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GROWTH, YIELD AND NUTRITIONAL STATE OF PEA PLANT AS AFFECTED BY PHOSPHORUS FERTILIZATION AND FULVIC ACID

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Abstract

Effect of fulvic acid foliar application and P fertilization on pea was investigated during the two successive cultivation seasons of 2018 and 2019. Phosphorus fertilization treatments (0, 15, 30 and 45 P_2O_5 kg fed^{-1}) were added during soil preparation. Foliar applications of fulvic acid (0, 0.5 and 1 Kg fed^{-1}) were added at 30 days after sowing, and repeat the spray every two weeks once. The results indicated a significant response to both growth and yield characteristics as a result of additives of phosphate fertilization and spraying fulvic acid. Sprinkling one kilo fulvic acid per acre improves the growth and yield of peas under different levels of phosphate fertilization. As well as spraying fulvic acid on pea leaves greatly helped the leaves content of macro and micronutrients under P fertilization levels. Spraying fulvic acid on pea plants greatly helped on improvement seed content of macro and micro nutrients under different phosphorus fertilization levels. The results showed that the best experimental treatments that gave the highest values of N, P and K as well as Fe, Zn and Mn when spraying pea plants at a kilogram per feddan of fulvic acid with the highest phosphate fertilization rate 45 Kg P_2O_5 fed^{-1}. The results of the paper can be summarized on the importance of paying attention to phosphate fertilization for leguminous plants, and spraying plants with fulvic acid during the period of plant growth improves increasing the efficiency use of phosphate fertilization and its effect on the growth and harvest of peas grown in sandy soil.

***Keyword*:** Fulvic acid, P fertilization, Pea plants, Growth, Yield, Nutritional state.

Introduction

Pea (*Pisum sativum* L.) is one of the major winter crops grown in Egypt for local and export markets. Pea seeds had high nutritional values due to their high contents of proteins and carbohydrates as well as vitamin A and B (Shedeed *et al.*, 2018).

Phosphorus is one of the most important nutrients significantly affecting all plants development. Phosphorus is a major yield limiting nutrient in most regions of the world, because the crops production on more than 30% of the world arable land is limited by P availability (Tesfaye *et al.,* 2007). Phosphorus may be a ticklish constraint of all legumes plant under low nutrient milieu because there is a substantial need for P in the N_2 fixation process(Tsvetkova and Georgiev, 2007). Phosphorus is essential for root growth, phospho-proteins, phospholipids and ATP, ADP formation (Loguerre, 2008).

Fulvic acid is the low molecular substances that deriving from humic substances which are smaller in the molecular size than humic acids and often used as complexing factors for attracting the nutrient solutions in foliar applications for improving the plant uptake. Fulvic acid is plant biostimulant that are produced mainly by biodegradation of lignin containing plant organic matter (Malan, 2015). Abd El-Rheem *et al.*, (2017) indicated that hormone-like effects of humic substances is more in acidic groups and smaller molecules than aliphatic ones. Fulvic acid has smaller molecules and more acidic groups than humic acids.

The study aimed to investigate the effect of spraying different levels of fulvic acid under different rate of phosphorus fertilizer on growth, yield and nutrients content of pea plants grown in sandy soil.

Material and Methods

This study was carried out at the Experimental Station of the National Research Centre, Beheira Governorate (north of Egypt), during the two winter seasons of 2018 and 2019 to investigate the response of pea (*Pisum sativum* L.) plants to different levels of P fertilization and fulvic acid. Some physical and chemical properties of the soil used in the experiments are shown in Table (1) using the standard procedures outlined by Cottenie (1980)

Table 1 : Some physical and chemical properties of the soil used.

Soil property	Value	Soil property	Value
Particle size distribution %		pH (1:2.5 soil suspension)	7.90
Sand	90.08	EC (dS m^{-1}), soil paste extract	1.34
Silt	0.66	Soluble ions (mmol L^{-1})	
Clay	9.26	Ca^{++}	7.02
Texture	Sandy	Mg^{++}	2.53
$CaCO_3$ %	2.10	Na^{+}	2.98
Saturation percent %	23.30	K^{+}	0.91
Organic matter%	0.10	CO_3^{--}	nd
Available N (mg kg^{-1})	10.3	HCO_3^{-}	2.20
Available P (mg kg^{-1})	1.2	Cl^{-}	3.98
		SO_4^{--}	7.22
Available K (mg kg^{-1})	36.5	CEC (cmol kg^{-1})	5.50

A field experiment was arranged as a factorial experiment (two ways) based on randomized complete block design with four repetitions. The first factor was rates of P fertilization (0, 15, 30 and 45 P_2O_5 kg fed^{-1}). The second factor was rates of foliar application of fulvic acid (0, 0.5 and 1 Kg fed^{-1}). Phosphorus treatments in the form of mono super phosphate (15 % P_2O_5) were added during soil preparation. Foliar applications of fulvic acid (15 %) were added at 30 days after sowing, and repeat the spray every two weeks once.

Measured Parameters:

Vegetative plant growth and yield: A random sample of four plants were taken at 75 days after planting to measure plant height, number of leaves per plant and plant dry weight were recorded. All yield parameters such as 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.

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). While Fe, Zn and Mn were determined using atomic absorption spectrophotometer using the method of (A.O.A.C., 1990).

Statistical Analysis:

All data were subjected to statistical analysis using Mstatc software. The comparison among means of the different treatments was determined, as illustrated by Snedecor and Cochran (1982). Means of the treatments were compared by the Least Significant Differences Test at (0.05) level of significance.

Results and Discussion

The results of Table (2) include the effect of different levels of P fertilization and fulvic acid on both growth and yield characteristics of pea plants grown in sandy soil in the two growing seasons 2018 and 2019. Where it is actually evident that there is a significant response to both the characteristics of growth (plant height, number of leaves per plant and dry weight of plant), as well as the yield parameters (pod length, number of seeds per pod, weight of 100 seeds, pod yield and protein)as a result of the addition rates of P and fulvic acid fertilization. The rareness of phosphorus in the growth environment plainly affects the growth of plants and consequently the data of the obtained crop, where it was found that an increase in the level of fertilizer from zero to 45 Kg P_2O_5 fed^{-1}led to a clear and significant increase in the parameters of growth and yield. Then the growth and quality and quantity of yield values increased significantly with the addition of fulvic acid, especially the rate of spraying one kilogram per feddan during the two growing seasons. The best experimental treatment that was gave the highest values in pea growth and yield when the high rate of phosphate fertilization (45 Kg P_2O_5 fed^{-1}) was added with the highest concentration of fulvic acid spray (1 $kgfed^{-1}$) during the two growing seasons.

Phosphorus (P) is highly needed to establish and maintain crops, it is an essential nutrient for plant growth and development and its deficiency is considered a major constraint to crop production worldwide (Siam *et al.*, 2008). Phosphorus deficit is a most important restrictive factor in plant growth and recognition of mechanisms that increase plant phosphorus use efficiency is important. Phosphorus is a major component in ATP, the molecule that provides ”energy” to that plant for such processes as photosynthesis, protein synthesis, nutrient translocation, nutrient uptake and respiration (Alinajatiand Mirshekari, 2011). Phosphorus is also a component of other compounds necessary for protein synthesis and transfer of genetic material DNA, RNA (Yosefi *et al.*, 2011).

Many beneficial effects are attributed to foliar application of fulvic acid, including stimulation of plant metabolism, increased enzyme activity(transaminase, invertase), increased bioavailability and uptake of nutrients (Nardi *et al.*, 2002) and increased crop growth and yield (Trevisan *et al.*, 2009). Fulvic acid has maximum influence on chemical reactions because of the presence of more electronegative oxygen atoms than any other humate molecules, which enhances membrane permeability (Priya *et al.*, 2014)

Table 2 : Effect of P fertilization and fulvic acid on pea growth and yield at two season's growth (2018-2019).

Treatments		Growth			Yield				
P fertilization Kg P_2O_5 fed^{-1}	Fulvic acid Kg fed^{-1}	Plant height cm	No. of leaves $plant^{-1}$	Dry weight $plant^{-1}$ g	Pod length cm	No. of seeds pod^{-1}	Weight of 100 seeds g	Pod yield ton fed^{-1}	Protein %
First season									
0	0	22.3	10.9	18.8	5.30	5.90	18.2	1.81	18.0
	0.5	31.4	11.8	20.2	5.80	7.10	21.4	2.19	23.1
	1	34.7	14.8	20.9	6.80	7.40	23.1	2.23	24.9
15	0	25.7	11.8	19.6	5.90	6.20	19.2	1.98	18.2
	0.5	33.1	13.2	25.7	6.80	7.30	23.5	2.28	24.8
	1	38.1	17.9	28.5	8.50	7.70	25.4	2.57	27.5
30	0	26.4	12.0	22.4	6.80	6.60	20.1	2.14	19.0
	0.5	37.5	14.1	31.8	7.90	7.60	27.8	2.62	29.0
	1	42.4	19.2	35.9	8.90	7.90	27.9	2.88	32.1
45	0	27.4	12.5	22.7	7.00	6.80	20.5	2.20	20.0
	0.5	37.8	14.6	32.2	8.90	7.70	27.9	2.76	32.0
	1	42.9	19.5	36.3	9.90	8.10	28.1	2.92	33.5
$LSD_{0.05}$		0.42	0.21	0.45	0.22	0.21	0.83	0.10	0.40

Second season									
0	0	23.4	11.9	19.5	5.50	5.80	19.2	1.82	18.5
	0.5	31.8	12.5	20.3	5.90	7.20	22.4	2.14	23.5
	1	32.9	15.4	21.9	7.00	7.30	24.1	2.26	24.8
15	0	24.8	12.5	21.1	6.20	6.40	20.2	1.94	18.6
	0.5	35.2	13.5	26.2	7.20	7.90	24.5	2.50	25.0
	1	38.8	18.6	28.0	8.50	8.01	26.4	2.72	27.5
30	0	27.5	12.8	22.9	6.90	6.70	21.1	2.11	19.1
	0.5	39.6	14.5	31.3	8.80	7.90	28.8	2.82	29.4
	1	41.4	19.5	36.4	10.1	8.10	29.9	2.88	32.4
45	0	28.3	13.0	23.1	7.80	7.10	21.5	2.22	20.1
	0.5	40.9	15.1	31.7	9.20	8.20	28.9	2.86	33.2
	1	44.8	19.8	36.8	10.5	8.60	29.1	2.90	33.6
$LSD_{0.05}$		0.42	0.21	0.45	0.22	0.21	0.83	0.10	0.40

Through the results presented in Table (3), which showed the effect of different rates of phosphate fertilization with the three spraying levels of fulvic acid on the pea seeds content of some macronutrients such as nitrogen, phosphorous and potassium, as well as their content of some micronutrients such as iron, zinc and manganese during the two growing seasons.

Table 3 : Effect of P fertilization and fulvic acid on N, P, K, Fe, Zn and Mn content on pea seeds at two season's growth (2018-2019).

Treatments		**N**	**P**	**K**	**Fe**	**Zn**	**Mn**
P fertilization Kg P_2O_5 fed^{-1}	**Fulvic acid Kg fed^{-1}**	**%**			**ppm**		
First season							
0	0	3.06	0.13	0.92	42.1	24.2	23.3
	0.5	3.36	0.18	0.99	43.0	24.5	23.9
	1	3.64	0.19	1.02	43.1	26.5	24.2
15	0	3.08	0.19	0.96	42.2	24.3	23.4
	0.5	3.61	0.23	1.08	44.1	25.9	25.6
	1	3.97	0.26	1.15	45.7	28.9	26.8
30	0	3.16	0.22	0.99	42.2	24.4	23.5
	0.5	4.32	0.29	1.16	47.1	32.7	27.3
	1	4.61	0.32	1.31	49.3	36.9	29.4
45	0	3.19	0.27	1.02	42.3	24.4	23.5
	0.5	4.60	0.31	1.19	47.6	33.1	27.9
	1	4.90	0.33	1.70	49.8	37.2	30.1
$LSD_{0.05}$		0.38	0.02	0.03	0.98	0.85	0.90
Second season							
0	0	3.09	0.15	0.91	41.1	22.2	21.3
	0.5	3.40	0.19	0.97	42.0	23.5	21.8
	1	3.66	0.21	1.03	43.2	25.5	23.0
15	0	3.10	0.18	0.96	42.1	23.3	21.4
	0.5	3.81	0.22	1.08	45.1	24.9	24.5
	1	3.95	0.25	1.17	46.7	27.9	25.7
30	0	3.15	0.21	1.04	43.2	24.2	22.5
	0.5	4.22	0.28	1.19	46.1	29.7	25.4
	1	4.51	0.31	1.33	49.0	30.9	28.4
45	0	3.19	0.24	1.06	43.3	24.4	23.1
	0.5	4.66	0.32	1.22	45.6	30.1	26.8
	1	4.91	0.34	1.60	49.7	34.2	30.2
$LSD_{0.05}$		0.38	0.02	0.03	0.98	0.85	0.90

Spraying fulvic acid on pea plants greatly helped on improvement content of macro and micro nutrients under different phosphorous fertilization levels. The results showed that the best experimental treatments that gave the highest values of N, P and K as well as Fe, Zn and Mn when spraying pea plants at a kilogram per feddan of fulvic acid with the highest phosphate fertilization rate 45 Kg P_2O_5 fed^{-1}.

Fulvic acid as an organic fertilizer is a non-toxic mineral chelating additive and water binder that maximizes uptake through leaves and stimulates plant productivity (Atiyeh *et al*., 2002). It attracts water molecules, helping the soil to remain moist and aiding the movement of nutrients into plant roots. Fulvic acid molecule consists of carboxylic groups (COOH), which issued its H atom to bind with cationic species such as the zinc, iron, copper, calcium etc. However, this binding is relatively weak. Thefulvic acid also stimulates the production of plant's own auxin and improving the capacity of the plasma membrane to the sense of the other growth hormones such as cytokinins and GA_3 (Gaoand Sun, 2011).

Researches have shown that root surface area increases in plants if there is not enough phosphorus. In addition, Liebersbach *et al.* (2004) reported that the large amounts of root exudates (i.e., mainly mucilage) from plants in dry soil counteract P deficiency under water scarce conditions. This indeed differentiates P uptake as well as the uptake of other nutrient elements of any plant. There are also plant species- and cultivar- dependent responses to P deficiency (Bargaz *et al*., 2017). An important strategy for increasing P uptake involves in taking advantage of the symbiosis between the roots and mycorrhiza, which in turn increase effective root surface area and eventually enhance both the growth and the uptake of P, Zn, Cu, Mn, and Fe (Bagayoko *et al*., 2000).

Conclusion

Spraying plants with fulvic acid during the period of plant growth improves increasing the efficiency use of phosphate fertilization and its effect on the growth and harvest of pea grown in sandy soil.

References

Abd El-Rheem, Kh.; Kassem, M.; Mohammed, A.S. and El-Damarawy, Y.A. (2017). Effect of humic and fulvic acid on growth, yield and nutrients balance of "costata" persimmon trees. J. Agric. Food. Tech.; 7:1-5.

Alinajati, S.S. and Mirshekari, B. (2011). Effect of phosphorus fertilization and seed bio fertilization on harvest index and phosphorus use efficiency of wheat cultivars. Journal of Food, Agricultural and Environment, 9: 388-397.

A.O.A.C. (1995). Method of analysis. Association of Official Agriculture Chemists. 16th e Washington D.C.; USA.

Atiyeh, R.M.; Edwards, C.A.; Metzger, J.D.; Lee, S. and Arancon, N.Q. (2002). The influence of humicacids derived from earthworm-processed organic wastes on plant growth. Biores. Technol.; 84: 7-14.

Bagayoko, M.; George, E.; Romheldand, V. and Buerkert, A.B. (2000). Effects of mycorrhizae and phosphorus on growth and nutrient uptake of millet, cowpea and sorghum on a West African soil. Journal of Agricultural Science, 135: 399- 407.

Bargaz, A.; Noyce, G.L.; Fulthorpe, R.; Carlsson, G.; Furze, J.R.; Jensen, E.S.; Dhiba, D. and Isaac, M.E. (2017). Species interactions enhance root allocation, microbial diversity and P acquisition in intercropped wheat and soybean under P deficiency. Applied Soil Ecology, 120: 179-188.

Cottenie, A. (1980). Soils and plant testing as a basis of fertilizer recommendation. F.A.O. Soil Bull.; 3812.

Gao, Y.F. and Sun, L.R. (2011). Investigation of fulvic acid efficiency. Shanxi Agricultural Science, 6: 100-103.

Liebersbach, H.; Steingrobe, B. and Claassen, N. (2004). Roots regulate ion transport in the rhizosphere to counteract reduced mobility in dry soil. Plant and Soil, 260: 79-88.

Loguerre, G. (2008). Plant phenology and genetic variability in root and nodule development strongly influence genetic structuring of Rhizobium leguminous arum biovarviciae populations nodulating pea. New Phytol, 179: 224-235.

Malan, C. (2015). Review: humic and fulvic acids. A Practical Approach. In Sustainable soil management symposium. Stellenbosch, 5-6 November 2015, Agrilibrium Publisher.

Motsara, M.R. and Roy, R.N. (2008). Guide to laboratory establishment for plant nutrient analysis. Food and agricultural organization of the United Nations FAO Fertilizer and Plant Nutrition Bulletin. Rome, pp: 219.

Nardi, S.; Pizzeghello, D.; Muscolo, A. and Vianello, A. (2002). Physiological effects ofhumic substances on higher plants. Soil Biol. Biochem.; 34: 1527–1536.

Priya, B.N.V.; Mahavishnan, K.; Gurumurthy, D.S.; Bindumadhava, H.; Ambika, P.U. and Navin, K.S. (2014). Fulvicacid for enhanced nutrient uptakeand growth: insights from biochemical and genomic studies. Journal of Crop Improvement, 28: 740–757.

Snedecor, G.W. and Cochran, W.G. (1982). Statistical Methods. 7 ed. Iowa State Univ. Press, Iowa, U.S.A.

Shaymaa, I.S.; Fawzy, Z.F. and El-Bassiony, A.M. (2018). Nano and mineral selenium foliar application effect on pea plants (*Pisum sativum* L.). Bioscience Research, 15: 645-654.

Siam, H.S.; Abd El-Moez, M.R. and El-Ashry, S.M. (2008). Response of lettuce followed by Sorghum to application of different types of phosphorus, compost and sulfur. Australian Journal of Basic and Applied Sciences, 2: 447-457.

Trevisan, S.; Pizzeghello, D.; Ruperti, B.; Francioso, O.; Sassi, A. and Palme, K. (2009). Humic substances induce lateral root formation and expression of the early auxin responsive IAA19 gene and DR5 synthetic element in Arabidopsis. Plant Biol.; 12: 604–614.

Tesfaye, M.; Liu, J.; Allan, D.L. and Vance, C.P. (2007). Genomic and genetic control of phosphate stress in legumes. Plant Physiol.; 144: 594- 603.

Tsvetkova, G.E. and Georgiev, G.I. (2007). Changes in phosphate fractions extracted from different organs of phosphorus starved nitrogen fixing pea plants. J. Plant Nutr.; 30, 2129-2140.

Yosefi K.H.; Galavi, M.; Ramrodi, M. and Mousavi, S.R. (2011). Effect of bio-phosphate and chemical phosphorus fertilizer accompanied with micronutrient foliar application a growth, yield and yield component of mazie (single cross704). Australian journal of crop science.175-180.