Effect of humic acid and seaweed extract rates on yield and yield components of barley (*Hordeum vulgare* L.)

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ABSTRACT

The present study was carried out at the Agricultural Experiment Farm, Faculty of Agriculture (Saba-Basha), Alexandria University, in 2022/2023 winter season to investigate the effect of humic acid levels (0, 6 and 12 k/fed) as soil application before the first irrigation as main-plot and seaweed extract (0, 3 and 6 l/fed) as foliar application before the second irrigation as sub-plot, on growth, yield, yield attributes and grain protein content of six-rowed barley (*Hordeum vulgare* L.), Giza 2000 variety. The experimental design was R.C.B.D. in split plot arrangement using three replicates. Obtained results indicated that increasing both humic acid and seaweed extract levels up to 12 kg/fed and 6 l/fed, respectively, significantly and gradually increased all the studied traits. The tallest plants (80.87 and 78.48 cm), highest number of pikes/m^2 (280.33 and 282.42), highest number of spikelets/spike (47.39 and 46.09), heaviest 1000-grain weight (37.65 and 35.82 g), highest grain yield (4.08 and 3.87 t/fed.), biological yield (9.62 and 9.06 t/fed.), harvest index (42.41 and 42.72 %) and grain protein content (8.70 and 8.88 %) resulted from application both humic acid and seaweed extracts at (12 kg and 6 l/fed.), respectively. Interaction between humic acid and seaweed levels had significant effect on all the studied traits of Giza 2000 barley variety. Combination between 12 kg/fed. humic acid, applied before the first irrigation and 6 l/fed. seaweed extract, sprayed before the second irrigation produced the highest values of the studied characters, except number of spikelets/spike, harvest index and grain protein content.

Keywords: Barley (*H. vulgare* L.), Humic acid, Seaweed extract, Yield, Protein content.

INTRODUCTION

Barley (*Hordeum vulgare* L.) is the fourth most important cereal crop, after wheat, rice and maize, in the world. It is used for food in some countries such as Libya, feed and malt industry. Barley is considered the most important winter crop in most Libyan soil types. The world acreage reached 47.9 million hectares with an average yield about 2.9 t/ha, however, the cultivated area of this crop in Libya reached 136247 ha, with an average about 0.5 ton/ ha (FAO, 2019). So, there is a gap between barley production and demand and there is an essential need to apply the recommended agricultural practices to decrease this gap.

Fahmi *et al.* (2020) reported that humic acid (HA) as an organic material has many advantages including phytohormone-like activities that influence plant physiology processes such as enhancing germination of seeds, increasing growth of root system, seedling growth and improving photosynthesis and consequently vegetative growth. Also, humic acid accelerates plant cell division, promoting development and increases root respiration and arrangement (Varanini & Pinton, 2001; Bijanzadeh and Perssarakli, 2020). Mauromicale *et al.* (2011) pointed out the effect of humic acid in controlling soil-borne diseases and improving mineral availability and nutrient uptake by plants.

Seaweed extract as a biostimulant contains macro and micro nutrients, vitamins, fatty and amino acids, growth-regulating hormones such as auxin, cytokinin and gibberellins (Issa *et al*., 2019). Altindal (2019) also reported that sea weed extracts were biologically degradable, non- polluting and non-toxic for the environment. Brown seaweed as a source of auxins, amino acids and vitamins enhanced crop growth and yield (Salvi *et al*., 2019 and El-Sheikh *et al*., 2020).

The present investigation was carried out to study the effect of humic acid and seaweed extracts on barley growth, yield, yield components and grain protein content.

MATERIALS AND METHODS

The present investigation was carried out at the Experimental Farm, Faculty of Agriculture (Saba-Basha), Alexandria University, Egypt, during the winter season of 2022/2023 to study the effect of humic acid levels and seaweed extract on yield and yield components of six-rowed barley (*Hordeum vulgare* L.), Giza 2000 variety.

The preceding crop was maize. Soil physical and chemical characteristics were determined using soil samples collected before sowing from 0- 30 cm depth for analysis according to Page *et al.* (1982) and Klute (1986). The full analysis of soil samples are presented in Table (1).

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Table 1. Physical and chemical properties of the experimental soil in 2022/ 2023 season

Physical properties			
Sand %	32	Silt %	30
Clay %	38	Texture	Clay loam soil
Chemical properties			
Av. N %	0.11	Mg^{2+} (meq/ l)	18.3
Av. P ppm	12.0	Na^{+} (meq/ l)	13.50
Av. K ppm	1.50	Cl^{-} (meq/ l)	20.4
O.M. %	1.41	$CO3^{2-}$ (meq/ l)	4.8
pH	8.2	HCO_3^{-} (meq/ l)	4.0
EC (dS/ m)	3.8	$CaCO_3$ (%)	6.5
Ca^{2+} (meq/ l)	9.4	SAR	7.99

A split plot experimental design, with three replications, was used. The main plots were devoted to three humic acid levels (0, 6 and 12 kg/fed.), while sub-plots were occupied by three rates, i.e. 0, 3 and 6 l/fed of seaweed extract. Humic acid was applied as soil application before the first irrigation, while was seaweed applied as foliar application before the second irrigation. Sub-plot area was 4.8 m^2 comprising six rows, each 4 m long and 0.2 m wide.

The date of sowing was December 4^{th} and rate of sowing was 40 kg/fed of Giza 2000 variety. Nitrogen fertilizer in the form of urea (46 % N) was applied at the rate of 60 kg N/fed in two equal doses before the first and second irrigations. Phosphorus fertilizer was applied at the rate of 15.5 kg P_2O_5/fed., during seed bed preparation, while potassium was applied at the rate of 24 kg K_2O/fed before the second irrigation. Other cultural practices were carried out as recommended for barley production in Alexandria Region.

At harvest, number of spike/m^2 was recorded and ten guarded plants were randomly taken from each sub-plot to determine average plant height, number of spikelets/spike and 1000-grain weight. A guarded area of 4 m^2 from each sub-plot were weighed to determine biological yield (kg) and converted to (ton/fed) then threshed to determine grain yield (kg) and converted to (t/fed.). Harvest index (HI %) was estimated according to the following equation:

$$\text{HI \%} = \frac{\text{Grain yield}}{\text{Biological yield}} * 100$$

Grain protein content (%) was determined by estimating the total nitrogen in the grains and multiplied by 6.25 to obtain the percentage of crude protein content according to A.O.A.C. (1990).

Data were statistically analyzed according to Gomez and Gomez (1984) using SAS ver 9.1 (2002). Least significant difference values at 0.05 level of probability were used to compare the differences between treatment means.

RESULTS AND DISCUSSION

Data presented in Table (2) revealed that both humic acid, seaweed levels and their interactions had significant effect on all the studied traits of barley.

Regarding humic acid effect, results showed that increasing humic acid levels up to 12 kg/fed gradually significantly increased growth, yield and its attributes and grain protein content traits.

Humic acid application at 12 kg/fed produced the tallest barley plants (80.87 cm), highest number of spikes/m^2 (280.33), number of spikelets/spike (47.39), heaviest 1000-grains (37.65 g), highest grain and biological yields (4.08 and 9.62 t/fed., respectively), harvest index and grain protein content (42.41 % and 8.70 %, respectively).

Many researchers reported the enhancing effect of humic acid on plant growth, grain yield, yield components and nutrients uptake such as David (1991); Neri *et al.* (2002) and El-Desuki (2004). Also, humic application increased soil microbial population, cation exchange capacity (CEC) and improved soil structure (Varanini & Pinton, 2001 and Chen *et al.*, 2004). On the other hand, Daur & Bakhashwain (2013) and Jaršová *et al.* (2014) indicated that increasing plant height might be due to the stimulatory effect of humic acid on cell division, elongation of internodes and increasing the activity of the intercellular meristem. Increasing number of spikes/ m^2 and grain protein content with increasing humic acid application agreed with those reported by Daur & Bakhashwain (2013) and Jaršová *et al.* (2014). Hashemi and Marashi (1992) reported that 1000-grain weight is determined by assimilates that are mobilized into spikes during heading stage until maturity and that related to the continuity of leaf area after heading and photosynthetic activity of spike and source-sink relationships.

With respect to the effect of seaweed on barley growth, grain yield and yield components, results presented in Table (2) showed that increasing seaweed levels significantly increased all the studied traits. The highest seaweed level (6 l/fed.) as foliar application gave the tallest barley plants (78.48 cm), highest number of spikes/ m^2 (282.42), number of spikelets/spike (46.09), heaviest 1000-grain weight (35.82 g), highest grain and biological yields (3.87 and 9.06 t/fed., respectively), and highest harvest index and grain protein content (42.72 % and 8.88 %, respectively). The favourable effect of the application of an algae extract could be due to increase in root weight which was positively correlated with grain yield and that could result in a better supply of water and nutrients for plant (Beckett and Van Staden, 1989). Similar results were reported Matysiak *et al.* (2012) and Shah *et al*. (2013).

Interaction effects between humic acid and seaweed extract levels were significant on the studied traits of barley crop as shown in Table (3). Data presented in that table demonstrated that combination of the highest levels of both humic acid and seaweed extract (12 kg and 6 l/fed) produced the tallest barley plants (87.94 cm), highest number of spikes/m^2 (316.21), highest grain and biological yields (4.80 and 11.22 t/fed., respectively), and 1000-grain weight (38.87 g) which did not significantly differ from combination of 12 kg humic acid and 3 l/fed seaweed extract. However, the combination of 6 kg humic acid and 6 l/fed. seaweed extract produced the highest number of spikelets/spike (49.69). Conversely, the highest harvest index and grain protein content (46.87 % and 9.24 %, respectively), resulted from 6 l/fed seaweed application. These results indicated that there is a complementary effect between humic acid and seaweed extract, which had favorable effect on barley plant growth, grain yield, yield attributes and grain protein content.

In conclusion, the results obtained from the present investigation indicated that Giza 2000 barley variety treated with 12 kg/fed humic acid before the first irrigation and 6 l/fed. seaweed extract sprayed before the second irrigation produced the highest grain yield, yield attributes and grain protein content.

Table 2. Means of plant height, grain yield, yield components and protein content as affected by humic acid and seaweed extract levels

Treatments	Plant height (cm)	No. of spikes/m^2	No. of spikelets/spike	1000-grain weight (g)	Grain yield (t/fed.)	Biological yield (t/fed)	Harvest Index (%)	Protein content (%)
Humic acid (kg/fed)								
0	67.88 c	234.50c	37.78 c	28.79 c	2.71 c	6.65 c	40.75 b	7.84 c
6	71.82 b	256.56 b	43.48 b	33.37 b	3.22 b	8.05 b	40.00 b	8.25 b
12	80.87 a	280.33 a	47.39 a	37.65 a	4.08 a	9.62 a	42.41 a	8.70 a
$L.S.D._{0.05}$	2.05	11.22	2.74	0.33	0.11	0.13	1.08	0.06
Seaweed (l/fed.)								
0	69.44 c	233.32 c	39.71 c	30.81 c	2.77 c	7.16 c	38.78 c	7.66 c
3	72.66 b	255.66 b	42.87 b	33.17 b	3.37 b	8.09 b	41.66 b	8.25 b
6	78.48 a	282.42 a	46.09 a	35.82 a	3.87 a	9.06 a	42.72 a	8.88 a
$L.S.D._{0.05}$	1.01	8.26	0.32	0.38	0.06	0.10	0.49	0.05
Interactions	**	**	*	*	*	*	*	*

Means followed by the same letter in the same column are statistically equal according to L.S.D.0.05 values
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table 3. Means of plant height, grain yield, yield components and protein content as affected by humic acid and seaweed extract interaction

Humic acid (kg/fed.)	Seaweed (l/fed.)	Plant height (cm)	No. of spikes/m^2	No. of spikelets/spike	1000-grain weight (g)	Grain yield (t/fed.)	Biological yield (t/fed)	Harvest Index (%)	Protein content (%)
	0	63.87 g	223.17 d	36.12 h	26.67 h	2.09 h	6.04 h	35.36 f	6.52 h
0	3	66.11 f	234.78 d	37.46 g	27.89 g	2.51 g	7.17 e	40.02 d	776 g
	6	73.66 cd	245.55 cd	39.76 e	31.81 e	3.53 c	6.74 g	46.87 a	9.24 a
	0	69.08 e	229.37 d	38.46 f	30.53 f	2.84 f	7.02 f	39.11 e	7.99 f
6	3	72.57 d	254.84 c	42.29 d	32.77 d	3.54 c	7.94 d	41.89 c	8.33 e
	6	73.81 cd	285.47 b	49.69 a	36.81 b	3.28 e	9.19 b	39.00 e	8.43 d
	0	75.37 c	247.42 cd	44.55 c	35.23 c	3.38 d	8.42 c	41.87 c	8.47 d
12	3	79.30 b	277.36 b	48.86 b	38.85 a	4.06 b	9.16 b	43.07 b	8.66 c
	6	87.94 a	316.21 a	48.82 b	38.87 a	4.80 a	11.22 a	43.29 b	8.97 b
L.S.D.0.05		2.11	14.38	0.63	0.79	0.09	0.15	0.82	0.08

Means followed by the same letter(s) in the same column are statistically equal according to L.S.D.0.05 values

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الملخص العربي

تأثير معدلات حمض الهيوميك ومستخلص الأعشاب البحرية على المحصول ومكوناته لنبات الشعير

أبوبكر صالح عبد العاطى بوكيلة، ناصر على صالح، محمود أبو عجيلة على رحومه

أجريت هذه الدراسة بالمزرعة البحثية- كلية الزراعة (سابا باشا)- جامعة الإسكندرية فى الموسم الشتوى ٢٠٢٢/ ٢٠٢٣ لدراسة تأثير ثلاثة مستويات من حمض الهيوميك (٠، ٦، ١٢ كجم/ ف) تمثل عامل القطع الرئيسية وثلاثة مستويات من مستخلص الأعشاب البحرية (٠، ٣، ٦ لتر/ ف) تمثل عامل القطع الفرعية على النمو والمحصول ومكوناته ومحتوى الحبة من البروتين لصنف الشعير سداسى الصفوف (جيزة ٢٠٠٠)- نفذت التجربة بتصميم القطاعات العشوائية الكاملة بترتيب قطع منشقة مرة واحدة فى ثلاث مكررات.

وقد أوضحت النتائج أن زيادة معدلات كل من حمض الهيوميك ومستخلص الأعشاب البحرية إلى (١٢ كجم/ ف، ٦ لتر/ ف) على الترتيب أدى إلى زيادة معنوية تدريجية فى جميع الصفات التى تم دراستها حيث تم الحصول على أطول النباتات (٨٠,٨٧، ٧٨,٤٩ سم)، أقصى عدد من النباتات/ م٢ (٢٨٠,٣٣، ٢٨٢,٤٢)، أقصى عدد من السنيبلات/ سنبلة (٤٧,٣٩، ٤٦,٠٩)، أثقل وزن للألف حبة (٣٧,٦٥، ٣٥,٨٢ جم)، أقصى محصول حبوب (٤,٠٨، ٣,٨٧ طن/ ف)، أعلى محصول بيولوجى (٩,٦٢، ٩,٠٦ طن/ ف) وكذلك أعلى معامل حصاد (٤٢,٤١، ٤٢,٧٢ %) وأعلى محتوى بروتين فى الحبوب (٨,٧٠، ٨,٨٨ %) وذلك من إضافة (١٢ كجم/ ف) من حمض الهيوميك والرش بمستخلص الأعشاب البحرية بمعدل (٦ لتر/ ف) على الترتيب- كذلك أدى التفاعل بين كل من حمض الهيوميك بمعدل (١٢ كجم/ ف) ومستخلص الأعشاب البحرية بمعدل (٦ لتر/ ف) إلى الحصول على أقصى القيم لجميع الصفات التى تم دراستها عدا عدد السنيبلات/ سنبلة، معامل الحصاد، محتوى الحبة من البروتين.