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Farming will never be a success unless the farmer had more voice in the disposal of his produce.—P. Morrel.

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THE IMMEDIATE EFFECT OF ARTIFICIAL SELF-FERTILIZATION ON SOME ECONOMIC CHARACTERS OF THE COTTON PLANT

By C. JAGANNATHA RAO, B.A.

Assistant to the Cotton Specialist, Nandyal.

Introduction.—The cotton flower being large and showy, attracts many insects and this results in a certain amount of cross-fertilization. Experimental evidence has been overwhelming to prove that vicinism ranging from nearly 2 to 100 per cent occurs in the various cottons investigated, the amounts being determined by the peculiar environmental conditions in each case (2).

In breeding work with cotton, in order to avoid cross-pollination, protection of flowers by artificial means becomes inevitable. Again, to evaluate the purity in the economic characters, the breeder is often forced to examine both the selfed and the naturally pollinated material. It is, therefore, in the fitness of things to know whether selfing affects the characters under study and if so in what direction. No apology is, therefore, needed to devote this paper to a study of the immediate effect of artificial self-fertilization as compared with the natural process.

Material.—The data for the present study were obtained from pure cultures grown during the two seasons—1927–28 and 1929–30—the first at the Agricultural Research Station, Koilpatti, Tinnevelly District, and the second at the Agricultural Research Station, Nandyal, Kurnool District. The cultures which furnished the material were No. 538, a pure strain of *Karunganni* (*G. indicum*) and No. 54, a pure strain from 'Northern' (*G. indicum*). During both the seasons, plants were raised from seeds derived from self-fertilized flowers.

SEASON

1927–28. At Kovilpatti.—The annual rainfall recorded for the year was 36·4 inches, i.e. about 5 inches over and above the average for the preceding 23 years. The monsoon or sowing rains broke at the usual time and the sowings of cotton were at normal period (end of October) and germination good. Unwanted rains to the total extent of 4 inches were received in February 1928.

1929–30. At Nandyal.—The total rainfall for the year was a little over 20 inches as against the rounded average of 30 inches for the preceding 23 years. Despite this exceptionally low rainfall for the year, its distribution must be declared to have been good, barring inadequate sowing rains. The result was a record cotton crop, the final yields far surpassing the initial expectations. The normal sowing time in this tract is towards the end of August and the year under review was no exception to this.

Method of selfing.—The process of selfing was done by the sewing method as described by Parnell and Hilson (10). It consists in sewing up the tip of the unopened flower bud on the evening immediately preceding the day or in the morning itself of the day of the opening of the flower bud and at the same time passing the piece of thread to the persistent bracts. This process renders the identification of the resulting 'selfed' boll at the time of its gathering. This is the usual method of self-fertilization adopted at the Agricultural Research Stations of the Madras Agricultural Department in all breeding work with cotton.

PLAN OF WORK

1927–28. (Culture 538).—Plants in a few rows of the plot of Culture 538 were earmarked for the experiment and numbered serially. Every morning, half the number of flower buds that are to open that day were sewn up, the remaining half being left for natural pollination to serve as controls for comparison. The selfing operation was begun from the 15th of February 1928 to the end of March and in all, 1,609 flowers were 'selfed' and 1,535 flowers were left for natural pollination. The flowers of each day, both selfed and non-selfed, were tagged with dated labels to indicate their flowering dates and also the serial numbers of the mother plants. As the bolls matured and burst, the selfed and the control non-selfed bolls were gathered separately every day with their capsules and dated tags, and kept duly labelled with their respective picking dates for examination in the laboratory. All the four-locked bolls were then sorted into three-day groups according to the flowering dates. Healthy selfed and naturally fertilized bolls were then picked in each group and the locks in each were separately examined for ovules and seeds and the respective averages calculated. Then, from each class, five representative seeds of third position as described in (1) *Agricultural Journal of India*, Vol. xxv, Part 1, were separated out for the determinations of staple length, the method followed being the usual one adopted by Hilson (4). From the remaining seeds of each lot, one-hundred representative seeds or as many as possible if less than hundred, were taken out for the determination of lint and seed weights. The samples were ginned and the weights of seeds and lint determined.

1929–30 (Culture 54 at Nandyal).—Two adjacent rows in the seed multiplication plot of Culture 54 were marked out and one hundred and fifty plants in one row were tagged for selfing the flowers that opened daily. An equal number in the adjacent row were labelled as control plants. This procedure was adopted with a view to obtain a larger amount of material for examination than could have been procured if it had been attempted to eliminate plant to plant variation as was done during 1927–28. Flowering records were maintained for the selfed and non-selfed lines. The rest of the procedure adopted was the same as in 1927–28 at Kovilpatti except that the blooms were not tagged daily with flowering dates and that the three-day grouping was on picking date basis. On each picking day, at intervals of three days, the selfed and the non-selfed bolls were separately gathered *en bloc*. For the determination of lint length, six seeds of the third position were combed instead of five as in 1927–28.

Selfing was commenced from November 16, 1929, and continued up to February 15, 1930 and in all 2,957 flowers were stitched up for self-fertilization. In this Culture 54, the predominating kind of boll was three-locked and hence bolls of this category alone were taken for the study of characters.

RESULTS

Flowering and Bolling curves (1929–30).—Plate I shows the flowering and bolling data of the selfed and the non-selfed lots worked to per plant per day and transformed into illustrative curves. The curves for the selfed and the non-selfed lots are practically identical and are suggestive of no material differences. Kearney (5) also finds no difference in the rate of flowering between selfed and non-selfed plants.

Characters of boll contents 1927–28 and 1929–30.—The characters studied are :—

1. Ovules per lock,
2. Seeds per lock,
3. Fertility index,
4. Lint length,
5. Kapas weight per seed,
6. Lint weight per seed,
7. Seed weight per seed, and
8. Ginning percentage.

In all these cases, readings of the same flowering date groups for results of 1927–28 and of the same picking date groups for results of 1929–30 were compared and their differences were tested statistically as per Student's method. The results are summarized in the table.

OVULES AND SEEDS PER LOCK AND FERTILITY INDEX

The table gives the averages and the differences for these characters. The term fertility index has been used to signify the percentage of ovules

developing into seeds. This index has been very high at Nandyal in the case of 54 cotton and this may be due to the peculiar conditions experienced during the year which resulted in bumper yields. Knowlton and Sevy (8) are of opinion that abnormally high temperatures at bloom (75° to 85°) may reduce the set by its permanently injurious effect on pollen tubes and pollen tube-growth. Among others, this may be one of the possible causal factors for a lower index at Kovilpatti. However, to say that it has been due to environmental conditions in the generality of years, evidence is lacking. In any case, it cannot be said to be a trait peculiar to strain 54, for, most other cottons during the same year exhibited remarkable fecundity. It seems to be a line worth pursuit as high fecundity conduces to yarn uniformity. In all these characters studied the differences found are seen to be statistically insignificant. The results shown in the present paper are not in agreement with the observations of Darwin and Kearney. Darwin (3) concluded that self-fertilization assures the production of a large supply of seeds in the case of many crops. Kearney and Porter (7) in 1927 published that 'bagged flowers produce fewer seeds per boll doubtless, because pollen reaches that part of the stigmas in contact with or immediately above the uppermost anthers.' Earlier still, Kearney (6) reported 'that the better pollination under natural conditions at Sacaton resulted in a higher average number of seeds per lock.' Short stigmas in our indigenous cottons possibly account for the existence of no difference in fertility between the selfed and the non-selfed flowers.

Lint length.—The two places which formed the centres of the experiment are so diverse in their soil and atmospheric conditions that in regard to lint length at Kovilpatti, the figures show a rise and a fall whereas at Nandyal a systematic drop in lint length is noticed with the advance of the season. Whether this phenomenon is found to hold good as a general rule with the other cottons also is yet to be seen. During both the years, even among the diversity there is uniformity in that the selfed and the non-selfed bolls do not exhibit any significant differences.

Kapas, lint and seed weights per seed and ginning percentage.—A study of the table and plate II brings out the averages, the errors and the general shapes of the curves. The curves further show that with 54 at Nandyal the weights per seed of kapas, lint and seed sustain more systematic falls with the advance of the season than 538 at Kovilpatti. Further, both at Kovilpatti and at Nandyal, the rate of fall in seed weight is more rapid than that in lint weight during the fag end of the season with the result that the ginning percentage at this period is not pulled down to the extent to which it would have fallen had the two rates of fall mentioned above been in the same proportion. The differences noted in these characters also are found to be statistically very insignificant.

LITERATURE AND CONCLUSION

Kearney (5) found 'that inbreeding Pima Egyptian cotton by controlled self-fertilization for seven generations brought about no reduction in the rate of flowering, in percentage of bolls retained, in the size, weight and seed content of the bolls or in the abundance of the fibre'. Compared with continually open-pollinated stock, Kearney found that inbreeding has no harmful effect on the improved strains of Pima cotton with which he worked. Brown (2) concludes 'in inbreeding work with Express cotton

carried on for three generations, there was no apparent loss in fertility of flowers but the strains appeared to decrease in vigour as compared with open pollinated strains. The weight of plants, rate of flower production, number of bolls produced and weight of seed cotton were taken as an index of vigour'. Kotowiski (9) working on cabbage observes 'that favourable cultural conditions are believed to tend to smooth down the differences between selfed and open-pollinated seedlings'.

Focussing attention on the two cottons 538 (of Koilpatti) and 54 (of Nandyal), both are strains evolved after the inevitable process of continued self-fertilization. Strain 54 has been continually self-fertilized for over eight years and No. 538 for a comparatively lesser number of years. It must be noted that it is only in the years of the present experiment that the control flowers have been naturally fertilized—the ancestors, both in the year immediately preceding and in the years further removed being continually selfed. A glance at the table will reveal that even among the slight differences in characters between the selfed and the non-selfed lots, No. 538 during 1927–28 has been exhibiting greater differences and errors systematically in most of the characters than No. 54 cotton in 1929–30.

A mathematical consideration of all the characters and the differences between the selfed and the non-selfed flowers summarized in the table must drive us to the conclusion that there is no immediate effect, either harmful or beneficial, as a result of artificial self-fertilization. In all the characters studied, the differences are found to be statistically very insignificant. In breeding work with cotton, the breeder has often to depend upon the results obtained from a study of the natural-fertilized plants in addition to the self-fertilized ones. Owing to the impracticability of selfing the whole material from considerations of time and labour, it is a good sign that the immediate effect of artificial self-fertilization in cotton in a state of genetic purity is nothing different compared to that of open-pollination. Hence, the material obtained from the selfed and the non-selfed plants can be used without any hesitation for the study of characters.

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SUMMARY

The above study demonstrates that:—

1. No appreciable differences are observed in the flowering and the bolling curves obtained from plants, the flowers of which are partly selfed and partly left for natural pollination.

2. The eight boll characters studied namely (*a*) ovules per lock, (*b*) seeds per lock, (*c*) fertility index, (*d*) lint length, (*e*) kapas weight per seed, (*f*) lint weight per seed, (*g*) weight per seed and (*h*) ginning percentage are not affected by the process of selfing the flowers, and this is a very healthy sign from the point of view of cotton breeding as naturally-fertilized material can also be used for the study of characters.

Table showing the differences in the economic characters of selfed and non-selfed bolls

KOVILPATTI 1927-28 No. 538 — NANDYAL 1929-30 No. 54

Character	Strain No.	Year	No. of locks	No. of Sets	Average of selfed bolls	Average of naturally pollinated bolls	Difference	σ difference	Difference σ + difference Z	P	Odds	Significant or not
Ovules per lock ...	538	1927-28	4	15	5·85	5·77	·08	·33	·24	·80	4 : 1	no
	54	1929-30	3	22	6·50	6·42	·08	·26	·31	·91	11:1	no
Seeds per lock ...	538	1927-28	4	15	4·06	4·19	·13	·71	·19	·75	3 : 1	no
	54	1929-30	3	22	6·21	6·15	·06	·33	·18	·79	4 : 1	no
Fertility per cent.	538	1927-28	4	15	69·60	72·87	3·27	11·05	·30	·86	6 : 1	no
	54	1929-30	3	22	95·45	95·63	·18	·87	·21	·83	5 : 1	no
Lint length ...	538	1927-28	4	14	23·57	23·29	·28	1·03	·28	·83	5 : 1	no
	54	1929-30	3	21	25·19	25·09	·10	·61	·16	·75	3 : 1	no
Kapas weight per seed.	538	1927-28	4	10	87·90	85·70	2·20	5·21	·42	·88	7 : 1	no
	54	1929-30	3	21	70·33	70·71	·38	3·01	·13	·71	2·5 : 1	no
Lint weight per seed.	538	1927-28	4	10	26·90	25·80	1·10	2·26	·49	·91	10 : 1	no
	54	1929-30	3	21	21·71	22·09	·38	1·21	·31	·91	10 : 1	no
Seed weight per seed.	538	1927-28	4	10	61·00	59·90	1·10	5·00	·22	·74	3 : 1	no
	54	1929-30	3	21	48·62	48·62	nil	2·23	nil	nil	nil	no
Ginning per cent.	538	1927-28	4	10	30·60	30·20	·40	2·94	·14	·66	2 : 1	no
	54	1929-30	3	21	30·81	31·19	·38	1·13	·34	·92	12 : 1	no

Remarks :—In No. 538, 4-locked bolls predominate and in 54, 3-locked ones.

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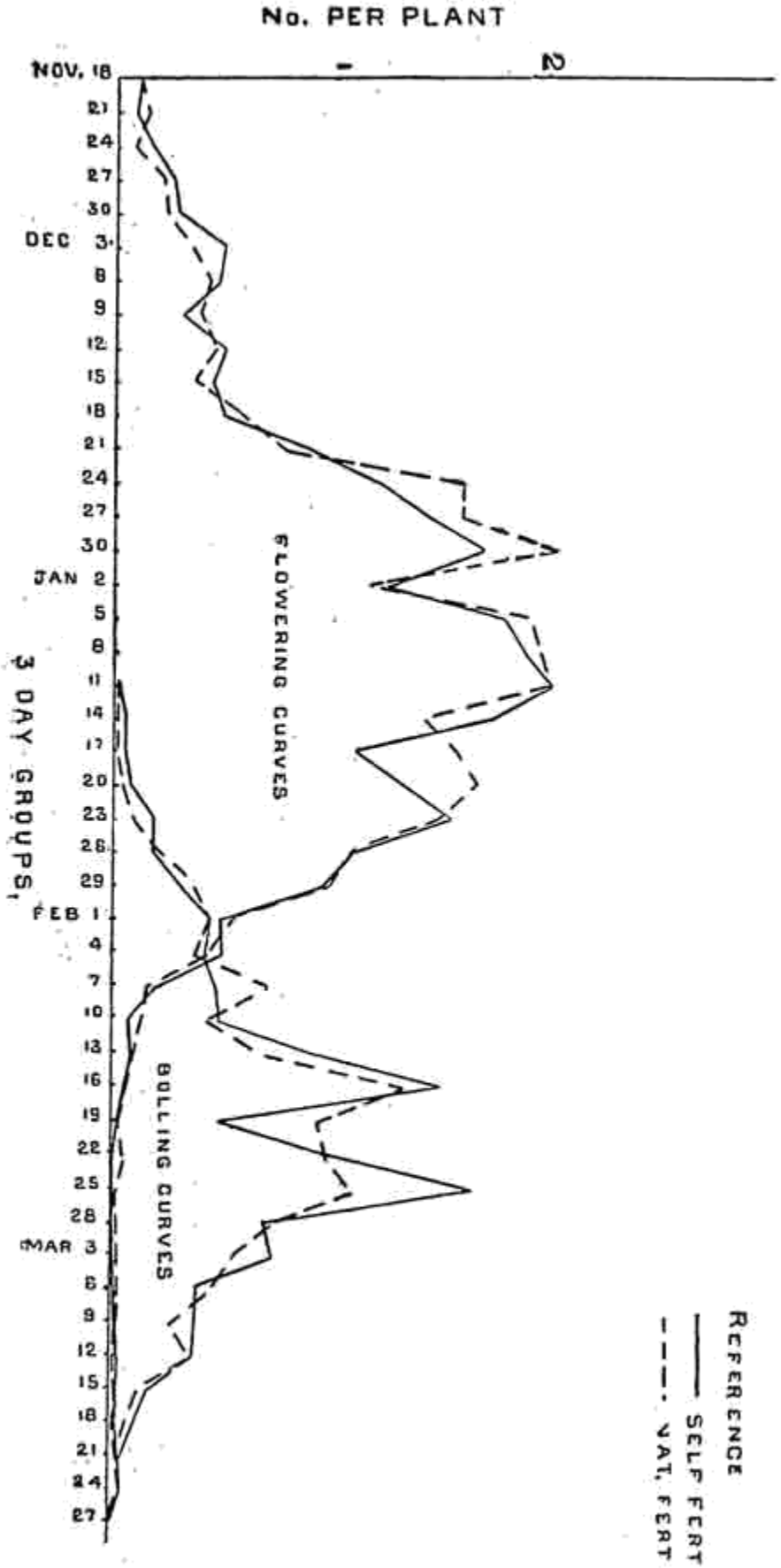
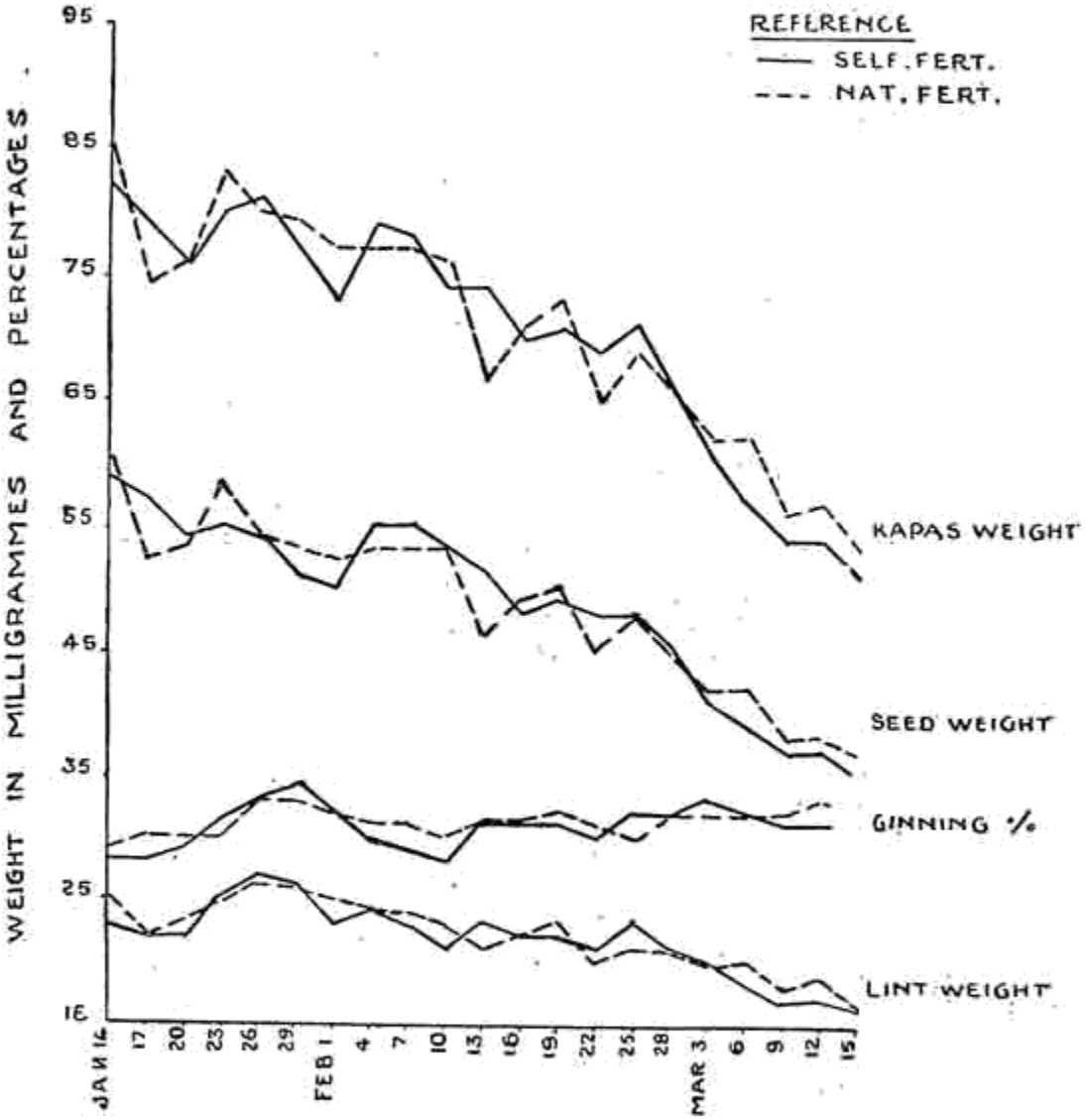


PLATE I

SELF-FERTILISATION *vs.* NATURAL POLLINATION, 1929–30
Nandyal Strain 54 Flowering and Bolling Curves.

SELF-FERTILISATION *vs.* NATURAL POLLINATION, 1929–30

Nandyal Strain 54—3-locked bolls Kapas, Lint and seed weights per seed and Ginning per cent.



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