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Effect of some Soil Additions and Foliar Treatments under Chemical Fertilizer Levels on Pea Plants

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ABSTRACT

Two field trials were carried out at a sequestered Farm in El-Zarqa City, Damietta Governorate, Egypt, throughout 2020/2021 and 2021/2022 seasons to investigate the effect of biochar (at 2000 kg/fed) and humic acid (at 5 kg/fed three times) soil addition and foliar application with trehalose (at 500 ppm) and seaweed (at 1000 ppm) under chemical NPK fertilizers levels (100, 75 and 50 % of the suggested quantities) on growth, yield and its components and quality of pea. This experiment was carried out in a split-split plot design with 3 replications. Data showed that each increase in chemical fertilizers (NPK) levels from 50, to 75 and 100 % accompanied with significant increases in all studied characters. Soil adding of humic acid at the rate of 5 kg/fed three times were the best soil additions treatment, which produced the highest values. There were considerable alterations in of growth, profit and its components and quality of pea amongst both foliar submission conducts and control conduct the highest values from foliar spraying plants three times with seaweed at the rate of 1000 ppm. It can be decided that to sustain highest growth, yield and its components and quality of green seed of pea at the identical time diminish production charges and ecological contamination when plants treated with humic acid at 5 kg/fed three times and mineral fertilizing with 75% and foliar scattering pea plants 3 times with seaweed at 1000 ppm.

***Keywords*: biochar, humic acid, trehalose, seaweed, NPK.**

INTRODUCTION

Pea (*Pisum sativum* L.) is one of the most important legume crops in Egypt for local consumption and exportation and being recognized as an important protein supplement vegetable crop. Pea seeds have high nutritional values due to their high contents of dry matter, proteins and carbohydrates as well as vitamins A and B. It is possible to use fresh seeds and pods as a fresh vegetable or as a frozen material. According to FAO Statistics (2024), the total area grown with green peas in Egypt in 2022 season was 38842 feddan, which produced 166126 tons with an average yield/ feddan was of 4.277 t/fed. While, the total area grown with dry peas was 221 feddan, which produced 274 tons with an average yield of 1.240 t/fed.

Further research is required under Egyptian conditions to develop guidelines for decreasing the use of chemical NPK fertilizers in order to enhance quality, increase yield, and minimize environmental pollution. This has prompted a spotlight on employing unconventional fertilizers, such as soil amendments and foliar applications.

Applying the appropriate amounts of nitrogen, phosphorus, and potassium is crucial for enhancing the growth, yield, and quality of peas. Proper NPK fertilization significantly contributes to increasing pea quality and productivity. Badr and Fayed (2020) demonstrated that NPK fertilization caused significant changes in yield, pod quality, and many growth parameters. The application of 100% and 75% of NPK produced the maximum plant height, leaves and branches/ plant, and pea yield when compared to the other NPK rates. Janusauskaite (2023) demonstrated that NPK fertilizers increased the average yield of peas by 10.6–12.9% as compared to unfertilized peas. The optimal rate of NPK fertilizers for peas was 15-45 : 40 : 80 kg ha^{-1} for highest growth, pod yield and green seeds quality. Raihan-Uddin *et al.* (2023) concluded that when only application chemical fertilizers (NPK) at 100% of the suggested quantities for pea plants, they gave higher performance for growth and pod yield than only application organic fertilizers.

Biochar is charcoal utilized as a soil enhancer. The biochar examined in this research is produced from citrus trees using pyrolysis. Abundant in carbon, biochar is a stable material that can endure in soil for thousands of years. It possesses the potential to enhance water retention capacity, boost agricultural productivity, improve fertility in acidic soils (low pH soils), and offer defense against certain foliar and soil-borne diseases (Bakewell-Stone, 2011). Hashmi *et al.* (2019) indicate that the soil application of 2% biochar has the best impact on pea vegetative growth and leaf chlorophyll and carotenoids concentrations. Alam *et al.* (2020) found that soil addition of biochar improving growth parameters and biomass production of pea. El-Shimi and El-Atbany (2022) showed that the treatment of biochar with compost gave the best growth, yield and its components on pea plants.

Humic acid is a water-soluble organic acid naturally found in soil organic matter. Humic substances exert significant effects on soil structure, microbial populations, and play a role in enhancing mechanisms related to plant growth, nutrient uptake, and yield. These substances have been shown to directly and indirectly influence plant growth. Directly, humic acid compounds can induce various biochemical effects at the cell wall, membrane, or cytoplasm levels, boosting photosynthesis and respiration rates,

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promoting protein synthesis, and mimicking plant hormone activity. Indirectly, humic compounds enhance soil fertility by improving soil structure, increasing beneficial microbial populations, and enhancing the cation exchange capacity and pH buffering capacity of the soil (Akinremi *et al.*, 2000). Badr and Fayed (2020) showed that significant differences amongst different growth attributes, pods yield and pods quality of pea as a result of application of humic acid. Hekal and Hashim (2022) demonstrated that with rising K-humate rates up to 100 kg K ha^{-1} as soil application in low-fertility sandy soil, growth and yield of pods of pea increased. Muhammad *et al.* (2023) showed that higher microbial carbon and nitrogen biomass and green seed yield of pea, acquired from the application of 15 kg ha^{-1} of humic acid compared to all other treatments. They concluded that organic amendments of 15 kg ha^{-1} of humic acid in arid soil, resulting in improvement of winter field pea productivity.

Throughout the last decade, there is a great demand for agro-chemical residue free fresh agricultural products. There is a worldwide trend to explore new natural products and safety substances such as trehalose and seaweed that serve as biostimulants for plants, giving priority to that improve the plant productivity and avoid negative and side effects on human health due to the excessive application of synthetic agro-chemicals.

Trehalose is a sugar of the disaccharidecloss produced by some fungi,yeasts,and similan organism. quantitatively important compatible solute and stress protectant in plants. These functions have largely been replaced by sucrose in vascular plants. Trehalose is involved in responses to salinity and cold, and in regulation of stomatal conductance and water-use efficiency. In plants, trehalose is synthesized via a phosphorylated intermediate, trehalose 6-phosphate (Lunn *et al.*, 2014). Abdallah *et al.* (2020) indicated that the application of trehalose enhanced plant antioxidative defense system against stress conditions as well as recorded the highest values of total soluble sugars. Zaky *et al.* (2021) indicated that snap bean plants sprayed with trehalose increased fresh and dry weight of leaves, branches, shoot dry weight, and total seed yield/fad. Razzaq *et al.* (2024) stated that trehalose significantly improved plant biomass, enhanced photosynthetic apparatus and antioxidants in addition to total phenolic compounds and ascorbic acid.

Due to its organic and biodegradable nature, seaweed is recognized as a crucial nutrient source for sustainable agriculture, particularly in recently reclaimed soil. Analyzing seaweed chemically has uncovered a variety of plant growth regulators, known to promote the establishment and elongation rate of root hairs and enhance their quantity, while also encouraging lateral growth through gibberellins (Zhang and Ervin, 2004). Elsharkawy *et al* (2019) demonstrated that foliar application of seaweed extract at a concentration of 10 ml L^{-1} significantly enhanced plant height, fresh weight, number of branches per plant, total yield, protein, as well as N and K contents in green pea seeds. Singh *et al* (2019) highlighted seaweed as a cost-effective input for plant growth, attributed to its rich nutrient composition and plant growth-promoting hormones that stimulate plant development. Ragab *et al* (2021) found that pea plants exhibited superior characteristics in plant height, fresh weight, dry weight, seed yield per plot, and fad when treated with seaweed extract. Naz and Ramzan (2023) reported that foliar application of seaweed extract at a rate of 4 ml L^{-1} enhanced pea growth, photosynthetic pigments, and yield-related traits.

This study aimed to examine the impact of incorporating biochar and humic acid into the soil, as well as applying trehalose and seaweed foliar treatments alongside chemical NPK fertilizers levels, on the growth, yield and components, quality of Hindi pea cultivar under the environmental conditions of El-Zarqa City, Damietta Governorate, Egypt.

MATERIALS AND METHODS

Analysis of soil:

Prior to soil preparation in both research seasons, soil samples were randomly collected from the experimental field area at a depth of 0 to 30 cm below the soil surface in order to estimate the physical and chemical parameters of the soil in compliance with Page (1982), as indicated in Table 1.

Table 1. The experimental soil's physical and chemical characteristics throughout the two seasons of cultivation of 2020–2021 and 2021–2022.

Soil analysis		2020/2021 Season	2021/2022 Season
A: Mechanical analysis			
Sand (%)		28.94	29.03
Silt (%)		42.65	42.82
Clay (%)		28.41	28.15
Texture class		Silty clay loam (SCL)	Silty clay loam (SCL)
Field Capacity (FC) (%)		18.00	18.50
Permanent wilt point (PWP) (%)		8.00	8.25
B: Chemical analysis			
EC $dS.m^{-1}$(1:5)		2.36	2.40
pH (1:2.5)		8.33	8.35
Organic matter (OM) %		1.46	1.45
$CaCO_3$ (%)		1.30	1.25
Available (ppm)	N	18.33	17.55
	P	3.41	3.45
	K	9.74	9.55
Soluble Cations (meq 100 g^{-1})	Ca^{++}	4.50	4.35
	Mg^{++}	0.80	0.75
	K^{+}	0.39	0.42
	Na^{+}	6.07	6.10
Soluble Anions (meq 100 g^{-1})	CO_3^{-}	0.00	0.00
	HCO_3^{-}	0.70	0.75
	Cl^{-}	1.00	1.15
	SO_4^{-}	10.06	9.45

The experimental design and treatments:

Two ridges, each measuring 70 cm in width and 8.0 m in length, were incorporated in each experimental basic unit, yielding an area of 11.20 m^2. The experimental field was divided into experimental units after being thoroughly prepped for each experiment by two plowings, leveling, compaction, and ridging.

Three replicats were used in a split-split plot randomize entire block design for this experiment. There were 27 treatments in every experiment.

Three chemical fertilizer levels were included in the main plots; 100% of the suggested quantities (80 kg N + 40 kg P_2O_5 + 80 K_2O/fed), 75% of the suggested quantities (60 kg N + 30 kg P_2O_5 + 60 K_2O/fed), and 50% of the suggested quantities (40 kg N + 20 kg P_2O_5 + 40 K_2O/fed). The levels of nitrogen, phosphorus, and potassium (NPK) were as follows. Throughout the soil preparation process, calcium super phosphate (15.0% P_2O_5) was administered as a source of phosphorus fertilizer. The potassium fertilizer was added as potassium sulphate (48.0% K_2O) and the nitrogen fertilizer was added as ammonium nitrate (33.5%). Two equal dosages of fertilizer were added: one before the first irrigation and one before the second.

Three different soil addition treatments were included in the sub-plots: humic acid at a rate of 5 kg/fed three times, biochar at a rate of 0.50 kg/m2 (2000 kg/fed), and without soil addition at all (control treatment). Charcoal used as a soil amendment is called biochar. Citrus trees are employed to make the biochar used in this study by pyrolysis.Prior to seeding, it was placed to the soil's surface and flipped over using a hack. The supplier of humic acid, Techno-Gene Company, Dokki, Giza, Egypt, provided potassium humate. Three additions of humic acid were made after 30, 40, and 50 days of seeding. Table 2 presents the results of the chemical analysis of the humic acid and used biochar.

Table 2. Chemical analysis of biochar and humic acid used in this study throughout the two growing seasons.

Humic acid		Biochar		
Analysis	**Value**			
Moisture	5 (%)	Total (DW%)	C	33.81
Organic matter (dry basis)	80.0 (%)		N	.92
Humic acid (dry basis)	70 (%)		S	.11
Potassium (dry basis) as K_2O	10 (%)	Mg\ Kg	P	18.66
Heavy elements	2.55 (ppm)		K	322
Water solubility	100 (%)		Mg	181
Appearance	Black shiny flake		Ca	665
			Fe	82.13
			Mn	172
			Zn	13.65
			pH	9.21

The sub-sub plots were devoted to three foliar application treatments as follows; foliar spraying with water (control treatment), trehalose at the rate of 500 ppm and seaweed at the rate of 1000 ppm. Trehalose ($C_{12}H_{22}O_{11}$) is a quantitatively important compatible solute and stress dissolution protectant in plants. These functions have largely been replaced by sucrose in vascular plants. Seaweed refers to thousands of species of macroscopic, multicellular and marine algae. Seaweed includes some types of *Rhodophyta* (red), *Phaeophyta* (brown) and *Chlorophyta* (green) macroalgae. Seaweed in the form of flake (15-18 % alginic acid, 45-55 % organic matter and N, P K). They were obtained from Techno-Gene Company,Dokki, Giza, Egypte. Foliar spraying with trehalose and seaweed were carried out three times after 30, 40 and 50 days from sowing.

Agricultural practices:

Pea seeds were sowed in the reasonably damp soil on November 26 for the first season and November 28 for the second. On three rows of each ridge, seeds were manually placed in hills (3 seeds/hill) at a distance of 10 cm. With the exception of the factors under investigation, all other agricultural practices were carried out throughout the growing seasons in accordance with the Ministry of Agriculture and Land Reclamation's instructions.

Studied Characters:

1- Vegetative growth:

Ten randomly selected plant samples were gathered from each experimental unit after 60 days after seeding in order to ascertain the following parameters:

- Height of plant (cm).
- Leaf area (cm^2) per plant; Leaf number per plant. Calculating plant leaf area was done using Koller's (1972) approach.
- Plant weights, both fresh and dry (g). Following the weight and oven drying at 70 °C of the plant samples, the dry matter was expressed as grams per plant.
- Fresh pea leaves were colorimetrically tested 60 days after seeding in both seasons to assess the levels of chlorophyll a and b (Rajalakshmi and Banu, 2015).

2- Quality parameters of green seeds:

At harvest time, after 110 days of planting the following data was taken:

- Total sugars percentage (%) was determined according to the method described by Sadasivam and Manickam (1996).
- Total carbohydrates percentage (%) was determined according method of Hedge and Hofreiter (1962).
- Crude protein percentage (%) and vitamin-C content (Ascorbic acid) were determined according to the method reported in AOAC (2000).

3- Yield and its components:

After 110 days of planting the following data was taken; number of pods/plant-pod length (cm) - pod diameter (mm) - pods yield/plant (g) were estimated as yield components and total green pods yield (t/fed).

Statistical analysis:

Using the "MSTAT-C" computer software program, all collected data were statistically examined in accordance with the analysis of variance (ANOVA) technique for the split-split plot design as published by Gomez and Gomez (1984). The least significant difference (LSD) approach, as outlined by Snedecor and Cochran (1980), was utilized to assess the differences between treatment means at the 5% level of probability.

RESULTS AND DISCUSSION

1. Effect of chemical fertilizers (NPK) levels:

The study's obtained results appear to have demonstrated that there was a significant effect of chemical fertilizers (NPK) levels on vegetative growth characters, quality parameters of green seeds, yield, and its components in both seasons, as indicated in Tables 3, 5, and 7. These results included information on the effects of NPK levels, namely 100%, 75%, and 50%, on these parameters.

As clear from the soil analysis Table 1 it is poor in its content of N, P and K.Therefore every increase in chemical fertilizer (NPK) levels from 50% to 75% and 100% of the recommended amounts was observed to be associated with a significant rise in every character examined in both seasons. As a result, fertilizing in both seasons at 100% of the recommended amounts produced the greatest values (Tables 3, 5 and 7). Applying 75% of the recommended amounts of chemical fertilizers in both seasons was the second-best level of NPK fertilizers.

These findings are readily explained by nitrogen's involvement in promoting leaf initiation, color, and vigor of the leaf canopy, as well as meristematic activity, which results in an increase in cell quantity in addition to cell expansion. Nitrogen also promotes the uptake of other elements by plants, increasing net assimilation rate and triggering the accumulation of carbohydrates. These effects were transferred from leaves to seeds, increasing pod yield/plant and shelling percentage and, ultimately, seed yields per unit area. Moreover, the function of phosphorus in plant energy transfer, preservation of the structural integrity of plant cell membranes, enhancement of plant development, and assimilation of carbohydrates, as evidenced by the yield of green pods per plant, shelling percentage, and total yield of green pods per feed. In addition, potassium's role in metabolite buildup, starch synthetase enzyme activation, and carbohydrate accumulation that went from leaves to seeds improved the output of pods per plant, the percentage of shelling, and the total yield of green pods per feed. Badr and Fayed (2020), Khangarot *et al.* (2020), Rohith *et al.* (2020), Mohanty *et al.* (2021), Sayed and Ouis (2022), Janusauskaite (2023) and Raihan-Uddin *et al.* (2023) confirmed these results.

2. Effect of soil additions treatments:

The obtained results of this study show that soil additions treatments (biochar at the rate of 0.50 kg/m^2 "2000 kg/fed", humic acid at the rate of "5 kg/fed three time" and without soil addition "control treatment") had significant effects on vegetative growth characters, quality parameters of green seeds and yield and its components in the two growing seasons as shown in Tables 3, 5 and 7.

From obtained results, it could be stated that soil addition of humic acid at the rate of (5 kg/fed three time) was the best soil additions treatment, which produced the highest values in both seasons. The second best values were obtained from biochar addition at the rate of 0.50 kg/m^2 (2000 kg/fed) in both seasons. While, the lowest values were obtained from without soil addition (control treatment) in both seasons.

These findings may be explained by the fact that humic acid which contains 80% organic matter (Table 2) has a variety of positive impacts on the microbial populations and soil structure in addition to altering the mechanisms responsible for enhancing plant development, nutrient uptake, and yield increases (Akinremi *et al*., 2000). Moreover, adding biochar to the soil enhances its physiochemical characteristics, such as its ability to retain water and aggregate (El-Naggar *et al*., 2019). These results are in accordance with those obtained by Alam *et al.* (2020), Badr and Fayed (2020), El-Shimi and El-Atbany (2022), Hekal and Hashim (2022) and Muhammad *et al.* (2023).

3. Effect of foliar application treatments:

The obtained data of this investigation show that foliar application treatments *i.e.* foliar spraying with water (control treatment), trehalose at the rate of 500 ppm and seaweed at the rate of 1000 ppm significantly affected vegetative growth characters, quality parameters of green seeds and yield and its components in both seasons as shown in Tables 3, 5 and 7.

There were substantial differences in of vegetative growth characters, quality parameters of green seeds and yield and its components of pea among both foliar application treatments and control treatment in both seasons. It can be seen that the highest values were formed from foliar spraying plants three times after 30, 40 and 50 days from sowing with seaweed at the rate of 1000 ppm. Followd by foliar spraying plants with trehalose at the rate of 500 ppm in both seasons.

Table 3. Plant height, number leaves/plant, leaf area/plant, fresh and dry weights/plant, chlorophyll a and b content in leaves of pea plants as affected by chemical fertilizers (NPK) levels, soil additions and foliar application treatments as well as their relations throughout 2020/2021 and 2021/2022 seasons.

Characters	Plant height (cm)		Number of leaves/plant		Leaf area/plant (cm^2)		Fresh weight of plant (g)		Dry weight of plant (g)		Chlorophyll a (mg/g tissue)		Chlorophyll b (mg/g tissue)	
Treatments	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022
A. NPK levels as ratio from the suggested quantities:														
100 %	46.72	48.10	16.36	17.03	232.1	237.4	34.58	35.59	5.49	5.71	1.009	1.051	0.700	0.729
75 %	43.81	45.22	15.77	16.40	207.2	211.8	32.49	33.55	5.09	5.29	0.950	0.988	0.663	0.690
50 %	41.38	42.75	14.98	15.57	194.3	198.2	27.43	28.33	4.75	4.93	0.824	0.857	0.589	0.612
LSD at 5 %	0.20	0.24	0.15	0.17	1.0	1.1	0.25	0.29	0.03	0.04	0.007	0.009	0.005	0.006
B. Soil additions treatments:														
Biochar	43.92	45.33	16.01	16.66	206.2	210.4	31.68	32.67	5.14	5.35	0.947	0.986	0.663	0.689
Humic acid	45.56	46.98	16.47	17.13	232.9	237.9	32.90	33.93	5.25	5.46	0.965	1.004	0.674	0.701
Without	42.43	43.77	14.63	15.21	194.5	199.2	29.91	30.87	4.94	5.13	0.871	0.906	0.615	0.640
LSD at 5 %	0.20	0.24	0.15	0.17	1.0	1.1	0.25	0.29	0.03	0.04	0.007	0.009	0.005	0.006
C. Foliar application treatments:														
Control	42.32	43.66	14.17	14.74	201.1	205.5	26.94	27.76	4.60	4.78	0.909	0.945	0.639	0.665
Trehalose	43.85	45.20	15.74	16.37	210.7	215.1	31.61	32.63	5.11	5.31	0.935	0.973	0.655	0.681
Seaweed	45.74	47.21	17.20	17.89	221.8	226.9	35.95	37.08	5.61	5.84	0.939	0.978	0.658	0.684
LSD at 5 %	0.31	0.32	0.08	0.10	1.5	1.6	0.21	0.23	0.02	0.03	0.004	0.005	0.004	0.004
D. Relations (F. test):														
A × B	*	*	*	*	*	*	*	*	*	*	*	*	*	*
A × C	*	*	*	*	NS	NS	*	*	*	*	NS	NS	NS	NS
B × C	*	*	*	*	*	*	*	*	*	*	*	*	*	*

These results may be due to the favourable effects of seaweed as an important source of fertilizer nutrients and organic matter, which have been used in agriculture as soil conditioners or plant stimulators (Crouch and Van-Staden, 1992). Besides, the role of trehalose in enhancing plant biomass, photosynthetic apparatus and antioxidants in addition to ascorbic acid, free proline and total phenolic compounds (Razzaq *et al.*, 2024). In addition, its favourable effect in improving early pea growth, more dry matter accumulation and stimulated the building of metabolic products which translocated to seeds. Furthermore, its advantageous effects in improving plant growth characters such as; plant height, number of branches and leaves/plant, leaf area/plant, stem diameter, fresh and dry weight of plant as well as yield components likes; number of pods/plant, pod length, diameter and weight as previously mentioned and discussed, which reflected on increasing yield components, which consequently increasing total green pods yield per unit area. These results are in partial compatible with those recorded by Ragab *et al.* (2021) and Naz *et al.* (2023).

4. Effect of interactions:

The various relations among the three studied factors *i.e.* chemical fertilizers (NPK) levels, soil additions and foliar application treatments had a many significant effects on vegetative growth characters, quality parameters of green seeds and yield and its components of pea in both seasons as shown in Tables 4, 6 and 8.

Table 4. Plant height, number leaves/plant, leaf area/plant, fresh and dry weights/plant, chlorophyll a and b content in leaves of pea plants as affected by the interaction among chemical fertilizers (NPK) levels, soil additions and foliar application treatments throughout 2020/2021 and 2021/2022 seasons.

Treatments			Plant height (cm)		Number of leaves/ plant		Leaf area/ plant (cm^2)		Fresh weight of plant (g)		Dry weight of plant (g)		Chlorophyll a (mg/g tissue)		Chlorophyll b (mg/g tissue)	
NPK levels	Soil additions	Foliar application	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022
100 %	Biochar	Control	44.94	46.37	15.50	16.13	220.7	225.8	29.36	30.15	4.95	5.15	1.017	1.104	0.707	0.735
		Trehalose	46.32	47.73	16.38	17.08	228.8	233.2	34.57	35.59	5.35	5.59	1.042	1.058	0.723	0.751
		Seaweed	50.50	51.99	18.05	18.84	249.5	254.4	42.70	43.98	6.43	6.71	1.057	1.086	0.731	0.759
	Humic acid	Control	47.61	49.01	16.12	16.78	239.5	244.9	30.02	30.85	5.03	5.23	1.027	1.070	0.713	0.741
		Trehalose	47.80	49.35	17.00	17.66	245.5	251.1	34.95	35.88	5.36	5.56	1.068	1.110	0.737	0.766
		Seaweed	51.00	52.53	18.88	19.73	253.7	258.6	43.53	44.76	6.62	6.92	1.081	1.131	0.746	0.776
	Without	Control	42.94	44.27	14.16	14.72	194.8	200.3	28.85	29.74	4.87	5.06	0.916	0.953	0.641	0.668
		Trehalose	43.89	45.11	15.05	15.64	216.3	221.7	31.93	33.00	5.20	5.40	0.929	0.966	0.649	0.677
		Seaweed	45.33	46.57	16.61	17.24	233.5	239.8	35.34	36.32	5.62	5.82	0.941	0.977	0.656	0.684
75 %	Biochar	Control	41.00	42.24	14.61	15.15	178.4	182.7	28.54	29.44	4.70	4.88	0.952	0.987	0.665	0.692
		Trehalose	44.27	45.66	16.27	16.88	205.0	209.1	31.82	32.87	5.11	5.31	0.984	1.021	0.682	0.712
		Seaweed	44.77	46.30	17.49	18.19	215.7	221.2	35.49	36.59	5.49	5.72	0.975	1.015	0.678	0.706
	Humic acid	Control	44.15	45.41	15.00	15.60	227.6	232.6	28.94	29.84	4.90	5.09	0.960	0.997	0.671	0.698
		Trehalose	44.82	46.30	16.31	16.96	230.7	236.0	34.37	35.61	5.17	5.37	0.994	1.034	0.691	0.718
		Seaweed	48.00	49.37	17.55	18.27	246.3	252.1	38.54	39.87	5.55	5.78	1.004	1.047	0.698	0.725
	Without	Control	40.94	42.20	13.50	14.05	173.3	177.0	28.33	29.27	4.40	4.58	0.883	0.921	0.621	0.645
		Trehalose	42.32	43.69	14.50	15.09	186.8	190.7	31.54	32.52	5.10	5.32	0.895	0.933	0.628	0.654
		Seaweed	44.27	45.85	16.22	16.85	208.1	212.3	34.84	35.99	5.41	5.63	0.904	0.940	0.633	0.658
50 %	Biochar	Control	39.15	40.55	12.94	13.51	172.2	174.3	22.95	23.66	4.26	4.45	0.816	0.854	0.581	0.605
		Trehalose	41.86	43.26	16.00	16.65	188.7	190.8	28.46	29.43	4.88	5.07	0.844	0.879	0.600	0.623
		Seaweed	42.50	43.85	17.41	18.07	200.6	205.4	31.30	32.34	5.09	5.29	0.836	0.869	0.596	0.619
	Humic acid	Control	41.11	42.51	13.32	13.82	212.8	216.9	24.31	25.08	4.25	4.42	0.828	0.859	0.590	0.612
		Trehalose	42.27	43.54	16.05	16.65	214.8	219.6	28.56	29.48	5.01	5.19	0.856	0.888	0.607	0.631
		Seaweed	43.27	44.81	17.50	18.14	221.6	226.0	32.94	33.99	5.38	5.59	0.867	0.900	0.615	0.638
	Without	Control	39.04	40.36	12.38	12.87	165.0	168.8	21.15	21.81	4.05	4.21	0.778	0.810	0.565	0.587
		Trehalose	40.94	42.18	14.17	14.72	179.4	182.7	28.35	29.29	4.86	5.04	0.789	0.821	0.569	0.592
		Seaweed	42.26	43.67	15.11	15.71	193.9	199.2	28.92	29.89	4.96	5.16	0.804	0.837	0.575	0.599
LSD at 5 %			0.92	0.98	0.28	0.31	4.3	4.7	0.64	0.70	0.09	0.11	0.015	0.015	0.010	0.012

Table 5. Total sugars, carbohydrates and crude protein percentages and vitamin-C content in green seeds of pea as affected by chemical fertilizers (NPK) levels, soil additions and foliar application treatments as well as their relations throughout 2020/2021 and 2021/2022 seasons.

Characters	Total sugars (%)		Carbohydrates (%)		Crude protein (%)		Vitamin-C (mg/100 g F.W.)	
Treatments	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022
A. NPK levels as ratio from the suggested quantities:								
100 %	14.85	15.59	47.03	48.42	23.27	23.64	30.94	32.18
75 %	13.92	14.60	45.39	46.87	21.82	22.12	29.88	31.10
50 %	11.74	12.32	42.71	44.11	18.14	18.45	27.42	28.49
LSD at 5 %	0.08	0.06	0.24	0.27	0.31	0.30	0.10	0.12
B. Soil additions treatments:								
Biochar	13.76	14.44	45.21	46.64	21.49	21.81	29.73	30.93
Humic acid	14.08	14.78	45.97	47.40	21.96	22.33	30.09	31.28
Without	12.67	13.29	43.94	45.37	19.76	20.08	28.43	29.56
LSD at 5 %	0.08	0.06	0.24	0.27	0.31	0.30	0.10	0.12
C. Foliar application treatments:								
Control	13.21	13.87	44.73	46.10	20.59	20.92	29.07	30.21
Trehalose	13.62	14.27	44.99	46.46	21.30	21.63	29.56	30.75
Seaweed	13.69	14.37	45.41	46.83	21.33	21.66	29.61	30.82
LSD at 5 %	0.09	0.10	0.32	0.31	0.25	0.20	0.09	0.10
D. Relations (F. test):								
A × B	*	*	*	*	*	*	*	*
A × C	NS	NS	*	NS	NS	*	NS	NS
B × C	*	*	NS	NS	NS	*	*	*

The highest values were resulted from soil addition of humic acid at the rate of (5 kg/fed three time) and mineral fertilizing with 100 % in addition to foliar spraying three times with seaweed at the rate of 1000 ppm in both seasons. The second best interaction treatment was soil addition of biochar at the rate of 2000 kg/fed and mineral fertilizing with 100 % in addition to foliar spraying three times with seaweed at the rate of 1000 ppm, followed by soil addition of humic acid at the rate of 5 kg/fed three time and mineral fertilizing with 75 % in addition to foliar spraying three times with seaweed at the rate of 1000 ppm in both seasons. While, without soil addition with humic acid or biochar and mineral fertilizing with 50 % without foliar spraying with seaweed or trehalose resulted in the lowest values in both seasons.

Table 6. Total sugars, carbohydrates and crude protein percentages and vitamin-C content in green seeds of pea as affected by the interaction among chemical fertilizers (NPK) levels, soil additions and foliar application treatments throughout 2020/2021 and 2021/2022 seasons.

Treatments			Total sugars (%)		Carbohydrates (%)		Crude protein (%)		Vitamin-C (mg/100 g F.W.)	
NPK levels	Soil additions	Foliar application	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022
100 %	Biochar	Control	14.97	15.71	47.25	48.60	23.50	23.86	31.05	32.24
		Trehalose	15.36	16.12	47.81	49.23	24.12	24.46	31.52	32.86
		Seaweed	15.49	16.21	48.00	49.52	24.29	24.66	31.71	33.14
	Humic acid	Control	15.16	15.95	47.43	48.72	23.83	24.24	31.28	32.47
		Trehalose	15.69	16.41	48.38	49.72	24.60	25.06	31.91	33.12
		Seaweed	15.87	16.73	48.56	49.93	24.77	25.29	32.14	33.38
	Without	Control	13.61	14.32	45.14	46.53	21.19	21.47	29.52	30.64
		Trehalose	13.71	14.39	45.23	46.72	21.48	21.76	29.66	30.82
		Seaweed	13.83	14.47	45.51	46.82	21.63	21.93	29.71	30.90
75 %	Biochar	Control	13.88	14.59	45.65	47.07	21.69	21.96	29.80	30.96
		Trehalose	14.36	15.08	43.39	44.87	22.52	22.83	30.41	31.72
		Seaweed	14.22	14.85	46.22	47.57	22.17	22.51	30.19	31.45
	Humic acid	Control	14.03	14.69	45.86	47.27	21.96	22.28	30.05	31.28
		Trehalose	14.61	15.36	46.75	48.35	22.88	23.16	30.62	31.86
		Seaweed	14.78	15.56	46.94	48.57	23.08	23.41	30.86	32.25
	Without	Control	12.92	13.57	44.31	45.83	20.42	20.74	28.79	30.01
		Trehalose	13.15	13.77	44.57	45.99	20.73	21.00	29.01	30.14
		Seaweed	13.32	13.94	44.80	46.30	20.92	21.24	29.17	30.27
50 %	Biochar	Control	11.54	12.13	42.46	43.77	17.94	18.20	27.20	28.22
		Trehalose	12.11	12.73	43.20	44.76	18.75	19.03	27.94	29.02
		Seaweed	11.92	12.51	42.95	44.35	18.50	18.75	27.70	28.78
	Humic acid	Control	11.72	12.29	42.75	44.08	18.17	18.51	27.44	28.51
		Trehalose	12.29	12.86	43.42	44.91	19.10	19.50	28.14	29.19
		Seaweed	12.58	13.20	43.68	45.04	19.27	19.48	28.35	29.46
	Without	Control	11.03	11.61	41.74	43.04	16.68	17.00	26.49	27.57
		Trehalose	11.14	11.65	41.95	43.35	17.35	17.71	26.67	27.71
		Seaweed	11.31	11.93	42.24	43.71	17.50	17.87	26.88	27.99
LSD at 5 %			0.18	0.20	0.96	0.95	0.48	0.46	0.17	0.22

Table 7. Number of pods/plant, pod length and diameter, pods yield/plant and total green pods yield/fed of pea as affected by chemical fertilizers (NPK) levels, soil additions and foliar application treatments as well as their relations throughout 2020/2021 and 2021/2022 seasons.

Characters	Number of pods/plant		Pod length (cm)		Pod diameter (mm)		Pods yield/plant (g)		Total green pods yield (t/fed)	
Treatments	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022
A. NPK levels as ratio from the suggested quantities:										
100 %	11.13	11.47	9.51	9.98	12.13	12.38	75.29	76.37	8.649	9.083
75 %	9.35	9.65	9.31	9.77	11.92	12.16	60.31	61.15	6.924	7.263
50 %	8.85	9.14	9.13	9.59	11.60	11.86	54.85	55.77	6.301	6.621
LSD at 5 %	0.12	0.14	0.04	0.05	0.20	0.27	0.91	0.94	0.185	0.171
B. Soil additions treatments:										
Biochar	9.73	10.04	9.30	9.76	11.86	12.09	63.29	64.23	7.268	7.634
Humic acid	10.14	10.47	9.45	9.92	12.12	12.37	67.67	68.62	7.773	8.153
Without	9.45	9.76	9.20	9.66	11.67	11.93	59.49	60.44	6.833	7.180
LSD at 5 %	0.12	0.14	0.04	0.05	0.20	0.27	0.91	0.94	0.185	0.171
C. Foliar application treatments:										
Control	9.23	9.53	9.00	9.45	11.56	11.79	57.37	58.25	6.591	6.926
Trehalose	9.46	9.77	9.35	9.81	11.89	12.14	61.52	62.50	7.067	7.425
Seaweed	10.63	10.97	9.60	10.08	12.20	12.45	71.56	72.54	8.217	8.617
LSD at 5 %	0.13	0.15	0.05	0.06	0.31	0.33	1.01	1.05	0.210	0.218
D. Relations (F. test):										
A × B	NS	NS	*	*	*	*	*	NS	*	*
A × C	*	*	*	NS	*	NS	*	*	*	*
B × C	*	NS	NS	NS	*	NS	*	NS	*	*

Table 8. Number of pods/plant, pod length and diameter, pods yield/plant and total green pods yield/fed of pea as affected by the interaction among chemical fertilizers (NPK) levels, soil additions and foliar application treatments throughout 2020/2021 and 2021/2022 seasons.

Treatments			Number of pods/plant		Pod length (cm)		Pod diameter (mm)		Pods yield/ plant (g)		Total green pods yield (t/fed)	
NPK levels	Soil additions	Foliar application	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022
100 %	Biochar	Control	10.75	11.04	9.22	9.67	11.85	12.08	69.45	70.71	7.980	8.403
		Trehalose	10.90	11.23	9.40	9.84	12.00	12.24	73.21	74.66	8.410	8.833
		Seaweed	11.92	12.27	9.86	10.35	12.42	12.63	83.92	84.86	9.640	10.080
	Humic acid	Control	11.00	11.37	9.32	9.79	11.95	12.15	73.70	74.72	8.470	8.913
		Trehalose	10.91	11.24	9.64	10.15	12.35	12.62	74.73	75.72	8.580	8.947
		Seaweed	12.08	12.46	10.01	10.55	12.91	13.14	85.16	86.12	9.780	10.280
	Without	Control	10.33	10.68	9.16	9.64	11.70	11.94	66.42	67.35	7.630	7.993
		Trehalose	10.50	10.82	9.38	9.84	11.89	12.16	68.88	69.92	7.910	8.353
		Seaweed	11.41	11.77	9.55	9.98	12.15	12.45	77.13	78.14	8.860	9.290
75 %	Biochar	Control	8.58	8.89	9.00	9.49	11.60	11.78	53.80	54.49	6.180	6.487
		Trehalose	9.00	9.30	9.37	9.85	11.95	12.18	57.96	58.67	6.660	6.993
		Seaweed	10.50	10.85	9.58	10.00	12.10	12.41	69.41	70.44	7.940	8.317
	Humic acid	Control	8.92	9.19	9.06	9.46	11.65	11.87	56.91	57.61	6.540	6.867
		Trehalose	9.16	9.48	9.45	9.94	12.20	12.43	59.54	60.49	6.840	7.153
		Seaweed	11.33	11.65	9.76	10.22	12.55	12.80	79.76	80.90	9.160	9.600
	Without	Control	8.41	8.70	8.86	9.30	11.55	11.73	49.02	49.75	5.630	5.917
		Trehalose	8.67	8.95	9.35	9.80	11.80	12.04	55.66	56.34	6.390	6.747
		Seaweed	10.00	10.32	9.49	9.95	11.92	12.18	65.80	66.84	7.560	7.943
50 %	Biochar	Control	8.25	8.52	8.71	9.15	11.12	11.34	47.52	48.19	5.460	5.727
		Trehalose	8.41	8.68	9.14	9.60	11.77	12.00	52.98	53.78	6.090	6.417
		Seaweed	9.32	9.63	9.41	9.89	11.92	12.18	61.38	62.24	7.050	7.453
	Humic acid	Control	8.67	8.95	8.98	9.44	11.60	11.87	54.10	55.08	6.210	6.553
		Trehalose	8.90	9.21	9.25	9.66	11.85	12.05	56.22	57.33	6.460	6.760
		Seaweed	10.34	10.67	9.61	10.10	12.10	12.37	68.93	69.64	7.920	8.303
	Without	Control	8.16	8.42	8.70	9.15	11.08	11.36	45.45	46.35	5.220	5.473
		Trehalose	8.33	8.61	9.10	9.54	11.25	11.59	49.48	50.43	5.680	5.970
		Seaweed	9.25	9.56	9.28	9.79	11.74	11.95	57.63	58.87	6.620	6.937
LSD at 5 %			0.43	0.47	0.18	0.20	0.93	1.00	3.04	3.16	0.340	0.355

CONCLUSION

The growth, yield, components, and quality of the Hindi cultivar of peas can be enhanced by adding humic acid to the soil at a rate of 5 kg/fed three times, mineral fertilizing with 100% of the recommended amounts, and foliar spraying the plants with seaweed three times at a rate of 1000 ppm Under the environmental conditions of the El-Zarqa district, Damietta Governorate, Egypt, it could be recommended to add humic acid to the soil three times at a rate of 5 kg/fed, to mineral fertilize with 75% of the recommended quantities, and to foliar spray pea plants three times with seaweed at a rate of 1000 ppm in order to maintain the highest growth, yield, and its components and quality, while also reducing production costs and environmental pollution.

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تأثير بعض الإضافات الأرضية ومعاملات الرش تحت مستويات من التسميد الكيماوى على نباتات البسلة

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الملخص

يهدف هذا البحث إلى دراسة تأثير إضافة الفحم الحيوي (البيوشار) وحمض الهيوميك في التربة والرش الورقي بالتريهالوز والأعشاب البحرية تحت مستويات الأسمدة الكيماوية (النيتروجين والفوسفور والبوتاسيوم)، على صفات النمو والمحصول ومكوناته وصفات الجودة للبذور الخضراء للبسلة الصنف هندي. لتحقيق هذا الغرض أقيمت التجارب الحقلية بمزرعة خاصة بمدينة الزرقاء، محافظة دمياط، مصر خلال الموسمين الشتويين المتتاليين 2021/2020 و 2022/2021. نفذت التجارب فى تصميم القطع المنشقة مرتين في ثلاث مكررات. وقد خصصت القطع الرئيسية لمستويات الأسمدة الكيماوية (النيتروجين والفوسفور والبوتاسيوم). كما خصصت القطع الشقية لثلاث معاملات للإضافة الأرضية، بينما تم تخصيص القطع الفرعية لثلاث معاملات للرش الورقي. لوحظ أن كل زيادة في مستويات الأسمدة الكيماوية من 50 إلى 75 و100% من الجرعات الموصى بها يصاحبها زيادات معنوية في جميع صفات المدروسة فى كلا الموسمين. إضافة حامض الهيوميك للتربة بمعدل (5 كجم/فدان ثلاث مرات) كانت أفضل معاملة إضافة للتربة، حيث أعطت أعلى قيم في كلا الموسمين. وجدت فروق معنوية في الصفات المدروسة بين معاملتي الرش الورقي ومعاملة المقارنة في كلا الموسمين. يمكن التوصية بإضافة حمض الهيوميك للتربة بمعدل (5 كجم/فدان ثلاث مرات) والتسميد المعدني بـ 75% بالإضافة إلى الرش الورقي لنباتات البسلة ثلاث مرات بالأعشاب البحرية بمعدل 1000 جزء في المليون لتعظيم صفات النمو الخضري، صفات الجودة والمحصول ومكوناته. وللمحافظة على صفات النمو الخضري، صفات الجودة والمحصول ومكوناته في نفس الوقت تقلل تكاليف الإنتاج والحد من التلوث البيئي .