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Sarfraz Ahmad
Department of Plant Breeding and Genetics, S.K.N. College of Agriculture, S.K.N. Agriculture University, Jobner, Rajasthan, India

Vikas Belwal
GB Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India

Corresponding Author:
Sarfraz Ahmad
Department of Plant Breeding and Genetics, S.K.N. College of Agriculture, S.K.N. Agriculture University, Jobner, Rajasthan, India

Study of correlation and path analysis for yield and yield attributing traits in mungbean [*Vigna radiata* (L.) Wilczek]

Sarfraz Ahmad and Vikas Belwal

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Abstract
The present study on association of various plant, pod and seed characters with seed yield was carried out using 112 diverse genotypes of mungbean, along with five high yielding checks. The field experiment was laid out in Augmented Block Design at N. E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar, India. Observations were recorded on fifteen morphological characters of plant, pod and seed. The genotype differed significantly for all the characters studied. Correlation analysis indicated that seed yield showed positive significant correlation with number of pod per plant, pod diameter, pod length, 100-seed weight, number of cluster, number of leaves, seed diameter, plant height, seed length, pod wall thickness, number of branches and seed density. Path analysis revealed that number of pod per plant and 100-seed weight exerted a high magnitude of positive direct effect, pod length showed moderate effect while number of cluster and seed density exerted positive but low magnitude of direct effect on seed yield. Selection strategy based on these characters having high direct effect coupled with positive correlation with seed yield will be rewarding in mungbean improvement programme.

Keywords: Correlation, mungbean, path analysis, seed yield, *Vigna radiata*

Introduction

Mungbean [*Vigna radiata* (L.) Wilczek] is priced among pulse crops as its seeds are high in essential dietary protein. In India, it is third most important legume crop and is one of the important grain legumes of global economic importance. Mungbean also known as green gram are cultivated in different agro-climatic conditions and soil types in India and various other countries like China, Thailand, Philippines, Indonesia, Burma, and Bangladesh and in hot and dry regions of South Europe and Southern USA (Singh *et al.*, 2005) [15]. Mungbean grain contains 51% carbohydrates, 26% protein, 10% moisture, 4% mineral and 3% vitamins. Mungbean grains are rich in iron (6 mg per 100g of dry seed). The amino acid profile of mungbean (in g/16g N) comprises lysine (7), cysteine (0.6), metheonine (1), threonine (3.5) and tryptophan (0.4) and is complementary to that of cereal grains (Asaduzzaman *et al.*, 2008) [3]. Correlation coefficient analysis measures the mutual relationship between plant characters and determines the component characters on which selection can be based for improvement in yield. If the association between two characters is considerably positive, it will increase the rate of genetic advancement, while the negative correlation will decrease the genetic improvement progress after selection for the character. Path coefficient analysis gives an idea about the contribution of each independent character to the dependent character, i.e. seed yield, in this study. Since the mutual relationship of component characters might vary both in the magnitude and direction, it may tend to vitiate the association of dependent character with the component characters. It is, therefore, necessary to partition the correlation coefficients of the component characters into their direct and indirect effects on the dependent character. In the present investigation, association of various plant, pod and seed characters with economic yield was determined by studying the correlation and direct/indirect effects of these characters on seed yield.

Materials and Methods

The study of correlation and path analysis in mungbean for yield and yield attributing traits was carried out at G.B. Pant University of Agriculture and Technology, Pantnagar, India, during *Kharif* 2010-2011. Geographically Pantnagar is situated at 29.0^0N latitude and 79.30^0E longitude and at an altitude of 243.84 m above the mean sea level. This falls in the humid subtropical zone and situated in the Tarai belt in the foothills of Shivalik range of the great Himalayas. The field experiment was laid out at N. E. Borlaug Crop Research Center in Augmented Block Design (Federer, 1961) [6], which consisted 4 blocks with 5 checks repeated in each block. Two rows of each entry were planted with keeping row length 4 meter, row to row distance 30 cm and plant to plant distance maintained at 10 cm. The experimental material consisted of 112 diverse germplasm lines of mungbean along with five high yielding checks (Table 1).

Observations were recorded from five randomly selected plant for fifteen morphological characters *viz.* days to 50 percent flowering, plant height (cm), number of leaves, number of branches, number of clusters, number of pods per cluster, number of pods per plant, pod length (cm), pod diameter (mm), pod wall thickness (mm), seed length (mm), seed diameter (mm), 100-seed weight (gm), seed density (gm/ml) and seed yield (kg/ha). The mean values from five randomly selected plants were calculated and used for the statistical analysis.

The estimation of correlation coefficient was done using formula given by Searle (1961) [13] and test of significance was carried out by method described by Snedecor and Cochran (1967) [16]. The correlation coefficient were further partitioned into direct and indirect effect with the help of path coefficient analysis as suggested by Wright (1921) [18] and elaborated by Dewey and Lu (1959) [5]. Seed yield was considered as dependent variable as factors assumed to be influenced by the other characters called independent variables as causes.

Table 1: Details of mungbean germplasm

S. N.	Germplasm	S. N.	Germplasm	S. N.	Germplasm	S. N.	Germplasm
1.	PM-2 (check)	31.	PM 06-48	61.	MH-318	89.	Pusa-672
2.	PM-3 (check)	32.	PM 06-49	62.	Mauritius Mung-1	90.	IPM 02-19
3.	PM-4 (check)	33.	PM 06-51			91.	IPM 02-17
4.	PM-5 (check)	34.	PM 06-57	63.	*V. radiata* var *sublobata*	92.	MH-521
5.	PM-6 (check)	35.	MH-429			93.	MH-318
6.	PM 03-2	36.	NH-54	64.	Pant Mung-5	94.	TM 96-2
7.	PM 03-4	37.	NM-94	65.	Harsha	95.	COGG-912
8.	PM 03-5	38.	NM-1(Mutant)	66.	KM-2241	96.	RMG-991
9.	PM 03-7	39.	ICM-1	67.	OBGG-52	97.	Pusa-871
10.	PM 03-9	40.	VC 6790 A	68.	12/333	98.	PM 06-32
11.	PM 03-11	41.	VC 6769(57-99)	69.	SML-668	99.	PM 06-33
12.	PM 03-12	42.	VC 7960-88	70.	45-8-1	100.	PM 06-34
13.	PM 03-13	43.	BDYR-1	71.	AKM-9904	101.	PM 06-35
14.	PM 03-15	44.	BDYR-2	72.	Pre Dred	102.	PM 06-36
15.	PM 03-16	45.	Barimung-4	73.	Samrat	103.	PM 06-37
16.	PM 03-17	46.	Barimung-5	74.	NDM 5-3	104.	PM 06-39
17.	PM 03-18	47.	Barimung-7	75.	MH-429	105.	PM 06-43
18.	PM 03-19	48.	Barisal Local	76.	NIABM	106.	PM 06-46
19.	PM 03-20	49.	Mauritius Local	77.	VC 1997 A	107.	KM 09-174
20.	PM 03-22	50.	Pusa Vishal	78.	VC 6040 A	108.	KM 09-182
21.	PM 03-23	51.	UPM 02-16	79.	VC-7960	109.	SM 10-505
22.	PM 03-24	52.	UPM 98-1	80.	HUM-16	110.	SM 10-503
23.	PM 03-25	53.	UPM-98	81.	NDM-1	111.	SM 10-533
24.	PM-3(M)	54.	UPM 03-18	82.	NDM 5-31	112.	SM 10-529
25.	PM 06-4	55.	UPM 98-10	83.	MH-418	113.	*V. trilobata* X
26.	PM 06-16	56.	UPM 93-3	84.	ML-133	114.	*V. sublobata* X
27.	PM 06-31	57.	PUM 99-3	85.	CN 9-5	115.	*V. silvestris* X
28.	PM 06-41	58.	PM 08-16	86.	Mung Local	116.	IPM 02-19
29.	PM 06-42	59.	PM 08-2	87.	Pusa Ratna	117.	PM 06-50
30.	PM 06-45	60	PM 08-1	88.	Pusa-9531		

Results and Discussion

Crop improvement programmes depends to a large extent on availability of sufficient variability and association among different characters which are the pre-requisite for executing an effective selection programme. Seed yield, being a complex quantitative trait, is dependent on a number of component characters. Therefore, knowledge of association of different components together with their relative contributions has immense value in selection.

Correlation

The estimation of correlation coefficients among different characters has been presented in Table 2. The seed yield showed highly significant and positive correlation with number of pod per plant (0.55), followed by pod diameter (0.54), pod length (0.54), 100-seed weight (0.52), number of cluster (0.47), number of leaves (0.42), seed diameter (0.42), plant height (0.38), seed length (0.36), pod wall thickness (0.34), number of branches (0.31) and seed density (0.30). Number of pod per cluster was significant and positively correlated with seed yield (0.31). Higher number of pods per plant with longer pod and seed size and diameter directly contributed towards the seed yield. Moreover, high correlation of 100-seed weight and plant height with seed yield also obtained in mungbean by Anwari and Sochandi (1999) [2]; Makeen *et al*. (2007) [9]; Tabassum *et al*. (2010) [17];

Reddy *et al.* (2011) [11]; Kumar *et al.* (2013) [10] and Hemavathy *et al.* (2015) [8]. The days to 50 % flowering had non-significant negative correlation (-0.11) with seed yield, similar negative correlation also reported by Rohman *et al.* (2003) [12] and Garg *et al.* (2017) [7] in mungbean.

Path analysis

The correlation coefficient becomes more meaningful when correlation coefficient are partitioned into components of direct and indirect effects through path analysis, because correlation coefficients indicate only the inter relationship of the characters irrespective of cause and effect (Dewey and Lu, 1959) [5]. For path analysis, seed yield was taken as the dependent variable and all other 14 characters used for correlation studies were taken as causal variables. The results are presented in table 3. Path analysis revealed that number of pod per plant (0.60) and 100-seed weight (0.47) exerted a high magnitude of positive direct effect on seed yield. These results were corroborating with the findings of Rohman *et al.* (2003) [12] and Makeen *et al.* (2007) [9]. Moderate direct effect showed by pod length (0.27) while number of cluster (0.14) and seed density (0.13) exerted low magnitude of direct effect. The moderate direct effect of pod length also had been observed study carried out among 54 genotype of mungbean by Alom *et al.* (2014) [1]. The direct effect on seed yield was observed negligible for rest of the characters.

Among the characters studied high positive indirect effect was obtained for number of pods per plant via plant height (0.315), number of leaves (0.428), number of cluster (0.445), number of pod per cluster (0.206), while high negative indirect effect obtained via 100-seed weight (-0.155) and seed density (-0.155). 100-seed weight exerted high positive indirect effect via pod length (0.26), pod diameter (0.284), seed length (0.301), seed diameter (0.248) and seed density (0.310). Such an observation was also reported by Rohman *et al.* (2003) [12], Biradar *et al.* (2007) [4] and Tabassum *et al.* (2010) [17]. The residual effect of path analysis was low (0.137), which shows that few more traits may be included in the study to see the pattern of interaction on seed yield. A greater yield response is obtained when the character for which indirect selection is practiced has a high heritability and a high correlation with yield. Searle (1965) [14] has given the minimum combinations of heritability and correlation coefficient values necessary for indirect selection to be more efficient than direct selection for yield.

Among the characters studied from the path analysis traits viz., number of pod per plant, number of cluster, 100-seed weight and seed density exerted a high magnitude of direct effect on seed yield and also exhibited highly significant and positive correlation with seed yield. Therefore, selection strategy based on these characters for seed yield improvement will be rewarding in mungbean.

Table 2: Correlations between different characters of Mungbean.

Character	Days to 50% flowering	Plant height	No. of leaves	No. of branches	No. of cluster	No. of pods/ cluster	No. of pods/ plant	Pod length	Pod diameter	Pod wall thickness	Seed length	Seed diameter	100-seed weight	Seed density	Seed yield
Days to 50% flowering	1.00														
Plant height	0.20*	1.00													
No. of leaves	0.22*	0.55**	1.00												
No. of branches	0.09	0.38**	0.33**	1.00											
No. of cluster	0.24**	0.48**	0.65**	0.17	1.00										
No. of pods/ cluster	0.03	0.39**	0.21*	0.31**	-0.001	1.00									
No. of pods/ plant	0.24**	0.53**	0.71**	0.29**	0.74**	0.34**	1.00								
Pod length	-0.33**	0.09	-0.11	0.09	-0.01	-0.004	-0.08	1.00							
Pod diameter	-0.29**	0.19*	-0.02	0.17	0.02	0.14	-0.02	0.70**	1.00						
Pod wall thickness	0.01	0.34**	0.18*	0.03	0.15	0.09	0.03	0.37**	0.49**	1.00					
Seed length	-0.28**	-0.004	-0.16	0.02	-0.15	-0.12	-0.19*	0.65**	0.73**	0.27**	1.00				
Seed diameter	-0.23*	0.17	0.01	0.09	-0.01	0.11	-0.06	0.65**	0.77**	0.39**	0.65**	1.00			
100-seed weight	-0.32**	-0.13	-0.15	0.03	-0.22*	-0.04	-0.27**	0.56**	0.61**	0.24**	0.65**	0.53**	1.00		
Seed density	-0.07	-0.18	-0.19*	-0.04	-0.24*	-0.11	-0.26**	0.22*	0.24*	0.12	0.34**	0.21*	0.67**	1.00	
Seed yield	-0.11	0.38**	0.42**	0.31**	0.47**	0.23*	0.55**	0.54**	0.54**	0.34**	0.36**	0.42**	0.52**	0.30**	1.00

* Significant at 5% of level of probability

** Significant at 1% of level of probability

Table 3: Path coefficient analysis showing direct and indirect effect of component characters on seed yield of mungbean

Characters	Correlation with seed yield	Direct effect	Indirect effect via													
			Days to 50% flowering	Plant height	No. of leaves	No. of branches	No. of cluster	No. of pods/ cluster	No. of pods/ plant	Pod length	Pod diameter	Pod wall thickness	Seed length	Seed diameter	100-seed weight	Seed density
Days to 50% flowering	-0.11	-0.07	-	-0.013	-0.014	-0.006	-0.016	-0.002	-0.016	0.022	0.019	-0.001	0.019	0.015	0.021	0.005
Plant height	0.38^{**}	0.04	0.007	-	0.021	0.014	0.018	0.015	0.020	0.003	0.007	0.013	-0.0001	0.006	-0.005	-0.007
No. of leaves	0.42^{**}	-0.03	-0.006	-0.015	-	-0.009	-0.017	-0.006	-0.019	0.003	0.001	-0.005	0.004	-0.0004	0.004	0.005
No. of branches	0.31^{**}	0.07	0.006	0.025	0.021	-	0.011	0.020	0.019	0.006	0.011	0.002	0.002	0.006	0.002	-0.003
No. of cluster	0.47^{**}	0.14	0.033	0.066	0.091	0.023	-	-0.00002	0.103	-0.002	0.003	0.021	-0.020	-0.001	-0.030	-0.033
No. of pods/ cluster	0.23^{*}	0.01	0.0002	0.003	0.001	0.002	0.000	-	0.002	-0.00003	0.001	0.001	-0.001	0.001	-0.0002	-0.001
No. of pods/ plant	0.55^{**}	0.60	0.146	0.315	0.428	0.176	0.445	0.206	-	-0.045	-0.011	0.015	-0.115	-0.035	-0.155	-0.155
Pod length	0.54^{**}	0.27	-0.091	0.024	-0.029	0.025	-0.003	-0.001	-0.021	-	0.193	0.102	0.177	0.177	0.153	0.061
Pod diameter	0.54^{**}	0.07	-0.020	0.013	-0.001	0.012	0.001	0.010	-0.001	0.049	-	0.034	0.051	0.054	0.042	0.017
Pod wall thickness	0.34^{**}	0.06	0.001	0.021	0.011	0.002	0.009	0.005	0.002	0.023	0.030	-	0.017	0.024	0.016	0.007
Seed length	0.36^{**}	-0.09	0.024	0.0003	0.014	-0.002	0.013	0.010	0.017	-0.057	-0.064	-0.024	-	-0.057	-0.057	-0.030
Seed diameter	0.42^{**}	-0.05	0.011	-0.008	-0.001	-0.004	0.0004	-0.005	0.003	-0.031	-0.037	-0.019	-0.031	-	-0.026	-0.010
100-seed weight	0.52^{**}	0.47	-0.147	-0.062	-0.070	0.016	-0.100	-0.017	-0.120	0.260	0.284	0.119	0.301	0.248	-	0.310
Seed density	0.30^{**}	0.13	-0.009	-0.023	-0.025	-0.006	-0.031	-0.014	-0.034	0.029	0.031	0.016	0.044	0.028	0.087	-

Residual factor = 0.137

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