STUDIES ON GENETIC VARIABILITY, CORRELATION AND PATH ANALYSIS IN Greengram [*Vigna radiata*(L.)Wilczek]

Abstract

Mungbean (Vigna radiata (L.) Wilczek) is an important pulse crop cultivated across Asia and other regions, valued for its high protein content and adaptability to various climates. This study aimed to assess the genetic variability, heritability, and genetic advance of 12 agronomic traits in mungbean, using 10 genotypes crossed in a half-diallel design, with 45 F_1 hybrids. Field trials were conducted in randomized block design with three replications during Kharif 2023 at the Crop Research Centre, Meerut, India. Observations were recorded for traits including plant height, pods per plant, 100-seed weight, and grain yield. High genotypic and phenotypic coefficients of variation were observed for the number of pods per plant and MYMV severity, while traits like grain yield and protein content showed moderate to low variability. Heritability was high for most traits, indicating strong genetic control, with genetic advance highest for the number of pods per plant. Genotypic correlation and path coefficient analysis revealed positive correlations between grain yield and key traits such as 100-seed weight and pod length. These findings provide valuable insights for the selection of high-yielding mungbean genotypes in breeding programs.

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Keywords: Mungbean, variability, correlation, path coefficient analysis, GCV and PCV.

Introduction

Mungbean (*Vigna radiata*(L.)Wilczek) is sometimes referred to as greengram. This ancient, well-known pulse crop, which is diploid and has 2n=2x=22 chromosomes, is a member of the Papilionoideae family and is native to South East Asia **(Mogotsi, 2006).** Vigna radiata is divided into three subgroups: Vigna radiata subsp. radiata, which is cultivated, and Vigna radiata subsp. sublobata, which is wild (Vigna radiata subsp. glabra). It is a little green bean with a circular form that is native to India and is widely grown throughout Asia, including Bangladesh, India, Thailand, Laos, Vietnam, Cambodia, Indonesia, Malaysia, and South China. One of the most popular edible legumes cultivated in Asia is mungbean, which has a significant impact on both human diets and agricultural cultivation systems.

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As a short-day plant, greengrams thrive best in warm, subtropical climates with an average temperature of 22 to 35 ºC and an annual rainfall of 60 to 100 cm. These regions are best suited for crop production when the mean sea level is between 1800 and 2000 meters. Sandy loam or deeply well-drained soils were necessary for its cultivation. Mungbean is an annual plant that is either upright or suberect, has branches, and tends to twine in the top branches. It typically reaches a height of 40 to 120 cm **(Basu et al.,2023)** The trifoliate leaf arrangement has big, oval, fully or sparingly lobed, membranous leaflets with hairs on both sides. The length of the pods varies from 10 to 15 cm; they are usually cylindrical, straight, or slightly curved, and the seeds are tiny, globular, or oblong, usually green but sometimes speckled with yellow-brown.

Worldwide, Mungbean is a crop with a short growing season that is commonly cultivated in temperate, subtropical, and tropical climates. Its cultivation is appropriate for a variety of cropping systems, the majority of which are dominated by staple food crops like wheat and rice. These crops are widely grown in many Asian nations, sub-Saharan Africa, arid regions of southern Europe, warmer parts of Canada, and the United States **(Nair et al., 2013; Hou et al., 2019; Kumar et al., 2024 and Chand et al., 2024).**Mungbean, one of the pulses that can withstand mild drought and heat stress, is important for rainfed agriculture in arid and semi-arid regions **(Pratap et al., 2019).**

Mungbean is an annual crop that is highly branched, measured 60-76 cm tall **(Oplinger et al. 1990),** with a slight tendency to twine in upper branches. The central stem of this crop is roughly erect, but the side branches are semi-erect. Mungbean can be consumed as whole grains, dal, or sprouted form, as it is a source of high-quality protein which is an excellent complement to rice in respect to balanced human nutrition.

It contributes significantly to diets in terms of proteins (240 g/kg), carbs (630 g/kg), and a variety of micronutrients **(Nair et al., 2013).** Of the 20–24 percent protein found in mungbean, the two main types are albumin and globulin, which make up almost 60% and 25% of the protein, respectively. Aside from that, it is frequently prescribed for Beriberi and is a rich source of vitamin B.

Materials and Methods

Materials for the present investigation comprised ten genotypes of mungbean *viz.*,PM-3, PM-5, PM-9, PM-4, WHM-16, IPM-0219, PUSA-9531, SMM 15-72, Indor Moong and MH-521collected from the department of Genetics and Plant Breeding. All the possible 45 F_1's hybrids, excluding reciprocals made among these ten parents during *kharif* season 2022. The research centre situated at an elevation of about 237 meters above mean sea level $29^o01'$ N latitude and $77^o45'$ E longitude, representing the North Western Plain Zone.Parents and crosses were sown at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut during the season of *Kharif* 2023. Seed of each of the parents and F_1's sown by hand dibbling method in two rows plot. The rows had 3 m long and spaced 30 cm apart. The plant to plant spacing maintained at 10 cm, and all the recommended agronomic inputs and practices were followed during the season to raise the healthy crops.

Observations recorded on five randomly selected competitive plants from each parent and F_1's populations in each replication for twelve characters namely, days to 50% flowering, days to maturity, plant height (cm), number of primary branches per plant, pod length (cm), number of pods per plant, MYMV, number of seeds per pod, protein content (%), 100 seed weight (gm), harvest index (%) and grain yield per plant (gm). The selected plants tagged and properly labelled for recording the observations.

Heritability was calculated using the formula suggested by **Crumpacker and Allard (1962)** based on the component analysis. The genetic advance was calculated using the formula given by **Robinson et al. (1949)**, estimation of correlation coefficients by **Searle (1961)**, path coefficient analysis by **Dewey and Lu.(1959)** and genotypic coefficient of variation by (**Fisher, 1918).**

Comment [H4]: Include the name of software or platform used in data analysis

Result and Discussion

1. Variability, heritability and genetic advance as a percentage of mean

1.1. Genotypic coefficient of variation (GCV)

High percentage of genotypic coefficient of variation (more than 25%) was recorded for no of pods/plant (27.78) and MYMVS (18.89), and moderate percentage of genotypic coefficient of variation (10-25%) was recorded for no of primary branches/plant (12.61) and 100 seed weight (g) (11.59). Plant Height (cm) (9.72), days to maturity (9.05), number of pods per plant 8.45, pod length (cm) (7.22), harvest index (%) (6.80), grain yield/plant (g) (5.96) and protein content (%) (4.86) showed low genotypic coefficient of variation (<10%). Similar results were found by [**Rahim et al., 2010;Surashe et al. 2017; Varma et al., 2018; Priya et al. 2024].**

Comment [H5]: Please include a detail discussion regarding how the GCV will affect the phenotypic expression of that trait. What are the consequence if GCV> PCV and *vise versa.*

1.2. Phenotypic coefficient of variation (PCV)

High percentage of phenotypic coefficient of variation (more than 25%) was recorded for number of pods/plant (28.11) and MYMVS (28.08) and moderate percentage of phenotypic coefficient of variation (10-25%) was recorded for number of primary branches/plant (12.96) and 100 seed weight (g) (12.37). Plant height (cm) (9.91), days to maturity (9.31), number of pods per plant (9.60), pod length (cm) (8.05), grain yield/plant

(g) (8.35) harvest index (%) (7.13) and protein content (%) (5.40) showed low phenotypic coefficient of variation (<10%).Similar observations were also reported by [**Payasi 2015; Anand et al. 2016; Kumar et al. 2022; Kumar, 2023].**

1.3. Heritability (h^2)

High heritability (> 60%) was found for all the characters *i.e.*, number of pods/plant (97.64), plant height (cm) (96.08), number of primary branches/plant (94.64), days to maturity (94.57), days to 50% flowering (94.53), harvest index (%) (91.19), 100 seed weight (g) (87.78), protein content (%) (80.87), pod length (cm) (80.42) and number of pods per plant (77.53) except grain yield/plant (g) (50.98) and MYMVS (45.26) which showed the moderate heritability. Similar observations were also reported by [**Babu et al. 201; Goyal et al. 2022; Yoseph et al. 2022;Kumar et al., 2023; Saravanan et al. 2023].**

1.4. Genetic advance (GA)

Expected genetic advance expressed as a percentage of mean was observed high (> 20%) forno of pods/plant (56.55), MYMVS (26.18), no of primary branches/plant (25.28), MYMVS (26.18), days to 50% flowering (23.15) and100 seed weight (g) (22.36),whereas moderate genetic advance as percentage of mean (10-20%) expressed for days to maturity (18.13), number of pods per plant (15.33), pod length (cm) (13.34), harvest index (%) (13.39) and low for grain yield/plant (g) (8.77) and protein content (%) (9.00).these characters have also been reported earlier by**[Asari et al. (2019), Majhi et al. (2020), Singh et al. (2022), Mundiyara et al. (2024)].**

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Comment [H7]: Include how the heritability coupled with genetic advance impact the breeding programme for a particular trait.

2. Genotypic correlation coefficient

The genotypic correlation coefficient (**Table No.-2)** revealed that grain yield per plant was highly significant positively correlated with 100 seed weight (g) (0.681**), no of seeds per pod (0.567**), pod length (cm) (0.553**), plant height (cm) (0.383**) and no of primary branches per plant (0.373**). It was found significant positively correlated with no of pods per plant (0.171*). The positive but non-significant correlation was observed for days to 50% flowering 0.139, harvest index (%) 0.131, protein content (%) 0.069 and days to maturity 0. 054.the negative but non-significant correlation was observed for MYMVS (-0.05).These results are similar to earlier reports of **[Khalid et al. (2021), Kumar et al. (2021), Singh et al. (2022), Kadam et al. (2023), Verma et al. (2023), Khan et al. (2024)].**

3. Path Coefficient Analysis (Direct and indirect effects).

The yield contributing characters were considered in path coefficient analysis to estimate their direct and indirect effect on seed yield. In the research study, path analysis was used to work out the direct and indirect effects of yield contributing characters on yield in 55 genotypes and the results are presented in Table No.-3.

Comment [H8]: Include why correlation and path analysis study are essential.

3.1.1. Direct effect

The genotypic path coefficient analysis revealed maximum positive direct effect was depicted by **100 seed weight g (0.5269)**, **pod length cm (0.4312)**, **number of pods per plant (0.2608)**, **plant height cm (0.2485)**, **protein content % (0.2064)**, **number of primary branches per plant (0.0845)**, **days to maturity (0.0602)**, **harvest index % (0.0719)** and **days to 50% flowering (0.0793).** However, negatively significant direct effect was observed for **no of pods/plant (-0.4391)** and **MYMVS (-0.0208)**.These results were similar to earlier reported by [**Kumar et al., 2018;Manivelan et al., 2019; Ahmad and Belwal, 2020; Dash et al., 2021; Joshi et al., 2021].**

4.7.1.2 Indirect effect

Days to 50% flowering expressed indirect and positive effect by protein content % no of primary branches/plant, plant height cm, 100 seed weight (g), and harvest index %.**Days to maturity** was affected indirectly and positively by the number of pods per plant, 100 seed weight, protein content, number of primary branches per plant, plant height, and pod length.Plant height showed an indirect and positive effect by pod length, the number of pods per plant, harvest index, 100 seed weight, days to maturity, MYMVS, days to 50% flowering, and the number of primary branches per plant.**Number of primary branches per plant** revealed an indirect and positive effect by 100 seed weight, the number of pods per plant, pod length, days to 50% flowering, days to maturity, and plant height.**Pod length** was affected indirectly and positively by plant height, the number of pods per plant, 100 seed weight, the number of primary branches per plant, and days to maturity.**Number of pods per plant** showed an indirect and positive effect by days to 50% flowering and harvest index.**MYMVS** was affected indirectly and positively by pod length, protein content, days to maturity, days to 50% flowering, and the number of primary branches per plant.Similar observations were also reported by **[Ramakrishnan et al., 2018; Asari et al.,**

2019;Manivelan et al., 2019; Ahmad and Belwal, 2020; Dash et al., 2021; Khatik et al., 2022; Kumar et al., 2023].

Number of seeds per pod expressed indirect and positive effects by 100 seed weight, the number of primary branches per plant, the number of pods per plant, pod length, days to maturity, plant height, and MYMVS.**Protein content** was revealed to have an indirect and positive effect by days to maturity, the number of pods per plant, days to 50% flowering, and harvest index.**100 seed weight** was affected indirectly and positively by MYMVS, plant height, days to 50% flowering, and protein content. **Harvest index** showed an indirect and positive effect by grains per panicle, days to maturity, days to 50% flowering, panicle length, grain length-to-width ratio, biological yield per plant, and plant height. These findings are by the results obtained in mungbean by**[Azam et al. (2018), Joshi et al. (2021, Satyanarayana et al. (2022), Thonta (2023), Srivastava et al. (2024)].**

Conclusion

This study provides significant insights into the genetic variability, heritability, and genetic advance of various agronomic traits in mungbean. The high heritability observed for most traits, including plant height, number of pods per plant, and 100-seed weight, suggests strong genetic control and potential for effective selection in breeding programs. The genotypic and phenotypic coefficients of variation indicated substantial variability for traits like the number of pods per plant and MYMV severity, highlighting these as critical targets for genetic improvement. Positive correlations between grain yield and traits such as 100-seed weight and pod length further emphasize their importance in enhancing mungbean productivity. Overall, the findings underscore the potential for developing high-yielding mungbean varieties through strategic selection and breeding, contributing to improved dietary protein intake and sustainable agriculture in diverse climatic regions.

Reference

Comment [H9]: Arrange according to journal guidelines

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Table- 1. Phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability and genetic advance as % of mean in Greengram.

SI. No.	Genotypes	GCV (%)	PCV (%)	Heritability (%)	Genetic Advance	Genetic Advance as % of mean
1.	Days to 50% flowering	11.56	11.89	94.53	8.50	23.15
2.	Days to maturity	9.05	9.31	94.57	11.91	18.13
3.	Plant height (cm)	9.72	9.91	96.08	9.21	19.62
4.	No of pri. Br/plant	12.61	12.96	94.64	1.02	25.28
5.	Pod length (cm)	7.22	8.05	80.42	1.02	13.34
6.	No of pods/plant	27.78	28.11	97.64	15.40	56.55
7.	MYMVS	18.89	28.08	45.26	3.87	26.18
8.	No of seeds/pod	8.45	9.60	77.53	1.61	15.33
9.	Protein content (%)	4.86	5.40	80.87	2.11	9.00
10.	100 Seed weight (g)	11.59	12.37	87.78	0.73	22.36
11.	Harvest index (%)	6.80	7.13	91.19	3.94	13.39
12.	Grain yield/plant (g)	5.96	8.35	50.98	0.74	8.77

Table-2. Estimates of Genotypic correlation coefficients for different traits in Greengram.

Parent/Hybrids	Days to 50% flowering	Days to maturity	Plant height (cm)	No of pri. Br/plant	Pod length (cm)	No of pods/plant	MYMVS	No of seeds/pod	Protein content (%)	100 Seed weight (g)	Harvest index (%)	Grain yield/plant (g)
Days to 50% flowering	1.000	-0.195*	0.024	0.103	-0.188*	-0.324**	-0.037	-0.193*	0.119	0.036	0.022	0.139
Days to maturity			0.046	0.094	0.043	0.425**	-0.050	0.172*	0.165*	0.167*	-0.133	0.054
Plant height (cm)				0.010	0.448**	0.274**	0.029	0.129	-0.090	0.063	0.124	0.383**
No of pri. Br/plant					0.189*	0.328**	-0.034	0.367**	-0.113	0.509**	-0.089	0.373**
Pod length (cm)						0.430**	-0.127	0.247**	-0.060	0.275**	-0.058	0.553**
No of pods/plant							0.052	0.365**	0.147	0.421**	-0.244**	0.171*
MYMVS								0.101	-0.108	0.056	0.221**	-0.050
No of seeds/pod									-0.078	0.613**	-0.038	0.567**
Protein content (%)										-0.031	0.002	0.069
100 Seed weight (g)											-0.049	0.681**
Harvest index (%)												0.131
Grain yield/plant (g)												1.000

*, ** significant at 5% and 1% level, respectively

Table-3. Estimates of (Genotypic) direct and indirect effects of different characters on yield per plant in Greengram.

Parent/Hybrids	Days to 50% flowering	Days to maturity	Plant height (cm)	No of pri. Br/plant	Pod length (cm)	No of pods/plant	MYMVS	No of seeds/pod	Protein content (%)	100 Seed weight (g)	Harvest index (%)	Grain yield/plant (g)
Days to 50% flowering	**0.0793**	-0.0118	0.0061	0.0087	-0.0811	0.1424	0.0008	-0.0505	0.0247	0.0188	0.0016	0.139
Days to maturity	-0.0155	**0.0602**	0.0115	0.0080	0.0185	-0.1866	0.0010	0.0448	0.0340	0.0881	-0.0096	0.054
Plant height (cm)	0.0019	0.0028	**0.2485**	0.0008	0.1931	-0.1203	-0.0006	0.0337	-0.0186	0.0330	0.0089	0.383**
No of pri. Br/plant	0.0081	0.0057	0.0024	**0.0845**	0.0813	-0.1440	0.0007	0.0956	-0.0234	0.2682	-0.0064	0.373**
Pod length (cm)	-0.0149	0.0026	0.1113	0.0159	**0.4312**	-0.1889	0.0026	0.0646	-0.0124	0.1452	-0.0041	0.553**
No of pods/plant	-0.0257	0.0256	0.0681	0.0277	0.1855	**-0.4391**	-0.0011	0.0951	0.0303	0.2220	-0.0176	0.171*
MYMVS	-0.0030	-0.0030	0.0072	-0.0029	-0.0547	-0.0228	**-0.0208**	0.0262	-0.0223	0.0297	0.0159	-0.050
No of seeds/pod	-0.0153	0.0103	0.0321	0.0310	0.1067	-0.1601	-0.0021	**0.2608**	-0.0162	0.3228	-0.0028	0.567**
Protein content (%)	0.0095	0.0099	-0.0224	-0.0096	-0.0260	-0.0644	0.0022	-0.0204	**0.2064**	-0.0166	0.0001	0.069
100 Seed weight (g)	0.0028	0.0101	0.0156	0.0430	0.1188	-0.1850	-0.0012	0.1598	-0.0065	**0.5269**	-0.0036	0.681**
Harvest index (%)	0.0017	-0.0080	0.0308	-0.0075	-0.0248	0.1072	-0.0046	-0.0100	0.0004	-0.0260	**0.0719**	0.131

Residual values = 0.0164

*, ** significant at 5% and 1% level, respectively