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Association analysis for yield, yield components and tolerance to fruit and shoot bored in F_2 population of brinjal (*Solanum melongena* L.)

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Abstract
Top crosses of brinjal Biliudda badane × mullu badane produced from F_1 generation were in augmented design at ZARS Shimogga in Kharif 2017. Evaluation of direction degree of association and path coefficient analysis between yield and yield attributes traits were studied in brinjal (*Solanum melongena* L.). Traits like days to first flowering, Number of fruits per plant, Number of flowers, Plant height, fruit width and fruit weight, fruit length, fruits per cluster were found to possess significant and positive correlation with fruit yield per plant and also showed positive direct effect in path co-efficient analysis. It was observed that with increase in plant height, there were corresponding increases of fruit yield per hectare. The number of branch per plant had significant negative association with fruit yield per plant. These characters play a major role in recombination breeding and suggested that direct selection based on these traits will be rewarded for crop improvement of brinjal.

Keywords: Association, augmented design, correlation, phenotypic variance, traits

Introduction
Brinjal (*Solanum melongena* L,) is one of the most common, widespread and principal vegetable crops grown in India and is also considered as the king of vegetables. The crop is highly productive and known as the poor man's crop. It belongs to the family *Solanaceae* and is native of Indo-Burma region and China (Vavilov, 1926). It stands second in area and production after China and occupies an area of 6.69 lakh hectares with an annual production of 124.01 lakh metric tonnes and average productivity of 19 tonnes per hectare (Anonymous, 2016). Brinjal occupies an area of 15.8 thousand hectares with an annual production of 4.03 lakh metric tonnes and productivity of 25.4 tonnes per hectare in Karnataka.
Brinjal or eggplant is a perennial but grown commercially as annual crop. Inflorescence is often solitary but some time it constitutes a cluster of 2-5 flowers. Solitary or clustering nature of inflorescence is a varietal character. Flower is complete and hermaphrodite. Heterostyly is a common feature, and fruit setting flower consist of long (70-86.7%) and medium styled (12-55.6%) flower. The non-fruit setting flowers consist of short styled and pseudo styled. It ranks fair in nutritional value (carbohydrates, proteins, and fiber). It is an essential source of carbohydrate (4.0 g), protein (1.4 g), fiber (1.3 g), vitamin-A (124 IU), phosphorus (47 mg), potassium (2.0 mg) and iron (0.3 mg) and recommended for diabetes, asthma, cholera, bronchitis and it protects the brain cell membranes from damage.
Study of correlation between different quantitative characters provides an idea of an association between yield attributing characters. Association of characteristics like yield, its components, and other economic traits is essential for making selection in the breeding programme. It suggests the advantage of a scheme of preference for more than one character at a time (Kalloo, 1994). The aim of the present study was to find out the association of characters between yield and yield components of brinjal.

Material and Methods
The field experiment under present investigation was conducted with top two crosses from F_1 including 1 check from Private company seeds, Shivamogga. Crosses were made between as line × testes, among them, top crosses were selected.
This experiment was conducted at ZAHRS, Shivamogga. The experimental material consisted of the F_2 population and checks. Sowing was carried out at 3rd week of July 2017. The seedlings were transplanted in main field after 22 days at a spacing of 90 cm between rows and 60 cm between plant to plant.

The crop was raised by following recommended package of practices.

Portrays were filled with a mixture of vermicompost and coco peat; seeds were sown and watered. These portray were covered with black polythene to build up humidity for better and early germination of seeds. After germination, polythene cover was removed, and watering was done either in the morning or evening hours. The main field was prepared to fine tilt by repeated ploughing and harrowing, and the FYM @ 25 t/ha was incorporated into the soil. Ridges and furrows were prepared at a spacing of 90 cm. Seedlings were planted on ridges at a spacing of 60 cm (*Anon.*, 2012). A total of 24 plants were planted on each ridge with a plot area of 6.75 m^2. A healthy crop was laid by adopting standard agronomic practices.

The correlation coefficient among all-important character combinations at phenotypic (rp) level was estimated by employing formula given by Al-Jibouri *et al.* (1958) [1].

$$\text{Phenotypic correlation} = r_{xy}(p) = \frac{Cov_{xy}(p)}{\sqrt{V_x(p)X}}$$

Where,

Covxy (P) = Phenotypic covariance between x and y characters

Vx (P) = Phenotypic variance of character 'x.'

Vy (P) = Phenotypic variance of character 'y.'

The test of significance for an association between characters was done by comparing table 'r' values at n-2 error degrees of freedom for phenotypic and genotypic correlations with estimated values, respectively.

Path coefficient analysis

Path co-efficient analysis suggested by Wright (1921) and Dewey and Lu (1959) was carried out to know the direct and indirect effect of the morphological traits on fruit yield. The following set of simultaneous equations were formed and solved for estimating various direct and indirect effects.

r1y = a + r12b + r13c + ……....+ r1Ii

r2y = a + r21a + b + r23c + ……..+ r2Ii

r3y = r31a + r32b + c + ……..+ r3Ii

r1y = r11a + r12b + r13c + ……..+ I

Where,

r1y to 11y = Co-efficient of correlation between causal factors 1 to 1 with dependent characters y.

r12 to r1I = Co-efficient of correlation among causal factors

a, b, c…i = Direct effects of characters 'a' to 'I' on the dependent character 'y.'

Residual effect (R) was computed as follows.

$$\text{Residual effect (R)} = 1 - \sqrt{a2 + b2 + c2 + \cdots i2 + 2abr12 + 2acr13 + \cdots}$$

Observations on quantitative characters were recorded for fruit yield and yield attributing traits *viz.*, days to first flowering, days to fifty percent flowering, Plant height (cm), fruit length (cm), fruit width (cm), No. of branches, number of fruit, number of flowers, fruit yield per plant (g).

Results and Discussion

The data generated in these observations were analyzed using WINDOSTAT 9.2 software. The correlation co-efficient between yield and yield components are shown in Table-1, Its improvement by direct selection is generally difficult because yield is governed by complex polygenic character largely influenced by its various component characters as well as by the environment. Hence, it becomes essential to estimate association of yield per plant with yield contributing characters and among themselves. The knowledge of magnitude and direction of correlation is used for judging how improvement in one character will cause simultaneous change in the other characters.

Table 1: Estimates of phenotypic correlation coefficients for nine characters in F_2 generation cross Biliudda badane × Mullu badane.

	X_1	**X_2**	**X_3**	**X_4**	**X_5**	**X_6**	**X_7**	**X_8**	**X_9**
X_1	1.000	0.473**	0.266**	0.181*	0.089	0.077	0.181*	0.331**	0.283**
X_2		1.000	0.270**	0.205**	0.197**	0.009	0.205**	0.291**	0.262**
X_3			1.000	0.100	-0.012	0.098	0.100	0.336**	0.213**
X_4				1.000	0.006	-0.017	0.342**	0.150*	0.053
X_5					1.000	0.193**	0.006	0.004	0.008
X_6						1.000	-0.017	-0.031	-0.068
X_7							1.000	0.150*	0.048
X_8								1.000	0.206**
X_9									1.000

X_1 - Days to first flowering
X_2 - Plant height (cm)
X_3 - Number of flowers per plant
X_4 – Number of fruits per cluster
X_5 - Number of branches per plant
X_6- Number of fruits per plant
X_7 - Fruit width (cm)
X_8 - Fruit length (cm)
X_9 – Fruit yield per plant

Table 2: Estimates of direct and indirect of fruit yield and its component at phenotypic level in F_2 generation of cross Biliudda badane × Mullu badane

	X_1	**X_2**	**X_3**	**X_4**	**X_5**	**X_6**	**X_7**	**X_8**
X_1	-0.032	-0.008	-0.006	-0.003	-0.002	-0.006	-0.011	-0.009
X_2	0.036	0.135	0.014	-0.002	0.013	0.014	0.045	0.029
X_3	-0.026	-0.014	-0.141	-0.008	0.002	-0.141	-0.021	-0.007
X_4	0.011	-0.002	0.007	0.128	0.025	0.007	0.005	0.001
X_5	0.010	0.013	-0.002	0.025	0.128	-0.002	-0.004	0.002

X_6	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
X_7	0.196	0.198	0.089	0.002	-0.018	0.089	0.591	0.122
X_8	-0.001	-0.007	-0.002	0.001	-0.001	-0.002	-0.007	-0.003
X_9	0.194	0.320	-0.047	0.149	0.148	-0.047	0.600	0.134

X_1 - Days to first flowering
X_2 - Plant height
X_3 – Number of flowers per plant
X_4 – Fruits per cluster
X_5 – Number of branches per plant
X_6 – Number of fruits per plant
X_7 – Fruits width
X_8 – Fruit length
X_9- Fruit yield per plant

Data presented in Table 1 indicated at the phenotypic level, the positive correlation with The association of fruit yield was highly significant and positive with days to first flowering (0.283) followed by plant height (0.262), number of flowers per plant (0.213), and fruit length (0.206). Contrary to this number of fruits per cluster (0.053) exhibited low positive but non-significant correlation. Whereas number of number of flowers (-0.068) was low (-0.048) was negligible. These results are in consonance with those reported like Srivastava and Sachan. (1973), Thangamani and Jansirani. (2012) [18], Bhukya *et al*. (2013) [3], reported similar results concerning significant and positive association with traits fruit yield. Days to first flowering a significant and positive association with fruit yield, similar results obtained by Thamburaj. (1996), Bhukya *et al*. (2013) [3]. Plant height exhibited a positive and significant association with yield which is on par with the results of Nainar *et al.* (1990) [10]. The number of fruits per plant exhibited negative but non-significant this coincides with the results of Samlindsujjin *et al.* (2016). However association of fruit width with low, positive but non-significant with fruit yield was similar to the findings of Hassan *et al.* (2015) and Ramesh *et al.* (2016). The number of branches was positive and significant with fruit yield this agrees with the results of Muniaappan *et al*. (2010), kumar. (2013).

Path coefficients of component traits on yield

The correlation co-efficient between yield and a particular yield component was the net result of the direct effect of that attribute and indirect effect through other yield contributing traits. Therefore, it is necessary to partition the total correlation coefficients into direct and indirect effect of causing as devised by Wright (1921). Path coefficient analysis provides an effective means of a critical examination of specific forces action to produce a given correlation and measure the relative importance of each factor. In this analysis, fruit yield was taken as dependent variable, and the rest of the characters were considered as independent variables. Among the 9 characters studied, fruit width (0.600) plant height (0.320), days to first flowering (0.194), number of fruits per cluster (0.149), Number of branch per plant (0.148) and fruit length (0.134) showed positive direct effect. Number of fruits per plant (-0.047), number of flowers per plant (-0.047), recorded the negative direct effect. The direct selection for these characters would be beneficial for crop improvement since most of these characters also should have positive coefficient of correlation in improving the fruit yield per plant. The results were in accordance with Randhawa et al. (1989) [13], Mishra and Mishra. (1990) [6], Nainar et al. (1990) [10], Thangamani and Jansirani. (2012) [18], Senapati and Senapati. (2006) [15]. Fruits per plant showed a positive direct effect on yield. Nainar et al. (1990) [10], Nair and Mehta. (2007) [8], Patel. (2007), Thangamani and Jansirani. (2012) [18], Bhukya *et al*. (2013) [3]. Fruit length showed the positive direct effect on yield Similar results were given by Sharma and Swaroop (2000) [16], Mohanty (2001), Senapati and Senapati (2006) [15], Naliyadhara *et al.* (2007) [8], Prabhu and Natarajan (2008a) [11], Prabhu *et al.* (2008b) [12], Jadhao *et al.* (2009) [4], Thangamani and Jansirani (2012) [19], Karak *et al.* (2012) [5] and Nayak and Nagre (2013) [3]. Fruits width showed the positive direct effect on yield Similar results were reported by the workers like Sharma and Swaroop (2000) [16], Mohanty (2001), Senapati and Senapati (2006) [15], Naliyadhara *et al.* (2007) [8], Prabhu and Natarajan (2008a) [11], Prabhu *et al.* (2008b) [12], Jadhao *et al.* (2009) [4], Thangamani and Jansirani (2012) [19], Karak *et al.* (2012) [5] and Nayak and Nagre (2013) [3]. Singh and Singh (2001) [17], Mohanty (2001), Jadhao *et al.* (2009) [4], Nair and Mehta. (2007) [9], Samlindsujjin *et al.* (2016) reported that days to first flowering showed a positive direct effect on yield. Nair and Mehta. (2007) [9], Bansal and Mehta. (2008) [2] reported that number of fruits per cluster showed a positive direct effect on yield. All have reported similar results in brinjal. The characters which recorded positive effect on yield had indirect positive impact via each other. Here fore, they do not affect each other adversely and hence, can be selected for improving the yield. In the present study, the residual path effect made a positive contribution which suggested that the characters which hold essential role in determining the total fruit yield are included in the present study. For the improvement of yield, emphasis should be made on all yield contributing characters which are influencing it directly or indirectly.

The degree of tolerance or susceptible to fruit borer infestation was assigned as per the scale F_2 of cross Biliudda badane × Mullu badane in Brinjal

Based on the fruit borer 200 F_2 plants of Biliudda badane × Mullu badane were classified in to resistant, tolerant susceptible and very susceptible.

Reaction to Fruit borer reaction

Among the 200 F_2 plants 105, 75, 17 and 3 plants recorded as tolerant, moderately tolerant susceptible and very susceptible respectively for fruit borer. In general, it was observed that the incidence of fruit borer increased with the age of the crop. Generally in vegetative phase population was comparatively less in all the plants than near maturing crop. Similar results were reported by Nirmala and Irene (2016) supports present investigation.

Conclusion

In this study, at phenotypic levels, days to first flowering, plant height, number of flowers per plant, fruit length, number of fruits per cluster, fruit girth, plant height, fruit width showed highly significant correlation with fruit yield per plant indicating, the direct effect of all above mentioned traits on fruit yield per plant favour yield improvement through selection that these characters can be used as surrogate characters for selecting high yielding genotypes. Hence, the correlation study conducted has revealed the characters that can be used for direct selection in the crop improvement programme. The direct effect of all above-mentioned traits on

fruit yield per plant favor yield improvement through selection.

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