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A STUDY OF SOME ECONOMIC CHARACTERS OF THE COTTON BOLL IN RELATION TO THE FLOWERING PERIOD AND BRANCHING. *

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Introduction. The present study with special reference to "Northerns" cotton has as its aim an analysis of some economic characters of the cotton boll such as shedding interval, maturation period, seed and lint weights and lint length in relation to the flowering period and to the development of the flower on primary or secondary fruiting branch. The cotton plant experiences a gradual rise in atmospheric temperature during the period of the development of its bolls and a very common observation is a general decrease in the values of some of the boll characters as the season advances (8, 17). It is also sought to present in this paper some aspects of variation of the cotton boll with reference to its position on the plant.

Material and Methods. Material for the present study was gathered from plants of two pure cultures, (1) Nandyal 14, a standard Indian Cotton and (2) No: 54, grown at the Agricultural Research Station, Nandyal, Kurnool District, during the season 1930—31. Both the cultures belong to the species indicum. The plants were spaced a foot and a half between rows and a foot in the row. They were hand-dibbled under field conditions and received all the cultural operations accorded to bulk crops on the station. For purposes of the present study, 25 plants [a] of each were selected in the two cultures, the choice being restricted to healthy normal plants not bored by the boll worm (*Earies Sp.*) and numbered serially. Each flower, as it opened, was numbered with dated tags and a record of its position (7, 17) as on monopodial or sympodial branch maintained. Daily collection of the shed labels afforded data as to shedding intervals of bolls dropped. Those, that persisted and burst were gathered individually and their picking dates noted. The boll-contents [*b] were examined in the laboratory and after the elimination of insect-damaged bolls, healthy ones were individually studied for seed and lint weights and lint length per seed, and ginning percentage. In the succeeding paragraphs the results of the following characters will be presented in order.

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[*a During the course of the investigation, some plants were rejected as bored by the *Earias Sp.*; and finally material from 17 plants of 54 and 21 plants of N. 1 were available for the present study.]

[*b. The bolls studied in the two cultures were of three locules or compartments. No. of 4-locked bolls were negligible.]

1. Flowering and bolling,
2. Maturation period (Interval in days between flowering and picking dates),
3. Shedding interval (Interval in days between flowering and shedding dates).
4. Weight per seed (determined from all available seed cotton of each boll) (mgm)
5. Lint weight per seed (do) (mgm)
6. Lint length (mgm) (Average of third position seed of each locule of the boll (16), combed according to Hilson's method (6).

Results. *Flowering and bolling.* That the cotton plant produces two kinds of branches, (1) the vegetative branches monopodials or limbs and (2) the fruiting branches or sympodials is a matter of common knowledge to all workers on cotton. The monopodia develop usually at the lower part of the main stem and produce sympodials which are termed secondary fruiting branches while the primary sympodials or the main fruiting branches develop at the upper nodes. The development and configuration of these two types of branches afford distinguishing characters for cotton selections. N. 14 is of a monopodial type, the average number of monopodia borne by each plant being from 3 to 8 during the year and the first fruiting branch starts at the 20th node while culture 54 is of a distinctly sympodial type. The number of monopodia developed by this cotton ranged from 1 to 3 and the first fruiting branch started at the 11th node.

The flowering in these cottons was in the usual regular succession, the flower opening in the beginning being low on the plant and nearest the main stem, the succeeding ones being away from the main stem or higher on the plant i. e., the order of opening being both " centrifugal and acropetal " (3). The flowering and bolling curves, in general, were as usual observed to rise somewhat slowly at first, then take a steep course, reach their maximum and then descend (3). The weekly flowering and bolling data of N. 14 and 54 analysed into sympodial and monopodial flowers according to their position are presented in Table 1 along with their respective totals. It will be seen in the case of N. 14 that the monopodial flowers form the majority as many as 58 % of the total while No. 54 shows itself as a distinctly sympodial type, the percentage of sympodial flowers to the total being 82. It is also noticed (Table 1) that in the case of 54, the sympodial flowers start slightly earlier that the monopodial flowers i. e., two weeks in advance, while in the case of No. 14 both the categories of flowers start simultaneously. In No. 54, 31 % of the flowers are seen to develop into bolls while 49 % develop in the case of No. 14. Analysing into

sympodial and monopodial bolls, 30 % of the sympodial and 36 % of the monopodial flowers develop into bolls in the case of No. 54 while the respective percentages in the case of No. 14 are 53 and 46 %. In other words, in the case of No. 54, 24·2 % of the bolls developed are sympodial in origin and 6·7 % monopodial, while in the case of No. 14, the percentages are 22·2 and 26·8, respectively.

Maturation period. The maturation period or the interval from flowering to the picking dates of the boll was investigated for sympodial bolls and weekly averages worked out. The data are presented in Table 2. The usual decrease in the maturation period with the advance of the season is seen most pronouncedly in both the monopodial and sympodial bolls of the two strains. The average maturation period of the sympodial boll is found to be slightly higher than that of the monopodial boll in both the cultures. When a comparison of the weekly averages of sympodial and monopodial boll maturation periods is made, it is found that the differences are not significant as per "Student's" method. This clearly shows that season is the factor responsible for the decrease in the maturation period with the increase in temperature and not its monopodial or sympodial origin. The higher averages in the case of sympodial bolls, are due to the production of sympodial bolls in the beginning of the flowering phase with no corresponding bolls on the monopodial branches in the case of 54 and due to the cessation of sympodial boll production towards the fag end of the season when monopodia have continued to bear, in the case of No. 14.

Shedding Interval. The shedding intervals of sympodial and monopodial bolls for No. 54 and N. 14 are cited in Table 3. In the case of sympodial bolls of 54, it is seen that the shedding intervals in the beginning and the end of the season are comparatively short in consideration with bolls of the mid-season. In the case of the monopodial bolls of 54 and both the sympodial and monopodial bolls of N 14, the short interval as the season comes to a close is pronounced. When the differences in the weekly shedding intervals of sympodial and monopodial bolls were considered as per "Student's" method, it was found that the averaged difference of the pairs compared was significant in the case of N54, while in the case of N14 the odds were insignificant. It is considered that season plays a prominent part in the shedding interval particularly during the advanced season while the physiological aspect of the plant has its own role especially in the early part of the season. The quick boll abcission during the beginning of the season in the case of No. 54 is to be accounted for as resulting due to the plant being ill-fitted at the time for proper reproductive activity.

Seed and lint weights & lint length. The variation found in the economic characters, seed and lint weights and lint length per seed

included in the present study is fairly wide. The data are given in Table 4. The difference between the highest and lowest values in the same season ranged from 7 to 55% of the means in the three characters. These variations are presented in Table 5, a and b, according to flowering periods and branching, sympodial and monopodial. A general fall in the values of the characters is noticeable in the case of both the cottons. The decline is most pronounced in the case of seed weight. In the case of lint weight it is gradual while it is very feeble in the case of lint length. Venkatraman (17) working with herbaceum cottons has observed similar declining tendencies.

The weekly mean seed weight of sympodial boll is higher than that of the monopodial boll in the case of 54 due mainly to the production of sympodial bolls in the beginning of the season without any monopodial bolls in the corresponding period. But when the available weekly average seed weight pairs of sympodial and monopodial bolls are compared, the observed difference is found to be statistically insignificant. In the case of N. 14, there is no difference in the general means and the comparison of weekly averages of sympodial and monopodial seed weights reveals no difference for statistical significance. The case of lint weight is similar to the behaviour of the corresponding seed weights in the two selections. No. 54 shows a higher sympodial mean with no significant difference in the weekly pairs, the contribution towards the higher lint weight mean being from the sympodial bolls occuring in the beginning of the season without any corresponding bolls on the monopodia as observed already in the foregoing paragraphs. In the case of N. 14, there is neither difference in the general mean nor in the weekly means of the lint weights of the two categories of bolls. As is to be expected, the case of ginning percentage (percentage of lint to seed-cotton) is similar to the seed and lint behaviours of the respective selections. The case of lint length is slightly different. In the case of No. 54, as in the case of the other selection, No. 14, there is neither difference in the general means nor in the comparisons of weekly average pairs. This is due to the fact that in the case of No. 54, the course of lint length has not been one of general decline; an optimum is indicated during the period January end to February beginning. The existence of sympodial bolls in the early part of the season without correspondingly any on the monopodia does not act as a factor for bringing about a higher average as in the case of the maturation period and seed and lint weights. It is noteworthy that season has a very prominent part in the trend of behaviour of these characters.

Literature. Hilson and others (7) working at Coimbatore, Buie (3) working at South Carolina, Zaitzev (18) working in Turkistan have recorded similar "centriful and acropetal" succession of flower opening as observed by the author.

As regards maturation period, Patel and Mann (15) working in Broach-Deshi cottons in Bombay observe "that the time required for the maturation of the boll would seem to be distinctly but feebly correlated with the seed weight.....and the time required for maturation of the bolls also affects lint weight and in fact to a greater extent than with seed weight." Venkatraman (17) working on herbaceum cottons at Coimbatore, concludes that the maturation period declines from day to day as the season advances. The results obtained in this paper are in agreement with the experiences of these authors while the experience of Loomis (10) at Sacaton, Arizona, that the maturation period of bolls of the same flowering date was longer on outer than on inner nodes of fruiting branches and that boll periods on all nodes lengthened as the season progressed, must be attributed to the entirely different seasonal conditions prevailing there. As observed in the present study, in the case of one of the cottons, No. 54, Venkatraman (17) has shown that the boll on the primary sympodial branch took a longer time to mature owing to the fact that the flowering curve of the primary sympodia is earlier than that of the secondary ones and that the bolls from flowers of the same date do not show any difference in the bolling period.

Zaitzer (18) observes that shedding of the bolls increases from bottom to top and from the centre laterally along the branches and that this latter direction is characterised by a greater increase in the rate of shedding than the first and that this is due to the difference in the nutrition of the separate bolls in dependence on their position on the branch. Loomis (10) concludes that boll shedding increased appreciably on the outer nodes of branches. The work of Balls (2) in Egypt confirmed by Lloyd's (9) studies "conducted under relatively humid conditions at Albama established a strong presumption that the major factor initiating abcission was a marked water deficit in the body of the plant." Ewing (4) working in Mississipi also attributed the disturbance in the water-balance of the plant as the main factor responsible for shedding. Harland (5) working in St. Vincent notes that shedding is heaviest after torrential rain and concludes that root absorption is interfered with as a result of the reduction in the oxygen-supplying power of the soil and that consequently a water-shortage ensures which is the immediate cause of shedding. Mihara and his collaborators (14) working in Corea opine that the phenomenon of shedding is accelerated by rain, excessive soil-moisture etc. Mason (13) working in St. Vincent concludes that the susceptibility to shedding is relatively small in the earlier stages of the flowering period but becomes much more marked in the later stages especially after the occurrence of growth cessation in the main axis. "Periods of day-times rain, low rates of evaporation and little direct solar radiation" were also opined to be "the precursors of augmented rates of shedding."

due to a check in the assimilative activities of the leaves. We have here in the present paper an indirect proof of agreement with Zaitzer's (18), Loomis's (10), and Mason's (13) results in the case of the cotton No. 14; shedding, here, is seen to increase with the advance of the season when flower production is confined to the upper and outer zones of the plant scaffolding. It has been mentioned that Balls (2) and Ewing (4) view a disturbance in the water-balance of the plant as the major factor responsible for shedding and that Harland (5) is of opinion that it is maximum after torrential rain. The day-to-day conditions at Nandyal during the flowering period no doubt tend to a decrease in the moisture content of the soil and as the course of temperature is one of a steady ascent unrelieved by rain Balls (2) and Ewing's (4) views may be taken as suitable explanation for shedding. But, in our present study, shedding in only one of the strains, No. 14, shows a direct relation to temperature; in other words, shedding increases in the later developed bolls which synchronize with increase in temperature. But, the same phenomenon does not hold good in the case of the other strain, No. 54, where shedding decreases with increase in temperature i. e. in the later developed parts of the plant. It is, therefore, probable that the causal factor that holds good for shedding in one strain may not be equally responsible for that in another. Elaboration and translocation of assimililates may not take place concurrently in the season in all strains. What exactly is the cause requires to be studied. It is also shown in this paper that the weekly percentages of shedding in the case of sympodial and monopodial bolls (Table 3) do not show any significant difference in both the strains, although the average of weekly percentages of shedding in the case of the sympodial boll of 54 for the entire flowering period is higher than the corresponding average for the monopodial bolls since the sympodial bolling curve starts earlier. It is, therefore, to be concluded that the same causes that are responsible for augmented or low rates of shedding in sympodial bolls are equally responsible in the case of monopodial bolls also.

The author has shown elsewhere (8) that the characters seed and lint weights distinctly decrease in value as the season advances while lint length and ginning percentage show only a slight falling off. Venkatraman (17) observes a positive and most pronounced fall in seed weight and lint length as the season advances while the case of lint weight is more gradual. Patel and Mann (15) observe a marked tendency for seed and lint weights to decrease in the later developed parts of the plant and in the younger parts of branches (especially in the sympodia) They further observe that there seems to be a tendency for the lint weight per seed to diminish faster than the seed weight i. e., for the ginning percentage to be less on the younger parts of shoots though some strains show the opposite tendency. In the present study,

the previous findings of the author (8) are confirmed and also as observed by Patel and Mann (15) the decrease in lint weight is noted to be faster than that of seed weight with the result that a fall in the ginning percentage is brought about with the advance of the season. As observed by Venkatraman (17) the boll on the sympodial branch is better in seed and lint weights and to a less extent in ginning percentage in one of the two cultures examined namely No. 54. than that on the monopodial due to the earlier flowering curve of the former but the result in the case of lint length of the same strain does not show any increase. Venkatraman (17) further finds that from flowers opening on the same dates the primary sympodial gives a higher seed and lint weight for the bolls than the secondary branch but not a greater lint length. The results (Tables 5-a & b) with the present cottons do not show any significant difference in these three characters and also in ginning percentage.

Conclusion. It is concluded that the general order of flowering follows much the same course of "centrifugal and acropetal" succession in the cottons studied and that with increased temperature, maturation period pronouncedly decreases; in other words, the later formed bolls in the upper and outer zones of the plant structure tend to dehisce quickly, the quickness being in proportion to the distance upwards and outwards from the centre of the plant. It is also seen that the position of the boll on the primary or secondary sympodia does not account for any difference in maturation period within the same flowering periods, although the general mean for the sympodial bolls is higher due to the earlier start in flower formation on this type of branch. Following the course of the maturation period, shedding also decreases with increase in temperature in one of the cultures (54) studied while, in the other (No. 14), the reverse is the case. Being an early strain, this selection, No. 54, perhaps behaves as an exception. It may be possible that in this case, by a suitable alteration in the sowing date, quite a different result might be obtained. It is further shown that bolls formed from flowers opening on the same date do not show any difference in shedding percentages due to differences in the type of branch. The course of seed and lint weights and ginning percentage is shown to be one of decline with the advance of the season, it being most prominent in the first two cases and moderate in the last. The variation in lint length is observed to be extremely small. No differences in these characters are met with due to the position of the boll as on primary or secondary sympodial although the general means of the primary sympodial characters were higher in the case of No. 54. due to the earlier start in the flowering phase as mentioned already. No doubt, as observed by Zaitzev (19), temperature is the most important factor determing the course of growth of the cotton plant, its influence affecting almost all stages of

its development but there may be certain strains where its influence may not be felt equally in all its stages, the deviations being attributable to a lack of physiological coordination with temperature. as in the case of rate of shedding in culture No. 54.

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Table 1. *Flowering and Bolling data of N-14 and 54 (per plant).*

Flowering Date	N-14						54					
	Flowers.			Bolls.			Flowers.			Bolls.		
	Symp.	Monop.	Total.	Symp.	Mon.	Total.	Symp.	Mono.	Total	Symp.	Mono.	Total.
1930 Dec. 7							1 06		1·06	0·06		0·06
14							1·71		1·71	0·29		0·29
21							2·41	0·06	2·47	0·47		0·47
28							2·76	0·12	2·88	0·53	0·06	0·59
1931 Jan. 4	1·00	0·10	1·10	0·57	0·10	0·67	3·24	0·41	3·65	1·06	...	1·06
11	1·57	0·66	2·23	0·57	0·43	1·00	3·41	0·41	3·82	1 06	0·18	1·24
18	2·38	2 90	5·28	1·52	1·76	3·28	3·88	0·71	4·59	0·82	0·12	0·94
25	2·67	2·86	5·53	1·33	1 81	3·19	3·88	0·29	4 17	0·88	0·06	0·94
Feb. 1	2·00	2·52	4·52	1·05	1·10	2·15	1·71	0·47	2·18	0·59	0·18	0 77
8	1·33	2·90	4·23	1 00	1·24	2·24	2·47	0·71	3·18	1·00	0·35	1·35
15	0·86	2 57	3 43	0·33	0·86	1·19	2·18	0·76	2·94	0·94	0·47	1·41
22	0·33	1·52	1·85	0·10	0·48	0 58	2·65	0 88	3·53	1·18	0·29	1·47
Mar. 1	0·33	0·86	1·19	0·05	0·19	0·24	3·71	1·59	5·30	1·53	0·65	2·18
8	0·10	0 38	0·48	0·05	0·05	0·10	2·82	2 18	5·00	0·82	0·76	1·58
Total.	12·57	17·27	29·84	6·62	8·02	14·64	37·89	8·59	46·48	11·23	3·12	14·35
%		58 % of total,		53 % of Symp. flowers.	46 % of Mono. flowers.	49% of flowers i.e., 22·2% Symp. 26·8% Mono.	82% of total.			30% of Symp. flowers.	36%of Mono. flowers.	31% of flowers i.e. 24·2% Symp. 6·7% Mono.

Table 2. *Maturation Period.* (*No. of days*).

Flowering date	N-14			54		
	Average Symp-	Average Mono	Average total.	Average Symp.	Average Mono.	Average total.
1931.						
Jan 4				44·8		44 6
11	43·0	41·5	42·2	44·2		44·2
18	42·1	41·8	41·9	41·9		41·9
25	40 6	40·2	40·3	40·2		40·6
Feb. 1	39·0	38·7	38·8	38·3	37·5	38·1
8	37·0	36·6	36·8	37·1	37·1	37·1
15	34·7	35 3	35·1	36·2	35·5	36·8
22		33 5	33·5	33·6	34·8	33·8
Mar. 1		33·5	33·5	33·2	34·3	34·0
8				32·7	32·4	32·6
Average.	39 40	37·64	37 80	38·22	35·27	38 31
Difference in comparable pairs.	+0·4			—0·1		
Odds in favour of difference. (Students' method).	7 : 1			1 : 1		

Table 3.

Shedding Interval (Days) and % of Shedding.

Flowering Date.	Shedding Interval.				% of Shedding (to flowers).					
	N14		54		N14			54		
	Symp.	Mono.	Symp.	Mono.	Sym.	Mon.	Total	Sym.	Mon.	Total
1930										
Dec. 7			10					94		94
14			10					83		83
21			11					80		81
28			9					81		80
1931										
Jan. 4	15		11	10	43	0	39	67		71
11	17	12	14	18	64	35	55	69	56	68
18	11	13	12	9	36	39	38	79	83	80
25	10	11	14	15	48	36	42	77	79	77
Feb. 1	13	10	20	9	47	56	52	65	62	65
8	10	9	15	10	25	57	47	60	51	58
15	8	9	13	9	62	67	65	57	38	52
22	12	8	13	7	70	68	69	55	67	58
Mar. 1	9	8	10	8	85	78	80	59	59	59
8		7	8	6	50	87	79	71	65	67
Average.	12	10	12	10	53·0	52·3	56·6	71·2	62·2	70·9
Difference in comparable pairs.	+1·25		+2·9		−0·7			−3·56		
Odds in favour of difference (Student's method).	7 : 1		28 1 Significant.		nil.			6 : 1		

Table 4.

Variation in Characters due to the flowering period.

Character.	Strain No.	Weekly means.				
		Maximum.	Minimum.	Mean.	Difference.	Difference as % of the mean.
Maturation period (Days)	N14	42·2	33·5	37·80	8·7	23·02
	54	44·8	32·6	38·31	12 2	31 9
Seed weight (mgm)	N14	47·3	39 0	44 66	8·3	18·6
	54	52·2	36·1	46·47	16·1	34·6
Lint weight (mgm)	N14	12·6	9 0	11·61	3·6	31·04
	54	21·7	11 9	17 81	9·8	55·1
Lint length (mm)	N14	27·2	25·3	26·66	1·9	7·1
	54	26·5	23·4	25·36	3·1	12·2

Table 5-a.

Seed and Lint weights, ginning percentage and Lint length.

N14

Flowering Date.	Seed weight.			Lint weight.			Ginning percentage.			Lint length.		
	Symp.	Mono.	Total.	Symp.	Mono.	Total.	Symp.	Mono.	Total.	Symp.	Mono.	Total.
1931. Jan. 11	50 5	44·7	47·3	14·0	11·5	12·6	21·7	20·5	21·0		26 3	26·5
18	46·1	47·1	46·6	11·9	12·3	12 1	20·5	20·7	20·6	26·8	27·0	26 9
25	43·2	47 0	45·3	12·3	12·5	12 4	22·2	21·0	21·5	27·5	27·1	27·2
Feb. 1	43·9	44·7	44·3	11·8	13 3	12·4	21·2	22·9	21·9	26·8	26·4	26·6
8	48·1	45·2	46·6	11·4	12·3	11·9	19·2	21·4	20·3	27·0	26·7	26·8
15	43·1	43·5	43·4	11·9	11·2	11·3	21·6	20 5	20·7	27·0	26·7	26·8
22		45·5	44·8		10·7	11·2		19·0	20·0		27·5	27·2
Mar. 1		41·5	39·0		8 8	9 0		17·5	18·8		26 0	25·3
Average.	45·82	44·9	44·66	12 22	11·. 8	11·61	21·07	20·44	20·60	27 02	26·71	26·66
Difference in comparable pairs.	+ 0 45			0			− 0·1			+ 0·2		
Odds in favour of difference. (Student's method).	2 : 1						nil.			7 : 1		

Table 5-b.

Seed and Lint weights, ginning percentage and Lint length.

54

Flowering Date.	Seed weight.			Lint weight.			Ginning percentage.			Lint length.		
	Symp.	Mono.	Total.	Symp.	Mono.	Total.	Symp.	Mono.	Total.	Symp.	Mono.	Total.
1931. Jan. 4	44 8		44·8	18·9		18·9	29·7		29·7	25·2		25·2
11	51·8		51·8	21·7		21·7	29·4		29·5	25 8		25·8
18	52·2		52 2	18 6		18·6	26·3		26·3	25·7		25·7
25	53 5		51·5	19·5		18·9	26·7		26·8	26 5		26·5
Feb. 1	52·1	50·2	51·7	19 3	19·5	19·3	27·0	28·0	27·2	26·3	26·7	26·4
8	52·0	37·9	48·6	19 4	13·9	18·5	27·2	26·8	27·6	26·1	25·8	26·0
15	45·5	41·2	44·0	18·2	15 3	17·1	28·6	27·1	28·0	25·5	25·2	25·4
22	43·2	44·2	43·4	18·2	17 5	18·1	29·6	28·4	29 4	24·8	25·7	24 9
Mar. 1	38·8	45·3	40·6	14 6	16·3	15·1	27·3	26·5	27·1	24·4	24·0	24·3
8	36·0	36·3	36·1	12·6	11·0	11·9	25 9	23·3	24·8	23·2	23 7	23·4
Average.	45·99	42·52	46·47	18·10	15·58	17·81	27 77	26·68	27·64	25·35	25·18	25·36
Difference in comparable pairs.	+ 2·1			+ 1·5			+ 0·9			− 0·1		
Odds in favour of difference (Student's method)	3 : 1			7 : 1			12 : 1			7 : 1		