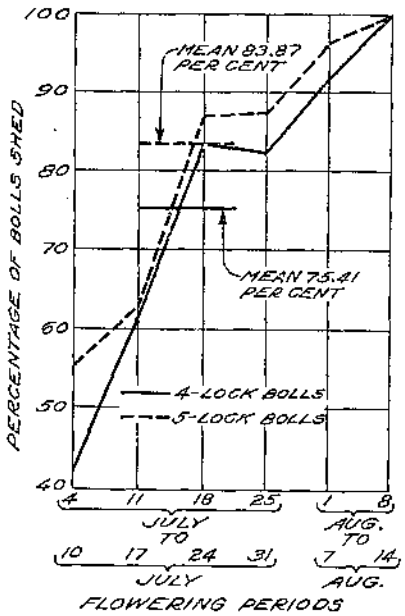

FIGURE 2.—Percentages of 4-lock and 5-lock bolls shed from flowers produced on 100 plants of Lone Star cotton at Greenville, Tex., from July 4 to August 14, 1925

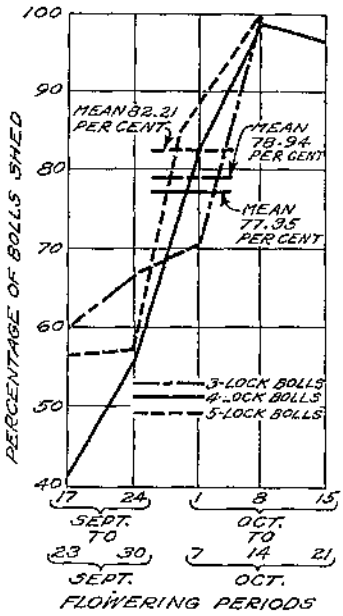

FIGURE 3.—Percentages of 3-lock, 4-lock, and 5-lock bolls shed from flowers produced on 100 plants of Lone Star cotton at Greenville, Tex., from September 17 to October 21, 1925

The numbers of 4-lock and 5-lock flowers produced on the 100 plants each day during the first flowering period, from July 4 to August 14, and the numbers of bolls subsequently shed are shown in Table 2. Totals of the 4-lock flowers produced and the bolls shed are given by weeks, with percentages of shedding. Similar data obtained during the second or late flowering period are presented in Table 3. The rate of shedding of 4-lock and 5-lock bolls during the early and late flowering periods are shown graphically in Figures 2 and 3. The abrupt termination of the second flowering period, as shown in Table 3, was due to an invasion of army worms which defoliated the plants and destroyed the floral buds.

TABLE 2.—*Four-lock and five-lock flowers produced and young bolls shed on 100 plants of Lone Star cotton at Greenville, Tex., July 4 to August 14, 1925*

Date	4-lock—		5-lock—	
	Flowers produced	Bolls shed	Flowers produced	Bolls shed
	Number	*Number*	*Number*	*Number*
July 4	7	4	2	0
5	9	3	6	0
6	6	1	13	7
7	2	0	4	1
8	18	8	10	12
9	15	8	8	6
10	16	7	18	13
Total	73	31	70	39
Per cent		42.46		55.71
July 11	29	17	20	10
12	21	10	22	8
13	36	22	35	17
14	17	12	29	19
15	18	6	26	16
16	24	18	53	33
17	25	19	41	38
Total	170	104	226	141
Per cent		61.18		62.39
July 18	18	12	71	57
19	47	31	113	87
20	31	25	83	64
21	32	[1] 24	92	[2] 81
22	65	60	120	118
23	51	50	108	101
24	38	34	97	93
Total	282	236	690	601
Per cent		83.69		87.10
July 25	33	32	79	71
26	45	36	131	110
July 27	50	43	145	125
28	43	26	105	78
29	27	25	115	111
30	17	15	74	72
31	5	4	44	40
Total	220	181	693	607
Per cent		82.27		87.59
Aug. 1	8	6	31	30
2	6	5	42	39
3	7	6	17	17
4	6	6	19	18
5	6	6	12	12
6	9	9	7	7
7	8	8	5	5
Total	50	46	133	128
Per cent		92.00		96.24
Aug. 8	3	3	8	8
9	3	3	9	9
10	0	0	4	4
11	0	0	0	0
12	0	0	2	2
13	0	0	0	0
14	0	0	0	0
Total	6	6	23	23
Per cent		100		100
Grand total	801	604	1,835	1,539
Per cent		75.41		83.87

[1] 2 bolls shed from traumatic causes. [2] Boll shed from traumatic causes.

TABLE 3.—*Three-lock, four-lock, and five-lock flowers produced and young bolls shed on 100 plants of Lone Star cotton at Greenville, Tex., September 17 to October 21, 1925*

Date	3-lock—		4-lock—		5-lock—	
	Flowers produced	Bolls shed	Flowers produced	Bolls shed	Flowers produced	Bolls shed
	Number	*Number*	*Number*	*Number*	*Number*	*Number*
Sept. 17	0	0	6	0	0	0
18	0	0	5	2	0	0
19	2	1	2	0	2	0
20	0	0	3	2	2	1
21	1	0	7	3	3	1
22	1	1	20	11	4	4
23	1	1	10	4	5	3
Total	5	3	53	22	16	9
Per cent		60.00		41.51		56.25
Sept. 24	1	1	13	5	6	5
25	0	0	18	10	8	3
26	0	0	6	4	6	2
27	0	0	6	2	3	2
28	0	0	14	6	6	6
29	1	0	14	9	2	1
30	1	1	14	11	4	1
Total	3	2	85	47	35	20
Per cent		66.66		55.29		57.14

TABLE 3.—*Three-lock, four-lock, and five-lock flowers produced and young bolls shed on 100 plants of Lone Star cotton at Greenville, Tex., etc.*—Continued

Date	3-lock—		4-lock—		5-lock—	
	Flowers produced	Bolls shed	Flowers produced	Bolls shed	Flowers produced	Bolls shed
	Number	*Number*	*Number*	*Number*	*Number*	*Number*
Oct. 1	1	1	13	6	4	3
2	2	1	26	10	1	1
3	2	2	29	25	7	5
4	4	2	37	34	9	10
5	5	3	32	24	11	8
6	2	2	30	26	10	8
7	1	1	28	26	7	7
Total	17	12	195	160	49	42
Per cent		70.59		82.05		85.71
Oct. 8	1	1	17	17	7	7
9	2	2	11	11	5	5
10	0	0	11	11	6	6
11	0	0	12	12	3	3
12	5	5	10	10	12	12
13	0	0	12	12	2	2
14	2	2	21	20	5	5
Total	10	10	103	102	40	40
Per cent		100.00		99.03		100.00
Oct. 15	1	1	11	11	6	6
16	1	1	4	3	2	2
17	0	0	3	3	5	5
18	0	0	2	2	2	2
19	1	1	0	0	3	3
20	0	0	3	3	1	1
21	0	0	9	9	4	4
Total	3	3	32	31	23	23
Per cent		100.00		96.88		100.00
Grand total	38	30	468	362	163	134
Per cent		78.95		77.35		82.21

During the early flowering period the 100 plants selected produced 1,835 flowers with 5 locks and 801 flowers with 4 locks. No 3-lock flowers were produced during that period. During the later flowering period these plants produced 163 flowers with 5 locks, 468 flowers with 4 locks, and 38 flowers with 3 locks. These figures indicate decided seasonal effects upon the relative production of 3-lock, 4-lock, and 5-lock bolls.

The percentage of the young bolls that were shed increased gradually from the first week of the early flowering period, ended July 10, when 42.47 per cent of the 4-lock bolls and 55.71 per cent of the 5-lock bolls were shed, to the last week of the early flowering period, ended August 14, when 100 per cent of both the 4-lock and the 5-lock bolls were shed. The later flowering period, beginning September 17, shows a shedding rate accelerating as did that of the early period, increasing from 41.51 per cent of the 4-lock bolls and 56.25 per cent of the 5-lock bolls for the week ended September 23, to 99.03 per cent of the 4-lock bolls and 100 per cent of the 5-lock bolls for the week ended October 14. The low shedding rate at the beginning of each flowering period and the increase in the rate of shedding through both flowering periods seem to indicate a very close relationship between the rate of shedding and the number of immature bolls being carried by the plants. Most of the bolls of the first flowering period were fully matured at the beginning of the second flowering period.

The percentage of shedding of the 5-lock bolls was greater than that of the 4-lock bolls in each of the weekly intervals through both flowering periods, except in the week ended August 14, when all the bolls of each type were shed. Of a total of 801 flowers with 4 locks produced during the early flowering period, 197 bolls, or 24.59 per cent, reached maturity, whereas of a total of 1,835 flowers with 5 locks only 296 bolls, or 16.13 per cent, matured.

During the late flowering period a large percentage of the bolls had 4 locks and some 3 locks, but the relations between the rates of shedding of 4-lock and 5-lock bolls remained practically the same. Of a total of 163 flowers with 5 locks produced during the late flowering period, 29 bolls, or 17.79 per cent, reached maturity, as compared with 468 flowers with 4 locks, of which 106 bolls, or 22.65 per cent, reached maturity, and with 38 flowers with 3 locks, of which 8 bolls, or 21.05 per cent, matured.

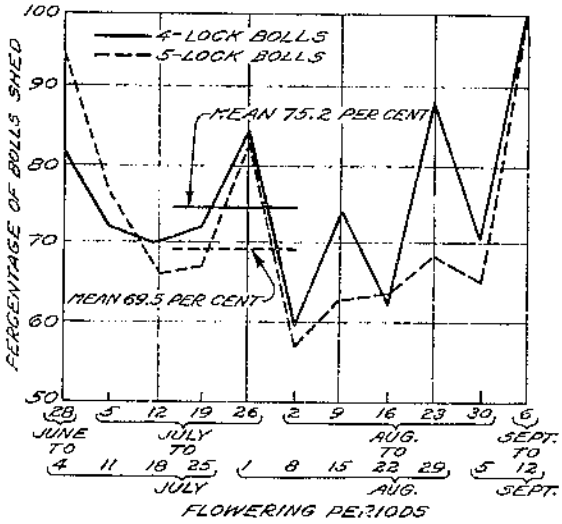

FIGURE 4.—Percentages of 4-lock and 5-lock bolls shed by 25 plants of Acala cotton grown at Bard, Calif., shown in weekly periods from June 28 to September 12, 1926, with mean percentages of bolls shed for the entire period

Of a grand total of 1,269 flowers with 4 locks, 303 bolls, or 23.88 per cent, reached maturity, as compared with a grand total of 1,998 flowers with 5 locks, of which 325 bolls, or 16.27 per cent, reached maturity.

The question still remains as to whether the increase in percentage of 4-lock bolls matured over the percentage of 5-lock bolls matured is due to a greater persistence of the 4-lock bolls, and whether the plants would be able to mature a greater quantity of seed cotton if only flowers with 4 locks were produced. As indicated by the percentages of bolls that matured, if all the flowers produced on the 100 plants had been 4-locked, the quantity of seed cotton would have been greater than if all the flowers produced had been 5-locked. Disregarding the 3-lock bolls, a crop of 780 4-lock bolls would have been matured, as against 531 5-lock bolls. Considering these 531 5-lock bolls as equivalent to 664 4-lock bolls, there is a difference of 116 4-lock bolls.

EXPERIMENTS AT BARD, CALIF.

RESULTS UNDER USUAL IRRIGATION AND CULTURAL METHODS

Records of the number of 4-lock and 5-lock flowers produced and of the percentages of bolls shed were kept on each of 25 plants grown at Bard, Calif., in 1926. These plants were selected in a field of

Acala cotton grown under irrigation according to the customary cultural methods employed at Bard. The individual records of these plants are arranged in Table 4 in the order in which the plants stood in the row. These records show a wide variation in the production and rate of shedding of both 4-lock and 5-lock bolls. The mean weekly percentages of 4-lock and 5-lock bolls shed by the 25 plants are shown in Figure 4.

TABLE 4.—*Individual records of 25 plants of Acala cotton grown at Bard, Calif., in 1926, showing number of flowers produced, percentage of bolls with 5 locks, and percentage of 4-lock and 5-lock bolls shed*

Plant No.	Flowers produced	Bolls with 5 locks	4-lock bolls shed	5-lock bolls shed	Plant No.	Flowers produced	Bolls with 5 locks	4-lock bolls shed	5-lock bolls shed
	Number	*Per cent*	*Per cent*	*Per cent*		*Number*	*Per cent*	*Per cent*	*Per cent*
1	128	67.2	64.3	66.3	15	73	75.1	88.9	65.5
2	82	67.1	81.5	63.5	16	76	67.0	80.0	58.9
3	61	72.1	64.7	58.5	17	120	54.1	78.3	70.8
4	90	77.8	60.0	64.3	18	99	68.7	91.1	72.0
5	40	67.5	66.9	55.5	19	61	74.8	81.2	68.9
6	56	73.2	66.6	75.6	20	55	68.1	76.4	60.5
7	137	77.4	67.7	52.9	21	89	74.2	74.9	79.2
8	135	64.5	50.0	69.0	22	99	79.8	75.0	62.1
9	56	93.7	75.0	61.0	23	82	83.4	50.0	72.3
10	102	66.7	82.4	60.3	24	94	70.2	71.3	60.7
11	110	62.7	68.3	68.1	25	67	64.1	75.0	55.3
12	145	63.9	71.1	62.0					
13	148	78.4	51.3	52.1	Total	2,293	70.6	75.2	69.5
14	88	59.1	77.7	65.4					

The total number of flowers produced per plant ranged from 40 for plant No. 5 to 148 for plant No. 13, with a mean of 91.72 flowers per plant. Of all the flowers produced, 70.6 per cent became 5-lock bolls. The percentage of flowers developing into 5-lock bolls ranged from 54.1 per cent on plant No. 17 to 93.7 per cent for plant No. 9.

Of the total number of 5-lock bolls produced, 69.5 per cent were shed. On individual plants percentages of 5-lock bolls that were shed ranged from 52.9 per cent for plant No. 7 to 79.2 per cent for plant No. 21.

Of all the 4-lock bolls produced, 75.2 per cent were shed. Individual plants shed from 50 per cent of their 4-lock bolls, as for plants Nos. 8 and 23, to 91.1 per cent for plant No. 18.

For 19 of the 25 plants in this series the percentage of 4-lock bolls shed was greater than the percentage of 5-lock bolls shed, and the mean percentage of 4-lock bolls shed was 5.7 per cent greater than that of the 5-lock bolls.

Although the differences were small between the rate of shedding of 4-lock and 5-lock bolls, the general trend was toward a higher shedding rate of 4-lock bolls and at variance with the results obtained in the previous studies.

Since this series of observations was conducted under widely different environmental and cultural conditions from those at Greenville, Tex., the results are not comparable. However, these differences have made it possible to study from various angles the number of locks per boll as a plant character, and to suggest probable causes of the higher rates of shedding of the 5-lock bolls as observed at Greenville, Tex., in 1925.

EFFECTS OF VARIED CONDITIONS OF IRRIGATION, POLLINATION, AND HANDLING

The next experiment, for reasons that had suggested themselves in the course of the previous studies, was projected upon somewhat different lines. Three series of observations were made, each including two groups of plants under contrasting conditions.

A plot of Acala cotton was planted at the United States Acclimatization Garden at Bard, Calif., and special arrangements were made to give contrasting irrigation treatments. The cotton was planted April 12, following irrigation of the land on April 9. The seedlings were thinned June 1 to approximately 1 foot apart in the rows. On June 2 the plot was divided into two equal sections by a high border running parallel with the rows. One side of the border was then designated the wet section and the other the dry section. The wet section was irrigated at 2-week intervals from June 2 to August 23 and again on October 19, while the dry section was irrigated only three times during the season—July 26, August 23, and October 19.

On June 24 the first series of observations was begun. Fifteen consecutive plants were selected from each section in order to compare the production and shedding of 4-lock and 5-lock bolls under normal and under stress conditions. All the flowers produced on these 30 plants were labeled with tags bearing the date of flowering and the number of stigma lobes, or locks per boll. The tags from shed bolls and from mature open bolls were collected and dated as in the previous studies. This study was designated the open-pollinated series, the flowers being left open to be pollinated by insects, as in previous studies.

For comparison with the foregoing series, 15 consecutive plants in rows adjacent to the open-pollinated plants were selected from each section. The flowers were self-pollinated, that is, each flower was kept closed to prevent the entrance of insects by placing a small rubber band over the tip of the corolla just before it began to open. Since the flowers of this series were not allowed to open, the number of locks could not be determined during anthesis but was recorded when the tags of the shed bolls and the mature open bolls were collected. These plants were designated the self-pollinated series.

On July 15 another series of observations was begun on 15 consecutive plants in each section, selected in rows adjacent to the open-pollinated series. These plants were treated in the same manner as those of the open-pollinated series, except that each flower was pollinated by hand, with pollen from another plant. The pollinating was done as soon as the anthers were well open, usually between 8 and 9 a. m. These plants were designated the hand-pollinated series.

The open-pollinated series was intended primarily as a basis for a study of the effects of stress conditions upon the production and the rate of shedding of 4-lock and 5-lock bolls. It also served as a check for the self-pollinated and hand-pollinated series, which were devised to study the effects of pollination upon the rate of shedding of 4-lock and 5-lock bolls. In comparing the wet and dry sections, consideration must be given to the fact that while fewer flowers were produced on the dry sections, higher percentages of the bolls were retained. On account of the abundance of bees, wasps, and other pollinating insects, little difference could be expected between

the results in the open-pollinated and hand-pollinated series. In one case it was certain that foreign pollen was introduced on to the stigma of each flower, and in the other case it was highly probable.

The different methods of pollination gave no apparent effects in these studies. At least no significant differences are traceable to this cause. However, the conditions existing at Bard, Calif., were unfa-

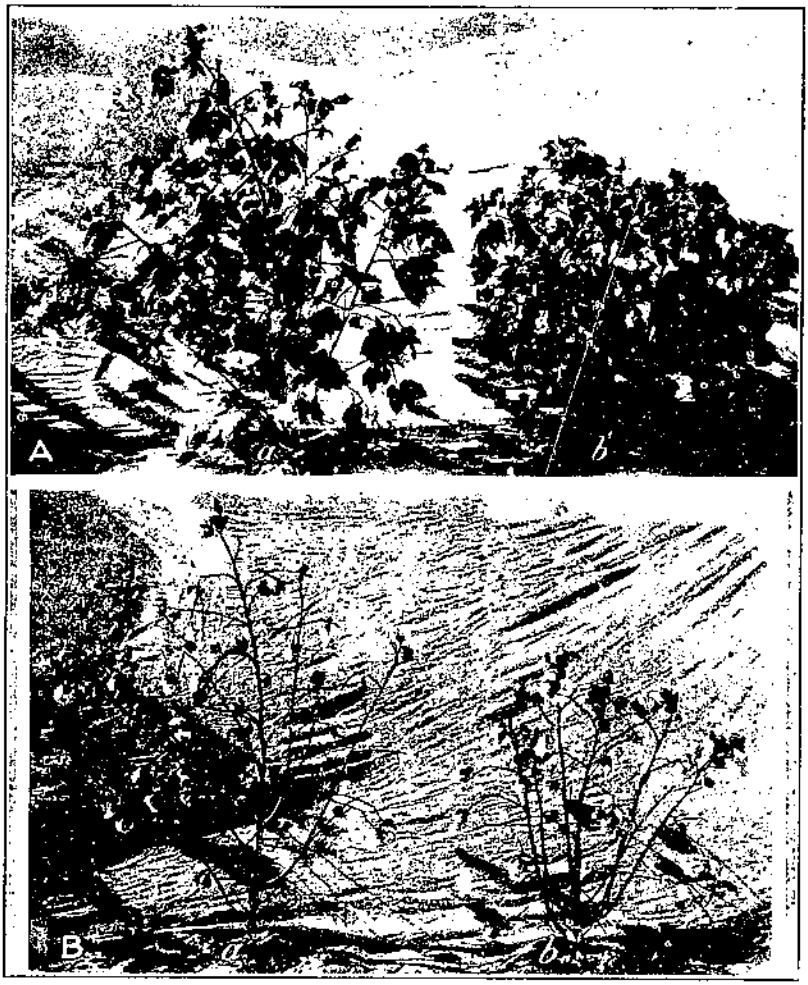

FIGURE 5. Effect of excessive handling on development of cotton plants: A, Plants in the wet section of the self-pollination series; *a*, normal plant; *b*, excessively handled plant in an adjacent row, showing more compact and rigid structure; B, same plants defoliated to show development of stalks and branches. Note the sturdy upright habit of the much-handled plant (*b*)

vorable for these studies because of the abundance of pollinating insects, and no conclusions can be drawn from the results obtained.

The comparability of the self-pollinated series is somewhat impaired by the striking effects of the handling of plants upon their habits of growth and physical development. (Figs. 5 and 6.) The effects of handling upon the open-pollinated and the hand-polli-

nated series were only slightly noticeable in comparison with plants in adjoining rows that were unmolested; but in the self-pollinated series, where more than double the amount of handling of the plants was required, the effect upon development was outstanding. The additional handling of the plants in the self-pollinated series was necessary because of the extra work of self-pollinating. This work was done between 4 and 6 a. m., before the flowers opened, and much bending and twisting of the stalks and branches was necessary in order to locate all of the buds that were ready to bloom. The plants receiving this treatment developed into compact, rigid structures, apparently in an effort to resist the bending and twisting to which they were subjected.

In addition to being more compact and rigid in structure, the excessively handled plants were observed to be exceedingly drought resistant. This difference in the habit of growth was very pronounced

FIGURE 6.—Comparison of excessively handled (A) and normal (B) cotton plants in the same row, in the wet section of the self-pollinated series. Note the compact form of the much-handled plants and the more open development of normal plants

and rendered it impracticable to reduce the plants of the self-pollinated series to a condition of stress by withholding water without running the risk of injuring the plants of the other series in adjacent rows. The foliage of the short, bushy plants of the self-pollinated series, crowded together, remained turgid throughout the season, while the leaves of adjoining plants often were distinctly wilted. This observation is made because it appears to have a direct bearing upon the data reported, though no explanation of the effects produced by the experimental manipulation is suggested.

The effects of stress conditions of water shortage upon the number of locks per boll were apparent in the open-pollinated and hand-pollinated plants. In the open-pollinated series 76.8 per cent of the bolls produced in the wet section had 5 locks, as compared with 70.7 per cent in the dry section, while in the hand-pollinated series 74.3 per cent of the bolls produced in the wet section had 5 locks as compared with 67.4 per cent in the dry section. In the self-pollinated

series, however, this tendency was reversed, the wet section producing 72.2 per cent of 5-lock bolls, and the dry section 77.0 per cent. This difference in the production of 5-lock bolls may be associated with the difference in growth and behavior of the much-handled plants and their obviously greater resistance to the drought conditions.

Differences in the rate of shedding of 4-lock and 5-lock bolls occurred in the wet and in the dry sections of the open-pollinated and

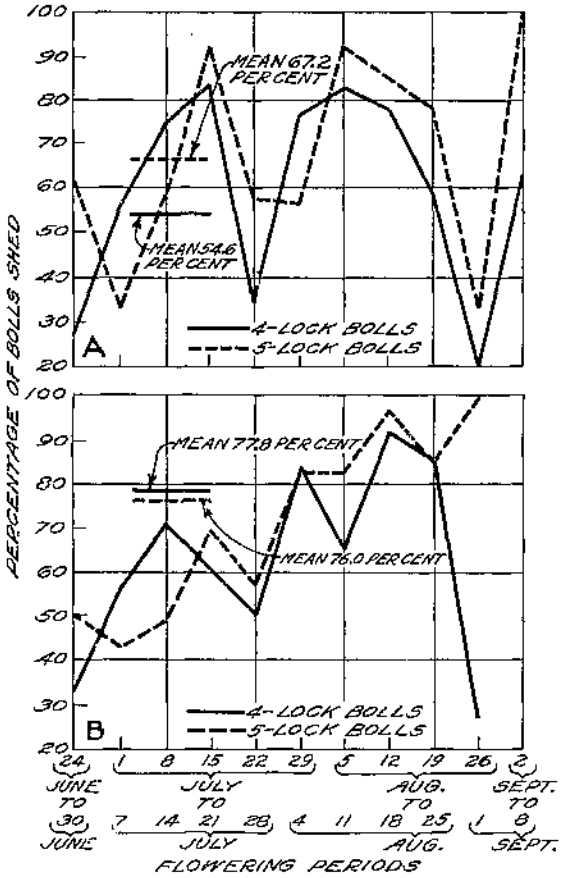

FIGURE 7.—Percentages of 4-lock and 5-lock bolls shed from flowers produced on 30 plants of Acala cotton in the dry (A) and wet (B) sections of the open-pollinated series during consecutive 7-day periods from June 24 to September 8, 1927, at Bard, Calif.

hand-pollinated series. In the wet section the shedding of 4-lock bolls was 1.8 per cent greater in the open-pollinated plants and 2.2 per cent greater in the hand-pollinated plants than the shedding of 5-lock bolls. These results coincide with those at Bard, Calif., in 1926; whereas in the dry section the shedding of 4-lock bolls was 12.6 per cent less than the shedding of 5-lock bolls in the open-pollinated plants and 24.1 per cent less in the hand-pollinated plants. Similar results were obtained at Greenville, Tex., in 1925.

In both sections of the self-pollinated series the percentage of shedding of 5-lock bolls was greater than that of the 4-lock bolls. In the wet section 73.7 per cent of the 4-lock bolls were shed, as compared with 82.8 per cent of the 5-lock bolls; and in the dry section 55.6 per cent of the 4-lock bolls were shed, as compared with 75.3 per cent of the 5-lock bolls. The more extensive shedding of the 5-lock bolls in the self-pollinated series may be partly due to imperfect fertilization.

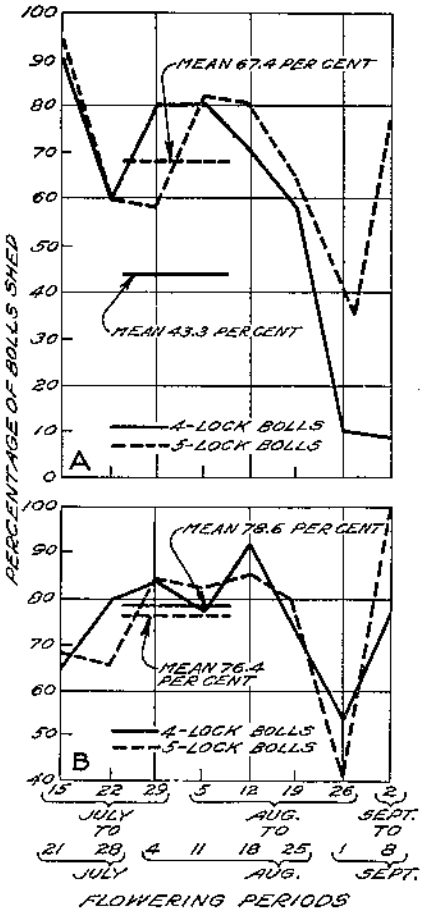

FIGURE 8.—Percentages of 4-lock and 5-lock bolls shed from flowers produced on 30 plants of Acala cotton in the dry (A) and wet (B) sections of the hand-pollinated series during consecutive 7-day periods from July 15 to September 8, 1927, at Bard, Calif.

The number of 4-lock and 5-lock flowers produced and the number and percentage of bolls shed in 7-day periods for the open-pollinated, hand-pollinated, and self-pollinated series are shown in Table 5. Also, the percentages of 4-lock and 5-lock bolls shed are shown in Figures 7, 8, and 9, representing the open-pollinated, hand-pollinated, and self-pollinated series, respectively.

The percentages of 4-lock and 5-lock bolls shed (figs. 7, 8, and 9) follow the same general trend in each series, but show differences between the wet and dry sections, due to the different methods of irrigation. Also, contrasting differences are apparent in comparing the graphs representing shedding under dry-land culture in Texas with those representing shedding under irrigation in California. Under the dry-land cultural conditions (figs. 1, 2, and 3) a gradual increase is shown in the rate of shedding throughout each flowering period. This regular behavior is in contrast to the variable shedding shown in Figures 6, 7, 8, and 9 where definite changes in rates of shedding are recorded with each irrigation.

TABLE 5.—*Four-lock and five-lock flowers produced and young bolls shed on 30 Acala cotton plants each in the wet and dry sections of the open-pollinated, hand-pollinated, and self-pollinated series for consecutive 7-day periods at Bard, Calif., 1927*

OPEN POLLINATED

Flowering period	Wet section						Dry section					
	4-lock—			5-lock—			4-lock—			5-lock—		
	Flowers produced	Bolls shed		Flowers produced	Bolls shed		Flowers produced	Bolls shed		Flowers produced	Bolls shed	
	Number	*Number*	*Per cent*	*Number*	*Number*	*Per cent*	*Number*	*Number*	*Per cent*	*Number*	*Number*	*Per cent*
June 24-30	3	1	33.3	2	1	50.0	7	2	28.6	8	5	62.5
July 1-7	9	5	55.6	14	6	42.9	16	9	56.3	23	8	34.8
July 8-14	10	7	70.0	56	24	48.0	8	6	75.0	75	44	58.7
July 15-21	5	3	60.0	74	51	68.9	6	5	83.3	106	99	91.7
July 22-28	8	4	50.0	223	126	56.5	14	5	35.7	157	91	58.0
July 29 to Aug. 4	67	56	83.6	257	212	82.5	13	10	76.9	55	31	56.4
Aug. 5-11	62	40	64.5	247	203	82.2	6	5	83.3	13	12	92.3
Aug. 12-18	87	80	92.0	142	136	95.8	14	11	78.6	20	17	85.0
Aug. 19-25	67	57	85.1	76	64	84.2	111	66	58.6	82	64	78.0
Aug. 26 to Sept. 1	11	3	27.3	5	5	100.0	35	7	20.0	27	9	33.3
Sept. 2-8	0	0	0	0	0	0	8	5	62.5	5	5	100.0
Total	329	256	77.8	1,090	828	76.0	238	130	54.6	573	385	67.2

HAND POLLINATED

July 15-21	11	7	63.6	95	63	66.3	9	8	88.9	109	101	92.7
July 22-28	14	11	78.6	220	143	65.0	10	6	60.0	146	85	58.2
July 29 to Aug. 4	56	46	82.1	230	192	83.5	20	16	80.0	54	31	57.4
Aug. 5-11	67	51	76.1	236	193	81.8	5	4	80.0	11	9	81.8
Aug. 12-18	101	94	93.1	165	140	84.8	10	7	70.0	15	12	80.0
Aug. 19-25	97	70	72.2	112	87	77.7	83	48	57.8	54	34	63.0
Aug. 26 to Sept. 1	28	15	53.6	31	13	41.9	50	5	10.0	40	14	35.0
Sept. 2-8	4	3	75.0	2	2	100.0	37	3	8.1	34	26	76.5
Total	378	297	78.6	1,091	833	76.4	224	97	43.3	463	312	67.4

SELF POLLINATED

June 24-30	5	4	80.0	10	4	40.0	1	1	100.0	3	1	33.3
July 1-7	9	8	88.9	17	17	100.0	2	1	50.0	11	6	54.5
July 8-14	23	19	82.6	82	80	97.6	7	6	85.7	63	59	95.2
July 15-21	12	10	83.3	116	108	93.4	7	5	71.4	128	107	83.6
July 22-28	12	8	66.7	238	202	84.9	16	7	43.8	260	168	64.6
July 29 to Aug. 4	62	45	72.6	263	237	90.1	46	34	73.9	200	155	77.5
Aug. 5-11	73	46	63.0	236	158	66.9	20	15	75.0	61	54	88.5
Aug. 12-18	121	109	90.1	175	156	89.1	14	13	92.9	20	20	100.0
Aug. 19-25	138	93	67.4	86	61	70.9	82	39	47.6	52	37	71.2
Aug. 26 to Sept. 1	24	10	41.7	24	11	45.8	37	12	32.4	8	1	12.5
Sept. 2-8	3	3	100.0	3	3	100.0	11	2	18.2	10	6	60.0
Total	482	355	73.7	1,250	1,035	82.8	213	135	55.6	815	614	75.3

SUMMARY

Data collected at Greenville, Tex., in 1925, and at Bard, Calif., in 1926 and 1927, indicate that 5-lock bolls may have a greater tendency to abort than 4-lock bolls. Also, 5-lock bolls are shown to be influenced by environmental and cultural conditions to a greater extent both in the number produced and in the rate of shedding, than are 4-lock bolls.

More favorable conditions tend to a lower rate of shedding of 5-lock bolls than of 4-lock bolls, as was shown in experiments conducted with Acala cotton under good conditions at Bard, Calif. These results contrast with those obtained with Lone Star cotton under less favorable conditions at Greenville, Tex., and with the Acala variety under artificial stress conditions at Bard, Calif.

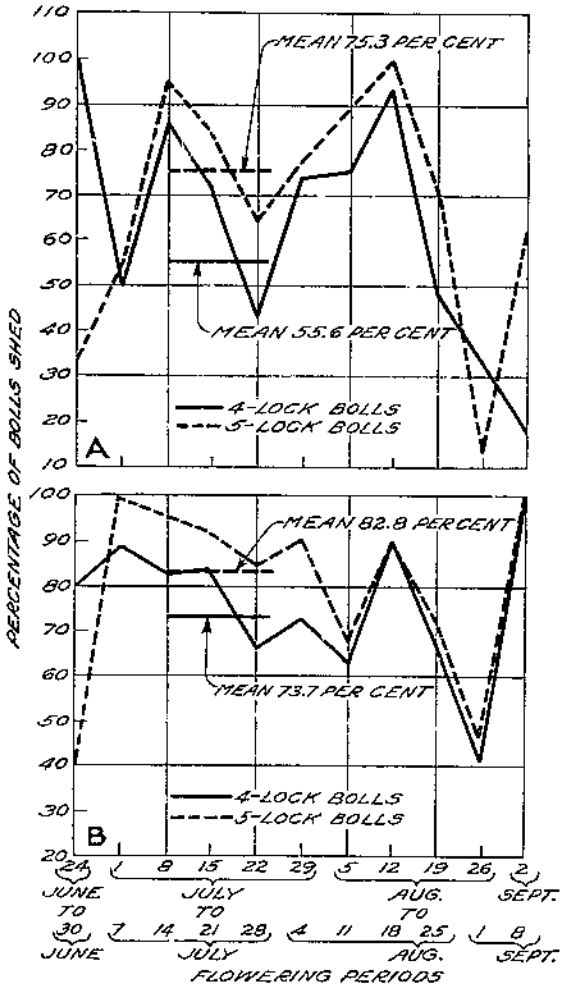

FIGURE 9.—Percentages of 4-lock and 5-lock bolls shed from flowers produced on 30 plants of Acala cotton in the dry (A) and wet (B) sections of the self-pollinated series during consecutive 7-day periods from June 24 to September 8, 1927, at Bard, Calif.

Under the dry-land cultural conditions at Greenville, Tex., the percentage of 5-lock bolls that aborted was consistently higher than that of the 4-lock bolls, whereas at Bard, Calif., under more favorable conditions of irrigation, the percentage of the 5-lock bolls that aborted was less than that of the 4-lock bolls, except in cases where the plants suffered for lack of water, or otherwise developed abnormally.

In each case at Bard, Calif., where the plants suffered for lack of water, a higher percentage of the 5-lock bolls than of the 4-lock bolls aborted. Also, a smaller percentage of the bolls were 5-locked in each case under the stress conditions. These data coincide with those collected under dry-land culture at Greenville and show that a lower percentage of 5-lock bolls are produced and a higher percentage of 5-lock bolls are shed when adverse conditions are encountered.

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