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Response of Faba Bean (*Vicia faba* L.) Crop to Potassium Soil Application and Zinc Foliar Application under Sandy Soil Condition

A.I. Rezk*; A. B. El-Nasharty; M.F. El-Masri and S.S.El-Nwehy

Fertilization Technology Department, National Research Centre, Dokki, Giza, Egypt

Abstract: Our objective was to evaluate the effect of foliar spray with Zinc- EDTA twice under different levels of soil potassium application on yield and several physiological and agronomic traits as well as chemical traits of faba bean (*vicia faba* L.) grown in sandy soil. Therefore, two field experiments were carried out at the fields of two farmers in Nubaria region, Egypt, during two successive seasons. Soil potassium application was carried out at 45 days after sowing and before flowering initiation with three rates 0 , 25 and 50 kg K_2O as potassium sulphate (50 % K_2O) / feddan and foliar spray with Zn- EDTA twice ; without spray, one spray and two sprays of 200 and 300 g Zn- EDTA (14 % Zn) / feddan were sprayed at flowering initiation stage (50 days after sowing) and three weeks later , respectively .The results indicate that soil potassium application (K50) or two zinc foliar sprays (Zn2) alone were significantly increased seed yield / feddan by 290 kg with relative increase of 20% compared with control (K0 and Zn0) and this is highly related to the highest K- and Zn- uptake. The highest rate of potassium (K50) with two foliar applications by Zinc- EDTA (Zn2) recorded the highest significant seed yield (1.89 ton/feddan) by relative increase of 33 % .The interaction effects between potassium and zinc applications were produced the highest relative increase percentages in No. of pods / plant (12.6%), one-hundred seeds weight (12.1%), seed and straw yield (33% and 21.7%) compared to control treatment. It can be concluded that treatments of both high rate of potassium (K50) and foliar spray with Zn- EDTA twice improved K and Zn- uptake and K use efficiency and also components of faba bean which reflects all on increasing the seed yield under sandy soil conditions.

Keywords: Faba bean, sandy soil, Potassium soil, foliar spray with Zn- EDTA, yield, K, Zn- uptake, K- use efficiency.

1. Introduction

Faba bean (*Vicia faba* L.) is an important feeding leguminous crop grown in winter season in Egypt. Ripe seeds of faba bean have high percentage of protein (average protein content of dried seeds being 20 - 36 %), moreover a food of high calorific and nutritive value especially in the diet of low income people [1]. In Egypt the production of faba bean just covered about 60 % of the national demands. Due to efforts should be directed towards increasing and improving the faba bean yield.

Moreover, a fertilizers cost is deem one of the major limitation to increase the economical yield of crops and attempts are necessary to decrease its reduction and to rising its economical utilize. Potassium plays a necessary function as macronutrient in plant growth and expecting crop production [2]. This refers to the function of K in plant biochemical pathways [3]. It increases the photosynthetic rates of crop leaves, assistance carbon movement and CO_2 assimilation [4]. Moreover, Potassium has a substantial function in the translocation of

photosynthesis from exporter to sinks[5]. Many of researches reached certain favorable response for potassium fertilizers on leguminous plants such as faba bean [6, 7] on lentil, [8] on mung bean and [9] soybeans. Newly, [10] found that potassium applications had a favorable effect on growth, grain yield and nutrient uptake on soybean. On the other side, according to the World Health Organization (WHO) found that human population of developing countries suffering from the deficiencies of zinc which is the fifth major cause of diseases and deaths in these countries [11].

Zinc is a major component and activator of several enzymes involved in metabolic activities [12.] Foliar fertilization used small amount of fertilizers, uniform distribution of fertilizer materials on plant leaves and quick responses to fertilizers. Foliar spraying of Zn was positively effective on faba bean yield and its components [13]. Zn is a component of a number of proteinases and dehydrogenises enzymes affecting electron transfer reaction and consequently Krebs cycle and energy production [14]. As well as seed quality were also reported by [15, 16, and 17.]

Fertilizer use efficiency is an objective for all involved in agriculture, the fertilizer industry, and researchers to helping farmers to increase crop yield .This describe between yield, nutrient efficiency, and the environment was soundly suitable by [18]. The objective of this work is to study the effects of potassium soil and zinc foliar applications and their interaction on growth characters, yield, uptake and their K-use and utilization efficiency on faba bean plants.

2. Materials and Methods

Two field experiments were carried out at sandy soil at the fields of two farmers in Nubaria district, EL-Behira Governorate, Egypt, during two winter successive seasons to study the effect of foliar spray with zinc under different levels of potassium as soil applications on faba bean yield and its components as well as some chemical constituents.

Some physical and chemical analysis of soil samples at 30 cm depth in experimental sites before soil preparation was determined according to [19]. The soils have a sandy texture, pH 8.1, EC 0.40 dS/m, total $CaCO_3$ 8.5% and organic matter 0.17%.While N,P,K, Fe ,Mn and Zn contents were : 60 ,13 ,93 ,4.5,1.4 and 0.9 ppm, respectively.

Faba bean seeds were sown on 25th and 31th October in the first and second season for two experiments, respectively. The experimental area was one and three feddan in the first and second season, respectively. Dose of 200 kg super phosphate (15.5% P_2O_5) / feddan was applied before sowing. After emergency 50 kg ammonium nitrate (33.5%N) / feddan were applied .The experimental design was split- plot design with three replicates and the plot area was 10.5 m^2 consisting of five rows (3.5 m length and 3 m width).Three potassium soil applications at the rate of 0 , 25 and 50 kg K_2O as potassium sulphate (50% K_2O)/feddan were assigned to the main plot and three foliar application using 1.0 g Zinc-EDTA (14% Zn)/L (without spray ,one spray and two sprays) were randomly hand out in the sub plots. Potassium sulfate was applied at 45 days after sowing and before flowering initiation. Zinc foliar spraying treatments were added at 50 days after sowing and three weeks later. The normal agronomic practices of growing faba bean were practiced till harvest as recommended by Legumes Research Dept., A.R.C., Giza, Egypt.

Several physiological traits, yield and agronomic traits as well as chemical traits were studied as follow : Number of pods per plant, one-hundred seeds weight (g) , straw and seed yield calculated as ton/feddan (feddan= 4200 m^2) .

Also potassium and zinc contents of faba bean plants were determined according to [19].

The K use efficiency (KUE) and K utilization efficiency (KUTE) were calculated as follow:

1. K use efficiency (KUE) = (Kg dry matter / Kg K applied)
2. K utilization efficiency (KUTE) = (g dry matter / g K uptake)

The equation used for calculating K use efficiency (KUE) and K utilization efficiency (KUTE) according to [20.]

All results were statistically analyzed according to [21]. The combined analysis was conducted for all data of the two seasons according to [22]. The significant least differences (L.S.D) were used to compare the means.

3. Results and Discussions

3.1. Yield and yield components:

3.1.1 Effect of soil potassium application:

The data offered in table (1) showed that faba bean yield and its components were increased by increasing K_2O rates. The maximum seed yield and yield components were obtained from the highest rate of potassium (50 kg K_2O/feddan) compared with the others.

Table 1: Mean values of faba bean yield and its components as affected by soil potassium and zinc foliar applications (combined analysis of two successive seasons)

potassium soil (kg K_2O /fed)	Number of Zinc(Zn) sprays	No. of pods /plant	100-seed weight (g)	Seed yield (ton/fed)	Straw yield (ton/fed)	Biological yield (ton/fed)
0	**0**	21.1	124.1	1.42	1.70	3.12
	1	23.0	128.4	1.51	1.76	3.27
	2	22.5	129.3	1.71	1.78	3.49
25	**0**	23.0	133.2	1.59	1.84	3.43
	1	25.2	144.8	1.79	1.90	3.69
	2	25.9	146.3	1.85	1.93	3.78
50	**0**	25.5	139.0	1.71	1.98	3.69
	1	26.2	147.7	1.86	2.03	3.89
	2	26.7	149.9	1.89	2.07	3.96
Mean values of K_2O	**0**	22.2	127.3	1.55	1.75	3.29
	25	24.7	141.4	1.74	1.89	3.63
	50	26.1	145.5	1.82	2.03	3.85
Mean values of Zn	**0**	23.2	132.1	1.57	1.84	3.41
	1	24.8	140.3	1.72	1.90	3.62
	2	25.0	141.8	1.82	1.93	3.75
LSD at 5 %	**K**	0.52	2.77	0.05	0.05	0.05
	Zn	0.60	2.17	0.05	0.02	0.02
	K x Zn	0.52	2.17	0.05	0.05	0.02

(One feddan = 4200 m^2)

The effect of K-fertilization show highly significance increases in No. of pods/ plant, one - hundred seeds weight (g), seed and straw yield (ton/feddan). It was also clear that soil application of potassium (K50) significantly increased seed yield by 270 kg /fed with a relative increase percent of 17% and straw yield by 280 kg /fed with 16% and the biological yield increased by 17 % compared to control treatment .While soil application of potassium at level (K25) gave increased in seed yield/fed by 190 kg by 12% and straw yield /fed by 140 kg by 8% and biological yield which increased by 10 % compared to control treatment. These results were agreement with the results concluded by [10]. Also, [23] reported that application of 50 kg K_2SO_4 /fed to faba bean after 4 weeks of sowing and beginning of flowering stage increased all yield parameters.

This may be due to the effect of potassium on enzyme and biological activities which induced nutrients content, vegetative growth and yield of plants [24, 25] concluded that plants grown at higher K level had better development of nodules and consequently higher nitrogen fixation.

3.1.2 Effect of foliar application of zinc:

The results of Table (1) showed that all the yield traits were significantly increased as a result of two foliar sprays with Zn- EDTA comparing with control.

Two foliar sprays with Zn- EDTA (Zn2) had the largest stimulatory effect on all the yield traits of faba bean comparing with control (Zn0). The same treatment also (Zn2) recorded the highest seed yield/fed (1.82 ton/feddan) with relative increase percentage of 16 % followed by Zn1 (1.72 ton/feddan) by relative increase of 10 % , while control treatment Zn0 produced the lowest seed yield (1.57 ton/feddan),also foliar spray with Zn-EDTA twice (Zn2) gave the highest values for all traits under study. These results may be due to Zn in particular form a major yield-limiting factor for faba bean. Accordingly, more pods or less pod-drop / plant resulted from Zn treatments through its positive effects on tryptophan and indol acetic acid content in faba bean plant. Thus, more pods i.e. less pod-drop per plant resulted from Zn treatment, leading to seed- increase. The same results were previously obtained by [16, 17, 15, and 13.]

3.1.3 Effects of the interaction between potassium soil and zinc foliar applications:

Data showed in figures (1 and 2) pointed out the interaction between potassium soil treatments and zinc spraying was significantly effected on all yield parameters. potassium soil treatment with zinc spraying (K50+ Zn2) produced the highest relative increase percentages in No. of pods/plant (27%), one – hundred weight (21%), seed and straw yield (33 % and 22%) compared with control treatment. While, relative increase due to potassium soil application (K50) without zinc spraying in No. of pods / plant , one- hundred seeds weight , seed and straw yield were 12,11,20 and 16 %, respectively.

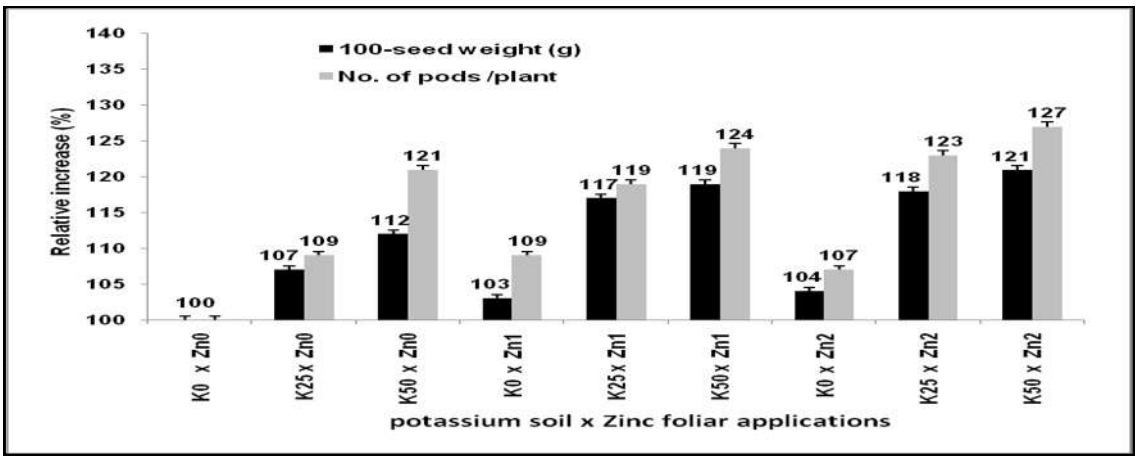

Fig. 1: Effect of interaction between potassium soil and zinc foliar applications on relative increase (%) of number of pod / plant and 100-seed weight (g) of faba bean.

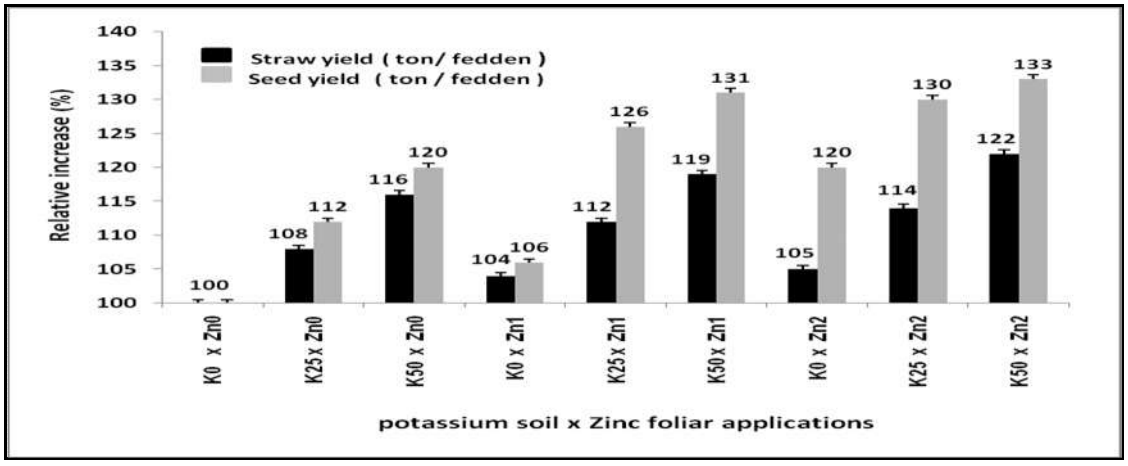

Fig. 2: Effect of interaction between potassium soil and zinc foliar applications on relative increase (%) of seed and straw yield of faba bean.

On the other side, the relative increase due to foliar spray with Zn- EDTA twice (Zn2) without potassium soil application in number of pods per plant,100-seed weight ,seed yield and straw yield were 11% ,10% , 20% and 5 %, respectively . Figures (1 and 2) illustrated that, especially at high dose of K (K50) with two sprays of zinc (Zn2), a highly significant effect on all the studied parameters of faba bean. The combination positive effect of potassium and zinc on one – hundred seed weight might be referred to: (1) carbohydrate metabolism processes required many zinc dependent enzymes, (2) role of K in regulation of stomata and (3) export of photosynthesize through the phloem from the leaves to the seeds [3] . These results were essentially due to the role of potassium and zinc in photosynthesis and metabolic processes [4].

3.2. Chemical composition:

3.2.1 Effect of soil potassium applications:

Potassium uptake (concentration × dry weight) by plant was significantly influenced by K rate. The data reported in Table (2) revealed that soil application of potassium had a significant effect on K- uptake of faba bean plant compared to the control.

The highest K- uptake by plant was recorded when the plants were treated with (50 kg K_2O) compared with control treatment. On the other hand, the increase in Zn uptake was due to their increased application could be ascribed to the variation in the availability of applied K in the root zone and their role in the growth and development of the plant [26]. [23] stated that application of 50 kg K_2SO_4 /fed to faba bean after 4 weeks of sowing and beginning of flowering stage increased uptake. On the other hand, there is a little information about K-use efficiency on faba bean plant. However, [27] stated that K have a higher use efficiency than N and P due to its more higher mobility in most soils and it is not also subject to the gaseous losses or the fixation reactions that affect P.

Table 2: Effect of potassium soil and zinc foliar applications on contents of K and Zn of faba bean plants (combined analysis of two successive seasons)

potassium soil (kg K_2O /fed)	Number of Zinc (Zn) sprays	K –uptake (g / plant)	K use efficiency (KUE) (Kg DM/Kg K applied)	K utilization efficiency (KUTE) (g dry matter / g K uptake)	Zn – uptake (mg / plant)
0	**0**	2.26	-	60.9	6.88
	1	2.26	-	63.1	9.26
	2	2.51	-	56.9	10.18
25	**0**	2.67	341	48.1	8.06
	1	2.90	354	53.2	11.79
	2	3.26	378	47.0	14.86
50	**0**	3.59	185	38.9	9.39
	1	3.75	195	38.6	13.53
	2	3.89	198	43.4	14.34
Mean values of K_2O	**0**	2.34	-	60.3	8.77
	25	2.94	358	49.4	11.57
	50	3.74	193	40.3	12.42
Mean values of Zinc	**0**	2.84	-		8.11
	1	2.97	-		11.53
	2	3.22	-		13.13
LSD at 5 %	**K**	0.33			0.29
	Zn	0.32			0.26
	K x Zn	0.34			0.24

Data presented in Table (2) indicate that KUE was influenced by K levels, where soil application of lower K level (25 kg K_2O) gave higher K-UE than higher K level (50 kg K_2O).These finding are in agreement with that of [28, 29, 30, 2] who reported that K application improved its efficiency over control in terms of quantity and quality in maize.

3.2.2 Effect of zinc foliar applications:

It is clear from Table (2) that zinc uptake increased with number of zinc (Zn) sprays. The zinc uptake by plants (mg / plant) ranged from 8.11 to 13.13 mg / plant. The highest Zn uptake (13.13 mg / plant) was observed at foliar spray with Zn- EDTA twice (Zn2). The increase in Zn uptake was accompanied with zinc foliar application which is rapidly absorbed by the leaves, then translocated to the seeds.

3.2.3 The Effect of interaction between potassium and zinc:

The data of table (2) detected the interaction effect between potassium soil and number of zinc foliar applications on K- and Zn- uptake was highly significant in most cases and we founded that treatments of both potassium soil (K50) and foliar spray with Zn- EDTA twice (Zn2) improved both K- and Zn- uptake and use efficiency of faba bean. Positive relationship was shown between different K levels and number of zinc foliar applications on KUE. The possible reason might the homogeneity of soil and weather for both years. Interaction of Zn×K has been reported by [31, 32]. They found that shoot K concentration was reduced according to low Zn supply, on the other hand, high K level increased Zn absorption by wheat and maize plants.

4. Conclusion

In conclusion, this study demonstrates the importance of application of both potassium as soil application and zinc as foliar application for improving yield and many agronomic and chemical traits of faba bean (*vicia faba* L.) grown in sandy soil. Accordingly, it can be maximizing faba bean yield and its components by applications of both 50 kg K_2O /feddan in two split and twice foliar spray with Zn- EDTA under sandy soil conditions. From these results it can be also concluded that zinc played an important role in metabolic processes and in turn affected the plant growth and yield.

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