IJAIR

International Journal of Agriculture Innovations and Research
Volume 3, Issue 4, ISSN (Online) 2319-1473
Manuscript Processing Details (dd/mm/yyyy) :
Received : 19/12/2014 | Accepted on : 26/12/2014 | Published : 12/02/2015

Study the Response of Mung Bean Genotypes to Drought Stress by Multivariate Analysis

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Abstract: **Drought stress does play determinant role in agriculture systems, particularly in arid and semi-arid regions, so that tolerant cultivars are released to endure water deficit during growth period. Thirty Mung bean genotypes, chosen from Iran national germplasm, Plus three commercial cultivars were tasted under normal and drought stress conditions. All the traits were analyzed by multivariate statistical to detect drought effects on traits performance. Regarding the statistic results although these genotypes were advanced lines, there was wide genetic diversity among genotypes. In both conditions, seed yield was significantly correlated with yield components and morphological and phonological traits, regression and path analysis illustrated that harvest index had the highest direct effect on economic yield. Factor analysis indicated that four independent factors explained 75% of total variance in normal condition and 78% in stress condition. Results of mean comparisons by Duncan method disclose almost in all traits check cultivars had the best performance in normal irrigation, however in the drought condition a few genotypes had better performance than cultivars that can be impressive to release new cultivars for semi-arid regions.**

Keywords: **Mung Bean, Drought, Multivariate Analysis.**

1. Introduction

Mung bean (Vigna radiate L.Wilezek) has been a major pulse and important legume in Asia and Iran [9]. This crop is potentially used to improve cropping systems, and it can be grown almost throughout the year. Mung bean seeds are rich in protein and amino acids including around 25 percent protein which is nearly three times as much as cereals [16], Thus they are consumed as a valuable protein source in rural societies and developing countries where meat proteins are not dominant in public diet. Plant agriculture must change fundamentally by mid-century, when 9 billion people are expected to inhabit the planet, consuming 70–100% more food than is currently available [5]. Water is the primary limiting factor in global agriculture, yet water availability and quality are diminishing for crops as cities grow and as irrigation and land-clearing salinize the soil and the underlying water tables [15]. Understanding plant’s response to drought has a great importance and also a fundamental part of making crops to endure abiotic stresses [12]. The relative performance of genotypes in drought and optimum environments seems to be a common starting point to identify desirable genotypes. [7] Although mung bean is defined as tolerant plant to drought, all aspects of growth and development in mung bean genotypes are influenced by water deficit, containing pod number, 100 seed weight, economic yield, biologic yield, pod length. It has been proved that flowering and pod filling stages are the most susceptible stages to soil moisture stress and supplement irrigation, particularly at the pod filling stage, improves final performance which results an increment in yield components. Multivariate analysis can be used to study relation among traits and determine key attributes that are involved in economic yield, also multivariate approaches are widely applied to simplify complex correlations observed among considered characteristics. The main aim of this study was to consider the significant impacts of water deficiency on various traits on mung bean genotypes and also comparison different genotypes with commercial cultivars to find out superior genotypes for breeding mung bean programs in southern regions of Iran.

2. Material and Method

A completely randomized block design with thirty Mung bean lines and three checks [Gohar,Parto and Mehr] in four replications was conducted under two situations, including irrigation at 50%FC (Stress) and irrigation at 90%FC (Normal). This study was done at research farm of university of Zabol during 2010-2011. The soil characteristics are shown at table 1, each genotype was sown in four rows with 6 m length with cultivation density 10 plants per m^2. All agricultural practices and agronomic operations were regularly done according to the guideline of the Institute of Agriculture Research. Breeding characteristics were phenotypically measured according to sampling of 10 plants per plot such as number of pods per plant(PP), number of seed per pod(SP), pod length(PL), plant height(PH), 100-kernel weight(KW), days to 50%flowering(DoF), days to 50% pod(DoP), However seed yield(SY), biologic yield(BY) and harvest index(HI) were measured from central two lines after removing of 30 cm margin and then converted to ton per hectare. To carry out drought level all plots had been normally and evenly irrigated by the second month after that a series of soil samples from root development area were sent to lab for measurement soil moisture then irrigation was done when soil moisture level reached to 50% of Filed Capacity. This process was lasting when all plants got matured, in normal conditions all plot were treated with normal irrigation till harvesting time.

Statistical Analysis

All collected data were analyzed for simple analysis of variance (ANOVA) with using PLABSTAT (Version,3A-pre). Means were compared by Duncan test at 5% probability level. Also different multivariate approaches were performed by using R (version 3.0.3).

Table1. Soil characteristics of the experimental station

year	pH	EC (dS/m)	N (%)	P (ppm)	K (ppm)	Sand (%)	Silt (%)	Clay (%)
2010-11	8	7.8	0.059	7.8	200	53	20	27

3. Result and Discussion

It is shown in table2 in which plant height experienced the most loss due to drought stress, nearly40% meaning that plants had been shorten to decrease green tissues and withstand water deficit. Likewise economic yield and biological yield took falling trends because obviously, reduction in yield components, such as the number of pods per plant and the number of seed per pod, are caused to reduction in seed yield that in here is defined as economic yield, however 100 kernel weight and pod length increased slightly. The result of prior researches achieved by other researchers confirmed our results [3], [8], [18].

According to the results at table 2, drought stress caused a significant decrease in the growth period. That is, days to 50% flowering and days to 50%pod had significant decline in all genotypes. Since reductions in phonologic traits are accompanied with yield loss, therefore these traits probably have positive correlation with seed yield [17].

The result of variance analysis at table 3 shows that almost in all traits treated in the normal condition (none stress) broad significant differences were found among the genotypes indicating a wide genetic diversity for the studied traits. The same as normal condition also in the drought condition considerable differences were observed among genotypes regarding the majority of considered traits, the results of ANOVE were relatively surprising because these genotypes had been selected from gene bank during 2 years selection process and it was predicted to see low variability, however mean comparisons were served to understand the insight of these differences. Since only those genotypes which had the same or slightly lower economic yield than check cultivars were interesting, those are shown in table 4. According to table 4-1 in the majority of traits commercial cultivars(Mehr, Gohar, Parto) had superiority in this experiment, in principle commercial cultivars are the best genotypes that are chosen to compare elite lines and in principle in normal condition their performance is considerably better than experimental materials, Nevertheless in stress condition, that alien factors like biotic and abiotic stresses are involved, new advances lines might be found that have got better function than commercial cultivars[13],[18]. In this experiment in drought conditions breeding materials are affected by water deficit, some genotypes had more satisfying performance than checks, which can be seen in table 4-2.

Correlation Coefficients

Correlation's analysis in table 5 among traits in the both conditions illustrated that the seed yield had the highest significant correlation not only with yield components but also with phonological and morphological traits that revealed in plants all attributes have got an impressive role in the final performance [1]. In the other words, any change in the expression of traits has an effect on economic and biologic performance. In some case these changes influence yield dramatically like the number of pod per plant. In the stress condition, seed yield had the highest positive correlation with the harvest index, the pod per plant and the pod length, respectively. Seed yield and plant height also were negatively correlated together according to the academic literatures, because stem structure in mung bean is vine type causing torsion plants and suppresses of penetrance sunlight into canopy consequently has a negative effect on seed yield. Similar results are reported by others [11], [16].

Stepwise Regression

Although correlation analysis gives important finding about relation among traits, regression analysis sets up an appropriate stage to look deeper to association between two traits while other traits are fixed [19]. Thereby stepwise regression is used to explain contribution different traits on the economic and biologic yield; Results are shown in table61 and 6-2.

In both environments seed yield was considered as independent variable. In the normal condition (Table6-1), three traits including the harvest index, the biological yield and the pod length explained the highest variations for the seed yield. These results were almost totally in agreement with the result of path analysis where the harvest index had directly the greatest determinant impact on grain yield (1.302), whilst the biologic yield and the pod length had the highest indirection impact on the seed yield, 1.042 and 0.533 respectively. In the stress condition (Table6-2), three traits including the harvest index, the biological yield and the 100-kernel weight covered a high proportion of changes on the seed yield. Indeed, these results are statistically in agreement with the correlation coefficients showing high association between seed yield with three above traits in drought environment.

Factor analysis is a multivariate statistical method that can facilitate the interpretation of data and grouping traits to small number of uncorrelated factors [2]. Perhaps factor analysis was applied to evaluate relationships between traits and finds independent factors out that explains phenotypic viability in genotypes. In this study factor analysis was done according to principal component analysis for each environment (Table 7-1). In the non-stress condition four factors described virtually 75.85 percent of phenotypic variation (Table 7-2). The first factor, called yield components' factor, with 36.4%, followed by morphologic and photoperiod factors with 16.8% and 12.6% respectively, compared to stress treatment that 78% of phenotypic variation was explained by 4 factors (table7-3), the first factor -namely photoperiod-morphology had the highest percentage in this matter, reaching 39.47%. Result are shown in Tables 7-1, 7-2 , 7-3.This results was in association with the outputs of the correlation, stepwise regression and path analysis, for example all traits in the first factor in both condition had the positive correlation together .thus, these traits are effective criteria in the mung bean breeding programs.

4. Conclusion

It is concluded that still exists variation among advanced lines that can be exploited for selection. Also it is predicted that selection based on genotypes performance in drought condition can be useful to find out superior lines that probably have better economic yield in water deficiency periods. For instance the amount of drought loss on traits' mean was not considerable compared to other drought researches that are reported around 50% on all traits [18], because these lines were elite line or advanced lines that had been selected for drought tolerance. It is shown in this study some of them had better performance in drought condition than commercial cultivars.

Almost all mung bean characteristics are affected due to drought damage; however morphologic traits like biologic yield and plant height showed the highest loss.

By using multivariate analysis, it can be resulted that in stress conditions, selecting the more dwarf lines with more harvest index and 100-seeds weight likely would cause an increment in the seed yield. However, in the normal conditions, according to results of stepwise regression and factor analysis the harvest index and the pod length had a positive and very significant correlation with the seed yield thus these three traits are associated with possessing higher economic yield.

one objective of this filed trial was identify genotypes who show better performance than check cultivars ,however mean comparisons in both condition indicated, in overall only genotypes 23, 32 and 21 had the better performance than commercial cultivars for economic yield in the drought condition, while they did not exceed in normal condition. More replication in different environments and various drought levels are essential to be done for better scientific results of mentioned breeding materials.

Table2. Mean of trait's performance in both conditions

Trait's names	Normal irrigation	Drought condition	Loss percent
PP	21.27	19.57	7
SP	11.61	10.99	5
PL	7.66	7.69	-0.3
KW	3.484	3.61	-3.6
SY	935	765	18
BY	3151	2691	14
HI(%)	29	28	3.4
DoF	72.12	65.84	8.7
DoP	86.85	80.45	7.3
PH	80.94	50.97	37

Table3. Mean Square of genotype effects in both environments.

	PP	SP	PL	KW	SD	BY	BI	DoF	DoP	PH
M.S(Normal)	30.72**	3.12**	0.58**	1.29**	315.8**	1947.3**	0.025**	121.67**	126.45**	263.3**
M.S (Drougth)	49.23**	5.12**	0.503**	0.29**	789.2**	2034.4**	0.04**	45.6**	146.4**	233.5**

*, **: significant at 5 % and 1%level of probability, Respectively.

Table4.1 Mean comparisons of different traits for superior genotypes in normal condition.

PP	SP	PL(mm)	KW(g)	SD(kg.h^{-1})	BY(kg.h^{-1})	BI(%)	DoF	DoP	PH(cm)
(23)26.8a	(11)12.35a	(17)8.7a	(Mehr)4.4a	(Gohar)1300a	(26)4554a	(14)61a	(1)82a	(81)96a	(20)97.1a
(3)25.4ab	(12)12.33a	(10)8.59a	(10)4.3a	(Mehr)1184a	(28)4370a	(Mehr)60a	(30)81.67a	(15)96a	(14)96a
(2)24.7b	(Mehr)12a	(4)8.4a	(33)4.46a	(Partov)1153a	(11)3956b	(Partov)53b	(9)81.67a	(1)95a	(28)95.4a
(24)24.1b	(9)12a	(26)7.9b	(Gohar)4.4ab	(23)1132a	(15)3910b	(30)53b	(15)79a	(3)95a	(2)93.4a
(11)24b	(26)11.96a	(9)7.85b	(26)4ab	(32)1080ab	(12)3680b	(32)53b	(14)78.67a	(15)94.6a	(1)91.1a
(27)23.7b	(15)11.90ab	(11)7.73b	(12)3.7b	(21)1013ab	(22)3611bc	(17)52b	(26)78a	(32)93.3a	(26)89.9a

Means followed by the same letter(s) within a column have not statistically different at the p= 5% level.

Table4.2 Mean comparisons of different traits for superior genotypes in drought condition.

PP	SP	PL(mm)	KW(g)	SD(kg.h^{-1})	BY(kg.h^{-1})	BI(%)	DoF	DoP	PH(cm)
(11)25.7a	(12)12.1a	(Partov)8.95a	(Gohar)5.75a	(23)1077a	(26)4094a	(23)68a	(28)89a	(1)92.25a	(29)75.1a
(23)25.7a	(5)12.07a	(Gohar)8.95a	(4)4.93ab	(Gohar)1063a	(28)4038a	(14)67a	(1)78b	(15)91.5a	(32)64.4b
(27)22.55b	(29)12.07a	(Mehr)8.6ab	(Partov)4.9ab	(21)914.2b	(11)3496ab	(24)55b	(15)78b	(19)86.5a	(16)62.5b
(18)22.32b	(15)12.05a	(8)8.52b	(27)3.8b	(11)905.4b	(15)3456ab	(Mehr)55b	(30)71.6b	(9)86.25a	(14)62.5b
(26)22.2b	(32)11.96a	(1)7.95b	(16)3.74b	(14)902.45b	(12)3197b	(17)54b	(32)71.2b	(28)86a	(6)61.9b
(8)21.94b	(31)11.9a	(11)7.93b	(20)3.71b	(32)850c	(22)3151b	(32)50b	(9)68.6bc	(32)83.5ab	(31)61.1b

Means followed by the same letter(s) within a column have not statistically different at the p= 5% level.

International Journal of Agriculture Innovations and Research
Volume 3, Issue 4, ISSN (Online) 2319-1473

Table5. Correlation coefficients of traits in both environments.

		PP	SP	PL	KW	SD	BY	BI	DoF	DoP	PH
PP	Normal	1									
	Drought	1									
SP	Normal	-0.35	1								
	Drought	0.12	1								
PL	Normal	0.26	0.65**	1							
	Drought	0.62	0.45*	1							
KW	Normal	0.23	0.65**	0.57*	1						
	Drought	-0.54	-.064**	0.63**	1						
SD	Normal	0.75**	0.56	0.62**	0.52*	1					
	Drought	0.61**	0.34	0.60**	0.54*	1					
BY	Normal	0.46*	-0.52*	-0.25	0.36	0.14	1				
	Drought	0.52*	-0.26	0.26	-0.25	0.04	1				
BI	Normal	0.56*	0.49*	0.78**	0.59*	0.62**	-0.5	1			
	Drought	0.45	0.68**	0.79**	0.64**	0.63**	-0.34	1			
DOF	Normal	0.56*	0.43	-0.51**	0.35	0.69**	0.32	0.42	1		
	Drought	0.26	0.45	-0.45	0.36	-0.60**	0.26	0.46*	1		
DoP	Normal	0.56**	0.41	-0.49*	-0.34	0.68**	0.22	-.45*	0.92**	1	
	Drought	0.13	0.5	-.048*	0.35	-0.54*	0.32	-0.25	0.90**	1	
PH	Normal	0.23	0.13	0.32	-0.71**	-0.65**	0.65**	-0. 26	-0.46*	-0.47	1
	Drought	0.26	0.18	0.65**	0.25	-0.52*	0.26	-0.16	-0.09	-0.15	1

*, **: significant at 5 % and 1%level of probability, Respectively.

Table6.1 Stepwise regression and path coefficients in normal condition

	HI	BY	KW	Correlation coef.
HI	1.302	-0.72	0.019	0.62**
BY	1.042	-0.899	-0.003	0.142
PL	0.047	0.533	-0.053	0.52*

*, **: significant at 5 % and 1%level of probability, Respectively.

Table6.2 Stepwise regression and path coefficients in drought condition

	HI	BY	KW	Correlation coef.
HI	1.418	-0.85	0.062	0.63**
BY	1.132	-1.065	-0.022	0.046
KW	0.172	0.51	-0.144	0.54*

*, **: significant at 5 % and 1%level of probability, Respectively.

Table7.1 Principle components analysis of mungbean genotypes in both environments.

	Normal				Drougth			
	PC1	PC2	PC3	PC4	PC1	PC2	PC3	PC4
Eigenvalue	4.73	2.19	1.62	1.3	5.13	2.44	1.46	1.1
Proportion σ2	36.43	16.86	12.52	10.03	39.47	18.8	11.26	8.5
Commulative σ2	36.43	53.29	65.8	75.85	39.47	58.28	69.54	78.06

Table7.2 factor analysis with varinax rotation of traits in both normal environment

Factor	PP	SP	PL	KW	SD	BY	BI	DoF	DoP	PH
PC1	0.54	0.3	0.84	0.79	0.64	0.024	0.46	0.2	0.24	0.09
PC2	0.17	0.66	-0.09	-0.17	-0.09	0.04	0.057	0.21	0.12	0.6
PC3	0.12	0.06	-0.011	-0.07	0.22	0.09	0.42	0.63	0.831	0.14
PC4	0.034	0.16	0.14	0.08	-0.16	0.93	-0.72	0.31	0.36	0.14

Table7.3 factor analysis with varinax rotation of traits in stress environment

Factor	PP	SP	PL	KW	SD	BY	BI	DoF	DoP	PH
PC1	0.097	0.78	-0.69	-0.85	-0.54	-0.003	-0.32	0.76	0.81	0.69
PC2	0.92	-0.14	0.68	-0.19	0.69	0.11	0.44	-0.032	-0.058	0.32
PC3	-0.13	0.05	0.14	0.04	0.42	-0.94	0.78	-0.24	-0.31	0.06
PC4	-0.014	-0.19	0.43	0.18	0.42	-0.006	-0.083	0.006	0.03	-0.07

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