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VARIABILITY AND CORRELATION OF AGRONOMIC CHARACTERS OF MUNGBEAN GERMPLASM AND THEIR UTILIZATION FOR VARIETY IMPROVEMENT PROGRAM

Lukman Hakim

Indonesian Center for Food Crops Research and Development, Jalan Merdeka No. 147, Bogor 16111, Indonesia

ABSTRACT

Information on the variability and correlation between agronomic characters of mungbean accessions with their yield are important for supporting breeding program of the plant. A total of 350 mungbean accessions were evaluated at Muara Experimental Farm, Indonesian Center for Food Crops Research and Development, Bogor, during the dry season of 2005. The experiment was conducted in a completely randomized block design with three replications. Each accession was planted in two rows of 5 m long. Plant spacing was 40 cm x 20 cm, two plants per hill. Correlation and path coefficient analyses were used to quantify the magnitude of the relationship between yield components and grain yield. The variability among the accessions was significant for most of the characters studied, especially for days to maturity, plant height, pods per plant, and seed size. Among the yield components, the number of pods per plant and plant height positively correlated with the grain yield, but the seed size negatively correlated with grain yield. The direct effects of the number of pods per plant and plant height on seed yield as indicated by path coefficient were the highest, while other causal effects were small or negative. Yield variation ($1-R^2$) attributable to the nine yield component variables was slightly high (61.23%), which means that mungbean accessions with high grain yield should have sufficient plant height and high number of pods per plant. Therefore, these parameters (number of pods per plant and plant height) can be used as the selection criteria in mungbean breeding program. These criteria can be visualized during bulk selection on the early generation stage of F2 to F4, and subsequently on line development of individual plant (pedigree) of F5.

[***Keywords***: *Vigna radiata*, germplasm, agronomic characters, genetic variation, plant breeding]

INTRODUCTION

Large number of mungbean germplasm accessions available at the Indonesian Center for Food Crops Research and Development is the foundation for mungbean cultivar development. Evaluation and characterization of the germplasm are necessary to identify qualitative and quantitative characters useful for breeding program. This study will assembly genetic variability of the germplasm and affirm the presence of any genetic variability attributable to seed yield, an essential character in a breeding program (Virmany *et al*. 1983).

Seed yield is associated with many other traits, such as number of pods per plant and seeds per pod (Poehlman 1991). Seed yield was reported to be positively correlated with plant height (Khan 1988). However, a negative correlation was also reported (Amanullah and Hatam 2000). Singh and Singh (1973) further reported that correlation between plant height and seed yield was inconsistent: genotype with taller plants may not always demonstrate higher yield.

Selection for pod number was regarded as important for improving seed yield. Pundir *et al.* (1992) suggested that pods per plant should be given priority in selecting for high yielding genotypes as it had positive direct and indirect effects on the seed yield. Shamsuzzaman *et al*. (1983) showed that among 12 agronomic characters of 240 mungbean accessions studied, characters showing the highest contribution to the grain yield were number of pods per plant, number of seeds per pod, number of branches, plant height, and seed size. Similar result was also reported by Singh and Singh (1973). Verma and Sandhu (1988), therefore, suggested that pods per plant, seeds per pod, and seed weight per plant should receive consideration when selecting mungbean for high seed yield.

In soybean, Sumarno and Zuraida (2006) found a direct effect of the number of pods per plant and plant height to grain yield as indicated by highest path coefficient, while other causal effects were small or negative. They then suggested that path coefficient analysis can be used to quantify the magnitude of causal relation between yield components and grain yield. The analysis will give more accurate measurement of the roles of each yield component on grain yield.

The objectives of this study were to investigate genetic variability and identify the most responsible yield components for seed yield among diverse mungbean germplasm accessions. The study finding should be useful for establishing selection criteria in the mungbean breeding program for high seed yield.

MATERIALS AND METHODS

A total of 350 mungbean germplasm accessions were evaluated at Muara Experimental Farm, the Indonesian Center for Food Crops Research and Development, Bogor during the dry season of 2005. The experiment was conducted in a completely randomized block design with three replications. Each accession was planted in two rows of 5 m long. Plant spacing was 40 cm x 20 cm, two plants per hill. Basal fertilizers were applied at the rate of 100 kg urea, 150 kg SP36, and 100 kg KCl ha^{-1}. Weeding was done two times to eliminate competition. To control insect pests and diseases, the plants were sprayed every week with decamethrin (1 kg ha^{-1}) and benomyl (1 kg ha^{-1}).

Observation was taken on 10 randomly selected plants from each of the accessions. Nine agronomic characters were recorded during investigation, such as days to flowering, days to maturity, plant height, number of branches, number of pods per cluster, number of pods per plant, number of seeds per pod, pod length, and 1000-seed weight (seed size). Seed yield per plot was also recorded to calculate grain yield per hectare of each accession.

Means, range of variability, and coefficient of variation (CV) were calculated for each accession. Correlation and path coefficient analysis were used in accordance with Singh and Choudhary (1979), to quantify the magnitude of causal relation between yield components and grain yield.

RESULTS AND DISCUSSION

Description of Mungbean Accessions

The mean, range and coefficient of variation for different characters are given in Table 1. The variability among the accessions were significant for most of the characters studied, especially for plant height, days to maturity, number of pods per plant and seed size, with coefficient of variation of 45.61%, 43.16%, 41.33%, and 37.50%, respectively. Days to flowering and days to maturity varied from 33 to 47 days and 56-107 days, average 40 and 82 days, respectively. The earliest maturing accessions were VR1381, VR2184 and VR3773 of 56, 60 and 63 days, respectively. Whereas accessions VR980 and VR1062 were the latest maturing (103 and 107 days).

Plant height was highly varied, ranged from 40.9 to 120.6 cm, average 80.7 cm and coefficient of variation was 45.61%. Accessions showing the tallest plant height were VR1051 and VR998 (115.8 and 120.6 cm, respectively), while the shortest accessions were VR1010, VR1029 and VR1028 (40.9, 43.7 and 47.1 cm, respectively).

Number of pods per plant ranged from 16 to 78, average 47 pods. Accessions produced the highest pod number per plant were VR2184 and VR3773 (78 and 71 pods, respectively), higher than the standard varieties of Merak and Walet which produced 43 and 51 pods per plant, respectively.

The 1000-seed weight (seed size) ranged from 34.1 to 70.3 g, average 52.2 g. The study identified 42 accessions (12%) having large seeds (> 61 g per 1000 seeds), 147 accessions (42%) having medium seed size (50-60 g per 1000 seeds), and 161 accessions (46%) having small seeds (<50 g per 1000 seeds). Accessions showing the largest seed size were VR2010 and VR1052 (70.3 and 69.8 g, respectively).

Variations with regard to grain yield were quite high ranging from 0.63 to 1.62 t ha^{-1} (average 1.12 t ha^{-1}) with coefficient of variation of 23.61%. The highest yielding accessions were VR3012 and VR1973 (1.59 and 1.62 t ha^{-1}, respectively) followed by VR6075, VR1089, and VR3543 (1.4 t ha^{-1}). Standard varieties Merak and Walet showed slightly lower yield (1.41 and 1.47 t ha^{-1}, respectively) than the highest yielding accessions VR3012 and VR1973 (Table 2). Based on the yield potential, all the 350 mungbean accessions studied can be grouped into three classes, i.e. high yield (1.4-1.6 t ha^{-1}) comprised of 7 accessions including the standard varieties Merak and Walet, moderate yield (1.23-1.35 t ha^{-1}) comprised of 159 accessions, and low yield (< 1.2 t ha^{-1}) comprised of 184 accessions.

Coefficient of Correlation

Correlation coefficient between yield with number of pods per plant and plant height was significant (r = 0.722 and 0.946, respectively). This indicates that accessions having both more pods per plant and taller plant height potentially produce higher yield. However, correlation between yield and plant height only was inconsistent. For examples, accessions VR1051 and VR998 which were the tallest (115.0 and 120.6 cm height) yielded lower (1.22 and 1.27 t ha^{-1}, respectively) than those of the medium height accessions such as VR3012 and VR1973 (67.81 and 71.2 cm height) which produced 1.59 and 1.6 t ha^{-1}, respectively (Table 2). Similar finding was reported by Singh and Singh (1973) showing that the genotypes with taller plants may not always demonstrate higher yield. However, plant with medium stature,

Table 1. Yield-associated character variability of 350 mungbean germplasm accessions, Muara Experimental Farm, dry season of 2005.

Characters	Range	Mean	Coefficient of variation (%)
Days to flowering	33-47	40.0	18.22
Days to maturity	56-107	82.0	43.16
Plant height (cm)	40.9-120.6	80.7	45.61
Number of branches per plant	3-11	7.0	27.24
Number of pods per cluster	6-14	10.0	23.20
Number of pods per plant	16-78	47.0	41.33
Pod length (cm)	8.4-12.6	10.5	19.21
Number of seeds per pod	7-15	11.0	15.26
1000-seeds weight or seed size (g)	34.1-70.3	52.2	37.50
Grain yield (t ha^{-1})	0.63-1.62	1.12	23.61

Table 2. Yield-associated characters of eleven best mungbean accessions, Muara Experimental Farm, dry season of 2005.

Accessions/ varieties	Yield (t ha^{-1})	Plant height (cm)	No. of pods per plant	No. of seeds per pod	1000-seed weight (g)	Days to maturity
VR3773	1.59	67.8	71	14	51.0	65
VR2184	1.62	71.2	78	14	47.8	67
VR6075	1.40	76.3	65	10	48.5	71
VR1089	1.46	63.8	67	12	47.3	66
VR3543	1.43	77.5	63	10	51.1	73
Merak	1.41	63.2	47	11	61.7	63
Walet	1.47	67.7	51	11	59.3	65
VR1051	1.22	115.8	31	10	47.9	78
VR998	1.27	120.6	36	12	50.3	83
VR2010	0.93	86.1	27	9	70.3	76
VR1052	0.87	75.5	23	7	69.8	73

erect growth habit, short internodes, and more effective flowering nodes may in fact utilize solar energy more effectively compared to the taller genotypes.

Correlation coefficient between plant height and number of pods per plant was significant (r = 0.128). Number of pods per plant also positively correlated with the grain yield. In this study, the high yielding accessions VR3012 and VR1973 demonstrated the highest pods per plant (73 and 78 pods, respectively), but both accessions had smaller seed size (51.0 g and 47.8 g per 1000 seeds, respectively) (Table 2).

Correlation coefficient between seed size and grain yield was negatively significant (r = -0.659). For example, accessions VR2010 and VR1052 which had large seeds (70.3 and 68.8 g per 1000 seeds) produced low yields (0.93 and 0.87 t ha^{-1}, respectively) because these accessions had low number of pods per plant (27 and 23 pods) and seeds per pod (9 and 7 seeds). Furthermore, seed size negatively correlated with plant height and number of seeds per pod (r = -0.160 and -0.151). This indicates that accessions with taller plants tend to possess small seeds and low number of seeds per pod. Similar finding was reported by Sandhu *et al.* (1979) that seed size negatively correlated with number of pods per cluster and pods per plant. This suggests that genotypes with larger seed size may possess low number of pods per cluster and pods per plant.

Days to flowering and days to maturity positively correlated with grain yield (r = 0.855 and 0.878, respectively) which means that late flowering and maturing accessions potentially produce higher yield compared to the early types. For example, the high yielding accessions VR3012 and VR1973 had a moderate maturity of 65 and 67 days, respectively. The result is comparable with those reported by Malik *et al.* (1982).

In general, the correlation coefficients of mungbean in this study indicate that the high yielding mungbean genotypes could be obtained by selecting taller or medium plants with more pods per plant, but with medium or small seed size. Pundir *et al*. (1992) suggested that pods per plant and plant height should be given a high priority in selecting for high yielding mungbean genotypes as they had positive direct and indirect effects on seed yield.

Path Coefficient Analysis

Correlation coefficients between number of pods per plant and plant height with grain yield were significant (r = 0.722 and 0.946), and the direct effects of number of pods per plant (X6) and plant height (X3) to grain yield were large (X6 = 0.418 and X3 = 0.372, respectively) (Table 3). This indicates that the high yielding mungbean genotypes could be obtained by selecting taller plants with more pods per plant, and a direct selection through these characters should be effective.

Correlation coefficients between number of branches, pods per cluster and seeds per pod with grain yield were also significant (r = 0.655, 0.580 and 0.241, respectively), but the direct effects of number of branches (X4), pods per cluster (X5) and seeds per pod (X8) to grain yield were small (X4 = 0.087, X5 = 0.041 and X8 = 0.065, respectively) (Table 3). The results indicate that grain yield is less associated with these characters, consequently direct selection through these characters will not be effective and the indirect causal factors to the grain yield must be considered. Selection program aiming to increase grain yield, therefore, should also consider number of pods per plant and plant height.

Correlation coefficients between days to flowering and days to maturity with grain yield were positively significant (r = 0.855 and 0.878), but the direct effects from days to flowering (X1) and days to maturity (X2) to grain yield were negative (X1 = -0.077 and X2 = -0.238). Similarly pod length positively correlated with grain yield (r = 0.811), but the direct effect from pod length (X7) to grain yield was negative (X7 = -0.083). In such situation, the indirect causal effects to the grain yield are to be considered. Selection to increase grain yield through yield components such as days to flowering, days to maturity, and pod length should also consider the number of pods per plant and plant height simultaneously.

Correlation coefficient between seed size and grain yield was negatively significant (r = -0.659), and the direct effect from seed size (X9) to grain yield was also negative (X9 = -0.310). It means that selection to increase grain yield through improvement of seed size should also consider the indirect causal factors of pods per plant and plant height.

The path coefficient analysis suggests that the most important contributors to the grain yield on mungbean are pods per plant and plant height. Similarly for seed size, but the direct effect of this character was negative. This indicates that the genotypes with large seed size tend to possess low yield. The path coefficient data showed that residual effects were quite high (0.622) which means that variations on the associated-grain yield characters were high (61.23%), especially for the characters of pods per plant and plant height. Based on the analysis, most of the characters had indirect effect on grain yield, except for the seed size which had direct negative effect on the grain yield. Satyan *et al*. (1986), Giriraj and Kumar (1974) reported that direct and indirect effects to grain yield on mungbean were additionally for one or more secondary yield components, such as days to flowering, days to maturity, branches per plant, pods per cluster, seeds per pod, seed size and others. In this study, number of pods per plant and plant height

Table 3. The path coefficient analyses of the yield components of mungbean (the direct effects were shown as the diagonal data, whereas the indirect effects were shown as the upper and lower diagonal), Muara Experimental Farm, dry season of 2005.

Characters	X1	X2	X3	X4	X5	X6	X7	X8	X9
X1	-0.077	0.603	-0.140	0.043	0.014	0.056	-0.022	0.013	0.013
X2	0.869	-0.238	-0.403	0.066	0.039	0.061	0.031	0.011	0.066
X3	0.106	0.307	0.372	0.177	0.033	0.428	0.041	0.051	-0.160
X4	0.026	0.226	0.340	0.087	0.088	0.001	-0.018	0.033	0.014
X5	0.067	0.067	0.121	0.163	0.041	0.265	-0.036	0.211	0.303
X6	0.073	0.022	0.428	0.211	0.817	0.418	0.031	0.023	-0.221
X7	0.029	0.029	0.031	-0.085	-0.238	-0.184	-0.083	-0.015	-0.213
X8	0.042	0.242	0.081	0.052	-0.037	-0.211	0.524	0.065	-0.151
X9	-0.280	-0.380	0.116	-0.059	-0.177	-0.112	0.343	-0.151	-0.310
Correlation (r)	0.855	0.878	0.946	0.655	0.580	0.722	0.811	0.241	-0.659

X1 = days to flowering X2 = days to maturity X3 = plant height X4 = no. of branches per plant
X5 = no. of pods per cluster X6 = no. of pods per plant X7 = pod length X8 = no. of seeds per pod
X9 = seed size

demonstrated high direct effects to grain yield, while seed size showed direct negative effect to grain yield. Similar results were reported by Singh and Malhotra (1970), Sandhu *et al*. (1979), and Gupta *et al*. (1982).

As with correlation analysis, path coefficient analysis also indicated that high yielding mungbean genotypes could be obtained by selecting genotypes with taller or medium plants and high number of pods per plant. However, characters like days to flowering, number of branches per plant, pods per cluster, pod length, and seeds per pod were not important contributing factors for grain yield. This information therefore, could be used as selection criteria in mungbean breeding program. These criteria can be applied visually during bulk selection in early generation stage (F2-F4), and subsequently in F5 for pedigree selection based on individual plant by selecting genotypes with taller or medium plants and high number of pods per plant.

CONCLUSION

Variability of yield-related characters among 350 accessions of mungbean was significant especially for characters of the days to maturity, plant height, pods per plant, and seed size with the coefficient of variations of 43.16%, 45.61%, 41.33% and 37.50%, respectively. Five new promising mungbean accessions have been identified, i.e. VR3012, VR1973, VR6075, VR1089, and VR3543 as well as two standard varieties Merak and Walet. These accessions demonstrated high yield ranged from 1.4 to 1.6 t ha^{-1} and early maturing (matured at 63-71 days).

Pods per plant and plant height positively and significantly correlated with grain yield (r = 0.722 and 0.946, respectively). The direct effects of the number of pods per plant and plant height on the grain yield were the highest (r = 0.418 and 0.372), while other causal effects were small or negative. Seed size negatively correlated with grain yield (r = -0.659) indicating that the genotypes with large seeds tended to possess low yield.

Correlation and path coefficient analyses indicated that high yielding mungbean genotypes could be obtained by selecting taller or medium plants with high number of pods per plant, and medium or small seed size. Number of pods per plant and plant height were the important yield components, and should be useful as selection criteria in the early generation stage (F2 to F4) of a mungbean breeding program.

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