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(Original Article)

Impact of Humic Acid and Foliar Application of Chitosan on Growth, Yield, and Seed Quality of Faba Bean Crop *(Vicia faba L.)*

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Abstract

Two field experiments were carried out at the Agriculture Research Station of Assiut Research Farm, Faculty of Agric., Assiut Univ., Egypt, for two winter seasons of 2021/2022 and 2022/2023. The aim of this study was to investigate the response of vegetative growth, yield components, and some seed Quality of faba bean (*Vicia faba* L.) cultivar "Giza 843", to soil application of humic acid and foliar application of chitosan (Ch). Humic acid was applied as soil application at four concentrations (0, 2, 4 and 6 kg/fed twice during growth period. Chitosan (Ch) was foliar applied at 0, 50,100,150 and 250 ppm) four times within growth period. The experiment was designed in split plot design. Humic acid was allocated in the main plot. Meanwhile, chitosan was applied to the sub plot. Results revealed that either humic acid or chitosan highly significantly affected all vegetative growth traits, yield components, and chemical seed quality. Also, combined application of humic acid at a rate of 6kg/fed combined with foliar application of chitosan at 250 ppm recorded the maximum results.

Keywords: *Chitosan, Faba bean, Humic acid, Productivity, Seed components.*

Introduction

Faba bean is the first leguminous crop in Egypt. The research problem is the decline in the areas planted with Faba beans in Egypt. The area planted with faba beans in Egypt decreased from approximately 306.63 thousand acres in 2000 to approximately 117.31 thousand acres in 2021. This means that the absolute decrease in the cultivated area during that period amounted to 189.32 thousand acres, representing approximately 61.64% of the area planted with the crop in 2000. Therefore, the total production of the crop decreased from approximately 353.92 thousand tons in 2000 to 168.44 thousand tons in 2021. Thus, the absolute decrease in the total production during that period was approximately 185.48 thousand tons, representing 52.41% of the total production in 2000 (Mahmoud, 2023).

Faba bean (*Vicia faba* L.) is a source of protein which plays a great role in food security in Egypt. The crop can provide the soil with 100 to 200 kg N ha^{-1} (Jensen *et al.*, 2010). Great attention was paid to increase faba bean crop productivity and overall production. Enhancing crop breeding and agronomy research could help achieve this (Ghareeb *et al.,* 2023).

Humic acid is complex substances derived from organic matter decomposition. Humic acid may play a very important role in plant growth under different soil

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conditions. Several investigations have been reported about the positive effects of humic acid on the growth (plant height, leaf number/plant, plant fresh and dry weight), yield and its attributes, quality and mineral percent (N, P and K) of different plants such as, potato (Rizk *et al.,* 2013), okra (Kandil *et al.,* 2015) and garlic (Shafeek *et al*., 2015). Similar impacts were stated by Abu Zinada and Sekh Eleid (2015) on potato, and Farnia and Moradi (2015) on tomato.

Sayed *et al*. (2014) concluded that soil application of humic acid at rate 10 kg humic /fed (1fed =4200m^2) and foliar application at rate 2g/L water had a favorable effect on yield and yield component and improve chemical constituents of faba bean and sandy soil.

El-Kholy *et al.* (2019) combined analysis of data revealed that, increasing humic acid rates up to 4 kg/fed, significantly increased number of pods/plant, weight of seeds/plant and protein yield/fed. However, hundred seed weight, plant height and number of branches/plant were not affected by the application of humic acid, meanwhile, biological and seed yields/fed., responded to the application of humic acid rate up to 2 kg/fed.

Ahmed *et al.* (2020) revealed that Faba bean yield components expressed as number of pods, weight of pods, seeds weight (g) / plant and 100-seed weight and seed yield (ardeb /fed) increased by using humic acid (200 mg kg^{-1} soil), compared to control.

Ding *et al* (2021) found that humic acid and potassium solubilizing 15 bacteria (PSB) that were applied to the faba bean plants fertilized with 50% of the recommended dose gave the maximum growth and yield.

Ramadan *et al.* (2023) revealed that under low water supply deficit irrigation (DI), addition of 10 kg ha^{-1} (H10) plus spraying with cytokinin at concentration of mg L^{-1} (C25) was the most efficient treatment for enhancing faba bean growth and all physiological faba bean traits.

Chitosan (CHT) is a poly (1,4)-2-amino-2-deoxy-β-D glucose that is a deacetylation derivative of chitin and is present in the exoskeletons of arthropods such as insects, crustaceans such as lobsters, shrimp and crabs, molluscan radulae, fish and squid, as well as the scales of Liss amphibians (Kurita, 2006). The agricultural and horticultural uses for chitosan, primarily for plant defense and yield increase, are based on how this glucosamine polymer influences the biochemistry and molecular biology of the plant cell. Battikha *et al.* (2020) stated that the application of chitosan with 15% nano nitrogen produced the maximum values of all characters, i.e. number of pods /plant, number of seeds/pod, seed index, total weight of plant, pod weight of plant, seed yield /plant and per fed, and straw yield per plant and per feddan.

Fouda *et al.* (2022) indicated that using a foliar spray of chitosan (750 ppm) on faba bean plants under an irrigation level of 4800 m^3 led to an improvement in the physiological properties of the plant, i.e., plant height, number of branches/plants, and the number pods plant^{-1} , the number of seed pods^{-1} , the weight of 100 seeds and seed yield ha^{-1} which increased to about 42.29, 89.47, 28.85, 75.91, 24.43, and 306.48% compared to control. The quality properties also improved, as the total chlorophyll, protein, carbohydrates, total phenols, and amino acids were higher than the control with a relative increase of 63.83, 29.58, 27.72, 37.54, and 64.19% compared to control.

Abdelhameed *et al.* (2024) indicated that foliar spraying with Chs (chitosan) improves faba bean growth, pigment fractions, protein, carbohydrates, reduces MDA and H_2O_2 contents while decreasing Pb concentrations under Pb stress. The research offers a thorough comprehension of the role of Chs in lessening the oxidative stress, which will encourage the use of Chs in agricultural plant protection.

Thus, the objective of this study was to evaluate the effects of humic acid as soil application and chitosan as foliar spraying and their interactions on the growth, yield and quality constituents of faba bean.

Material and Methods

Two field experiments were conducted on faba bean (*Vicia faba* L.) cv. Giza 843, The study was carried out during two consecutive winter seasons of 2020/2021 and 2021/2022 in the Agricultural Research Station Farm, Agric., Fac., Assiut Univ., Egypt. The investigation aimed to study the response of vegetative growth, yield, yield components, and some Quality traits of faba bean (*Vicia faba* L.) seeds, to soil application of humic acid (HA) and foliar application of chitosan (Ch). Humic acid (HA) was applied at four concentrations (0, 2, 4 and 6 kg/fed). Chitosan (Ch) was applied at 0, 100, 150, 200, and 250 ppm). The experiment was designed in split plot design with three replicates. Humic acid was allocated in the main plot. Meanwhile, chitosan was conducted in the sub plot. The experiment contains (4 HA × 5 Ch) × 3 rep. with a total of 60 experimental units). The plot area was 10.5 m^2 (3.0m × 3.5 m) each consisted of five ridges, 70 cm apart. Seeds were planted at the rate of 70 kg/feddan using the dry planting on the two sides of the ridge in hills, the distance between hills was 25 cm.

Humic acid was applied as a soil application with irrigation water two times; the first one was done two weeks after planting and the second application was applied after four weeks**.** Meanwhile, Chitosan was foliar applied four times starting seven weeks after planting then at two weeks interval. Surface irrigation method was used in the experiment.

Calcium superphosphate (15.5% P_2O_5) was added pre-sowing at 200 kg/fed., to the soil; similarly, nitrogen in the form of ammonium nitrate (33.0% N) was applied at the rate of 100 kg N/fed., as start dose before the first irrigation. Meanwhile, potassium sulphate (48% K_2O) was added to the soil during seed bed preparation.

The soil was analyzed chemically according to the procedures described by Page *et al*. (1982) and Klute (1986). Soil properties are shown in Table (1). Sowing occurred on the 20^{th} and 25^{th} November in both seasons, respectively. Harvest was performed on 26^{th} and 29^{th} April in both seasons, respectively. The recommended practices of faba bean production were followed.

Table 1. Some physical and chemical properties of the soil in both seasons

Season	Sand %	Silt %	Clay %	Texture	pH 1:1	ECe dS/m	Total CaCO
2021/2022	**19.3**	31.0	49.7	Clay	7.59	1.44	3.10
2022/2023	**21**	29.4	49.6	Clay	8.06	1.32	3.75

Season	Total N %	Available nutrients ppm				
		P	K	Fe	Mn	Zn
2021/2022	1.85	16.7	354	10.7	9.3	1.0
2022/2023	1.80	14.8	325	8.6	8.0	1.1

At maturity, the middle three rows of each plot were harvested and air-dried to determine some vegetative growth: plant height, number of branches/plant and number of pods/plant. Seed traits: number of seeds/pod, seed yield/plant, seed Index and seed yield ard/fed (1 ard= 150kg) and some seed components including protein, total carbohydrate, and starch percentage were determined.

The yielded dry seeds were used to determine total carbohydrate, starch, and protein content. Total soluble carbohydrate was estimated using the method of Mecozzi (2005). Starch content was determined as the method of Chow and Landhausser (2004). Total protein was determined according to the method of Pedrol and Tamayo (2001).

The data obtained from each trial were subjected to the analysis of variance of split-plot design using the computer program MSTAT-C as described by Snedecor and Cochran (1990).

Results and discussion

1-Vegetative growth

Results revealed that humic acid application significantly increased means of plant growth characteristics (plant height, number of branches/plant and number of pods/plant) in both seasons (Table 2). Gradual increases were found in vegetative growth with increasing the tested level of humic acid from 0% up to the highest level of 6 kg/fed. Date indicated that increasing humic acid rates highly significantly increased all vegetative growth. The highest rate of humic acid (6 kg/fed) recorded the maximum values of all vegetative growth under the study.

The increase percentages in plant height, No. of branches/plant and No. of pods/plant as a result of applying 6 kg humic acid were recorded (30.30 and 29.55% %), (23.85 and 22.69%), and (52.41 and 45.39%) in the 1st and 2nd seasons, respectively.

The increase in vegetative growth of faba bean could be due to the role of humic acid in enhancement soil structure and changing physical, chemical, and biological properties of soil by promoting the chelation of many nutrients and make these available to plants, enhancement of photosynthesis density and plant root respiration has resulted in greater plant growth with humate application (Nardi *et al*. 2002).

The stimulatory effects of humic substances have been directly correlated with enhanced plant growth and productivity of faba bean Sayed *et al*. (2014). These results confirm those of El-Kholy *et al.* (2019) and Ahmed *et al.,* 2020)

Regarding chitosan, all treatments significantly affected the mean values of all growth characteristics in both seasons and the most effective treatment for enhancing the plant height, No. of branches/plant, and No. of pods/plant was the highest chitosan level (250 ppm).

Plant height significantly increased from (85.52 cm to 119.1 cm) and from (87.87 cm to 121.2 cm) with an increasing percentage of 39.36% and 37.93% in comparison to the control treatment in the 1st and 2nd seasons, respectively. Moreover, the percentage increase in No. of branches/plant and No. of pods/plant as affected by 250 ppm foliar application were (34.34 and 32.98%) and (67.21 and 57.20%) in comparison to the control treatment in the 1st and 2nd seasons, respectively.

The favorable effects of chitosan on growth of faba bean plants may be attributed to increasing key enzyme activities of nitrogen metabolism and improved the transportation of nitrogen in the functional leaves which enhanced plant growth and development (Kurita, 2006). Also, chitosan stimulates plant growth by enhancing cell division like gibberellins (Al-ahmadi, 2015). Fouda *et al.* (2022) indicated that using a foliar spray of chitosan (750 ppm) on faba bean plants under an irrigation level of 4800 m^3 led to an improvement in the physiological properties of the plant, i.e., plant height, the number of branches/plants, and the number of plants, pods $plant^{-1}$, the number of seed $pods^{-1}$, the weight of 100 seeds and seed yield ha^{-1} increased with relative increase about 42.29, 89.47, 28.85, 75.91, 24.43, and 306.48% compared to control. In addition, foliar spray with chitosan at rate of 200 ppm increased plant growth (height, leaf number, fresh and dry weight), yield, N, P, K and protein percent of shoot and seed of common bean plant (Abu-Muriefah, 2013).

Table 2. Main Effects of humic acid and chitosan application on vegetative growth of faba bean plants in 2021/22 and 2022/23 seasons

Main effect	Plant height (cm)		Number of branches/plant		Number of pods/plant	
Charac.	2021/22	2022/23	2021/22	2022/23	2021/22	2022/23
			HO (H)			
Control	92.63	95.02	5.315	5.477	11.39	12.91
2	101.0	102.9	5.683	5.847	13.87	15.36
4	115.1	116.6	6.378	6.515	16.20	17.64
6	120.7	123.1	6.583	6.720	17.36	18.77
F-test	**	**	**	**	**	**
LSD 5%	3.12	3.27	0.123	0.128	1.21	1.42
			CH (C)			
Control	85.52	87.87	4.828	4.981	10.31	11.87
100	105.9	108.0	6.055	6.224	14.41	15.86
150	109.7	111.5	6.165	6.316	15.12	16.55
200	116.5	118.6	6.415	6.555	16.47	17.90
250	119.1	121.2	6.486	6.624	17.24	18.66
F-test	**	**	**	**	**	**
LSD5%	4.62	4.81	0.137	0.143	1.47	1.56

**: significant differences at 0.01.

2-Interaction effects between humic acid and chitosan on vegetative growth

As for the interaction between humic acid and chitosan levels (Table 3), the highest plants were those received the highest humic acid and chitosan levels. The differences among treatments were highly significant in both seasons. The maximum values of vegetative growth were recorded due to the combined application of humic acid at a rate of 6 kg/fed and foliar application by chitosan at 250 ppm in both seasons. Plant height, No. of branches/plant, and No. of pods/plant were recorded (136.5 and 139.3 cm), (7.132 and 7.257) and (21.25 and 22.61) in comparison to the control treatment in both seasons, respectively.

Table 3. Interaction effects between humic acid and chitosan application on vegetative growth in 2021/22 and 2022/23 seasons.

Effect of interaction treatments		Plant height (cm)		Number of branches/plant		Number of pods/plant	
H	CH	2021/22	2022/23	2021/22	2022/23	2021/22	2022/23
C	C	81.16	84.86	4.652	4.809	10.11	11.76
	100	91.50	94.00	5.363	5.530	11.07	12.57
	150	94.53	96.19	5.412	5.586	11.33	12.82
	200	97.22	99.14	5.534	5.688	11.76	13.25
	250	98.73	100.9	5.615	5.774	12.67	14.15
2	C	84.51	86.55	4.684	4.825	10.21	11.82
	100	100.3	102.0	5.732	5.957	13.11	14.58
	150	103.1	105.1	5.851	6.006	14.51	15.97
	200	107.3	109.1	6.036	6.191	15.67	17.12
	250	109.6	111.8	6.112	6.255	15.86	17.31
4	C	87.28	88.90	4.875	5.022	10.36	11.88
	100	112.8	114.2	6.412	6.558	16.26	17.72
	150	116.5	118.4	6.532	6.671	16.89	18.27
	200	127.3	129.1	6.987	7.114	18.33	19.77
	250	131.7	132.6	7.084	7.211	19.17	20.57
6	C	89.11	91.16	5.102	5.267	10.54	12.03
	100	119.1	121.6	6.714	6.851	17.19	18.57
	150	124.5	126.4	6.865	6.999	17.73	19.15
	200	134.2	137.1	7.102	7.226	20.11	21.47
	250	136.5	139.3	7.132	7.257	21.25	22.61
F-test		**	**	**	**	**	**
LSD5%		3.13	3.24	0.174	0.184	1.64	1.71

**: significant differences at 0.01.

3-Seed yield traits

The highest rates of humic acid and chitosan gave the highest mean values of number of seeds/pod, seed yield/plant, seed Index, and seed yield/ ard/fed in the two growing seasons (Table 4). Date revealed that increasing the rate of humic acid significantly increased seed yield components. Also, the maximum increase percentage of No. of seeds/pod, seed yield/plant, seed Index, and seed yield/ ard/fed reached (19.07 and 17.66 %), (44.01 and 42.92%), (24.65 and 24.19%), and (26.46 and 14.34%) in comparison to the control treatment due to humic acid application at 6 kg/fed in comparison to the control treatment in both seasons, respectively. Increasing humic acid rates from zero to 2 then to 4 kg/fed, significantly increased weight of seeds/plant in both seasons. Other investigations reported that increasing humic acid rates up to 4 g/l and 8 ml/l (500 l/fed., three times at 21, 45 and 60 days after sowing) significantly increased faba bean seed yield (Shafeek *et al*., 2013; Khafaga *et al.,* 2014), respectively.

Table 4. Main Effects of humic acid and chitosan application on seed traits of faba bean plants in 2021/22 and 2022/23 seasons

Main effect	Number of seeds/pod		Seed yield/plant gm		Seed index 100s gm		Seed yield/ard/fed	
Charac.	2021/22	2022/23	2021/22	2022/23	2021/22	2022/23	2021/22	2022/23
HO (H)								
Control	2.668	2.808	51.29	52.44	70.76	72.98	11.11	12.41
2	2.782	2.916	58.05	59.58	75.15	76.36	12.39	13.66
4	2.989	3.118	69.96	71.47	82.83	84.03	13.29	14.56
6	3.177	3.304	76.04	77.48	85.71	86.91	14.05	15.26
F-test	**	**	**	**	**	**	**	**
LSD5%	0.087	0.094	2.17	2.42	1.86	1.94	1.04	1.12
CH(C)								
Control	2.554	2.701	50.84	53.18	65.69	66.91	10.29	11.67
100	2.835	2.966	62.94	64.27	77.50	78.70	12.63	13.87
150	2.881	3.011	66.00	67.12	79.18	80.38	12.90	14.13
200	3.086	3.215	71.14	72.41	83.12	84.32	13.69	14.92
250	3.165	3.292	75.15	76.43	85.10	86.30	14.05	15.28
F-test	**	**	**	**	**	**	**	**
LSD5%	0.091	0.097	2.34	2.57	2.07	2.18	1.13	1.24

**: significant differences at 0.01.

Yield and yield components of faba bean significantly increased by application of humic acid (El-Ghamry *et al.,* 2009; Fouda, 2017). This could be explained that humic acid is rich in both organic and mineral substances which are essential to plant growth and consequently increasing yield quality and quantity (El-Bassiony *et al.,* 2010). Also, humic acid reduces soil pH and EC (El-Galad *et al.,* 2013). According to El-Kholy *et al.* (2019) the combined analysis of data revealed that, increasing humic acid rates up to 4 kg/fed, significantly increased number of pods/plant, weight of seeds/plant, and protein yield/fed. However, 100-seed weight, plant height, and number of branches/plant were not affected by the application of humic acid. Meanwhile, biological and seed yields/fed responded to the application of humic acid rate up to 2 kg/fed.

Concerning the effect of chitosan on seed traits, the results in Table (4) emphasized that foliar application by chitosan at 250 ppm recorded maximum increase in No. of seeds/pod, seed yield/plant, seed index and seed yield/ ard/fed (23.92 and 21.88), (47.81 and 43.71%), (29.39 and 28.97%), and (36.54 and 30.93%) due to foliar application of chitosan at 250 ppm in comparison to the control treatment in both seasons, respectively. Chitosan levels had significant effect on seed traits of faba bean (Table 4). In general, there were gradual increases in seed traits values with increasing the chitosan level. The same trend was reported by Battikha *et al.* (2020) stated that the application of chitosan with 15% nano nitrogen produced the maximum values of all characters i.e. number of pods /plant, number of seeds/pod, seed index, total weight of plant, pod weight of plant, seed yield /plant and per fed, and strew yield per plant and per fed. This result may be due to the role of glucosamine polymer which influences the biochemistry and molecular biology of the plant cell. The cellular targets are plasma membrane and nuclear chromatin. Subsequent changes occur in cell membranes, chromatin, DNA, calcium, MAP Kinase, oxidative burst, reactive oxygen species, callose pathogenesis-related (PR) genes and phytoalexins (Hadwiger, 2013).; can increase the microbial population by large numbers, and transforms organic nutrient into inorganic nutrients that are easily absorbed by plant roots (Bolot *et al*., 2004).

4-Interaction effects between humic acid and chitosan on seed traits

There were significant differences among treatments in both seasons regarding the effect of interaction between humic acid and chitosan level on seed traits, i.e., number of seeds/plant, seed yield/ plant, seed index, and seed yield/ard/fed, (Table 5). Application of 6 kg humic acid/fed combined with 200 ppm chitosan gave the highest values of seed components under the study. The lowest values were recorded by control treatment, in both seasons.

The satisfactory influence of using the humic acid and chitosan applications on seed yield and its components may be due to its favorable effect on plant growth (Table 3).

Table 5. Interaction effects between humic acid and chitosan application on seed traits in 2021/22 and 2022/23 seasons.

Effect of interaction treatments		Number of seeds/plot		Seed yield/plant gm		Seed index 100s gm		Seed yield /ard/fed	
H	CH	2021/22	2022/23	2021/22	2022/23	2021/22	2022/23	2021/22	2022/23
C	C	2.506	2.653	38.84	41.29	65.01	66.24	10.01	11.53
	100	2.636	2.775	47.04	48.40	67.18	68.39	10.89	12.21
	150	2.698	2.838	50.20	50.76	69.05	70.28	11.33	12.57
	200	2.733	2.872	52.15	53.49	70.36	71.57	11.25	12.43
	250	2.767	2.904	55.76	57.09	72.21	73.42	12.09	13.31
2	C	2.535	2.685	39.15	41.58	65.33	66.56	10.13	11.51
	100	2.801	2.935	58.21	59.51	74.67	75.88	12.27	13.47
	150	2.823	2.954	61.06	62.36	76.33	77.52	12.61	13.83
	200	2.867	2.997	64.13	65.42	78.76	79.97	13.86	15.16
	250	2.884	3.011	67.70	69.01	80.67	81.87	13.06	14.31
4	C	2.561	2.707	41.16	43.47	66.07	67.30	10.33	11.68
	100	2.933	3.059	70.19	71.51	82.97	84.17	13.47	14.70
	150	2.987	3.113	73.11	74.46	84.10	85.31	13.66	14.94
	200	3.132	3.255	81.05	82.31	89.67	90.86	14.33	15.55
	250	3.333	3.456	84.31	85.58	91.33	92.52	14.67	15.93
6	C	2.614	2.758	44.20	46.37	66.33	67.54	10.67	11.96
	100	2.971	3.094	76.33	77.66	85.16	86.35	13.89	15.09
	150	3.014	3.137	79.61	80.91	87.23	88.42	13.98	15.17
	200	3.612	3.735	87.21	88.41	93.67	94.86	15.33	16.52
	250	3.674	3.797	92.84	94.03	96.18	97.37	16.38	17.57
F-test		**	**	**	**	**	**	**	**
LSD5%		0.097	1.023	2.48	2.72	2.26	2.41	1.27	1.36

**: significant differences at 0.01.

5-Seeds chemical quality

The results demonstrated in Table (6) revealed that increasing humic acid rate and foliar application levels significantly increased Protein content, total carbohydrate and starch percentage in both seasons. The maximum mean values were obtained from the application of humic acid at 6 kg/fed and 250 ppm from chitosan applications in both seasons. The increase percentage in Protein content reached (14.47 and 14.34%) due to the application of 6 kg humic acid compared with the control treatment in both seasons, respectively. In this respect, Sayed *et al.,* (2014) who found that the relative increase of mean values for protein (%) in faba bean seeds were (4.26 and 1.42) in the first and second seasons as soil treated with application of 10 kg humic acid/ fed compared with applied 5 kg humic acid, respectively. Humic acids are considered as an important source of organic matter and their effects on yield and its components could be through their enhancing effect on increase soil moisture holding capacity, improve soil texture as well as promote the uptake of nutrients leading to stimulation of plant growth (higher biomass production) and consequently on total pods yield and its components (Zhang *et al*., 2003).

Moreover, the increase percentage in protein content reached (15.55 and 17.52%) due to the application of 250 ppm of chitosan compared with the control treatment in both seasons, respectively. Dawood *et al.* (2024) shown that all applied chitosan concentration treatments significantly increased total soluble protein in bean plants grown either under well watered conditions or drought stress conditions. These increases could be attributed to the role of chitosan in improving cytokinin contents that stimulate chlorophyll synthesis and/or increasing the availability of amino compounds released from chitosan (Chibu and Shibayama, 2001). Moreover, El-Galad *et al*. (2013) and Shafeek *et al.* (2013) showed that, increasing humic acid rate up to 15 kg/fed., and 2 g/l, respectively significantly increased seed protein content, while El-Bassiony *et al.* (2010) and Khafaga *et al.* (2014) showed that seed protein content was not affected by humic acid rates.

Total carbohydrate values recorded the maximum values (53.58 and 54.76%) and (52.68 and 53.89 %) as results of humic acid at a rate of 6 kg/fed and chitosan at 250 ppm in comparison to the control treatment in both seasons, respectively. This could be explained that humic acid is rich in both organic and mineral substances which are essential to plant growth and consequently increasing yield quality and quantity (El-Bassiony *et al.,* 2010). Also, humic acid reduces soil pH and EC (El-Galad *et al.,* 2013). According to El-Kholy *et al.* (2019) showed that the data combined analysis revealed that increasing humic acid rates up to 4 kg/fed significantly increased the number of pods/plant, weight of seeds/plant, and protein yield/fed.

However, using humic acid at a higher rate (6 L/fed.) resulted in the highest percentage of protein in both seasons compared to medium and low levels (4 or 2L /fed.) In contrast, the application of various humic acid levels produced a promotion effect in the accumulation of total carbohydrate percentage. Moreover, the highest humic acid level caused the maximum significant level for total carbohydrate content. In this respect, Shehata *et al.* (2017) reported that treating snap bean plants with HA as soil application shows an increase in protein and total carbohydrate by (18.31 and 24.30 %) compared to untreated plants (15.80 and 22.34%), respectively. Fouda *et al.* (2022) indicated that using a foliar spray of chitosan (750 ppm) on faba bean plants under an irrigation level of 4800 m^3 led to an improvement in the quality properties of faba bean, such as total chlorophyll, protein, carbohydrates, total phenols, and amino acids which were higher than the control with a relative increase of 63.83, 29.58, 27.72, 37.54, and 64.19%. Starch % recorded the highest mean values (20.05 and 21.23%) and (19.61 and 20.82%) due to humic acid at a rate of 6 kg/fed and chitosan at 250 ppm in comparison to the control treatment in both seasons, respectively. Faba beans also contain significant amounts of starch (40–44%) (*Crépon et al.*, 2010).

Table 6. Main Effects of humic acid and chitosan application on some seed quality of faba bean plants in 2021/22 and 2022/23 seasons

Main effect Charac.	Protein (%)		Total carbohydrate (%)		Starch (%)	
	2021/22	**2022/23**	**2021/22**	**2022/23**	**2021/22**	**2022/23**
			HO (H)			
Control	21.14	22.24	36.01	37.11	15.52	16.61
2	21.82	22.94	41.79	42.91	16.47	17.58
4	23.52	24.73	50.71	51.92	18.92	20.12
6	24.25	25.43	53.58	54.76	20.05	21.23
F-test	**	**	**	**	**	**
LSD 5%	0.87	0.85	0.72	0.81	0.66	0.68
			CH (C)			
Control	20.25	21.40	40.36	41.51	14.92	16.02
100	22.65	23.71	44.95	46.01	17.41	18.47
150	22.96	24.17	46.89	48.09	17.79	19.00
200	23.61	24.75	50.74	51.88	18.98	20.12
250	23.94	25.15	52.68	53.89	19.61	20.82
F-test	**	**	**	**	**	**
LSD5%	0.91	0.89	0.78	0.87	0.73	0.76

**: significant differences at 0.01.

6-Interaction effects between humic acid and chitosan on seed quality

The interaction between humic acid and chitosan levels (Table 7) indicated that the application of 6 kg humic acid/fed combined with 200 ppm chitosan recorded the highest number of all quality under the study. The lowest values were recorded by control treatment, in both seasons. Protein %, total carbohydrate %, and starch % were significantly influenced by the combined application of humic acid at a rate of 6 kg/fed and chitosan at 250 ppm. In this respect, Fouda *et al.* (2022) stated that applying chitosan at 750 ppm improved the quality properties also improved, as the total chlorophyll, protein, carbohydrates, total phenols, and amino acids were higher than the control with a relative increase of 63.83, 29.58, 27.72, 37.54, and 64.19%.

Table 7 reflects the effects of the interactions between humic acid and chitosan application in both seasons. Increasing humic acid application rate up to 6 kg/fed combined with chitosan at 250 ppm, significantly and constantly increased protein, carbohydrate, and starch as compared to control treatment. Also, increasing humic acid applied level from 0 to 6 kg/fed together with chitosan at 250 ppm increased seed quality as compared to the control treatment. The interactive effect of humic acids (30 L ha^{-1} humic acids) and chitosan (200 mg L^{-1} chitosan) could be attributed to the exhibited favorable changes in antioxidant defense and stomata performance causing improvements in yield and sugar quality traits under low water supply (Makhlouf *et al.,* 2022). The stimulatory effects of humic substances have been directly correlated with enhanced uptake of macronutrients, such as nitrogen, phosphorus, and sulfur (Chen and Aviad, 1990).

Table 7. Interaction effects between humic acid and chitosan application on some seed quality in 2021/22 and 2022/23 seasons.

Effect of interaction treatments		Protein (%)		Total carbohydrate (%)		Starch (%)	
H	CH	2021/22	2022/23	2021/22	2022/23	2021/22	2022/23
C	C	19.98	21.14	31.26	32.41	14.66	15.74
	100	21.04	21.98	34.76	35.70	15.33	16.27
	150	21.33	22.52	36.86	38.05	15.66	16.85
	200	21.57	22.60	37.51	38.54	15.97	17.00
	250	21.76	22.95	39.65	40.84	16.00	17.19
2	C	20.01	21.05	31.56	32.62	14.86	15.87
	100	21.96	22.87	41.57	42.48	16.33	17.24
	150	22.06	23.25	43.25	44.44	16.79	17.98
	200	22.33	23.52	45.21	46.40	17.04	18.23
	250	22.76	24.00	47.35	48.59	17.33	18.57
4	C	20.33	21.55	32.86	34.09	14.98	16.17
	100	23.27	24.46	49.86	51.05	18.66	19.85
	150	23.79	25.04	51.64	52.89	18.86	20.11
	200	24.87	26.03	58.66	59.82	20.23	21.39
	250	25.33	26.55	60.54	61.76	21.86	23.08
6	C	20.67	21.84	33.76	34.93	15.16	16.30
	100	24.33	25.52	53.62	54.81	19.33	20.52
	150	24.67	25.85	55.79	56.97	19.86	21.04
	200	25.67	26.86	61.57	62.76	22.66	23.85
	250	25.91	27.10	63.16	64.35	23.24	24.43
F-test		**	**	**		**	
LSD5%		0.87	0.96	0.92		0.81	

**: significant differences at 0.01.

Conclusion

From the obtained results, it could be recommend that using humic acid as soil application at 6 kg/fed twice during season (the first half was done after two weeks of planting and the second half applied six weeks after planting) interacted with foliar application of chitosan at 250 ppm four times (starting from seven weeks after planting then at two weeks interval) during season as an effective and inexpensive alternative to plant nutrition for enhance growth and yield.

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تأثير حمض الهيومك والرش الورقي بالشيتوزان على نمو وإنتاجية جودة بذور محصول الفول البلدي

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الملخص

أجريت تجربتان حقليتان في محطة البحوث الزراعة بمزرعة بحوث كلية الزراعة، جامعة أسيوط، محافظة أسيوط، مصر، خلال موسمي الشتاء 2022/2021، 2023/2022. وكان الهدف من هذه الدراسة هو دراسة استجابة النمو الخضري والمحصول ومكونات المحصول وبعض صفات الفول البلدي (*Vicia faba* L.) صنف "جيزة 843" للإضافة الأرضية الهيومك أسد وكذلك للرش الورقي الشيتوزان (Ch).

تم إضافة حمض الهيوميك للتربة بأربعة تركيزات (0 و2 و4 و6 كجم/فدان) مرتين خلال فترة النمو. تم رش الشيتوزان (Ch) ورقيًا بتركيزات 0 و50 و100 و150 و250 جزء في المليون) أربع مرات خلال فترة النمو.. كان التصميم الإحصائي في كل تجربة بتصميم قطعة منشقه. تم توزيع حمض الهيوميك في القطعة الرئيسية. وفي الوقت نفسه، تم رش الشيتوزان في القطعة الفرعية.

أظهرت النتائج أن حمض الهيوميك والشيتوزان كان لهما تأثير معنوي عالي على جميع مكونات النمو الخضري وجودة البذور الكيميايه (% لكل من النشا والكربوهيدرات البروتين)، كما سجلت المعاملة المشتركة لحمض الهيوميك بمعدل 6 كجم/فدان مع المعاملة الورقية بالشيتوزان بمعدل 250 جزء في المليون أعلى النتائج.

الكلمات المفتاحية: *الإنتاجية، الشيتوزان، الفول البلدي، حمض الهيوميك، مكونات البذور.*