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Response of Seed Yield, Its Components, Chlorophyll Content and Proline Concentration of Mung bean (*Vigna radiate* L.) To Apply Sulphate Potassium Fertilizer under Salinity Stress Situation

Fatemeh Jahan Ahmadi[1], Mani Mojaddam*[2]

1- *Msc. Graduated, Department of Agronomy, Ahvaz branch, Islamic Azad University, Ahvaz, Iran.*

2- *Assistant Professor, Department of Agronomy, Ahvaz branch, Islamic Azad University, Ahvaz, Iran.*

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ABSTRACT

BACKGROUND: Among the environmental stresses soil salinity is a widespread environmental problem that has been found to affect more than 77 million hectares or 5% of the cultivable land of the universe. Potassium has a positive role in plant growth under saline conditions, because this element plays an essential role in photosynthesis, osmo regulatory adaptations of plant to water stress.

OBJECTIVES: Current research was carried out to evaluate effect of different level of potassium and salinity stress on quantitative and qualitative traits of Mung bean.

METHODS: This study was conducted according factorial experiment based on completely randomized design with three replications along 2015 year. The treatments included potassium fertilizer (0, 100 and 200 $kg.ha^{-1}$) from sulphate potassium source and four level of salinity (0, 2, 4 and 6 $ds.m^{-1}$).

RESULT: Result of analysis of variance showed effect of different level of salinity stress and potassium fertilizer on all studied traits were significant. Evaluation mean comparison result of interaction effect of treatments indicated maximum amount of seed and biologic yield (15.20 and 39.40 $gr.plant^{-1}$) was noted for control and 200 $kg.ha^{-1}$ potassium fertilizer and lowest ones (6.86 and 24.60 $gr.plant^{-1}$) belonged to 6 $ds.m^{-1}$ salinity stress and control treatment. Increasing salinity level led to decrease measured traits (instead proline concentration) but increasing potassium fertilizer level led to improve seed yield and its components.

CONCLUSION: Application the treatment of 4 $ds.m^{-1}$ and 100 $kg.ha^{-1}$ potassium fertilizer was able to prevent the reduction of Mung bean crop production, which was not significantly different from the treatment of 200 $kg.ha^{-1}$.

KEYWORDS: *Crop production, NaCl, Nutrition, Pulse, Seed weight.*

***Corresponding Author:** Mani Mojaddam ✉ manimojaddam47@gmail.com

1. BACKGROUND

Fabaceae family is one of the most important sources of protein and energy. Food legumes, after maize, wheat and rice, are the most important crops used for feeding the world's people, especially in the developing countries (Mohtashami *et al*., 2016a). By having 17-40% protein, legumes play an important role in the production of protein and calories needed by humans (Mohtashami *et al*., 2016b). Mung bean is an important pulse crops having high nutritive value. It not only plays an important role in human diet but also in improving the soil fertility by fixing the atmospheric nitrogen (Nadeem *et al*., 2004). Its seed is more palatable, nutritive, digestible and non-flatulent than other pulses (Anjum *et al*., 2006). In Iran, mung bean production is often undertaken on small farms using marginal soils low in N and P and with minimal technical inputs. In addition, the nodulation of mung bean is poor under the agro-ecological conditions of Iran. Fertilizer is one of the most important factors that affect crop production. Fertilizer recommendation for soils and crops is a dynamic process in view of the generation of the new knowledge, changes in soil nutrient status, changes in plants and planting patterns and associated management practices (Rafiqul Hoque *et al*., 2004). The management of fertilizers is one of the important factors that greatly affect the growth, development and yield of mung bean (Asaduzzaman *et al*., 2008). Soil salinity is a global problem that adversely affects 20% of irrigated land and reduces crop yields (Qadir *et al*., 2014). Among the environmental stresses soil salinity is a widespread environmental problem that has been found to affect more than 77 million hectares or 5% of the cultivable land of the universe (Athar and Ashraf, 2009). Salinity adversely affects the plant growth and productivity. The yield reduction due to salt stress may account for substantial reduction of the average yield of major crops by more than 50% (Bray *et al*., 2000). The nature of damages due to salt stress is very complex because it causes both osmotic stress and ionic toxicity (Hasanuzzaman *et al*., 2013). Na^+ and K^+ balance plays a key role in the growth and development of higher plants under saline conditions. Several physiological processes, including the maintenance of membrane potential and turgor, stomatal movement, regulation of osmotic pressure, and tropisms are dependent on the presence of potassium (Rahneshan *et al*., 2018). Potassium is a macronutrient for plants that is required for physiological processes such as the maintenance of membrane potential and turgor, activation of enzymes, regulation of osmotic pressure, stomata movement and tropisms (Golldack *et al*., 2003). Nelson (1978) believed that potassium has a positive role in plant growth under saline conditions, because this element plays an essential role in photosynthesis, osmo regulatory adaptations of plant to water stress. Adequate potassium supply is also desirable for the efficient use of iron element, while the higher potassium application results to competition with Fe (Celik *et al*., 2010).

2. OBJECTIVES

Current research was carried out to evaluate effect of different level of potassium and on quantitative and qualitative traits of Mung bean under salinity stress condition.

3. MATERIALS AND METHODS

3.1. Lab and Treatments Information

This study was conducted according factorial experiment based on completely randomized design with three replications along 2015 year. This study was done in Lab of Islamic Azad university of Ahvaz in Khuzestan province (Southwest of Iran). The treatments included potassium fertilizer (0, 100 and 200 $kg.ha^{-1}$) from sulphate potassium source and four level of salinity (0, 2, 4 and 6 $ds.m^{-1}$). For this experiment, 72 plastic pots with an opening diameter of 28 cm and a height of 30 cm were used. The soil physical and chemical properties were mentioned in table 1.

Table 1. Physical and chemical properties of studied field

Depth of soil (cm)	Saturation percentage (%)	EC ($ds.m^{-1}$)	pH	Organic carbon (%)	Phosphorus (ppm)	potassium (ppm)	Soil texture
0-15	34.9	3.4	7.1	0.2	9.2	110.12	Clay loam

3.2. Lab Management

Seed planting depth was two centimeters and the soil used according to the soil test had a loamy clay texture with a pH of 7.8. The fertilizer used in each pot according to the area of the pots (50 $kg.ha^{-1}$ of pure nitrogen fertilizer and 80 kg of pure phosphorus) was measured at the rate of 0.5 gr of nitrogen and 0.8 gr phosphorus and the determined amounts of potassium sulfate fertilizer were mixed with the soil and poured into the pots. In order to prevent the accumulation of salt in the pots, three holes with a diameter of one centimeter were installed in the bottom of each pot as drainage. After all the pots were filled with the same level of soil, we planted 5 Mung bean seeds soaked in water for 24 hours in five parts of the pot. The pots were irrigated with ordinary water (without salinity levels) for two weeks until emergence. After complete establishment of seedlings, three plants were kept in each pot and another was removed. Salinity treatment was carried out through irrigation water and using solutions with certain electrical conductivity from the four-leaf stage.

3.3. Measured Traits

At plant maturity stage, number of pods per plant, numbers of seeds per pod were measured and 1000-seed weight, seed yield and biological yield after plant harvest were calculated. Chlorophyll index (Spad number) was measured with a spadmeter (spad-502), with 10 leaves at flowering. The concentration of proline accumulated in plant was calculated using with spectrophotometer at wavelength of 520 nm according to standard curve obtained from different concentrations of proline at 50% pod stage, in terms of $mg.g^{-1}$ fresh leaf weight (Bates *et al*., 1973).

3.4. Statistical Analysis

Analysis of variance and mean comparisons were done via SAS (Ver.8) software and Duncan multiple range test at 5% probability level.

4. RESULT AND DISCUSSION

4.1. Number of pod per plant

According result of analysis of variance effect of different level of salinity stress and potassium fertilizer on number of pod per plant was significant at 1% probability level but interaction effect of treatments was not significant (Table 2). Mean comparison result of different level of salinity stress indicated that maximum number of pod per plant (12.89) was noted for control and minimum of that (8.23) belonged to 6 $ds.m^{-1}$ treatment (Table 3). It seems that under salinity stress, restriction of nutrient uptake by roots leads to reduced production of photosynthetic material and reduced allocation to reproductive organs. So, lack of resources during the flowering period causes the shedding of reproductive organs and fertile flowers, especially young pods, which results in a decrease in the number of mature pods. Similar result reported by Ahmed (2009). Liu *et al.* (2004) reported the decrease in the number of pods may be due to an increase in the hormone abscisic acid because too much of this hormone can cause the death of pollen grains as a result of the number of inoculated cells and the number of pods decreases. Because of the applied stress, on the one hand, it accelerates flowering and reduces the length of flowering period, and on the other hand, it causes less vegetative growth and consequently less photosynthetic material production. Under these conditions, the plant guarantees its survival by reducing the number of pods. Ahmed (2009) studied the effect of salinity stress on of Mung bean production and reported that the decrease in seed yield in the plant was more pronounced under salinity stress. Also, the number of pods per plant and 100-seed weight under salinity stress was less than the control treatment. Salinity stress had the greatest effect on vegetative growth, flowering and grain filling stages, which was consistent with the results of current study. As for Duncan classification made with respect to different level of potassium fertilizer maximum and minimum amount of number of pod per plant belonged to 200 $kg.ha^{-1}$ (11.71) and control (9.1) (Table 4). Shirvanipour *et al.* (2014) reported the effect of potash fertilizer on the number of pods per plant and number of seeds per pod was significant and the highest number of pods per plant was obtained from 100 $kg.ha^{-1}$ potash treatments and the lowest was from non-application of potash fertilizer. Abbas *et al.* (2011) by evaluate the Mung bean plant reported that the number of pods per plant and seed yield were significantly affected by potassium fertilizer application. The minimum amount number of pods and number of seeds per pod were obtained from control treatment. In their studies, they pointed to the vital role of potassium in plant growth and sustainable crop production, which was consistent with the results of the current research.

Table 2. Result analysis of variance of measured traits

S.O.V.	df	No. pod per plant	No. seed per pod	100-seed weight	Seed yield	Biologic yield	Chlorophyll index	Proline
Salinity stress (S)	3	10.58^{**}	9.89^{**}	7.03^{**}	88.21^{**}	426.40^{**}	8.25^{**}	5.76^{**}
Potassium fertilizer (P)	2	11.49^{**}	10.2^{**}	6.01**	23.79^{**}	820.80^{**}	14.46^{**}	15.42^{**}
S×P	6	0.325^{ns}	0.058^{ns}	0.09^{ns}	10.81^{**}	136.3^{**}	0.37^{ns}	0.11^{ns}
Error	24	0.54	0.153	0.22	0.49	10.30	0.43	0.56
CV(%)	-	7	4.2	7.08	4.67	10.91	2.15	13.03

$^{ns,\ *\ and\ **}$: no significant, significant at 5% and 1% of probability level, respectively.

4.2. Number of seed per pod

Result of analysis of variance revealed effect of different level of salinity stress and potassium fertilizer on number of seed per pod was significant at 1% probability level, but interaction effect of treatments was not significant (Table 2). According result of mean comparison maximum of number of seed per pod (10.68) was obtained for control and minimum of that (7.65) was for 6 $ds.m^{-1}$ treatment (Table 3). Nabizadeh Marvdasht *et al.* (2003) reported seed weight loss due to change in the path of photosynthetic materials to counteract the effects of salinity stress. Evaluation mean comparison result indicated in different level of potassium fertilizer the maximum number of seed per pod (10.12) was noted for 200 $kg.ha^{-1}$ and minimum of that (7.81) belonged to control treatment (Table 4). In this study, factors such as salinity, increasing osmotic pressure and environmental factors reduced the number of grains in the pod. The reason for the high number of seeds per plant in fertilizer treatments may be due to the lack of source restrictions in terms of potassium fertilizer application. The presence of potassium fertilizer in the plant prevents excessive abortion of seeds. Therefore, in the absence of resource constraints, reservoir constraints are less common. These results were consistent with the findings of Kumar *et al.* (2014) who reported that the number of seeds per pod increased with the application of potassium fertilizer. Abbas *et al.* (2011) by study on the application different levels of potassium sulfate in Mung bean, reported number of pods per plant, number of seeds per pod and seed yield were significantly affected by potassium. The minimum number of pods and number of seeds per pod were obtained from control treatment. Alavi Matin *et al.* (2015) by investigating role of K fertilizer on salinity stress tolerance reported salinity stress reduced seed yield by 68% compared to the control. In contrast, use of different types of K under salinity conditions, reduced adverse effects of salinity on seed yield by 25% compared to the control. Under salinity stress, K fertilizer maintains photosynthesis by reducing adverse effects of Na accumulation, adjustment osmotic pressure, relative water content, increasing stomata conductance, maintaining chlorophyll, so reducing adverse effects of salinity stress on seed yield.

Table 3. Mean comparison effect of different level of salinity stress on measured traits

Salinity stress ($ds.m^{-1}$)	No. Pod per Plant	No. seed per Pod	100-seed weight (gr)	Chlorophyll index	Proline ($mg.gr^{-1}$ fresh weight)
S_1	12.89[a]	10.68[a]	8.54[a]	57.40[a]	3.8[bc]
S_2	11.61[ab]	10.05[ab]	7.99[ab]	57.03[a]	4.73[b]
S_3	9.72[b]	8.87[b]	5.92[b]	55.14[b]	6.68[a]
S_4	8.23[c]	7.65[c]	4.48[c]	52.05[c]	7.76[a]

*Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.
S_1= Control, S_2= 2 $ds.m^{-1}$, S_3= 4 $ds.m^{-1}$ S_4=6 $ds.m^{-1}$ Salinity stress.

4.3. 1000-seed weight

According result of analysis of variance effect of different level of salinity stress and potassium fertilizer on 1000-seed weight was significant at 1% probability level but interaction effect of treatments was not significant (Table 2). Assessment mean comparison result indicated in different level of salinity stress the maximum 1000-seed weight (8.54 gr) was noted for control and minimum of that (4.48 gr) belonged to 6 $ds.m^{-1}$ treatment (Table 3). Compare different level of potassium fertilizer showed that the maximum and the minimum amount of 1000-seed weight belonged to 200 $kg.ha^{-1}$ (8.03 gr) and control (5 gr) treatments (Table 4).

4.4. Seed yield

Result of analysis of variance showed effect of salinity stress, potassium fertilizer and interaction effect of treatments on seed yield was significant at 1% probability level (Table 2). Evaluation mean comparison result of interaction effect of treatments indicated maximum seed yield (15.20 $gr.plant^{-1}$) was noted for control and 200 $kg.ha^{-1}$ potassium fertilizer and lowest one (6.86 $gr.plant^{-1}$) belonged to 6 $ds.m^{-1}$ salinity stress and control treatment (Table 5). Bean yield is a complex and quantitative trait and its components are, pod number, seeds number in pod and seed weight (Padilla-Ramirez *et al*, 2005). Alavi Matin *et al*. (2015) reported the role of potassium in salinity stress tolerance, and salinity stress reduced seed yield by 68% compared to the control. In contrast, the application of different types of potassium under salinity conditions, reduced the adverse effects of salinity on seed yield by 25% compared to the control treatment.

4.5. Biologic yield

According result of analysis of variance effect of salinity stress, potassium fertilizer and interaction effect of treatments on biologic yield was significant at 1% probability level (Table 2). Evaluation mean comparison result of interaction effect of treatments indicated maximum biologic yield (39.97 $gr.plant^{-1}$) was noted for control and 200 $kg.ha^{-1}$ potassium fertilizer and lowest one (24.60 $gr.plant^{-1}$) belonged to 6 $ds.m^{-1}$ salinity stress and control treatment (Table 5). Alavi Matin *et al.* (2015) reported that salinity stress reduced biological yield by 51% compared to the control. But the application of different types of potassium under salinity conditions, reduced the adverse effects of salinity on biological yield by 27% compared to the control treatment. Shirvanipour *et al.* (2014) reported the effect of potash fertilizer on biological yield was significant. Therefore the highest amount of biological yield (198.4 $gr.m^{-2}$) was obtained from application 100 $kg.ha^{-1}$ of potash and the lowest one (117.1 $gr.m^{-2}$) was obtained from non-application of potash fertilizer treatment.

Table 4. Mean comparison effect of different level of potassium fertilizer on measured traits

Potassium fertilizer ($Kg.ha^{-1}$)	No. Pod per Plant	No. seed per Pod	100-seed weight (gr)	Chlorophyll index	Proline ($mg.gr^{-1}$ fresh weight)
P_1	9.1^{b}	7.81^{b}	5.0^{b}	52^{b}	4.02^{b}
P_2	10.99^{ab}	9.98^{ab}	7.21^{a}	56.99^{ab}	5.97^{ab}
P_3	11.71^{a}	10.12^{a}	8.03^{a}	57.15^{a}	7.13^{a}

*Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.
P_1= Control, P_2= 100 $kg.ha^{-1}$ and P_3= 200 $kg.ha^{-1}$ Potassium fertilizer.

4.6. Chlorophyll index

Result of analysis of variance revealed effect of different level of salinity stress and potassium fertilizer on chlorophyll index was significant at 1% probability level, but interaction effect of the treatments was not significant (Table 2). Mean comparison result of different level of salinity stress indicated that maximum chlorophyll index (57.40) was noted for control treatment and minimum of that (52.05) belonged to 6 $ds.m^{-1}$ (Table 3). As for Duncan classification made with respect to different level of potassium fertilizer maximum and minimum amount of chlorophyll index belonged to 200 $kg.ha^{-1}$ (57.15) and control (52) (Table 4). In current study, chlorophyll index also decreased under salinity stress. Also the decrease in chlorophyll concentration is due to the inhibitory effects of the accumulation of different salt ions on the biosynthesis of different chlorophyll sections. Chloroplasts is depend on the strength of the membrane, which rarely remains healthy under high salinity and causes a decrease in chlorophyll content. Kaya *et al.* (2006) reported chlorophyll depletion has been reported due to salinity. One of the reasons for this decrease could be the weakening of chlorophyll binding to chloroplast proteins, which depends on the amount of ions. Under the influence of salinity, the amount of Na^{+} and CL^{-} ions increases and reaches toxicity in severe salinity. Decreased absorption of nutrients such as potassium, calcium and magnesium occurs, which can be another reason for the decrease in chlorophyll. This reduction can cause inefficiency of leaves in photosynthesis and ultimately reduce plant growth and yield. It seems that the higher chlorophyll index in fertilizer treatments is due to the fact that potassium activates many enzymes so that it is necessary for the synthesis of chlorophyll and the formation of carbohydrates which was consistent with the results of Ganjipour (2007).

Table 5. Mean comparison interaction effect of treatments on studied traits

Treatment	Seed yield ($gr.plant^{-1}$)	Biologic yield ($gr.plant^{-1}$)
S_1P_1	13.0^{b}	34.80^{b}
S_1P_2	15.20^{ab}	39.40^{ab}
S_1P_3	15.98^{a}	39.97^{a}
S_2P_1	12.10^{b}	33.65^{b}
S_2P_2	14.86^{ab}	38.54^{ab}
S_2P_3	15.00^{ab}	39.00^{ab}
S_3P_1	9.40^{cd}	29.70^{c}
S_3P_2	12.66^{b}	34.80^{b}
S_3P_3	12.92^{b}	35.54^{b}
S_4P_1	6.86^{e}	24.60^{e}
S_4P_2	8.61^{d}	27.76^{d}
S_4P_3	10.0^{c}	30.40^{c}

*Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.

S_1= Control, S_2= 2 $ds.m^{-1}$, S_3= 4 $ds.m^{-1}$ S_4=6 $ds.m^{-1}$ Salinity stress.

P_1= Control, P_2= 100 $kg.ha^{-1}$ and P_3= 200 $kg.ha^{-1}$ Potassium fertilizer.

4.7. Proline concentration

According result of analysis of variance effect of different level of salinity stress and potassium fertilizer on proline concentration was significant at 1% probability level but interaction effect of treatments was not significant (Table 2). Mean comparison result of different level of salinity stress indicated that maximum proline concentration (7.76 $mg.gr^{-1}$ fresh weight) was noted for 6 $ds.m^{-1}$ and minimum of that (3.8 $mg.gr^{-1}$ fresh weight) belonged to control treatment (Table 3). As for Duncan classification made with respect to different level of potassium fertilizer maximum and minimum amount of proline concentration belonged to 200 $kg.ha^{-1}$ (7.13 $mg.gr^{-1}$ fresh weight) and control (4.02 $mg.gr^{-1}$ fresh weight) (Table 4). With increasing salinity level, the amount of amino acids such as proline for osmotic regulation increases, which in some plants makes up 10-20% of the dry weight of the plant (Bandurska and Stroinski, 2003). It seems that in this study, by consumption of potassium sulfate increasing the uptake of potassium elements, increasing protein content, maintaining leaf chlorophyll and increasing proline concentration in plant leaves improved Mung bean resistance to salinity stress (Asghar *et al.,* 2006). Proline is a non-protein amino acid that is formed in the leaf tissues of plants exposed to water deficit and, together with sugar, is readily metabolized in leaves after recovery from water stress (Gideon *et al.*, 2016). Accumulation of Pro is often suggested as a selection criterion for the stress tolerance of most plant species (Hayat *et al.*, 2012). Proline osmolytes that causes osmotic adaptation and its accumulation in response to osmotic stress is mainly reported (Ashraf and Foolad, 2007).

5. CONCLUSION

Salinity level led to decrease measured traits (instead proline concentration) but increasing potassium fertilizer level led to improve seed yield and its components. Application the treatment of 4 $ds.m^{-1}$ and 100 $kg.ha^{-1}$ potassium fertilizer was able to prevent the reduction of Mung bean crop production, which was not significantly different from the treatment of 200 $kg.ha^{-1}$.

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FOOTNOTES

AUTHORS' CONTRIBUTION: All authors are equally involved.

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