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Direct and indirect effects of yield components and water use efficiency related traits on seed yield in F_2 populations of three superior crosses of mungbean

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ABSTRACT

Water stress and heat stress are prominent which highly influence the mungbean productivity. The present investigations were conducted to determine the genetic potential of mungbean genotypes with high yield and drought and heat stress tolerance. Path coefficient analysis was carried out in F_2 populations of three superior crosses of mungbean viz ML 267 × LGG 528, MGG 390 × LM 95 and LM 95 × EC 362096 for fourteen quantitative characters to estimate the direct and indirect effects of the individual character on yield. The path analysis for seed yield revealed that direct effect of number of pods per plant was high and positive in all the three F_2 populations of ML 267 × LGG 528, MGG 390 × LM 95 and LM 95 × EC 362096. It indicates that this trait is the major contributing factor to seed yield and hence emphasis should be given on this character while making selection for realizing improvement in seed yield in mungbean. In the cross ML 267 × LGG 528, number of pods per plant, harvest index, number of pods per cluster and 100-seed weight which exhibited positive direct effects may be considered as the most important yield contributing characters and appropriate prominence should be placed on these components during selection. In the cross MGG 390 × LM 95, selection based on number of pods per plant, specific leaf area, 100-seed weight and number of branches per plant may result in high yielding types. In the cross LM 95 × EC 362096, emphasis should be laid on number of pods per plant, number of pods per cluster, days to maturity and SCMR during selection for breeding high yielding types.

Keywords: Mungbean; path coefficient analysis; water use efficiency; yield components

INTRODUCTION

Among the wide array of pulses cultivated in India, mungbean ranks third in area and production after Bengal gram and redgram. The per capita availability of pulses declined steadily on account of sluggish growth in their production. In order to meet the 40 grams per day per capita requirement of pulses as per WHO, attention has to be paid to increase production. Our national production and productivity levels of mungbean are low which indirectly affect the nutrient availability of people resulting in malnutrition. Among several reasons for low productivity, various biotic and abiotic factors play a major role. Among the abiotic stresses, drought stress and heat stress are prominent which highly influence the mungbean productivity. Water deficits and high temperature occur together in many environments and both stresses can interact to reduce yields. Although intensive research work has been done on genetic architecture of yield and yield attributes of mungbean, limited work has been done on yield attributes along with water use efficiency (WUE) and heat stress tolerance related traits. Realizing the significant effect of drought and heat stress on yield components, there is an immediate need to enhance the genetic potential of mungbean genotypes with high yield and drought stress and heat stress tolerance.

Drought stress and heat stress resistance is quantitative character with complex inheritance. In order to formulate proper and effective breeding objectives in a drought breeding programme, the breeder should understand the nature of the trait to be manipulated. WUE can be used as a selection criterion for drought resistance (Teare et al 1982). Passioura (1996) proposed to view grain yield as a partial function of WUE in his equation (Y= T × WUE × HI) signifying the importance of total transpiration (T) and water use efficiency (WUE) in determining the total biomass production and yield. This equation highlights that increase in yield can be achieved through increase in WUE.

To exploit the existing genetic variability for seed yield as efficiently as possible, the breeder would need a comprehensive knowledge regarding the association of component traits with yield. This would facilitate effective selection for simultaneous improvement of one or more yield influencing components. However the correlation between yield and its component characters is often misleading since it is affected by the inter-relationships among the component traits. Hence path coefficient analysis developed by Wright (1921) helps in partitioning the correlation coefficients into direct and indirect effects and to assess the relative contribution of each component character to seed yield. Integration of information on correlation, path analysis for seed yield and its component traits and their application in selection of superior segregants will be helpful in bringing varietal improvement in mungbean. Path analysis provides information about the cause and effect situation in understanding the cause of association between two variables. It reveals whether the association of characters with yield is due to their direct effect on yield or it is a consequence of their indirect effects via other component characters. It helps in determining yield contributing characters and thus is useful in indirect selection.

MATERIAL and METHODS

The present experiment was conducted at dryland farm of Sri Venkateswara Agricultural College, Tirupati, Andhra Pradesh situated at an altitude of 182.9 amsl, 32.27°N latitude and 79.36°E longitude geographically in southern agro-climatic zone of Andhra Pradesh. The F_1s of three superior crosses selected based on their yield, WUE and heat stress tolerance related attributes viz ML 267 × LGG 528, MGG 390 × LM 95 and LM 95 × EC 362096 and their five parents viz ML 267, LGG 528, MGG 390, LM 95 and EC 362096 were sown during kharif 2017. The F_2 seed was harvested from selfed-F_1 population.

The experimental material comprising F_2 populations of three crosses viz ML 267 × LGG 528, MGG 390 × LM 95 and LM 95 × EC 362096, was grown during rabi 2017 in compact family block design with two replications. F_2 populations were raised in 10 rows of three meter length following a spacing of 30 cm between the rows and 10 cm between the plants within a row. As a basal dressing, fertilizers urea and single super phosphate to supply 20 kg N and 40 kg P_2O_5/ha were applied respectively. Thinning was done to leave single seedling per hill after 15 days of sowing. Irrigation, weeding and plant protection measures were carried out as and when needed during the crop growth period as per the standard recommended package of practices to raise a good and healthy crop.

Observations were recorded on 80 randomly chosen competitive plants from each genotype in each replication for all the characters. The values of 80 competitive plants were averaged and expressed as means of the respective characters. Path coefficient analysis was carried out by the procedure originally proposed by Wright (1921) which was subsequently elaborated by Dewey and Lu (1959) to estimate the direct and indirect effects of the individual character on yield.

RESULTS and DISCUSSION

Direct and indirect effects of yield components and water use efficiency related traits on seed yield in F_2 population of ML 267 × LGG 528

Path coefficient analysis was done for the traits number of pods per cluster, number of pods per plant, 100-seed weight and harvest index which exhibited significant correlation with seed yield (Table 1).

Pods per cluster had low direct positive effect (0.1169) on seed yield per plant but its correlation with seed yield per plant was positive and significant (0.719). The positive correlation was mainly due to its high indirect positive effects via pods per plant (0.5882). Pods per plant exhibited high direct positive effect (0.8216) on seed yield and its low indirect positive effects via pods per cluster resulted in significant positive correlation (0.917) with seed yield. Though the direct effect of 100-seed weight on seed yield per plant was negligible (0.0994), it exhibited significant

Table 1. Direct and indirect effects of yield components and WUE related traits as partitioned by path analysis in mungbean in F_2 population of ML 267 × LGG 528

Component	Number of pods/cluster	Number of pods/plant	100-seed weight (g)	Harvest index (%)	Seed yield/ plant (g)
Number of pods/cluster	**0.1169**	0.5882	0.0080	0.0060	0.719**
Number of pods/plant	0.0837	**0.8216**	0.0050	0.0063	0.917**
100-seed weight (g)	0.0095	0.0414	**0.0994**	0.0257	0.176**
Harvest index (%)	0.0057	0.0417	0.0205	**0.1246**	0.192**

Residual effect= 0.12, **Significant at 1% LoS

positive correlation (0.176) with seed yield per plant due to negligible positive indirect effects via pods per cluster (0.0095), pods per plant (0.0414) and harvest index (0.0257). The low direct positive effect (0.1246) of harvest index combined with negligible positive indirect effects via pods per cluster (0.0057), pods per plant (0.0417) and 100-seed weight (0.0205) resulted in significant positive correlation (0.192) with seed yield per plant.

Direct and indirect effects of yield components and water use efficiency related traits on seed yield in F_2 population of MGG 390 × LM 95

Characters which exhibited significant correlation with seed yield viz plant height, number of branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant, 100-seed weight, specific leaf area and specific leaf weight were taken for path coefficient analysis (Table 2).

Plant height exhibited negligible direct positive effect (0.0224) on seed yield per plant and its correlation with seed yield was also positive and significant (0.201). The significant positive correlation was mainly due to its indirect positive effect through number of pods per plant (0.1585), number of branches per plant (0.0962), specific leaf weight (0.0587) and 100-seed weight (0.0120).

The significant positive correlation (0.221) of number of branches per plant with seed yield per plant was mainly due to its low direct positive effect and its positive indirect effect through pods per plant (0.1794). The number of clusters per plant exhibited negligible direct negative effect (-0.0790) on seed yield per plant but its correlation with seed yield was positive and significant (0.240). The positive correlation was mainly due to its indirect positive effect through number of pods per plant (0.2281), number of branches per plant (0.0943), specific leaf weight (0.0511), plant height (0.0178) and 100-seed weight (0.0092).

Correlation of number of pods per cluster with seed yield was positive and significant (0.438) though its direct effect was positive but negligible (0.0483) which was due to its high indirect positive effect through pods per plant (0.4220) and negligible indirect positive effects via number of clusters per plant (0.0495) and specific leaf area (0.0929).

The significant positive correlation of number of pods per plant with seed yield per plant (0.907) was mainly due to its high direct positive effect (0.8903) and its negligible positive indirect effects via plant height (0.0040), number of branches per plant (0.0220), number of pods per cluster (0.0229), 100-seed weight (0.0035) and specific leaf area (0.0873).

The direct effect of 100-seed weight on seed yield per plant was low and positive (0.1297) which contributed to its significant positive correlation with seed yield (0.165) along with its negligible indirect positive effects through plant height (0.0021), number of branches per plant (0.0083), number of pods per plant (0.0238) and specific leaf weight (0.0141).

The trait specific leaf area had high positive direct effect (0.4526) on seed yield per plant with low and positive indirect effect (0.1716) via pods per plant. However its correlation with seed yield was only 0.157 due to its high negative indirect effect via specific leaf weight (-0.4654).

Specific leaf weight exhibited high positive direct effect (0.4718) on seed yield per plant but its correlation with seed yield was significant and negative (-0.165) which was due to its high negative indirect effect through specific leaf area (-0.4465) and low

Table 2. Direct and indirect effects of yield components and WUE related traits as partitioned by path analysis in mungbean in F_2 population of MGG 390 × LM 95

Component	Plant height (cm)	Number of branches/ plant	Number of clusters/ plant	Number of pods/ cluster	Number of pods/ plant	100-seed weight (g)	Specific leaf area (cm^2/g)	Specific leaf weight (g/cm^2)	Seed yield/ plant (g)
Plant height (cm)	**0.0224**	0.0962	-0.0626	-0.0245	0.1585	0.0120	-0.0597	0.0587	0.201**
Number of branches/plant	0.0198	**0.1090**	-0.0683	-0.0245	0.1794	0.0099	-0.0663	0.0617	0.221**
Number of clusters/plant	0.0178	0.0943	**-0.0790**	-0.0303	0.2281	0.0092	-0.0515	0.0511	0.240**
Number of pods/cluster	-0.0114	-0.0554	0.0495	**0.0483**	0.4220	-0.0047	0.0929	-0.1036	0.438**
Number of pods/plant	0.0040	0.0220	-0.0202	0.0229	**0.8903**	0.0035	0.0873	-0.1026	0.907**
100-seed weight (g)	0.0021	0.0083	-0.0056	-0.0018	0.0238	**0.1297**	-0.0055	0.0141	0.165*
Specific leaf area (cm^2/g)	-0.0030	-0.0160	0.0090	0.0099	0.1716	-0.0016	**0.4526**	-0.4654	0.157*
Specific leaf weight (g/cm^2)	0.0028	0.0143	-0.0086	-0.0106	-0.1937	0.0039	-0.4465	**0.4718**	-0.165*

Residual effect= 0.15, *Significant at 5% LoS, **Significant at 1% LoS

negative indirect effect through pods per plant (-0.1937).

Direct and indirect effects of yield components and water use efficiency related traits on seed yield in F_2 population of LM 95 x EC 362096

In F_2 population of the cross LM 95 x EC 362096 path coefficient analysis was done for the traits days to maturity, plant height, number of branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant and SCMR which exhibited significant correlation with seed yield per plant (Table 3).

The significant positive correlation of days to maturity with seed yield per plant (0.219) was mainly due to its low positive direct effect (0.0994) and its moderate indirect positive effect through number of pods per plant (0.2118). Plant height had negligible negative direct effect (-0.0002) on seed yield per plant but its high positive indirect effect through number of pods per plant (0.7691) resulted in its significant positive correlation (0.612) with seed yield per plant. The number of branches per plant showed significant positive correlation (0.683) with seed yield due to its high indirect positive effect (0.8034) through number of pods per plant even though its direct effect was negligible (0.0003).

The direct effect of number of clusters per plant (-0.2366) on seed yield per plant was negative but it showed significant positive correlation (0.754) with seed yield per plant due to high positive indirect effect via number of pods per plant (0.8852). Significant positive correlation of number of pods per cluster with seed yield (0.253) was observed due to its low positive direct effect (0.1103) and high indirect effect through pods per plant (0.3238). The number of pods per plant exhibited very high positive direct effect (1.1121) on seed yield per plant which resulted in its significant positive correlation with seed yield per plant (0.945) in spite of its low negative indirect effect through clusters per plant (-0.1804).

SPAD chlorophyll meter reading had negligible positive direct effect (0.0382) on seed yield per plant but it exhibited significant positive correlation with seed yield per plant (0.197) which was mainly due to its indirect moderate positive effect through number of pods per plant (0.2041).

In the present study, the residual effects were 0.12, 0.15 and 0.12 in the three crosses ML 267 × LGG 528, MGG 390 × LM 95 and LM 95 X EC 362096 respectively for path coefficient analysis which indicated that the traits considered in this experiment were sufficient to account for variation in yield.

Table 3. Direct and indirect effects of yield components and WUE related traits as partitioned by path analysis in mungbean in F_2 population of LM 95 × EC 362096

Component	Days to maturity	Plant height (cm)	Number of branches/ plant	Number of clusters/ plant	Number of pods /cluster	Number of pods/ plant	SPAD chlorophyll meter reading	Seed yield/ plant (g)
Days to maturity	**0.0994**	0.0032	-0.0017	-0.0324	-0.0190	0.2118	-0.0427	0.219**
Plant height (cm)	0.0049	**-0.0002**	0.0002	-0.1848	0.0169	0.7691	0.0060	0.612**
Number of branches/plant	0.0117	-0.0001	**0.0003**	-0.1986	0.0599	0.8034	0.0068	0.683**
Number of clusters/plant	0.0142	-0.0001	0.0003	**-0.2366**	0.0833	0.8852	0.0079	0.754**
Number of pods/cluster	-0.0110	0.0000	-0.0001	-0.1711	**0.1103**	0.3238	0.0007	0.253**
Number of pods/plant	0.0100	-0.0001	0.0142	-0.1804	-0.0206	**1.1121**	0.0094	0.945**
SPAD chlorophyll meter reading	0.0044	0.0000	0.0001	-0.0469	-0.0031	0.2041	**0.0382**	0.197**

Residual effect= 0.12, **Significant at 1% LoS

These results are in accordance with Ajmal and Hassan (2001), Rao et al (2006), Pandey et al (2007), Narasimhulu et al (2013), Govardhan et al (2015) and Dhoot et al (2017) for harvest index; Kumar et al (2017) for days to maturity; Zubair and Srinivas (1986), Lakshman and Ruben (1989), Lavanya and Toms (2009), Kumar et al (2013), Srikanth et al (2013) and Dhoot et al (2017) for number of clusters per plant; Naidu et al (1994), Venkateswarlu (2001), Wani et al (2007), Reddy et al (2011), Ahmad et al (2013), Kate et al (2017) and Dhoot et al (2017) for number of pods per plant and Swathi (2013) for SCMR.

Analysis of the results of path analysis for seed yield revealed that direct effect of number of pods per plant was high and positive in all the three F_2 populations of ML 267 × LGG 528, MGG 390 × LM 95 and LM 95 × EC 362096. It indicates that this trait is the major contributing factor to seed yield and hence emphasis should be given on this character while making selection for realizing improvement in seed yield in mungbean. Pods per plant was identified as important yield component by Lakshman and Ruben (1989), Pandey et al (2007), Khajudparn and Tantasawat (2011), Ahmad et al (2013), Nand and Anuradha (2013), Srikanth et al (2013), Lalinia and Khameneh (2014) and Kate et al (2017).

In the cross ML 267 x LGG 528, the traits number of pods per plant, harvest index, number of pods per cluster and 100-seed weight which exhibited positive direct effects may be considered as the most important yield contributing characters and appropriate prominence should be placed on these components during selection. In the cross MGG 390 x LM 95, selection based on number of pods per plant, specific leaf area, hundred seed weight and number of branches per plant may result in high yielding types. In the cross LM 95 x EC 362096, emphasis should be laid on number of pods per plant, number of pods per cluster, days to maturity and SCMR during selection for breeding high yielding types.

CONCLUSION

Analysis of the results of path analysis for seed yield revealed that direct effect of number of pods per plant was high and positive in all the three F_2 populations of ML 267 x LGG 528, MGG 390 × LM 95 and LM 95 × EC 362096. It indicates that this trait is the major contributing factor to seed yield and hence emphasis should be given on this character while making selection for realizing improvement in seed yield in mungbean.

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