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Research Article

Genetic variability investigations on early maturity indicators and their inter-relationships in upland cotton (*Gossypium hirsutum* L.) cultivars

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Abstract
Cotton breeding programs aim to develop early-maturing varieties that yield high. Towards this, a study was conducted at the Agricultural Research Station, Dharwad farm, during *kharif* 2021-22 comprising 20 genotypes. Thirteen early maturity-related traits, along with seed cotton yield were analyzed. The examination indicated significant disparities in the early maturity traits *viz.,* days to first flower (DFF), days to first boll opening (DFB), per cent crop harvested at the first (PCH-1) and second pickings (PCH-2), Bartlett's Index (BI), node number of the first fruiting branch (NNFFB), plant height (PH), earliness percentage (EP), mean maturity date (MMD) and production rate index (PRI). Some traits, including PCH-1, PCH-2 and PRI presented higher estimations of GCV and PCV, along with high heritability and genetic advance, making them reliable indicators for selection. Seed cotton yield showed a significant negative correlation with DFF, DFB and MMD. Conversely, it showed a significant positive correlation with the PRI, PCH-1, PCH-2 and BI. Furthermore, DFB and PRI exhibited highly significant direct positive effects, while DFF had a negative direct effect, followed by the FBP. Based on this study, the genotypes ESS-3, ESS-20, NNDC-30 and S-32 were identified as early-maturing compared to ESS-13, FLT-25 and URT-21. These genetically diverse genotypes can be valuable resources for forthcoming cotton breeding programs.

Keywords: Cotton, early maturity, seed cotton yield, Bartlett's Index,

INTRODUCTION

Gossypium hirsutum, commonly known as Upland cotton or American cotton, has emerged as the dominant species in the global cotton industry (Ganapathy and Natarajan, 2008) and leads the world cotton trade. India ranks first in terms of acreage, occupying 37% of the world's cotton cultivation area, and is the largest producer accounting for 22% of global cotton production (Cotton Corporation of India, 2022). Although cotton is habitually grown as an annual crop, it displays some characteristics of perennial plants. As a result, many crop breeders have a special focus on early maturity traits in the genotypes. The intention of cultivating early maturing cotton is to upsurge the likelihood of harvesting prior to the onset of cold and rainy weather. Additionally, early maturation of cotton means reduced fertilizer use, irrigation and crop protection. However, the biggest achievement, hitherto unseen could be fitting another crop after cotton within the year.

Measuring earliness traits in cotton can be complex due to the extended duration of flowering and boll opening. This comprehensive trait has many indicators, including days to first flower, days to first boll opening, seedling period, bud period and flower and boll period; first fruiting branch node; height of first fruiting branch node; and yield percentage before frost. Various measurements have

been used to evaluate early maturity in cotton, such as growth period, ratios of primary and secondary yields to total yield, average maturity period and productivity index (Yu, 2007). Richmond and Radwan (1962) suggested that the most practical method by which to measure maturity involves examining the ratio of weights during early harvests to total seed cotton harvested., Ray and Richmond (1966), who studied various morphological measures of early maturity in cotton, selected the node number of first fruiting branch as the most reliable and practical measurement. Because early-maturing cotton cultivars generally show lower first fruiting branch and height values (Yu, 2007), the latter has been used to measure early maturity in cotton (Li *et al*., 2012). However, cotton breeders have a particular interest in creating promising early varieties capable of replacing existing ones. The extent and nature of the genetic variability present in the germplasm provide cotton breeders an ample opportunity for its utilization in successful breeding programs intended (Ahsan *et al*., 2015, Gnanasekaran *et al.,* 2018)

Given the possibility of a relationship between yield and early maturing features, a breeder frequently reports findings based on the selection of required economic characters using simple correlation and path analysis (Dewey and Lu, 1959). Understanding the relationships between characteristics that affect yield is therefore an essential requirement when determining the right breeding strategy. Keeping in view the significance of genetic diversity, the present research was conducted to explore the genetic divergence and relationship among cotton genotypes for early maturity indicators and yield.

MATERIALS AND METHODS

Twenty cotton genotypes with diverse pedigree were evaluated in this study. The current investigation was carried out in upland cotton (*Gossypium hirsutum* L.) during *kharif* 2021-22 at Agricultural Research Station, Dharwad Farm under rainfed conditions. The 20 genotypes were sown with a spacing of 60 cm between rows with 30 cm between plants in a row under Randomised Complete Block Design (RCBD) with two replications. Each entry consisted of three rows with 4.2 m length accommodating around 15 plants per row. Hills were thinned at the seedling stage to keep a constant stand of one plant/hill. The suggested agricultural practices were applied at the appropriate time.

Data were recorded on five well-guarded and tagged plants for 13 early maturity component traits along with cotton yield *i.e.,* days to first flower (DFF), days to first boll opening (DBF), flowering to boll opening period (FBP), per cent crop harvested at first pick (PCH-1; ratio of weight of seed cotton harvested at the first picking to total weight of seed cotton harvested, expressed as a percentage), per cent crop harvested at second picking (PCH-2; ratio of weight of seed cotton harvested in combined first and second pickings to total weight of seed cotton harvested, expressed as a percentage; which is being referred as Earliness Index in reports delivered by Shakeel *et al*. (2008) and Mahrous (2012), node number of first fruiting branch (NNFFB; Node number at which first sympodia arises with cotyledonary node numbered as zero), height of first fruiting branch (HFFB; height from ground to first fruiting branch), plant height (PH), Bartlett's Index (BI), earliness percentage (EP), mean maturity date (MMD), production rate index (PRI) and seed cotton yield (SCY). The formula for BI, EP, MMD and PRI are given below.

Bartlett's index: The seed cotton was harvested from each genotype five times at 12 days interval starting from 126 DAS. The Earliness index was worked out by Bartlett's formula.

Bartlett's index **=**

$$\frac{P_1+(P_1+P_2)+(P_1+P_2+P_3)+\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(+P_n)}{n(P_1+P_2+P_3+P_4+\cdots\ldots\ldots\ldots\ldots+P_n)}$$

where, P_1, P_2, P_n are the weights of seed cotton picked during the first, second and n^{th} picking; n is the total number of pickings. The higher the value of Bartlett's Index, the earlier would be the maturity.

Earliness percentage (%) = (Seed cotton yield of first picking / weight of first two pickings) *100 (Attiea, 2019)

Mean maturity data (MMD): The procedure to calculate MMD was given by Christidis and Harrison (1955) which is generalized as follows:

$$MMD = \frac{(W_1H_1) + (W_2H_2) + \ldots + (W_nH_n)}{W_1 + W_2 + \ldots + W_n}$$

where W = weight of seed cotton; H = number of days from planting to harvest; and 1, 2, ..., n = consecutive periodic harvest number.

Production rate index (PRI): The total seed cotton plot weight obtained was divided by the MMD (Bliboro and Quisenberry, 1973)

The average of recorded data was subjected to analysis for significance using ANOVA and genetic variability parameters were assessed using a variability package embedded in RStudio. For a better understanding of the link between the examined traits, Pearson's correlation was used across mean performances, while path analysis was implemented to study the direct and indirect effects of the considered characters. Figures representing correlation and variability parameters were shaped from RStudio and MS Excel respectively.

RESULTS AND DISCUSSION

Analysis of variance: The analysis of variance for all the measured traits are furnished in **Table 1**. The studied early maturity traits like DFF, DFB, PCH-1, PCH-2, BI, NNFFB, PH, EP, MMD and PRI including seed cotton yield, exposed significant variations excluding FBP, NPP, EP and HFFB. The range, mean, minimum and maximum for all the traits are represented in **Table 2**. Genotype ESS-3 showed a minimum number of days to first flower (66.83) followed by ESS-20 (67.17) and NNDC-30 (67.33). Being earlier to flower, ESS-3 also displayed the highest percentage of crop harvest at first (16.91%) and second pick (61.99%), the highest value for earliness percentage (26.83%), Bartlett's Index (0.75) and production rate index (11.71) with minimum number of days for first boll opening (120.33) and mean maturity date (143.25). The similar pattern of behaviour for percentage harvest at first and second pick, earliness percentage, Bartlett's index and production rate index was also demonstrated by genotypes such as ESS-20, NNDC-30 and S-32 (**Table 2**). The genotypes ESS-13, FLT-25 and URT-21 uncovered maximum number of days to first flower (78.33, 76.17, 77.50 respectively) and boll opening (128.00, 127.00, 127.00 respectively) resulting in less percentage of crop harvest at first (<4%) and second pick (<35%), lowest earliness percentage and production rate index. Thus, these three genotypes required more mean maturity days to attain maturity and showed very low Bartlett's Index values. This pattern of behaviour of these late-maturing genotypes is precisely contradictory to that of early maturing genotypes like ESS-20, ESS-3, NNDC-30 and S-32. Further, the genotypes ESS-3 and ESS-20 apart from being very early to mature also displayed good yield *i.e.,* 2221.63 and 2185.32 kg/ha, respectively. Similar kind of results were also noticed by Bliboro and Quisenberry (1973). Thus, genotypes classified into late and early maturing categories based on these statistics can further be involved in the crossing programme to identify gene action responsible for the earliness traits.

The genetic parameters like genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability in the broad sense (h^2_{bs}), genetic advance (GA) and expected genetic advance as the percentage of means (GAM) were determined. The PCV estimates ranged from 1.87 to 50.92 while GCV estimates ranged from 1.31 to 49.45 and also displayed a nearby kinship with each other for all traits under study (**Fig.1.**). The least GCV and PCV were observed for days to the first boll opening and mean maturity date, respectively. For all of the attributes under study, it turned out that phenotypic and genotypic variances were remarkably similar, indicating little environmental influence on the expression of each characteristic. The percentage of harvest at initial picking and earliness are two factors that revealed higher GCV and PCV predictions, implying that there is significant genetic variability for both of these characteristics. It will

Table 1. Analysis of variance for various early maturity indicating traits in cotton genotypes

Character	Source of variation			Mean	SE ± mean	CD @ 5%	CV %
	Replication (df=1)	Treatment (df=19)	Residuals (df=19)				
DFF	9.34	21.53**	6.25	72.48	1.77	5.23	3.45
DFB	0.04	8.90*	3.60	124.05	1.34	3.97	1.53
FBP	8.10*	4.24*	1.84	51.57	0.96	2.84	2.63
PCH-1 (%)	1.66	29.75**	0.87	7.68	0.66	1.95	12.15
PCH-2 (%)	101.72	179.75**	41.87	47.03	4.58	13.54	13.76
BI	0.001	0.004*	0.001	0.67	0.03	0.08	5.57
PH (cm)	7.23	84.76*	32.68	81.60	4.04	11.97	7.01
HFFB (cm)	1.30	5.54	4.86	21.37	1.56	4.62	10.32
NFFB	0.84	1.03**	0.42	4.88	0.46	1.36	13.36
NPP	1.44	1.54	1.31	15.99	0.81	2.40	7.17
EP (%)	103.96*	53.29**	14.35	15.32	2.68	7.93	24.73
MMD	1.09	11.98**	3.27	147.85	1.28	3.79	1.29
PRI (g/day)	0.70	0.70**	0.70	9.40	0.54	1.61	2.11
SCY (kg/ha)	22120	112786**	23970	1835.51	109.47	324.04	8.43

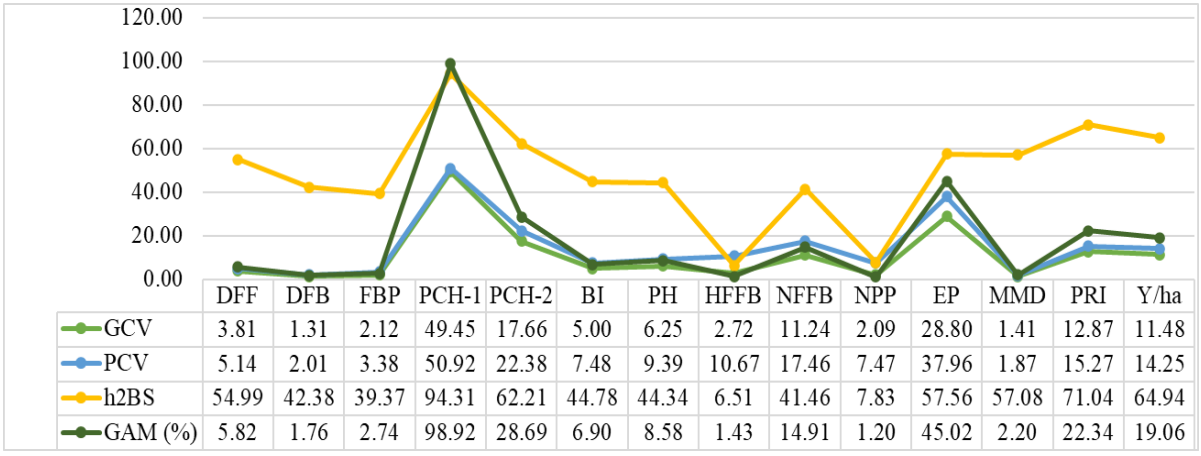
**, * - significance at 1 % and 5 % probability respectively

DFF: Days to first flower, DFB: Days to First Boll opening, FBP: Flowering to Boll opening period, PCH-1: Percent crop harvest at first pick, PCH-2: Percent crop harvested at second pick, BI: Bartlett's Index, SCY: seed cotton yield per hectare, PH- Plant height, HFFB-Height of First Fruiting branch, NNFFB: Node number of first fruiting branch, NPP: Number of Nodes per plant, MMD: Mean maturity date, EP: Earliness percentage, PRI: Production rate Index

Table 2. Mean performance of 20 genotypes for various early maturity deciding variables in cotton

Genotype	DFF	DFB	FBP	PCH-1	PCH-2	BI	PH	HFFB	NFFB	NPP	EP	MMD	PRI	SCY
ESS-20	67.17	121.50	54.33	12.76	58.70	0.72	88.40	24.60	5.50	17.60	21.89	144.91	11.40	2185.32
NNDC-30	67.33	120.67	53.33	14.58	63.30	0.73	73.00	18.50	3.50	14.60	23.16	143.92	10.04	1911.44
ESS-11	75.67	127.17	51.50	2.85	36.33	0.62	70.00	18.70	4.40	14.50	7.73	150.78	9.38	1870.37
NNDC-47	69.50	122.17	52.67	7.98	47.55	0.62	84.10	20.30	4.50	17.10	16.75	147.43	11.55	2252.72
ESS-3	66.83	120.33	53.50	16.91	61.99	0.75	76.90	20.50	4.30	14.40	26.83	143.25	11.71	2221.63
ESS-13	78.33	128.00	49.67	3.84	31.94	0.62	73.90	22.90	5.60	16.00	11.80	150.87	7.48	1491.40
ESS-19	72.17	123.00	50.83	9.34	50.10	0.69	79.00	20.00	4.50	16.20	18.72	146.72	9.47	1838.89
FLT-25	76.17	127.00	50.83	2.41	34.19	0.60	82.80	20.60	5.70	16.30	7.35	151.73	7.87	1579.50
ESS-22	74.33	124.00	49.67	8.89	55.00	0.70	89.90	24.40	4.80	16.10	16.12	146.01	8.84	1706.61
ESS-18	70.17	123.17	53.00	8.85	52.65	0.69	77.00	21.70	4.60	15.60	16.50	146.73	10.59	2054.03
URT-21	77.50	127.00	49.50	3.04	33.32	0.62	80.00	21.70	5.20	15.90	7.77	150.92	8.17	1632.34
ESS-17	74.00	123.50	49.50	6.72	43.31	0.65	80.00	21.40	5.10	16.10	15.67	148.99	8.83	1741.07
S-32	70.00	123.00	53.00	9.56	52.81	0.70	84.50	20.40	4.20	15.50	18.06	146.28	10.83	2095.44
A-2	74.33	124.67	50.33	8.19	51.73	0.68	86.20	19.90	5.30	16.20	15.34	146.98	9.13	1775.26
ARBC-1651	73.17	124.00	50.83	5.94	47.94	0.67	94.60	20.50	4.40	16.20	11.40	147.82	9.81	1918.72
DSC-1651	71.00	123.33	52.33	7.54	53.39	0.70	86.90	23.50	4.90	16.40	14.20	146.22	9.07	1753.31
ARBH-813	73.33	124.83	51.50	4.34	38.69	0.64	80.00	22.20	5.80	16.00	11.12	149.71	8.11	1605.95
SAHANA	72.17	123.83	51.67	8.56	46.56	0.67	87.60	21.70	5.10	16.90	18.41	147.68	9.90	1934.19
RAH-100	72.83	125.17	52.33	4.39	37.50	0.63	84.70	22.60	6.40	17.20	11.91	150.42	8.55	1699.74
SURAJ	73.67	124.67	51.00	7.01	43.57	0.64	72.40	21.30	4.20	15.00	15.63	149.59	7.29	1442.20
MEAN	72.48	124.05	51.57	7.68	47.03	0.67	81.60	21.37	4.88	15.99	15.32	147.85	9.40	1835.51
MINIMUM	66.83	120.33	49.50	2.41	31.94	0.60	70.00	18.50	3.50	14.40	7.35	143.25	7.29	1442.20
MAXIMUM	78.33	128.00	54.33	16.91	63.30	0.75	94.60	24.60	6.40	17.60	26.83	151.73	11.71	2252.72

DFF: Days to first flower, DFB:Days to First Boll opening, FBP: Flowering to Boll opening period, PCH-1: Percent crop harvest at first pick, PCH-2: Percent crop harvested at second pick, BI: Bartlett's Index, SCY: seed cotton yield per hectare, PH- Plant height, HFFB-Height of First Fruiting branch, NNFFB: Node number of first fruiting branch, NPP: Number of Nodes per plant, MMD: Mean maturity date, EP: Earliness percentage, PRI: Production rate Index.



	DFF	DFB	FBP	PCH-1	PCH-2	BI	PH	HFFB	NFFB	NPP	EP	MMD	PRI	Y/ha
GCV	3.81	1.31	2.12	49.45	17.66	5.00	6.25	2.72	11.24	2.09	28.80	1.41	12.87	11.48
PCV	5.14	2.01	3.38	50.92	22.38	7.48	9.39	10.67	17.46	7.47	37.96	1.87	15.27	14.25
h2BS	54.99	42.38	39.37	94.31	62.21	44.78	44.34	6.51	41.46	7.83	57.56	57.08	71.04	64.94
GAM (%)	5.82	1.76	2.74	98.92	28.69	6.90	8.58	1.43	14.91	1.20	45.02	2.20	22.34	19.06

Fig 1. Genetic variability parameters of various early maturity indicators examined in upland cotton cultivars

be valuable to employ direct selection based on these characteristics to uncover promising genotypes to utilise them in succeeding breeding efforts. The aforementioned results coincided with the report of Godoy and Polomo (1999a). The GCV and PCV estimates for SCY, Node number of fruiting branch, production rate index, and PCH-2 were moderate. Similar results have been reported by Jogender *et al*. (2023), Zafar *et al*. (2022), and Farooq *et al*. (2015). Lower GCV and PCV was observed for the attributes *viz.,* DFF, DFB, BI, PH and MMD. These results are parallel with the reports of Zafar *et al*. (2022), Bhatti *et al*. (2020) and Jogender *et al*. (2023).

The results of heritability analysis indicated values ranging from 6.51 to 94.31, with the highest heritability observed in PCH-1 (94.31) and the lowest in the height of the first fruiting branch (6.51). The selection of traits becomes practically valuable if the heritability and genetic advance are high. In the present study, the genetic advance expressed as a percentage of the mean, varied from 1.20 to 98.92% across 14 traits. PCH-1 exhibited the highest genetic advance as a percentage over the mean (98.92%), followed by earliness percentage (45.02%). The traits PCH-1, PCH-2 and PRI demonstrated both high heritability and significant genetic advance, making them reliable indicators during the selection process. On the other hand, seed cotton yield displayed high heritability with moderate genetic advance. These findings align with the results of Jatoi *et al*. (2022). Bartlett's index indicated moderate heritability accompanied by low genetic advance, which concurs with the research conducted by Sowmya and Patil (2021).

Correlation analysis: The Pearson correlation coefficients between seed cotton yield per plot and earliness parameters, and the relationships between characters with each other are presented in **Fig 2**. The results indicated that seed cotton yield showed highly significant and negative correlation with days to first flower (r= -0.70), days to first boll opening (r=-0.62) and mean maturity date (r=-0.52) and significant positive correlation with production rate index (r=0.99), percent crop harvest at first pick (r= 0.61), percent crop harvest at second pick (r=0.48), flowering to boll opening period (R=0.61) and Bartlett's index (r=0.36). Therefore, variability for the traits with significant correlation in evaluated genotypes is valuable information to carry out selection under different breeding programs. This finding is in line with Godoy and Palomo (1999a), Godoy and Palomo (1999b) and Mahdi and Emam, (2020). The three traits *viz.,* MMD, DFF and DFB showed significant negative correlation with early maturity indicators like PCH-1 (r=-0.85, -0.72, -0.73), PCH-2 (r=-0.97, -0.68, -0.76), BI (r=-0.92, -0.54, -0.65), EP (r=-0.81, -0.77, -0.77) and PRI (r=-0.60, -0.74, -0.67) respectively, in addition to positive correlation with the node number of first fruiting branch (r=0.41, 0.43, 0.47).

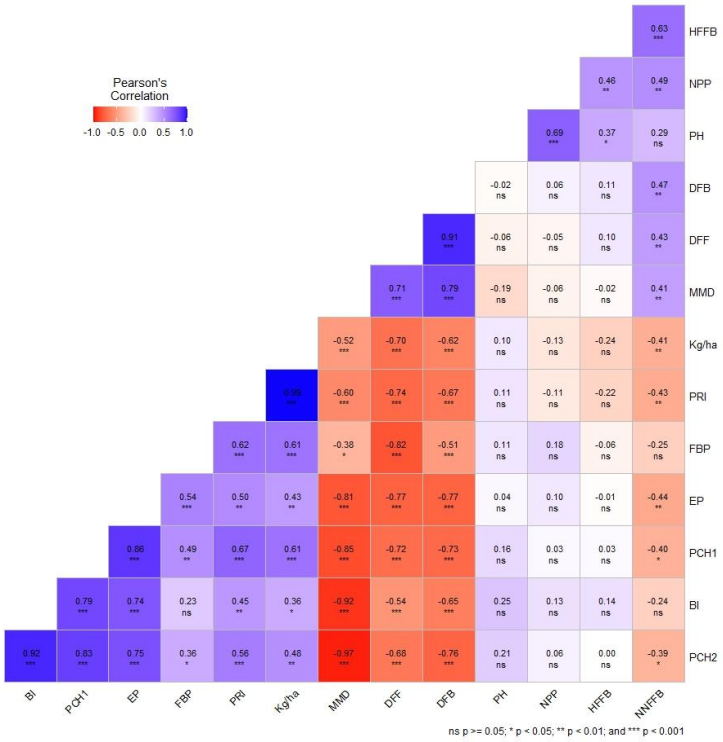


Fig. 2. Pearson correlation coefficients among various early maturity indicators and seed cotton yield

Also, they showed highly significant positive correlation among themselves. Godoy and Palomo (1999b), Imran *et al*. (2011), Song *et al*. (2012), Valu *et al*. (2021) also reported similar results. So, these three traits can serve as key indicators for selecting genotypes with early maturity. Bartlett's index, the commonly used gauge for measuring earliness showed a positive significant relationship with percent crop harvest at both first (r=0.79) and second pickings (r=0.92) and earliness percentage (r=0.74). Further, node number of first fruiting branch showed negative association with PCH-1(r=-0.40), PCH-2 (r=-0.39) and earliness percentage (r=-0.44) in addition to positive relation with height of first fruiting branch (r=0.63). The results obtained in this study are in line with Godoy and Palomo (1999b), Shah *et al*. (2010) and Farooq *et al*. (2018). Nodes per plant showed non-significant association with many of the early maturity traits except that it was significantly positive with node number, height of first fruiting branch and plant height. These results were comparable to reports of Damayanthi *et al*. (2010), Shao *et al*. (2016) and Bhatti *et al*. (2020).

Path Analysis: The 13 early maturity-related traits were regressed with seed cotton yield to explore their inter-relationship (**Table 3**). The traits like production rate index (1.076), days to first boll opening (0.695), mean maturity date (0.146), Bartlett's Index (0.045) and plant height (0.0030) showed direct positive effect. Highest negative direct effect was shown by days to first flowering (-1.052) followed by flowering to boll opening period (-0.491), percent harvest at second pick (-0.022), percent harvest at first pick (-0.021) and earliness percentage (-0.013). The results obtained for DFB and PRI are completely in accordance with results published by Mahdi and Emam, (2020). Since the traits of days to first boll opening, production rate index and Bartlett's Index had high positive effect, direct selection through these characters will be useful to increase cotton yield. Further, the results obtained for plant height, days to first flower, nodes per plant and days to first boll opening are in line with Selvaraj *et al*. (2023), Farooq *et al*. (2018), Zhang and Yang, (2015) and Nawaz *et al*. (2019) respectively. In our study, the low residual effect of 0.0011 proved that the traits included in this study were adequate. An indirect effect of days to first flower opening through other remaining traits has also been found highly significant, indicating the importance of these traits. This needs to be carefully considered when simultaneously selecting for earliness and yield improvement in cotton.

The findings derived from this study have the potential to be decidedly beneficial for cotton farmers and researchers. They can use these outcomes effectively to boost crop yield and expand the deeper understanding of the intricate acquaintances between key variables accountable for early maturity in cotton that affect production. The variances of all sources of variation revealed that the majority of evaluated features differed significantly. The characters like PCH-1, PCH-2, earliness

Table 3. Phenotypic path analysis showing the direct (diagonal) and indirect effect of the 13 explanatory early maturity variables on seed cotton yield in cotton

Trait	DFF	DFB	FBP	PCH-1	PCH-2	PH	HFFB	NFFB	NPP	EP	MMD	PRI	BI	SCY
DFF	**-1.052**	0.637	0.404	0.015	0.016	-0.0002	0.0001	-0.006	0.0000	0.010	0.106	-0.823	-0.032	-0.725**
DFB	-0.965	**0.695**	0.259	0.015	0.017	-0.0001	0.0001	-0.007	0.0001	0.010	0.116	-0.728	-0.036	-0.625**
FBP	0.864	-0.367	**-0.491**	-0.010	-0.009	0.0003	-0.0001	0.003	0.0002	-0.007	-0.060	0.715	0.015	0.655**
PCH-1	0.759	-0.510	-0.241	**-0.021**	-0.019	0.0005	0.0000	0.006	0.0000	-0.012	-0.125	0.734	0.045	0.617**
PCH-2	0.749	-0.536	-0.205	-0.018	**-0.022**	0.0007	0.0000	0.006	0.0001	-0.011	-0.142	0.600	0.051	0.474**
PH	0.061	-0.014	-0.046	-0.003	-0.005	**0.0030**	0.0004	-0.005	0.0010	0.000	-0.029	0.128	0.014	0.105
HFFB	-0.096	0.074	0.021	-0.001	0.000	0.0011	**0.0012**	-0.009	0.0007	0.000	-0.003	-0.246	0.007	-0.251
NFFB	-0.436	0.327	0.104	0.008	0.009	0.0009	0.0007	**-0.015**	0.0008	0.005	0.062	-0.489	-0.016	-0.437**
NPP	0.028	0.043	-0.072	0.000	-0.002	0.0021	0.0006	-0.008	**0.0014**	-0.001	-0.011	-0.104	0.009	-0.113
EP	0.807	-0.550	-0.248	-0.018	-0.019	0.0001	0.0000	0.006	0.0001	**-0.013**	-0.127	0.590	0.045	0.473**
MMD	-0.760	0.549	0.202	0.018	0.022	-0.0006	0.0000	-0.006	-0.0001	0.011	**0.146**	-0.642	-0.052	-0.513**
PRI	0.805	-0.470	-0.327	-0.014	-0.012	0.0004	-0.0003	0.007	-0.0001	-0.007	-0.087	**1.076**	0.025	0.995**
BI	0.593	-0.450	-0.135	-0.017	-0.020	0.0008	0.0001	0.004	0.0002	-0.010	-0.136	0.480	**0.045**	0.354**

Residual: 0.0011

DFF: Days to first flower, DFB:Days to First Boll opening, FBP: Flowering to Boll opening period, PCH-1: Percent crop harvest at first pick, PCH-2: Percent crop harvested at second pick, BI: Bartlett's Index, SCY: seed cotton yield per hectare, PH- Plant height, HFFB-Height of First Fruiting branch, NNFFB: Node number of first fruiting branch, NPP: Number of Nodes per plant, MMD: Mean maturity date, EP: Earliness percentage, PRI: Production rate Index

percentage and production rate inxhibited moderate to high heritability and high GAM indicating the prevalence of additive gene effects and can be relied upon for selection. The lines ESS-3, ESS-20, NNDC-30 and S-32 were found earlier in maturity as comparable to ESS-13, FLT-25 and URT-21 based on early maturity indicators employed in this research. Diverse genotypes, belonging to early and late maturing categories, identified from the study can be crossed in a definite fashion to derive segregating populations to understand the inheritance pattern of plant type as well as earliness, in cotton. These promising genotypes can also be best utilized in future cotton breeding efforts to generate hybrids that are better yielding and earlier to mature. The results of correlation and path coefficient analysis revealed that earliness percentage and production rate index were high and had a positive relationship with seed cotton yield and most other earliness measures contributing to yield. Thus, these may be considered effective criteria for selection to increase Indian cotton yield and also develop early genotypes to fit in crop rotation.

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