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Correlating fruit yield with important attributing traits in *Abelmoschus esculentus* (L.) moench.

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ABSTRACT

In the present study it was observed that total yield had significant positive phenotypic correlation with plant height, number of branches per plant, fruit length, number of fruits per plant and fruit weight whereas, fruit diameter exhibited negative correlation. It was further observed that the total yield expressed significant positive genotypic correlation with number of branches per plant, fruit length, plant height, fruit weight and number of fruits per plant. However, fruit diameter showed significant negative correlation with yield. The path analysis revealed that fruit weight had the maximum direct effect on yield while its indirect effects were positive via plant height, number of fruits per plant, number of branches per plant and fruit diameter. Finally it was observed that the characters like fruit weight, number of branches per plant, plant height and number of fruits per plant, had highly significant positive correlation with yield, further it was observed that it had high direct effect on yield. These are important characters for effective genetic improvement programme of this crop.

Key Words: *Abelmoschus esculentus, Bhindi, Correlation coefficient, Path coefficient analysis*

INTRODUCTION

Bhindi or okra *Abelmoschus esculentus* (L) Moencoh (family Malvaceae) is popular vegetable crop cultivated across the world in countries like India, Africa and Turkey. It is usually consumed as vegetables, salads and soups, and known to be good source of vitamins and minerals including vitamin A, B and C, calcium, iron and excellent source of iodine besides its mucilage having medicinal value as detoxifying agent (Cook *et al* 2000, Chadha 2001, Gemede *et al* 2015). For improving Bhindi through conventional breeding and selection, adequate knowledge of association that exists between yield and yield related characters is essential for the identification of selection procedure. In general, plant breeders commonly select for yield components which indirectly increase yield since direct selection for yield per se may not be the most efficient method for its improvement. Indirect selection for other yield - related characters, which are closely associated with yield, will be more effective. The appropriate knowledge of such interrelationships between pod yield and its contributing components can significantly improve the efficiency of a breeding program through the use of appropriate selection indices. Thus, correlation and path coefficient analyses are prerequisites for improvement of any crop including Bhindi for selection of superior genotypes and improvement of any character. In plant breeding, correlation analysis provides information about yield components and thus helps in selection of superior genotypes from diverse genetic populations. The correlation studies simply measure the associations between yield and other traits. Usefulness of the information obtained from the correlation coefficients can be enhanced by

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partitioning into direct and indirect effects for a set of a pair-wise cause-effect inter relationships (Kang *et al* 1983). There are several reports of correlation and path coefficient analyses based studies in Bhindi to measure the associations between yield and other traits and to clarify interrelation between pod yield and other traits, respectively. Somashekhar *et al* (2011) reported that the high significant associations of pod yield were observed with plant height, number of branches per plant, internodal length, days to 50% flowering, fruit length, fruit width, total number of fruits per plant, plant height, number of branches per plant, internodal length, fruit length, fruit weight and number of fruits per plant were identified as potential selection criteria in breeding programs aiming at higher yield (Mehta *et al* 2006, Mohapatra *et al* 2007). The study of path coefficients elucidates the intrinsic nature of observed association between yield and it attributes. It also reveals the magnitude of contribution made by different plant characters towards yield there by imparting confidence in selection of important yield attributes. The present study aimed (1) to assess the association of different yield attributing characters with yield and (2) to find out the extent of association between yield attributing character in terms of their direct and indirect effects on yield.

MATERIALS AND METHODS

The present investigations entitled "Genetic variability and path analysis in Bhindi" was undertaken in the Department of Horticulture (Vegetable & Floriculture), at the Bihar Agriculture College, Sabour. The genotypes/lines used in the present study are listed in Table 1. The other material consisting of field implements and tools farm yard manures, plant protections chemicals, pan-balance, and meter scale slide calliper, etc were utilized as when necessary. The experimental plot was ploughed and cross ploughed four times, followed by planking. First ploughing was given by mould bold plough and the rest by *desi* plough. Weeds, root stubbles and other crop residues were removed by harrowing and the land was properly levelled. Organic manure in the form of rotten farm yard manners @ 250 Q/ha was applied at the time of last ploughing. The experiment was statistically laid out in the field adopting randomized block design with 25 treatments, replicated thrice. The plot size comprised of the double rows of 1.50 meters lengths and 1.20 meters breadth. Each treatment was allocated to individual plot with the help of random table. Ten plants were kept in each plot at the spacing of 60 cm from row to row and 30 cm from plant to plant.

Statistical analysis: The experimental data for twelve characters namely, plant height (cm), number of branches per plant, days to flower, days to fruit set, days taken from fruit set to first harvest, number of fruit per plant, fruit length (cm), fruit diameter (cm), fruit weight (g), early yield (Kg), total yield (Kg), and 1000 seeds weight (g) was recorded and subjected to statistical analysis using suitable technique for different characters. The technique of analysis of various for Randomised Block Design was adopted, as suggested by Panse and Sukhatme (1967). Phenotypic covariance was calculated by adding mean sum of product at error level to the genotypic covariance as suggested by Pillai and Singh (1968). Phenotypic and genotypic correlation coefficients were calculated as per formula suggested by Al-Jibouri *et al* (1958) and Miller (1958). Path coefficient being the ratio of the standards deviation of the effect due to a given cause to the total standard deviation of the effect was calculated as per method suggested by Dewey and Lu (1959).

RESULTS

We assessed the variability in Bhindi on the aspects, such as analysis of variance, range of variation, mean performance, phenotypic variability, genotypic variability, genotypic variance as percentage of phenotypic variance, environmental variance, environmental variance as percentage of phenotypic variance, coefficient of variation, phenotypic coefficient of variation, genotypic coefficient of

variation, heritability and genetic advance (data not shown) using observation for twelve characters mentioned in materials and methods section. As for genetic improvement of any crop through conventional breeding approach using selection, the adequate knowledge of association between yield and yield related characters is essential for the identification of selection procedure. Therefore, findings of the present study will be more useful in the estimation of association and inter-relationship among the yield contributing components.

Correlation analysis: The genotypic and phenotypic correlation coefficients between different yield contributing characters have been presented in Table 2. A perusal of the data revealed that the total yield had significant positive correlation with plant height (0.9697), number of branches per plant (0.7648), fruit length (0.7332), number of fruits per plant(0.6332) and fruit weight (0.5136) whereas, fruit diameter exhibited negative correlation (-0.3270). Inter-correlation studies revealed that plant height had significant positive correlation with number of fruits per plant (0.6324) (Table 2). It also exhibited positive correlation with number of branches per plant (0.3295), fruit length (0.2887), fruit diameter (0.0086) and fruit weight (0.1249). Number of branches per plant was significantly positive correlated with number of fruits per plant (0.5183). However, it also showed positive correlation with fruit length (0.0117), fruit diameter (0.0927) and fruit weight (0.1257).

Table 1 Genotypes/lines used in the present study.

Genotypes/lines	Symbol	Genotypes/Lines	Symbol
Pusa Sawani	T_1	Sel-4	T_{14}
VaishaliVadhu	T_2	79-2	T_{15}
PBN -57	T_3	86-1	T_{16}
AROH-1	T_4	Sel-8	T_{17}
71-38	T_5	KS-312	T_{18}
Pusa Makhamali	T_6	B.O.-2	T_{19}
N.D.O.-25	T_7	B.O.-1	T_{20}
71-12	T_8	Sel-2	T_{21}
86-2	T_9	79-7	T_{22}
71-3	T_{10}	81-1	T_{23}
71-36	T_{11}	Sel-7	T_{24}
71-14	T_{12}	Sel-10	T_{25}
Punjab Padmini	T_{13}		

Table 2 Genotypic and phenotypic correlation coefficient for different pairs of quantitative characters of Bhindi.

Name of characters		No. of branches per plant	No. of fruits per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Total yield (Kg)
Plant height (cm)	G	0.3332	0.7720**	0.4962*	-0.4237*	0.3733	0.5506**
	P	0.3295	0.6324**	0.2887	0.0086	0.1249	0.9697**
No. of branches per plant	G		0.7133**	0.4103*	-0.3245	0.2111	0.5142**
	P		0.5183**	0.0117	0.0927	0.1257	0.7648**
No. of fruits per plant	G			0.5519**	-0.5154**	0.8852**	0.8251**
	P			0.3067	0.0556	0.1033	0.6332**
Fruit length (cm)	G				-0.3846	0.6708**	0.5344**
	P				-0.0751	-0.0121	0.7332**
Fruit diameter (cm)	G					-0.6246**	-0.5234**
	P					-0.1860	-0.3270
Fruit weight (g)	G						0.6245**
	P						0.5136**

G: Genotypic correlation coefficient, P: Phenotypic correlation coefficient, ** Significant at 1% level; * Significant at 5% level

Table 3 Path coefficient analysis for seven quantitative characters of Bhindi.

Name of characters	Plant height	No. of branches per plant	No. of fruits per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Total yield (Kg)
Plant height (cm)	0.2354	0.0957	0.0642	-0.0128	0.0245	0.1432	0.5501**
No. of branches per plant	0.0784	0.2872	0.0593	-0.0106	0.0188	0.0810	0.5141**
No. of fruits per plant	0.1817	0.2049	0.0831	-0.0142	0.0298	0.3396	0.8248**
Fruit length (cm)	0.1168	0.1178	0.059	-0.0258	0.0222	0.2573	0.5543**
Fruit diameter (cm)	-0.0997	-0.0932	-0.0428	0.0099	-0.0578	-0.2396	-0.5232**
Fruit weight (g)	0.0879	0.0606	0.0736	-0.0173	0.0361	0.3836	0.6245**

** Significant at 1% level; * Significant at 5% level.

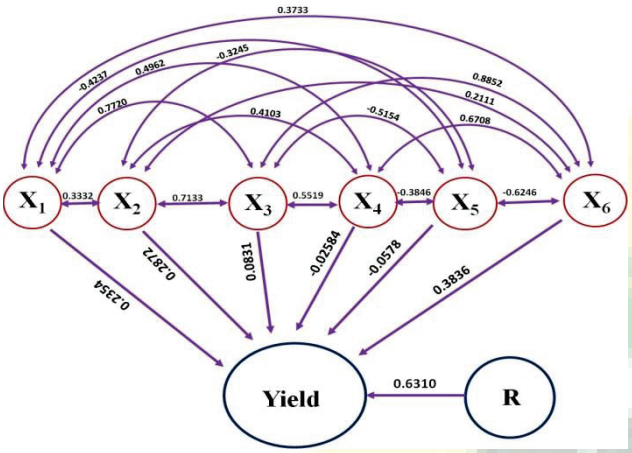

Figure 1 Path diagram depicting effects of different characters on yield.

X1: Plant height, X2: Number of branches per plant, X3: Number of fruits per plant, X4: Fruit length, X5: Fruit diameter, X6: Fruit weight, R: Residual effect, Single arrowed line: Direct effect on yield, double arrowed line: Indirect effect on yield

Number of fruits per plant showed positive correlation with fruits length (0.3067), diameter of fruit (0.0556) and fruit weight (0.1033). While, the fruit length was found to be negatively correlated with diameter of fruit (-0.0751) and fruit weight (-0.0121). Further, the diameter of fruit had negative correlation with fruit weight (-0.1860). The genotypic correlation coefficients among different characters have been presented in Table 2. In general, it was observed that the genotypic correlation coefficients were higher than their corresponding phenotypic correlation coefficients. The total yield expressed significant positive correlation with number of branches per plant (0.5142), fruit length (0.5344), plant height (0.5506), fruit weight (0.6245) and number of fruits per plant (0.8251). However, fruit diameter (-0.5234) showed significant negative correlation with yield.

Inter-correlation studies revealed that the plant height showed significant positive correlation with number of fruits per plant (0.7720) and fruit length (0.4962) (Table 2). It also exhibited positive correlation with number of branches per plant (0.3332) and fruit weight (0.3733) while it had significant negative correlation with fruit diameter (-0.4237). Number of branches per plant had significant positive correlation with number of fruits per plant (0.7133) and fruit length (0.4103). It also showed positive correlation with fruit weight (0.2111) whereas, it had negative correlation with fruit diameter (-0.3245).

Number of fruits per plant showed significant positive correlation with fruit length (0.5519) and fruit weight (0.8852). However, it had significant negative correlation with fruit diameter (-0.5154). Fruit length exhibited significant positive correlation with fruit weight (0.6708). It had negative correlation with diameter of fruit (-0.3846). Fruit diameter had significant negative correlation with fruit weight (-0.6246).

Path coefficient analysis: Path coefficient analysis showing direct and indirect contribution towards yield has been presented in Table 3 and Figure 1. The scrutiny of the data revealed that fruit weight expressed the maximum direct effect (0.3836) on yield. Its indirect effects were positive via plant height (0.0879), number of fruits per plant (0.0736), number of branches per plant (0.0606) and fruit diameter (0.0361). It indicated indirect negative

association through fruit length (-0.0173). The direct positive contribution of number of branches per plant (0.2872) to yield ranked second in merit. Its indirect effects were positive via fruit weight (0.0810), plant height (0.0784), number of fruits per plant (0.0593) and fruit diameter (0.0188). It indicated small amount of indirect negative effect through fruit length (-0.0106). Plant height had also direct positive effects (0.2354) on yield. Its indirect positive effects were nominal via fruit weight (0.1432), number of branches per plant (0.0957), number of fruits per plant (0.0642) and fruit diameter (0.0245). It indicated small amount of indirect negative effect through fruit length (-0.0128). Number of fruits per plant exerted direct positive effect (0.0831) on yield. It indicated indirect positive effects via fruit weight (0.3396), number of branches per plant (0.2049), plant height (0.1817) and fruit diameter (0.0298). It had indirect negative effect through fruit length (-0.0142). Fruit length of fruit showed direct negative effect (-0.0258) on yield. It exhibited indirect positive effects via fruit weight (0.2573), number of branches per plant (0.1178), plant height (0.1168), and number of fruits per plant (0.0459) and fruit diameter (0.0222). Fruit diameter expressed direct negative effect (-0.0578) on yield. It also showed negative effects through fruit weight (-0.2396), plant height (-0.0997), number of branches per plant (-0.0932) and number of fruits.

The residual effect appeared to be very small (0.6310), which indicated that the most of the important yield contributing components in Bhindi have been accounted for in the present study.

DISCUSSION

Prior knowledge of association between the component characters is essential for making any judicious selection for cop improvement. Path coefficient analysis is also very useful in formulating breeding strategy to develop elite genotypes through selection in advanced generations. Thus, the nature and magnitude of variability present in the gene pool for different characters and relationship with each other determine the success of genetic improvement of a character. Since the pattern of inheritance of quantitative characters is highly complex, therefore the present investigation was undertaken to study the association among different components and their direct and indirect contribution to fruit yield in Bhindi.

In Bhindi, correlation and path coefficient analyses have been used by several researchers to measure the associations between yield and other traits and to clarify interrelation between pod yield and other traits, respectively (Jaiprakashnarayan *et al* 2004, Singh *et al* 2006, Rashwan *et al* 2011, Prasath *et al* 2017). Since, yield is a quantitative character and polygenic in nature, it is often influenced by environmental cues. Therefore, information on the extent and nature of association between yield and its components could felicitate breeders to identify the actual components of yield and provide an effective basis of phenotypic selection. On the other hand, the path coefficient analysis helps in the portioning of correlation coefficient into direct and indirect effects. This elucidates the magnitude of contribution or wieghtage of different plant characters towards yield there by boosting the confidence in selection of yield components.

On the phenotypic level, the total yield (pod) expressed significant positive correlation with plant height, number of branches per plant, number of fruits per plant, fruit length and fruit weight (Table 2). Somashekhar *et al* (2011) reported high significant associations of pod yield with characters like plant height, number of branches per plant, fruit length, fruit weight, total number of fruits per plant. There were several similar reports on correlation between pod yield and its contributing traits (Bendale *et al* 2003, Jaiprakashnarayan and Mulge 2004, Mehta *et al* 2006 Patro and Sankar 2006). Inter-correlation studies on the phenotypic level revealed that plant height had significant positive association with number of fruits per plant. Number of branches

per plant had also significant positive correlation number of fruits per plant. Number of fruits per plant was positively correlated with fruits length, fruit diameter and fruit weight. Fruit length had negative association with fruit diameter was negatively correlated with fruit weight.

On the genotypic level, the total yield exhibited significant positive association with plant height, number of branches per plant, number of fruits per plant, fruit length and fruit weight (Table 2). Inter-correlation studies on the genotypic level indicated that plant height had significant positive association with number of fruits per plant and fruit length while it had significant negative correlation with fruit diameter (Table 2). Number of branches per plant was also significantly positively correlated with number of fruits per plant and fruit length. Number of fruits per plant had significant positive association with fruit length and fruit weight while it had significant negative association with fruit diameter. Fruit length was significantly positively correlated with fruit weight. However fruit diameter had significant negative correlation with fruit weight.

Path coefficient analysis revealed that fruit weight, number of branches per plant, plant height and number of fruits per plant expressed maximum direct effect on yield (Table 3). Mehta *et al* (2006) reported that the pod yield influenced by high direct effects of plant height, number of branches per plant, fruit length, fruit weight. The pod yield was also reported to be influenced by direct effect of total number of fruits per plant (Patro and Sankar 2006, Mohapatra *et al* 2007). The plant characters such as, plant height, number of branches per plant, fruit length, fruit weight and number of fruits per plant were identified as potential selection criteria in breeding programs aiming at higher yield in Bhindi (Mehta *et al* 2006, Patro and Sankar 2006, Mohapatra *et al* 2007). Thus, it may be concluded that fruit weight, number of branches per plant, plant height and number of fruits per plant had highly significant positive correlation with yield and also had high direct effect on yield. Furthermore, these characters also had high genotypic and phenotypic coefficient of variation, high heritability together with high genetic advance. The results of the present experiment indicated that the selection would be effective in the improvement of this crop if the characters like fruit weight, number of branches per plant, plant height and number of fruits per plant were subjected to selecting pressure and utilized as basis of selection of desirable parents or progenies in hybridization breeding programme.

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