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EFFECT OF POTASSIUM, ZINC AND MANGANESE ON AGRONOMIC TRAITS OF SOYBEAN

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Abstract

In order to evaluation of the potassium, zinc and manganese effects on agronomic traits of soybean, a factorial experiment was conducted on 2008 growing season with three replications at Kohne-kan research field in Bojnourd, Iran. This experiment was done based on RCBD design. Treatments were, potassium in three level(0, 80 and 160 kg/ha K_2O in form of potassium sulphate fertilizer) and application of micronutrients including of, control, Zinc Librel, Manganese Librel, Zinc + Manganese Librel (1.5/1000 v/v) and also Solopotash, trade mark for soluble potassium sulphate, spraying (2/1000 v/v). Results showed potassium had no significant effects on yield, but Zn^{2+}+Mn^{2+}, and Solopotash increased yield via effect on yield components. The highest seed yield was obtained from application of Solopotash alone, about 4767 kg/ha. This is a result of increasing in seed number per pod, branch number and seed weight at that treatment. The greatest seed per pod was obtained from 160 kg/ha K_2O + Solopotash. Application of only Mn^{2+}, increased the harvest index.

***Key words**: Glycine max, potassium, zinc, manganese, potassium sulphate, harvest index.*

INTRODUCTION

Potassium and yield formation in soybean

Potassium concentration in soybean varies depends on K^+ availability in soil. Plant absorbs wide range of K^+ concentration from the soil. Potassium plays an important role in activation of enzymes, particularly the enzymes that are active for CO_2 reduction. Plant water content preservation is facilitated by K^+. Potassium helps N fixation in pulses too (Laegreid et al., 2000). Mahler et al. (1985) explored K^+ fertilizer rate effect on soybean, during its floral stage and concluded that applying 90 kg/ha of potassium leads to significant increase of yield and 100-seed weight. Gill and Kamprath (1990) in an acidosis soil with K^+ deficient conditions added various rates of K^+, mixed with lime to soil. They concluded that K^+ increases soybean yield. High available K^+ in soil leads to higher accumulation of this ion in growing parts of plant such that when the plant arrives at R_5 stages, developing seed benefits from redistribution of K^+ inside the plant. However, when K^+ reduces, developing seeds are less protected and stem stock of K^+ does not meet the requirements.

Zinc and yield formation in soybean

Zinc plays very metabolic role in the plant. Zn^{2+} is required for Tryptophan and Gibberellin synthesis. Auxin production requires Tryptophan substrates too. Zn^{2+} contributes in N metabolism, when it decreases.Also RNA and Ribosomes are reduced, leading to lower protein production and higher glucose as well as non-protein nitrogen based substances. In zinc deficient plants, protein synthesis is observed while amino acids, amides and nitrates accumulation in the plant also increase. Zn^{2+} contributes in following parameters in soybean, i.e. length of floral stage, pod set and seed filling period, higher oil and protein rate, as an enzyme activator in carbohydrate metabolism, protein formation and finally seed yield (Savithri et al., 1985). Khampariva (1996) stated that Zn^{2+} contributes in plant height, number of pods per plant, biological yield, harvest index and finally seed yield in soybean. Rose et al. (2002) explored spray treatment before floral stage on four soybean cultivars and found higher seed yield and protein content percent in seeds. Martens and Westerman

(1991) studied plant sensation levels and found that soybean represents medium sensation towards Zn^{2+} element. They held that Zn^{2+} application in soybean leads to its higher seed yield.

Manganese and yield formation in soybean

Soybean shows great sensitivity to Manganese loss, happening in high pH or neutral soils and leading to yellow leaves and dwarf stems. Singh (1997) reported that seed and biological yield of soybean were increased by Manganese (10 mg). Parker et al. (1981) concluded that treatment of Manganese sulphate (11.2-22.4 kg/ha) leads to 27% increase of seed yield comparing to control, due to higher weight of seeds. Mitra et al. (1985) stated that application of manganese (5-10 mg /pot) increases seed yield and 100-seed weight of soybean.

MATERIALS AND METHODS

This study performed in Kohne-kan research field near to Bojnourd city (Lat. 37° 28' N & Longt. 57° 19' E) in North-East of Iran. The soil was Silty Clay Loam with pH=8.35. This highland region has a colder climate with 258.9 mm annual precipitation and 13.2°C mean temperature. This experiment was done based on RCBD design. Treatment were, potassium in three levels of (0, 80 and 160 kg/ha K_2O from potassium sulphate fertilizer) and application of micronutrients including, Control, Zinc Librel, Manganese Librel, Zinc+ Manganese Librel (1.5/1000 v/v) and also Solopotash spraying (2/1000 v/v). The measured traits were as follows: Seed yield, number of productive nodes in main stem, number of pods per main stem, number of seeds per pod, 100 seed weight, seed weight in branches and harvest index.

RESULTS AND DISCUSSIONS

The results of analysis of variance (Table 1) showed, potassium had significant effect on number of pods per plant, number of branches, number of seeds per pod and 100 seed weight. Zn^{2+} nutrient represents significant effect on number of pods per plant, number of seeds per pod, 100-seed weight, seed weight in branches and total seed yield. Potassium× micronutrients correlation showed statistically significant effect in terms of number of pods per plant, number of branches , number of seeds per pod, 100 seed weight, branches seed weight, total seed yield and harvest index.

Table 2, shows the average rates. Fertilizers had no significant effect on productive nodes per main stem. Manganese alone produced the highest pods per node of main stem (2.19, on average). The researchers reported positive effect of manganese on this feature (Mitra et al., 1985). 80 kg/ha K_2O as well as Solopotash treatment represented highest number of pods per plant. Hemantarajan and Trioedi (1997) studied sulphur effect on pod production in soybean and reported that, it increases this feature as well as pod length. Solopotash alone could produce highest number of branch per plant. Combination of micronutrients and potassium showed less important increase of branches. It seems that sulphur and potassium elements in solopotash play an important role in branch production. Application of combined solopotash + potassium (160 kg/ha) produced highest seeds per pod (3.35, on average).

Solopotash alone showed such a effect. Application of 80 kg/ha K_2O + Zn^{2+}+ Mn^{2+} as combined, produced the highest 100 seed weight (12.44 gr). Previously, researchers insisted on positive effect of Zn^{2+} and Mn^{2+} application on 100-seed weight (Azizi, 1999). Potassium oxide (80 kg/ha) created the highest seed weight per branches. Solopotash alone could produce the same result. It seems that the potassium in fertilizer contributes in the weight gain of seed in branches, leading to yield increase. Table 2, shows that solopotash alone has produced highest seed yield (4767 kg/ha). It seems that sulphur and potassium play more important role than other elements available in the fertilizer. This fertilizer is used as spray, so it is easily fixed in soil. Tanpon (1993) reported that a lot of sulphur is absorbed by soybean and it contributes in soybean yield. Sulphur absorption in soybean can facilitate interactively the absorption of other nutrients including phosphorus. Potassium (160 kg/ha) and Zn^{2+} and Mn^{2+} nutrients were used in interactive treatment and the yield ranked as the second highest (4632 kg/ha). Amara and Nasr (1995) showed that Mn^{2+} and Zn^{2+} improve soybean yield. Therefore, the experiments illustrate that solopotash alone can cover positive effect of Mn^{2+}, Zn^{2+} and other similar potassium- based fertilizers and they are able to produce better yield than other treatments. The highest harvest index was produced by Mn^{2+} (33.94%).Simultaneous use of Mn^{2+} and Zn^{2+} decreased harvest index (15.23%). It seems that availability of enough Mn^{2+} for plant can follow photosynthetic enzymes efficiency gain and it may prevent the thylakoid membrane reconstruction. Increasing photosynthesis efficiency leads to dry matter production increase and ultimately to improve substances translocation to seed (Khoshgoftarmanesh, 2008).

Table 1. Analysis of variance and F values for soybean yield and its components in experimental conditions
*, ** *represent statistically significant difference ($p\leq0.05$),and very significant difference($p\leq0.01$) respectively*

SOV	df	Number of productive nodes per main stem	Number of pods per main stem	Number of pods per plant	Branch numbers	Number of seeds per pod	100-seed weight (gr)	Seed weight per branch	Seed yield (Kg/ha)	Harvest Index
Replication	2	4.41*	3.42*	1.79	3.15	0.36	0.54	3.3	0.22	0.0004
K^+	2	1.85	2.65	3.87*	6.55**	5.43*	6.77**	1.97	1.89	2.27
Micronutrient	4	1.41	2.61	3.24*	2.43	8.1**	2.89*	3.1*	8.1**	2.51
K^+×Micronutrient	8	1.84	1.36	3.22**	4.51**	4.39**	2.86*	4.47**	2.68*	4.71**
Error	28	-	-	-	-	-	-	-	-	-
CV%		6.32	9.59	14.59	31.47	2.24	4.66	53.62	7.65	17.88

Table 2. Comparison of interaction effects of yield and yield components means in experimental conditions

Treatments	Number of productive nodes per main stem	Number of pods per main stem	Number of pods per plant	Number of branches	Number of seeds per pod	100 seed weight (g)	Seed weight per branch	Seed yield (Kg/ha)	Harvest Index
K0+S0	18.73a	2.16a	58.13abc	1.27bcd	3.05e	11.83abcd	2.29bc	3751de	18.71bc
K0+Zn	18ab	2.14a	56.47abc	0.87cd	3.25abc	11.61abcd	1.53bc	3720de	18.14bc
K0+Mn	18.87ab	2.19a	66.67ab	2ab	3.24abc	11.09cd	4.48abc	4235abcd	33.94a
K0+Zn+Mn	17.2ab	2.08ab	59.2abc	1.4bcd	3.1de	12.33ab	3.21bc	4256abcd	22.63bc
K0+Solopotash	17.4ab	2.1ab	67ab	2.4a	3.34a	11.33bcd	5.13ab	4767a	20.33bc
K80+S0	17.93ab	2.04ab	70.73a	1.93ab	3.13cde	12.13abc	6.86a	3623e	23.55b
K80+Zn	17.47ab	1.91ab	50.67bc	0.93cd	3.18bcde	11.68abcd	1.81bc	4014cde	22.43bc
K80+Mn	16.33b	2.16a	60abc	1.2bcd	3.27ab	11.58abcd	3.82abc	4261abcd	17.21bc
K80+Zn+Mn	16.67ab	2.04ab	50.08bc	0.53d	3.16bcde	12.44a	0.95c	4393abc	20.1bc
K80+Solopotash	16.2b	1.74b	47.07c	1.33bcd	3.23abcd	12abc	2.22bc	3625e	20.26bc
K160+S0	17.73ab	2.15ab	56.07abc	1.2bcd	3.29ab	11.06cd	2.24bc	3656de	21.04bc
K160+Zn	16.73ab	1.81ab	55.73abc	1.67abc	3.23abcd	11.63abcd	2.89bc	4115bcde	22.21bc
K160+Mn	17.53ab	1.91ab	52.27bc	1.6abc	3.16bcde	11.54abcd	2.71bc	4398abc	22.15bc
K160+Zn+Mn	18.2ab	2.03ab	52.13bc	0.93cd	3.34a	11.61abcd	1.73bc	4632ab	15.23c
K160+Solopotash	17.07ab	1.88ab	50.53bc	1.2bcd	3.35a	10.87d	2.26bc	4185abcd	18.88bc

CONCLUSIONS

Seed yield and its components were increased with application of potassium, Zn^{2+}, and/or these two combinations. Pods per node of main stem took the highest effect from nutrient treatments especially for Zn^{2+}. Potassium increased number of branches. The highest seed yield was achieved in Solopotash application alone, and afterwards with combination of K_2O + Mn^{2+} + Zn^{2+} without any statistically differences. It seems that sulphur and potassium (in form of Solopotash) play more important role than other elements available in the fertilizer for soybean, and it can be compensate the effect of other micronutrients for adjusting higher soybean seed yield.

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