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Can Supplemented Potassium Foliar Feeding Reduce the Recommended Soil Potassium?

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Abstract: Two field experiments were conducted during 1999/2000 and 2000/2001 seasons at the Agricultural Research Station of National Research Center (NRC), Shalkan, Qalubia Governorate to study the possibility of reducing the amount of soil potassium fertilizers applied to feed faba bean through potassium foliar feeding. Five potassium treatments per feddan including negative (0.0 kg K_2O) and positive control (48 kg K_2O) in addition to three treatments (36, 24 and 12 kg K_2O) supplemented with potassium foliar feeding were applied. No significant differences on plant height and branch number was found. Applying 36 kg K_2O supplemented with foliar potassium feeding gave the highest marked increase in 100 seed weight, number of pods and seed yield. Applying the recommended soil potassium fertilizer (48 kg K_2O) gave the highest increase in straw yield. Applying 36 kg K_2O supplemented with foliar potassium feeding showed the highest leaf N, K and Fe, while 24 kg K_2O supplemented with foliar potassium feeding showed the highest marked increase in leaf P concentration. No significant effect on leaf Mg, Mn and Zn due to potassium treatments were recorded.

Key words: Faba bean, potassium, soil application, foliar application

Introduction

Potassium is an essential macronutrient for all living organisms required in large amounts for normal plant growth and development (Marchner, 1986). It is the most important cation not only in regard to its content in plant tissues but also with respect to its physiological functions. Besides its well-known involvement in meristematic growth, potassium plays a key role in plant resistance to water and salt stress which are two situations quite frequently met in arid and semi-arid regions (Agabani *et al.*, 1993). Most of the Egyptian soils suffer from lack of potassium caused by the intensive cultivation and reduction in potassium supply (Eid, 1997). Potassium fixation in soil and a greater demand for potassium by modern high yielding cultivars are also the causes of potassium deficiency in soils (Oosterhuis, 1998). The situation has been further aggravated by rising prices of potassium fertilizers.

Research efforts have been concentrated to improve the fertilizer use efficiency by employing various techniques including foliar fertilization. Roemheld and El-Fouly (1999) mentioned that nutrient uptake by roots can be a limiting factor to achieve adequate growth and optimal yield. This can be the case during critical periods of plant development or during environmental conditions. Under these conditions, foliar fertilization is advantageous (Mengel and Kirkby, 1987). Oosterhuis (1998) reported that foliar feeding of a nutrient might actually promote the root absorption of the same nutrient. In this respect, Ahmad (1998) stated that spraying nutrients not only can increase the crop yields but also can reduce the quantities of fertilizer applied through soil. Furthermore, excessive potassium application to the soil can induce magnesium deficiency and reduce the yield if fertilizer recommendation are not followed closely (Oosterhuis, 1998).

The objective of this study was to study the possibility of reducing costs and environmental pollution through reducing the amounts of soil potassium application by using foliar potassium as a supplementary nutrient application.

Materials and Methods

Two field experiments were carried out in two consecutive seasons (1999/2000 and 2000/2001) at the Agricultural Research Station of NRC, Shalakan, Qalubia Governorate. A composite soil sample was taken from the experimental site representing the depth of 30 cm in each growing season. Detailed results of physico-chemical characteristics of soil are presented in Table 1.

The experiment included 5 treatments as follows:

0.0 kg K_2O/ fed. (negative control)
48 kg K_2O/ fed. (recommended dose, positive control)
36 kg K_2O/ fed.
24 kg K_2O/ fed.
12 kg K_2O/ fed.

The plants of 3, 4 and 5 treatments were supplemented with two foliar sprays of 2.5% potassium sulphate (48% kg K_2O).

The experimental design was randomized complete block (RCBD) with four replicates. The experimental plot size was 3.5 m long and 3 m wide. Each plot contained 5 ridges of 60-cm width.

Seeds of faba bean cv. Giza 3 were secured from Seed Propagation Station, Ministry of Agriculture each year and sown at the rate of 75 kg/ fed on November 20 and 26 in 1999/2000 and 2000/2001 seasons, respectively. The crop was uniformly fertilized with 31 kg P_2O_5/fed in the form of single superphosphate (15.5% P_2O_5) during seed bed preparation and 20 kg N /fed in the form of ammonium nitrate (31% N) applied before the second irrigation. However the soil potassium treatments were applied after 50 days from sowing. The supplemental foliar feeding with potassium was applied in two foliar sprays at rate of 2.5% potassium sulphate at 85 and 100 days from sowing.

The commonly known "Afear" Method of sowing was used in which the soil was dried and the dry seeds drilled on the two sides of the ridge, then soil was irrigated. After emergence, seedlings were thinned to two plants per hill. Distance between hills was 20 cm.

Two weeks after the second spray (115 days from sowing), five plants were randomly chosen from each plot to record the following: -

Plant height (cm)
Number of branches per plant.
Leaf macro and micronutrient concentrations.

At harvest the following data were recorded:-

Pod number per plant
100 seeds weight
Seed yield (ton) per fed.
Straw yield (ton) per fed.
Seed and straw yields were determined from the middle two rows and then converted to kg per fed.

Leaf analysis: The upper third leaves of 115 day's age were prepared for macro- and micro nutrients analysis according to Chapman and Pratt (1978), where the ground plant organs were dry ashed in Muffle furnace at 550° C, then extracted by 2N HCl. Total N was determined in the dry plant organ using Bushi digestion and N_2-distillation unit.

Total P was determined photometrically using the Molybdate-Vanadate method according to Jackson (1973).

Total K, Na and Ca were determined using Dr. Lang-M8D flame photometer.

Micro nutrients and Mg were determined using Atomic Absorption Spectro-photometer.

Table 1: Soil physico-chemical characteristics.

Characters	Season 1999/2000	Season 2000/2001
Sand %	16.8	14.8
Silt %	34.0	33.0
Clay %	51.2	50.2
Texture	Clay loam	Clay loam
pH	8.75	8.61
E.C. dS/m	0.21	0.25
$CaCO_3$	2.80	2.60
Organic matter %	1.9	1.5
Macro nutrients (mg/100 g soil)		
P	2.60	2.73
K	30.53	27.35
Mg	158.00	184.00
Micro nutrients (mg/kg soil)		
Fe	9.7	8.6
Mn	3.50	4.3
Zn	0.60	0.70

Texture	:	Bauyoucos (1954)
pH & E.C. (1 soil: 2.5 water)	:	Jackson (1973)
$CaCO_3$	:	Walkely and Black (1934)
K , Na & Mg	:	Jackson (1973)
P	:	Olsen *et al.* (1954)
Fe, Mn & Zn	:	Lindsay and Norvel (1978)

The data were statistically analyzed as randomized complete block design according to Snedecor and Cochran (1967). Comparisons among means of treatments were tested for significance against LSD values at 5% level of probabilities.

Results

Soil: According to the tentative values of soil characteristics and available nutrient concentrations by Ankerman and Large (1974), data presented in Table 1 indicates that the soils in both seasons were clay loam in texture, alkaline in reaction, had satisfactory contents of potassium and magnesium, high content of phosphorus. The soils were also poor in organic matter and micronutrient contents without any salinity problems.

Growth: All potassium treatments generally, increased plant height and number of branches per plant (Table 2). However, increases obtained were statistically insignificant in both growing seasons.

Yield components

100 seeds weight: Hundred seeds weight increased significantly due to potassium treatments as compared with the negative control treatment (0.0 kg K_2O) (Table 3). The increments ranged between 11-25% and 7-39% in 1999/2000 and 2000 /2001 seasons, respectively. The highest increment in 100 seed weight in both growing seasons was obtained when 36 kg K_2O was supplemented with K foliar feeding. However, the lowest increase was obtained when 12 kg K_2O was supplemented with K foliar feeding.

Number of pods/plant: It is quite clear from the results presented in Table 3 that number of pods/plant markedly increased by 26-61% and 15-47% due to potassium treatments in the first and second season, respectively as compared with the negative control treatments. The maximum as well as the minimum increase recorded was obtained through addition of all recommended K fertilizer to the soil and addition of ¼ the recommended K which supplemented with K foliar feeding in both growing seasons.

Yield:

Seed yield (ton /fed.): Potassium treatments had highly significant positive effect on seed yield (Table 4). However, seed yield increment ranged between 43-142 in the first season, it ranged

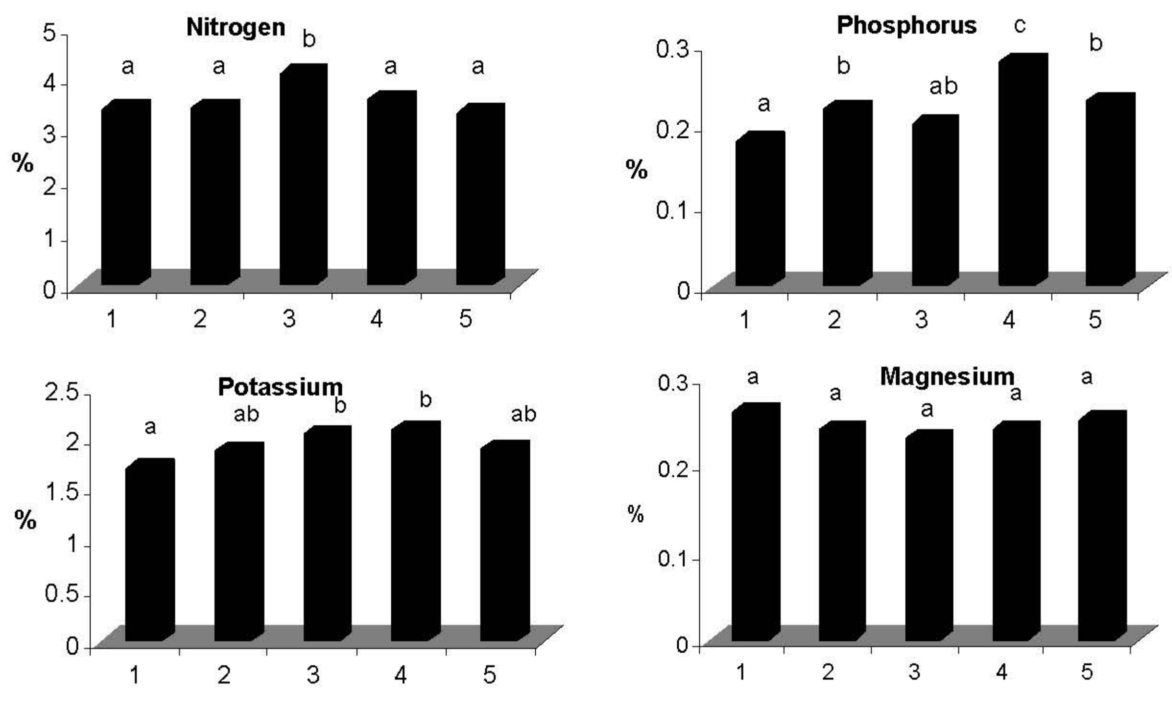

Fig. 1: Effect of supplemental potassium foliar spray on leaf macronutrient concentrations of faba bean plants.
1 = negative control (0.0 kg K_2O) 2 = positive control (48 kg K_2O) 3 = 36 kg K_2O + foliar K feeding
4 = 24 kg K_2O + foliar K feeding 5 = 12 kg K_2O + foliar K deeding

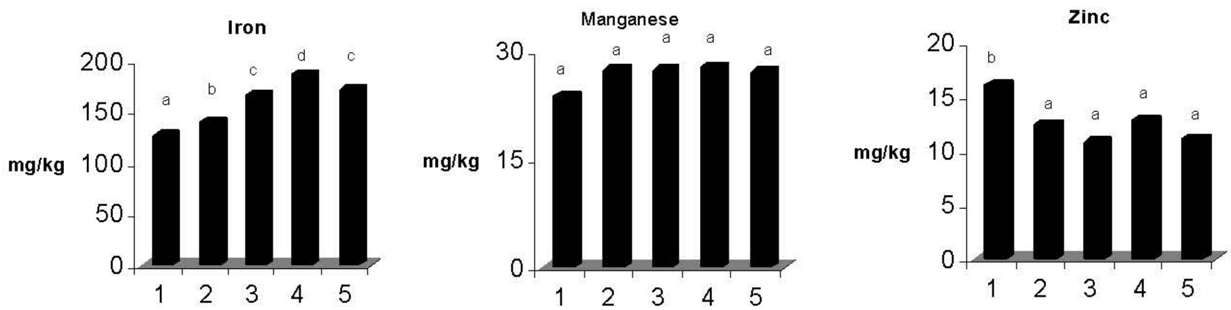

Fig. 2: Effect of supplemental potassium foliar spray on leaf micronutrient concentrations of faba bean plants (columns with the same letter are not significantly different)

between 41-136% in the second season, compared with the negative control treatment. The maximum increase in seed yield was recorded by soil application of 36 kg K_2O that supplemented with K foliar feeding. On the other hand, the minimum increase was obtained from soil application of 12 kg K_2O that supplemented with K foliar feeding. It is also important to notice that as compared with the positive control treatment (all recommended K applied to the soil), The lowest addition of soil K that supplemented with K foliar feeding could keep the yield at the same level.

Straw yield (ton/fed.): Concerning straw yield, data presented in Table 4 revealed that marked increase was obtained in both seasons due to potassium treatments. The increments ranged between 29-77% in 1999/2000 and 0-75% in 2000/2001 seasons, compared with negative control treatment. The maximum as well as the minimum increase recorded was obtained through addition of all recommended K fertilizer to the soil and addition of ¼ the recommended K which supplemented with K foliar feeding in both growing seasons.

Leaf macronutrient concentrations (%)

Nitrogen: K-treatments generally, increased N concentration. But only soil treatment of 36 kg K_2O supplemented with K foliar feeding showed significant increase in N, as compared with other treatments (Fig. 1).

Phosphorus: Generally, leaf phosphorus concentration significantly increased by K-treatments as compared with the negative control treatment (Fig. 1). The highest increase recorded was by soil application of 50% of the recommended potassium dose supplemented with K foliar feeding.

Potassium: As shown in Fig. 1 leaf potassium concentration increased significantly by K-treatments as compared with the negative control treatment. The highest significant increase was noticed by either soil application of 36 kg K_2O or 24 kg K_2O supplemented with K foliar feeding.

Magnesium: As shown in Fig. 1 magnesium concentration insignificantly decreased due to potassium treatments as compared with the negative control treatment.

Leaf micronutrient concentration: The most affected nutrient due to K-treatments was Fe. However, as compared with the negative control treatment, marked increases among the other treatments were recorded (Fig. 2). Addition of 50% of the recommended K that supplemented with K foliar feeding gave the highest increment. On the other hand, no marked differences among treatments in leaf Mn concentration were recorded. Insignificant reduction in leaf Zn concentration due to K-treatments was noticed.

Discussion

The above mentioned results indicate that the experimental soil was clay loam in texture with more than 50% clay content. The exchangeable soil K was satisfactory in level. The high clay content has probably contributed to more potassium fixation by clay minerals, leading to reduce K availability in the soil solution. Several research works proved that the exchangeable K does not reflect the actual K availability to the plants. That means the greater the clay content the more the K fixation in the soil. Thus such soils require large quantities of K- fertilizer to recover the fixed K by clay minerals and prevent potassium deficiency (Grimme, 1980; El-Fouly and El-Sayed, 1997 and El-Sayed and Shaaban, 1999) . Mengel and Kirkby (1987) stated that foliar application of plant nutrients can be very efficient under certain condition, but it should be born in mind that leaves are only able to take up a relatively small quantities of nutrients in comparison with the plant's demand. At the same time, Oosterhuis (1998) stated that foliar feeding of a nutrient may actually promote absorption of the same nutrient, leading to increase the crop yields and reduce the quantities of fertilizers applied through soil (Ahmad, 1998). The positive effect of soil application of K that supplemented with K foliar feeding on faba bean yield and its component could therefore, have been due to the better K nutrition which improve pod setting and leads to stimulate the storage capacity for assimilates which in turn, induce remarkable increase in 100 seed weight and number of pods/plant. Beringer (1980) came to the same conclusion and added that better K nutrition improved nitrogen metabolism by stimulating the activity of nitrate reductase to promote the formation of peptides and protein. Generally, increasing faba been yield would find an interpretation through metabolic function of K in plant. For Instance, Oosterhuis (1998) reviewed the importance of potassium for plant growth. He mentioned that K is not a constituent of any known component, but it is implicated in over 60 enzymatic reactions involving many processes in the plant such as photosynthesis, respiration, carbohydrate metabolism, translocation and protein synthesis. In this connection, on cotton, Bednarz and Oosterhuis (1996) found that chlorophyll content decreased under K deficiency, leading to highly marked reduction of leaf photosynthesis reached to 95%. Roemheld and El-Fouly (1999) explain why the efficiency of foliar fertilization is higher than that of soil application? They reported that one reason is because of the supply of the required nutrient directly to the location of demand in the leaves, and its relatively quick absorption. Concerning leaf macro- and micronutrient concentrations, it is quite clear that in spite of some nutrients were increased and some others were decreased due to K-treatments, the dry matter

Table 2: Effect of potassium application treatments on growth of faba bean in 1999/2000 and 000/2001 seasons.

Treatments	Plant height (cm)		No. of branches	
(Kg K_2O)	1999/2000	2000/2001	1999/2000	2000/2001
0 "negative control"	137.5	134.0	4.0	4.5
48"positive control"	142.8	136.3	4.5	5.3
36 + foliar feeding	139.5	135.1	5.3	5.5
24 + foliar feeding	138.5	136.8	4.8	5.3
12 + foliar feeding	137.5	133.6	4.3	4.5
LSD 5%	NS	NS	NS	NS

Table 3: Effect of potassium application treatments on yield component of faba bean in 1999/2000 and 2000/2001 seasons.

Treatments (Kg K_2O)	100 seeds weight(g)				No. of pods/ plant			
	1999/2000	%	2000/2001	%	1999/2000	%	2000/2001	%
0 "negative control"	54.22	100	45.97	100	36.3	100	46.5	100
48"positive control"	63.30	117	60.25	131	58.3	161	68.3	147
36 + foliar feeding	67.93	125	63.77	139	56.3	155	67.3	145
24 + foliar feeding	62.43	115	52.67	115	49.8	137	59.3	128
12 + foliar feeding	60.41	111	48.99	107	45.8	126	53.5	115
LSD 5%	2.32		3.84		6.6		4.5	

Table 4: Effect of potassium application treatments on yield (ton/fed.*) of faba bean In 1999/2000 and 2000/2001 seasons.

Treatments (Kg K_2O)	Seed yield (ton/fed.)				Straw yield (ton/fed.)			
	1999/2000	%	2000/2001	%	1999/2000	%	2000/2001	%
0 "negative control"	0.840	100	0.905	100	2.250	100	2.249	100
48"positive control"	1.273	152	1.414	156	3.987	177	3.936	175
36 + foliar feeding	2.031	241	2.138	236	2.971	132	2.943	130
24 + foliar feeding	1.758	209	2.094	231	3.609	160	3.177	141
12 + foliar feeding	1.200	143	1.275	141	2.908	129	2.257	100
LSD 5%	0.174		0.157		0.685		0.449	

* Fed. = feddan = 4200 m^2

production in terms of seed and straw yields showed great increase as compared with the negative control treatment. That means, generally, the uptake of nutrients was increased. Hence, the insignificant decrements in some nutrients could be as a result of dilution effect.

Under the present experimental conditions, it could be concluded that foliar fertilization as supplementary potassium application can not only reduce the amounts of soil potassium application, but also can have a positive effect on yield and its quality.

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References

Agabani, M., M. Badraoui, Y. Daoud and F. Etourneaved, 1993. K use and crop response in North Africa: Proc. Symp." K Availability of Soils in West Asia and North Africa: Status and Perspective) Tehran, Iran, June 19-22, Eds. Mengel, K. and A. Krauss, 57-81.

Ahmad, N., 1998. Foliar fertilization in Pakistan. : Status, scope and constraints. Proc. Symp. " Foliar Fertilization: A Technique to Improve Production and Decrease Pollution" 10-14 Dec. 1995 Cairo, Egypt, Eds. El-Fouly M.M. ; F.E. Abdalla and A.A. Abdel-Maguid, Publ. NRC, Cairo, 7-15

Ankerman, D. and L. Large, 1974. Soil and Plant Analysis. A & L Agricultural Laboratories. Inc., New York, USA.

Bauyoucos, H.H., 1954. A recalibration of hydrometer for mechanical analysis of soil. Agron. J., 42: 343.

Beringer, H., 1980. The role of potassium in yield formation. Proc. Int. Workshop "Role of K in crop production" Cairo, 20-22 Nov. 1979, Eds. Saurat, A. and M.M. El-Fouly: 7-12

Bednarz, C.W. and D.M. Oosterhuis, 1996. Physiological aspects of potassium deficiency in cotton. IX International Colloquium for the "Optimization of Plant Nutrition"8-15 Sept., 1996, Prague- Czech Republic: 260-163.

Chapman, H.D. and P.F. Pratt, 1978. Methods of analysis, Agronomy, No. 9 part 2, Amer. Soc. Agron. Madison, Wasconsin, USA.

Eid, E.T., M.H. Abdel-Al, M.S. Ismail and O.M.M. Wassel, 1997. Response of Egyptian cotton to potassium and micronutrient application. Proc. FAO-IRCRNC; Joint Meeting of the Working Groups 4&39 Cotton Nutrition & Growth Regulators) 20-23 March, 1995 Cairo, Egypt, Eds. El-Fouly M.M.; D.M. Oosterhuis and K. Kosmidou-Dimitropoulou: 139-145.

El-Fouly, M.M. and A.A. El-Sayed, 1997. Potassium status in the soil and crops, recommendations and present use in Egypt. Proc. of The Regional Workshop of the International Potash Institute, 26-30 May, 1997, Bornovoa, Izmir, Turkey, Ed. Johnston, A.E., 50-65.

El-Sayed, A.A. and M.M. Shaaban, 1999. Monthly monitoring of nutrient status in citrus leaves as a guide for proper fertilization. Agricultural Sci., Sultan Qaboos Univ., 17-22.

Grimme, H., 1980. Factors controlling potassium availability to plants. Proc. Int. Workshop "Role of K in Crop Production "Cairo, 20-22 Nov., 1979, Eds. Saurat, A. and M.M. El-Fouly, 33-47.

Jackson, M.L., 1973. Soil Chemical Analysis. Prentice – Hall of Indian, New Delhi.

Lindsay, W.L. and W.A. Norvel, 1978. Development of DTPA micro nutrients soil test for zinc, iron, manganese and copper. Soil Sci. Am. J., 42: 421-428.

Marchner, H., 1986. Mineral Nutrition of Higher Plants. Academic Press, UK., pp: 674.

Mengel, K. and E.A. Kirkby, 1987. Principles of Plant Nutrition. International Potash Institute, Bern, Switzerland, 687- .

Snedecor, G.M. and W.G. Cochran, 1967. Statistical Methods 6th ed., Iowa State Univ. Press.

Olsen, S.R., C.W. Cole, S.S. Watnabe and L.A. Dean, 1954. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. USDA. Agric. Circular No. 930: 1-19.

Oosterhuis, D.M., 1998. Foliar fertilization of cotton with potassium in the USA. Proc. Symp. " Foliar Fertilization: A Technique to Improve Production and Decrease Pollution" 10-14 Dec. 1995 Cairo, Egypt, Eds. El-Fouly M.M. ; F.E. Abdalla and A.A. Abdel-Maguid, Publ. NRC, Cairo, 49-64

Roemheld, V. and M.M. El-Fouly, 1999. Foliar nutrient application: Challenge and limits in crop production. Proc. 2nd Int. Workshop on "Foliar Fertilization", 4-10 April, 1999, Bangkok, Thailand, 1-32.

Walkely, A. and I.A. Black, 1934. An examination of the Degrjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci., 37: 29-38.