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RELATIONSHIPS BETWEEN SEED YIELD AND ITS COMPONENTS IN EXOTIC AND INDIGENOUS GERMPLASM OF MUNGBEAN (*Vigna radiata* (L.) Wilczek.

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ABSTRACT

For exploitation of the yield components to to formulate a selection criteria, eighteen diverse type of mungbean genotypes from different countries under IAEA/RCA project were planted in 3 repeats having a plot size of 7.2 m^2. Data pertaining to different morphological attributes viz. days to flower, days to mature, plant height, clusters per plant, pods per plant, pod length, seeds per pod, biomass yield, seed yield, thousand seed weight and harvest index were recorded. Genetic parameters, correlation and direct and indirect effects of these traits were computed. Highly significant differences among the lines/ varieties were observed for all the traits except seeds per pod. Phenotypic co-efficient of variability was generally higher than corresponding genotypic co-efficient of variability. More than 50% heritability values were also observed for all the traits except seeds per pod. Maximum genetic advance was observed for cluster per plant (50.03) followed by biomass yield (45.78) and seed yield (44.68). It means additive type of genes mainly control such characters. Very low genetic advance was observed in case of seeds per pod (1.53) and harvest index (2.89). It means these traits are governed by non-additive type of genes. Seed yield had positive genotypic and phenotypic correlations with all the traits. Pod length and biomass showed highest positive direct effects along with positive genotypic correlation coefficient. Hence these characters may be taken directly for the improvement of seed yield in mungbean.

Key-words:

INTRODUCTION

Mungbean (*Vigna radiata* (L.) Wilczek) belongs to family Leguminosae and genus V*igna*. It is an important short duration pulse crop in many countries. Due to its rapid growth and early maturity, it is adapted in multiple cropping systems in the drier and warmer climates of the lowland tropics and subtropics. Temperatures of 28-30 C are optimum for seed germination and plant growth (Poehlman, 1978). Flowering in mungbean is photoperiod and temperature sensitive, being delayed by long photoperiod and hasten by high temperature (Rawson and Craven, 1979). It can be grown in a wide range of soil types, but thrives best on deep loamy or sandy loam soil. Dry weather is favourable for maturity, harvesting, threshing and in prevention of seed damage. For food, the seeds are prepared by cooking, fermenting, milling or sprouting. They are utilized in making soups, curries, bread, sweets, noodles, salads and many other culinary products. Among the pulses, the mungbean is favored for children and the elderly due to its easy digestibility and low production of flatulence. The mungbean protein is rich in lysine, an essential amino acid deficient in cereal grains. Mungbean protein is deficient in Methionine and Cystein; sulfur-containing amino acids found abundantly in cereal grains.

In Pakistan, mungbean is grown on an area of 225 thousand hectares with an annual production of 130 thousand tonnes having an average seed yield of 577 Kg ha^{-1} (Anon., 2004-2005) which is very low and cannot meet the demand of ever rising population, so attempts should be made to increase seed yield per hectare of mungbean. Inability to visually recognize small differences in quantitative traits among the single plants have led to frequent attempts to find associated traits more amenable to visual selection. The correlation co-efficient (r) gives the measure of the relationships between traits and provides the degree to which various characters are associated with productivity.

Gill *et al* (1995) observed that in general genotypic co-efficient of variability was higher than corresponding phenotypic co-efficient of variability. Positive correlation of seed yield with seeds per pod, pods per plant, hundred seed weight, clusters per plant, pod length, plant height and primary branches have been reported by (Byregowda *et al* (1997), Haq (1997), Haritha *et al*., (2000)**,** Sarwar *et al* (2004), Abbas *et al* (2005) and Sadiq *et al* (2005). Highest direct effect of pods per plant, seeds per pod, and thousand seed weight have been reported by (Byregowda *et al* (1997) and Khattak *et al* (1997). Highest heritability for seed yield has been reported by Venkatswarlu (2001).

Seed yield is the result of direct and indirect effects of a number of plant traits and selection based on these characters rather than seed yield would be more effective. Determination of direct and indirect effects is helpful in assessing the real contribution of various components traits towards seed yield, so that direction for desired improvement may be developed. Knowledge of genetic parameters is very important for breeding ideotypes with special emphasis on certain characters. If the understanding of genetic behaviour of traits at an early segregating generation is known, the ideotypes selection may be carried out. Selection based on yield components is

advantageous if different yield related traits have been well documented (Johnson *et al*., (1955); Panse, (1957); Tickoo *et al*., (1988); Poehlman, (1978); Singh *et al* (1995)**.**
Considering all these facts, the present study was aimed to determine association between seed yield and yield components in exotic and indigenous mungbean germplasm. Correlation will be partitioned into direct and indirect effects. The information thus achieved would be quite useful to identify the characters, which could be used as selection criteria in breeding mungbean genotypes with better yield potential.

MATERIALS AND METHODS

The experiment was conducted at Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad during spring, 2005. The experimental material comprised of eighteen lines/ varieties of mungbean contributed by different countries involved in an IAEA/RCA project. NIAB shared eight lines/ varieties i.e. Var. 6601, NM 20-21, NM 51, NM-54, NM-92, NM-98, NIAB MUNG 2006, and NM-51 x VC 1973A, Indonesia four (Camar, Gelatik, Psj-B-II-6, and Psj-S-31), China two (VC 2719A and 1–176), Philippines two (Native variety and PAEC-3) and Thailand two (KPS-2, and CN-72). All the eighteen genotypes were planted in randomized complete block design (RCBD) keeping inter and intra row spacing of 30 and 10 cm respectively. Six rows of each genotypes having 4-meter row length (7.2 m^2 plot size) were sown in three repeats. Five guarded plants of each genotype were taken from each replication and data on days to flower, days to mature, clusters per plant, pods per plant, pod length, seeds per pod, thousand seed weight, biomass yield, seed yield and harvest index were recorded. Mean values were used for statistical analysis following Steel and Torrie (1984). Genetic parameters (genotypic, phenotypic variances, heritability, genetic advance), correlation and path co-efficient analysis was performed according to Singh and Chaudhary (1985).

RESULTS AND DISCUSSION

Highly significant differences were observed for all the traits except seeds per pod (Table-1). Days taken to flower and mature ranged from 36-49, and 67 to 81 respectively. Clusters per plant ranged from 6.00-16.00 with maximum number of clusters per plant in NIAB MUNG 2006 and minimum were produced by NM-92 (Table-2). Pods per plant ranged from 16.00 to 34.00. Variety 6601 produced maximum pods (34.00) and minimum (16.00) were produced by NM-54. Var. 6601 is a small seeded local variety of Pakistan origin and normally it has been observed that small seeded varieties having long maturity period bear more number of pods per plant especially during spring season. Thousand seed weight ranged from 41.07 g to 80.67 g. Maximum thousand seed weight (80.67) was attained by an Indonesian line i.e. Psj-B-II-17-6 and minimum was produced by NM 20-21. Maximum seed yield (1379 Kg/ha) was produced by NIAB MUNG 2006 and minimum (607 Kg/ha) was produced by Camar, an Indonesian line. Maximum harvest index (49) was attained by NM 92 followed by NM 54 and NM 51 x VC 1973A that attained a harvest index of 41 and 40 respectively.

High phenotypic co-efficient of variability (PCV) was observed as compared to genotypic co-efficient of variability (GCV) which is due to presence of environmental effects (Table-3). Highest values of PCV and GCV were observed in harvest index and clusters per plant, more than 50% heritability was observed in all the characters except seeds per pod with maximum value of 99.60% in thousand seed weight followed by days to mature (97.70%). The genetic advance was highest in case of cluster per plant (50.03 % of mean) followed by biomass yield (45.78%), 1000- seed weight (44.68) and seed yield (36.63%). Overall the results indicated that clusters per plant, pods per plant, 1000- seed weight, biomass yield and seed yield are governed by additive type of genes and selection based on these traits will be trustworthy and beneficial for future breeding programme in this type of population. Days to mature, pod length, seeds per pod and harvest index may be given less preference and selection should not be based on these attributes in such type of population because genes controlling these traits are of non-additive nature (Dominance or epistasis type).

Correlation among traits may results from pleiotropy or physiological association among the traits. From breeder point of view the type of association of seed yield with other agronomic characters is of paramount importance. Genotypic correlations were generally higher than corresponding phenotypic correlation co-efficient (Table-4). The low phenotypic correlation could be due to a low modifying effect of the environment on association of the characters at the gene level. Days to flower showed positive genotypic and phenotypic correlations with all the traits except clusters per plant and pods per plant. Days to mature had negative correlation with pod length, seeds per pod, 1000-seed weight and harvest index while, with clusters per plant, pods per plant, biomass yield and seed yield showed positive association. Biomass yield showed highly significant correlated with days to mature both at the genotypic (0.80), and phenotypic (0.75) levels. This reflects that long duration genotypes produced more biomass yield in this particular environment. Number of clusters per plant were negatively correlated with pod length, thousand seed weight and harvest index. Positive and significant correlation was observed between clusters per plant and pods per plant both at the genotypic and phenotypic levels.

Table 1. Range and mean square of different traits in diversified mungbean genotypes.

CHARACTERS	RANGE	MEAN SQUARE
Days to flower	36.00 – 49.00	38.10^{**}
Days to mature	67.00 – 81.00	43.34^{**}
Clusters/plant	6.00 – 16.00	20.67^{**}
Pods/plant	16.00– 34.00	65.72^{**}
Pod length	7.00 – 9.00	1.23^{**}
Seeds/pod	11.00 – 12.00	0.32^{NS}
1000- seed weight (g)	41.00– 81.00	497.79^{**}
Biomass yield	1300 – 3700	1272471^{**}
Seed yield (Kg/ha)	437 – 1388	63711.77^{**}
Harvest Index	19.00 – 49.00	197.48^{**}

NS Non-Significant ** Highly Significant

Table 2. Mean values of morphological attributes of diversified mungbean genotypes.

	Days to flower	Days to Mature	Clus. /Plant	Pods/ Plant	Pod Length (cm)	Seeds/ Pod	1000 Seed Weight	Bio. Yield (g/Plot)	Seed Yield (Kg/ha)	H.I
Camar	38.0^{I}	67.0^{H}	**12.0^{BC}**	25.0^{CD}	7.3^{E}	11.0	43.8^{K}	2300^{IJK}	606.1^{J}	19.0^{I}
NM-54	42.0^{G}	70.0^{G}	**8.0^{H}**	16.0^{G}	9.0^{AB}	11.0	69.8^{C}	2100^{K}	1199.0^{CDE}	40.5^{B}
Psj-B-II-17-6	48.0^{AB}	72.0^{F}	**7.0^{HI}**	22.0^{DE}	9.0^{AB}	11.0	80.7^{A}	3600^{ABC}	1277.0^{BC}	25.7^{FGH}
GELATIK	46.0^{BCD}	75.0^{CD}	**8.0^{FGH}**	21.0^{DEF}	8.7^{ABC}	11.0	53.7^{I}	3300^{CD}	1231.0^{BCD}	26.8^{FG}
NM 20-21	40.0^{H}	71.0^{F}	**8.0^{FGH}**	24.0^{D}	8.0^{CDE}	11.0	41.1^{L}	2267^{IJK}	1078.0^{F}	34.4^{C}
Psj-32-g	47.0^{BC}	75.0^{CD}	**9.0^{EFGH}**	27.0^{BC}	9.0^{AB}	11.0	68.7^{C}	2633^{GHI}	773.0^{I}	21.3^{HI}
2917A	47.0^{BC}	76.0^{BC}	**9.0^{EFGH}**	25.0^{CD}	8.0^{CDE}	11.0	59.6^{F}	3033^{DEF}	1200.0^{DE}	28.0^{EFG}
Var.6601	43.0^{FG}	76.0^{BC}	**11.0^{CD}**	34.0^{A}	8.0^{CDE}	12.0	43.0^{K}	3233^{CDE}	1295.0^{AB}	28.1^{EFG}
1-176	47.0^{BC}	76.0^{BC}	**10.0^{DEFG}**	29.0^{B}	7.7^{DE}	11.0	58.9^{FG}	3300^{BCD}	1254.0^{BCD}	27.5^{EFG}
NM-98	45.0^{DEF}	73.0^{DEF}	**10.0^{DEFG}**	30.0^{B}	8.3^{BCD}	12.0	61.7^{E}	2433^{HIJK}	1124.0^{EF}	33.4^{CD}
PAEC-3	36.0^{J}	81.0^{A}	**14.0^{B}**	28.0^{B}	7.7^{DE}	11.0	45.2^{J}	3700^{A}	962.0^{G}	18.8^{I}
KPS-2	48.0^{AB}	77.0^{B}	**10.0^{DEF}**	19.0^{FG}	9.3^{A}	11.0	41.1^{L}	2733^{FGH}	902.0^{GH}	23.9^{GH}
NM-92	44.3^{EF}	76.0^{I}	**6.0^{I}**	22.0^{DE}	8.7^{ABC}	11.0	77.5^{B}	1300^{L}	870.0^{H}	48.5^{A}
CN-72	49.0^{A}	76.0^{BC}	**8.0^{GH}**	18.0^{FG}	8.7^{ABC}	11.0	77.1^{B}	3667^{AB}	1203.0^{BCDE}	23.6^{GH}
NIAB MUNG 2006	45.0^{DEF}	70.0^{G}	**16.0^{A}**	28.0^{B}	9.3^{A}	11.0	66.7^{D}	2533^{GHIJ}	1379.0^{A}	39.4^{B}
NM 51	47.0^{BC}	74.0^{D}	**14.0^{B}**	29.0^{B}	9.0^{AB}	11.0	57.7^{G}	2900^{EFG}	1161.0^{DEF}	28.9^{DEF}
NM51 x VC1973A	$44.^{FG}$	70.0^{G}	**9.0^{EFGH}**	20.0^{EF}	9.3^{A}	11.0	55.7^{H}	2133^{K}	1180.0^{DE}	40.0^{B}
Native variety	46.0^{CDE}	73.0^{E}	**10.0^{DE}**	23.0^{DE}	8.0^{CDE}	10.7	65.8^{D}	2200^{JK}	986.0^{G}	32.3^{CDE}

Clusters per plant had positive correlation with seeds per pod, biomass yield and seed yield. The results are in agreement with the earlier findings of Haritha *et al*., (2000) and Abbas *et al* (2005). Pods per plant have positive and highly significant genotypic correlation (0.62) with seeds per pod. It was also positive at the phenotypic level. Pod length, thousand seed weight and harvest index have negative correlation with pods per plant. Pod length, seeds per pod and seed weight showed non-significant correlation with other traits. Biomass yield showed highly significant negative correlation with harvest index but positive correlation with seed yield. Earlier studying F_3/F_4 generation of mungbean Sarwar *et al* (2004), reported positive correlation of seed yield with pods per plant. Pod length showed positive correlation with all the traits except biomass yield. The results are in accordance with the earlier findings of Sadiq *et al* (2005), who reported positive correlation between pod length and seed yield both at the genotypic and phenotypic levels.

Seeds per pod have negative correlation with thousand seed weight and harvest index. It means that by increasing seeds per pod, seed weight will decreased. Biomass yield and seed yield have positive correlation with seeds per pod. The results are in accordance with the findings of Byregowda *et al* (1997), who reported positive correlation between seeds per pod and seed yield. Thousand seed weight showed negative correlation with biomass yield. Harvest index and seed yield were positively correlated with thousand seed weight. These results were in agreement with the earlier findings of Sadiq *et al* (2005). Biomass yield has negative correlation with harvest index, whereas positive correlation between biomass yield with seed yield was observed. So it may be concluded that by increasing biomass yield harvest index will decreased and this indicate the increment in seed yield without maximizing the vegetative portion. The results are in accordance with the earlier findings of Haq (1997). Harvest index also has positive genotypic and phenotypic correlation with seed yield.

Table 3. Genetic parameters for various traits in diversified mungbean genotypes.

Character	PV	PCV	GV	GCV	Hb (%)	G.A (%) of Mean
Days to flower	13.25	8.16	12.43	7.91	93.80	15.80
Days to mature	14.68	5.23	14.33	5.17	97.70	10.55
Clusters/plant	7.49	27.52	6.60	25.82	88.10	50.03
Pods/plant	24.05	20.08	20.83	18.69	86.60	35.90
Pod length	0.56	8.80	0.33	6.79	59.60	10.81
Seeds/ Pod	0.24	4.46	0.04	1.82	16.60	1.53
100- seed weight	166.41	21.75	165.69	21.70	99.60	44.68
Biomass yield	453253.70	24.55	409608.5	23.34	90.40	45.78
Seed yield (g)	22173.85	18.95	20768.96	18.34	93.70	36.63
Harvest Index	70.41	27.97	63.53	26.60	90.20	2.89

PV: Phenotypic Variance PCV Phenotypic Coefficient of Variability
GV: Genotypic Variance GCV Genotypic Coefficient of Variability
Hb: Heritability in Broad Sense G.A Genetic Advance as % of Mean

Table 4. Genotypic and phenotypic Correlation co-efficient in diversified mungbean genotypes.

Character	Days to flower	Days to mature	Clusters /plant	Pods /plant	Pod length	Seeds/ pod	Seed Weight	Biomass Yield	H.I
Days to flower									
Days to mature	0.12 rg 0.10 rp								
Clusters /plant	-0.32 -0.29	0.22 0.20							
Pods /plant	-0.18 -0.15	0.29 0.25	0.58* 0.55*						
Pod length	0.58 0.44	-0.20 -0.15	-0.13 -0.07	-0.47* -0.34					
Seeds/pod	0.07 0.13	-0.007 -0.001	0.18 0.12	0.62** 0.29	0.03 0.06				
1000-Seed weight	0.54* 0.53*	-0.32 -0.32	-0.39 -0.37	-0.30 -0.28	0.45 0.34	-0.03 -0.007			
Biomass Yield	0.21 0.18	0.80** 0.75**	0.21 0.17	0.23 0.21	-0.19 -0.11	0.19 0.06	-0.008 -0.08		
Harvest Index	0.03 0.04	-0.68** -0.65**	-0.27 -0.22	-0.22 -0.18	0.42 0.30	-0.19 -0.02	0.36 0.34	-0.73** -0.72**	
Seed Yield (g)	0.38 0.37	0.17 0.15	0.05 0.05	0.10 0.12	0.31 0.25	0.28 0.06	0.22 0.22	0.40 0.40	0.28 0.29

rg, Genotypic Correlation; rp, Phenotypic Correlation

Traits like days to flower, days to mature, clusters per plant, pods per plant, pod length, seeds per pod, thousand seed weight, biomass yield and harvest index showed positive but non-significant correlation with seed yield hence they may be used as selection indices for evolving high yielding genotypes. The direct effect of days to flower was negative (-0.42) (Table-5). Days to flower effect negatively and indirectly through days to maturity, pods per plant, seeds per pod and thousand seed weight. The results are in agreement with the earlier findings of Sadiq *et al* (2005). Highest positive direct effects were estimated in biomass yield (3.08) followed by pods per plant (2.32) and pod length (1.59), whereas all other traits showed negative direct effects with highest value in seeds per pod (-1.71) followed by days to mature (-1.68). Highest positive indirect effect was observed in biomass yield (2.45) via days to mature followed by pods per plant via clusters per plant (1.34) and harvest index (1.14) via days to mature. Biomass yield showed positive genotypic correlation along with positive direct effect followed by pod length with highest positive genotypic correlation (0.31) along with positive direct effect (1.59). Pods per plant also showed higher positive direct effect (2.32) but lower positive genotypic correlation (0.10). As compared to this Sarwar *et al* (2004) observed positive direct effects for branches per plant, pods per plant, 100 seed weight and seeds per pod in F_4 population of mungbean. Sadiq *et al* (2005) estimated positive direct effects on seed yield in case of plant height, primary branches, pods per plant, pod length and 100- seed weight. Characters like these which showed highest positive combination of direct effect along with high positive genotypic correlation may be selected directly for positive and stable improvement, however characters which showed indirect effects like high biomass via days to mature, pods per plant via clusters per plant and harvest index via days to mature may be selected indirectly through which their effect was high. For other characters where neither rg was highest nor direct or indirect effects were negative restricted model of selection is followed.

Table-5. Direct and indirect effects of different traits on seed yield in diversified mungbean genotypes.

Characters	Days to Flower	Days to mature	Clusters /plant	Pods /plant	Pod length	Seed /Pod	1000-Seed weight	Biomass yield	H.I	rg
Days to Flower	(-0.42)	-0.20	0.36	-0.41	0.92	-0.11	-0.45	0.65	0.04	0.38
Days to mature	-0.05	(-1.68)	-0.25	0.66	-0.31	0.01	0.27	2.45	-0.94	0.17
Clusters /plant	0.14	-0.38	(-1.13)	1.34	-0.21	-0.30	0.33	0.64	-0.37	0.05
Pods /plant	0.08	-0.48	-0.65	(2.32)	-0.74	-1.07	0.25	0.72	-0.31	0.10
Pod length	-0.25	0.33	0.15	-1.08	(1.59)	-0.05	-0.37	-0.59	0.59	0.31
Seeds/pod	-0.03	0.01	-0.20	1.44	0.045	(-1.71)	0.02	0.57	0.12	0.28
1000-Seed weight	-0.23	0.54	0.44	-0.69	0.72	0.05	(-0.83)	-0.27	0.49	0.22
Biomass yield	-0.09	-1.33	-0.23	0.54	-0.31	-0.32	0.07	(3.08)	-1.00	0.40
Harvest Index	-0.01	1.14	0.30	-0.52	0.67	-0.14	-0.30	-2.24	(1.38)	0.28

From the results of direct end indirect effects, it is concluded that pods per plant, pod length, biomass yield and harvest index can be used directly to evolve high yielding varieties of mungbean.

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