Plant Archives Vol. 24, No. 2, 2024 pp. 369-374 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2024.v24.no.2.051

BARTLETT'S INDEX FOR MEASURING EARLINESS AND PLANT TYPE CHARACTERIZATION IN COTTON (*GOSSYPIUM HIRSUTUM* L.)

M.S. Sowmya[1]*, Keerthi A. Patil[2], H.S. Saritha[1] and R.S. Patil[3]

[1]Department of Genetics and Plant Breeding, University of Agricultural Sciences, Bangalore - 560 065, Karnataka, India.
[2]Department of Genetics and Plant Breeding, University of Agricultural Sciences, Dharwad - 580 005, Karnataka, India.
[3]Agricultural Research Station, Dharwad - 580 007, Karnataka, India.
*Corresponding author E-mail : sowmyashegde96@gmail.com

(Date of Receiving-10-02-2024; Date of Acceptance-25-04-2024)

ABSTRACT

A set of 25 cotton genotypes was evaluated to assess the early maturity using Bartlett's index and further categorization into different plant types based on the Index Score method. The higher the value of Bartlett's index earlier is the maturity. Among the evaluated genotypes E-20 and S-32 showed higher values of Bartlett's index indicating early maturity. The genotypes were grouped into six plant type classes based on plant height and diameter. Out of 25 genotypes, nine were grouped as Super compact, four as Compact type, another four genotypes each as Tall compact and Robust, respectively and two were grouped as highly robust. None of the genotypes was categorized as compact spreading. Genotype E-20 was identified as super compact and early maturing suggesting its suitability to high density planting and can be included as a member crop in multiple cropping systems.

Key words : Cotton, Compact cotton, Plant type, Bartlett's index, Earliness.

Introduction

Cotton is the most important cash crop and natural fibre in the world for textile manufacture, accounting for about 50 per cent of all fibres used in the textile industry. It is a member of the Malvaceae family and genus *Gossypium*. There are four species in the genus *Gossypium*: *G. hirsutum* L., *G. barbadense* L., *G. arboreum* L. and *G. herbaceum* L. that were domesticated independently as sources of textile fibre (Brubaker *et al*., 1999). *Gossypium hirsutum* L. is known as New World or Upland cotton. The major countries/regions of cotton production include the USA, India, China, the Middle East and Australia. Globally, India has the largest area of cotton cultivation that contributes 23 percent to cotton production. It occupies a unique position in the Indian economy in terms of income generation in the agricultural and industrial sectors (Damayanthi *et al*., 2016). Upland cotton, *Gossypium hirsutum* L., is the world's leading fibre producing crop and is grown in more than 80 countries with an annual production of 20 million tons. It is primarily cultivated for its lint, which is spun into yarn. Yarn is used for textile and several industrial uses. Raw cotton is also used for medical and surgical purposes (Aktar *et al*., 2019).

Increasing cotton production is one of the threshold areas of interest to most cotton breeders, it can be realized by increasing the yield per unit area or by mitigating cotton loss due to various biotic and abiotic factors by breeding for early maturity.

Earliness in cotton is important for the avoidance of frost damage, insect and disease build-up, soil moisture depletion and weathering of the open cotton. It has other advantages like allowing crop rotation with a winter crop. Therefore, greater emphasis is given to earliness in cotton by plant breeders to increase production efficiencies by decreasing the input of fertilizers, water, crop protection and in part pest management consideration (Anjum *et al.*, 2001). Earliness in cotton cannot be measured easily because it sets flowers and bolls over a long period. Hearn (1969), stated that faster squaring or flowering can determine the early maturity of cotton. Godoy (1994), indicated that node number of the first fruiting branch, plant height, days to the first square, days to first flower and days to first boll opening can effectively be used as an indicator to estimate the maturity in cotton. Ray and Richmond (1966) suggested that the node number of the first fruiting branch is a morphological measure of earliness. Soil *et al*. (1989) concluded that days to first flowering from sowing provided a reliable estimation of the earliness of maturity. Plant breeders can utilize per cent open bolls to measure the relative maturity of cotton varieties (Hosseini, 2017). Morphological traits that impact earliness include root/shoot ratio and leaf shape (Iqbal *et al.*, 2003). Divided leaves allow sunlight to penetrate deeper into the canopy, which improves the early boll set. Similarly, Bartlett's index is useful in assessing the earliness of maturity in cotton (Chang *et al.*, 2001). For the farming community and textile industry, early maturing cotton cultivars are more suited because they can elevate cotton production by reducing the end-season risks linked with pest menace and critical weather conditions (Neil, 1991). Early maturing cotton cultivars complete much of their life span during the crop's most desirable weather conditions, thereby preventing damage caused by adverse weather conditions.

Plant type characterization or ideotyping in cotton is gaining importance in India because of the increased need to improve cotton production per unit area. One such way to meet increasing cotton demand is to go for high density planting. The available genotypes in India are mostly resource hungry and hence occupy higher three-dimensional space in the field to express their potential. Genotypes with lesser plant height and plant diameter occupy lesser three-dimensional space in the field and thus become amenable to high density planting. The yield per unit area is high in compact cotton compared to the robust type because of good boll package. If such compact types are also early in maturity, they can fit very well in rainfed situations. They are less resource demanding and can be picked with mechanical harvesters thereby bringing the cost of cultivation down and making cotton production economical. Thus, compact cotton increases the overall profitability through increased productivity.

In the given set of 25 cotton genotypes, identifying the genotype with compact stature and early maturity is the target of this study. Bartlett's index of earliness was calculated by periodical boll harvesting at regular intervals. Other phenotypic observations, which specify early maturity and plant type in cotton were also considered in the study.

Materials and Methods

A set of 25 cotton genotypes was grown in a randomized complete block design with three replications and a spacing of 60 × 15 cm was followed at Agricultural Research Station, Dharwad Farm during *Kharif* 2019-20. Three released robust varieties Sahana, ARBH-813 and RAH-100 and a compact variety Suraj were grown at the same spacing as checks.

Bartlett's index of earliness was calculated based on the formula given below by Bartlett (1973).

$$\text{Bartlett's index} = \frac{P_1 + (P_1 + P_2) + (P_1 + P_2 + P_3) + ...(+ P_n)}{n(P_1 + P_2 + P_3.... + P_n)}$$

where,

P_1, P_2, P_n are the weight of seed cotton picked during the first, second till n^{th} picking and n is the total number of pickings.

Regular picking was done at 15 days interval in all the 25 genotypes in all three replications and picking was started from 140 DAS and five pickings were accomplished till 200 DAS.

Plant type categorization was done as per the method of Rajesh Patil *et al*. (2016). Plant diameter was calculated from the sympodial length at 50 per cent plant height and the sympodial angle at 50 per cent plant height was measured using a protractor (Fig. 1). The sympodial

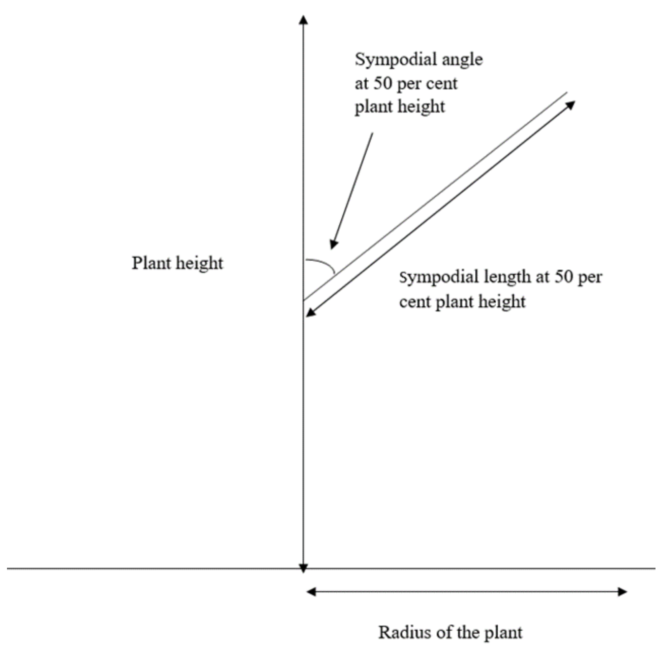

Fig. 1 : Determination of plant diameter.

angle in degrees was converted to radian using the following formula

$$\text{Radian} = \frac{\textit{Sympodial angle at } 50 \textit{ per cent plant weight} \times 3.14}{180}$$

The radian was converted into the Sine of a radian and then into a radius using the below formula and expressed in cm.

Radius = Sine (Radian) × Sympodial length at 50 per cent plant height

The diameter was obtained by doubling the radius and expressed in cm.

Table 1 : Analysis of variance for the five pickings carried out in cotton.

Source of variation	Replication	Treatment	Error
Degrees of freedom	2	24	48
First picking (140 DAS)	7.60	314.34**	9.85
Second picking (155 DAS)	23.52	957.44**	52.80
Third picking (170 DAS)	45.28	439.68**	130.50
Fourth picking (185 DAS)	9.94	473.09**	71.02
Fifth picking (200 DAS)	7.60	314.34**	9.85

Table 2 : Picking wise seed cotton contribution in per cent.

Genotypes	140 DAS	155 DAS	170 DAS	185 DAS	200 DAS
E-20	25.22	17.82	14.07	14.76	9.48
N-30	25.28	12.12	8.75	9.37	8.56
E-11	21.47	12.83	10.97	13.24	9.46
E-8	33.33	25.31	17.08	13.73	21.23
F-17	19.61	15.52	11.01	7.90	5.51
F-21	21.40	10.35	9.89	9.98	13.55
F-22	7.02	14.38	12.49	8.61	3.88
F-25	18.91	8.41	12.88	7.03	10.05
F-31	21.51	9.72	12.49	8.65	7.60
E-18	20.36	19.45	19.74	15.79	20.53
U-21	7.52	14.15	8.50	11.61	11.17
S-32	17.89	11.95	9.17	7.78	7.12
S-34	25.42	11.95	8.70	7.37	11.70
A-2	12.60	11.70	8.80	10.17	7.43
A-11	25.87	12.76	10.56	7.39	17.29
A-16	17.14	10.42	9.58	6.48	13.87
A-31	30.42	11.87	11.60	6.42	7.80
BRCC-1601	42.61	14.57	10.65	10.92	7.67
BRCC-1602	17.96	12.19	10.62	10.63	12.43
SCS-1206	26.63	12.19	13.14	8.73	10.85
ABRH-813	20.07	9.40	9.74	7.85	8.19
SAHANA	22.76	11.58	9.75	6.84	5.21
RAH-100	6.23	9.82	9.16	8.23	7.31
SURAJ	18.16	8.79	9.60	6.65	8.10
ARBC-64	17.12	14.31	10.69	5.37	6.14

Results and Discussion

Analysis of variance showed significant differences among the genotypes in all five pickings indicating that the genotypes differ significantly for maturity and results are given in Table 1.

Per cent, the contribution of seed cotton during the first pick was highest in BRCC-1601, which accounts for 42.61 per cent, followed by E- 8 (33.33%) and A-31 (30.42%). Per cent, the contribution of seed cotton yield in different pickings is given in Table 2.

The genotype E-20, showed the highest mean performance during the first pick while F-22 contributed the least during the first pick (Table 3). The cumulative contribution percentage of seed cotton weight showed that after the second pick the gap among the cultivars narrowed down and by the end of the third picking which was carried out at 170 DAS, the per cent contribution was almost the same. These results also confirm the view of Richmond and Radwan (1962), who opined that the most practical method to measure early maturity is the combined weights of the first and the second pickings expressed as the percentages of the total seed cotton harvested. Bartlett's index of earliness was calculated to establish the earliness of varieties. The data presented (Table 4) indicated that E-20 had the highest value of Bartlett's index of earliness 0.71, followed by S-32 (0.67), F-17, Sahana and ARBC-64 (0.63) indicating early maturity of these genotypes compared to the others.

The plant type categories in cotton are dependent on plant diameter and plant height wherein the range of the two traits was equally divided into their respective categories. This was based on the Index Score method given by Singh and Chaudhary (1985). The range of plant height was divided into two categories *viz*., Tall (89.10 – 102.46 cm) and Dwarf (69.73- 86.09 cm). The range of plant diameter was divided into three categories *viz*., Low (32.65-37.94 cm), Medium (37.95 – 43.24 cm) and High (43.25 – 48.51 cm) and the mean values for these across the genotypes are given in Table 5.

The chequer board was then developed and classified into 6 plant type categories *viz*., Super compact, Compact, Compact spreading, Tall compact, Robust and Highly robust. Each genotype was then assigned to a plant type category based on its diameter and height. The result of the categorization of 25 cotton

Table 3 : Mean plant yield of the genotypes in five pickings (g).

Genotypes	140 DAS	155 DAS	170 DAS	185 DAS	200 DAS	Total (g)
E-20	4.86	9.52	7.15	4.36	0.52	26.41
N-30	0.94	3.33	5.20	3.58	1.50	14.55
E-11	0.52	4.67	4.61	7.27	0.88	17.94
E-8	0.62	4.97	8.95	5.29	3.30	23.14
F-17	1.24	4.55	5.32	3.12	0.98	15.20
F-21	1.29	2.73	5.85	3.71	1.67	15.24
F-22	0.23	3.88	5.80	3.94	0.42	14.27
F-25	0.89	1.70	5.62	4.52	1.74	14.47
F-31	0.79	2.55	6.42	4.70	1.20	15.65
E-18	2.00	6.18	7.23	5.52	1.71	22.64
U-21	0.36	3.09	5.11	6.15	1.53	16.24
S-32	3.56	4.48	4.47	3.92	0.97	17.41
S-34	1.66	3.58	4.47	3.65	2.67	16.03
A-2	1.21	5.58	6.73	3.89	1.03	18.44
A-11	1.18	3.88	6.52	3.12	4.73	19.42
A-16	0.85	3.27	5.88	3.06	1.92	14.98
A-31	0.62	2.79	7.50	2.74	1.74	15.39
BRCC-1601	1.32	4.00	5.24	4.45	0.48	15.50
BRCC-1602	0.31	3.15	5.44	3.48	0.83	13.22
SCS-1206	0.95	3.03	6.95	3.52	1.33	15.78
ABRH-813	0.83	3.21	5.48	4.56	1.79	15.88
SAHANA	1.64	4.85	5.79	2.45	1.00	15.73
RAH-100	0.35	2.73	6.33	4.24	1.36	15.02
SURAJ	0.73	1.70	4.50	2.73	1.26	10.91
ARBC-64	1.27	4.61	4.85	2.73	1.06	14.52

Table 4 : Bartlett's index of genotypes.

Genotypes	E-20	N-30	E-11	E-8	F-17	F-21	F-22	F-25	F-31	E-18	U-21	S-32	S-34
Bartlett's index	0.71	0.58	0.57	0.55	0.63	0.58	0.59	0.54	0.56	0.61	0.54	0.67	0.56

Genotypes	A-2	A-11	A-16	A-31	BRCC -1601	BRCC -1602	SCS -1206	ARBH -813	Sahana	RAH -100	Suraj	ARBC -64
Bartlett's index	0.62	0.55	0.57	0.57	0.61	0.58	0.58	0.56	0.63	0.55	0.56	0.63

genotypes into different plant categories in the present study is as follows (Table 6, Fig. 2), genotypes E-20, N-30, E-11, F-22, U-21, S-32, A-31, BRCC-1602 and ARBC-64 were categorized as Super compact type. Genotypes A-2, A-16, BRCC-1601 and SCS-1206 fell in the Compact category.

None of the genotypes was found in compact spreading. Genotypes F-21, F-31, E-18, A-11 and Suraj were categorized as Tall compact. Genotypes grouped under the robust category were F-17, S-34, ARBH-813, Sahana and RAH-100. Genotypes E-8 and F-25 were highly robust.

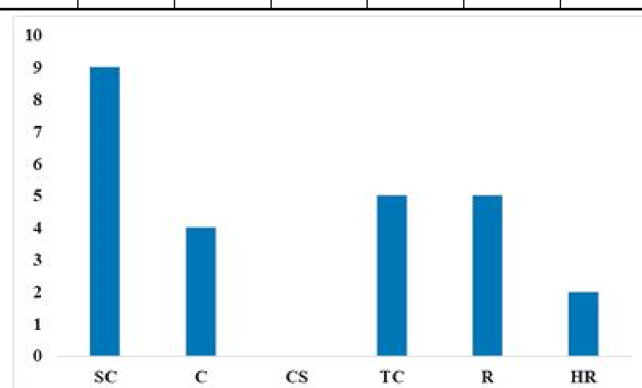

Fig. 2 : Distribution of genotypes based on plant type characters.

SC: Super Compact **C:** Compact **CS:** Compact Spreading
TC: Tall Compact **R:** Robust **HR:** Highly Robust

Table 5 : Mean performance of the genotypes for plant type governing traits.

S. no.	Genotypes	PH (cm)	SL50 (cm)	SA50	PD (cm)
1.	E-20	79.20	18.60	79.80	36.28
2.	N-30	76.00	19.07	75.03	36.59
3.	E-11	83.20	16.87	79.03	32.65
4.	E-8	92.40	24.13	77.67	46.70
5.	F-17	92.67	20.60	80.00	40.44
6.	F-21	90.73	18.93	81.67	37.11
7.	F-22	84.20	17.33	77.33	33.54
8.	F-25	102.47	24.80	80.00	48.51
9.	F-31	86.73	20.20	79.67	39.24
10.	E-18	86.60	18.00	81.33	35.25
11.	U-21	81.33	18.07	76.03	34.77
12.	S-32	83.60	19.13	78.67	37.33
13.	S-34	99.73	20.47	78.00	38.29
14.	A-2	80.80	20.07	80.00	39.27
15.	A-11	86.40	19.27	80.67	37.77
16.	A-16	85.67	21.07	77.33	40.88
17.	A-31	84.20	17.27	77.00	33.51
18.	BRCC-1601	72.20	21.73	77.00	41.99
19.	BRCC-1602	69.73	19.27	73.67	36.83
20.	SCS-1206	79.67	20.00	74.00	38.24
21.	ARBC-64	80.07	18.67	75.60	35.64
Checks					
22.	ARBH-813	91.93	20.93	82.33	40.95
23.	SAHANA	94.33	20.93	80.00	40.72
24.	RAH-100	96.13	21.13	74.67	40.24
25.	SURAJ	89.40	19.20	78.67	37.27
	Mean	85.97	19.82	78.20	38.39
	CV	9.73	16.21	5.00	16.33
	SE±mean	4.83	1.86	2.26	3.62
	CD at 5%	13.74	5.28	6.42	10.29

Table 5 continued...

Table 5 continued...

Table 6 : Plant type characterization of cotton genotypes based on plant height and diameter index criteria.

Plant height	Plant diameter		
	Low (32.65 – 37.94 cm)	**Medium (37.95 – 43.24 cm)**	**High (43.25 – 48.51 cm)**
Dwarf (69.73- 86.09 cm)	**Super compact** E-20, N -30, E -11, F-22, U-21, S-32, A-31, BRCC-1602, ARBC-64	**Compact** A-2, A-16, BRCC-1601, SCS -1206	**Compact spreading** (No genotypes found)
Tall (89.10 – 102.46cm)	**Tall compact** F-21, F-31, E-18, A-11, Suraj	**Robust** F-17, S-34, ARBH-813, Sahana, RAH-100	**Highly robust** E-8, F-25

Conclusion

The genotypes were evaluated under high-density planting which accommodated 1,11,111 plants per hectare as against the regular density of 55,555 by altering the regular spacing of 90 cm × 20 cm to 60 cm ×15 cm. By their plant type, compact genotypes were highly suited to closer spacing. Genotypes E-20 and S-32 were identified as promising super compact genotypes with high yield, early maturity and acceptable fibre qualities.

The identified early maturing compact genotypes could be effectively used in breeding programmes to hasten up cotton production and to make cotton a member crop in multiple cropping systems.

Conflict of interest

The authors have declared that no competing or conflict of interest exists.

Author contributions

Rajesh Patil and H.S. Saritha conceived and designed the experiment. M.S. Sowmya conducted the experiments and analysed the data. Sowmya and Keerthi participated in the data analysis. Sowmya, Keerthi and H.S. Saritha drafted the manuscript. Rajesh Patil revised the manuscript. All authors read and approved the final version.

Data availability statement

All data generated or analysed during this study are included in this article.

References

Akter, T., Islam A.K.M.A., Rasul M.G., Kundu S., Khalequzzaman and Ahmed J.U. (2019). Evaluation of genetic diversity in short duration cotton (*Gossypium hirsutum* L.). *J Cotton Res*., **2(1)**, 2-6.

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

Bartlett, M.S. (1973). Some examples of statistical methods of research in agriculture and applied botany. *J Royal Stat. Soc.*, **4B**, 137-170.

Brubaker, C.L., Bourland F.M. and Wendel J.F. (1999). The origin and domestication of cotton. In: Smith, C.W. and Cothren J.T. (Eds.) *Cotton; origin, history, technology and production*. John Wiley, New York, pp. 3–31.

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

Damayanthi, K.P.M., Manickam S. and Rathinavel K. (2016). Genetic variability studies in *Gossypium barbadense* L. genotypes for seed cotton yield and its yield components. *Electron J Plant Breed.*, **1(4)**, 961-965.

Godoy, S. (1994). Comparative studies of earliness estimators in cotton (*Gossypium hirsutum* L.). *ITEA Production – Vegetal.*, **90**, 175- 186.

Hearn, A.B. (1969). Growth and performance of cotton in desert environment, morphological development of the crop. *J Agric Sci.*, **73**, 65-74.

Hosseini, G.H. (2017). New earliness index and integration of earliness additive genes in the newgenotype of cotton (*Gossypium hirsutum* L.). *Intl J Life Sci Scientific Res.*, **3(3)**, 1016-1019.

Iqbal, M., Chang M.A., Iqbal M.Z., Hassan M.U., Nasir A. and Islam N.U. (2003). Correlation and path coefficient analysis of earliness and agronomic characters of upland cotton in Multan. *Pak J Agron.*, **2**, 160-168.

Neil, F. (1991). Strategies for prevention of development of pesticide resistance. *Proc. ICAC- CCRI-Reg. Consult Insecticide Resist. Manage. Cotton.* June 28- July 1.

Rajesh, S., Patil B.M., Khadi, Katageri I.S., Vamadevaiah H.M. and Patil S.S. (2016). Breeding forproductive compact cotton varieties and a method to categorise the plant type in *Gossypium hirsutum* L. in *World Cotton Research Conference-6, Official program and abstracts*, Brazil, pp 40.

Ray, L.L. and Richmond T.R. (1966). Morphological measures of earliness of cotton. *Crop Sci.*, **6**, 527- 631.

Richmond, T.R. and Radwan S.R.H. (1962). A comparative study of seven methods of measuring earliness of crop maturity in cotton. *Crop Sci.*, 2, 397-400. https://doi.org/10.2135/cropsci1962.0011183X000200050010

Singh, R.K. and Choudhary B.D. (1985). *Biometrical methods in quantitative genetic analysis*. pp. 39-68. Kalyani publishes, New Delhi.

Soils, R.O., Cabangbang R.P. and Bader R.F. (1989). Phenological and product quantity measures of earliness in cotton (*Gossypium hirsutum* L.). *Philippine*, **72**, 279-289.