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Assess Effect of Drought Stress and Potassium Sulfate on Agronomic Characteristics of Mung bean Genotypes at North of Khuzestan Province

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ABSTRACT

BACKGROUND: Suitable and useful usage of different kind of fertilizers is the main way for reformation and potential of soil fertility and increasing of crops yield.

OBJECTIVES: This study was conducted with the aim of evaluating the effect of drought stress and potassium sulfate application on the crop production and qualitative traits of mung bean genotypes.

METHODS: Current research was done according a factorial split plot based on randomized complete block design with three replications at two years in the summer of 2010 and 2011 at the Safiabad Agricultural Research Center, Dezful. Different irrigation levels (irrigation after 120, 180 and 240 mm of evaporation) belonged to main plot and potassium fertilizer (without fertilizer consumption, 37.5 and 75 $kg.ha^{-1}$ from potassium sulfate source) with genotype (included the varieties of Parto, Indian mass and the promising lines VC6173, KPS1, Cn95) were placed in subplots.

RESULT: The results showed that water deficit stress significantly affected the yield traits, stomatal conductance, harvest index and the amount of chlorophyll, so that severe and mild drought stress reduced the seed yield by 30.4 and 21.9%, respectively, compared to the optimal conditions. Among genotypes, the highest seed yield belonged to Pratto variety and VC6173 line were selected under optimal irrigation conditions and lowest one was related to KPS1 line. The use of potassium fertilizer increased the tolerance of all genotypes to drought stress. The use of potassium sulfate is due to its positive effect on the better absorption of other elements, especially nitrogen and phosphorus and increased tolerance to drought stress was effective. In general, drought stress had a significant negative effect on physiological traits of mung bean, and these characteristics also had a significant effect on the components of seed yield, so, potassium consumption had a positive and significant effect on physiological characteristics of the plant and Improved yield components.

CONCLUSION: Optimal irrigation, potassium consumption of 37.5 $kg.ha^{-1}$ and use of Pratu variety, Indian mass and promising VC6173 line were recommended.

KEYWORDS: *Chlorophyll, Fertilizer, Harvest index, Irrigation, Pulse.*

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1. BACKGROUND

Among agricultural plants, legumes, due to their important and fundamental role in increasing soil organic matter in crop rotation, the constructive effects of organic matter on physical (soil grain stability), chemical (increasing elemental storage capacity) and biological (microbial biological function activity) characteristics, which they are known as the pillar of soil fertility, they are important. One of the climatic factors that affects the distribution and distribution of plants all over the world and can cause many morphological, physiological and biochemical changes in the plant is the lack of available water (Hasani and Omid Beigi, 2002). Environmental stress is a very important factor in the distribution of plant species. Although stomatal and non-stomatal factors play a role in reducing photosynthesis, depending on the intensity and duration of drought stress and at what stage of growth it occurs one of these factors can have a greater effect on the leaf assimilation capacity under drought stress conditions (Gupta, 1976). In an experiment aimed at the effect of limited irrigation in mung bean, Sadeghipour (2018) stated the effect of the irrigation cycle on the yield and its components was significant. The treatment without irrigation in the flowering stage reduced the number of pods in the plant, the number of seeds in the pod and the seed yield, while the limited irrigation in the pod filling stage reduced the 1000-seed weight. Efficient cell development and growth of plant tissues, transport, storage of assimilates and other internal actions which are mostly based on physiological, biochemical and biophysical interactions, need sufficient potassium in the cell sap. Potassium plays a role in plant water status and overcomes soil moisture stress (Marscner, 1995). The role of potassium in reducing the effects of stresses such as drought, cold and high light intensity in plants has been reported (Waraich *et al*., 2012).

2. OBJECTIVES

This study was conducted with the aim of evaluating the effect of drought stress and potassium sulfate application on the crop production and qualitative traits of mung bean genotypes.

3. MATERIALS AND METHODS

3.1. *Field and Treatments Information*

This research was carried out in the summer of 2010 and 2011 as a factorial split plot in the form of a basic randomized complete block design (RCBD) with three replications at the Safi Abad Dezful Research Center. The average rainfall of the area was 275 mm, the average annual temperature was 23.9 degrees Celsius, and the soil type was silty clay lome. Irrigation levels in the main plot, as well as potassium and genotype were factorially placed in the sub-plots. Irrigation cycle (drought stress) as the main factor including three levels: 1- irrigation after 120 mm of evaporation from the evaporation pan (I_1), 2- irrigation after 180 mm (I_2) and 3- irrigation after 240 mm of evaporation from the evaporation pan (I_3). Irrigation treatments were applied after the second irrigation and at the six-leaf stage of plant growth. Potassium fertilizer from the source of potassium sulfate as a secondary factor including three levels without fertilizer (K_0), consumption of 37.5 kg (K_1) and consumption of 75 kg.ha^{-1} (K_2) and mung bean genotype including Prato (V_1), Indian mass (V_2) and promising lines VC 6173 (V_3), KPS1 (V_4) and Cn95 (V_5) were considered as sub-plots. The experiment was conducted in three replications and included a total of 135 treatments in this experiment. The area of each experimental plot was 16 square meters and the distance between the main irrigation treatments was 1.5 meters. Thus, area of each repetition was 850 square meters and the sum of three repetitions with the intervals between repetitions was 2650 square meters.

3.2. *Farm Management*

Before land preparation, irrigation was done on first of July. Each experimental plot consisted of four planting lines with a length of five meters. Fertilization operation was performed simultaneously with seed cultivation, as soil application and according concentration of potassium in potassium sulfate fertilizer (48%), in treatment of 37.5 kg, amount of 90 kg was used and for treatment of 75 kg, amount of 180 kg.ha^{-1} of potassium sulfate was used.

3.3. *Measured Traits*

The evaluated traits included seed yield, harvest index, stomatal conductance and leaf chlorophyll content in the flowering stage. In order to measure stomatal conductance in terms of mmol H_2O. m^{-2}.s^{-1}, an IRGA device model LTD Hoddoson UK LCA4 (ADC Biosentetic), was used. All measurements were made at 9-11 in the morning in the light intensity of 1200 to 1400 micromol photons per square meter, because gas exchanges do not change significantly in this time range. For this purpose, 3 plants were selected from the two middle lines from each experimental plot and measurements were made from the third fully developed leaf from the top of the plant (Costa *et al.*, 2002). First, the middle part of the middle leaf was placed inside the device chamber and after necessary time (about 43 seconds) to calibrate the device, the desired data were recorded. The spad device was used to measure chlorophyll.

3.4. *Statistical analysis*

Analysis of variance and mean comparisons were done via SAS (Ver.9.1) software and Duncan multiple range test at 5% probability level.

4. RESULT AND DISCUSSION

4.1. *Seed yield*

The results of combine variance analysis (Table 1) showed that the seed yield was significantly affected by irrigation, genotype, interaction effect of potassium and irrigation, irrigation and genotype, fertilizer and genotype, as well as triple interaction of treatments at 1% probability level. With increase of drought stress, seed yield decreased so that the highest (3568 kg.ha^{-1}) and lowest (2483 kg.ha^{-1}) one was for optimal irrigation and severe stress, among fertilizer application treatments, the highest (3040 kg.ha^{-1}) and lowest (2873 kg.ha^{-1}) seed yield were related to using 75 kg potassium sulfate and control.

Table 1. Summary of variance analysis results of treatment effects on studied traits

S.O.V	df	Seed yield	Harvest index	Stomatal conductance	Totall chlorophyll
Replication	2	682621^{ns}	1.918^{ns}	3631.2^{ns}	180.94^{ns}
Irrigation	2	28198710**	87.03**	17400.8**	1450.48**
Error I	4	358.18	3.54	2332.2	497.225
Potassium Fertilizer	2	652393*	226.85**	642.5^{ns}	474.4*
Irrigation × Fertilizer	4	4541530**	324.78**	14369.7**	4152.6**
Genotype	4	4616604**	103.17**	37.1025**	386.28*
Irrigation × Genotype	8	1081436**	42.20**	2067.9^{ns}	456.19**
Genotype × Fertilizer	8	13086647**	85.25**	2698.1^{ns}	104.93^{ns}
Irrigation × Fertilizer × Genotype	16	1574204**	69.39**	4079.4*	333.9**
Error II	84	198941.8	9.269	2091.1	134.5
CV%		15.13	10.95	19.26	18.79

^{ns}, * and ** : non-significant, significant at 1 and 5 % probability level, respectively.

Among genotypes, the highest yield (3270 kg.ha^{-1}) and lowest yield (2488 kg.ha^{-1}) belonged to Indian mass and promising line Kps1 (Table 2). In the interaction of irrigation and fertilizer consumption, the highest (3943 kg.ha^{-1}) and the lowest (2291 kg.ha^{-1}) seed yield were assigned to optimal irrigation in treatment of 75 kg of potassium sulfate fertilizer and severe stress in the treatment without fertilizer (Table 3). The highest (3860 kg.ha^{-1}) and the lowest (1940 kg.ha^{-1}) seed yield was observed for promising line VC6173 in favorable irrigation and the promising line KPS1 in severe stress (Table 4). The results showed that drought stress has a significant effect on yield directly by affecting the yield components, and the use of potassium fertilizer has been able to compensate some of this decrease in yield due to dehydration by improving the yield components. Between interaction of fertilizer and genotype, the highest (3542 kg.ha^{-1}) and the lowest (2673 kg.ha^{-1}) seed yield was attributed to the treatment of 37.5 kg of potassium sulfate fertilizer in Prato and kps1 line in the treatment of 37.5 kg of fertilizer (Table 5). With increasing stress and decreasing fertilizer consumption, the yield of genotypes decreased. So the highest yield (4365 kg.ha^{-1}) and lowest one (1550 kg.ha^{-1}), respectively, were attributed to optimal irrigation in the treatment of using 37.5 kg of potassium sulfate fertilizer in Parto variety and severe stress in the treatment of using 37.5 kg of fertilizer in the KPS1 line was related (Table 6). The yield of mung beans decreased drastically with increasing stress (Pannu and Singh, 1993). Drought stress, by affecting yield components and physiological traits, causes a decrease in stomatal conductance and ability of plant to use available inputs, including micronutrient, causing a decrease in seed yield.

Table 2. The mean comparison of irrigation, potassium fertilizer and genotypes on studied traits

Treatment	Seed yield ($kg.ha^{-1}$)	Harvest index (%)	Stomatal conduction (mmol $H_2O.m^{-2}.S^{-1}$)	Total chlorophyll (Spad)
Irrigation				
Optimal irrigation (I_1)	3568a*	26.4c	178a	63a
Mild tension (I_2)	2788b	29.2a	167ab	59.8b
Intense tension (I_3)	2483b	27.7b	140b	61.3ab
Potassium fertilizer (K)				
No fertilizer (K_0)	2873b	30.2a	160b	59.4b
37.5kg.ha^{-1} (K_1)	2926ab	27.4a	166ab	60.9ab
75kg.ha^{-1} (K_2)	3040a	25.8c	168a	63.8a
Genotype (V)				
Parto (V_1)	3056b	24d	156b	62.8b
Indian mass (V_2)	3270a	25.9c	152bc	58.2bc
VC6173 (V_3)	3046b	26.7c	191a	74/8a
KPS1 (V_4)	2489d	29b	132c	67ab
CN95 (V_5)	2871c	33a	179ab	47c

*Mean which have a least once common letter are not significant different at the 5% probability level.
I_1, I_2 and I_3: Irrigation after 120, 180 and 240 mm of evaporation from the evaporation pan, respectively.
K_0, K_1 and K_2: no-using, consumption of 37.5 and 75 potassium($kg.ha^{-1}$) , respectively.
V_1, V_2, V_3, V_4 and V_5: Parto, Indian mass, VC6173, KPS1 and Cn95 genotypes, respectively.

By using an element like potassium, which can increase the plant's tolerance to lack of water in these conditions, it is possible to avoid a significant decrease in yield. These results were consistent with the reports of Chavez *et al*. (2002) and Ebrahimi *et al*., (2010).

4.2. Harvest index

The harvest index was influenced by irrigation, genotype, fertilizer, irrigation and fertilizer interaction, irrigation and genotype, fertilizer and genotype interaction and also the triple interaction was significant at 1% probability level (Table 1). The mild stress treatment and optimal irrigation had the highest (29.4%) and the lowest (26.7%) harvest index, respectively, among the treatments of using potassium fertilizer, the treatment without using fertilizer and the treatment of using 75 kg of fertilizer, respectively, the highest (30.4%) and the the lowest (26.2%) harvest index, and among the genotypes, the highest (33%) and lowest (24.6%) harvest index were for kps1 line and Prato variety (Table 2). The use of potassium fertilizer increased growth rate of vegetative organs and changed the balance of dry matter with seed yield in favor of dry matter, so the harvest index decreased.

Table 3. The mean comparison interaction effect of irrigation and fertilizer on studied traits

Irrigation × Fertilizer	Seed yield (kg.ha^{-1})	Harvest index (%)	Stomatal conduction during stress (mmol $H_2O.m^{-2}.S^{-1}$)	Total chlorophyll (Spad)
I1×K0	3303 ab	31.3a	171b	61b
I1×K1	3457 ab	23.1e	170b	65ab
I1×K2	3943 a	24.9de	194a	63b
I2×K0	2966 b	29.6b	118e	60bc
I2×K1	3055 b	31.4a	155c	58c
I2×K2	3065 b	26.5cd	148c	62ab
I3×K0	2291 e	29.7b	108f	57c
I3×K1	2349 d	27.5c	144c	59bc
I3×K2	2807 c	25.9d	136d	67a

*Mean which have a least once common letter are not significant different at the 5% probability level.
I_1, I_2 and I_3: Irrigation after 120, 180 and 240 mm of evaporation from the evaporation pan, respectively.
K_0, K_1 and K_2: no-using, consumption of 37.5 and 75 potassium (kg.ha^{-1}) , respectively.

The highest (31.4%) and the lowest (23.6%) harvest index were assigned to the mild stress treatment in the treatment of 37.5 kg and optimal irrigation without using fertilizer (Table 3). Also, kps1 line in mild stress and vc 6173 line in optimal irrigation had the highest (35.9%) and lowest (24%) harvest index, respectively (Table 4). The cn95 line had the highest (36.3%) harvest index in the treatment without fertilizer use, and the Indian mass and the VC6173 line had the lowest (22%) harvest index in the 75 kg fertilizer treatment (Table 5). Also, the vc6173 line in the mild stress treatment with the consumption of 37.5 kg of fertilizer had the highest (41.3%) and the vc6173 line in the optimal irrigation treatment and the consumption of 75 kg of fertilizer had the lowest (16.5%) harvest index (Table 6). The harvest index of tropical legumes is significantly lower than that of cereals (Fageria, 1992). Generally, it is reported that irrigation reduces the yield of mung bean through a reducing effect on biological yield and harvest index (Thomas *et al*., 2003). Costa-Franca *et al*., (2000) proposed that optimal irrigation increases harvest index by 34-36%, while mild and severe stress gives harvest index by 21 and 16%, respectively. The research results of Rafie and Asgharpour (2009) on mung bean plant showed that due to increase of irrigation intervals, most of characteristics, especially 100-weight seeds and harvest index, are affected and reduced. The results showed that due to application of drought stress throughout plant growth period, harvest index has increased significantly due to decrease in biological yield in mild stress treatment compared to optimal irrigation. But in severe stress, it has decreased due to decrease in number of stems, the number of pods in the plant, the number of seeds in the pod and the increase in seed abortion. If stress is applied only in vegetative period, harvest index increases and if it is in the reproductive period, harvest index decreases (Sadeghipour, 2018).

Table 4. The mean comparison interaction effect of irrigation and genotype on studied traits

Irrigation × Genotype	Seed yield ($kg.ha^{-1}$)	Harvest index (%)	Stomatal conduction during stress ($mmol\ H_2O.m^{-2}.S^{-1}$)	Total chlorophyll (Spad)
I1×V1	3640a	22.2e	157b	62c
I1×V2	3481 b	24.4cd	186ab	63c
I1×V3	3860 a	23.6d	213a	73ab
I1×V4	3110 c	33.9ab	141bc	71ab
I1×V5	3751 ab	28.1b	195ab	46e
I2×V1	3020 c	25.6c	159b	61c
I2×V2	3283 bc	25c	156b	60c
I2×V3	2762 d	28.4b	199ab	79a
I2×V4	2416 e	35.9a	120c	60c
I2×V5	2461 e	31. 2b	193ab	38f
I3×V1	2510 de	24.7c	153b	63c
I3×V2	3047 c	28.2b	123bc	52d
I3×V3	2515 de	28/1b	160b	72ab
I3×V4	1940 f	22/6d	126bc	70b
I3×V5	2402 e	28b	149b	50d

*Mean which have a least once common letter are not significant different at the 5% probability level.
I_1, I_2 and I_3: Irrigation after 120, 180 and 240 mm of evaporation from the evaporation pan, respectively.
V_1, V_2, V_3, V_4 and V_5: Parto, Indian mass, VC6173, KPS1 and Cn95 genotypes, respectively.

High harvest index is very important for increasing yield potential in crops, but this quality is very complex in legumes. Because harvest index in legumes is sensitive to environmental variables (Ayaz, 2001). The results were consistent with reports of Liu *et al*., (2023).

4.3. *Stomatal conduction*

The results of analysis of variance (Table 1) showed that stomatal conductance (during drought stress) was affected by irrigation treatments, genotype, interaction of treatments and also triple interaction of treatments at 1% probability level. Optimal irrigation treatment and severe stress had the highest (178 $mmol\ H_2O.\ m^{-2}.s^{-1}$) and lowest (140 $mmol\ H_2O.\ m^{-2}.s^{-1}$) stomatal conductance respectively, highest (191 $mmol\ H_2O.\ m^{-2}.s^{-1}$) and lowest (132 $mmol\ H_2O.\ m^{-2}.s^{-1}$) stomatal conductance to VC6173 and KPS1 lines were assigned, the treatment without using fertilizer and the 75 kg treatment had the highest (166 $mmol\ H_2O.\ m^{-2}.s^{-1}$) and the lowest (159 $mmol\ H_2O.\ m^{-2}.s^{-1}$), respectively (Table 2). The highest (194 $mmol\ H_2O.\ m^{-2}.s^{-1}$) and lowest (118 $mmol\ H_2O.\ m^{-2}.s^{-1}$) of stomatal conductance were assigned to optimal irrigation treatment in treatment of using 75 kg of potassium fertilizer and mild stress in treatment without using fertilizer, respectively (Table 3). Between irrigation and genotype interaction treatments, the highest (213 $mmol\ H_2O.\ m^{-2}.s^{-1}$) and lowest (120 $mmol\ H_2O.\ m^{-2}.s^{-1}$) stomatal conductance were assigned to optimal irrigation treatment in promising line vc6173 and severe stress in kps1 line (Table 4).

Table 5. The mean comparison interaction effect of fertilizer and genotypes on studied traits

Genotype × Fertilizer	Seed yield ($kg.ha^{-1}$)	Harvest index (%)	Stomatal conduction during stress (mmol $H_2O.m^{-2}.S^{-1}$)	Total chlorophyll (Spad)
V1* K0	2873d	24.7e	164a	55.9c
V2* K0	3072c	28.9cd	151a	50.2d
V3* K0	2861d	27.7d	191a	76.1ab
V4* K0	2673e	36.3a	116a	64.1b
V5* K0	2885d	33.4ab	180a	44.6e
V1* K1	3482ab	24.9e	173a	65.2b
V2* K1	3271b	26.8de	159a	57.1c
V3* K1	2978cd	30.7bc	212a	79.2a
V4* K1	2750de	30.1bc	150a	64.8b
V5* K1	2982cd	24.7de	179a	45.4e
V1* K2	3542a	22.9f	132a	62.9bc
V2* K2	3467ab	22f	145a	62.7bc
V3* K2	2999cd	22f	169a	78.7a
V4* K2	2840d	32/9b	131a	74.4ab
V5* K2	3114bc	29/2c	177a	44.1e

*Mean which have a least once common letter are not significant different at the 5% probability level.
V_1, V_2, V_3, V_4 and V_5: Parto, Indian mass, VC6173, KPS1 and Cn95 genotypes, respectively.
K_0, K_1 and K_2: no-using, consumption of 37.5 and 75 potassium($kg.ha^{-1}$) , respectively.

The VC6173 line in optimum irrigation treatment with 75 kg of fertilizer consumption and Indian mass in mild stress in no fertilizer treatment had the highest (289 *mmol* H_2O. $m^{-2}.s^{-1}$) and lowest (62 *mmol* H_2O. $m^{-2}.s^{-1}$) stomatal conductance respectively (Table 6). In optimal conditions stomatal conductivity in legumes is more than 200 (mmol H2o.$m^{-2}.s^{-1}$) and in stress conditions it is less than 200, but the amount of this number changes in growth stages and different climatic regions, but in plants Cereal family is higher than legumes (Chavez *et al*., 2002). The results showed a significant reduction effect of stress on stomatal conductance, the reduction of stomatal conductance decreases the entry of carbon dioxide into the leaves, and as a result, it causes a decrease in the level of production in the photosynthetic organ of the plant. On the other hand, potassium consumption has a positive effect on the optimal functioning of stomata, stomatal activity, cell development, storage of assimilates, preservation of cell mass, root strengthening, root elongation, osmotic regulation, respiration regulation, transfer of photosynthetic materials, opening and closing of stomata. Leaf movements and tropisms and ultimately improving the rate of photosynthesis cause the plant to overcome the effects of drought stress. The results of this research were consistent with the findings of EL Hafid (1998), Costa-Franca *et al*. (2000), Chavez *et al*. (2002) and Moradi *et al*. (2008) who stated that drought stress had significant effects on reducing stomatal conductance.

Table 6. The interaction effects of irrigation, fertilizer and genotype on studied traits

Treatment	Seed yield (kg.ha^{-1})	Harvest index (%)	Stomatal conduction (mmol $H_2O.m^{-2}.S^{-1}$)	Total chlorophyll (Spad)
I1×K0×V1	3280ef*	20.3de	176e	57.5g
I1×K0×V2	3298ef	22.8d	215cd	51.8h
I1×K0×V3	3510d	30.7c	182de	82.3c
I1×K0×V4	3020g	38ab	99k	66.8ef
I1×K0×V5	3411d	36b	183de	56.5g
I1×K1×V1	4365a	20.2de	174e	59.9fg
I1×K1×V2	3045g	27.4cd	171ef	67.6ef
I1×K1×V3	3789bc	24d	167ef	62.9f
I1×K1×V4	2964g	27.3cd	162f	92.a
I1×K1×V5	3123ef	23d	176e	63.7ef
I1×K2×V1	3275ef	26cd	121h	62.4f
I1×K2×V2	4099b	20.3de	173e	61.9f
I1×K2×V3	4281ab	16.5e	289a	86.3bc
I1×K2×V4	3344e	37.6b	169ef	79.5cd
I1×K2×V5	3687c	23.5d	226c	47.9hi
I2×K0×V1	2955g	26.3cd	168ef	55.8gh
I2×K0×V2	3072g	27.4cd	62l	56.4gh
I2×K0×V3	3124ef	22.7de	133gh	76.7d
I2×K0×V4	2842gh	23.8d	110ij	67.7ef
I2×K0×V5	2837gh	36b	115i	50.8h
I2×K1×V1	3626c	27.6d	160f	64.5ef
I2×K1×V2	4160ab	23.7d	157f	57.9g
I2×K1×V3	3031g	41.3a	156f	90.5ab
I2×K1×V4	1782m	36b	114i	50.2h
I2×K1×V5	2550j	27.6cd	189d	36.8ij

*Mean which have a least once common letter are not significant different at the 5% probability level.
I_1, I_2 and I_3: Irrigation after 120, 180 and 240 mm of evaporation from the evaporation pan, respectively.
K_0, K_1 and K_2: no-using, consumption of 37.5 and 75 potassium (kg.ha^{-1}) , respectively.
V_1, V_2, V_3, V_4 and V_5: Parto, Indian mass, VC6173, KPS1 and Cn95 genotypes, respectively.

4.4. *Total chlorophyll*

The value of chlorophyll in flowering stage was affected by the treatments of irrigation, irrigation and genotype, irrigation and fertilizer, as well as triple interaction of treatments at 1% and use of fertilizer and genotype at the 5% of probability level (Table 1). Optimal irrigation and severe stress treatments had highest (67.6) and lowest (56) chlorophyll, respectively, the treatment with consumption of 75 kg fertilizer and no fertilizer had the highest (63) and lowest (59.6) chlorophyll values, respectively. Among the genotypes, the highest (77.9) and lowest (45) chlorophyll values were related to vc6173 and cn95 lines (Table 2). The highest (67) and lowest (57) chlorophyll was assigned to optimal irrigation treatment and application of 37.5 kg of fertilizer and severe stress in control (Table 3). The highest (79.3) and lowest (40) values were assigned to optimal irrigation in promising line (vc6173) and severe stress in same line, respectively (Table 4).

Continue table 6.

Treatment	Seed yield ($kg.ha^{-1}$)	Harvest index (%)	Stomatal conduction ($mmol\ H_2O.m^{-2}.S^{-1}$)	Total chlorophyll (Spad)
I2×K2×V1	2477j	27.3cd	131gh	64ef
I2×K2×V2	2614i	23d	119h	67.8ef
I2×K2×V3	2132l	21.3de	191d	88.3b
I2×K2×V4	2623i	33.3bc	153fg	51.5h
I2×K2×V5	1969lm	31c	144g	24j
I3×K0×V1	2384k	23.7d	147g	51.6h
I3×K0×V2	2845gh	37.3b	175e	36.3ij
I3×K0×V3	1850lm	27.9cd	257b	63.8f
I3×K0×V4	2156l	23.9d	138gh	57.7gh
I3×K0×V5	2408j	23.8d	242bc	27.5ij
I3×K1×V1	2454j	27.7cd	185de	70.4e
I3×K1×V2	2607i	23.8d	150fg	49.4i
I3×K1×V3	2113l	27.6cd	185de	74.7de
I3×K1×V4	2114l	30.7c	174e	52.3h
I3×K1×V5	2168l	23.4d	173e	22j
I3×K2×V1	2689i	19de	144g	60.6fg
I3×K2×V2	3689c	22.7cd	142g	56.7gh
I3×K2×V3	3480d	28cd	155fg	66ef
I3×K2×V4	1550n	27.8cd	88kl	92.3a
I3×K2×V5	2630hi	21.3d	160f	45.8i

*Mean which have a least once common letter are not significant different at the 5% probability level.
I_1, I_2 and I_3: Irrigation after 120, 180 and 240 mm of evaporation from the evaporation pan, respectively.
K_0, K_1 and K_2: no-using, consumption of 37.5 and 75 potassium ($kg.ha^{-1}$) , respectively.
V_1, V_2, V_3, V_4 and V_5: Parto, Indian mass, VC6173, KPS1 and Cn95 genotypes, respectively.

In the interaction of genotype and fertilizer, the highest (2.79) and the lowest (1.44) chlorophyll were assigned to vc6173 l in 37.5 kg treatments and cn95 line in 75 kg fertilizer treatment (Table 5). The highest (92.3) and the lowest (27.5) of chlorophyll value in the flowering stage were assigned to the kps1 line in the severe stress treatment and the consumption of 75 kg of fertilizer per hectare and the cn95 line in the severe stress and the treatment of the consumption of 75 kg of fertilizer per hectare (Table 6). Chlorophyll loss is often associated with environmental stress, and a change in the amount of chlorophyll can be an acceptable sign of stress in the plant (Iturbe Ormaetxe *et al.*, 1998). Drought stress reduces the amount of photosynthesis, and this reduction in materialization and reduction of carbon dioxide entry, closing of stomata, reduction of carbohydrates and severe changes of starch to sugars, and as a result, partially increases the percentage of protein (Johnson and Nguyen, 1982). From the results, it can be concluded that the first main and influential component in plant production is chlorophylls, and any factor that increases, decreases, or disrupts the balance between them has an effect on plant production. In the meantime, lack of water leads to irreparable damage in plant production by reducing the amount of chlorophyll, and on the other hand, potassium fertilizer by affecting the physiological characteristics of the plant and also affecting the absorption of other nutrients, especially nitrogen and phosphorus, reduces the damage caused by drought stress on chlorophyll production and as a result, the yield of the plant is reduced. On the other hand, the vc6173 line was superior among genotypes due to its physiological and genetic characteristics, which can be important for breeding works. The mentioned results were consistent with the findings of Jahanbakhshi *et al*. (2022).

5. CONCLUSION

Based on the results, optimal irrigation, potassium consumption of 37.5 $kg.ha^{-1}$ treatment and the use of Pratu variety, Indian mass and promising VC6173 line are recommended to achieve the economic yield of mung bean plant in Khuzestan.

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FOOTNOTES

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