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Studies on correlation and path analysis for yield and yield related characters in green gram (*Vigna radiata* (L.) Wilczek)

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Abstract
Fifty green gram genotypes were evaluated for 10 quantitative characters *viz*., days to 50% flowering, days to maturity, plant height (cm), number of primary branches per plant, number of clusters per plant, number of pods per plant, pod length (cm), number of seeds per pod, 100 seed weight (g) and seed yield per plant (g). The correlation and path analysis was done to study the character association and to understand the direct and indirect effects of different characters on seed yield per plant. The correlation analysis revealed that seed yield per plant exhibited significant and positive correlation with 100 seed weight, number of clusters per plant, pod length, plant height, number of pods per plant and number of seeds per pod at both genotypic and phenotypic levels. Hence, selection for characters can improve yield in green gram. Path analysis revealed the 100 seed weight and days to maturity recorded positive and high direct effect towards seed yield per plant, moderate direct effect was observed for number of clusters per plant and low direct effect on yield was recorded by number of pods per plant and pant height. The direct effect of the remaining characters on seed yield was negligible. Thus 100 seed weight had a highly significant and positive correlation with seed yield per plant and its direct effect on yield per plant was high, selection for this character should be given emphasis in breeding programmes for yield improvement yield in green gram.

Keywords: Green gram, germplasm, correlation, path analysis, selection

Introduction
Greengram (*Vigna radiata* L. Wilczek) is the third most important pulse crop in India after pigeon pea and chick pea. It is diploid in nature with 2n=2x=22 (Karpechenko, 1925) [6] and has a small genome of size 579 Mb (Somta and Srinives, 2007) [13]. It is a short duration grain legume crop which is suitable for various multiple and inter-cropping systems. It is an excellent green fodder crop and can be grown as a cover crop for enriching soil fertility due to its high atmospheric nitrogen fixation ability. It contains high quality easily digestible protein (22-26%), carbohydrate (54 -56%), fat (1.3%), fiber (3-8%), sugar (4-10%), ash (3-4%), calcium (124 mg), phosphorus (326 mg) and vitamin B. It is a major source of dietary protein with low flatulence and is predominantly used in vegetarian diet due to its low oligosaccharide content. It is cultivated in Asia, Tropical and Sub-tropical Africa, Australia, West Indies, South and North America. In India, green gram is grown in mostly cultivated in Rajasthan, Madhya Pradesh, Karnataka, Maharashtra, Bihar, Andhra Pradesh, Odisha, Tamil Nadu and Telangana in all the cropping seasons and in rice fallows.
Seed yield being a complex inherited trait is subjected to environmental fluctuations; direct selection for yield based on *per se* performance does not give expected results due to high Genotype x Environment interaction. Selection based on simply inherited and highly heritable yield attributes is most effective and reliable approach as compared to direct selection on yield itself. Correlation studies provide information on the nature and extent of association between any two metric traits and thus help in genetic upgradation in one trait by selection of the other of a pair. Understanding the nature and extent of association of different yield components with yield and inter relationship among themselves is an essential pre requisite for the formulation of breeding procedure for effective improvement of yield and its components.

Thus the character which is highly correlated with yield can be used for indirect selection for improving yield. Seed yield is a dependent trait and is the result of many component characters. Selection for yield will not be fruitful as it polygenic in nature. Thus indirect selection for component characters with high positive effect on yield is done for improving yield of a genotype. Correlation coefficient which measures the association between any two variables may not necessarily be the proof of a direct causal relationship as it doesn't indicate about the contribution of the variation in one character in relation to variation observed in the other. Thus correlation coefficients do not give an idea whether this association is due to direct effect or indirectly through other characters. Path coefficient partitions the association between seed yield per plant and contributing traits into indirect and direct effects. Thus path analysis provides more reliable choice of yield contributing traits for indirect selection for improving yield. In this context, the present study was done with an objective to study the association between different characters with seed yield and to understand their direct and indirect effect of these characters on seed yield.

Materials and Methods

The present investigation was carried out at the Department of Plant Breeding and Genetics, OUAT, Bhubaneswar, Odisha. Fifty green gram genotypes were grown in randomized complete block design with 3 replications in rows of two-meter length with 30 cm x 10 cm spacing. All the recommended agronomic practices along with necessary prophylactic plant protection measures were followed to raise a good crop. The data was recorded on 10 yield and yield contributing characters *viz*., days to 50% flowering, days to maturity, plant height (cm), number of primary branches per plant, number of clusters per plant, number of pods per plant, pod length (cm), number of seeds per pod, 100 seed weight (g) and seed yield per plant (g). The observations were recorded from five randomly selected plants of each genotype from three replications and the mean value was calculated. The statistical analysis of the data was done using Indostat software. The genotypic and phenotypic correlation coefficients were computed using genotypic and phenotypic variances and covariances using the formula provided by Falconer (1964) [3]. The path coefficient analysis was done according to the method suggested by Dewey and Lu (1959) [2] to understand the direct and indirect effect of various characters to yield.

Results and Discussion

Correlation studies: The correlation and path coefficient analysis was studied to understand the relationship between yield and other characters. The correlation analysis between seed yield per plant and other yield contributing characters in 50 green gram genotypes were calculated and presented in Table 1. It was observed that the genotypic correlation coefficients were found higher than phenotypic correlation coefficients for all the characters studied. This indicates that the associations between the characters are genetic and thus effect of environment is very less. Seed yield per plant exhibited significant and positive correlation with 100 seed weight followed by number of clusters per plant, pod length, plant height, number of pods per plant and number of seeds per pod at both genotypic and phenotypic levels. Strong correlation between seed yield and the above mentioned characters indicated that yield is highly influenced by these characters and improvement for yield can be done through simple selection for these characters. These findings were in agreement with the findings of Joshi and Kabaria (1973) [5], Gul *et al*, 2008 [4], Malik *et al.* (1987) [8], Natarajan *et al.* (1988) [9], Patil and Deshmuk (1988) [11], Khorgade *et al.* (1990), Patil and Narkhede (1989) [10], Choi *et al.* (1986) [1], Sreelakshmi and Reddysekhar (2011) [14], Raut *et al.* (1988) [12] and Venkateshwarlu (2001) [15]. While significant but negative was observed between seed yield per plant and days to maturity (-0.172). The seed yield per plant exhibited negative and non-significant correlation with days to 50% flowering, days to maturity and number of primary branches per plant at both genotypic and phenotypic levels. Among the component characters under study, plant height, number of clusters per plant and number of pods per plant recorded significant and positive inter correlations with most of the characters.

The correlation studies between yield per plant and other traits indicated that 100 seed weight, number of clusters per plant, pod length, plant height, number of pods per plant and number of seeds per pod were the important yield component traits. Indirect selection for these characters should be done for yield improvement in green gram. The maturity duration had a negative correlation with seed yield. The undesirable association of some of the component characters may act as deterrent for the formulation of a comprehensive selection programme involving these traits so while formulating a comprehensive selection programme these factors must be considered.

Table 1: Genotypic and phenotypic correlation coefficients among yield and its component characters in 50 green gram genotypes

Characters		Days to maturity	Plant height (cm)	No of primary branches	No of clusters per plant	No of pods per plant	Pod length (cm)	No of seeds per pod	100- seed weight (g)	Seed yield per plant (g)
Days to 50% flowering	Rg	0.999**	0.238**	0.304**	-0.112	-0.140	0.055	0.224**	-0.087	-0.143
	Rp	0.996**	0.144	0.270**	-0.106	-0.118	0.044	0.181*	-0.073	-0.105
Days to maturity	Rg		0.239**	0.307**	-0.118	-0.126	0.011	0.219**	-0.131	-0.172*
	Rp		0.147	0.270**	-0.106	-0.112	0.001	0.169*	-0.112	-0.131
Plant height (cm)	Rg			0.077	0.503**	0.361**	0.166*	0.592**	0.011	0.329**
	Rp			0.075	0.428**	0.310**	0.131	0.536**	0.011	0.261**
No of primary branches	Rg				0.018	0.110	-0.221**	-0.230**	-0.123	-0.051
	Rp				0.018	0.099	-0.185*	-0.197	-0.120	-0.017
No of clusters per plant	Rg					0.738**	-0.030	0.253**	-0.024	0.447**
	Rp					0.660**	-0.040	0.208*	-0.018	0.389**
No of pods per plant	Rg						-0.148	0.204*	-0.241**	0.238**
	Rp						-0.155	0.166*	-0.220**	0.194*
Pod length (cm)	Rg							0.344**	0.700**	0.418**
	Rp							0.335**	0.660**	0.399**

No of seeds per pod	Rg								0.057	0.209*
	Rp								0.057	0.187*
100- seed weight (g)	Rg									0.704**
	Rp									0.636**

* Significant at P =0.05 ** Significant at P =0.01

Path analysis

Path analysis was done to understand the direct and indirect effects of each character with seed yield per plant and the results are presented in Table 2. Residual effect was found as 0.24. The genotypic path diagram is represented as Fig. 1. It was observed that the direct effect of 100 seed weight (0.899) and days to maturity (0.367) on seed yield per plant was found positive and high. The direct effect on seed yield per plant was moderate for number of clusters per plant (0.254). The low and positive direct effect on seed yield per plant was found for number of pods per plant (0.158) and plant height (0.141). The number of seeds per pod (0.067) and number of primary branches per plant (0.012) had a negligible direct effect on yield. Days to 50 per cent flowering (-0.422) and pod length (-0.254) exhibited negative direct effects on seed yield per plant.

Thus it can be concluded that yield improvement can done through selection for high cluster number, pod number and 100 seed weight in the green gram germplasm studied. The correlation between 100 seed weight and yield was highly significant positive and its direct effect on yield per plant was high. This depicts the significance of this character on yield improvement. The value of residual effect (0.24) indicated that 86 per cent of variations in the genotypes are due to the 10 characters studied. Thus moderate residual value suggested the adequacy of the traits for defining diversity in the present study.

Table 2: Direct (diagonal) and indirect effects of yield component characters on grain yield

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	No of primary branches	No of clusters per plant	No of pods per plant	Pod length (cm)	No of seeds per pod	100- seed weight (g)	Seed yield per plant (g)
Days to 50% flowering	-0.422	0.367	0.034	0.004	-0.029	-0.022	-0.011	0.015	-0.078	-0.143
Days to maturity	-0.422	0.367	0.034	0.004	-0.030	-0.020	-0.002	0.015	-0.118	-0.1728*
Plant height (cm)	-0.100	0.088	0.141	0.001	0.128	0.057	-0.034	0.039	0.010	0.329**
No of primary branches	-0.128	0.113	0.011	0.012	0.005	0.017	0.045	-0.015	-0.111	-0.051
No of clusters per plant	0.047	-0.043	0.071	0.000	0.254	0.117	0.006	0.017	-0.0220	0.447**
No of pods per plant	0.059	-0.046	0.051	0.001	0.188	0.158	0.030	0.014	-0.217	0.238**
Pod length (cm)	-0.023	0.004	0.023	-0.003	-0.008	-0.023	-0.205	0.023	0.630	0.418**
No of seeds per pod	-0.095	0.080	0.083	-0.003	0.064	0.032	-0.071	0.066	0.051	0.209*
100- seed weight (g)	0.037	-0.048	0.002	-0.002	-0.006	-0.038	-0.144	0.004	0.899	0.704**

Residual effect: 0.24, * Significant at P =0.05, ** Significant at P =0.01

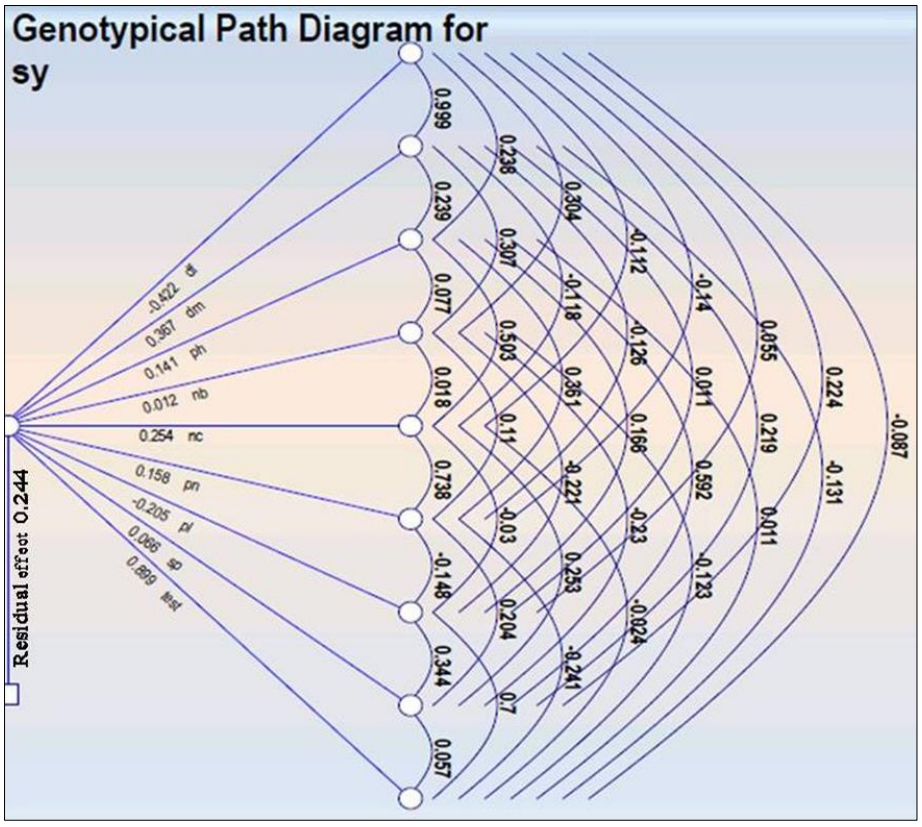

Fig 1: Genotypic path diagram for seed yield per plant in 50 green gram genotypes

Conclusion

The correlation and path analysis studies in the present investigation revealed that 100 seed weight recorded both positive and significant association with seed yield per plant and also exhibited high positive direct effects on seed yield per plant. Thus it is the major yield attributing character among the other characters studied in 50 green gram genotypes. Hence, selection for this character should be done for yield improvement in green gram and thus this character should be included in the comprehensive selection programme for yield improvement in green gram.

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