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European Journal of Experimental Biology, 2013, 3(5):511-515

ISSN: 2248 –9215
CODEN (USA): EJEBAU

Interrelationships among some agronomic traits in mungbean under drought stress and non-stress conditions

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ABSTRACT

Five mungbean genotypes were planted in pots under drought stress and non-stress conditions at the individual garden, Shiraz, Iran using a randomized complete block design with 3 replications in 2010. Initiation of differential irrigation was started at 50% flowering stage and continued through crop maturity. Pots under drought stress were irrigated to FC (Field Capacity) when the weight of each pot reached to 50% of FC. Non-stress pots were irrigated every other day. The correlation coefficients are significantly positive between grain yield and root dry weight, root length, pods number plant-1, plant dry weight, pods weight and leaves number under non-stress condition. Pod length, leaves number and plant dry weight significantly positively correlates with grain yield under stress condition. The results of path analysis indicates that direct effect of root dry weight on grain yield is highest and positive under non-stress condition, indicating that direct selection to improve yield with this trait would be effective. Root dry weight has the highest indirect effect on grain yield under non-stress condition. Leaves number and plant height have the highest positive and negative indirect effects on grain yield, respectively under stress condition. The highest positive and negative indirect effects on grain yield also relates to leaves number and plant height, respectively.

Keywords: Correlation, differential irrigation, path analysis, *Vigna radiate* (L.) Wilczek

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INTRODUCTION

Drought problems for mungbeans are worsening with the rapid expansion of water stressed areas of the world including 3 billion people by 2030 [16]. Crop yield of mungbean is more dependent on an adequate supply of water than on any other single environmental factor [9]. Knowledge of correlation coefficients is an invaluable aid in selecting the breeding material for improving the complex traits [23]. However, this alone disregards interrelations among traits and do not show the cause and effect interrelationships. Hence, information obtained from the correlation coefficient can be enhanced by partitioning into direct and indirect effects for a set of a prior cause-effect relationship [8, 21, 23].

Sadeghipour [20] reports that seed yield of mungbean positively correlates with harvest index, biomass and plant height. Water stress at the flowering stage is more effective than vegetative stage on harvest index and biomass, but less effective on plant height. Makeen et al [12] find that pods per plant and pod height have significant positive correlation with seed yield. Maximum direct effect on seed yield observes through pods per plant, test weight and plant height. In other research, high significant correlation records for pods per plant and harvest index at both genotypic and phenotypic levels with seed yield per plant and plant height, primary branch per plant, clusters per branch and days to maturity has direct positive effect on seed yield [10].

Naveed et al [15] reports that biomass per plant, number of pods per plant, number of secondary branches per plant, number of seeds per pod and 100-seed weight, number of days taken to flowering, number of number of days taken to maturity, primary branches per plant and secondary branches per plant can be used as selection criteria for higher yielding chickpea genotypes. In other study, positive correlations are found between grain yield and number of peduncles plant^{-1}, flowers plant^{-1}, pods plant^{-1} and 100-seed weight. Path analysis shows high positive direct effects of number of peduncles plant^{-1}, flowers plant^{-1} and 100-seed weight. Numbers of peduncles plant^{-1}, flowers plant^{-1}, pods plant^{-1} and 100-seed weight are identified as selection criteria for obtaining good parental lines in cowpea breeding programs [13].

This study carries out to determine the dependence relationship between grain yield of mungbean genotypes and other traits and then identify the best selection criteria for genetic improvement of this trait via indirect selection.

MATERIALS AND METHODS

Five mungbean genotypes Taiwan (G1), Pakistan (G2), India (G3), Marvdasht (G4) and Arsanjan (G5) were planted in pots containing 5 kg pots using a randomized complete block design with three replications under drought stress and non-stress conditions at the individual garden, Shiraz, Iran (29.37ºN, 52.32ºE and 1540 m above sea level) in 2010. Initiation of differential irrigation was started at 50% flowering stage and continued through crop maturity. Pots under drought stress were irrigated to FC (Field Capacity) when the weight of each pot reached to 50% of FC. Irrigation treatment was carried based on pot weight. Non-stress pots were irrigated every other day. The studied traits were plant height, leaves number, pod length, pods number plant^{-1}, pods weight, root dry weight, root length, plant dry weight and grain yield.

The phenotypic correlation between variable x and y (r_{xy}) were performed in SAS [19] that it was estimated following Kwon & Torrie [11] using the formula:

$$r_{xy} = \frac{Cov_{xy}}{\sqrt{(Var_x . Var_y)}} \quad (1)$$

where, Cov_{xy} = covariance between variable x and y, Var_x = variance of x and Var_y = variance of y.

Step-wise regression was achieved for determination of the best model, which accounted for variation exists in grain yield as dependent variable. The path analysis technique performed according to the method suggested by Dewey & Lu [5] using the procedure PROC CALIS of the SAS software version 8.00 [19].

RESULTS AND DISCUSSION

The results of correlation coefficient show significant relationship between most of the studied traits under non-stress condition (Table 1). Plant dry weight and root dry weight have the highest correlation coefficient (r = 0.94) among traits indicating positive influence of root to absorb nutrient materials from soil for plant growth and development. Similar results are reported by Sharma and Yadav [22]. On the other hand, correlation coefficients among traits are not significant under drought stress condition, indicating that drought stress can decrease relationship among traits (Table 1). Root dry weight and root length have the highest positive correlation with grain yield (r = 0.68 and r = 0.64, respectively) in non-stress condition, but is not significant between these traits with grain yield in stress condition.

Pods number plant^{-1} positively significantly correlates with grain yield (r = 0.62) under non-stress condition, indicating that this trait is the most important yield component to improve grain yield in plant breeding programs (Table 1). Therefore, simultaneous selection regarding numbers of pods per plant and grain yield is possible. This result confirm findings of Rohman et al [18], Dhuppe et al [6], Makeen et al [12], Kumat et al [10] and Aremu [3], who reports that grain yield correlates with pods number plant^{-1}. The correlation coefficient between grain yield and pods number plant^{-1} is not significant under stress condition, indicating different genetic potential of mungbean cultivars for these traits against drought.

A positive correlation occurs between plant dry weight and grain yield under non-stress and stress conditions (r = 0.58 and r = 0.52, respectively). Vijaylaxmi & Bhattacharya [24] indicate that grain yield positively correlates with plant dry weight under non-stress condition. In other researches, grain yield positively correlates with plant dry weight under stress condition [17, 25]. Pods weight correlates with grain yield under non-stress condition (r = 0.56), but is not significant between these traits under stress condition (r = 0.11). Pods weight seems to be a suitable trait to improve grain yield under non-stress condition. Leaves number positively correlates with grain yield under non-stress and stress conditions (r = 0.54 and r = 0.56, respectively). This relationship is probably due to the higher transfer of photosynthesis materials to seeds by cultivars posses more leaves number than less leaves under both conditions. These results are in agreement with the work of Kanimozhi and Panneerselvam [7].

Table 1. Correlation coefficients between plant height, leaves number, pod length, pods number plant^{-1}, pods weight, root dry weight, root length, plant dry weight and grain yield traits calculated from five genotypes of mungbean under non-stress (upper value per row) and stress (lower value) conditions

Trait	plant height (cm)	leaves number	pod length (cm)	pods number plant^{-1}	pods weight (g)	root dry weight (g)	root length (cm)	plant dry weight (g)
leaves number	0.72 ** 0.62 *							
pod length (cm)	0.31 ^{ns} 0.49 ^{ns}	0.44 ^{ns} 0.70 **						
pods number plant^{-1}	0.52 * 0.60 *	0.64 ** 0.88 **	0.65 ** 0.49 ^{ns}					
pods weight (g)	0.48 ^{ns} 0.67 **	0.40 ^{ns} 0.70 **	0.52 * 0.48 ^{ns}	0.72 ** 0.86 **				
root dry weight (g)	0.50 ^{ns} 0.31 ^{ns}	0.79 ** 0.44 ^{ns}	0.67 ** 0.69 **	0.89 ** 0.36 ^{ns}	0.64 ** 0.43 ^{ns}			
root length (cm)	-0.03 ^{ns} 0.54 *	0.15 ^{ns} 0.22 ^{ns}	0.54 * 0.47 ^{ns}	0.34 ^{ns} 0.13 ^{ns}	0.54 * 0.27 ^{ns}	0.38 ^{ns} 0.18 ^{ns}		
plant dry weight (g)	0.65 ** 0.45 ^{ns}	0.85 ** 0.46 ^{ns}	0.60 * 0.72 **	0.81 ** 0.25 ^{ns}	0.56 * 0.21 ^{ns}	0.94 ** 0.40 ^{ns}	0.23 ^{ns} 0.72 **	
grain yield (g plant^{-1})	0.25 ^{ns} -0.05 ^{ns}	0.54 * 0.56 *	0.51 ^{ns} 0.64 **	0.62 * 0.43 ^{ns}	0.56 * 0.11 ^{ns}	0.68 ** 0.41 ^{ns}	0.64 ** 0.02 ^{ns}	0.58 * 0.52 *

*ns, * and **: Not significant, significant at the 5% and 1% levels of probability, respectively.*

Positive correlations occurs between pod length and grain yield under stress condition (r = 0.64), indicating that grain yield increase can be obtained if pod length is increased.

The correlation between the traits may be due to linkage or pleiotropy [2] or environment [1]. Some correlation coefficients under non-stress conditions are different from those of stress conditions (Table 1), indicating that these traits are influenced by drought stress conditions.

In stepwise regression analysis, grain yield considers as a dependent variable, while other traits consider as independent variables. All the traits are put into regression model and finally two traits of root dry weight and root length remained in the regression model under non-stress condition. This model generally justify 76 percent of changes, relates to the grain yield trait (Table 2). The highest level of determination coefficients is for root dry weight (R^2 = 0.47). When grain yield considers a dependent variable and pod length, plant height, leaves number and plant dry weight as independent variables, the model determination coefficient is R^2=0.79. Most of this, R^2=0.41, is for pod length trait under stress conditions (Table 3).

Table 2. Analysis of stepwise regression of root dry weight, root length traits in mungbean under non-stress condition

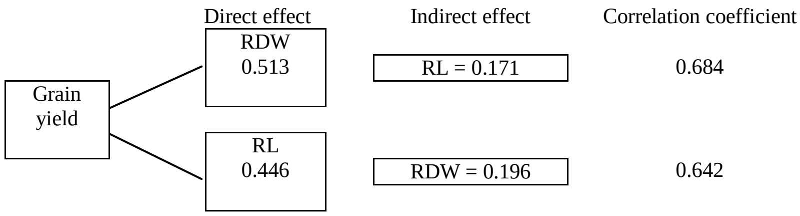
Traits	Parameter estimate	Standard error	R^2	T	Probability
root dry weight (g)	5.44	2.00	0.47	2.72	0.0185
root length (cm)	1.30	0.55	0.76	2.37	0.0357

The correlation values decide only the nature and degree of association existing between pairs of traits. A trait like grain yield is dependent on several mutually associated component traits and change in any one of the components is likely to affect the whole network of cause and effect relationship. This in turn might affect the true association of component traits, both in magnitude and direction and tend to vitiate association of grain yield and yield components. Hence it is necessary to partition the phenotypic correlations of component traits into direct and indirect effects [4].

Table 3. Analysis of stepwise regression of pod length, plant height, leaves number and plant dry weight trairs in mungbean under stress condition

Traits	Parameter estimate	Standard error	R^2	T	Probability
pod length (cm)	3.47	3.14	0.41	1.11	0.2947
plant height (cm)	-1.13	0.28	0.58	-4.01	0.0025
leaves number	0.83	0.28	0.73	2.92	0.0153
plant dry weight (g)	1.72	1.06	0.79	1.63	0.1351

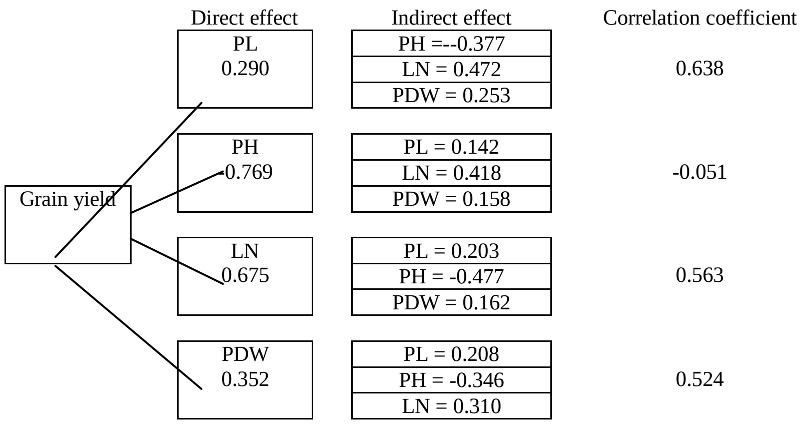
The correlation coefficient between root dry weight and grain yield under non-stress condition is 0.684 (Figure 1). The direct effect of root dry weight on grain yield is 0.513. Direct selection through root dry weight would be effective to improve grain yield. Indirect effect of root dry weight via root length is relatively high and positive (0.171) (Figure 1). Mohankumar et al [14] are found similar results in rice reporting highest direct effect of root dry weight on grain yield. Estimated phenotypic coefficients of correlation between root length and grain yield is 0.642, but partial analysis of correlation coefficients indicates moderate direct effects of root length on grain yield (0.446). The root length has relatively moderate indirect positive effects on grain yield via root dry weight (0.196) and causes to increase the correlation between root length and grain yield (Figure 1). Mohankumar et al [14] also reports similar results for root length.



Root dry weight (RDW), root length (RL)
Figure 1. Path-coefficient values estimated for grain yield and other traits

Path analysis under stress condition reveals that the total positive effect of pod length (0.638) on grain yield is the result of positive direct effects of pod length (0.290) and positive and negative indirect effects of leaves number and pod dry weight (0.472 and 0.253, respectively) and negative indirect effect of plant height (-0.377) (Figure 2). The total negative effect of plant height on grain yield (-0.051) seems to be due to the negative and high direct effect of plant height (-0.769) and positive indirect effects of pod length, leaves number and pod dry weight (0.142, 0.418 and 0.158, respectively).

Positive direct effect on grain yield occurs due to leaves number (0.675). The corresponding correlation coefficient of this trait on grain yield is positive, 0.563. This is likely due to positive indirect effect of pod length (0.203) and pod dry weight (0.162) and negative indirect effect of plant height (-0.477) (Figure 2). The direct effect of pod dry weight is 0.352 on grain yield (Figure 2). The total positive effect of pod dry weight (0.524) on grain yield is likely due to positive indirect effects of pod length and leaves number (0.208 and 0.310, respectively) and negative indirect effect of plant height (-0.346).



pod length (PL), plant height (PH), leaves number (LN), pod dry weight (PDW).

Figure 2. Path-coefficient values estimated for grain yield and other traits

CONCLUSION

Direct effect of root dry weight on grain yield is highest and positive under non-stress condition, indicating that direct selection to improve yield with this trait would be effective. Root dry weight has the highest indirect effect on grain yield under non-stress condition. Leaves number and plant height has the highest positive and negative indirect effects on grain yield, respectively under stress condition. The highest positive and negative indirect effects on grain yield also relates to leaves number and plant height, respectively.

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