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INFLUENCE OF FLOWERING TIME AND FRUITING PATTERN ON YIELD COMPONENTS OF THREE COTTON GENOTYPES

ABSTRACT

Cotton genotypes H-6, H-4 (*Gossypium hirsutum* L.) and V_{797} (*Gossypium herbaceum* L.) were analyzed for fruiting pattern (i.e. distribution of flowers, numbers of bolls and its dry weight on different branches) and percent (%) dry matter partitioning into the different components of the boll (seed, fiber and boll wall). Percent distribution of flowers, bolls and dry weight within the plant varied distinctly among the genotypes studied. In higher yielding genotypes (H-4 and H-6), during the initial stage of plant growth for about 10 days, 60-80% of dry matter was partitioned into boll wall and decreased up to 12-15% as the boll developed (nearly 45 days). Contrary to this, seed and fiber accumulated dry matter during development (60-75%). Abscission rate increased with an increase in boll load in all three genotypes and it was significantly higher in the lower yielding variety, $V_{797.\ A}$ reduction in boll and seed number, seed and fiber dry weight was observed with the progress in the season and was significantly higher in V_{797} as compared to H-4 and H-6.

Key words: active boll load, cotton, dry matter partitioning, flowering time, fruiting pattern, yield components,

Abbreviations: DAP – days after plantation; C – photosynthetically – fixed carbon; LAI – leaf area index.

INTRODUCTION

Cotton plant is more complex structurally than any other major field crop. Cotton with its impermanent growth habit produces vegetative and reproductive growth simultaneously over a relative long period (150- 180 days). Even with such complexity, growth and development of the cotton plant follow on orderly and predictable sequence where growing conditions are favorable. Fruit formation in cotton begins with the appearance of the first square (flower bud) on the first fruiting branch, and continues until the first open boll. Under normal conditions, the first square can be expected between 5 to 8 weeks after cotton is planted, depending on the growing area and temperature (Guinn 1974).

Net photosynthesis during cotton leaf ontogeny is seldom synchronized with the C (carbon) demands of developing fruiting forms (Constable and Rawson 1980). Further, net C production by an individual leaf along a sympodial branch was insuf-

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ficient to support the C requirement for the observed boll growth (Wullschleger and Oosterhuis 1990). This competition for assimilates induces abscission of young bolls (Guinn 1974). Cotton plant sheds up to 70% of all the fruiting structures during various reproductive stages of development. Nearly 25-50% of the flower buds (squares) abscise before blooming while other fruiting structure abscise as young bolls drastically affecting yield potential (Peoples and Matthews 1981). Increased photosynthesis has considerably decreased abscission of squares and young bolls (Guinn 1974). It has been suggested that a 15% higher photosynthetic rate could result in a 50% higher boll yield (Landivar *et al.* 1983). This problem prompts the question as to how the cotton plant might be manipulated to increase C availability for yield productivity.

Although selection programs can increase leaf photosynthesis, seldom are these improvements reflected in seed yield or harvest index (Pettigrew and Meredith 1994). However, Meredith and Wells (1989) suggested that high reproductive/vegetative ratios and early fruiting may determine boll yield or may attributed to higher yield of modern genotypes.

The partitioning of dry matter into the major components of the boll may also determine yield potentials of different genotypes (Kohel and Benedict 1984). Further, Jones *et al.* (1996a) found that boll weight was positively correlated with fiber properties and was related to the amount of competition among developing bolls. However, no detailed studies are available on pattern of C partitioning among different genotypes for yield components over the season.

Therefore, the objectives of this study were to compare: (i) date of first flower for the three genotypes, (ii) the rate of flowering and boll retention, (iii) distribution of flower, bolls and boll dry weight in (different) branches, and (iv) normal growth and dry matter partitioning into different components of boll in three genotypes of cotton, differing substantially in their seed and lint yield.

MATERIALS AND METHODS

Seeds of three cotton genotypes viz., H-4, H-6 and V_{797} (varying in their seed size and dry weight at maturity i.e. 130, 115 and 75 mg seed ^{1} respectively) were obtained from the Cotton Research Center, GAU, Junagadh. Seeds of uniform size were sown in polythene bags (8 × 12 cm) filled with finely powdered black cotton soil and farmyard manure in 3:1 ratio (18th June). In each bag, 2 seeds were kept at a depth of 1 cm and watered daily. After 36 days (on 24th July), healthy seedlings were transplanted into previously prepared rows in a filed. Cultural practices including irrigation, weeding operations, application of fertilizers and insecticides etc. were conducted to optimize plant growth and yield. To minimize border effects, the rows used for flower counting and tagging were at least two rows from the edge of the plot. All tagged flowers were at least 2 m from the end of the row. In H-4 and H-6, flowering initiated on 24th August, whereas in V_{797} first flower bloomed on 23rd September.

Experiment-I

An experiment was conducted to investigate the effects of flowering date (i.e. progress in season) on subsequent flowering, boll retention and the "boll carrying capacity" of individual plants. On each day the number of flowers were counted and tagged with dated tags. At the end of the season (10^{th} December) 10 plants were randomly selected and analyzed for determination of boll retention. The numbers of bolls present on individual plants were counted along with dated tags. The number of flowers × day^{-1} × $plant^{-1}$ and number of bolls retained × day^{-1} × $plant^{-1}$ were calculated. The active boll load was calculated by recovering the retained tags in the fall and calculating the total number of bolls from one through 40 days old which were present on a plant on a given date. Bolls older than 40 days were not included, nor were bolls that abscised.

Experiment-II

This experiment, the same genotypes were investigated for:

(1) percent (%) distribution of flowers, bolls and boll dry weight at different branches of an individual plant,

(2) the effect of flowering date on growth of boll and its components.

Flowers were counted and tagged with dated tags on the day of anthesis. Branching nodes were numbered from cotyledonary node (as number 1) to the apex (the node refers the place on the main stem where sympodial or monopodial branches arise). Each new flower on an individual branch were counted every day. At the end of the season, 10 plants were randomly selected from the plot of each genotype and tags on retained bolls of individual branches were counted. Bolls were oven-dried at 80° C for three days and dry weight determined. Seeds and fibers were separated and the number of seeds in boll determined. The dry weight of seeds and fibers per boll were also determined.

The percent (%) of flowers initiated and bolls retained on each branch were calculated as the mean value from corresponding branches of 10 plants. Similarly, percent distribution of boll dry weight at different nodes was calculated as the mean from the total boll dry weight of 10 plants.

From the boll collected with the progress in season, each boll was dissected into seed, fiber and boll wall. Dry weight of each component was determined and seed number was counted. A linear regression analysis of boll dry weight and its components (seed weight, fiber weight and seed number $boll^{-1}$) versus the date of flowering (i.e. progress of the season) was performed and correlation coefficients (r) were calculated.

Experiment-III

In this experiment, 5 to 7 bolls (randomly selected) were separated into different parts viz., boll wall, septa, seed and fibers. Each individual part was weighed after oven drying at 70°C for 3 days. Percent (%) partitioning of dry matter in to different organs were calculated from the mean total boll weight. Each such result represents an average of at least five bolls harvested randomly at a given age.

RESULTS AND DISCUSSION

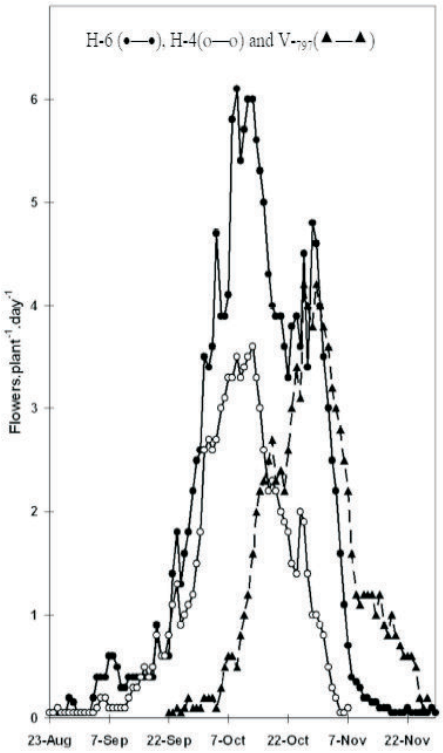

Fig. 1. Average number of flowers produced per plant per day during the entire blooming season in cotton genotypes

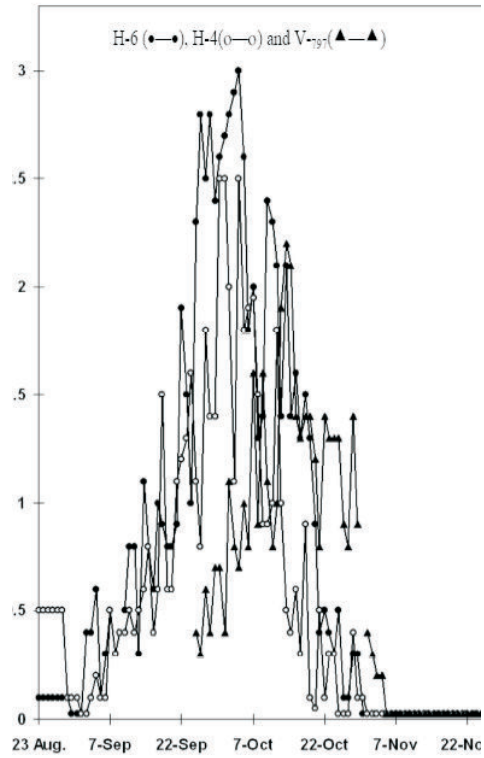

Fig. 2. Bolls retained per plant per day during the entire blooming season in cotton genotypes

Data on the number of flowers produced per plant per day in the three genotypes (Fig. 1) showed that peak flowering occurred between 8-12 October in H-6 and H-4 i.e 115 days after plantation (DAP), while, in genotype V_{797}, it was delayed by nearly one month and peak flowering was recorded between October 27-1 November i.e 174 DAP. The number of flowers produced/plant /day were maximum in V_{797} followed by H-4 and H-6, respectively (Fig.1). However, rate of abscission was also higher in V_{797} followed by H-4 and H-6. Thus boll retained per plant per day was more in H-6, followed by H-4 and V_{797} (Fig.2). The total weight of bolls retained per plant per season was, therefore, significantly higher in H-6 in comparison to H-4 and V_{797} (Table-1).

Active boll load can have pronounced effect on boll retention (Guinn 1985) and hence on yield (Heitholt 1993). In H-6 the rate of boll retention/day/plant (Fig.2) continued to increase untill 1st October when the active boll load was around 33 bolls per plant, after which it decreased. Interestingly, this was much prior to the maximum rate of flowering, achieved on October 8th. No boll retention was observed after 1 November and the maximum active boll load achieved in H-6 was around 62 bolls / plant. The rate of flowering decreased soon after the maximum active boll load was attained. Sim-

ilar trends were observed in H-4 and V_{797}. However, maximum active boll load in H-4 was around 46 per plant bolls while; in V_{797} it was 38 bolls per plant (Fig. 3).

Table 1

Relationship between day of flowering (X) and different yield components (Y) viz.,dry weight of boll, seeds/boll, fibres/boll and seed number/boll in three cotton genotypes: H-6, H-4, V_{797}. Note the influence of progress of the season on the development of boll and its components

Component	Linear regression coefficient				Significance level (P)
	r	n	a	b	
			Boll dry wt [g]		
H-6	8.7359	-0.0883	-0.4680	593	0.001
H-4	9.0751	-0.0722	-0.4214	369	0.001
V_{-797}	3.7125	-0.0258	-0.4142	393	0.001
			Seed dry wt/boll [g]		
H-6	3.6554	-0.0383	-0.5085	590	0.001
H-4	4.2543	-0.0404	-0.4632	361	0.001
V_{-797}	1.8490	-0.0158	-0.4974	391	0.001
			Fibre dry wt/boll [g]		
H-6	2.1106	-0.0206	-0.4647	588	0.001
H-4	2.1159	-0.0135	-0.2947	365	0.01
V_{-797}	1.1230	-0.0085	-0.3498	391	0.001
			Seed number/boll		
H-6	34.4777	-0.1606	-0.2604	589	0.01
H-4	31.6040	-0.0826	-0.1371	362	NS
V_{-797}	22.2633	-0.1079	-0.2835	391	0.01

r= regression coefficient, b= slope and a= intercept. n = number of samples, NS = not significant

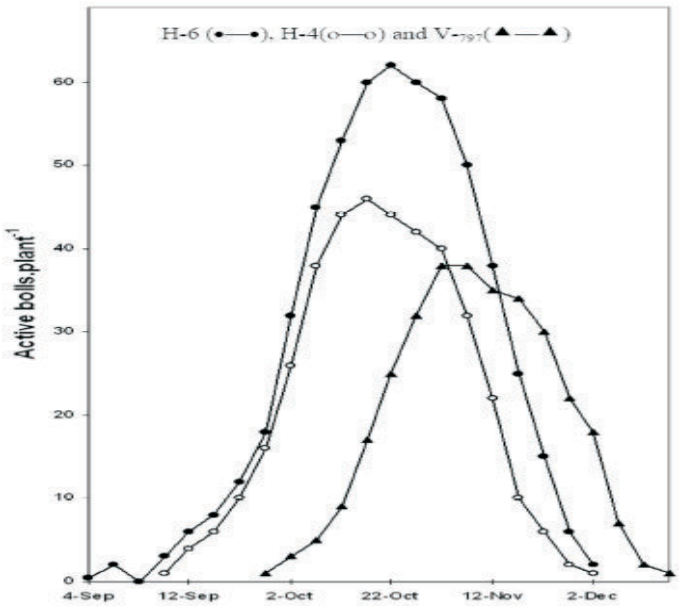

Fig. 3. Active boll load as influenced by progress in the season in genotypes

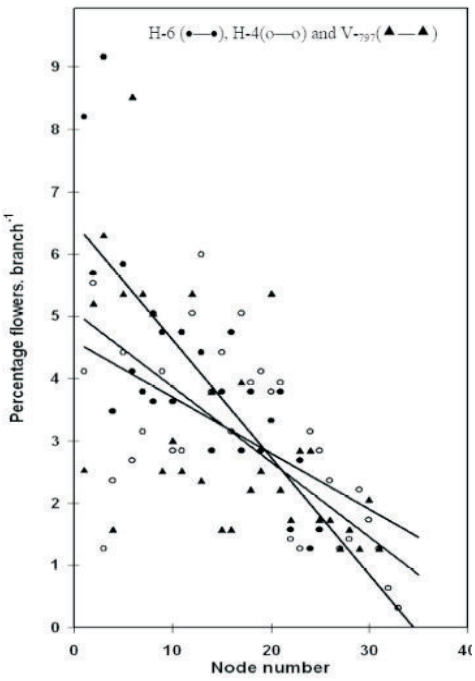

Fig. 4. Relationship between percentage distribution of flowers at different branches on a plant averaged in the three cotton genotypes viz

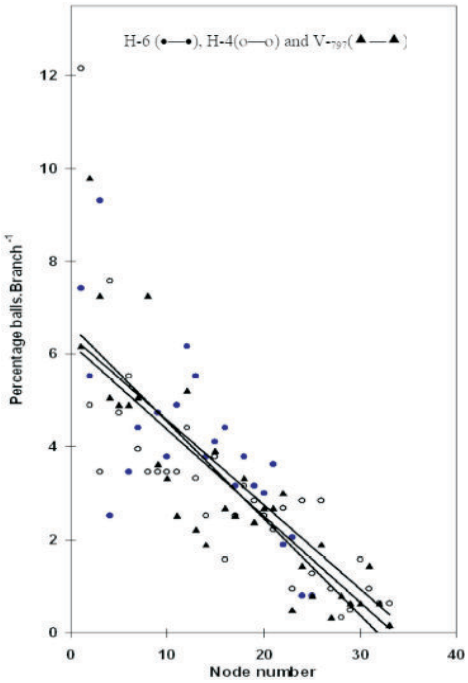

Fig. 5. Relationship between percentage distribution of boll at different branches on a plant averaged in the three cotton genotypes viz.

In summary, H-6 had a higher active boll load than H-4 or V_{797}, H-4 compared to V_{797}, showed that even though V_{797} had higher rate of flower production, a greater number of flowers abscised (without insect pressure) and maximum active boll load achieved in this genotype was lower than in H-4, thus, indicating that active boll load may be an important determinant in cotton yield. Boll number per plant was also considered as an important determinant for cotton yield (Bridge *et al.* 1971). Guinn (1985) reported that abscission rate was higher in normally fruited one than in partially defruited plants. Similarly, Verhalen *et al.* (1975) found a linear decrease in boll retention as boll load increased. Thus, boll load had an influence on boll abscission rate.

A plot of number of flowers/ branch and boll dry weight with progress of the season in the three genotypes showed inverse correlations (Figs. 4-5). A linear regression of seed weight, seed number and fiber weight/boll versus progress of the season also showed that these three components of boll were significantly affected (Table 1). In V_{797}, all the three components were significantly low, and hence the yield was significantly less as compared to H-6 and H-4. Recently, Jones *et al.* (1996b) observed that the later developing bolls, often thought to be unimportant, are needed to achieve maximum yield.

Among the three genotypes, the average number of branches plant^{1} clearly varied. H-6 had 25 branches while H-4 and V-$_{797}$ had an average of 33 branches. Bhardwaj (1988) described an inefficient genotype as one which was tall, possessing a large number of sympodial branches and large leaf area index. The continued growth of

plant parts, after boll initiation, decreased the number of bolls, partly because vegetative and reproductive parts of plant act as sinks that compete with each other for available assimilates (Wells and Meredith 1984). Thus, a low yielding genotype partitionions dry matter into excess LAI at the expense of fruit (Heitholt 1994). Different genotypes apparently differ in the competitive advantage of their bolls versus other parts of the plant. May and Bridges (1995) have demonstrated that breeding cotton for simultaneous improvement of both lint yield and fiber traits is difficult.

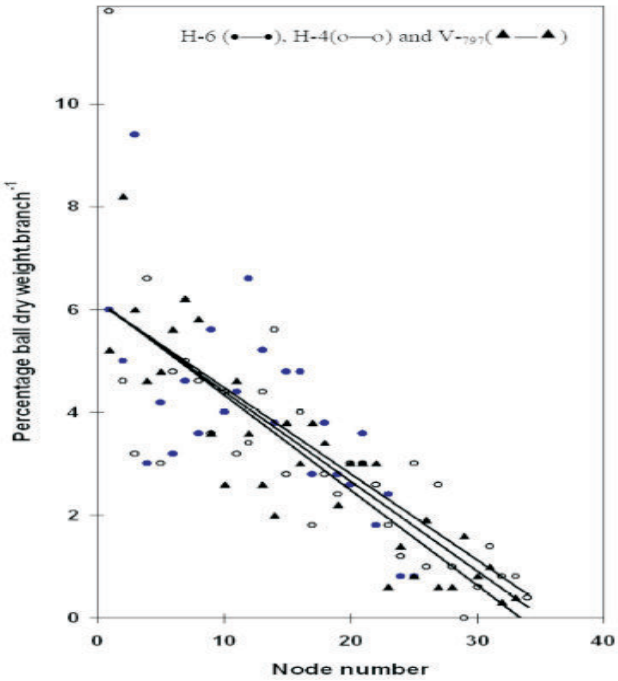

Fig. 6. Relationship between percentage distribution of boll dry weight at different branches on a plant averaged in the three cotton genotypes viz

Percentage distribution of flower, bolls and boll dry weight within the plant also varied across nodes in each genotype (Fig. 4-6). In H-6, all these parameters tended to increase from node 4 up through node 12 and decreased thereafter. In H-4, on the other hand, percent number of bolls per branch and percent boll dry weight per branch both decreased gradually from node 4 up through node 33. In genotype V_{797}, both these parameters decreased sharply from node 2 up through node 14, maintained levels up through node 22 and showed very low content thereafter.

Jenkins *et al.* (1990) showed complex interactions between fruiting sites, fruiting time, physiological and climatic conditions. In the present study, the boll dry weight decreases as the season progressed. Further, it has been emphasized that high yielding genotypes generally make an early transition from the vegetative to the reproductive phase and may have better coordination of assimilatory capacity with increasing reproductive sink activity during the time when maximum leaf number and area are present (Wells and Meredith 1984, Jenkins *et al.* 1990). Thus, boll retention is an important parameter for higher yield in cotton.

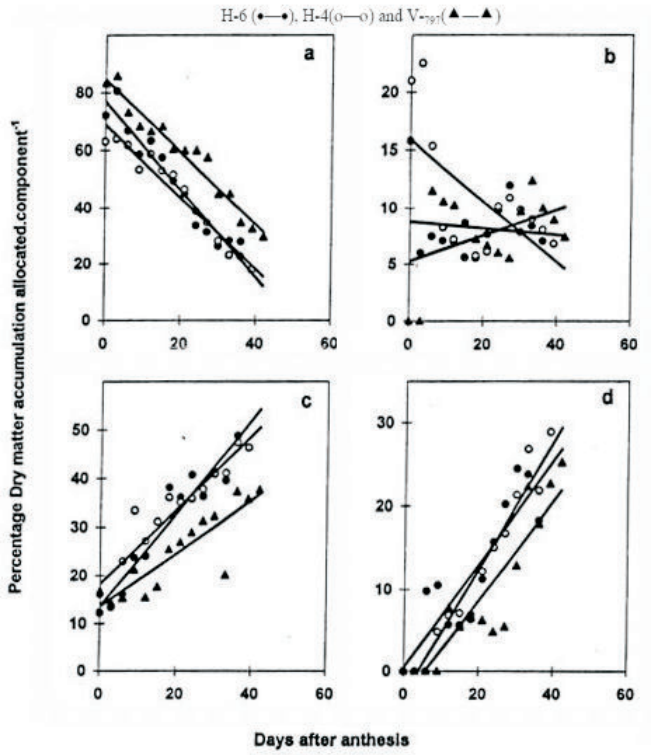

Fig. 7. Percentage partitioning of dry matter into different components of developing boll viz., boll wall (a), septa (b), seed (c) and fibre (d) in the three cotton genotypes viz

Percent partitioning of dry matter into different components of developing bolls viz., boll wall, septa, seed and fiber (Fig. 7) showed that during the initial stages of boll development, maximum dry matter (60-80%) was partitioned into boll wall and it decreased as the boll developed (12-15%) for all three genotypes. During early boll development, contribution to seed and fiber was low however, it continuously increased during boll development later (60-75%). Even though total boll dry weight of V_{797} was nearly half than that of H-6 and H-4, it partitioned a higher percentage of dry matter into the boll wall Thus, H-6 and H-4 contributed a higher percentage of dry matter to seed and fiber as compared to V_{797}. The contribution of boll wall to the nutrition of the developing boll has been studied however, C-assimilation by boll wall and its subsequent contribution to yield productivity, has generally been regarded as insignificant (Wullschleger and Oosterhuis 1990). A unique capacity for the re-assimilation of internally produced CO_2 in the boll wall was demonstrated by Caley *et al.* (1990). Further, Wullschleger *et al.* (1991) also showed that the boll wall possesses a highly efficient light-dependent mechanism for the recycling of respired CO_2. This recycling of CO_2 occurred exclusively via outer boll wall and was 35-40% of the photosynthetic capacity of the leaves.

On the basis of the comparative analysis of the three genotypes presented in this paper, it appears that early, more rapidly maturing, dwarf-type genotypes with

higher rates of flower production and boll retention together with an ability to carry a higher active boll load, suggested as some of the preferred characters for better seed and lint yield in cotton crop.

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