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Correlation and path analysis for seed cotton yield and yield attributing traits in multiple cross derivatives of upland cotton (*Gossypium hirsutum* L.) under high density planting system

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ABSTRACT: India is one of the leading producers of cotton in the world and the productivity of cotton is stagnated in the recent past due to cultivation of robust hybrids by adopting wider spacing. One of the options to enhance cotton productivity is to develop short and compact plant types amenable for high density planting system. Keeping in view, the need of the hour, an experiment was conducted at Agricultural College, Aswaraopet during *Kharif 2016* to understand the nature and magnitude of relationship among yield and yield attributing traits in 52 multiple cross derivatives of cotton by partitioning correlation coefficients between yield and its' contributing traits into direct and indirect effects. Data was recorded on seed cotton yield and eight yield contributing characters like days to 50% flowering, plant height, number of monopodia, number of sympodia, length of the sympodial branches, number of bolls, boll weight and 100-seed weight. The results of correlation revealed that seed cotton yield exhibited high positive correlation with boll weight, number of bolls, length of the sympodial branches and moderate positive association with number of sympodia and plant height, indicating the importance of these traits in enhancing yield under high density planting system. Path coefficient analysis revealed that the highest positive direct effect on seed cotton yield was registered by boll weight and number of bolls plant^{-1}. Thus, from the studies on correlation and path analyses, it could be suggested that the characters *viz*., boll weight, number of bolls plant^{-1}, length of the sympodial branches, number of sympodia and plant height could be used as selection criteria for improving seed cotton yield under high density planting system.

Keywords: Correlation, path coefficient, multiple cross derivatives, seed cotton yield and high density planting system.

INTRODUCTION

Cotton is considered as one of the most leading plant fibre crop and is said to be the king of fibres. It is playing a significant role in Indian economy through its' commercial output, promoting industrial activity, employment generation and foreign exchange. Globally, it is cultivated in an area of 331.88 lakh ha with the production of 25.73 million tonnes and productivity of 775 kg ha^{-1}. India is holding top position both in area and production of 126.50 lakh haand5.9 million tonnes respectively with the productivity of 466 kg ha^{-1} (Anon., 2022). In the last decade, the cotton productivity has stagnated which may be due to adoption of high yielding robust Bt cotton hybrids by more than 90% of the farmers and cultivation of more than 60% of cotton under rainfed conditions (Venugopalan, 2019). The major problem associated with rainfed cotton cultivation is terminal moisture stress particularly during boll formation which results in poor boll formation / retention particularly in shallow to medium deep soils. In India, the cotton productivity is stagnated at 440 kg/ha (Annual report, AICRP cotton, 2022-23) which is very low when compared to the countries like China (1844 kg ha^{-1}), Australia (1226kg ha^{-1}), Turkey (1735kg ha^{-1}), Brazil (1772kg ha^{-1}), Mexico (1592kg ha^{-1}) and USA (987kg ha^{-1}) (Anon., 2022) that is attributed due to adoption of high density planting system by developing suitable varieties for higher plant densities (Gunasekaran *et al.*, 2014) whereas in India, the plant population is ranging from 15000 – 25000 plants/ha due to adoption of a spacing of 90-120 cm between the rows and 30-90 cm within the rows. It is learnt from the past three decades that, low plant density, mismatch between growth and fruiting pattern, rainfall pattern and soil moisture supply are the main reasons for low productivity in cotton (Venugopalan, 2019).

Under the present scenario, one of the options for enhancing the productivity of cotton is to adopt high density planting system with a spacing of 45-90 cm x 10 cm to maintain a plant population of 1.1 lakh – 2.45 lakh plants/ha, which demands for development of dwarf, semi-compact to compact plant types with boll number 6-8 bolls/plant, early maturity, short sympodial branches, zero monopodia, more number of sympodial branches, boll weight of 3-4 g (Pradeep and Murthy, 2019; Venugopalan, 2019). Some of the varieites *viz*., CSH 3075, PKV 081, Suraj, NH 615, NH 630, ADB 39, LRK 516, F2383, NDLH 1938 and KC 3 in *G. hirsutum* and Phule Dhanwantary and AKA 7 in *G. arboretum* that have morphological traits to fit into high density planting system (HDPS) besides possessing earliness and yield advantage of 30% were developed in India (Venugopalan, 2019). In addition to focus on breeding for compact plant types, there is a need to enhance yield / plant in developing varieties suitable for HDPS. Yield is a complex trait governed by many genes and is the product of epistatic interactions between its' contributory traits. As such, it is essential for plant breeders to understand the extent of relationship between yield and its' contributing traits which will enable him for selection of plants with desirable characteristics (Tulasi *et al.*, 2012). Correlation analysis measures the extent of relationship between various characters and determine the component traits on which selection can be based. Further, path coefficient analysis gives a picture of direct and indirect effects of various traits on yield in order to identify the most influencing character to be used as selection criteria in cotton breeding for development of varieties suitable for HDPS with higher yield. Hence, the present investigation was carried out to elucidate the relationship between seed cotton yield and its' contributing traits.

MATERIALS AND METHODS

The material for present study consisted of 52 multiple cross derivatives by involving eight strains of cotton *viz.*, Renuka, Narasimha, LRA 5166, L 604, MCU 5, DHY 286, ADB 39 and NDL 1588 through multiple crossing. All the eight strains were used in single; double and three way crossing and hybrids were developed. The F_1s so obtained were again crossed either with single, double or three way F_1s to obtain the multiple cross hybrids involving four, six and seven different parents viz., Renuka, Narasimha, SRT – 1, ADB 11, ADB 320, LRA 5166, L 604, MCU 5, DHY 286, ADB 39, AC 738 and NDL 1588. All the 52 multiple cross derivatives were evaluated at Agricultural College, Aswaraopet, PJTSAU during *kharif* 2016 by adopting a spacing of 60 cm between the rows and 60 cm within the rows in a randomized block design replicated thrice that is by adopting narrow spacing. All the recommended package of practices were adopted to raise the healthy crop. Five plants from each line were randomly selected and the data were recorded on nine parameters *viz*., days to 50% flowering, plant height (cm), number of monopodia plant^{-1}, number of sympodiaplant^{-1}, length of the sympodia (cm), number of bolls plant^{-1}, boll weight (g), 100-seed weight (g) and seed cotton yield plant^{-1}(g). The data was analysed by using INDOSTAT software. Correlation coefficients among various characters were worked out as per the procedure given by Singh and Narayanan (1993) whereas phenotypic and genotypic correlation coefficients were further partitioned into direct and indirect effects by path analysis as advocated by Dewey and Lu (1959).

RESULTS AND DISCUSSION

Correlation studies indicate the nature, scope and direction of relationship between yield and yield attributing traits. Selection based only on correlation without taking into consideration how the individual characters interact can occasionally be deceptive. Selection for yield will be successful when it is based on the traits that contribute to it rather than yield itself (Grafius, 1960). Several studies were carried out to estimate the significance of character relationship between seed cotton yield per plant, its' contributing traits. Studies on association between yield and its' component traits would help the breeders to improve complex traits like yield and selection solely based on yield is ineffective and hence, knowledge on magnitude and direction of association between yield and its' contributing characters is very important in identifying key parameters for enhancing yield through suitable breeding programme particularly in breeding varieties for higher plant densities.

The genotypic and phenotypic correlation coefficients between yield and its' associated traits is presented in Table 1 and it was found that the phenotypic correlation coefficients were higher in magnitude than genotypic correlation coefficients except for number of sympodia and boll weight suggesting that both environmental and genotypic correlations are acting in same direction. The results of the present study revealed that, the characters boll weight (0.8079 / 0.5859), number of bolls plant^{-1} (0.4914 / 0.7467), length of sympodia (0.5747 / 0.5182) plant height (0.3009 / 0.4469) and number of sympodia (0.1243 / 0.4249), had shown non-significant positive association with seed cotton yield while the traits like days to 50% flowering (-0.0838 / 0.0564) and number of monopodia (-0.2379 / 0.0964) exhibited non-significant negative and low positive relation at genotypic and phenotypic level respectively, similar observations were also reported by Kumar *et al.* (2019) for days to 50% flowering. The positive significant association of plant height, number of sympodial branches plant^{-1}, number of bolls plant^{-1} was also reported earlier by Rehman *et al.* (2020); Shruti *et al.* (2020); Kumar *et al.* (2019); Memon *et al.* (2017); Abdullah *et al.* (2016); Angadi *et al.* (2016); Ahsan *et al.* (2015); Padmavathi *et al.* (2015); Reddy *et al.* (2015); Erande *et al.* (2014); Farooq *et al.* (2014); Pradeep *et al.* (2014); Patel *et al.* (2013); Vinodhana *et al.* (2013); Tulasi *et al.* (2012); Ashok Kumar and Ravikesavan (2010); Mahantesh *et al.* (2010); Shazia *et al.* (2010); Thiyagu *et al.* (2010); Eswara Rao *et al.* (2009); Rasheed *et al*. (2009); Sharma *et al.* (2005); Naveed *et al.* (2004) and Muthuswamy *et al.* (2004), while significant positive association of number of sympodial branches plant^{-1}, number of bolls plant^{-1} and boll weight was reported by Sainath *et al.* (2022); Amanu *et al.* (2020); Hampannavar *et al.* (2020); Pooja *et al.* (2020); Kumar *et al.* (2019); Ashok Kumar and Ravikesavan (2010); Iqbal *et al.* (2003) and Rehman *et al.* (2020).

Reddy *et al.* (2019) suggested the presence of positive correlation of seed cotton yield with number of bolls plant^{-1} and boll weight and negative association with plant height, Mankar *et al.* (2021) reported positive non-significant correlation of number of sympodia plant^{-1}andnumber of bollsplant^{-1}with seed cotton yield and significant positive association of boll weight and plant height by Chapepa *et al.* (2020). Khalid *et al.* (2018) and Shazia *et al.* (2010) reported positive significant correlation between seed cotton yield with plant height, number of bolls plant^{-1} and boll weight, while Rauf *et al.* (2004) observed the same for number of sympodia plant^{-1} and number of bolls plant^{-1}. Among all the eight characters 100-seed weight had shown negative correlation with seed cotton yield (-0.1965 / -0.2977) at phenotypic and genotypic level through the negative association with other traits, the results are in accordance with the findings of Chapepa *et al.* (2020) who reported significant negative association of seed weight with seed cotton yield at phenotypic level.

The relationship between different traits often showed by the estimates of correlation coefficients, but does not provide information on cause and effect. In order to elucidate the information on cause and effect, breeders can use path analysis in determining the index of selection. The path coefficient analysis separates direct and indirect effects through other features by partitioning the correlations whereas the correlation coefficients simply depict the relationship between two variables (Wright, 1921). The direct and indirect effects of different characters on yield were presented in Table 2 and Fig. 1.

Table 1: Phenotypic (P) and Genotypic (G) correlation coefficient of nine characters in 52 multiple cross derivatives of cotton (*Gossypium hirsutum* L.).

		DFF	PH	NM	NS	LS	NBP	BW	100 - SW	SCY
DFF	**G**	**1.0000**	-0.0406	-0.0806	-0.5312	-0.1086	-0.3942	0.0929	0.1111	-0.0838
	P	**1.0000**	0.1009	-0.1032	-0.0569	0.0687	-0.0204	0.0880	0.0425	0.0564
PH	**G**		**1.0000**	-0.563	0.5994	0.7096	0.3124	0.1024	-0.3293	0.3009
	P		**1.000**	0.1359	0.6333***	0.6533***	0.4821***	0.1035	-0.2449**	0.4469
NM	**G**			**1.000**	0.4331	-0.3144	0.1142	-0.4177	-0.0949	-0.2379
	P			**1.000**	0.2317**	-0.0579	0.2634***	-0.1897*	-0.0483	0.0964
NS	**G**				**1.000**	0.2664	0.3276	-0.0595	-0.3330	0.1243
	P				**1.000**	0.4111***	0.5780***	-0.0134	-0.1768*	0.4249
LS	**G**					**1.0000**	0.4390	0.3291	-0.2562	0.5747
	P					**1.0000**	0.4922***	0.1982*	-0.2069**	0.5182
NBP	**G**						**1.0000**	-0.1141	-0.4963	0.4914
	P						**1.0000**	-0.0500	-0.2405**	0.7467
BW	**G**							**1.0000**	-0.0905	0.8079
	P							**1.0000**	-0.0690	0.5859
100-SW	**G**								**1.0000**	-0.2977
	P								**1.0000**	-0.1965

* Significant at (p=0.05) level; ** Significant at (p=0.01) level

P -represents phenotypic correlation coefficient; G- represents genotypic correlation coefficient. DFF-Days to 50% flowering, PH-Plant height (cm), NM - Number of monopodia plant^{-1}NS – Number of sympodia plant^{-1}, LS – Length of sympodia, NBP – Number of bolls plant^{-1}, BW – Boll weight (g), 100-SW – 100 Seed weight (g), SCY – Seed cotton yield plant^{-1} (g)

Table 2: Direct and indirect effects of yield components on seed cotton yield in 52 multiple cross derivatives of cotton (*Gossypium hirsutum* L.).

		DFF	PH	NM	NS	LS	NBP	BW	100 - SW	SCY
DFF	**G**	**0.0380**	-0.0015	-0.0031	-0.0202	-0.0041	-0.0150	0.0035	0.0042	-0.0838
	P	**0.0120**	0.0012	-0.0012	-0.0007	0.0008	-0.0002	0.0011	0.0005	0.0564
PH	**G**	-0.0038	**0.0937**	-0.0053	0.0562	0.0665	0.0293	0.0096	-0.0308	0.3009
	P	0.0023	**0.0229**	0.0031	0.0145	0.0150	0.0111	0.0024	-0.0056	0.4469
NM	**G**	-0.0117	-0.0082	**0.1457**	0.0631	-0.0458	0.0166	-0.0609	-0.0138	-0.2379
	P	-0.0018	0.0024	**0.0178**	0.0041	-0.0010	0.0047	-0.0034	-0.0009	0.0964
NS	**G**	0.0521	-0.0588	-0.0425	**-0.0981**	-0.0261	-0.0321	0.0058	0.0327	0.1243
	P	0.0022	-0.0248	-0.0091	**-0.0392**	-0.0161	-0.0226	0.0005	0.0069	0.4249
LS	**G**	-0.0029	0.0190	-0.0084	0.0071	**0.0268**	0.0118	0.0088	-0.0069	0.5747
	P	0.0012	0.0110	-0.0010	0.0069	**0.0169**	0.0083	0.0033	-0.0035	0.5182
NBP	**G**	-0.2550	0.2021	0.0739	0.2119	0.2840	**0.6469**	-0.0738	-0.3211	0.4914
	P	-0.0160	0.3789	0.2070	0.4543	0.3868	**0.7859**	-0.0393	-0.1890	0.7467
BW	**G**	0.0860	0.0948	-0.3867	-0.0551	0.3047	-0.1056	**0.9258**	-0.0838	0.8079
	P	0.0549	0.0646	-0.1184	-0.0083	0.1237	-0.0312	**0.6240**	-0.0431	0.5859
100-SW	**G**	0.0135	-0.0401	-0.0116	-0.0406	-0.0312	-0.0605	-0.0110	**0.1218**	-0.2977
	P	0.0016	-0.0093	-0.0018	-0.0067	-0.0079	-0.0092	-0.0026	**0.0381**	-01965

* Significant at (p=0.05) level; ** Significant at (p=0.01) level; bold values are direct effects; Phenotypic Residual effect= 0.2242

P -represents phenotypic correlation, coefficient; G- represents genotypic correlation coefficient. DFF-Days to 50% flowering, PH-Plant height (cm), NM - Number of monopodia plant^{-1}NS – Number of sympodia plant^{-1}, LS – Length of sympodia, NBP – Number of bolls plant^{-1}, BW – Boll weight (g), 100-SW – 100 Seed weight (g), SCY – Seed cotton yield plant^{-1} (g).

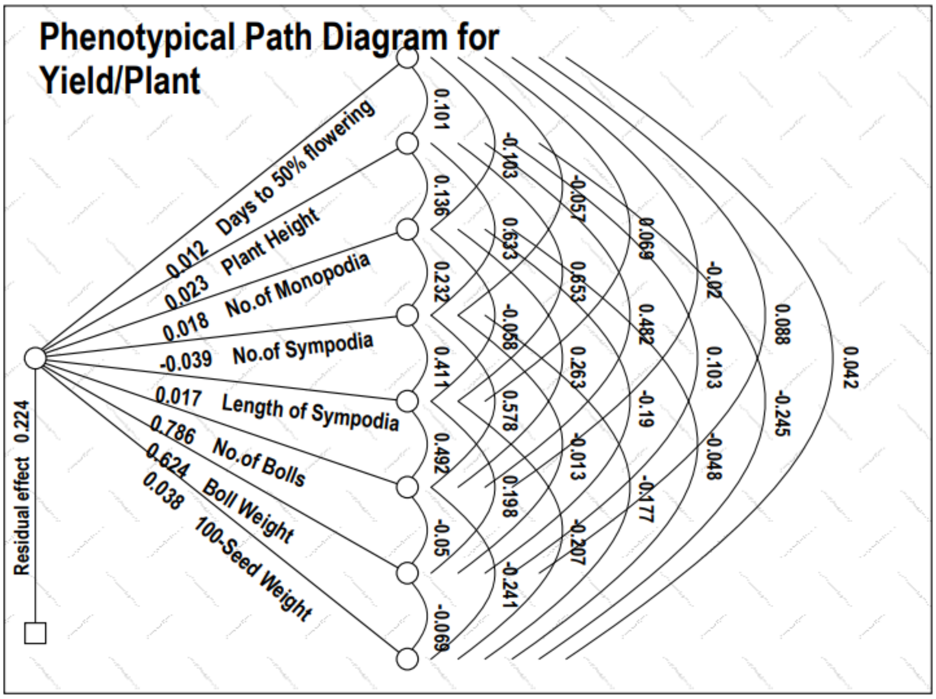

Fig. 1. Phenotypic path diagram for seed cotton yield plant^{-1}.

The perusal of results of path analysis indicated that, boll weight (0.624; 0.926) and number of bolls plant^{-1} (0.7859; 0.6469) were found to registered highest direct effect on seed cotton yield plant^{-1} at both phenotypic and genotypic level and these results are in conformity with the findings of Sainath *et al.* (2022); Mankar *et al.* (2021); Manomani *et al.* (2019); Kumar *et al.* (2019); Monicashree and Balu (2018); Tulasi *et al*. (2012); Ashok Kumar and Ravikesavan (2010) and Iqbal *et al.* (2003). The characters days to 50% flowering, plant height, number of monopodia, length of sympodia and 100-seed weight had shown low direct positive effect on seed cotton yield plant^{-1}, similar results were also reported earlier by Mankar *et al.* (2021); Manonmani *et al.* (2019) for days to 50% flowering, Tulasi *et al.* (2012) and Rauf *et al.* (2004) for plant height, Sainath *et al.* (2022) for plant height and number of monopodia plant^{-1} while number of sympodia exhibited lowest negative direct effect which is in tune with the results of Rauf *et al.* (2004) and was found inconsistent with the findings of Mankar *et al.* (2021); Srinivasulu (2009); Padmavathi (2018); Leelapratap *et al.* (2007) and Neelima *et al.* (2005). Path coefficient analysis suggested that the traits *viz*., number of bolls plant^{-1} and boll weight shall be used as selection criteria for improvement of yield while days to 50% flowering, plant height, number of monopodia, length of sympodia and 100-seed weight that had shown low direct positive effect on seed cotton yield plant^{-1} and hence, restricted selection model of direct selection for such characters may exploited for enhancement of seed cotton yield.

CONCLUSION

The results of the present study concluded that the traits *viz*., boll weight, number of bolls plant^{-1}, length of the sympodia, plant height and number of sympodia plant-^{1} were found to be key parameters indicating that the increase in seed cotton yield is due to increase in one or more of the above traits and therefore selection on these traits would be useful to enhance yield whereas boll weight, number of bolls plant-^{1} were found to exhibit direct effect with seed cotton yield plant-^{1} and need to be considered as significant criteria for improvement of seed cotton yield under narrow spacing.

FUTURE SCOPE

Keeping in view of the importance of magnitude of relationship and direct and indirect impact of yield related traits on yield, correlation and path coefficient analyses serves an important tool for identification of key selection parameters for improving the yield and hence, it is very much essential to understand the relationship between yield and yield contributing traits in developing varieties suitable for narrow and ultra narrow space planning systems. Further, it is suggested that, multiple crossing could be attempted among available compact plant types to create sufficient variability and the resulting multiple cross derivatives may be evaluated extensively to develop varieties / hybrids suitable for HDPS.

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