Original Research Article

Assessment of Variability and Character Relationships forSeed Yield in Black Gram[*Vigna mungo* (L.) Hepper]

Abstract

This study aimed to evaluate the variability generated through hybridization using various parameters, including variability, correlation and path analysis.High GCV and PCV values observed for traits such as branches per plant, clusters per plant, pods per plant, and seed yield per plant (g). High heritability coupled with high genetic advance as per cent of mean was recorded for branches per plant, clusters per plant, pods per plant, pod length (cm), 100 seed weight (g), days to maturity, harvest index (%) and seed yield per plant (g). Seed yield per plant(g) exhibited strong positive associations with plant height (cm), pod length (cm), seeds per pod, clusters per plant, pods per plant, and harvest index (%). Pathanalysis highlighted that the highest positive direct effects on seed yield per plant were attributed to pods per plant, followed by clusters per plant and seeds per pod.

Keywordsvariability, correlation analysis and path analysis.

Introduction

Pulses, often referred to as the "Poor Man's Meat" (Nunes *et al.*, 2006), play a crucial role as a primary source of dietary protein for vegetarians. The growing awareness of health and nutrition among people has drawn the attention of plant breeders toward enhancing pulse production rates while emphasizing nutritional aspects. In India, the total pulse production for the year 2021-22 is estimated at 27.69 million tonnes (Anonymous, 2022). Legumes, including pulses, are well-suited to agronomic cropping systems, providing nutritionally significant crops with high economic value, and they also contribute to soil fertility improvement by fixing atmospheric nitrogen.Among the pulse crops, black gram [*Vigna mungo* (L.) Hepper, 2n = 22] holds a prominent position and is cultivated worldwide. Black gram is a self-pollinated, short-duration, fast-growing warm-weather crop, primarily grown in rice fallow areas under rainfed conditions. The major challenges in achieving higher productivity in black gram cultivation include the lack of suitable crop types, limited genetic variability, a narrow genetic base (resulting in a higher degree of relativeness among varieties), and susceptibility to both biotic and abiotic stresses (Souframanien*et al.*, 2004). Genetic variability is a crucial resource for improving yield and other complex polygenic traits (Swamy *et al.*, 2004). The success of selection depends on the extent and nature of genetic variability within the population (Johnson *et al.*, 1995).Correlation coefficients provide valuable insights into the direction and strength of the associations and interactions between yield and its components (Vyas *et al.*, 2018), facilitating the selection of the most suitable combinations of traits for improving black gram yield (Kumar *et al.*, 2003). Path coefficient analysis is designed to quantify the interrelationships between yield components and their direct and indirect effects on seed yield (Sushmitharaj*et al.*, 2018).For crop improvement, understanding genetic variability for specific economic traits, their heritability, and genetic advances are crucial in developing high-yielding black gram genotypes in breeding programs (Rao *et al.*, 2006). Given the current status of black gram cultivation and future prospects, plant breeders aim to develop superior germplasm with stable and high yield potential, along with broader adaptability to different cultivation regions. In pursuit of characterizing superior germplasm, the present research project, titled "Genetic variability analysis for yield and its attributes in F_4 Progenies of Black Gram [*Vigna mungo* (L.) Hepper]," was designed to assess the significant variability of agro-morphological traits that can be harnessed for future agricultural improvement.

Materials and Methods

The experiment was conducted at the Research Farm of the Department of Genetics and Plant Breeding, Navsari Agricultural University, Navsari, during the late *kharif* season of 2022-2023. A total of hundred F_4 progenies, resulting from the cross between NUK-15-02 and NUK-15-07, were used for the study. The experimental design employed was the Augmented Block Design, with four standard checks, namely NUK-15-02, NUK-15-07, GU-1, and GU-3, included in the experiment. These checks were replicated in five blocks such that in each row, there were 20 plants of a single progeny, with a spacing of 20 cm between rows and 10 cm between individual plants within the row. Standard agronomic practices were meticulously followed to cultivate healthy and uniform crops. Observations were recorded for ten randomly selected plants from each progeny, excluding the border plants. For the traits days to 50% flowering and days to maturity, data were collected on a population basis.A total of eleven quantitative traits were assessed, including days to 50% flowering, plant height (cm), branches per plant, clusters per plant,pods per plant,seeds per pod,pod length (cm),100 seed weight (g),seed yield per plant(g),days to maturity and harvest index (%). The collected data were subjected to standard statistical analyses to compute various parameters related to genetic variability. These parameters included the genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) (Burton, 1952), heritability (Allard, 1960), genetic advance (Johnson, 1955), and correlation and path analysis (Dewey and Lu, 1959).This research aimed to provide valuable insights into the genetic diversity and interrelationships between various traits in black gram progenies, contributing to the development of improved varieties with higher yield potential and adaptability for different regions of cultivation.

Results and Discussion

Thevariability parameters for various traits in F_4 progenies of black gram was presented in (Table 1, Fig 1 and Fig 2). The genetic coefficient of variation (GCV) ranged from 3.94(for days to 50% flowering) to 37.79(for pods per plant), while the phenotypic coefficient of variation (PCV) ranged from 4.09(for days to 50% flowering) to 39.05 (for single plant yield). High GCV and PCV values were observed for branches per plant (32.29 and 32.64), clusters per plant (36.08 and 37.26), pods per plant (37.79 and 38.17), and seed yield per plant (34.70 and 39.05), respectively. These findings align with previous studies by Panigrahi *et al.,* (2014), Gowsalya*et al.*, (2016)and Patel and Madhu Bala(2020b). Conversely, days to 50% flowering (3.94 and4.09) and seeds per pod (7.97 and 9.86) exhibited low GCV and PCV values, similar with observations of Panigrahi *et al*., (2014), Gowsalya*et al*., (2016) and Bishnoi *et al.*, (2017). Pod length displayed moderate values for GCV (10.31) and PCV (10.83), while plant height (9.48 and 14.72) and days to maturity (9.97 and 10.0) exhibited low GCV and moderate PCV, consistent with the findings of Kiran and Lal (2021). For 100seed weight (19.33 and 20.25) and harvest index (15.93 and 20.34), moderate GCV and high PCV were observed, which are in par with results reported by Panda *et al*., (2017). The relatively high genetic advance as percent of mean in conjunction with heritability, presents a promising opportunity for the improvement of all yield-related traits.

The outcomes of this study demonstrate the significance of heritability and its implications for genetic improvement in black gram. The heritability values ranged from 41.48 % for plant height to 99.29 % for days to maturity. Notably, traits like pods per plant (98.03% and 43.85%), pod length (90.62% and 20.20%), branches per plant (97.83% and 65.88%), clusters per plant (93.75% and 72.07%), 100 seed weight (91.07% and 38.05%), days to maturity (99.29% and 20.50%), harvest index (61.35% and 25.74%), and seed yield per plant (78.95% and 63.60%) displayed both high heritability and high genetic advance as percent of mean, suggesting a substantial role of additive gene effects and making them effective for selection. Similar results have been reported by Panigrahi *et al.,* (2014), Gowsalya*et al*., (2016), and Kondagari*et al.*, (2017).In contrast, traits such as seed per pod exhibited high heritability (65.32% and 13.28%) coupled with moderate genetic advance as percent of mean, indicating that these traits are primarily under genetic control and can be improved through phenotypic selection. This pattern aligns with findings reported by Panigrahi *et al.*, (2014) and Kondagari*et al.*, (2017). Conversely, days to 50% flowering showed high heritability (92.88%) but low genetic advance as percent of mean (7.83%), suggesting less environmental influence on this trait. Plant height exhibited moderate heritability (41.48%) and genetic advance as per cent of mean (12.59%), indicating the potential involvement of non-additive gene action. Similarly, high heritability coupled with low genetic advance as per cent of mean implies the presence of non-additive gene action.

Correlation analysis reveals the nature and strength of relationships between yield-related traits.Phenotypic correlation coefficients(Table 2)were calculated for 11 traits in F_4 progenies of black gram to assess their associations with seed yield per plant. Seed yield per plant displayed significant and positive correlations with plant height (0.281), clusters per plant (0.273), and pods per plant (0.526), consistent with findings from studies by Kumar *et al.*, (2014), Panigrahi *et al.*, (2014), Gowsalya*et al.*, (2016) and Patel and Madhu Bala (2020a). Additionally, positiveand significant correlations were observed with pod length, seeds per plant, and harvest index similar to the correlation patterns identified by Panigrahi *et al.*, (2014) for pod length. These correlation findings suggest that improving seed yield in black gram would benefit from selecting plant types with high plant height, more clusters per plant, and more pods per plant. Furthermore, traits such as pod length, seed per pod, and harvest index can also serve as selection criteria for enhancing seed yield in black gram.

Path coefficient analysis provides insights into their direct and indirect effects on yield. The results (Table 3 and Fig.3) of path coefficient analysis revealed that days to 50% flowering exhibited a non-significant but negative correlation with seed yield per plant (-0.078) and had a negative direct effect on seed yield per plant (-0.1376). However, it exerted positive indirect effects on clusters per plant, pods per plant, pod length, seeds per pod, 100 seed weight, days to maturity, and harvest index. Similar negative and direct effects were reported in previous studies by Sathees *et al.*, (2019) and Rana *et al.*, (2022). Plant height showed a positive and highly significant correlation with seed yield per plant (0.281) and had a positive direct effect on seed yield per plant (0.0655), similar with the positive and direct effects reported by Kumar *et al.*, (2014), Partap *et al.*, (2019)and Sathees *et al.*, (2019). Branches per plant exhibited a positive but non-significant correlation with seed yield per plant (0.179) and had a negative direct effect on seed yield per plant (-0.2496). It exerted positive indirect effects on plant height, clusters per plant, pods per plant, days to maturity and harvest index. This pattern agreed with previous findings by Kumar *et al.*, (2014) and Sathees *et al.*, (2019). Clusters per plant displayed a positive and highly significant correlation with seed yield per plant (0.273) and had a positive direct effect on seed yield per plant (0.2231), consistent with positive direct effects reported by Kumar *et al.*, (2014), Sathees *et al.*, (2019), Kiran and Lal (2021) and Rana *et al.*, (2022). Pods per plant exhibited a positive and highly significant correlation with seed yield per plant (0.526) and had a positive direct effect on seed yield per plant (0.4869). Similarly, pod length showed a positive and significant correlation with seed yield per plant (0.252) and had a positive direct effect on seed yield per plant (0.1352). These results were in par with findings reported by Partap *et al.*, (2019), Sathees *et al.*, (2019), Kiran and Lal (2021)and Rana *et al,*. (2022) for pods per plant and pod length.100 seed weight displayed a positive but statistically non-significant correlation with seed yield per plant (0.094) and exhibited a positive direct effect on seed yield per plant (0.0597). In contrast, days to maturity showed a significant negative correlation with seed yield per plant (-0.164) and had a negative direct effect on seed yield per plant (-0.1844). Harvest index demonstrated a positive and significant correlation with seed yield per plant (0.208) and had a positive direct effect on seed yield per plant (0.0177). This aligns with similar positive and direct effects of harvest index (%) on seed yield per plant reported by Kumar *et al.,* (2014), Partap *et al.,* (2019), Kiran and Lal (2021) and Rana *et al.*,(2022). Among the traits analyzed, branches per plant exhibited the highest negative direct effects on seed yield per plant, followed by days to maturity and days to 50% flowering, indicating their relatively lower significance in selection for higher seed yield in black gram. Conversely, the traits with the highest positive direct effects on seed yield per plant were pods per plant, followed by clusters per plant and seeds per pod. Therefore, special attention should be given to these three characters during the selection process to enhance seed yield per plant in black gram. Path coefficient analysis for seed yield revealed a residual effect of 0.57, suggesting that future studies should consider incorporating additional traits to capture a broader spectrum of available variation.

Conclusion

In summary, the findings of this study indicate thatthere is a significant amount of variability within the studied black gram progenies.Traits with high heritability and high genetic advance, suggesting the significant role of additive gene effects and show effective selection and improvement. Seed yield per plant (g) is positively correlated withyield-related components such as plant height (cm), pod length (cm), seeds per pod, clusters per plant, pods per plant, and harvest index (%). This indicates that these traits can be simultaneously improved with seed yield per plant through direct selection. Path analysis highlights that the most influential direct effects on seed yield per plant are exhibited by pods per plant, followed by clusters per plant and seeds per pod.In conclusion, the results of this study provide valuable insights into the genetic variability, heritability, and interrelationships among various traits in black gram F_4 progenies. These findings can guide breeding programs aimed at enhancing the yield and agronomic characteristics of black gram varieties through effective selection strategies.

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Table 1: Measures of variability parameters for different characters in F_4 progenies of black gram

Character	Range		σ^2_g	σ^2_p	GCV (%)	PCV (%)	h^2_{bs}(%)	GA	GAM as % of mean
	Min.	Max.							
Days to 50% flowering	58.00	66.00	5.87	6.32	3.94	4.09	92.88	4.82	7.83
Plant height (cm)	32.10	58.01	20.10	48.46	9.48	14.72	41.48	5.96	12.59
Branches per plant	1.30	9.20	3.79	3.87	32.29	32.64	97.83	3.97	65.88
Clusters per plant	6.80	29.00	35.17	37.51	36.08	37.26	93.75	11.85	72.07
Pods per plant	13.80	88.40	460.8	470.1	37.79	38.17	98.03	43.85	77.20
Pod length (cm)	3.56	5.80	0.19	0.21	10.31	10.83	90.62	0.85	20.20
Seeds per pod	4.40	8.00	0.23	0.36	7.97	9.86	65.32	0.81	13.28
100 Seed weight (g)	1.80	6.50	0.75	0.82	19.33	20.25	91.07	1.70	38.05
Days to maturity	87.00	123.0	101.6	102.3	9.97	10.01	99.29	20.73	20.50
Harvest index (%)	19.84	63.96	60.86	99.20	15.93	20.34	61.35	12.61	25.74
Seed yield per plant (g)	2.66	19.30	22.13	28.03	34.70	39.05	78.95	8.62	63.60

σ^2_g = Genotypic variance σ^2_p = Phenotypic variance GCV = Genotypic coefficient of variation

PCV = Phenotypic coefficient of variation h^2_{bs} (%) = Heritability (Broad sense) GA = Genetic advance

GAM = Genetic advance as per cent of mean (%)

Table 2: Phenotypic correlation coefficients of seed yield per plant with other characters in F_4 progenies of black gram

Traits	**DTF**	**PH**	**BPP**	**CPP**	**PPP**	**PL**	**SPP**	**SW**	**DTM**	**HI**	**SY**
DTF	**1.000**										
PH	-0.012^{NS}	**1.000**									
BPP	0.035^{NS}	0.841**	**1.000**								
CPP	0.104^{NS}	0.790**	0.771**	**1.000**							
PPP	0.004^{NS}	0.515**	0.448**	0.450**	**1.000**						
PL	0.082^{NS}	0.028^{NS}	-0.033^{NS}	-0.011^{NS}	0.166^{NS}	**1.000**					
SPP	0.032^{NS}	-0.134^{NS}	-0.160^{NS}	-0.137^{NS}	-0.056^{NS}	0.212*	**1.000**				
SW	0.107^{NS}	-0.099^{NS}	-0.093^{NS}	-0.079^{NS}	-0.022^{NS}	0.120^{NS}	0.060^{NS}	**1.000**			
DTM	-0.098^{NS}	-0.081^{NS}	-0.096^{NS}	-0.051^{NS}	-0.005^{NS}	0.079^{NS}	0.008^{NS}	-0.175^{NS}	**1.000**		
HI	0.077^{NS}	0.746**	0.857**	0.749**	0.436**	0.008^{NS}	-0.054^{NS}	-0.099^{NS}	-0.017^{NS}	**1.000**	
SY	-0.078^{NS}	0.281**	0.179^{NS}	0.273**	0.526**	0.252*	0.220*	0.094^{NS}	-0.164^{NS}	0.208*	**1.000**

** Significant at 1% level of probability, * Significant at 5.0 % level of probability

DTF = Days to 50% flowering PH = Plant height (cm) BPP = Branches per plant CPP = Clusters per plant

PPP = Pods per plant PL = Pod length (cm) SPP = Seeds per pod SW = 100 Seed weight (g)

DTM = Days to maturity HI = Harvest index SY = Seed yield per plant (g)

Table 3: Phenotypic path coefficient analysis of component characters towards seed yield per plant in F_4 progenies of black gram

Traits	DTF	PH	BPP	CPP	PPP	PL	SPP	SW	DTM	HI	Correlation with seed yield per plant
DTF	**-0.1376**	-0.0007	-0.0087	0.0234	0.0017	0.0111	0.0070	0.0064	0.0180	0.0013	**-0.078^{NS}**
PH	0.0015	**0.0655**	-0.2099	0.1763	0.2505	0.0037	-0.0295	-0.0059	0.0149	0.0132	**0.281****
BPP	-0.0048	0.0551	**-0.2496**	0.1721	0.2183	-0.0044	-0.0353	-0.0055	0.0177	0.0152	**0.179^{NS}**
CPP	-0.0143	0.0518	-0.1925	**0.2231**	0.2191	-0.0015	-0.0302	-0.0046	0.0094	0.0133	**0.273****
PPP	-0.0004	0.0337	-0.1119	0.1004	**0.4869**	0.0224	-0.0124	-0.0013	0.0008	0.0077	**0.526****
PL	-0.0113	0.0018	0.0081	-0.0025	0.0807	**0.1352**	0.0468	0.0071	-0.0146	0.0001	**0.252***
SPP	-0.0043	-0.0087	0.0398	-0.0305	-0.0274	0.0286	**0.2211**	0.0035	-0.0014	-0.0009	**0.220***
SW	-0.0148	-0.0064	0.0232	-0.0175	-0.0105	0.0161	0.0131	**0.0597**	0.0323	-0.0017	**0.094^{NS}**
DTM	0.0134	-0.0053	0.0240	-0.0114	-0.0022	0.0107	0.0017	-0.0104	**-0.1844**	-0.0003	**-0.164^{NS}**
HI	-0.0105	0.0489	-0.2139	0.1670	0.2124	0.0010	-0.0119	-0.0059	0.0031	**0.0177**	**0.208***

** Significant at 1.0 per cent level of probability, * Significant at 5.0 per cent level of probability, Residual =0.57, Bold diagonal figures are the direct effects

DTF = Days to 50% flowering
PH = Plant height (cm)
BPP = Branches per plant
CPP = Clusters per plant
PPP = Pods per plant
PL = Pod length (cm)
SPP = Seeds per pod
SW = 100 Seed weight (g)
DTM = Days to maturity
HI = Harvest index (%)

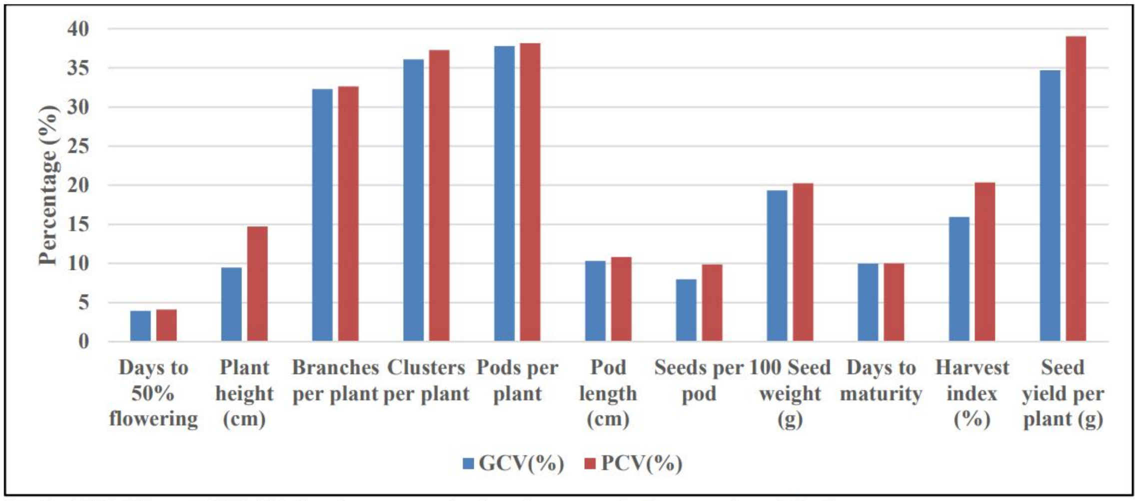

Fig 1: GCV (%) and PCV (%) for eleven quantitative characters in F_4 progenies of black gram

GCV (%) = Genotypic coefficient of variation PCV (%) = Phenotypic coefficient of variation

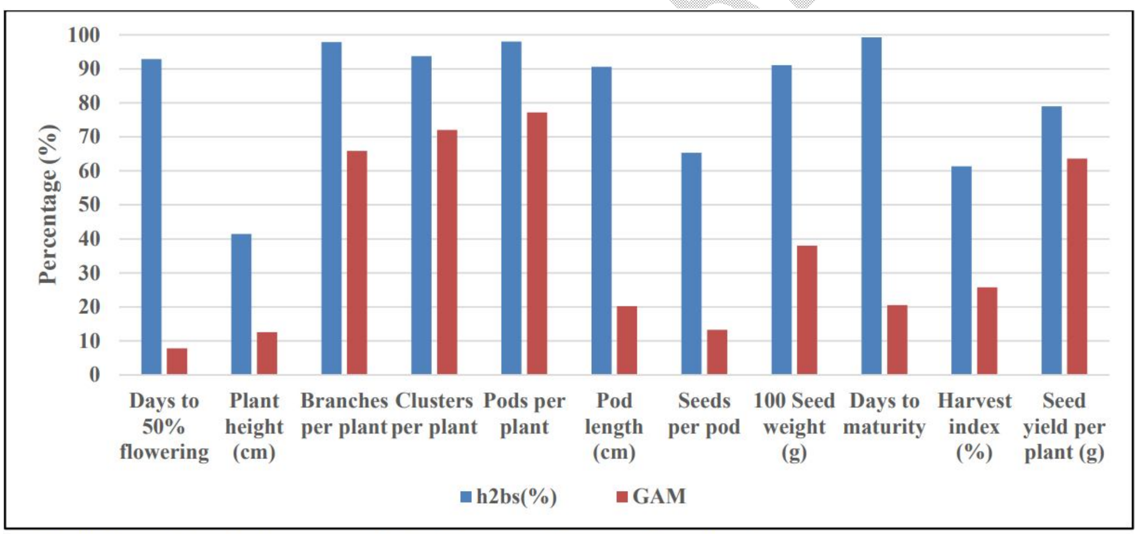

Fig 2: GAM and $h^2_{(bs)}$ for eleven quantitative characters in F_4 progenies of black gram

GAM = Genetic advance as per cent of mean (%) $h^2_{(bs)}$ (%) = Heritability (Broad sense) (%)

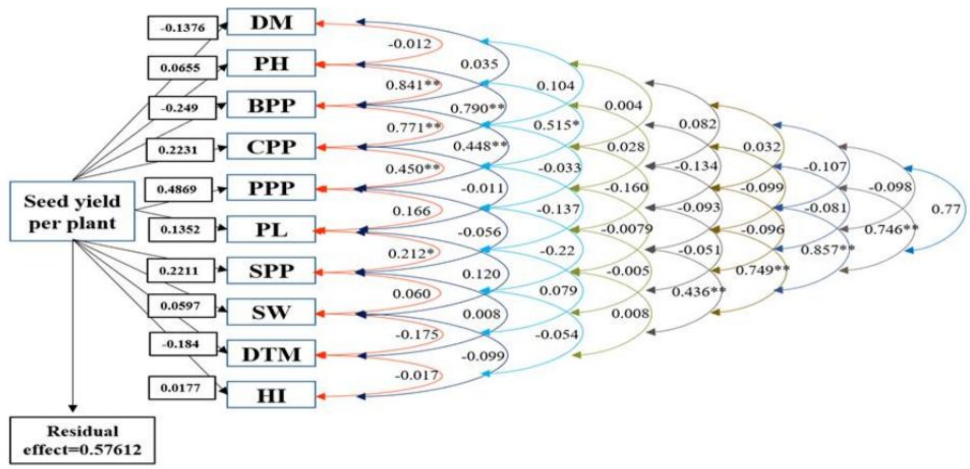

Fig 3. Phenotypic path diagram for seed yield per plant (g) in F_4 progenies of black gram

DTF = Days to 50% flowering	PH = Plant height (cm)	BPP = Branches per plant	CPP = Clusters per plant	PPP = Pods per plant
PL = Pod length (cm)	SPP = Seeds per pod	SW = 100 Seed weight (g)	DTM = Days to maturity	HI = Harvest index (%)