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Effect of Foliar Application with Two Antioxidants and Humic Acid on Growth, Yield and Yield Components of Peas (*Pisum sativum L.*)

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Abstract: This experiment was suggested to study the beneficial effects of foliar application with some antioxidants, i.e. ascorbic acid, salicylic acid at the concentrations of 0.0, 200ppm and mixture between both of them at 100ppm and humic acid at the rate of 0.0, 1.0 and 2.0g/L on plants growth, green pods, seed yield, yield components, quality and seeds chemical composition of pea cv. Master. All experiments were achieved at Sids Horticultural Research Station at Beni Sueif Governorate, Horticulture Research Institute, Agriculture Research Center, Giza, Egypt, during two successive winter seasons of 2009/2010 and 2010/ 2011. Results showed that foliar spray with ascorbic acid at 200ppm increased plant height, N% and protein % of seeds in the two growing seasons. The treatments increased number of branches/plant in the first season and pod length in second season. Moreover, foliar application of salicylic acid at 200ppm produced the highest plant dry weight, pod diameter, fresh seeds weight/pod, number of fresh seeds/pod, green pod yield, seeds weight/dry pod, dry seed yield and phosphorus percentages in the two growing seasons, increased the fresh pod weight in the second season and 1000-seed weight in the first season. Meanwhile, the potassium percentage in the dry seeds was increased by foliar spraying with ascorbic and salicylic acids at 200ppm in the second season only. On the other hand, foliar application with humic acid at 2g/L increased most of the studied characteristics. The interaction between foliar spray with both antioxidant treatments and humic acid had insignificant effects on all studied characteristics. Based on the obtained results, it may be recommended to grow peas cv. Master and foliar treat the plants with salicylic acid at the concentration of 200ppm and humic acid at the rate of 1g/L to produce high quality fresh pods and seed yields under Sids area and similar growing conditions.

Key words: Peas · ascorbic · salicylic and humic acids · foliar application

INTRODUCTION

Pea (*Pisum sativum* L.) is one of the most important and popular legume vegetable crops grown in Egypt and many countries all over the world. It has many nutritional values such as high content of protein, carbohydrates, phosphorus, iron, calcium and vitamins A and B [1, 2]. Increasing the production of peas green pods and dry seeds with high quality is considered an important aim and this aim could be achieved through using the foliar application of antioxidants, i.e. ascorbic acid (AA), salicylic acid (SA) and/or humic acid (HA).

Ascorbic acid as an abundant component of plants functions as an antioxidant and an enzyme cofactor. It participates in a variety of processes, including photosynthesis, cell wall growth and cell expansion, resistance to environmental stresses and synthesis of ethylene, gibberellins, anthocyanine and hydroxyl proline [3, 4].

The word salicylic acid (SA) was derived from Latin word Salix, meaning willow tree. It is ubiquitously distributed in the whole plant kingdom [5] and is classified under the group of plant hormones [6]. SA is assigned diverse regulatory roles in the metabolism of plants. Salicylic acid is a phenolic derivative, distributed in a wide range of plant species. It is a natural product of phenylpropanoid metabolism. Decarboxylation of transcinnamic acid to

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benzoic acid and its subsequent 2- hydroxylation results to Salicylic Acid. It undergoes metabolism by conjugating with glucose to SA glucoside and an ester [7]. SA has direct involvement in plant growth, thermogenesis, flower induction and uptake of ions. It affects ethylene biosynthesis, stomatal movement and also reverses the effects of ABA on leaf abscission. Enhancement of the level of chlorophyll and carotenoid pigments, photosynthetic rate and modifying the activity of some of the important enzymes are other roles assigned to SA [3, 8]. Salicylic acid (SA), at one stage of time, was the world's best selling drug synthesized in 1898 in Germany [9]. However, John Buchner in 1928 isolated salicyl alcohol glucoside (Salicine) from willow bark at Munich that was later named by Rafaele Piria in 1938 as salicylic acid. Salicylic acid can inhibit the proteinase inhibitor synthesis induced by wounding [10]. Elad [11] claimed that salicylic acid plays as a signal in plant-microbe interaction and added that antioxidants which are considered safe to human and environment had been used successfully to control some plant diseases.

Nowadays the use of humic acid has increased with increasing the agricultural production and the most economical humic acid is almost applied directly to the soil and/or as a foliar application to the plants. Bio-organic fertilizer has been reported to be important in reducing the chemical fertilizers application and hence reducing the environmental pollution along with reducing the production cost. The mode of action of humic acid on plant growth can be divided into direct and indirect effects as it affects the membranes resulting in improved transport of nutritional elements, enhanced protein synthesis, enhanced photosynthesis, solublization of micronutrients, reduction of active levels of toxic elements, enhancement of microbial population, enhanced soil structure improvement and increased both cation exchange capacity and water retention [12]. Singaroval *et al.* [13] claimed that the increase in dry matter production with humic acid might be due to its direct action on plant growth auxin activity, contributing to increase the dry matter. Moreover, application of humic acid also increased the seed weight due to better mobilization of nutrients to seeds. Nardi *et al.* [14] found that the biological activity of the humic acid was attributed to their chemical structure and their functional groups, which could interact with harmonic-binding proteins in the membrane system, evoking a hormone-like response.

The present investigation aimed to study the effect of foliar applications with two antioxidants, i.e. ascorbic acid and salicylic acid along with humic acid on growth, green pods and dry seed yields and their components in order to obtained high quality yield.

MATERIALS AND METHODS

These experiments were carried out during the two successive winter seasons of 2009/2010 and 2010/2011 at Sids Horticulture Research Station, Beni Sueif Governorate, Horticulture Research Institute, Agriculture Research Center, Giza, Egypt. Soil samples were taken at the depth of 0-30cm before planting for physical and chemical analysis as shown in (Table 1) according the methods of page [15].

The Applied Treatments Were:

Antioxidant Compounds:

- Control (without antioxidants or humic acid).
- Ascorbic acid (AA) with a concentration of 200 ppm.
- Salicylic acid (SA) with a concentration of 200 ppm.
- The combination between AA+SA with a concentration of 100 ppm for each.

Humic Acid (HA): (made in Germany) in a solid form as potassium humate (85%) at the rate of 0.0, 1.0 and 2.0g/L.

Pea seeds cv. Master were sown on October 26th and 24th 2009 and 2010, respectively. Plants were sprayed with antioxidants at three times, starting 20 days after sowing and at ten days intervals, also plants were sprayed with humic acid at three times, starting seven days after spraying with all used antioxidant treatments.

Table 1: Some physical and chemical data of the experimental soil before planting at the depth of 0 -30 cm

	Particle size analysis								Available nutrients "ppm"		
Season	Sand%	Silt %	Clay %	Texture grade	$CaCO_3$ %	pH	E.C mmhos	Organic matter %	N	P	K
2009/2010	12.00	23.88	64.12	Clay	2.6	7.8	0.63	1.8	20.5	12.7	310
2010/2011	10.60	19.47	69.93	Clay	2.4	7.4	0.61	2.1	25.2	16.3	331

The compound of potassium humate granule contained of: 85% potassium humates, 12% potassium oxide, 1% iron, 0.9 organic nitrogen, 1.1% other compounds and with a pH= 7.0.

Experimental Design: A split plot in a Randomized Complete Blocks Design (RCBD) with four replications was used. The main plots were assigned for spraying with the aforementioned antioxidants treatments, where the sub plots were used for the humic acid foliar applications. The sub plot area was (11.2 m^2). Each plot contained four rows (where the length was 4.0m and the width was 70cm).

All the recommended cultural practices for pea production were followed according to the Egyptian Ministry of Agriculture.
Data were recorded as follows:

Plant Growth Characteristics: at the end of the growing season, samples of 10 plants were taken at random from each experimental plot to determine the following characters:

- Plant height (cm).
- Number of branches/plant.
- Dry weight/plant (g).

Green Pod Yield and its Components: Green pod yield was started to be harvested on the 20th and 18th of January in 2010 and 2011, respectively. Two rows from each experimental plot was harvested three times at 10 days intervals in the two growing seasons and then the green pod yield/fed was calculated. Twenty pods were taken at random from each experimental plot from the second harvest in the two growing seasons to determine the following characteristics:

- Average fresh pod length (cm).
- Average fresh pod diameter (cm).
- Average fresh pod weight (g).
- Average fresh seeds weight/pod (g).
- Number of fresh seeds/pod.

Dry Seed Yield and its Components: Harvesting of dry pods of the other two rows per plot was started on 18th and 14th of March in the years 2010 and 2011, respectively and the following data were recorded:

- Dry seed yield/fed (tons).
- Shell-out percentage, where

Shell-out percentage = Dry seed yield/ Dry pod yield×100

Twenty pods were taken at random from each expermintal plot to determine the following characteristics:

- Average seeds weight/dry pod (g).
- 1000-seed weight (g).

Chemical Composition of Dry Seeds: Seed samples were taken randomly from each experimental plot (from the second harvest), oven dried at 70°C until constant weights and then dried samples were ground and digested to determine the following chemical contents:

- Total nitrogen percentage (N %) by micro-Kjeldahl apparatus of Parnase and Wangar as described by Pregl [16].
- Protein percentage by multiplying the total nitrogen (N) values by 6.25 according to Pregl [16].
- Phosphorus content (P %) according to Watonable and Olsen [17].
- Potassium percentage (K %) using Unicom Sp. 1900 Atomic Absorption Spectrophotometer [18].

Statistical Analysis: All obtained data were subjected to the statistical analysis of variance and means were compared using the LSD [19] by using the computer software MSTAT-C Version 4.0.

RESULTS AND DISCUSSION

Plant Growth Characters: Data in Table 2 revealed that foliar spray with two different antioxidant compounds markedly affected pea plant height, plant dry weight (in the two growing seasons) and number of branches (in only the first season). Plants treated with AA at 200ppm produced the highest values of plant height and number of branches/plant. On the other hand, plant dry weight was increased by foliar application with SA at the concentration of 200ppm in the two growing seasons. These results are in agreement with those obtained by Gad El-Hak *et al*. [20] on potato and with results of previous studies on tomato [8] ; peas [21- 23] ; *Vicia faba* [24] and mungbean [25]. Gad El-Hak *et al.* [20] mentioned that applying AA on potato plants enhanced the plant height. Kumari *et al.* [23] claimed that the vegetative growth of pea plants was enhanced by foliar application with AA at 2mM+ 2mM putrescince. Kamalendu and Srivastava [22] mentioned that pea growth and biomass

Table 2: Effect of foliar application with some antioxidants and humic acid treatments on plant height, number of branches and plant dry weight of peas during 2009/2010 and 2010/2011 seasons

Treatments		First season 2009/2010			Second season 2010/2011		
Antioxidants ppm "A"	Humic acid (g) "B"	Plant height (cm)	Number of branches	Plant dry weight (g)	Plant height (cm)	No. of branches/plant	Plant dry weight(g)
Without	0	62.19	2.36	18.87	68.13	2.17	21.55
	1	65.72	2.53	25.54	64.96	2.58	29.24
	2	68.83	2.65	21.85	74.51	3.04	24.17
Mean of (A)		65.58	2.51	22.09	69.20	2.59	24.99
Ascorbic Acid (AA)	0	68356	2.56	24.32	74.34	2.40	26.01
200 ppm	1	66.70	2.74	32.04	69.76	2.84	33.92
	2	73.60	2.92	27.36	83.03	3.24	31.73
Mean of (A)		69.62	2.74	27.91	75.71	2.83	30.55
Salicylic acid (SA)	0	66.46	2.49	27.63	70.30	2.21	29.44
200 ppm	1	64.53	2.61	39.07	70.09	2.75	43.40
	2	70.29	2.76	31.85	78.89	3.10	34.17
Mean of (A)		67.09	2.62	32.83	73.09	2.68	35.67
AA + SA	0	63.32	2.12	22.50	67.99	1.89	25.55
(100 + 100 ppm)	1	64.49	2.21	27.10	61.31	2.42	32.59
	2	67.15	2.38	25.07	73.87	2.83	27.70
Mean of (A)		64.99	2.24	24.97	67.72	2.38	28.61
Mean of (B)	0	65.13	2.38	23.34	70.19	2.17	25.64
	1	65.36	2.52	30.92	66.53	2.65	34.79
	2	69.97	2.68	26.60	77.58	3.05	29.45
L .S. D at 5% for:							
Antioxidants (A)		3.162	0.205	4.994	4.139	N.S	4.439
Humic acid (B)		2.700	0.219	2.742	2.080	0.251	2.214
Interaction (A ×B)		N . S	N.S	N.S	N.S	N.S	N.S

production was increased by foliar spraying with Vitamin C at 1.0mM+$K_2C_2O_7$ than $K_2C_2O_7$ alone. Also, some researchers reported that the highest plant growth values were obtained from the SA foliar application on mungbean [26]; on pea [27] and on cowpea [28]. Moreover, Farooq *et al* .[27] stated that pea seeds soaked in priming solutions (ethanol 0.5% + SA 1.0%) increased values of seedlings fresh and dry weights.

Regarding the humic acid treatments, data of plant growth parameters (Table 2), i.e. plant height, number of branches/plant and plant dry weight obviously show that spraying pea plants with humic acid at the high rate of 2.0g/L produced the tallest plants and the highest values of number of branches/plant in the two growing seasons. However, the plant dry weight was significantly increased by foliar spray with humic acid at the rate of 1.0g/L in the two growing seasons. Similar results were obtained by Senesi *et al* .[29] and Deffune [30] on wheat; Padem *et al* .[31] on pepper and eggplant; Neri *et al* .[32] on cowpea; Zaky *et al*. [33] on beans. Senesi and Loffredo [34] showed that peas dry weight, shoots and roots weights produced the highest values by foliar application with humic acid at the rate of 100mg+herbicides. Furthermore, Kamenova *et al* .[35] found that the vegetative growth of micro-propagated young pea was improved by humic acid application which grew in nutrient medium containing 4.0mg/L. Azarpour *et al* .[36] noticed that humic acid foliar application at 50mg/L plus 45.0kg N/ha gave the best and highest plant height values of cowpea.

On the other hand, results obtained in the same table, declared that the interaction among foliar spray with the used antioxidants and humic acid insignificantly affected the studied plant growth parameters in the two growing seasons.

Humic substances have been reported to influence plant growth both directly and indirectly. The indirect effects of humic compounds on soil fertility include, increase in the soil microbial population including beneficial microorganisms, improved soil structure and increase in the cation exchange capacity and the pH buffering capacity of the soil [37].

Table 3: Effect of foliar application with some antioxidants and humic acid treatments on pod length, Pod diameter, pod weight and seeds weight/fresh pod of peas during 2009/2010 and 2010/2011 growing seasons

Treatments		First season 2009/2010				Second season 2010/2011			
Antioxidants ppm "A"	Humic acid (g) "B"	Pod length (cm)	Pod diameter (cm)	Pod weight (g)	Seeds weight/ fresh pod (g)	Pod length (cm)	Pod diameter (cm)	Pod weight (g)	Seeds weight/ fresh pod (g)
Without	0	9.85	1.04	7.24	3.16	10.39	1.05	7.41	3.35
	1	10.20	1.08	7.88	3.77	10.60	1.10	8.63	4.31
	2	10.66	1.10	7.59	3.52	10.76	1.16	8.00	4.10
Mean of (A)		10.24	1.07	7.57	3.49	10.58	1.10	8.01	3.92
Ascorbic Acid	0	10.18	1.10	8.00	3.62	11.15	1.10	8.45	4.08
(AA) 200 ppm	1	10.78	1.10	8.65	4.76	11.34	1.13	8.82	4.80
	2	11.07	1.18	8.48	4.51	11.67	1.19	8.59	4.66
Mean of (A)		10.67	1.13	8.38	4.30	11.39	1.14	8.62	4.51
Salicylic acid	0	10.13	1.13	8.51	4.47	10.47	1.13	8.78	4.68
(SA) 200 ppm	1	10.39	1.16	8.96	4.92	10.73	1.19	9.58	5.21
	2	10.70	1.21	8.73	4.70	11.20	1.25	9.27	4.92
Mean of (A)		10.41	1.17	8.74	4.70	10.80	1.19	9.21	4.94
AA + SA	0	10.06	1.02	7.38	3.87	10.05	0.93	8.22	4.00
(100 + 100 ppm)	1	10.10	1.03	8.44	4.39	10.22	1.02	8.50	4.57
	2	10.33	1.07	8.10	4.14	10.60	1.06	8.33	4.42
Mean of (A)		10.16	1.04	7.98	4.13	10.29	1.00	8.35	4.33
Mean of (B)	0	10.05	1.07	7.78	3.78	10.51	1.05	8.22	4.03
	1	10.37	1.09	8.48	4.46	10.72	1.11	8.88	4.72
	2	10.69	1.14	8.23	4.22	11.06	1.17	8.55	4.53
L .S. D at 5% for :									
Antioxidants (A)		N.S	0.068	N.S	0.395	0.394	0.111	0.751	0.504
Humic acid (B)		0.400	0.042	0.423	0.301	0.293	N.S	0.488	0.167
Interaction (A ×B)		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Table 4: Effect of foliar application with some antioxidants and humic acid treatments on number of fresh seeds/pod, green pod yield, seed weight/dry pod and 1000-seed weight of peas during 2009/2010 and 2010/2011 growing seasons

Treatments		First season 2009/2010				Second season 2010/2011			
Antioxidants ppm "A"	Humic acid (g) "B"	Number of fresh seeds/pod	Green pod yield (ton/fed)	Seeds weight/ dry pod (g)	1000seeds weight (g)	Number of fresh seeds/pod	Green pod yield (ton/fed)	Seeds weight/ dry pod (g)	1000seed weight (g)
Without	0	7.63	3.075	1.39	175.54	7.83	3.306	1.37	199.34
	1	8.46	3.646	1.74	224.14	8.71	3.982	1.58	233.66
	2	8.10	3.314	1.58	189.22	8.53	3.545	1.50	210.89
Mean of (A)		8.06	3.345	1.57	196.30	8.36	3.611	1.49	211.30
Ascorbic Acid	0	8.00	3.681	1.44	208.99	8.33	3.898	1.61	210.92
(AA) 200 ppm	1	8.80	4.310	1.86	238.17	8.19	4.679	1.90	259.49
	2	8.51	3.831	1.62	227.45	8.62	4.139	1.76	238.18
Mean of (A)		8.44	3.941	1.64	224.87	8.55	4.239	1.76	236.20
Salicylic acid	0	8.06	3.546	1.63	220.22	8.55	4.025	1.77	216.69
(SA) 200 ppm	1	9.09	4.462	1.98	250.09	8.95	4.847	1.97	271.69
	2	8.68	4.204	1.76	235.51	8.73	4.605	1.81	243.05
Mean of (A)		8.61	4.071	1.79	235.28	8.75	4.492	1.85	243.71
AA + SA	0	7.27	3.268	1.27	187.18	7.75	3.575	1.54	194.80
(100 + 100 ppm)	1	8.12	3.846	1.56	232.34	8.14	4.438	1.83	245.54
	2	7.73	3.613	1.42	218.16	8.01	4.048	1.69	215.86
Mean of (A)		7.71	3.576	1.42	212.56	7.97	4..021	1.69	218.73
Mean of (B)	0	7.74	3.392	1.43	197.99	8.12	3.701	1.58	205.37
	1	8.62	4.066	1.78	236.19	8.63	4.487	1.82	250.10
	2	8.25	3.741	1.60	217.59	8.47	4.084	1.69	226.91
L .S. D at 5% for :									
Antioxidants (A)		0.446	0.398	0.158	20.989	0.500	0.473	0.141	N.S
Humic acid (B)		0.358	0.203	0.091	9.795	N.S	0.174	0.146	14.001
Interaction (AxB)		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Furthermore, directly, humic acid compounds may have various biochemical effects either at cell wall, membrane level or in the cytoplasm, including increased photosynthesis and respiration rates in plants, enhanced protein synthesis and plant hormone like activity [38]. In other words, humic substances may possibly enhance the uptake of minerals through the stimulation of microbiological activity [39].

Green Pod Yield and its Components: The obtained data in Tables 3 and 4 mentioned that foliar application with some antioxidants significantly affected green pod yield and its components in the two seasons, with exception of fresh pod length and fresh pod weight in the second season. Foliar application with AA at the concentration of 200ppm markedly increased fresh pod length in the second season. On the other hand, pod diameter, fresh seeds weight/pod, number of fresh seeds/pod and green pod yield were significantly increased by SA foliar application at the same concentration in the two growing seasons, also it increased fresh pod weight in the second season. The effect of foliar application with antioxidants on increasing green pod yield/fed could be a results of the effect of the used antioxidants on enhancing plant growth through increasing plant height, number of branches and plant dry weight. Also, increasing fresh pod length, pod diameter, fresh pod weight, fresh seeds/pod and number of fresh seeds/pod might be attributed in increasing green pod yield/fed. These results are in agreement with those reported on peas [40, 41]; *Cajanus cajan* [42]; *Vicia faba* [43]; pea [44] and field pea [45]. In addition, Gahalain *et al.* [40] reported that pod yield of pea plants was increased by foliar spray with SA at the concentration of 100ppm plus some phyto-hormones. Ghulam [44] mentioned that treated pea seeds and foliar sprayed pea plants with SA produced the highest green pod yield and yield components values. Moreover, El-Hendaway *et al* .[46] claimed that faba bean yield was improved by foliar spraying the plants with SA at the concentration of 10mM under both greenhouse and open field growing conditions.

Concerning the effect of the foliar application with humic acid, the obtained results in Tables 3 and 4 showed that green pod yield and its components were markedly affected by humic acid treatment during the two growing seasons with exception of pod diameter and number of fresh seeds/pod. Humic acid foliar application at the rate of 1g/L produced higher values of fresh pod weight, fresh seeds weight/pod and green pod yield in the two growing seasons. Also it increased number of fresh seeds/pod in the first season whereas, fresh pod length and diameter were significantly increased by foliar spraying with humic acid at the concentration of 2g/L in the two growing seasons, respectively compared with the control treatment. This could be explained as humic acid is rich in both organic and mineral substances which are essential to plant growth and consequently increase yield quality and quantity. Many investigators e.g., Zaky *et al*. [33] on beans; Neri *et al*. [47] on strawberry; and Forgac and Czimbalmos [48] on pea plants used the humic acid foliar application in greenhouse and/or open field cultivations and found that number of pods/plant, total yield/plant and average pod fresh weight were markedly increased by the treatment at the rate of 1g/L combined with irrigation water. Furthermore, Forgac and Czimbalmos [48] showed that foliar application with humic acid + a moderate rate of the recommended dose of NPK gave the highest yield of pea. In regards to the interaction effect among the studied treatments, data in Tables 3 and 4 declared that this interaction had insignificant effects on green pod yield and its components.

Dry Seed Yield and its Components: Data in Tables 3 and 4 showed that the sprayed plants with SA at the concentration of 200ppm gave the heaviest seeds and the best dry seed yield in the two growing seasons. It increased the 1000-seed weight, shell-out percentage in the first season when compared with the control treatment. These obtained results are in accordance with those mentioned by Datta and Nanda [49] on mungbeans and El- Bassiouny [50] on faba bean plants as they claimed that the highest seed yield values were obtained from plants foliar sprayed with antioxidants.

Data presented in Tables 4 and 5 indicated that dry seed yield and its components e.g., seed weight per/pod, 1000-seed weight, shell-out percentage and dry seed yield were significantly increased by foliar application with humic acid during the two growing seasons compared to the control treatment. The highest mean values were obtained from plants foliar sprayed with humic acid at the concentration of 1g/L. Similar results were obtained by Malik and Azam [51] on wheat; Putintsev and Platonova [52] on pea; Salib [53] on peanut; Habashy *et al*. [54] on peanut and faba bean and Azarpour *et al*. [36] on cowpea plants as they reported that foliar spray with humic acid increased the dry seed yield and its parameters. In addition, Putintsev and Platonova [52] mentioned that the highest number of pods/plant, 1000-seed weight and seed yield were obtained by pea seeds treated with 2.5% sodium humate.

Table 5: Effect of foliar application with some antioxidants and humic acid treatments on shell-out percentage, dry seed yield, nitrogen percentage, protein percentage, phosphorus percentage and potassium percentage in dry seeds of peas during 2009/2010 and 2010/2011 growing seasons

Treatments		First season 2009/2010						Second season 2010/2011					
Antioxidants ppm "A"	Humic acid (g)"B"	Shell out %	Dry seed yield (ton/fed)	N%	Protein%	P%	K%	Shell out%	Dry seed yield (ton/fed)	N%	Protein%	P%	K%
Without	0	70.58	0.556	3.02	18.90	0.19	1.07	72.62	0.598	3.18	19.90	0.21	1.05
	1	73.41	0.595	3.25	20.33	0.25	1.15	79.07	0.634	3.32	20.78	0.28	1.10
	2	71.27	0.577	3.38	21.15	0.21	1.17	75.71	0.620	3.44	21.48	0.23	1.18
Mean of (A)		71.75	0.576	3.22	20.13	0.22	1.13	75.80	0.618	3.32	20.72	0.24	1.11
Ascorbic Acid	0	73.69	0.617	3.53	22.06	0.22	1.13	73.31	0.643	3.70	23.15	0.24	1.12
(AA) 200 ppm	1	79.83	0.700	3.82	23.87	0.26	1.17	79.82	0.730	3.88	24.23	0.29	1.25
	2	77.10	0.655	3.99	24.95	0.22	1.21	78.63	0.701	3.93	24.55	0.25	1.30
Mean of (A)		76.88	0.657	3.78	23.63	0.23	1.17	77.26	0.691	3.84	23.98	0.26	1.23
Salicylic acid	0	76.38	0.648	3.37	21.09	0.24	1.10	74.62	0.670	3.48	21.73	0.27	1.10
(SA) 200 ppm	1	82.72	0.724	3.54	21.45	0.30	1.18	81.19	0.752	3.68	23.00	0.30	1.28
	2	79.06	0.693	3.66	22.89	0.28	1.30	78.23	0.724	3.80	23.73	0.29	1.30
Mean of (A)		79.39	0.688	3.52	21.81	0.27	1.19	78.01	0.715	3.65	22.82	0.29	1.23
AA+SA	0	69.82	0.601	3.32	20.73	0.16	1.11	70.44	0.631	3.34	20.86	0.17	1.08
(100+100 ppm)	1	75.71	0.664	3.46	21.62	0.23	1.16	76.52	0.686	3.49	21.81	0.25	1.25
	2	70.15	0.639	3.55	22.20	0.22	1.18	73.32	0.649	3.56	22.26	0.21	1.20
Mean of (A)		71.89	0.634	3.44	21.52	0.20	1.15	73.43	0.655	3.46	21.64	0.21	1.18
Mean of (B)	0	72.62	0.606	3.31	20.70	0.20	1.10	72.75	0.636	3.43	21.41	0.22	1.09
	1	77.92	0.671	3.52	21.82	0.26	1.16	79.15	0.701	3.59	22.46	0.28	1.22
	2	74.39	0.641	3.65	22.80	0.23	1.22	76.47	0.673	3.68	23.01	0.24	1.25
L.S.D at 5% for:													
Antioxidants (A)		3.52	0.067	0.09	0.50	0.02	N.S	N.S	0.042	0.15	0.97	0.03	0.08
Humic acid (B)		2.18	0.038	0.01	0.62	0.04	0.06	1.90	0.042	N.S	N.S	0.02	0.10
Interaction (A ×B)		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Furthermore, Habashy *et al* .[54] working on peanut, found that the highest values of seed yield, foliage yield and weight of 100-seed were obtained from the foliar application of humic acid at 500mg/L combined with EM (at the rate of 2cc/L). Also, Azarpour *et al* .[36] found that foliar spraying the cowpea plants with humic acid at the concentration of 50mg/L in presence of the N fertilizer (45kg/ha) produced the highest values of seed yield, number of pods/plant, number of seeds/pod, pod length, seed length and seed width. On the other hand, results in tables 4 and 5 showed that the interactions between foliar spraying with antioxidants and humic acid showed insignificant effects on dry seed yield and its components.

Chemical Composition of Seeds: Data in Table 5 indicated that foliar application with antioxidants significantly affected the nitrogen (N), protein and phosphorus (P) percentages in the two growing seasons as compared to the control treatment. The N and protein % were markedly increased by AA foliar application at the concentration of 200ppm. Jyotsna and Srivastava [55] stated that pigeon pea seeds pre-planting soaked in AA at 50ppm improved protein, free amino acids and soluble sugars contents. Trachevsky *et al*. [56] mentioned that pea plants foliar sprayed with SA produced higher protein contents, while; foliar application with SA at 200ppm gave the best P percentages. On the other hand, K percentages were increased by foliar spraying the plants with SA or AA at 200ppm. These results are similar to those reported by El-Bassiouny [50] who mentioned that faba bean plants foliar sprayed with AA at the rates up to 400mg/L increased the total carbohydrate, crude protein, K, P and Ca contents in seeds.

Presently, there is no direct evidence may be used to prove the transportability of SA, however, the physical properties of SA suggest that it could be transported, metabolized and/or conjugated in the plants [3,8]. Moreover, the exogenously applied SA seems to be carried away from the sites of its initial application to different other tissues of the plants to generate response [9]. It is well documented that phenolic compounds exert

their influence on physiological and biochemical processes including, photosynthesis, ion uptake, membrane permeability, enzyme activities, flowering, heat production and growth and development of plants. One, such a natural compound is SA that may function as a plant growth regulator [57].

Concerning the effect of foliar application with humic acid on pea chemical composition, results in the same table showed that foliar application with humic acid resulted in the highest values of N% and protein% in the first season, also it increased P% and K% in the two seasons compared with the control treatment. Moreover, humic acid at the concentration of 2g/L gave significant increases in N%, protein % and K%. Habashy *et al*. [54] found similar results on peanut and faba bean. Zaky *et al*. [33] on beans and El-Hefny [58] on cowpea, found that foliar spraying the plants with humic acid enhanced the chemical composition of these crops. Habashy *et al* .[54] added that foliar application with humic acid at the rate of 500mg/L + EM at the rate of 2cc/L significantly increased N%, P%, K% and protein % of peanut and faba bean plants. On the other side, El-Hefny [58] claimed that humic acid application up to 6kg/fed increased the highest N, P and K uptake and increased K/Na, Ca/ Na ratio, protein and carbohydrates contents of cowpea plants. Meanwhile, data in Table 5 showed that the interaction between foliar spraying with antioxidants and humic acid insignificantly affected these characteristics in the two growing seasons. It is known that, when adequate humic substances present within the soil, the requirement for nitrogen, phosphorus and potassium fertilizer applications may be reduced [59]. Humic substances are major components of organic matter often constitute 60-70% of the total organic matter [60].

Humic substances have a very profound influence on the growth of plant roots. When humic acids and fulvic acids are applied to the soil, enhancement of root initiation and increased root growth may be observed [59]. The stimulatory effects of humic substances have been directly correlated with enhanced uptake of_@macronutrients, such as nitrogen, phosphorus and sulfur [38], and micronutrients, that is, Fe, Zn, Cu and Mn [61].

CONCLUSION

The obtained results revealed that foliar spraying pea plants with both antioxidant compounds and/or humic acid is very beneficial to the crop growth and yield along with fresh and dry pods and seeds. Hence, it could be suggested that pea plants grown under the experiment and similar growing conditions and foliar sprayed with SA at 200ppm and humic acid at 1g/L to produce high quantity and good quality of green pods and dry seed yields suitable for marketing.

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