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Identification of Plant Traits for Characterization of Early Maturing Upland Cotton Varieties

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Abstract. Thirteen upland cotton varieties with morphologically distinguished plant traits were evaluated so, as to characterize early maturing cotton. According to ANOVA test, the varieties differed significantly for all the traits studied. The varieties, in days taken to set first flower varied from 41.0 to 48.0; sympodial branch node numbers 5.5 to 9.0; 1st effective boll setting branch number 6.3 to 10.3; sympodial branch length 14.2 to 35.7 cm; boll opening 53.0 to 81.0%; boll weight 2.7 to 4.5 g, and seed cotton yield 126.0 to 196.3 g. It was observed that most of the plant traits simultaneously favoured the varieties in their characterization for earliness. Thus as compared to late maturing varieties, early varieties took minimum of 41.0 days to set first flower, produced lower sympodial branches at 5.5 to 6.5th nodes; set first effective boll at 6.3 to 7.5th nodes; produced shorter sympodial branches of 14.2 to 21.6 cm; opened 75.0 to 81.0% of bolls at 120 days after planting, gave medium bolls of 3.0 to 3.5 g. According to short season's classification, the varieties which opened 75 to 81% of their bolls were if picked after 145 days, the boll opening percent may have reached about 95%. Thus such varieties could be considered as early maturing ones. In present studies, varieties CIM-511, CIM-506, NIAB-999, BH-147, CRIS-467, CRIS-168 and CRIS-342 can be characterized as early maturing cotton. Significant correlation coefficient (r) values between earliness plant traits further suggested that selection of one trait for earliness can indirectly but simultaneously improve another trait related to earliness.

Keywords: morphological plant traits, early maturity, upland cotton varieties

Introduction

Early maturing cotton varieties are desirable for a number of the reasons in that, they require relatively less inputs like fertilizer, irrigation and labour. Thus provide increased economic returns on account of reduced costs of inputs and crop management. Besides, early maturing cottons are exposed to environmental conditions for a shorter period, thus provide an escape to late season pest attack, specially boll worm pest complex. Short season cottons are also of immense importance in the countries where sequence of other crops succeed cotton crop, thus fitting well in both food (cereals specially wheat) and cotton crops in subsistence agriculture.

Breeding for early maturing cottons, in many countries of the world, cotton breeders are ought to establish some reliable characterization based on morphological plant traits so that early varieties could easily be developed without encountering some other confounding effects. Countries like Uganda, where 100% of cotton production is rain fed and shortage of land, labour and short season constraints, all these have forced cotton breeders to develop early maturing varieties (Kairon and Singh, 1996). Anderson *et al.* (1976) also reported an increase in economic returns by growing early season cotton strains in the Mississippi Delta. Bridge and McDonald (1987) reported a major shift to adaptation of short season cultivars to 100% in the States of Mississippi, Arkansas and Tennessee. Ngigi (1994), however; discussed the rationale of preference of late maturing cotton cultivars in Eastern and Central Kenya because of exhibition of higher yields and better quality cotton over short season types. Despite these controversial results, Uzbekistan and Indian breeders had already made head ways in evolving short duration cotton cultivars which are not only early maturing but at the same time are high yielding with desirable fibre traits.

A number of indicators have already been proposed which determine earliness in cotton are: reduction in monopodia, profuse flowering, higher boll setting and opening at early stages, less and smaller leaves, short internodes length, semi-determinate types, lower sympodial node number, short sympodial branches, cluster fruit bearing types, medium boll size, sub-okra and dwarf stature (Kairon and Singh, 1996). Godoy (1994) worked on several early maturing lines and one full-season cultivar and observed that, number of nodes to first fruiting branch , plant height, days to first flower and date of first open bolls were most efficient criteria to identify early maturing cotton varieties. Ray and Richmond (1966) noted that node number to first fruiting branch is a good estimator of earliness in cotton. Baloch and Baloch (2004) carried out an extensive study on morphological characters to estimate

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earliness of 15 phenotypically diversified *hirsutum* varieties. They observed that sympodial branch at lower nodes, short sympodial branches, short internodes, medium or smaller leaves, moderate boll size; higher percent of boll opening at early stage of the crop were the most important plant attributes to characterize short/early season cotton varieties. Indian breeders, while considering some above morphological characters of early season cottons succeeding in reduced growing period by 80-95 days in *hirsutum*, 20-25 days in *arboreum*, 55-60 days in *herbaceum*, 45 days in *barbadense*, and 50-55 days in commercial cotton hybrids (Kairon and Singh, 1996). Chinese breeders have also succeeded in breeding cotton varieties like Zhong Mian Snoto with 115-120 days maturation and Heishan Mian-1 of 117-122. Del Cerro and some other storm proof cottons of USA are also reported as early maturing ones.

Because of high cropping intensity, shortage of irrigation water, high input costs on fertilizer and insecticides, attack of late season pests, all have forced cotton breeders to establish some reliable selection criteria for evolving early maturing cotton varieties. Thus several morphological plant traits have been included in the present studies to characterize early maturing cottons so as to facilitate future breeders in taking-up such tasks more effectively and efficiently.

Materials and Methods

Thirteen cotton genotypes including eleven commercial varieties (CIM-707, CIM-499, CIM-511, CIM-505, FH-945, FH-1000, FH-925, NIAB-999, VH-142, BH-147 and CRIS-467) and two advanced strains (CRIS-168 and CRIS-342) with apparently distinguished morphological traits were evaluated for their plant traits to characterize early maturing cotton varieties, during 2004 crop year. The plant traits studied were; days taken to set first flower, 1st sympodial branch node number on the main stem, 1st effective boll setting on sympodial branch number, sympodial branch length (cm), percent of open bolls at 120 days after planting, boll weight (g) and seed cotton yield per plant (g). The experiment was carried out in a randomized complete block design (RCBD) with four repeats in a plot size of 50 x 12.5 feet. The plant to plant and row to row distances were maintained at 2.5 feet and 9.0 inches, respectively. For taking the observations, ten plants from each repeat of each variety, hence a total of 40 plants were randomly tagged. Fertilizer was applied as: 1 bag of DAP/acre at the time of sowing and 2 bags of Urea/acre in three split doses i.e. half bag with 1st irrigation, one and half bags with 3rd irrigation and remaining one bag at the time of peak flowering. In total, seven irrigations were applied, 1st irrigation applied after 35 days of sowing whereas, remaining irrigations at 15 days intervals. For controlling the insects-pests, insecticides Endosulfan 35EC @ 800 ml acre and Cyper-methrin 10EC @ of 250 ml acre were applied for sucking and boll worms, respectively. The analysis of variance was carried out by using MSTATC statistical software developed by Fisher (1991) so as to determine the differences among the varieties for various morphological traits, earliness and yield parameters. The least significant difference test at 5% probability level was used to separate the means of varieties for various plant traits.

Simple correlation coefficients (r) between pair of choice plant traits were also determined so as to know the level of association between the early maturing traits.

Results and Discussion

Development of early maturing cotton varieties has now a days become an important objective of cotton breeders world over because of many reasons; such as it fits better in cotton-wheat rotation, desirable in intensive cropping system (double and triple cropping pattern) requires minimum irrigation, fertilizer, labour and also provides an escape to late season pest attack.

Thirteen upland cotton varieties having diversified plant traits were studied to know their position in respect of early maturity. According to ANOVA, there existed significant genotypic differences for various characters studied (Table1). The means of plant traits considered as having relationship with early maturity are presented in Table 2. The varieties differed significantly in days taken to set first white flower that ranged from 41.0 to 48.0 days. It is normally assumed that, fewer the number of days taken to produce first flower, the earlier the boll setting and opening, hence earlier the variety. It is also noted that first three positions on each sympodial branch represent the key sites for fruiting and highly contributing to total yield. Thus, the lower the varietal node number, the better in maturity. The varieties under test differed significantly in producing 1st sympodial branch which varied from 5.5 to 9th nodes. Kairon and Singh (1996) pointed out that short duration cottons of Texas, USA, set fruiting branches at 4th or 5th nodes while long duration varieties set them at 8th or 9th node. Ahmed and Malik (1996) estimated that one node decrease in sympodial branch matures the cotton crop by approximately 4 to 7 days earlier.

Other earlier workers (Baloch and Baloch, 2004; Kairon and Singh, 1996; Kerby *et al.*, 1990) had also reported for strong relationship between early maturity and lower sympodial branch node number. Among thirteen varieties evaluated, eight of them, CIM-707, CIM-506,VH-142, NIAB-999, BH-147, CRIS-467, CRIS-168 and CRIS-342 produced 1st sym-

Table1. Mean squares from ANOVA for various morphological plant traits used to characterize early maturing upland cotton varieties

Source of variation	Degrees of freedom	Mean squares						
		Days to 1st flower	1st sympodial branch node no.	Sympodial branch no. with 1st effective boll	Sympodial branch length	Boll opening % at 120 dap*	Boll weight	Seed cotton yield per plant
Replication	3	0.635	0.769	0.974	1.092	1.301	0.004	0.429
Variety	12	26.974**	5.651**	7.603**	178.110**	357.215**	1.096	2051.353**
Error	36	0.385	0.394	0.474	0.426	1.899	0.030	2.152

** = significant at 1% probability level; * = dap (days after planting)

Table 2. Means of various plant traits used to characterize early maturing upland cotton varieties

Variety/strains	Days taken to set 1st flower	1st sympodial branch node no.	Sympodial branch no. with 1st effective boll	Sympodial branch length (cm)	Boll opening % at 120 dap*	Boll weight (g)	Seed cotton yield per plant (g)
CIM-707	42.3	5.5	7.3	14.2	71.0	3.5	193.5
CIM-499	48.0	7.5	9.3	30.5	65.0	4.1	143.5
CIM-511	43.5	6.8	8.5	27.2	75.0	3.5	126.0
CIM-506	41.5	5.5	6.5	15.2	76.5	3.1	144.8
FH-945	46.5	7.5	10.3	35.5	54.8	4.2	156.0
FH-1000	47.5	8.5	10.0	35.7	59.5	4.1	155.3
FH-925	47.0	9.0	9.0	28.1	53.0	4.5	175.8
VH-142	42.5	6.5	9.8	24.3	71.0	3.5	161.5
NIAB-999	42.5	5.5	7.5	21.6	81.0	2.7	196.3
BH-147	44.5	5.5	8.5	23.5	75.5	3.1	143.8
CRIS-467	42.5	5.8	7.5	25.5	76.5	3.3	181.5
CRIS-168	40.5	6.5	6.5	27.0	76.3	3.3	186.0
CRIS-342	41.0	6.0	6.3	19.0	80.8	3.1	187.5
Average	43.8	6.6	8.2	25.2	70.5	3.5	165.5
LSD (5%)	0.89	0.90	0.99	0.94	1.98	0.25	2.10

* = dap (days after planting)

podial branch in the range of 5.5 to 6.5th nodes which can be considered as early or medium maturing cotton varieties.

Setting-up of 1st effective boll on lower sympodial branches can also be regarded as one of the criterion for early maturing varieties. The ANOVA (Table-1) revealed significant differences among the varieties for the formation of 1st effective boll which ranged from a lowest of 6.3 to a highest of 10.3 sympodial branch numbers. It is also assumed that the closer the distance between the 1st sympodial branch node and 1st effective boll setting branch, the variety would be earlier. In our case, six varieties viz. CIM-707, CIM-505, NIAB-999, CRIS-467, CRIS168 and CRIS-342 had shown such type of correlation, thus are earlier in maturity.

The varieties also differed significantly in sympodial branch (fruiting branch) length that varied from a minimum length of 14.2 cm to a maximum of 35.7 cm. The varieties CIM-707, CIM-506, NIAB-999 and CRIS-342 were among the 4 varieties which produced relatively shorter branches in the range of 14.2 to 21.6 cm. Uzbekistan cotton breeders have succeeded in developing early maturing varieties with short sympodial branches. Some other workers (Baloch and Baloch, 2004; Kairon and Singh, 1996) also rated varieties with short sympodial branches as early maturing ones.

Boll opening percentage at specified period of time is probably considered as the major criterion for cotton breeders to select early maturing varieties. Indian breeders however have classified maturity into three groups based on 90% of bolls picked. According to their classification, short duration cotton matures in 125 to 145 days, medium maturing in 145 to 165 days and long duration in 170 to 190 days (Kairon and

Singh, 1996). Our cotton crop is normally harvested in 150 to 165 days after planting with about 90% of bolls opened, however, these cottons cause some delay in wheat sowing if the crop is left for 2nd or 3rd picking. The varieties differed significantly for percent of open bolls after 120 days of sowing which varied from 53.0 to 81.0%. The top seven early maturing varieties CIM-511, CIM-506, NIAB-99, BH-147, CRIS-467, CRIS-168 and CRIS-342 however, opened their bolls in the range of 75 to 81.0%. Though boll opening percent was recorded at 120 days after planting and if picking was extended for more 25 days (a period required for short duration cottons), these varieties would have opened above 90% of their bolls, thus could be regarded as early maturing cottons based on maturity classification as mentioned above.

It has now become a well recognized fact that the boll size has a strong negative correlation with earliness. Hence cotton breeders had always made compromise to evolve varieties with medium boll size, still having an acceptable level of crop maturity and yield. Baloch and Baloch (2004), have observed that moderate boll weight ranging from 3.5 to 4.0 g is a reliable criterion for developing early maturing cotton varieties with an acceptable yield production. The varie-ties under present study produced bolls weighing 2.7 to 4.5 g. However, we consider bolls weighing in the range of 3.0 to 3.5 g as moderate bolls. Among 13 tested varieties, eight of them i.e. CIM-707, CIM-511, CIM-506, VH-142, BH-147, CRIS-467, CRIS-168 and CRIS-342 produced moderate boll size. Baloch and Baloch (2004), and Tunio *et al.* (2002) also reported that early maturing cottons formed comparatively smaller or moderate bolls but still gave better yields, may be due to setting and picking more number of bolls at early stages of boll opening, as compared to late maturing cottons.

It is generally believed that most of the morphological characters related to earliness as discussed above impose adverse effects on seed cotton yield. For instance, longer sympodial branches may have more fruiting positions, thus can produce higher number of bolls as compared shorter sympodial branches. Also, if number of bolls for a particular variety is considered constant, the bigger size bolls of long duration or say late maturing varieties would yield higher than early maturing varieties. In fact, the varieties which produce bigger bolls, adversely set fewer number of bolls, whereas varieties that produce smaller bolls, set higher number, consequently give more yield. Thus number of bolls in cotton is more important in increasing the yield rather than increasing the boll weight. Keeping in view these facts, a compromise level needs to be determined where shorter season cottons are developed without causing significant losses to seed cotton yields. Our results of Table 2, indicating that majority of varieties like CIM-707, NIAB-999, CRIS-168, CRIS-342 and others which have shown early maturity also produced better yields. This situation might change if the crop is left for 2nd or 3rd pick where late maturing varieties could yield higher than early maturing cottons. Uzbekistan breeders have succeeded in evolving several worlds' earliest maturing, high yielding and quality cultivars like C-6037, Termez-14, Termez-16, Termez-24 and Karshin-8 (Egamberdiev, 1996).

It is also very imperative to determine the level of association between earliness to related parameters so that selection of one parameter may simultaneously bring an improvement into another parameter. Thus, in addition to evaluating morphological traits, correlation coefficients (r) between pair of choice characters related to earliness were also determined (Table 3). The correlation coefficient (r) values revealed highly significant and positive associations between days to 1st flower with sympodial branch (r = 0.677) and also with 1st effective boll setting sympodial branch (r = 0.705). Also positive correlation (r = 0.678) between 1st sympodial branch with 1st effective boll setting branch was noted. However, sympodial branch length was significantly but negatively correlated (r = -0.663) with boll opening percent whereas, boll opening percent was negatively correlated (r = -0.906) with boll weight. While boll weight itself was insignificantly negatively correlated (r = -0.281) with yield. These results are generally

Table 3. Correlation coefficient between plant traits used to characterize early maturing upland cotton varieties

Character association	Correlation coefficients (r)
Days taken to set 1st flower versus 1st sympodial branch node number	0.677**
Days taken to set 1st flower versus sympodial branch node number with 1st effective boll	0.705**
1st sympodial branch node number versus sympodial branch number with 1st effective boll	0.678**
Sympodial branch length versus boll opening percent at 120 days after planting	-0.663**
Boll opening % at 120 days after planting versus boll weight	-0.906**
Boll opening % at 120 days after planting versus seed cotton yield	0.219
Boll weight versus seed cotton yield	-0.281*

**, * = significant at 1 and 5% probability levels, respectively coinciding with plant trait results used to characterize early season cottons in that, the early maturing varieties took less days to set first flower, also produced lower sympodial branches, set effective bolls on lower sympodial nodes, produced shorter sympodial branches, gave higher early boll opening percent and produced medium boll size. Present results are also in accordance with earlier findings of Baloch and Baloch (2004) and Jatoi (2007) who noted that early maturing cottons set lower but shorter sympodial branches and also gave higher percent of early boll setting and opening.

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