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Impact of Phosphorus Fertilizer and Potassium Humate on the Productivity and Nutritional Status of Pea Plants Irrigated with Saline Water

[1]Abd El-Rheem Kh. M., [2]Abd El-Baky M.M.H. and [3]Sahar M. Zaghloul

[1]Soil and Water Use Dept., Agricultural & Biological Research Institute, National Research Centre (NRC), 33 El-Buhouth St., 12622 Dokki, Egypt.
[2]Vegetable Res. Dept., Agricultural & Biological Research Institute, National Research Centre (NRC), 33 El-Buhouth St., 12622 Dokki, Egypt.
[3]Plant Nutrition Dept., Agricultural & Biological Research Institute, National Research Centre (NRC), 33 El-Buhouth St., 12622 Dokki, Egypt.

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ABSTRACT

Two field experiments were carried out in consecutive winter season of 2022 and 2023 at the Research and Production Station of the National Research Centre at the Nubaria site in Beheira Governorate, Egypt, to determine the response of pea (*Pisum sativum* L.) to foliar application of humic acid and phosphorus fertilization on growth, yield parameters and nutrients content of pea plant. Phosphorus fertilization rates (0, 38, 76 and 114 P_2O_5 kg ha^{-1}) were used as the main factor, while K-humate concentrations (0, 1000 and 2000 mg l^{-1}) were used as a second factor. The results demonstrated that applying phosphorus fertilizer and spraying K-humate had a substantial impact on growth and production. The growth and yield of peas in two consecutive growing seasons were impacted by increasing the rate at which K-humate at different concentrations was applied while also increasing the rate at which phosphorus fertilizer was applied. For the pea growth and yield coordinates, the experimental treatment (K-humate at 2000 mgl^{-1} + 114 kg P_2O_5 ha^{-1} of phosphorus fertilizer) received the greatest values. The nitrogen, phosphorus, and potassium content of pea seeds increased as the concentration of K-humate spraying increased. The study's findings highlight the significance of phosphorus fertilization and show that applying K-humate spray to plants while they are growing can boost the fertilizer's efficacy and impact on pea plants that are irrigated with salty water.

Keywords: Phosphorous fertilization, K-humate, Pea plants, growth, yield, nutrients content

1. Introduction

Pea (*Pisum sativum* L.) is one of the main winter crops grown in Egypt for domestic and export markets. Peas are highly nutritious, as they are rich in protein, carbohydrates, and some vitamins (Shedeed *et al*., 2018).

One of the general essential nutrients that significantly influences the growth of all crops is phosphorus. According to Tesfaye *et al*., (2007), phosphorus availability limits over 30% of worldwide agricultural production, making it a significant nutrient that limits productivity in most parts of the world.

Due to the high phosphorus requirements during N_2 fixation, phosphorus can be a nuisance restriction for all legumes in nutrient-poor settings (Tsvetkova and Georgiev, 2007). Root development and the synthesis of phospholipids and phosphoproteins depend on phosphorus (Loguerre, 2008).

Potassium humate (K-humate) is commonly utilized as a source of K through foliar application (Okba *et al*., 2021). Spraying plants with K-humate increases the permeability of plant membranes owing to humate application, which enhances root growth, increases cell division and improves

Corresponding Author: Abd El-Rheem Kh. M., Soil and Water Use Dept., Agricultural & Biological Research Institute, National Research Centre (NRC), 33 El-Buhouth St., 12622 Dokki, Egypt.

productivity (Aytaç *et al*., 2022). Humates are widespread carbonaceous materials of plant and animal residues resulting from biological and chemical decomposition (Turan *et al*., 2022).

The study's goal was to find out how varying potassium humate concentrations and phosphorus fertilizer proportions affected the nutritional status, growth, and yield parameters of peas cultivated on sandy soil with saline water irrigation.

2. Materials and Methods

The study examined how pea (*Pisum sativum* L.) plants responded to different rates of P fertilization and K-humate concentrations throughout the winter months of 2022 and 2023 at the National Research Centre Experimental Station in Beheira Governorate. Using the standard protocols described by Cottenie (1980), Table (1) displays some of the physical and chemical characteristics of the soil used in the irrigation water trials and analysis (Table, 2).

Table 1: Some physical and chemical properties of the test soil at the beginning of the experiment

Soil properties		**Values**	
		First season	**Second season**
Particle size distribution (%)	Sand	93.32	94.0
	Silt	4.68	3.56
	Clay	2.00	2.44
	Texture	Sandy soil	Sandy soil
$CaCO_3$ (%)		2.21	2.24
pH (1:2.5 soil suspension)		8.21	8.20
EC (dS m^{-1})		1.98	1.80
Soluble cations (mmol L^{-1})	Ca^{++}	8.02	7.96
	Mg^{++}	2.88	3.16
	Na^{+}	5.95	5.20
	K^{+}	2.95	1.68
Soluble anions (mmol L^{-1})	CO_3^{--}	-	-
	HCO_3^{-}	1.52	1.52
	Cl^{-}	8.30	7.82
	SO_4^{--}	9.98	8.66
Available nutrients mg kg^{-1}	N	24.2	26.5
	P	2.05	2.00
	K	68.6	59.5
	Fe	4.11	3.95
	Mn	0.97	1.01
	Zn	1.20	0.99

The field experiment was designed as a factorial experiment in a randomized complete block design with four replications. The first factor was the phosphorus fertilizer application rates (0, 38, 76 and 114 P_2O_5 kg ha^{-1}). The second factor was the foliar application of humic acid concentrations (0, 1000 and 2000 mg l^{-1}). Phosphorus treatments in the form of mono super phosphate (15 % P_2O_5) were added during soil preparation. Foliar applications of humic acid (85 %) were added at 30 days after sowing, and repeat the spray every two weeks once.

Table 2: Some chemical analyses of irrigation water

pH	**EC dS m^{-1}**	**Soluble cation**				**Soluble anions**			
		meq. L^{-1}							
		Ca	**Mg**	**Na**	**K**	**CO_3**	**HCO_3**	**Cl**	**SO_4**
7.10	2.69	7.45	3.81	15.2	0.44	nd.	5.20	14.6	7.10

2.1. Measured Parameters

2.1.1. Plant Growth and Plant Productivity

A random sample of four plants was taken 75 days after planting to measure plant height, number of leaves per plant, and dry weight. All production indicators were recorded: pod length, number of seeds per pod, weight of 100 seed, pod yield per plant, seeds yield per plant and protein content were recorded also.

2.1.2. Nutritional Status

Total nitrogen content was estimated by modified Kjeldahl's methods Motsara and Roy (2008). Phosphorus was determined calorimetrically by NH –Metavanidate method Motsara and Roy (2008). Potassium was flame-photometrically estimated Motsara and Roy (2008).

2.2. Statistical Analysis

All data were subjected to statistical analysis using Mstatc software. Different treatments were compared as described by Snedecor and Cochran (1982).

Results and Discussion:

The results (Table 3) showed the effects of increasing the application rate of different concentrations of K-humate and increasing rates of phosphorus fertilization on the characteristics growth of pea plants during two successive growing seasons. Increasing the concentration of K-humate from zero to 2000 mgl^{-1} with increasing the phosphorus fertilizer rate from zero to 114 Kg P_2O_5 ha^{-1}, led to significantly increased the growth parameters of pea. The experimental treatment (K-humate at 2000 mgl^{-1} + 114 Kg P_2O_5 $ha^{-1}$of phosphorus fertilizer) was given the highest values for the pea growth coordinates in two consecutive seasons. The experimental treatment (K-humate at 2000 mgl^{-1} + 114 Kg P_2O_5 ha^{-1} of phosphorus fertilizer) resulted in the highest values of pea growth coordinates for two consecutive seasons.

Table 3: Effect of P fertilization and K-humate on pea growth at two season's growth (2022-2023).

P fertilization Kg P_2O_5 ha^{-1}	K-humate mgl^{-1}	Plant height cm	No. of leaves $plant^{-1}$	Dry weight $plant^{-1}$ g	Plant height cm	No. of leaves $plant^{-1}$	Dry weight $plant^{-1}$ g
		2021			2022		
0	0	21.2	10.7	17.9	21.4	10.5	17.6
	1000	30.5	11.9	19.8	30.6	11.7	19.5
	2000	35.6	14.5	20.8	34.9	14.3	20.4
38	0	24.6	11.3	18.6	24.4	11.2	18.5
	1000	32.3	13.4	25.4	32.3	13.6	25.1
	2000	39.1	17.8	28.2	38.8	16.9	28.0
76	0	26.4	12.2	22.1	26.4	12.0	22.3
	1000	37.3	14.3	31.2	37.0	14.1	31.0
	2000	41.4	19.1	35.6	41.2	18.8	34.5
114	0	28.3	12.6	22.5	28.5	12.4	22.4
	1000	38.0	14.5	32.0	37.9	14.3	31.9
	2000	43.2	19.2	36.1	42.1	19.0	36.0
$LSD_{0.05}$		2.42	0.051	0.67	2.39	0.50	0.66

The growth and development of plants are significantly influenced by phosphorus, a vital macronutrient. However, crop yield is severely hampered by the soil's inadequate supply of phosphorus (Khan *et al*., 2023). Afifi *et al*. (2010) demonstrated that humic acid applied topically enhances nutritional status and boosts the growth and production of legumes. According to Fouda (2017), humic acid spraying of the leaves raised the dry weight of faba bean plants at varying degrees of phosphorus fertilization.

The findings (Table 4) demonstrate how the pea yield metrics were affected over the course of two consecutive growing seasons by spraying K-humate at concentrations ranging from 0 to 2000 mgl^{-1}, which overlapped with varying rates of phosphorus fertilization (0 to 114 Kg P_2O_5 ha^{-1}). The growth index and growth characteristics improved significantly as a result of increasing the amount of phosphorus fertilizer applied and improving the humic acid spraying effect. This improved effect of the experimental treatments continued to have an effect on the yield and its various characteristics over the course of two consecutive growing seasons, particularly with the highest concentrations of K-humate and the highest rate of phosphorus fertilizer. Because the third rate of phosphorus fertilization (76 kg P_2O_5 ha^{-1}) produced the best values for the yield and its characteristics, it was observed that increasing the concentration of K-humate spraying up to 2000 mg l^{-1} increased the efficiency of using phosphorous fertilizer. This was in contrast to the yield values obtained when adding the higher rate of phosphorus fertilizer (114 kg P_2O_5 ha^{-1}), with a high spraying concentration of humic acid.

Table 4: Effect of P fertilization and K-humate on pea yield at two season's growth (2022-2023)

P fertilization Kg P_2O_5 ha^{-1}	**K-humate mgl^{-1}**	**Pod length cm**	**No. of seeds pod^{-1}**	**Weight of 100 seeds g**	**Pod yield Ton/ ha^{-1}**	**Protein %**
				2022		
	0	4.89	5.44	18.0	4.25	17.9
0	1000	5.44	6.89	21.2	5.06	23.0
	2000	6.78	7.10	23.0	5.35	24.7
	0	5.56	6.11	19.0	4.68	18.0
38	1000	6.22	7.29	23.4	5.45	24.6
	2000	8.00	7.68	25.6	6.12	27.3
	0	6.63	6.55	20.2	5.11	18.9
76	1000	7.82	7.54	27.4	6.24	28.8
	2000	8.92	7.82	27.6	6.89	32.0
	0	7.01	6.77	20.6	5.33	20.1
114	1000	8.66	7.69	27.6	6.46	31.9
	2000	9.56	8.00	28.0	6.91	33.4
$LSD_{0.05}$		0.76	0.33	0.26	0.20	0.40
				2023		
	0	4.88	5.39	17.9	4.32	18.0
0	1000	5.39	6.88	21.0	5.11	23.1
	2000	6.74	7.11	22.9	5.52	24.8
	0	5.53	6.08	19.1	4.78	18.1
38	1000	6.20	7.28	23.5	5.52	24.7
	2000	8.01	7.69	25.5	6.24	27.2
	0	6.61	6.54	20.3	5.14	18.8
76	1000	7.80	7.53	27.6	6.22	28.7
	2000	8.91	7.81	27.8	6.89	31.9
	0	7.00	6.72	20.5	5.38	20.0
114	1000	8.59	7.68	26.8	6.43	31.7
	2000	9.49	8.01	27.9	6.89	33.1
$LSD_{0.05}$		0.75	0.35	0.30	0.25	0.39

According to Mesut *et al*. (2010), pepper plants grown in growth chamber conditions under moderate salt stress had improved yield characteristics when ferilized with humic acid and phosphate. According to Forgac and Czimbalmos (2011), applying 1 g^{-1} K-humate to pea plants greatly boosted their average freshness and weight as well as the number of pods per plant and total yield per plant. The primary component of ATP, the chemical that gives plants "energy" to perform functions including respiration, nutrient transport, nutrient absorption, protein synthesis, and photosynthesis, is phosphorus (Alinajati & Mirshekari, 2011). According to Gad El-Hak *et al*. (2012), pea plants cultivated in clay soil benefit from and yield more when K-humate is sprayed at a concentration of 2 gl^{-1}.

As seen in Table 5, the addition of phosphorus fertilization and the application of K-humate spraying enhanced the nutritional content of pea seeds. During the two consecutive growth seasons, pea seeds with higher humic acid spray concentrations had higher levels of nitrogen, phosphorus, and potassium as well as higher rates of phosphate fertilization.

It has been demonstrated that applying humic acids topically to plants enhances the chemical makeup of cowpea plants (El-Hefny, 2010). According to Ahmed and El-Abagy (2007), the amount of nitrogen, phosphorus, and potassium in bean plants' leaves increased as phosphorus fertilizers were applied more frequently.

Table 5: Effect of P fertilization and K-humate on N, P and K content on pea seeds at two season's growth (2022-2023).

P fertilization Kg P_2O_5 ha^{-1}	K-humate mgl^{-1}	N	P %	K	N	P %	K
			2022			2023	
	0	3.00	0.10	0.91	3.01	0.11	0.92
0	1000	3.29	0.18	0.98	3.30	0.18	0.97
	2000	3.56	0.19	1.03	3.57	0.19	1.04
	0	3.07	0.19	0.96	3.08	0.19	0.96
38	1000	3.46	0.23	1.08	3.47	0.24	1.08
	2000	3.88	0.25	1.16	3.90	0.26	1.17
	0	3.12	0.22	1.00	3.11	0.23	1.01
76	1000	4.01	0.28	1.17	4.02	0.28	1.18
	2000	4.36	0.31	1.31	4.40	0.30	1.32
	0	3.20	0.27	1.03	3.21	0.28	1.04
114	1000	4.55	0.32	1.20	4.56	0.33	1.21
	2000	4.76	0.34	1.67	4.77	0.35	1.68
$LSD_{0.05}$		0.37	0.02	0.05	0.40	0.02	0.05

4. Conclusion

The productivity and nutritional status of pea plants watered with saline water are greatly improved by the simultaneous application of potassium humate and phosphorus fertilizer. Phosphorus plays a crucial role in root development, energy transfer, and overall plant vigor, helping mitigate the adverse effects of salinity. On the other hand, potassium humate acts as a biostimulant that increases plant stress tolerance while also improving soil structure, nutrient availability, and water retention. Together, these inputs improve plant growth parameters, increase pod yield, and enhance nutrient uptake efficiency under saline conditions. Potassium humate and phosphorus fertilizer integration thus offers a sustainable way to enhance pea crop performance in soils impacted by salt.

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