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Effect of Natural Phosphate and Potassium Fertilizer on Growth, Yield and Seed Composition of Pea Plant in New Reclaimed Soil

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Abstract: Two field experiments were carried out at the newly reclaimed soils in Khatatba, Giza Governorate during the winter seasons of 2003 and 2004 to study the response of pea plant to different sources of phosphorus and potassium fertilizers (chemical and/or natural) were addition alone or mixture. The characters of pea plant growth as expressed by length, average leaves and stem numbers, leaf area plant as well as the fresh and dry weight of stem, all of them had their peaks with addition mixture phosphorus and potassium fertilizers compared with either alone. The response of the total pigments content, number of pods/plant, weight of pods per plot (kg), weight of 100 seeds as well as the green seeds tissues in the elemental values of P and K to the mixture phosphorus and potassium fertilizers addition followed the same pattern of change as the plant growth. All parameters of plant growth, total leaf pigment contents, total yield and yield components as well as the chemical composition of green pea seeds tissues recorded the highest significant values with applying the chemical sources of phosphorus and potassium fertilizers addition compared with the natural source.

Key words: Pea plant, phosphorus, potassium, chemical, natural fertilizers

INTRODUCTION

Soil forms from rock in the first place, poor soil can be improved by adding specific types of rock dust chosen for their mineral content. The volcanic basalt, granite, dolomite rock phosphate and rock potash in the Alroc, slowly release a complete spectrum of minerals and trace elements which provides the perfect environment for natural farming. Since, rock in the long term improvement of their soil structure and increased productivity crops without negative affects on the environment.

Legumes respond well to rock phosphate grower's comment on the strong root systems, increased nodulation, good growth, report less fungal problems and increased crop production[1-3]. However, Aboel-Soud *et al.*[4], Mohamed[5] and Shafeek *et al.*[6] found that chemical phosphate application increased dry weight of shoots, number of pods, number of seeds/pod, pod length and weight also higher seed yield as well as NPK content of cowpea and broad bean plants as compared to those obtainer by rock phosphate. On the contrary, Kole and Hajra[7] and Kotb *et al.*[8] reported that no significant differences between the two sources of phosphate (Ca-super phosphate or rock phosphate) on plant growth and total yield.

Potassium application in poorly fertile soil is essential to obtained high yield, since it plays an important role in many processes in plant cells. It has a significant role in the activation of more than 60 enzymes which catalyze various metabolic processes[9] up take and translocation nitrate from roots to shoots[10]. Owing, to its role in many biochemical processes such as protein synthesis and carbohydrate metabolism. However, the highest growth, Yield, yield components, protein, N and K plant and seeds contents of legumes crop were obtained by adding 360 kg/fed natural rock potassium (feldspar) and no significant increase with recommended treatments[11]. On the contrary, Siqueira *et al.*[12] suggested that the potassium rock as such couldn't be used as a potassium source for maize plant.

Therefore, the present research was conducted to determine the natural phosphate and potassium fertilizers to replace chemical fertilizer and to negative affects on the environment.

MATERIALS AND METHODS

Two different trials of experiments were conducted at the newly reclaimed soils in khatatba, Giza Governorate during winter growing season of 2003/2004 and 2004/ 2005

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to study the effect of two sources of phosphate application (chemical super phosphate or natural rock phosphate) and two sources of potassium application (chemical potassium sulfate or natural rock potassium) on growth, yield components and seed chemical composition of pea plant.

The following treatments were conducted:

T_1 : Chemical Ca-super phosphate 15.5 % P_2O_5
T_2 : Natural rock phosphate 7.5 % P_2O_5
T_3 : Chemical potassium sulfate 48 % K_2O
T_4 : Natural rock potassium (Feldspar) 11% K_2O
T_5 : Chemical Ca super phosphate + Chemical potassium sulfate.
T_6 : Chemical Ca super phosphate + Natural rock potassium.
T_7 : Natural rock phosphate + Chemical potassium sulfate.
T_8 : Natural rock phosphate + Natural rock potassium.

A split plot design with 4 replications was used. The experimental plot area as 10.5 m^2 and included 5 rows (each was 3.5 m length and 60 cm width). All treatments received the recommended dose of nitrogen (15 kg N/fed.) as ammonium sulfate 20.5% N twice, at planting and 30 days after planting. But, the chemical and the natural fertilizers were applied as one dose at planting 100 kg/fed of Ca super phosphate and 50 kg/fed of potassium sulfate and the natural rock fertilizers were used in 200 kg/fed of rock phosphate and 220 kg/fed of rock potassium. Recommended agronomic practices were followed. The seed of pea c.v. little marvel were inoculated with *Risopum* and were applied at a rate of 300 g per 60 kg seed, using Arabic gum solution (16%) as a sticking agent and were sown on the last week of October in both 2003 and 2004 seasons. The seeds were sown on one side of the ridge; 20 cm apart were performed according to Jackson[13] (Table 1).

Five pea plants were uprooted from each plot after 60 days of sowing to assay plant length (cm), number of shoots and leaves per plant, fresh and dry weight of stems as (g/plant) as well as leaf area plant (cm^2). Also foliage samples were taken to the determination of total pigments, i.e. chlorophyll a, d and carotene as (mg/100 g) fresh wt. according the methods decrypted by Wettstein[14]. Pea pods were harvested weekly and at 3rd picking 10 pods sample were collected and the following assessment were written: number and average green pod weight (g/pod), number of seeds /pod and weight of 100 g seeds as well as the weight of green pods and the weight of seeds per plot were recorded. Sampler of green seeds were taken for the chemical determination of the elemental nutrition content, Whereas N, P and K were determined according to the procedure described by Koch and MC Meelin[15], Trough and Meyer[16] and Brown and Lilleland[17], respectively. The total carbohydrate and crude protein were determined in green seeds using the method of AOAC[18]. All obtained data values were subjected to the Analysis of Variance by Gomez and Gomez[19].

Table 1: Physical and chemical properties of experiment soil in 2003/2004 and 2004/2005 seasons

	Seasons	
Properties	2003/2004	2004/2005
Textural	Sandy	Sandy
Sand (%)	82.64	89.50
Silt (%)	5.82	9.36
Clay (%)	4.68	8.00
pH	7.82	7.71
EC	1.98	2.29
Soluble cations (meq l^{-1})		
Ca^{++}	6.85	8.65
Mg^{++}	6.24	6.82
Na^{+}	4.82	4.46
K^{+}	2.15	2.23
Soluble anions (meq L^{-1})		
Co_3^{-}	0.00	0.00
HCo_3^{-}	7.15	7.28
Cl^{-}	4.23	5.14
So_4^{-}	8.68	9.74
Total N (ppm)	9.2	10.5
Available P (ppm)	8.6	09.5
Available K (ppm)	400.0	360.0

RESULTS AND DISCUSSION

Plant growth characteristics: The presented data in Table 2 clearly showed that, mixture of phosphorus and potassium additions fertilizers had a superiority compared with the addition of either of alone. These results were true in the two experimental seasons and for all plant growth characters. The statistical analysis of the obtained data reveals that, the differences within the mixture of chemical and rock P and K treatments were enough to be significant at 5% level compared with either alone addition, concerning to all plant growth parameters in both seasons. In the same respect, the chemical form of phosphorus fertilizer (super phosphate) increased the plant length, number of stem and leaf area plant compared with rock phosphorus form fertilizer in both seasons.

Pea plant witch supplied with chemical form of P and K were more vigor than that plants supplied with rock form. This superiority might be attributed to the availability and speed solubility of chemical phosphorus and potassium form which hence the rooting system of pea plant directly absorbed it in short time[20]. Also, the

Table 2: Effect of chemical and natural phosphate and potassium fertilisers on growth characters of pea plant

	2003/2004 season						2004/2005 season					
		No. of plant		Weight of stem (g)				No. of plant		Weight of stem (g)		
Treaments	Plant length (cm)	Stems	Leaves	Fresh	Dry	Leaf area (cm^2)	Plant length (cm)	Stems	Leaves	Fresh	Dry	Leaf area (cm^2)
T_1	40.25	3.25	13.20	21.67	4.52	166.0	40.63	3.15	13.50	22.37	4.27	169.2
T_2	40.09	3.10	13.14	21.67	4.28	165.2	40.36	3.01	13.36	22.14	4.17	170.4
T_3	40.11	3.20	13.19	21.57	4.41	166.6	40.34	3.15	13.44	22.18	4.20	171.2
T_4	40.10	3.10	13.12	21.47	4.36	165.1	40.39	3.06	13.43	22.15	4.16	170.3
T_5	42.83	4.26	15.33	24.68	5.09	174.2	43.56	4.31	15.76	24.80	4.96	178.9
T_6	41.15	4.04	15.12	23.65	4.97	170.3	41.28	4.03	15.36	23.89	4.77	175.3
T_7	41.20	4.04	15.16	23.83	5.04	170.9	41.49	4.06	15.46	23.11	4.86	175.6
T_8	42.19	3.89	15.15	22.88	4.99	170.0	42.45	4.09	15.33	23.77	4.56	173.5
LSD at 5%	00.14	0.10	00.12	01.22	0.39	00.54	00.26	0.05	00.17	00.77	0.18	0.73

Table 3: Effect of chemical and natural phosphate and potassium fertilisers on the pigment content in pea plant leaves

	2003/2004 season mg/100 g fresh weight				2004/2005 season mg/100 g fresh weight			
Treaments	Chlorophyll (a)	Chlorophyll (b)	Carotene	Total	Chlorophyll (a)	Chlorophyll (b)	Carotene	Total
T_1	0.47	0.22	0.42	1.11	0.48	0.23	0.42	1.13
T_2	0.44	0.21	0.41	1.06	0.47	0.21	0.38	1.06
T_3	0.48	0.23	0.43	1.14	0.50	0.23	0.41	1.14
T_4	0.45	0.22	0.38	1.05	0.49	0.22	0.43	1.14
T_5	0.64	0.32	0.58	1.54	0.59	0.34	0.59	1.52
T_6	0.61	0.30	0.49	1.30	0.56	0.30	0.57	1.43
T_7	0.64	0.33	0.49	1.46	0.66	0.33	0.54	1.53
T_8	0.63	0.30	0.46	1.39	0.59	0.30	0.50	1.39
LSD	0.08	0.03	0.11	0.12	0.06	0.04	0.09	0.13

Table 4: Effect of chemical and natural phosphate and potassium fertilisers on the yield and yield components of pea

	2003/2004 season						2004/2005 season					
	Pods/plant		Weight of plot (kg)				Pods/plant		Weight of plot (kg)			
Treaments	Number	Weight	Pod	Seed	No. of seeds seeds/pod	Weight of 100 seeds	Number	Weight	Pods	Weight	No. of seeds seeds/pod	Weight of 100 seeds
T_1	11.65	52.9	9.41	6.72	7.91	51.06	12.75	56.85	10.52	6.64	8.08	50.42
T_2	11.59	51.97	9.33	6.83	7.89	50.48	12.67	56.32	10.29	6.41	8.05	49.60
T_3	11.84	52.22	9.36	7.06	7.92	51.01	12.89	56.86	10.33	6.90	8.06	50.19
T_4	11.59	51.97	9.30	6.94	7.90	50.77	12.73	56.39	10.31	6.65	8.03	50.09
T_5	14.13	56.83	10.62	7.94	8.06	54.53	15.08	60.53	10.97	7.78	8.10	53.19
T_6	13.40	53.17	9.97	7.15	7.93	53.63	13.47	57.68	10.71	7.33	8.08	52.06
T_7	13.90	56.23	10.36	7.32	7.95	54.31	14.88	60.19	10.94	7.25	8.07	52.60
T_8	13.31	56.05	10.20	7.06	7.93	51.88	14.70	59.57	10.86	6.93	8.06	50.42
LSD at 5%	00.85	03.37	00.43	0.64	NS	02.32	00.51	03.22	00.29	0.38	NS	01.15

Table 5: Effect of chemical and natural phosphate and potassium fertilizers on the chemical composition of green seeds of pea

	2003/2004 season % in green seeds					2004/2005 season % in green seeds				
Treaments	N	P	K	Protein	Vitamin C (mg/100 g)	N	P	K	Protein	Vitamin C (mg/100 g)
T_1	3.35	0.48	1.17	21.31	26.09	3.97	0.45	1.18	23.29	26.05
T_2	3.44	0.47	1.18	20.58	25.46	4.01	0.37	1.17	22.81	26.04
T_3	3.39	0.47	1.17	21.17	25.77	4.01	0.46	1.18	23.17	26.07
T_4	3.42	0.47	1.17	21.35	25.42	4.00	0.46	1.19	22.81	26.06
T_5	4.46	0.73	1.26	23.18	28.79	5.16	0.73	1.33	27.60	28.72
T_6	4.08	0.67	1.21	22.25	27.29	4.43	0.65	1.28	25.65	26.46
T_7	4.13	0.71	1.23	21.95	27.63	4.50	0.70	1.31	25.40	26.81
T_8	4.02	0.65	1.20	22.00	26.14	4.66	0.58	1.20	25.21	26.08
LSD at 5%	0.76	0.03	0.06	01.39	02.19	0.70	0.12	0.11	03.02	01.67

low effect of rock potassium fertilizer is due to its low K supplying capacity as shown by the total K uptake by the plant. These data support earlier studies using chemical extract ants in the laboratory and show the low availability of the K form this rock to maize plants[12].

These results are in agreement with those obtained by other researcheers[4-6,12] on the K effect.

Pigments content: The addition of mixture of phosphorus and potassium fertilizers for pea plant was statistically significant affected the pigment contents (Table 3). However, the content of total pigments (Chlorophyll a, b and carotene) increased to record their peaks with plants which received the P and K fertilisers compared to be added alone. These results held well in the two

experiments of 2003 and 2004. The superiority in chlorophylls and carotene content with adding chemical P and K might be attributed to its important role in plant metabolism and the unknown minerals in rock P and K which could be inhibited plant growth and caused an inhibition in the absorption of other minerals and the low water solubility of rock phosphor and potassium maintain higher P and K concentration in soil solution due to its lower solubility[5].

Table 3 clearly shows that plants of pea which supplied with P and K fertilizers in the chemical form had the higher values of chlorophylls and carotenes. These findings were true in both experimental seasons.

The greener pea plants which received chemical P and K may be attributed to the availability and the more solubility of chemical form of P and K compared to the rock one, consequently speed in its absorption by rooting system. It is known that, phosphorus and potassium has an important role in many bio chemical processes such as photosynthesis, respiration and protein synthesis and carbohydrate metabolism[10].

Total pod yield and yield components: Table 4 indicates clearly that, adding P+K fertilizers resulted in an increase in number of pods plant, weight of pods per plot and weight of 100 seeds. These findings were true in the two experiments compared were added P and K alone. Moreover, the statistical analysis of the obtained data reveals that the different P+K treatments affected significantly total pods yield and its components in both seasons.

Chemical P and K added to pea plant resulted in the heavier weight of pods per plot in kg (10.62 and 10.97 for 1st and 2nd season, respectively) compared to the added rock form of P and K (10.20 and 10.86 kg/plot for the same respective seasons). Also, the chemical fertilizer recorded were 7.94 and 7.78 kg/plot of the green seeds of pea if compared by 7.06 and 6.93 kg/plot for the rock production in 1st and 2nd seasons, respectively.

The response of weight of 100 seeds followed the same pattern of change like that previous mentioned in both two experimental seasons. Moreover, the statistical analysis of the resulted data reveals that, the differences within the two forms of phosphorus and potassium were great enough to be significant at 5% level.

It could be concluded that, chemical P and K form has the heaviest and best pods yield. This might be attributed to the better plant growth and the higher pigments contents of the chemical P and K fertilizers compared to the natural (rock P and K) form and the limited solubility of rock phosphorus and potassium. In this connection, Romer and Lehne[21] found that insufficient K supply to legumes may reduce their N_2 fixation capacity., consequently the total yield may also reduce. The response of total pods and seeds yield per plot of pea plant and its components to the P and K form followed the same pattern of change as that obtained by many researchers[1-5] on the phosphorus effect and Ezzat *et al.*[11]and Siqueira *et al.*[12] in the potassium fertilizer effect.

Chemical composition of green seeds: The statistical analyses of the obtained data indicate that the differences within the two treatments of P+K fertilizers compared to added P or K added alone were enough to be significantly at 5% level. These were true in values of P and K in tissues of green seeds in both seasons. However, the response of N, Protein and vitamin C were not significant in the two seasons (Table 5) except the addition of mixture of the chemical form of P+K in both two seasons compared Concerning to the chemical composition of green seeds tissues of pea particularly P, K and vitamin C, the obtained data of both experiments shows that, their higher percentages were resulted with plants received P and K fertilizers in the chemical form. The other nutritional value, i.e. N and total protein in green seeds tissues recorded a fluctuation values within all treatments. In spite of the fluctuation and the in significant response of N and protein % to the fertilization of rock and/or chemical P and K fertilizers, the obtained data showed that, values of different nutritional values almost nearly. It could be concluded that, using rock fertilizer form of P and K gave nutritional values equal or little less than that, which were obtained when chemical form of P and K fertilizers were used.

The previous investigation on the benefits of rock and/or chemical P and K fertilizer particularly for the nutritional value of green seeds of pea tissues are in accordance with that reported by Ezzat *et al.*[11] and Siqeira *et al.*[12] on the potassium effect and Mohamed[5] and Shafeek *et al.*[6] on the phosphorus effect.

It could be concluded that using natural rock phosphorus and potassium fertilizers at reclaimed lands will give pod, seed yields and quality close to those obtained by chemical phosphorus and potassium application, with no significant difference between them. However, replacing the phosphorus and potassium by natural one will help in reducing environmental pollution and produce safe human food.

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