Pak. J. Bot., 40(3): 1201-1207, 2008.

ASSESSMENT OF YIELD-RELATED MORHOLOGICAL MEASURES FOR EARLINESS IN UPLAND COTTON (*GOSSYPIUM HIRSUTUM* L.)

SAEED AHMAD[1], SAGHIR AHMAD[2*], MUHAMMAD ASHRAF[3], NOOR-UL-ISLAM KHAN[4] AND NADEEM IQBAL[5]

[1]*Cotton Research Station, Vehari, Pakistan,*
[2]*Cotton Botanist, Cotton Research Station, Vehari, Pakistan,*
[3]*Department of Botany, University of Agriculture, Faisalabad, Pakistan*
[4]*Director, Cotton Research Institute, Faisalabad, Pakistan*
[5]*Regional Agricultural Economic Development Centre, Vehari, Pakistan.*

Abstract

Assessment of yield-related morphological measures for earliness is a key factor for developing short duration varieties in cotton. For this purpose, 13 upland cotton genotypes were used for studying different morphological traits related with earliness i.e., days to first flower, first sympodial branch node number, sympodial branch number with first effective boll, sympodial branch length, boll opening (%) after 120 days of planting, boll weight and seed cotton yield per plant. All the varieties differed significantly for all these traits showing a variation range of 41 to 48, 5.0 to 9.0, 5.0 to 10.3, 14.2 to 35.7 cm, 53.0 to 81.0%, 2.7 to 4.5g, 126.0 to 196.3g, respectively. The new strain VH-144 and VH-156 exhibited great yield potential for earliness as they took minimum days to first flower (40.5 and 41.4, respectively) and more boll opening percentage at 120 days after planting (81 and 80.9, respectively). In order to make rapid improvement in earliness**,** correlation between choice parameters related with earliness were also determined. Highly positively significant correlation existed between days taken to first flower and sympodial branch node number with first effective boll (r= 0.807), days taken to first flower and boll opening percentage at 120 days after planting (r= 0.705), sympodial branch node number with first effective boll and boll opening percentage at 120 days after planting (0.501), whereas negative correlation was found between sympodial branch length and boll opening percentage at 120 days after planting (*r*=-0.663), boll weight and seed cotton yield (*r*=-0.281). It can thus be concluded that selection for early setting of first flower, lower value of first sympodial branch with first effective boll and boll opening after 120 days of planting can lead to development of early maturing variety in cotton.

Introduction

Cotton (*Gossypium hirsutum* L.) is the most leading fibre crop in the world (Fryxell, 1992). The attainment of earliness is a basic breeding objective in upland cotton (Braden & Smith, 2004). Cotton plant, perennial in nature with indeterminate growth habit, has been adapted to annual cultivation due to enormous efforts of plant breeders (Ali *et al*., 2003; Rauf *et al*., 2005). Earliness in cotton is important in alleviating late season risks of insects/pests (particularly bollworms), diseases, un-favorable weather conditions and increase in economic return by reducing input cost (Anderson *et al*., 1976). Another advantage of growing early maturing cotton cultivars is the provision of proper time for rotation of other crops allowing timely sowing of wheat in cotton – wheat – cotton cropping system as in Pakistan (Ali *et al*., 2003).

[*]Corresponding author: saghirahmad_1@yahoo.com

Various plant characteristics have been used to determine earliness in cotton. For instance, Ahmed & Malik (1996) estimated that one node decrease in sympodial branch matures the cotton crop by approximately 4 to 7 days earlier. Kairon & Singh (1996) determined that short duration cottons set fruits at 4^{th} or 5^{th} nodes while long duration varieties set them at 8^{th} or 9^{th} node. Several other workers (Kirby *et al*., 1990; Kairon & Singh, 1996; Baloch & Baloch, 2004) have reported strong relationship between early maturity and lower sympodial branch node number and sympodial branch length. Similarly other studies reveal that rate of first picking or boll opening (Richmond & Ray, 1966), node to first sympodial branch and rate of first picking (Tiffany & Nalm, 1981), first sympodial branch node number and days taken to first flower (Munro, 1971; Aden, 1997; Anjum *et al*., 2001; Panhwar *et al*., 2002), date of first square, first flower and first boll open (Godoy, 1994), number of nodes to first fruiting branch, first sympodial branch number, date of first square, date of first flower and first picking (Godoy, 1994: Godoy & Palomo, 1999), main stem node number of first sympodial branch and days taken to first flower (Babar *et al*., 2002), days taken to appearance of first flower (Ali *et al*., 2003), number of node to first sympodial branch (Iqbal *et al*., 2003) and number of first sympodial branch node and length of first sympodial branch (Rauf *et al*., 2005) have direct or indirect effect on the earliness of cotton. Tunis *et al.*, (2002) and Bloch & Bloch (2004) have observed that moderate boll weight ranging from 3.5 to 4.0 gm is a reliable criterion for developing early maturing varieties of cotton. Uzbekistan breeders have developed several world's earliest maturing, high yielding and quality cultivars like C-6037, Termez-14, Termez-16, Termez-24 and Karashin-8 (Egamberdiev, 1996).

Richmond & Radwan (1962) reported significant positive correlation between phenological traits i.e., first flower, boll opening, sympodial branch node number and total yield in cotton. Rauf *et al*., (2005) also revealed positive correlation between percent of first picking and all earliness characteristics in cotton.

Negative correlation between first fruiting node/first effective boll and days to first flower has been found by Gopang (2003). The present report gives on account of the yield related morphological measures for earliness in upland cotton.

Materials and Methods

The genetic material evaluated comprised 13 cotton genotypes (CIM-448, CIM-473, BH-160, VH-142, BH-162, FH-1000, FH-930, VH-156, VH-148, VH-183, VH-155, VH-144 and VH-145). The experiment was sown during May 2005 in a Randomized Complete Block Design with four repeats. The plot size of each strain was 50 x 12.5 feet. Plant to plant and row-to-row distance was 1.5 feet and 2.5 feet, respectively. Recommended agronomic practices were carried out for the whole experimental genetic material. The plant traits studied are; days taken to set first flower, Ist sympodial branch node number on the main stem, first effective boll setting on sympodial branch number, sympodial branch length (cm), opened bolls percentage at 120 days after planting, boll weight (g) and seed cotton yield per plant (g).

The analysis of variance was carried-out by using the procedure outlined by Steel & Torrie (1980) and the correlation was calculated by using formulae given by Kwon & Torrie (1964).

Table 1. Mean squares from ANOVA for various morphological plant traits used to characterize early maturing upland cotton varieties.

SOV	DOF	DFF	FSBNN	SBNFEB	SBL	BO (%) A 120 P	BW	SCYPP
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 0.05 and 0.01 probability levels, respectively.
ns = Non-significant
Source of variation (SOV), degree of freedom (DOF), days to first flower (DFF), first sympodial branch node number (FSBNN), sympodial branch number with first effective boll (SBNFEB), sympodial branch length (SBL), boll opening percentage at 120 days after planting (BOA120 DAP), boll weight (BW) and seed cotton yield per plant (SCYPP).

Table 2. Means of first flower (DFF), first sympodial branch node number (FSBNN), sympodial branch number with first effective boll (SBNFEB), sympodial branch length (SBL), boll opening (%) at 120 days after planting (BOA120 DAP), boll weight (BW) and seed cotton yield per plant (SCYPP) plant traits used to characterize early maturing upland cotton varieties.

Variety/ Strain	DFF	FSBNN	SBNFEB	SBL (cm)	BO (%) A 120 P	BW (g)	SCYPP (g)
BH-160	43.5	6.8	8.5	27.2	75.0	3.5	126.0
BH-162	47.0	9.0	9.0	28.1	53.0	4.5	175.8
CIM-448	42.3	5.5	7.3	14.2	71.0	3.5	193.5
CIM-473	48.0	7.5	9.3	30.5	65.	4.1	143.5
FH-930	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
VH-142	41.5	5.5	5.2	15.2	76.5	3.1	144.8
VH-148	42.5	6.5	9.8	24.3	71.0	3.8	161.5
VH-156	41.4	5.4	6.5	21.6	81.0	3.5	196.3
VH-183	44.5	5.5	8.5	23.5	75.5	2.7	143.8
VH-155	42.5	5.8	7.5	25.5	76.5	3.0	181.5
VH-144	40.5	5.0	5.0	17.0	80.9	3.5	193.5
VH-145	41.5	6.0	6.3	19.0	80.8	3.3	187.5
Average	43.8	6.5	7.9	24.4	70.8	3.6	166.1

Results and Discussion

Analysis of variance revealed highly significant genotypic differences for days to first flower (Table 1) showing a variation range of 41.0 to 48.0 days (Table 2). The new strains VH-144 took minimum days (40.5) to first flower followed by VH-156, which set first flower 41.4 days after sowing. It is normally assumed that fewer the number of days taken to produce first flower the earliest is the boll setting and opening hence earlier the variety. The experimental results are in agreement with the previous research work conducted by Munro, (1971), Aden, (1997), Anjum *et al.*, (2001), Babar *et al.*, (2002), Panhwar *et al*., (2002) and Ali *et al*., (2003) who also reported positive linkage between first flower and earliness.

It is has been noted that the lower the first sympodial branch node number (FSBNN), the earlier the maturity. The varieties under test differed significantly for producing first sympodial branch node number (Table 1), which showed variation from 5.0 to 9.0 (Table 2). VH-144 had the lowest value of 5.0 followed by VH-156 with respective value of 5.4, whereas the other genotypes produced first sympodial branch node in the range of 5.5 to 9.0. The two strains VH-144 and VH-156 also had less number of days to set first flower, an important trait for earliness. Several other workers (Tiffany & Nalm, 1981; Kirby *et al*., 1990; Kairon & Singh, 1996; Panhwar *et al*., 2002; Baloch & Baloch, 2004) have also reported strong relationship between lower sympodial branch node number and early maturity in cotton.

Setting-up of first effective boll on lower sympodial branches can also be regarded as one of the criterion for early maturing varieties. Data for mean values (Table 2) also showed wide range of variation in respect of formation of sympodial branch node number with first effective boll. The lowest value of 5.0 was exhibited by VH-144 followed by VH-142 (5.2), and the highest by FH-1000 with a value of 10.0 (Table 2). Kairon & Singh (1996) also pointed out that short duration cottons set fruits at 4^{th} or 5^{th} nodes while long duration varieties set them at 8^{th} or 9^{th} node. Ahmed & Malik (1996) estimated that one node decrease in sympodial branch brings about approximately 4 to 7 days early maturity in cotton crop. Strong relationship between early maturity and lower sympodial branch node number with effective boll have been reported by several other cotton breeders Kirby *et al*. (1990), Godoy (1994), Godoy & Palomo (1999), Kairon & Singh (1996) and Baloch & Baloch (2004). It is also assumed that, closer the distance between the first sympodial branch node and first effective boll setting branch, the earlier the variety would be. This behaviour, besides VH-144 and VH-142 and VH-156, has also been expressed by VH-145, CIM-448 and VH-155.

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 (Table 2). Among the thirteen genotypes, CIM-448, VH-142 and VH-144 produced relatively shorter branches with respective value of 14.2, 15.2 and 17.0 cm (Table 2). Uzbekistan cotton breeders have succeeded in developing early maturing varieties with short sympodial branches. Some other workers (Karin & Singh, 1996; Baloch & Baloch, 2004; Rauf *et al*., 2005;) 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 criteria for cotton breeders to select early maturing varieties. In our study, all genotypes differed significantly for percentage of boll opening after 120 days of sowing. Wide range of variation from 53.0 to 81.0 % was observed for this trait. The new strain VH-156 completed maximum boll opening at 120 days after planting (81%) followed by VH-144 (80.9%). Godoy, (1994), Godoy & Palomo (1999), Kairon & Singh (1994) and Richmond & Ray (1966) have also reported this trait as an important one for developing early maturing varieties of cotton. Indian breeders however have made three classification of maturity 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 & Singh, 1996). Our cotton crop is normally harvested in 150 to 165 days after in wheat sowing if the crop is left for 2^{nd} picking. Therefore developing varieties like VH-156 and VH-144 can be best choice in our crop rotation of cotton-wheat-cotton, so as to increase our wheat production as well.

It has now become a well-recognized fact that, 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. The varieties under present study produced bolls weighing 2.7 g (VH-183) to 4.5 g (BH-162). We consider bolls weighing in the range of 3.0 to 3.5 g, as moderate bolls which give more yield. Among 13 varieties tested, except VH-183 all the other genotypes had boll weight value of 3 or more than 3 g thus indicating potential for high yield. These results are in a accordance to the observations of Tunis *et al*., (2002) and Baloch & Baloch

(2004) who reported that early maturing cottons although had comparatively smaller or moderate bolls but produced 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. On the other hand, Indian breeders (Singh, 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.

Seed cotton yield is the most important and ultimate objective of any breeder while evolving a new variety. The more the variation, the more the chances of selection and improvement of crop variety. In the present study highly significant differences existed among the genotypes (Table 1). The highest yield was recorded for VH-156 (196.3 g per plant) followed by VH-144 (193.5 g). The new cultivar BH-160 produced the lowest yield (126 g) thus showing a decrease of about 70g from the top yielding strain VH-156. The two new strains VH-156 and VH-144 have shown consistent performance in terms of days taken to set first flower, first sympodial branch node number, boll opening and seed cotton yield per plant. It thus be concluded that these two strains are early maturing and also have high yield potential. Uzbekistan breeders have succeeded in evolving several world's earliest maturing, high yielding and quality cultivars like C-6037, Termez-14, Termez-16, Termez-24 and Karashin-8 (Egamberdiev, 1996).

It is also very imperative to determine the level of association between the earliness related parameters so that selection of one parameter may simultaneously bring about significant improvement of another parameter. Thus, in addition to evaluating morphological traits, correlation coefficients (*r*) between choice characters related to earliness like days taken to first flower and sympodial branch node number with first effective boll, days taken to first flower and boll opening percentage at 120 days after planting, sympodial branch node number with first effective boll and boll opening percentage at 120 days after planting, sympodial branch length and boll opening percentage at 120 days after planting, boll opening percentage at 120 days after planting and seed cotton yield and boll weight and seed cotton yield was also determined (Table-3). The correlation coefficient values (Table 3) revealed highly significant and positive association between days to first flower and sympodial branch node number with first effective boll (*r* = 0.807), days to first flower and boll opening percentage at 120 days after planting (*r* = 0.705), sympodial branch node number with first effective boll setting and boll opening percentage at 120 days after planting (*r*= 0.501). These results are in accordance with earlier studies reported by Richmond & Radwan (1962), but in contrary to Gopang (2003), who found negative correlation between these parameters. We found positive correlation between days to first flower and sympodial branch node number with first effective boll setting (*r*=0.678). Highly significant negative correlation (*r*= -0.663) existed between sympodial branch length and boll opening percentage after 120 days of planting, and boll weight and seed cotton yield (*r*= -0.281), whereas non-significant correlation was found between boll opening percentage after 120 days of planting and seed cotton yield. Similar findings have been reported by Rauf *et al*., (2005).

Development of early maturing cotton varieties has become an important objective of cotton breeders world over because of many reasons such as less requirements for irrigation and fertilizer, providing escape to late season pest attack, reduced labour cost and also fitting better in cotton-wheat-cotton crop rotation and intensive cropping system (double and triple cropping pattern).

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

Sr. No.	Character association	Correlation coefficients (r)
1.	Days taken to first flower and sympodial branch node number with first effective boll.	0.807**
2.	Days taken to first flower and boll opening percentage at 120 days after planting.	0.705**
3.	Sympodial branch number with first effective boll and boll opening percentage at 120 days after planting.	0.501**
4.	Sympodial branch length and boll opening percentage at 120 days after planting.	-0.663**
5.	Boll opening percentage at 120 days after planting and seed cotton yield.	0.219ns
6.	Boll weight and seed cotton yield.	-0.281

** = Significant at 0.05 and 0.01 probability levels, respectively.
ns = Non-significant

The morphological characteristics such as days taken to first flower, sympodial branch number with first effective boll and boll opening percentage at 120 days after planting have been found the main traits associated with earliness in cotton. We can thus predict that selection for these traits could be helpful in evolving early maturing varieties in cotton.

References

Aden, S.A. 1997. *Impact of nodal development, fruiting pattern and boll retention ability on earliness and yield in upland cotton*. M.Sc.Thesis, Sind Agri. Uni., Tandojam.

Ahmad, Z. and M.N. Malik. 1996. How a short season changes physiological needs of cotton plant? 55th Plenary Meeting of the ICAC, Tashkent, Uzbekistan, pp-16-21.

Ali, C.R., M. Arshad, M.I. Khan and M. Fzal. 2003. Study of earliness in commercial cotton (*G.hirsutum* L.) genotypes. *J. Res. (Sci.*), 14 (2): 153-157.

Anderson, J.M., R.R Bridge, A.H. Heagler and G.R. Tupper. 1976. The economic impact of recently developed early season cotton strains on firm and regional cropping system and income. *Proceed. Belt wide Cott. Prod. Res. Conf., National Cotton Council of America, Memphis, T.N. USA*., pp. 98-100.

Anjum, R., A.R. Soomro and M.A. Chang. 2001. Measurement of earliness in upland cotton. *Pak. J. Biol. Sci.*, 4: 462-463.

Babar, S.B., A.R. Soomro, R. Anjum, A.M. Memon and A.W. Soomro. 2002. Two preliminary reliable indicators on earliness and yield in cotton – II. *Asian J. Plant Sci.*, 1(2): 121-122.

Baloch, M.J. and Q.B. Baloch. 2004. Plant characters in relation to earliness in cotton (*Gossypium hirsutum* L.*). Proc. Pak. Acad. Sci*., 41(2): 103-108.

Braden, C.A. and C.W. Smith. 2004. Phenotypic measurements of fiber associations of near-long staple upland cotton. *Crop Sci.*, 44: 2032-2037.

Egamberdiev, A.E. 1996. Breeding for early maturing varieties of cotton. 55th plenary meeting of the ICAC, Tashkent, Uzbekistan, pp. 9-12.

Godoy, S. 1994. Comparative study of earliness estimators in cotton (*Gossypium hirsutum L.*). Red De Fibras-Algodon, CIFAP-Laguna-INFAP, Apdo, Postal 247, Torreon, Mexico. *ITEA-Production-Vegetal*, 90: 175-186.

Godoy, A.S. and G.A. Palomo. 1999. Genetic analysis of earliness in upland cotton (*G. hirsutum* L.). II. Yield and lint percentage. *Euphytica*, 105: 161-166.

Gopang, A.D. 2003. Studies on correlation of some morphological characters with earliness in cotton. *Sci. Technol. Devel*., 22(3): 23-31.

Iqbal, M., M.A. Chang, A. Jabbar, M.Z. Iqbal, M. Hassan and N. Isalm. 2003. Inheritance of earliness and other characters in upland cotton. *Online J. Biol. Sci.,* 3(6): 585-390.

Kairon, M.S. and V.V. Singh. 1996. Genetic diversity of short duration cottons. 55th plenary meeting of the ICAC, Tashkent, Uzbekistan, pp. 5-9.

Kerby, T.A, K.G. Gasman and M. Keeley. 1990. Genotypes and plant densities for narrow row cotton systems, I. Height, nodes, earliness, location and yield. *Crop Sci.,* 30: 644-649.

Kwon, S.H. and J.H. Torrie. 1964. Heritability of inter-relationship among traits of two soybean populations. *Crop Sci*., 4: 196-198.

Munro, J.M. 1987. Cotton (Tropical Agriculture Series). Longman group UK Limited, 1987.

Ray, L.L. and T.R. Richmond. 1966. Morphological measures of earliness in cotton. *Crop Sci*., 6: 527-531.

Singh, P. 2004. *Cotton Breeding*. 2nd Edition. pp. 118.

Steel, R.G.D. and J.H. Torrie. 1980. *Principles and procedures of statistics, a biological approach*. Second Edition. McGraw Hill Inc., New York, Toronto, London.

Tiffany, D. and N.R. Nalm. 1981. A comparison of twelve method measuring earliness in upland cotton. *Beltwide Cotton Prod. Res. Conf*., pp. 101-103.

Tunis, G.H., M.J. Baloch, A.R Lakho, M.H Arain and M.S. Chang. 2002. Earliness comparison of newly developed cotton strains with commercial varieties. *Sindh Bal. J. Plant Sci.,* 4: 78-81.

(Received for publication 4 January 2008)