Published May, 1975

Effect of Flat-square in Cotton on Selected Agronomic Characters[1]

H. Khalifa, L. S. Stith, and W. D. Fisher[2]

ABSTRACT

Data were collected from flat and nonflat-square cotton (*Gossypium hirsutum* L.) plants in replicated experiments to evaluate their relative performances for yield components and fiber characteristics. Results indicate that the flat-square trait has an adverse effect on seed cotton yield, boll weight, lint percentage, lint index, fiber fineness, and strength. Flat-square plants produced more flowers than nonflat-square plants at Tucson, Marana, and Phoenix, Ariz.; but flat-square plants had a higher rate of shedding of deformed and incomplete flowers as well as reduced boll weight, lint percentage, and lint index. Thus, nonflat-square plants produced more seed cotton at harvest time, but they had similar crop maturity. Pedigree selection is suggested as one breeding procedure to effectively eliminate or minimize this abnormality.

***Additional index words:* *Gossypium hirsutum* L., Flowering curves, Fiber quality, Yield, Yield components, Selection.**

FLAT-SQUARE appeared in some Arizona cotton (*Gossypium hirsutum* L.) fields and spread in large proportions in 1962; yield of seed cotton dropped sharply, but there were no statistical records available. Shields and Gries (5) described flat-square as an abnormality in which two or three bracts were found in the usual positions occupied by flowers, but the other flower parts were absent. This disorder was usually associated with other growth abnormalities such as development of extralateral branches (i.e., two or three fruiting branches growing from each node resulting in a bushy plant appearance). Excessive shedding of fruiting parts was also observed on flat-square plants. As the phenomenon may potentially result in large economic losses, this research was undertaken to study the flowering behavier of flat-square plants, to investigate the effect of the trait on yield, yield components, and fiber properties and to propose a breeding program for elimination or minimization of the problem.

MATERIALS AND METHODS

The genetic stocks used in this study were selfed lines of 'Acala 44' parentage that exhibited flat-square and a selfed doubled haploid of the same cultivar, which was apparently free from flat-square. In 1966, single plants were selected from the progeny rows of flat and nonflat-square lines to serve as parental sources. These plants were selected in such a way that they did not show much variation in some of their agronomic characters. To exclude the possibility that insects were the causative agents for this disorder, flat-square parental lines were protected by nylon net-cages. Reciprocal crosses were made, and each parent was selfed. Seed was collected from three pairs of parental lines; each hereafter represented a separate family. The three seed lots (designated as families A, B, and C) were sent to Iguala, Mexico, for further propagation and hybridization. Ten populations were produced and studied in each family, including P_{nf} (nonflat-square parent), P_f (flat-square parent), reciprocal F_1's, backcrosses to each parent, and the two F_2 progenies.

In 1967, the populations of the three families were planted in two evaluation trials, one at Phoenix (cotton research center) and the other at Tucson (Campell Ave. farm). The trials were set up in a split-split plot design with three replications. The families A, B, and C were assigned to the main plots, each of which was subdivided into two parental cytoplasms (flat and nonflat-square) with their corresponding generations. The spacing was 90 cm between rows and 40 cm between plants. The plants were thinned to three/hill at the age of 1 week. At the end of the maturity period, seed cotton samples were collected from each generation separately in all replications. They were ginned on a miniature roller-gin. Differences among the generations for yield components and fiber characteristics were statistically evaluated. Fiber length (UHM, in mm), strength (Pressley index, at 1/8 in. gauge), and fineness (micronaire) were measured in the U. of Ariz. Cotton Fiber Lab.

In 1968, the parental lines (flat and nonflat-square plants from each family) were grown in two yield trials, one at Phoenix (cotton research center) and the other at Marana (U. of Ariz. Farm) using randomized, complete block designs with 10 replications. The spacing was 90 cm between rows and 40 cm between plants. The plants were thinned to one plant/hill at the age of 1 week. Four replications of each parental line were selected at random in each location for flower counts. The number of flowers produced by each population was recorded at 2 to 3-day intervals, and later the average number of flowers/plant at weekly intervals throughout the flowering period were calculated. Thirty flowers were selected at random at different intervals from each replication for the two parental lines, and the flowering and opening dates were recorded on labels tied to them. Boll maturation periods were calculated. Seed cotton samples were also collected to evaluate yields and yield components for flat and nonflat-square plants. At Tucson (Campell Ave. farm), another similar experiment was conducted to compare the flowering behavior and boll maturation period from flat and nonflat-square plants. In this experiment, flower counts were recorded daily, and again the average number of flowers/plant were calculated at weekly intervals for each parental line. Flowering curves showing the distribution of flower production throughout the season in the three locations were constructed. Data for seed cotton yield, lint percentage, boll weight, and maturation period from flat and nonflat-square plants were analyzed.

RESULTS AND DISCUSSION

1967 Experiment

Flat and nonflat-square plants were genetic lines derived from 'Acala 44' and thus were closely related. Few significant differences between the two lines and their respective progeny generations would be expected in yield and fiber quality components other than that caused by the flat-square trait. Flat-square parents had lower lint index, fiber fineness, and strength at both locations (Table 1). Differences between locations may be partially attributed to the use of insect control measures and presumably to some favorable environmental factors at Phoenix.

[1] Contribution from Ariz. Agric. Exp. Stn. as journal series no. 2297. Submitted by the senior author in partial fulfillment of the requirements for the Ph.D. degree. Received Sept. 20, 1974.

[2] Presently senior cotton breeder, Shambat Res. Stn., P. O. Box 30, Khartoum North, Sudan and professors in the Dep. of Agron. and Plant Genet., U. of Ariz., Tucson, AZ 85721, respectively.

Table 1. Comparisons between flat and nonflat-square plants for selected yield and fiber quality components as measured at Tucson and Phoenix, 1967.

Parental line	Lint index		UHM, mm		Micronaire		Pressley index	
	Phoenix	Tucson	Phoenix	Tucson	Phoenix	Tucson	Phoenix	Tucson
P_{nf}	7.45*	7.07*	28.600	25.857	4.29*	3.68*	3.45*	3.21*
P_f	6.32*	5.41*	28.372	25.578	3.53*	3.52*	3.01*	2.88*

* Denotes significant difference between flat and nonflat-square plants at the 0.05 level of probability.

1968 Experiment

The number of flowers produced and retained by the plant to maturity are important criteria in the selection of a high-yielding cultivar of cotton. Flat-square plants produced more flowers than nonflat-square plants (Figs. 1, 2, 3) at Tucson, Marana, and Phoenix. The flowering curves depict similarities among the three families at the three locations, and statistical analyses indicated highly significant differences in flower production between flat and nonflat-square plants. Comparisons of the mean number of flowers/plant produced by each parental line over families at the three locations are shown in Table 2. Flat-square plants produced more flowers than nonflat-square plants. Morphologically, flat-square plants appeared more bushy than did the nonflat-square plants. This finding is in accordance with that of Shields and Gries (5) who reported development of extralateral branches from each node. The production of lateral branches may in turn lead to the development of more sympodial branches, which could partly explain the increase in flower production by flat-square plants.

Assuming equal boll size and lint percentage the amount of seed cotton produced by the plant is a direct measure of the number of fertilized flowers retained to maturity. Although flat-square plants produced more flowers, their seed cotton production was less than the nonflat-square plants (Table 2). This suggests that the proportion of flowers retained to maturity is greater in the nonflat-square plants and that the disorder has an adverse effect on seed cotton yield. Both parents have more or less similar boll maturation periods at the three locations.

Some square and flower shedding is inevitable for any genotype in cotton. Shedding rate may be af-

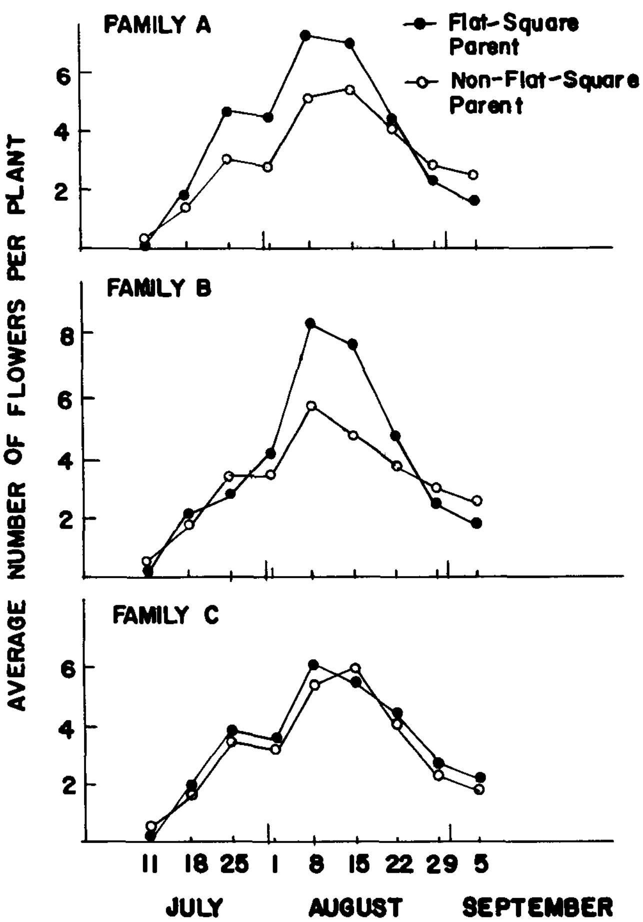

Fig. 1. Flower production of flat and nonflat-square plants of three families, Tucson, 1968.

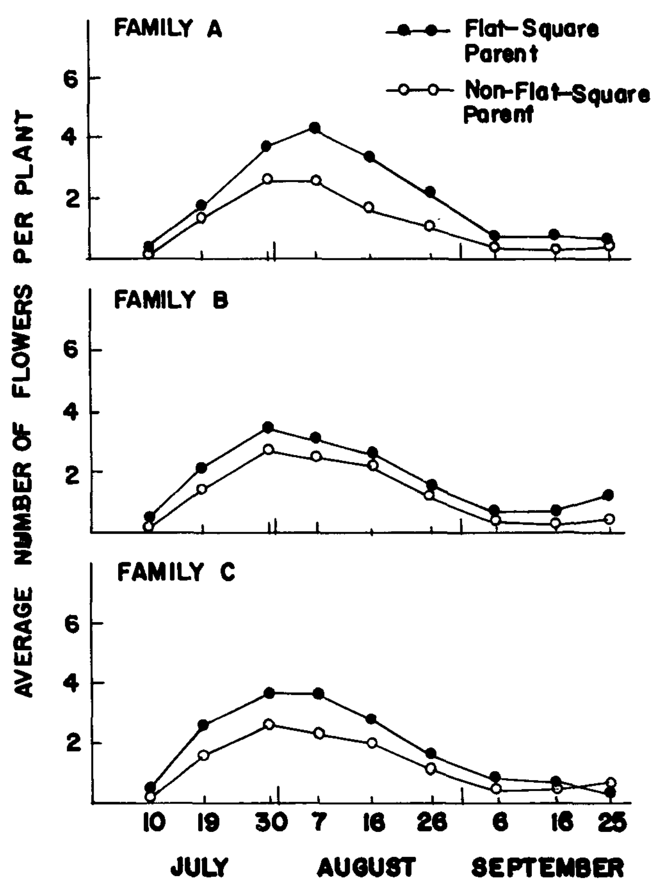

Fig. 2. Flower production of flat and nonflat-square plants of three families, Marana, 1968.

Table 2. Flat and nonflat-square plants at selected Arizona locations, 1968.

Parental line	Mean no. of flowers/plant†			Seed cotton yields		Lint	Boll wt	Boll maturation period‡		
	Tucson	Marana	Phoenix	Marana	Phoenix	Marana	Marana	Tucson	Marana	Phoenix
				kg/plot		%	g		days	
P_{nf}	28.2*	11.5*	21.3*	5.55*	5.89*	38.8*	7.16*	57	58	55
P_f	33.2*	16.7*	33.5*	4.49*	4.33*	36.0*	5.82*	54	56	53

*,** Denotes significant difference between, flat and nonflat-square plants, at the 0.05 level of probability. † Means based on 40 plants. ‡ Mean number of days from flower opening to boll opening.

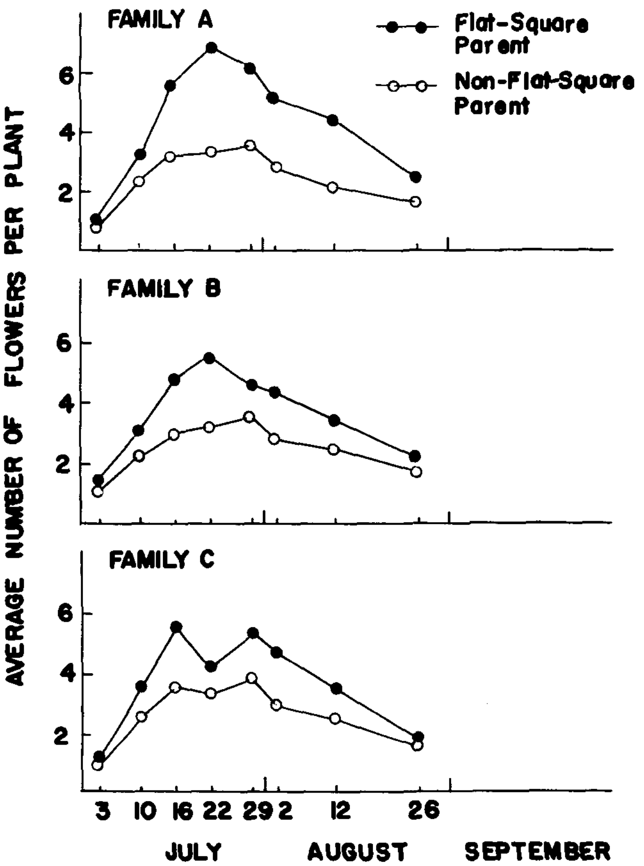

Fig. 3. Flower production of flat and nonflat-square plants of three families, Phoenix, 1968.

fected by hormones and may vary in relation to environmental and nutritional conditions that prevail at various times during the life of the plant. Kearney and Peebles (2) and Kohel and Richmond (4) suggested that shedding was usually genetically controlled. The higher production of flowers in flat-square plants may partially be explained by work of Eaton and Rigler (1), who found that debudded plants produced more vegetative branches, had higher concentrations of carbohydrates, and produced more flowers than did normal plants. It may be hypothesized that since flat-square plants tend to produce a higher number of abnormal and incomplete flowers that shed, most of their energy will be triggered toward the production of more vegetative and fruiting branches. The increased number of branches will eventually result in the production of yet more flowers. Nonflat-square plants, on the other hand, tend to retain a higher proportion of their flowers to maturity and hence produce more seed cotton.

The analysis of yield component data from Marana indicated that nonflat-square plants exceeded the flat-square plants in two yield components, lint percentage and boll weight (Table 2), which suggested additional reasons for poor seed cotton yield by flat-square plants.

From an economic point of view, this disorder may cause an appreciable reduction in yield in any cotton cultivar. The flat-square syndrome may also have an adverse effect on fiber properties (i.e., fineness and strength); therefore the breeders would be advised in screening their material to eliminate all plants with flat-squares. This apparent association of flat-square syndrome with some undersirable economic characters makes it seem likely that these plants would automatically be eliminated, while selecting for better yield and quality components. However, since flat-square is quantitatively inherited and has a low heritability, approx. 6%, (3) indicate that elimination of the trait will not be simple if it had been overlooked and hence incorporated into a population. Selfing and strict pedigree selection in optimal environments for flat-square expression may be most effective in eliminating or minimizing factors controlling this trait from such genotypes.

REFERENCES

1. Eaton, F. M., and N. E. Rigler. 1945. Effect of light intensity, nitrogen supply, and fruiting on carbohydrate utilization by the cotton plant. Plant Physiol. 20:380-411.
2. Kearney, T. H., and R. H. Peebles. 1926. Heritability of different rates of shedding in cotton. J. Agric. Res. 33:651-661.
3. Khalifa, H., W. T. Starmer, W. D. Fisher, and L. S. Smith. 1974. Flatsquare in cotton, Acala type. I. Its mode of inheritance and heritability. Crop Sci. 14:519-521.
4. Kohel, R. J., and T. R. Richmond. 1962. The genetics of flowering response in cotton. IV. Quantitative analysis of photoperiodism of Texas 86, *Gossypium hirsutum* race *latifolium,* in cross with an inbred line of cultivated American upland cotton. Genetics 47:1,535-1,542.
5. Shields, I. J., and G. A. Gries. 1962. Flat squares: mystery malady of cotton. Prog. Agric. Ariz. 14:16-17.