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Response of Green Bean to Fertilization with Potassium and Magnesium

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Abstract: Two field experiments were carried out during the two successive growing seasons of 2004/2005 and 2005/2006 in the experimental farm of EL-Bousialy Protected Cultivation Site, El-Behaira governorate, Egypt, to study the effect of different levels of potassium (48, 72 and 96 kg K_2O /fed.) and magnesium (0, 3 and 6 kg MgO/fed.) on the growth, yield and quality of green bean (*Phaseolus vulgaris* L.) cv. Paulista. With respect to the effect of potassium application, plant growth characters, i.e., plant height, number of leaves and branches, fresh and dry weight and total chlorophyll, as well as green pod yield (early, local, exportable and total green pod yield) and pod quality, i.e., pod length, thickness, fibers content, TSS%, total protein percentage, were increased by increasing the level of K fertilizer from 48 up to 96 kg K_2O/fed. Respecting the effect of Mg application, the results clear that the vegetative growth of snap bean plants and green pod yield as well as pod quality were improved by increasing the level of Mg fertilizer from 0 to 6 kg MgO / fed. Respecting the effect of the interaction treatments, result clear that all vegetative growth parameters, green pod yield and its components were significantly affected by the interaction between potassium and magnesium application. The highest values were recorded with the highest levels of potassium and magnesium. As for pod quality, pod length, thickness and fiber were not significantly affected by the interaction treatments. However, TSS and total protein contents were significantly increased with increasing the levels of potassium and magnesium application up to the highest levels.

Key words: Potassium-Magnesium - *Phaseolus vulgaris* L. - Paulista - Exportable - Quality

INTRODUCTION

Green bean (*Phaseolus vulgaris L.*) is one of the most important leguminous crops in Egypt for exportation and local consumption. Mineral nutrient is one of the most important factors, which greatly affect snap bean plant growth and productivity, especially under newly reclaimed soil.

Potassium and magnesium had marked effect on snap bean productivity and quality. Potassium is a regulator for many of the metabolic processes in the cells, plays an important role on promotion of enzyme activity and enhancing the translocation of assimilates and protein synthesis]1]. Many investigators reported that potassium application caused an increase in plant growth, yield and quality of green bean[2-15].

Magnesium is the central atom of the chlorophyll molecule and plays an important non-specific role in the process of phosphate transfer. It also acts as an activator for certain enzymic reactions[1]. The Mg application enhanced snap bean growth, yield and quality as reported by Fageria and Souza [16]; Boaro *et al.*[17]; Alt *et al.*[18,19] ; Wang-Hong *et al.*[20]; Oliveira *et al.*[21] and Swierczewska and Sztuder [22].

So that this experiment aimed to study the effect of three levels of K application with three levels of Mg application on growth, yield and quality of snap bean.

MATERIALS AND METHODS

Two field experiments were carried out during the two successive growing seasons of 2004/2005 and 2005/2006 in the experimental farm of EL-Bousialy Protected Cultivation Site, El-Behaira governorate, Egypt.

The experiments aimed to study the effect of different levels of potassium and magnesium on the growth, yield and quality of green bean.

Seeds of green beans (*Phaseolus vulgaris* L.) cv. Paulista were sown in the first week of September. After preparing the soil for cultivation, ditches of 20 cm width was performed and the distance between the ditches was 75 cm apart. Organic manure and fertilizers (100 and 150 kg/fed. of ammonium sulphate and super- phosphate, respectively) were added through the ditches and then it was covered by sand. Laterals

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of drip irrigation system were spread over the ditches. Seeds were sown in hills 5 cm apart on both sides of irrigation line. The distance between the planting rows was 25 cm apart.

The soil of the experimental field was sandy in texture. The chemical analysis of the experimental soil was presented in Table (A) and the meteorological data at EL-Bousialy was present in Table (B).

Treatments: This experiment included 9 treatments which were the combinations between three levels of potassium and three levels of magnesium application. Potassium sulphate (48% K_2O) was applied at 48, 72 and 96 kg K_2O/fed. Magnesium sulphate (9.8% Mg) was applied at 0, 3 and 6 kg MgO/fed.

A split plot design with four replications were used, the potassium levels were arranged in the main plots and the levels of magnesium were allotted at random in sub-plots. Plot area was 15 m^2 which contained four line of drip irrigation with 75 cm in width and 5 m in length.

Data Recorded:

Plant Growth Measurements: A representative sample of 6 plants was taken by random 45 days after sowing (flowering stage), from each experimental plot for measuring the plant growth characters, as follows:

Plant height from soil surface to the highest point of the plant, number of leaves and branches per plant, total fresh weight and dry weight of plant (determined at 65ºC for 72 hours using the standard methods as illustrated by A.O.A.C.,[23].

Total Chlorophyll: Total chlorophyll content of the sixth mature leaves was measured as SPAD units using monitor chlorophyll meter (SPAD-501).

Green Pod Yield and its Attributes: At harvest stage (60 days from seeds sowing), green pods were collected along the harvesting season (40 days) and the following data were recorded: early, exportable, local and total green pod yields per feddan.

Green Pod Quality: A random sample of 100 green pods at 2-picking were taken, average pod length and thickness were recorded.

Nutritive Value: A random sample of 50 green pods at 2-picking were taken and the following data were recorded:

The total soluble solids (T. S. S. %): it was obtained by using the hand refractometer, according to method described by A.O.A.C.[23]. Fiber percentage in pods: it was determined according to Rai and Mudgal [24]. Total protein percentage in pods: a factor of 6.25 was used for conversion of total nitrogen to protein percentage [23].

Statistical Analysis: All data were subjected to statistical analysis according to the procedures reported by Snedecor and Cochran [25] and means were compared by Duncan's[26] multiple range tests at the 5 % level of probability in the two seasons of experimentation.

The permanent wilting point (PWP) and field capacity (FC) of the trial soil were determined according to Israelsen and Hansen [27].

RESULTS AND DISCUSSION

Effect on Vegetative Growth: Data in Table (1) show the effect of potassium and magnesium applications and their interaction on vegetative growth of snap bean plants, i.e. plant height, number of leaves and branches, fresh and dry weight and total chlorophyll. Results clear that all vegetative growth parameters were gradually and significantly increased by increasing the level of K from 48 up to 96 kg K_2O/fed. This result was true in both growing seasons.

Respecting to the effect of Mg-application, the results clear that the tested characters of vegetative growth of snap bean plants were significantly increased with increasing the level of Mg from 0 up to 6 kg MgO/fed., as shown in both growing seasons.

Regarding to the effect of the interaction between potassium and magnesium application, data show that all vegetative growth parameters were significantly affected by the interaction treatments. The highest values of vegetative growth were recorded with adding the highest level of K (96 kg K_2O/fed.) and the highest level of Mg (6 kg MgO/fed.). However, the lowest values were recorded with adding the lowest level of K (48 kg K_2O/fed.) without Mg application. This result was true in both growing seasons.

Effect on Green Pod Yield: Data in Table (2) show the effect of potassium and magnesium application on green pod yield. With respect to K-application, result show that early, local, exportable and total green pod yields were gradually and significantly increased by increasing the level of K from 48 up to 96 kg K_2O/fed. This result was true in both growing seasons, except for local green pod yield in second season, where there was no significant differences between adding 48 and 72 kg K_2O/fed.

Table A: Chemical and physical properties of the soil of the experiment analyzed two weeks before cultivation in September of 2004.

Chemical properties							
Ec m/moh	pH	Ca++ meq/l	Mg++ meq/l	Na+ meq/l	K+ meq/l	HCO3- meq/l	Cl - meq/l
3	7.89	30	10	14.26	1.66	2.5	12.6
Physical properties							
Sand %	Clay%	Silt%	Texture	FC %	PWP %	Bulk density g/cm3	
95.31	4.295	0.36	Sandy	16.77	5.65	1.435	

Table B: The maximum; minimum; mean of temperatures, relative humidity and total rain at EL-Bousialy region during 2004/2005 and 2005/2006.

Month	Maximum Temp. (∘C)	Minimum Temp. (∘C)	Mean Temp. (∘C)	Mean RH	Total Rain (mm)
			2004/2005		
September	33.88	21.26	27.57	52.47	1.22
October	30.62	19.53	25.07	53.84	1.18
November	27.06	13.81	20.43	54.32	0.59
December	20.81	8.45	14.63	54.98	2.42
January	19.02	6.37	12.7	56.74	1.49
			2005/2006		
September	35.11	22.45	28.78	52.87	1.12
October	29.78	18.05	23.92	54.94	1.06
November	25.37	11.87	18.61	55.5	0.32
December	23.2	11.67	17.44	54.87	2.92
January	20.31	7.46	13.88	53.76	2.70

Table 1: Effect of potassium and magnesium levels on plant height (cm), number of leaves and branches per plant, fresh and dry weight of plant (g) and total chlorophyll (SPAD) of green bean plants at flowering stage (45 days after sowing) in 2004/2005 and 2005/2006 seasons.

Treatments		First season (2004/2005)						Second season (2004/2005)					
K_2O (Kg)	MgO (Kg)	Plant height (cm)	Number of leaves per plant	Number of branches per plant	Fresh weight of plant (g)	Dry weight of plant (g)	Total chlorophyll (SPAD)	Plant height (cm)	Number of leaves per plant	Number of branches per plant	Fresh weight of plant (g)	Dry weight of plant (g)	Total chlorophyll (SPAD)
							K_2O levels						
48		58.20 B	21.02 C	11.39 C	82.88 B	13.63 C	29.00 B	57.79 B	18.17 B	9.65 B	65.48 C	10.30 C	28.54 B
72		58.95 B	23.13 B	12.24 B	88.58 AB	15.52 B	30.03 AB	60.01 AB	18.49 B	10.71 B	75.80 B	12.57 B	29.62 A
96		61.60 A	24.80 A	13.15 A	93.82 A	16.98 A	31.11 A	62.42 A	22.92 A	12.68 A	84.63 A	15.18 A	30.60 A
							MgO levels						
	0	58.38 B	21.92 C	11.44 B	82.79 C	13.90 C	27.15 C	57.79 B	18.70 B	10.06 B	67.34 C	11.46 C	26.83 C
	3	59.55 B	22.83 B	12.35 A	88.46 B	15.38 B	30.27 B	60.01 AB	19.08 B	11.02 AB	75.51 B	12.65 B	29.64 B
	6	60.81 A	24.20 A	12.99 A	94.02 A	16.85 A	32.72 A	62.42 A	21.79 A	11.96 A	83.05 A	13.94 A	32.28 A
							Interaction between K_2O and MgO						
48	0	57.58 d	19.93 f	10.61 d	76.31 e	12.31 d	26.14 f	54.31 d	16.45 c	8.71 e	57.92 d	8.88 e	25.92 f
	3	58.11 d	20.95 ef	11.48 cd	83.58 cde	13.51 cd	29.38 d	57.08 cd	19.36 bc	9.71 de	67.51 cd	10.71 d	28.47 de
	6	58.90 cd	22.17 de	12.08 bcd	88.73 bcd	15.06 bc	31.47 bc	58.48 bcd	18.68 bc	10.52 cde	71.00 c	11.32 d	31.22 abc
72	0	57.17 d	22.24 de	11.39 cd	83.11 de	14.28 bc	27.13 ef	57.27 cd	17.55 c	9.79 cde	67.26 cd	11.37 d	26.79 ef
	3	59.11 cd	22.92 cd	12.27 abcd	88.67 bcd	15.28 b	30.05 cd	59.63 bc	17.34 c	10.75 bcd	75.53 bc	12.42 cd	29.57 cd
	6	60.59 bc	24.22 bc	13.07 abc	93.96 ab	17.00 a	32.91 ab	61.96 bc	20.59 bc	11.61 bcd	84.62 ab	13.93 bc	32.50 ab
96	0	60.40 bc	23.59 bcd	12.32 abc	88.95 bcd	15.10 bc	28.19 de	61.80 bc	22.11 b	11.68 bc	76.85 bc	14.14 b	27.77 def
	3	61.44 ab	24.62 b	13.30 ab	93.15 abc	17.35 a	31.38 bc	63.32 ab	20.54 bc	12.60 ab	83.51 ab	14.81 b	30.89 bc
	6	62.95 a	26.20 a	13.82 a	99.36 a	18.49 a	33.76 a	66.82 a	26.10 a	13.77 a	93.53 a	16.57 a	33.13 a

Values followed by the same letter (s) are not significantly different at 5 %

Table 2: Effect of potassium, magnesium and iron levels on early, local, exportable and total green pod yield(t/fed.) of green bean in 2004/2005 and 2005/2006 seasons.

Treatments		First season (2004/2005)								Second season (2004/2005)							
K_2O (Kg)	MgO (Kg)	Early green pod yield (t/fed.)		Local green pod yield (t/fed.)		Exportable green pod yield (t/fed.)		Total green pod yield (t/fed.)		Early green pod yield (t/fed.)		Local green pod yield (t/fed.)		Exportable green pod yield (t/fed.)		Total green pod yield (t/fed.)	
K_2O levels																	
48		1.61	C	1.94	C	3.15	C	5.09	C	1.55	C	1.90	B	3.08	C	4.98	C
72		2.23	B	2.11	B	3.53	B	5.65	B	2.12	B	2.03	B	3.50	B	5.53	B
96		2.48	A	2.32	A	4.02	A	6.33	A	2.43	A	2.23	A	3.94	A	6.17	A
MgO levels																	
	0	1.88	C	2.08	A	3.27	C	5.35	C	1.82	C	2.04	A	3.20	C	5.25	C
	3	2.10	B	2.15	A	3.52	B	5.68	B	2.03	B	2.08	A	3.44	B	5.52	B
	6	2.34	A	2.14	A	3.90	A	6.04	A	2.26	A	2.04	A	3.86	A	5.90	A
Interaction between K_2O and MgO																	
48	0	1.28	f	1.82	d	2.79	f	4.61	f	1.24	g	1.86	b	2.73	f	4.59	g
	3	1.56	e	1.99	cd	3.16	e	5.14	e	1.55	f	1.91	b	3.07	e	4.98	fg
	6	1.98	d	2.01	cd	3.49	cd	5.51	de	1.87	e	1.93	b	3.43	cd	5.36	def
72	0	1.99	d	2.03	cd	3.35	de	5.38	e	1.95	de	1.98	b	3.28	de	5.26	ef
	3	2.23	c	2.07	bcd	3.53	cd	5.60	cde	2.07	d	2.03	ab	3.47	bcd	5.50	cde
	6	2.46	ab	2.24	abc	3.73	bc	5.96	bcd	2.35	bc	2.08	ab	3.75	bc	5.83	bcd
96	0	2.35	bc	2.37	ab	3.69	bc	6.06	bc	2.27	c	2.29	a	3.61	bc	5.90	bc
	3	2.51	ab	2.40	a	3.89	b	6.29	ab	2.47	ab	2.30	a	3.79	b	6.09	ab
	6	2.58	a	2.18	abc	4.47	a	6.65	a	2.56	a	2.11	ab	4.41	a	6.52	a

Values followed by the same letter (s) are not significantly different at 5 %

Regarding to Mg application, data show that green pod yield and its components were gradually and significantly increased by increasing the level of Mg from 0 up to 6 kg MgO/fed., as shown in both growing seasons. Except for local green pod yield which was not significantly affected by increasing the level of Mg, in both growing seasons.

Respecting to the effect of the interaction treatments, result clear that green pod yield and its components were significantly affected by the interaction between potassium and magnesium application. The highest values were recorded with adding the highest levels of K and Mg (96 kg K_2O/fed. and 6 kg MgO/fed., respectively), followed by adding the highest level of K with medium level of Mg (3 kg MgO/fed.). But the lowest values were recorded with adding the lowest level of K (48 kg K2O/fed.) without Mg application. This result was true in both growing seasons for early, exportable and total green pod yield. However, the highest values of local green pod yield were recorded with adding the highest level of K (96 kg K_2O/fed.) and medium level of Mg (3 kg MgO/fed.), in both growing seasons.

Effect on Green Pod Quality and Nutritive Value: Data in Table (3) show the effect of potassium and magnesium applications and their interaction on green pod quality, i.e., pod length, thickness, fiber content, TSS%, total protein percentage.

With respect to K application, results clear that pod length, thickness and fiber content were not significantly affected by increasing the level of K as shown in both growing seasons, except for pod thickness in the second season, which was significantly decrease by increasing the level of K up to the highest level (96 kg K_2O/fed.) as compared with low or medium level of K. Results also show that TSS% and total protein percentage, were gradually and significantly increased by increasing the level of K in both growing seasons. However, no significant differences were detected in protein content between adding 72 and 96 kg K_2O/fed., in the first season.

Regarding to the effect of Mg application, data show that pod length and pod thickness were not significantly affected by Mg application, in both growing seasons. Fiber contents were not significantly affected by Mg application in the first season, however in the second season it was significantly decreased by increasing the level of Mg from 0 up to 6 kg MgO/fed., with no significant differences between adding 3 or 6 kg MgO/fed. TSS% and total protein content were gradually and significantly increased by increasing the level of Mg from 0 up to 6 kg MgO/fed. This result was true in both growing seasons.

Respecting to the effect of the interaction treatments, result clear that pod length, thickness and fiber were slightly affected by the interaction treatments. However, TSS and total protein content were significantly increased with increasing the levels of potassium and magnesium, the highest values were recorded with adding 96 kg K_2O/fed. and 6 kg MgO/fed., in both growing seasons.

Table 3: Effect of potassium and magnesium levels on length and thickness of pod (cm), fiber percentage, T.S.S. and total protein percentage of green bean pods in 2004/2005 and 2005/2006 seasons.

Treatments		First season (2004/2005)								Second season (2004/2005)							
K_2O (Kg)	MgO (Kg)	Length of pod (cm)		Thickness of pod (cm)		Fiber (percentage)		T.S.S.		Total protein percentage		Length of pod (cm)		Thickness of pod (cm)		Fiber (percentage)		T.S.S.		Total protein percentage	
								K_2O levels													
48		12.29	A	0.71	A	6.54	A	4.34	C	15.25	B	12.83	A	0.74	A	5.87	A	4.30	C	14.80	C
72		12.44	A	0.73	A	6.49	A	4.59	B	18.83	A	12.42	A	0.75	A	5.75	A	4.49	B	18.00	B
96		12.44	A	0.73	A	6.53	A	4.80	A	20.75	A	12.41	A	0.72	B	5.93	A	4.72	A	20.22	A
								MgO levels													
	0	12.49	A	0.72	A	6.52	A	4.47	B	16.77	C	12.64	A	0.74	A	6.05	A	4.38	C	16.51	C
	3	12.22	A	0.72	A	6.46	A	4.58	AB	18.40	B	12.51	A	0.74	A	5.79	B	4.50	B	17.44	B
	6	12.46	A	0.73	A	6.58	A	4.68	A	19.64	A	12.52	A	0.73	A	5.71	B	4.61	A	19.05	A
								Interaction between K_2O and MgO													
48	0	12.52	ab	0.72	ab	6.50	a	4.23	d	13.50	f	13.48	a	0.74	ab	6.13	a	4.16	f	13.21	e
	3	11.90	b	0.69	b	6.52	a	4.29	cd	15.20	e	12.58	ab	0.75	a	5.96	ab	4.26	ef	14.46	d
	6	12.46	ab	0.72	ab	6.61	a	4.51	bc	17.04	d	12.42	ab	0.74	ab	5.51	c	4.48	cd	16.72	c
72	0	12.35	ab	0.71	ab	6.66	a	4.49	bc	17.16	d	12.29	b	0.75	a	6.37	a	4.39	de	16.95	c
	3	12.29	ab	0.73	a	6.33	a	4.60	b	19.12	c	12.32	ab	0.75	a	5.34	c	4.51	cd	17.89	c
	6	12.68	a	0.75	a	6.47	a	4.66	ab	20.19	bc	12.66	ab	0.75	a	5.54	c	4.56	bcd	19.15	b
96	0	12.60	ab	0.73	ab	6.41	a	4.70	ab	19.66	bc	12.14	b	0.72	ab	5.63	bc	4.61	bc	19.36	b
	3	12.47	ab	0.74	a	6.51	a	4.84	a	20.86	ab	12.62	ab	0.72	ab	6.07	a	4.74	ab	19.98	b
	6	12.25	ab	0.72	ab	6.67	a	4.87	a	21.73	a	12.46	ab	0.71	b	6.08	a	4.80	a	21.31	a

Values followed by the same letter (s) are not significantly different at 5 %

The increment in vegetative growth of green bean plants by increasing the level of K fertilizer may be due to the role of potassium on regulation of the metabolic processes in the cells, plays an important role on promotion of enzyme activity and enhancing the translocation of assimilates and protein synthesis [1]. Added to that, increasing the vegetative growth (Table, 1) caused an increase in total green pod yield and its components as well as gave the best quality of green pod of bean.

The results are in harmony with those reported by Devlin and Witham [1], Ascencio [2], Costigan [3], Evanylo and Zehnder [4], Gavras [5], Saxena and Verma [7], Singh *et al.*[8], Sangakkara *et al.*[6], Sangakkara [9], Sangakkara *et al.*[10,11], Kanaujia *et al.*[12], El-Tohamy *et al.*[13], Islam *et al.*[14] and Abdel-Mawgoud *et al.*[15]. They reported that increasing the level of K fertilizer caused a significant increase in vegetative growth, yield of green bean and gave the best quality of green pods.

The increasing of the vegetative growth of green bean plant by increasing the level of Mg fertilizer may be due to the role of magnesium as an activator for certain enzymic reactions, phosphate transfer and chlorophyll synthesis.

Moreover, increasing the vegetative growth (Table, 1) turn on increasing pods yield and gave the best quality of green pods of green bean. The results are in harmony with those reported by Devlin and Witham [1], Fageria and Souza [16], Boaro *et al.*[17], Alt *et al.*[19], Wang-Hong *et al.*[20], Oliveira *et al.*[21] and Swierczewska and Sztuder[22]. They reported that adding magnesium caused increasing in the vegetative growth, pod yield as well as gave the best quality of green pods of green bean.

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