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Research Article

Genetic variability and traits association among mungbean (*Vigna radiate*) genotypes under rainfed condition

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Abstract
Development of superior cultivars is the prime objective of any plant breeding program. This research was conducted with the aim to study genetic variability and trait association among the mungbean genotypes for yield attributes under rainfed conditions. Fourteen mungbean genotypes were tested in randomized complete block design with three replications at the University of Agriculture Peshawar during spring 2017. Data were noted on different yield contributing traits like days to maturity, plant height, pods plant^{-1}, pod length, clusters plant^{-1}, 100-grain weight and grain yield plant^{-1}. Analysis of variance revealed highly significant difference for all the studied traits. Maximum number of clusters plant^{-1} were showed by genotypes Mung-Azri-06 (9) VC 6321(9), Mung NM-06 (9) and Mung-Chakwal-06 (9). Mung-Azri-06 revealed maximum pod length (8.6 cm), pods plant^{-1} (27.37), 100-grain weight 4.40 g) and grain yield (17.90 g). Grain yield showed significant correlation with cluster plant^{-1}(r = 0.71**), pods plant^{-1} (r = 0.80**), pod length (r = 0.59*) and 100-grain weight (r = 0.97**). Promising genotypes Mung-Azri-06, Mung-Chakwal-06 and Mung- NCM-257-2 performed best than other genotypes and can be used in future breeding programs.

Keywords: Genetic variability; Mungbean (*Vigna radiate*); Rainfed condition; Traits association

Introduction
Mungbean is the most important pulse crop, belongs to family laguminoseae, genus Vigna and specie radiate. It chromosome number is 2n = 2x = 22. It is native to India but also cultivated in China, Pakistan, Europe, Vietnam and USA. Mungbean is usually grown for their edible seed [1]. The seeds are easily digestible and easy to cook. Their Seeds are rich in proteins, calories, minerals, and vitamins. Mungbean seed contain protein (22-24%), carbohydrates (60%), fats (1-1.5%) and fibers (3.4-4.7%) [2]. Mungbean is herbaceous and branchy plant having succulent stem that is hollow from inside. Leaves of mungbean are green and trifoliate, flowers are yellow and pods are brownish and each pod consists of 10 to 12 seeds. The seed is green and round in shape. Mungbean plants require less amount of fertilizers because their plants are having nodules in their roots. It has a strong tap root system and has the ability to fix atmospheric nitrogen into ammonia which can be used as fertilizer [3].

Mungbean is a tropical and subtropical crop, require warm temperature of 30 to 35 ^{0}C. Its germination is epigeal and is self-pollinated crop. Mungbean require sandy and loem soil to be grown better, having soil PH 6.3 to 7.1. Its growth rate is rapid and requires 76 to 89 days to mature. Mungbean plant grows up to three feet high, it can also be used as a crop rotation practices. It is sown in both summer and spring seasons [4].

In Pakistan, mungbean ranks second among the pulse legumes after chickpea. It is mostly cultivated in Punjab, southern Sindh, Khyber Pakhtunkhwa and Northern parts of country [5]. The world annual production area of mungbean is about 5.5 million hectare with a rate of increase of 2.5% per annum. In Pakistan, Punjab accounts for 89% of total area and 86% of production. In Pakistan mungbean is grown on 2.6 million hectares with a production of 1.9 million ton and with an average yield of 723 kg/ha. In Pakistan, Khyber Pakhtunkhwa has covered an area of 10 thousand hectares with total production of 6.4 thousand ton and with an average yield of 634 kg/ha [6]. In Pakistan mungbean yield per hectare is very low as compared to other mungbean producing countries of the world. Powdery mildew, yellow mosaic virus, stems and root rot are common diseases that affect the yield of mungbean crop. Yellow mosaic viruses are commonly observed in Pakistan. These viruses cause greater damage to mungbean crop. Aphids and caterpillars are the common insects, they attack the mungbean crop result in damaging leaves [7].

The term correlation is the relationship between two variables. Coefficient of correlation ranges from 0±1. Statistically correlation refers to a quantifiable relationship between two variables. Furthermore, it is a measure of the strength and direction of that association. It is necessary for plant breeder to study the association among the traits to decide the suitable selection criteria for breeding program [8]. The information thus obtained could be used for the improvement of inclusive breeding programme to develop vigorous mungbean genotypes [9, 10].

There is greater genetic variability in yield components of mungbean genotypes due to which each and every genotype shows difference performance in yield component. The genetic variability and heritability estimated for quantitative characters are important in selecting suitable genotypes and reliable yield components for efficient yield improvement. [11]. This study was conducted to determine genetic variability in mungbean genotypes under rainfed condition and to investigate the correlation among yield and its component traits.

Materials and methods

The research was conducted at the University of Agriculture Peshawar during spring season 2017. The breeding materials were comprised of KM1, Chashma 96, Mung NM 11, Mung Chakwal 11, Mung NM 06, Mung NCM-257-2, Mung Azri-06, Mung 97, VC 6321, VC 6369, VC6370, VC6368, and NM-19-19. These Fourteen genotypes have sown during March 2017 in a randomized complete block (RCB) design with three replications and row length of 4m was kept. Each row was having 40 plants. Plant to plant and row to row distance were kept 10 cm and 30 cm respectively. All the standard cultural practices were carried out uniformly throughout the season. Data were noted on days to maturity, plant height, pods plant^{-1}, pod length, clusters plant^{-1}, 100-grain weight and grain yield plant^{-1}.

Results and discussion

Days to maturity

Breeding for early maturity is one of the main objectives of a plant breeding program. Early maturity reduce the overall maturity group of crop. Mean squares of days to maturity showed significant ($P \geq 0.01$) differences among the genotypes (Table 1). Mean values for days to maturity varies from 81 to 89 days with a grand mean of 85 days. Genotype NM-06 took less (81 days) to physiological maturity followed by

KM-1(82 days), while mung-97 took more (89 days). Coefficient of variance and coefficient of determination were 0.87 and 0.93 respectively. Significant difference for days to maturity was also showed by [12]. Days to maturity showed positive association with grain yield (r = 0.13), cluster plant^{-1} (r = 0.08), 100 grain weight (r = 0.13) while, negative relationship was noted with plant height (r = -0.28), pod length (r = -0.04) (Table 3). Our result are in resemblance with [13], who noted positive correlation of maturity with grain yield.

Table 1. Mean squares, coefficient of variation and coefficient of determination of yield attributes of mungbean genotypes

Source of variation	DF	Days to maturity	Plant height	Pods plant^{-1}	Pod length	Clusterplant^{-1}	100 grain weight	Grain yield
Replications	2	0.38	4.87	0.53	0.03	0.22	0.00	0.92
Genotypes	13	15.42**	45.75**	15.73**	0.71*	3.62**	0.40**	32.16**
Error	26	0.56	4.44	2.13	0.32	0.76	0.01	0.87
CV		0.87	4.01	6.84	7.37	12.58	3.14	10.08
R^2		0.93	0.83	0.78	0.52	0.70	0.94	0.94

CV= Coefficient of variation and R^2 = Coefficient of determination
*, ** = Significant at 5% and 1% probability level respectively

Plant height

Plant height is an important character of mungbean crop because of its close relationship with yield as it provide base for new branches, leaves and pods. However, intermediate plant height is desired because of resistance to lodgings. Mean square showed highly significant difference among mungbean genotypes for plant height (Table 1). The coefficient of variation of plant height was 4.01% and R^2 value was 0.83. Plant height of ranged from 40.1 to 54.5 cm (Table 2). Genotype Mung Azri-06 had shortest plants (40.1 cm) followed by VC 6368 (43.5 cm) among 14 mungbean genotypes. Whereas, the genotype Mung Chakwal-06 was tallest 54.5 cm, followed by Mung NM-11(53.9 cm) and NM-96 (53.0 cm). Significant differences for plant height among the mungbean genotypes was also noted by [14, 15]. Plant height showed negative correlation with grain yield (r = -0.24), pods plant^{-1} (r = -0.42), pod length (r = -0.005), clusters plant^{-1} (r = -0.19), days to maturity (r = -0.28) and 100-grain weight(r = -0.24). Negative correlation of plant height with grain yield was also noted by [16].

Table 2. Mean values of yield attributes of mungbean genotypes under rainfed condition

Genotypes	Days to maturity (days)	Plant height (cm)	Pods plant^{-1} (no)	Pod length (cm)	Cluster Plant^{-1} (no)	100-grain weight (g)	Grain yield plant^{-1} (g)
KM1	82	48.37	24.33	8.4	8	4.15	16.99
CHASHMA 96	83	52.50	18.80	8.0	6	3.27	8.07
MUNG NM 11	85	53.62	22.37	7.7	7	3.56	10.69
MUNG CHAKWAL	85	54.43	22.47	7.6	9	4.10	15.38
MUNG NM 06	82	47.70	21.07	7.4	9	3.56	10.30
MUNG NCM-257-2	86	47.17	19.53	7.7	8	3.46	9.47
MUNG AZRI-06	88	40.13	27.37	8.6	9	4.40	17.90
MUNG 97	89	47.27	21.67	7.7	8	3.52	10.64
VC 6321	86	48.80	21.30	8.0	9	4.00	14.39
VC 6369	86	50.17	19.37	8.0	6	3.50	9.36
VC 6370	86	45.77	22.17	7.1	7	3.45	9.22
VC 6368	86	44.10	18.73	6.7	6	3.24	9.00
NM-19-19	82	49.37	21.33	7.9	7	3.47	9.25
NM-96	86	52.63	21.33	7.7	7	3.30	9.23

Pods plant^{-1}

The data regarding pod plant^{-1} evinced prominent variation among the genotypes. The coefficient of variation and R^2 value was 6.84% and 0.78 respectively. The pods plant^{-1} value ranged from 18.7 to 27.4 among the 14 mungbean genotypes (Table 2). The maximum pods plant^{-1} were recoded for Mung azri-06 (27.4 pod plant^{-1}), while the minimum pods plant^{-1} were recorded for genotype VC 6368 (18.7 pod plant^{-1}) followed by genotype Chashma 96 (18.8 pod plant^{-1}). Pod plant^{-1} was highly significantly correlated with grain yield 100-grain (r = 0.63) while significantly correlated with 100-grain weight (r = 0.59) and pods plant^{-1} (r = 0.54). Our findings are resemblance with that of **[17, 18]**, who studied variation among the genotypes for pods plant^{-1}. Pod plant^{-1} was positively associated with clusters plant^{-1} (r = 0.31), while negative correlated with plant height (r = -0.005) and maturity (r = -0.04) (Table 3). **[19]** also reported significant association of pods plant^{-1} with grain yield

Pod length

The analysis of variance showed highly significant (P ≥ 0.01) difference among mungbean genotypes for pod length (Table 1). The coefficient of variation of pod length was 7.37%, the R^2 value was 0.52. Pod length of mungbean genotypes varies from 6.7 to 8.6 cm with a grand mean value of 7.7 cm (Table 2). The maximum pod length was recorded for Mung Azri-06 (8.6 cm) followed by genotype KM1 (8.4 cm) and Chashma 96, VC 6321, VC 6369 and NM-19-19 (8.0 cm), while minimum pod length was recorded for genotype VC 6368 (6.7 cm). Our findings are resembled with **[20]**, who noted significant (P ≥ 0.01) differences for pod length among the mungbean genotypes. Pod length was highly significant correlated with 100-grain weight (r = 0.63), while significantly associated with grain yield (r = 0.59) and pods plant^{-1} (r = 0.54) (Table 3). The mentioned trait was positively correlated with clusters plant^{-1} (r = 0.31), while negatively correlated with plant height (r = -0.005) and days to maturity (r = -0.04). Our findings are resemblance with that of **[21]**, who observed positive correlation with grain yield.

Cluster plant^{-1}

Mean squares exhibited significant (P ≥ 0.01) differences among the mungbean genotypes for cluster plant^{-1}. It mean values ranged from 5.8 to 9.1 with an average value of 7.4 (Table 2). Maximum numbers of cluster per plant (9) were recorded for Mung Chakwal-06 (9) and NM-06 while VC-6368 and VC 6369 had six clusters plant^{-1}. Coefficient of variance for clusters plant^{-1} was 12.58% and R^2 value was 0.70. Our findings are resemblance with **[15, 22]**, who reported significant variations among mungbean genotypes for clusters plant^{-1}. The correlation of cluster plant^{-1} was highly significant with grain yield (r = 0.71) and grain weight (r = 0.74), similarly significant association was showed with pods plant^{-1} (r = 0.60). Clusters plant^{-1} was positively associated with pod length (r = 0.31), nodules plant^{-1} (r = 0.07) and days to maturity (r = 0.19) while negative correlated with plant height (r = -0.19) (Table 3). Our findings are in line with **[23]**, who noted positive correlation of clusters plant^{-1} with grain yield.

100-grain weight

Analysis of variance of 100 grain weight showed prominent differences (P ≥ 0.01) among the mungbean genotypes (Table 1). Grain weight ranged from 11.0 to 16.4 g with a grand mean value of 13.34 g. The maximum pod weight (16.4 g) was recorded for KM-1, while minimum (11.0 g) pod weight was recorded for NM-96. CV and R square value were 3.14% and 0.94 respectively for grain weight. Our findings are in accordance with that of **[24]**, who studied variation among the mungbean genotypes for grain weight. The correlation of 100-grain weight was highly significant with grain yield (r = 0.97), pods plant^{-1} (r = 0.80), pod length (r = 0.63) and cluster plant^{-1} (r = 0.74). 100-grain weight was positively associated with days to maturity (r = 0.13), while negatively associated with plant height (r = -0.24) (Table 3). Our findings are in line with that of [25], who also showed positive association between 100-grain weight and grain yield.

Table 3. Correlation coefficient among various traits of mungbean genotypes for yield attributes

Traits	Days to maturity	Plant height	Pods plant^{-1}	Pod length	Clusters plant^{-1}	100 grain weight
Plant height	-0.28					
Pods plant^{-1}	0.20	-0.42				
Pod length	-0.04	-0.005	0.54*			
Clusters plant^{-1}	0.08	-0.19	0.60*	0.31		
100 grain weight	0.13	-0.24	0.80**	0.63**	0.74**	
Grain yield	0.13	-0.24	0.80**	0.59*	0.71**	0.97**

*, ** = Significant at 5% and 1% probability level respectively

Grain yield plant^{-1}

Analysis of variance of grain yield exhibited significant (P ≥ 0.001) differences among the mungbean genotypes (Table 1). Grain yield varies from 8.1 to 17.9 g with an average value of 11.39 g. Mung Azri-06 (17.9 g) have maximum grain yield among the fourteen mungbean genotypes followed by KM-1 (17.0 g). Chasma-96 (8.1 g), VC-6368 (9.0 g), and NM-96 (9.1 g). Coefficient of variance recorded for grain yield were 10.08% and the R^2 value was 0.94. Our findings are resemblance with [26], who showed variation among the mungbean genotypes for the said trait. Grain yield was highly significantly associated with 100-grain weight (r = 0.97), pods plant^{-1} (r = 0.80), cluster plant^{-1} (r = 0.71), while significant correlation was noted with pod length (r = 0.59). Grain yield was positively correlated with days to maturity (r = 0.13), while negatively correlated with plant height (r = -0.24). [27] Also noted significant association of grain yield with clusters plant^{-1} and pods plant^{-1}. Similarly [28] noted positive association of grain yield with number of clusters plant^{-1}.

Conclusions

All genotypes showed significant differences under rainfed condition of Peshawar. Mung NM-06 took minimum days to maturity and can be used in further breeding programs. Mung Chakwal 06, mung NM 06, VC 6321 and mung Azri 06 had maximum number of cluster plant^{-1} (9). Mung Azri 06 had maximum number of pod plant^{-1} (27), pod length (8.6) grain yield (17.9) and 100-grain weight (4.5). Grain yield exhibited significant correlation with cluster plant^{-1}, pods plant^{-1}, pod length and 100-grain weight. Mung Azri, mung Chakwal 06 and Mung NCM-257-2 were better performing genotypes and could be used for varietal development.

Authors' contributions

Conceived and designed the experiments: A Sohail & SMA Shah, Performed the experiments: A Sohail, Analyzed the data: A Sohail, S Ali & Manzoor, Contributed reagents/ materials/ analysis tools: A Ali, Q Hussain, T Burni & F Hadi, Wrote the paper: A Sohail.

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