Effects of Spacing, Humic Acid and Boron on Growth, Seed Production and Quality of Broad Bean (*Vicia faba var major L*)

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ABSTRACT

Two field experiments were carried out in a private farm located at Bangar El Sokar region - Borg Al-Arab - Alexandria, Egypt, during winter growing season of 2014/2015 to study the effects of three spacing (10, 20 and 30 cm), three Humic acid (HA) rates (control, 1000 and 2000 mg l^{-1}) and three boric acid rates (control, 2.5 and 5 mg l^{-1}) on the vegetative growth, seed yield and its quality of broad bean plants.

The results indicated that increasing spacing between broad bean plants lead to an increase in the numbers of branchesplant^{-1} and poor seeds percentage. While, plant height, seed yield fed^{-1} (ton) and good seeds percentage characters were decreased by increasing spacing.

Treated broad bean plants with humic acid increased plant height and the numbers of branches. However, using humic acid at rate 2000 mg l^{-1}gave the highest mean value of fresh mass plant^{-1}. While, increasing humic acid rate was lead to decrease the nods setting percentage. In addition to, application of 1000 mg l^{-1} of humic acid gave the highest mean value of the seed yield fed^{-1}and good seed percentage, as well as the lowest percentage of poor seeds.

The results showed that the highest mean values of plant height (cm) were obtained from treated plants with 2.5 mg l^{-1} boric acid. Also, increasing boric acid rates up to 5 mg l^{-1} decreased the fresh mass of plant^{-1}. Whereas, the highest mean value of the earliness and nods setting percentage achieved by application 5 mg l^{-1} of boric acid. Increasing the boric acid rates up to 5 mg l^{-1} was associated with increments in the average seed yield fed^{-1} and the good seed percentage. In general, the highest dry seed yield fed^{-1}, under conditions of Bangar El Sokar region - Borg Al-Arab – Alexandria, were achieved when sowing broad bean plants at 10 cm with the application of humic acid at rate 1000 mg l^{-1} and foliar application of boric acid at rate 5 mg l^{-1}.

Key wards: Broad bean, Boric acid, Humic acid, Fresh mass, Seed yield characters

INTRODUCTION

Broad bean (*Viciafaba var. major. L*) is considered as one of the most important leguminous crops (winter season) in the world. It is not only a cheap source of protein, but also it improves the soil by fixing N and increasing soil fertility. In Egypt, broad bean grown in different types of soils. Its green seeds are eaten either raw or cooked, where its cultivated area reached about 6737 and 89708 fed., with an average production of 5.97 and 1.47 ton fed^{-1} from green pods and dry seeds, respectively, in 2013/2014.

Spacing (plant density) is one of the most agricultural practices that affect growth and yield of broad bean and it is well known that the number of any crop plants/unit area is one of the most important factors determining productivity(Nawar*et al.* 2010). Such plant density depends on components of planting method; such as hill spacing. The optimum plant density is a factor, which achieves the highest possible crop yield, as recommended by the (Ministry of Agriculture & Land Reclamation, 2004).Divergent studies on the effect of plant density on faba bean traits were conducted by various researchers(Ibrahim (2009), Shamsi (2009), Bakry et al. (2011), Mehasen and Ahmed (2012), Yucel (2013), Abd El-Azeem et al. (2014), and Mekkei (2014).

Humic acid (HA) is very large and complex molecules. It is rich in both organic and mineral substances which are essential to plant growth and consequently increase yield quality and quantity (Gad El-Hak *et al.* 2012). HA is also a source of plant nutrients essential for the plant growth (Yildirim, 2007). The uptake of HA in plant tissue results in various biochemical effects through an increase in nutrient uptake, preserving vitamins and amino acids level in plant tissues, thus stimulate the growth of roots and whole plant (Nardi *et al*., 1996). Many investigators showed several beneficial effects of HA such as increasing cell membrane permeability (Sial*et al.,* 2007), oxygen uptake and photosynthesis (Chen *et al.,* 1994), phosphorus uptake and root elongation (Cimrin and Yilmaz, 2005).Addition, HA has a role in decreased the damage of chocolate spot, damping-off and rust diseases of faba bean (El-Ghamry *et al.*,2009 and Abdel-Monaim *et al.*, 2011).

Boron(B) is vital to plant growth and development and necessary for the sexual reproduction stages (increases flower production, pollen germination and its tube elongation, and development of the seed and fruit). Its deficiency causes different effects on many processes in vascular plants such as root elongation, indole acetic acid (IAA) oxidase activity, sugar translocation, carbohydrate metabolism and nucleic acid synthesis (PilbeamaandKirkbya1983 and Camacho-Cristobal et. *al*. 2008). A small amount of B is beneficial to vegetable plants, but higher concentration can be toxic to living organisms including plants. It reduces growth, particularly of shoots, and causes chlorosis of leaf tip and margins of mature leaves (Gupta *et.al*. 1985).

The broad bean is a multi-purpose crop that plays an important role in the socio-economic life of various communities in Egypt. Therefore, it is important to get a maximized yield of broad bean. In this respect, the present investigation aimed to study the effects of plant spacing, humic acid and boron concentrations on vegetative growth, seed yield and quality of broad bean.

MATERIALS AND METHODS

Two field experiments were carried outin a private farm located at Bangar El Sokar region - Borg Al-Arab - Alexandria, during the winter growing seasons of 2014/2015, to study the effects of spacing, humic acid (HA) and boron (B) on vegetative growth, seed yield and its quality of broad bean plants. Prior to the initiation of the experiments, soil samples were collected at depth 30 cm, and analyzed for some physical and chemical properties. The results of the soil analyses are shown in Table (1).

Broad bean cultivar Loz de otono was used in this investigation, where it is well adapted for Egyptian environmental conditions,sowing seeds were done at three spacing 10, 20 and 30 cm on the one ridge side and one seed per hill, on 25th October, 2014, in twoexperiments. Humic acidwas used as potassium humate at three levels, i.e.0 (control, sprayed with distilled water), 1000 and 2000 mg l^{-1}, which were added as a soil and foliar applications. The soil application was done after 30 days from planting (about 100 ml plant^{-1}), while, the foliar application was twice, the first was after 45 days from planting and the second time was after two weeks from the first one.

Boric acid (H_3Bo_3)17% boron was used as a source of boron at three levels, i.e.0 (control, sprayed with distilled water), 2.5 and 5 mg l^{-1} applied as a foliar application, through the flowering stage, just one time after 40 days from planting. Through the growing season, the other cultural practices were conducted whenever they were needed and as recommended in the commercial production of broad bean plants under conditions of the Bangar El Sokar region - Borg Al-Arab – Alexandria.

Experimental Design:

Split-split plot system in a Randomized Complete Block Design with four replications was used, in the experiments. Spacing treatments were allocated in the main plots; while the sub-plots were devoted to the application of HA concentrations and the sub-sub-plots were devoted to the application of B levels. Each sub-sub-plot consisted of two ridges (7 m long × 65 cm wide). The experimental unit (the sub-sub-plot) area was 9.1 m^2.

Collection of Experimental Data: a sample consisting of 4 plants was selected at random from each sub- sub plot for recording the various vegetative growth parameters, i.e. plant height (cm), branches number plant^{-1} and fresh mass plant^{-1}(g) were recorded after 90 days from sowing. At the beginning of the flowering stage, flowering characters of broad bean plants were determined as follows: Earliness: It was expressed as the number of nodes up to first flower cluster.Nods setting percentage: It was recorded as number of settings nods: number of flowering nods, at the end flowering stage.Dry Seed Yield fed^{-1}(Kg) and Crude protein in Seeds (g/100g) were recorded at botanical maturity stage after harvested, sun-dried and separating seeds. Seed grading was done on sample about 500g dry seeds, randomly chosen from sub-sub-plot, where the dry seeds were divided into large and medium size as (good seeds) meanwhile small seeds (poor seeds), then calculated the ratio for each one, based on weight.

Statistical analysis: All obtained data of the present study were analyzed according to the design used by the CO-Stat computer software program. The comparisons among means of the different treatments were carried out by using the revised L.S.D. test at 0.05 level.

RESULTS AND DISCUSSION

Vegetative Growth Characters

Effects of Spacing

The results presented in Tables (2) indicated that sowing broad bean plants at wide spacing (30 cm) recorded the significantly higher number of branches plant^{-1}and fresh mass plant^{-1}(in both experiments), and nods setting percentage (in the first experiment only), while, at 10 cm spacing achieved significantly the highest plant height and earliness compared with the wider spacing (30 cm) in both experiments. Such results might be expected on the assumption that competition among the growing plants for nutrition and light intensity would be more in the case of narrow spacing (high plant densities). Accordingly, under high plant density, the low light intensity seemed to encourage somewhat the stem elongation of broad bean plants. In addition, the less available nutrients under the conditions of high plant density would not allow for excessive rates of photosynthesis and accumulation of stored food in the leaves of broad bean plants. These results agreed to a great extent with those reported by AL-Rifaee *et al*., 2004, Ibrahim (2009), Shamsi (2009), Bakry *et al*. (2011), Yucel (2013), Dahmardeh *et al* (2010), Nawar *et al* (2010) and Mekkei (2014).

Table 1: Soil's physical and chemical properties of the seasons soil sites, during the winter seasons of 2014/2015*.

season	Physical properties				Chemical properties		Soluble cations (m. eq l^{-1})				Soluble anions (m. eq l^{-1})				
	San d %	Silt %	Clay %	Soil texture	pH	E.C. ($dS.m^{-1}$)	Ca^{+}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^-	Cl^-	$CaCO_3$ %	Organic matter %
2014/ 2015	71	12	17	Sandy Loam	8.45	0.39	1.6	1.0	8.39	1.4	0.4	2.0	3.0	25.42	0.75

*These analyses were carried out at Faculty of Agriculture, Alexandria University.

Table 2: The main effects of some vegetative growthandflowering characters of broad bean plants as affected by spacing, humic acid and boric acids in the winter season 2014/2015.

Treatments	First experiment					Second experiment				
	Plant height (cm)	Branches No. plant^{-1}	Fresh mass plant^{-1}(g)	Earliness**	Nods setting percentage	Plant height (cm)	Branches No. plant^{-1}	Fresh mass plant^{-1}(g)	Earliness	Nods setting percentage
Spacing (cm)										
10	90.6 A*	6.2 C	522.6 C	7.3 A	53.4 B	81.8 A	7.0 C	550.6 C	7.3 A	55.3 A
20	72.4 B	8.5 B	637.7 B	6.2 B	55.5AB	67.0 B	9.0 B	660.3 B	6.8AB	56.8 A
30	63.4 C	9.4 A	694.0 A	5.9 B	61.0 A	59.1 C	9.8 A	721.9 A	6.1 B	59.7 A
Humic acid (mg l^{-1})										
0	74.1 B	7.8 B	620.7 A	6.5 A	61.7 A	68.4 A	8.6 A	650.8AB	6.9 A	57.3 A
1000	76.0 AB	8.0 A	587.6 B	6.3 A	55.7 B	68.3 A	8.6 A	625.8 B	6.8 A	56.4 A
2000	76.4 A	8.2 A	646.0 A	6.6 A	52.5 B	71.1 A	8.7 A	656.1 A	6.6 A	58.1 A
Boric acid (mg l^{-1})										
0	74.5 B	8.0 A	616.7 A	6.7 A	51.7 C	70.3 A	8.5 A	660.6 A	6.6 A	55.3 A
2.5	76.8 A	8.1 A	613.7 A	6.4AB	56.4 B	68.3 A	8.6 A	641.1AB	6.9 A	56.6 A
5	75.1 AB	8.0 A	623.9 A	6.3 B	61.8 A	69.3 A	8.7 A	631.1 B	6.7 A	59.9 A

** Earliness: the number of nodes up to first flower cluster.
*Values having the same alphabetical letter in common, within each character, do not significantly differ, using the revised L.S.D test at 0.05 level.

On the other hand, Mehasen and Ahmed (2012) and Alazaki and Al-Shebani (2012) they indicated that hill spacing of 8 cm between hills (highest density) produced tallest plants, maximum number of leaves and branches plant^{-1}.

Effects of Humic acid

The results in Tables (2) showed that treating broad bean plants with HA at rates 1000 and 2000 mg l^{-1} resulted in a significant increase in plant height, number of branches, (in the first experiment) and fresh mass of plant^{-1} (g), in both experiments. Increasing applied rate of HA up to 2000 mg l^{-1} was significantly decreased the nods setting percentage, in the first experiment only. On the other hand, humic acid had not significant effect on other flowering characters. This result can be explained on the basis of some plant hormone-like substances seem to be present in the HA acids, thus exerting a possible stimulating effect on the growth and development of chlorophyll (Liu *et al*., 1998). Also, caused the enlarged root system (deeper and greater mass) and increased stimulation of plant-growth due to hormones (Hopkins and Stark, 2003). A positive response of HA acid was previously obtained by El-Ghamry *et al*. (2009), who reported that all morphological characters of faba bean plants (plant height, number of branches and leaves plant^{-1}) were significantly increased by the application with HA acid at 2000 ppm. These results are in accordance with the findings of El-Bassiony *et al.* (2010), El-Hefny (2010), Azarpour *et al* (2011), Haghighi *et al* (2011), EL-Baz *et al* (2012), Gad El-Hak *et al* (2012), Shafeek*et al* (2013).

Effects of Boron

The obtained results in Tables (2) clarified that application of boric acid at rate 2.5 mg^{-1} led to a significant increase in plant height (in the first experiment only), in addition increasing boric acid rates up to 5 mg l^{-1} was associated with corresponding successive reductions in the fresh mass of plant^{-1} (in the second experiment) and earliness (in the first experiment). While, boric acid had no significant effect on the number of branches in the first experiment. This positive effect of boron on plant growth may be due to the main functions of boron relate to cell wall strength and development, cell division, fruit and seed development, sugar transport and hormone development (Waqar *et al*., 2009) and the imperative role of B in maintaining of cell integrity, enhancing respiration rate, increasing uptake of certain nutrients and metabolic activities such as IAA, which increases the fruit set (Shnain *et al*., 2014). These results are in agreement with Sharaf *et al.* (2009), Abou EL-Yazied and Mady (2012), Abd El-Azeem *et al.* (2014) and Moghazy *et al*., (2014).

Interaction Effects

The second-degree interaction effects among the three main studied factors in Table (3)indicated that the highest values of plant height, in both experiments, produced from the treatment combinations of 10 cm spacing with treated broad bean plants by 1000 mg l^{-1} of HA acid and 5 mg l^{-1}of boric acid. While, in the case of the number of branches plant^{-1} character, the best treatment combination, which gave the maximum mean values was planting broad bean plants at 30 cm spacing combined with application of HA acid at rate 2000 mg l^{-1} and boric acid at level 2.5 mg l^{-1}, in the two experiments. In addition, the two treatment combinations of spacing 30 cm with application of 2000 mg l^{-1} of humic acid with the use of any of 5 mg l^{-1} or 2.5 mg l^{-1} boric acid gave the highest mean value of fresh mass of plant^{-1}, in the first and second experiment, respectively. On the contrary, the two treatment combinations of spacing 10 cm with 1000 mg l^{-1} of humic with the use of any of 5 mg l^{-1} and 2.5 mg l^{-1}of boric acid gave the lowest values of it, in the first and second experiment, respectively.

The highest mean values of the earliness were achieved from the two treatment combinations of narrow spacing (10 cm) with using 2000 mg l^{-1} humic and addition of 0.0 mg l^{-1} boric, as well as of narrow spacing (10 cm) with application 0 mg l^{-1} of humic and 2.5 mg l^{-1} of boric, in the first and second experiment, respectively. Moreover, the treatment combination of spacing 30 cm with using 0 mg l^{-1} humic and application of 5 mg l^{-1} boric acid gives the highest mean value of the nods setting percentage, in the first experiment only.

Seed Yield and its Quality

Effects of Spacing

The results in Table(4) showed that broad bean plants that sowed at narrow spacing (10 cm) gave significantly the highest average of the total seed yield fed^{-1} and good seeds percentage as well as the lowest average of the poor seeds percentage, compared with the wider spacing (30 cm) in both experiments. On the other hand, the three spacing that used did not show significant differences in their effects on the seed protein content, in both experiments. This is actually expected based on decreasing spacing (increasing plant density) means increasing the numbers of growing plants per unit area. Similar results were reported by AL- Rifaee *et al*. (2004), Abdel Latif (2008), Dahmardeh *et al.* (2010), Bakry *et al.* (2011), Khamooshi *et al.* (2012) and Abd El-Azeem *et al.* (2014). In addition, these results are not in concordance with the findings of Luikham *et al.* (2009) in broad bean and Mekkei (2014) in faba bean for crude protein content.

Effects of Humic acid

Concerning the humic effects, the obtained results in Table (4) showed clearly that treating broad bean plants with HA acid levels at rate 1000 mg l^{-1} increased significantly average good seed percentage

Table 3: Interaction effects of spacing, humic acid and boric acid on growth and flowering characters of broad bean plants in the winter season of 2014/2015.

Spacing (cm)	Humic acid (mg l^{-1})	Boric acid (mg l^{-1})	First experiment: Plant height (cm)	Branches No plant^{-1}	Fresh mass plant^{-1} (g)	Earliness**	Nods setting percentage	Second experiment: Plant height (cm)	Branches No plant^{-1}	Fresh mass plant^{-1} (g)	Earliness	Nods setting percentage
10	0	0	82.1 c*	6.8 g	551.7 ijk	7.4 bc	49.4 g-j	77.3 b-f	7.5 c-f	655.0 c-f	7.8 abc	50.3 a
		2.5	89.7 b	6.0 g	552.8 ijk	7.0 bcd	66.3 abc	79.8 a-c	6.5 f	587.5 cfg	8.1 a	59.0 a
		5	90.0 b	6.3 g	489.9 k	7.0 bcd	63.5 a-d	84.3 abc	7.3 def	482.5 h	6.4 d-i	54.8 a
	1000	0	94.9 ab	6.5 g	496.1 k	7.0 b-e	45.8 ij	83.5 abc	7.0 ef	582.5 fg	6.6 c-i	53.3 a
		2.5	91.8 b	6.4 g	496.1 k	6.4 d-g	60.0 b-g	76.5 c-g	7.5 c-f	455.0 h	7.3 a-f	60.5 a
		5	100.4 a	5.9 g	383.3 l	7.0 bcd	52.2 e-j	87.8 a	6.8 f	492.5 h	7.2 a-g	51.5 a
	2000	0	92.9 b	6.2 g	603.9 f-j	8.6 a	46.3 ij	86.0 ab	6.8 f	590.0 efg	7.9 ab	55.3 a
		2.5	91.1 b	5.8 g	540.5 jk	7.6 b	42.0 j	81.5 a-d	7.0 ef	522.5 gh	6.8 a-h	49.0 a
		5	82.6 c	6.4 g	588.9 f-j	7.4 bc	55.3 c-i	80.3 a-e	6.8 f	587.5 efg	7.5 a-d	64.5 a
20	0	0	71.1 efg	8.0 f	642.8 d-h	6.8 b-f	44.7 ij	68.5 f-k	8.8 bcd	695.0 bcd	7.2 a-g	50.5 a
		2.5	80.3 cd	8.1 ef	601.7 f-j	6.6 c-g	54.1 d-i	66.3 g-l	8.5 b-e	620.0 def	7.3 a-f	55.3 a
		5	66.8 ghij	8.5 c-f	713.9 a-d	5.3 jk	70.5 ab	62.0 j-m	9.5 ab	662.5 cde	6.7 b-h	64.3 a
	1000	0	66.6 ghij	8.4 def	628.9 c-i	6.6 c-g	61.1 b-f	59.3 klm	9.0 abc	667.5 cd	6.6 c-i	58.8 a
		2.5	74.3 ef	8.4 def	670.0 b-f	5.1 k	51.6 f-j	69.3 f-j	9.0 abc	682.5 cd	6.9 a-h	52.3 a
		5	71.1 efg	8.0 f	558.3 h-k	6.4 d-h	58.6 c-h	64.5 h-m	8.8 bcd	692.5 bcd	7.4 a-e	64.0 a
	2000	0	73.7 ef	8.8 c-f	585.0 g-j	5.9 g-k	47.9 hij	73.8 d-h	9.3 ab	705.0 bc	6.4 d-i	50.0 a
		2.5	75.4 de	9.2 bcd	585.0 g-j	6.4 d-h	52.4 d-j	71.8 e-i	9.0 abc	695.0 bcd	7.0 a-h	53.3 a
		5	72.2 efg	8.6 c-f	753.3 ab	6.3 d-h	58.5 c-h	67.8 f-k	9.5 ab	522.5 gh	6.0 e-i	63.3 a
30	0	0	62.2 ijk	8.8 c-f	626.7 c-i	6.6 c-g	65.9 abc	60.3 j-m	9.8 ab	677.5 cd	6.0 f-i	56.3 a
		2.5	62.9 ijk	9.0 b-f	745.6 abc	5.4 jk	66.5 abc	60.3 j-m	9.8 ab	712.5 bc	5.9 ghi	63.0 a
		5	61.4 jk	9.1 b-e	661.1 c-g	6.1 e-j	74.7 a	57.0 lm	10.0 ab	765.0 ab	6.6 c-i	62.8 a
	1000	0	64.0 hij	10.0 ab	690.0 a-e	5.9 f-k	54.6 d-i	62.3 i-m	9.3 ab	672.5 cd	5.8 hi	55.8 a
		2.5	58.0 k	9.2 bcd	662.5 c-g	6.3 d-i	54.2 d-i	55.0 m	10.0 ab	680.0 cd	6.9 a-h	53.8 a
		5	62.7 ijk	9.5 bc	702.8 a-e	6.0 f-j	63.0 b-e	58.0 lm	10.0 ab	707.5 bc	6.6 b-i	57.8 a
	2000	0	63.0 ijk	8.7 c-f	725.0 a-d	5.5 h-k	49.3 g-j	62.3 i-m	9.3 ab	700.0 bc	5.3 i	67.8 a
		2.5	67.4 ghi	10.7 a	668.9 b-g	5.4 ijk	60.4 b-g	55.0 m	10.5 a	815.0 a	6.5 d-i	63.8 a
		5	69.2 fgh	9.4 bcd	763.9 a	6.1 e-j	60.3 b-g	61.8 j-m	10.0 ab	767.5 ab	6.0 f-i	56.3 a

**Earliness: the number of nodes up to first flower cluster.

*Values having the same alphabetical letter in common, within each character, do not significantly differ, using the revised L.S.D test at 0.05 level and decreased the percentage of poor seeds in the first experiment as well as increased significantly average total seed yield fed^{-1}, in the second experiment, compared with the lowest level (control). It has been reported that application of HA increased the growth and yields of various vegetable crops (Hayes and Wilson, 1997; Zandonadi *et al*. 2007).These results seemed to be in accordance with those reported by Abdel-Monaim *et al* (2011), Azarpour *et al* (2011), EL-Baz *et al.* (2012), Gad El-Hak *et al.* (2012). Also, Barakat *et al* (2015) who indicated that number of dry pods $plant^{-1}$, weight of 100 dry seeds and dry seeds yield $plant^{-1}$ and fed^{-1} of common bean plants were positively responded to application of potassium humate at rate 100 kg fed^{-1}.

Effects of Boron

Regarding the effects of boric acid, it was noticed that increasing the boric acid rates either2.5 or 5 mg l^{-1} was associated with increments in the average seed yield fed^{-1}, in the first experiment and the good seed percentage, in the second experiment (Table 4). In the case of poor seed percentage, in the second experiment, the medium rate of boric acid (2.5 mg l^{-1}) gave significantly lower values compared with control treatment. Similar results were reported by Harmankaya *et al.* (2008), Jasim and Amir, (2014) and Abd El-Azeem *et al.* (2014). Moreover, Moghazy *et al*. (2014) who found that the foliar application of B at concentration of 50 ppm was caused a significant increase in the number of pea pods, weight of pods $plant^{-1}$, and weight of pod, total green pod yield $fed^{-1}$and total dry seed yield compared to untreated plants. The seed protein percentage didn't affect significantly by application of boric acid, in the two experiments. Such finding was not similar with Hemantaranjan *et al.* (2000), Bellaloui *et al.* (2010) and Abou EL-Yazied and Mady (2012) they indicated that the foliar application of 50 ppm increased NPK, crude protein and total carbohydrate contents in the seeds.

Interaction Effects

The results illustrated the presence of some significant interaction effects of the second type among the three main studied factors on seed yield and quality characters (Table 5). The highest values of seed yield fed^{-1}, in the first experiment, were produced from the two treatment combinations of 10 cm spacing with control treatment of humic acid and 2.5 or 5 mg l^{-1} of boric acid. While, in the second experiment, the treatment combinations of the same spacing with 1000 mg l^{-1} of humic and 5 mg l^{-1} of boric acid, was achieved the highest seed yield fed^{-1}.On the contrary, the two treatment combinations of wide spacing (30 cm) with humic at rate 2000 mg l^{-1} and 0 mg l^{-1} boric acid and same spacing with 1000 mg l^{-1} and boric acid at rate 5 mg l^{-1} achieved the lowest values seed yield fed^{-1}; in the first and second experiment, respectively. Additionlly, in the first experiment, the treatment combinations of 10 cm spacing with 0 mg l^{-1} of humic and 2.5 mg l^{-1} of boric acid, as well as of 30 cm spacing with 1000 mg l^{-1} of humic acid and 0 mg l^{-1} of boric acid were achieved the highest and lowest values of good and poor seed percentages, respectively. While, in the second experiment, the same result was achieved from the treatment combinations that involving of 10 cm spacing with 1000 mg l^{-1} of humic acid and 2.5 mg l^{-1} of boric acid.However, the highest mean values of seed protein percentage were achieved from treatments combinations of medium spacing (20 cm) with using 1000 mg l^{-1} of humic and either of 5 or 2.5 mg l^{-1} of boric acid, respectively, in both experiments.

Table 4: The main effects of dry seed yield and its quality of broad bean plants as affected by spacing, humic acid and boric acid in the winter season of 2014/2015.

Treatments	First experiment				Second experiment			
	Seed yield ton fed^{-1}	Seed Grading: Good seeds (%)	Seed Grading: Poor seeds (%)	Seed protein (%)	Seed yield ton fed^{-1}	Seed Grading: Good seeds (%)	Seed Grading: Poor seeds (%)	Seed protein (%)
Spacing (cm)								
10	1.851 A*	90.4 A	9.6 C	32.0 A	1.774 A	90.2 A	9.8 B	22.0 A
20	1.709AB	87.4 B	12.6 B	33.2 A	1.659 AB	88.1 B	12.9 A	22.7 A
30	1.551 B	86.4 C	14.4 A	31.8 A	1.461 B	85.8 C	14.3 A	21.9 A
Humic acid (mg l^{-1})								
0	1.728 A	88.1 B	11.9 B	32.2 A	1.544 B	88.1 A	11.9 A	22.3 A
1000	1.693 A	89.2 A	11.5 B	33.1 A	1.701 A	88.0 A	12.1 A	23.0 A
2000	1.691 A	87.0 C	13.0 A	31.7 A	1.648 AB	87.1 A	13.0 A	21.4 A
Boric acid (mg l^{-1})								
0	1.590 B	88.4 A	11.5 A	32.0 A	1.638 A	87.2 B	12.8 A	22.0 A
2.5	1.770 A	88.1 A	11.9 A	33.0 A	1.606 A	88.1 A	11.9 B	22.6 A
5	1.751 A	87.8 A	12.2 A	32.0 A	1.650 A	87.8 A	12.2AB	22.2 A

*Values having the same alphabetical letter in common, within each character, do not significantly differ, using the revised L.S.D test at 0.05 level.

Table 5: Interaction effects of spacing, humic acid and boric acid on dry seed yield and its quality of broad bean plants in the winter season of 2014/2015.

Spacing (cm)	Humic acid (mg l^{-1})	Boric acid (mg l^{-1})	First experiment: Seed yield ton fed^{-1}	First experiment: Seed Grading – Good seeds (%)	First experiment: Seed Grading – Poor seeds (%)	First experiment: Seed protein (%)	Second experiment: Seed yield ton fed^{-1}	Second experiment: Seed Grading – Good seeds (%)	Second experiment: Seed Grading – Poor seeds (%)	Second experiment: Seed protein (%)
10	0	0	1.643b-e*	89.8 a-d	10.2g-j	35.3 ab	1.671 c-f	89.9 a-e	10.11-p	25.3 ab
		2.5	2.032 ab	92.0 a	8.0 j	30.9bcd	1.730 b-f	91.4 abc	8.6nop	20.7a-d
		5	2.368 a	90.7 abc	9.3 hij	31.3 bc	1.471 ef	90.4 a-d	9.6m-p	21.7 a-d
	1000	0	1.547 b-e	91.0 ab	9.0 ij	33.7 abc	1.773 b-e	87.7 f-k	12.3f-k	23.7abc
		2.5	1.976 abc	91.2 ab	8.8 ij	33.0 a-d	1.654 c-f	91.9 a	8.1 p	23.0 a-d
		5	1.727 b-e	90.7 abc	9.3 hij	32.7 a-d	2.238 a	89.7 b-f	10.3k-o	23.0 cd
	2000	0	1.736 b-e	89.5bcd	10.5ghi	28.7 cd	1.982abc	89.2 d-h	10.8 i-m	18.7 cd
		2.5	1.981 abc	90.7 abc	9.3 hij	31.1 bc	1.792 b-e	91.7 ab	8.3 op	21.0 a-d
		5	1.651 b-e	88.5 c-g	11.5 d-h	30.9bcd	1.654 c-f	89.9 a-e	10.1 l-p	21.0 a-d
20	0	0	1.544 b-e	87.0 e-h	13.0 c-f	34.8 ab	1.502 ef	86.7 j-n	13.3 d-g	24.7 ab
		2.5	1.668 b-e	86.7 f-i	13.3 b-e	33.5 a–d	1.513 ef	86.0 k-n	14.0 c-f	23.3 a-d
		5	1.457 de	87.5 d-h	12.5 c-g	31.9 a–d	1.646 c-f	87.5 g-l	12.5 e-j	22.0 a-d
	1000	0	1.713 b-e	88.8 b-f	11.2 c-i	30.1bcd	1.600 c-f	89.5 c-g	10.5 j-n	20.0bcd
		2.5	1.733 b-e	86.5 f-i	13.5 b-e	37.5 a	1.544 ef	87.5 g-l	12.5 e-j	26.0 a
		5	1.874 a-d	89.2 b-e	10.8 f-i	33.9 abc	2.080 ab	88.2 e-j	11.8 g-l	24.0abc
	2000	0	1.541 b-e	86.5 f-i	13.5 b-e	32.0 a–d	1.575 def	85.5 l-o	14.5 b-e	22.0 a-d
		2.5	1.962 abc	86.3 ghi	13.7bcd	34.7 abc	1.934 a-d	86.0 k-n	14.0 c-f	22.0 a-d
		5	1.886 a-d	88.5 c-g	11.5 d-h	30.5 bc	1.533 ef	87.5 g-l	12.5 e-j	20.7 a-d
30	0	0	1.716 b-e	85.3 hij	14.7 abc	27.4 d	1.485 ef	85.1 mn	15.0 bc	17.7 d
		2.5	1.448 de	87.5 d-h	12.5 c-g	30.5 bc	1.445 ef	88.9 d-i	11.2h-m	20.7 a-d
		5	1.674 b-e	86.0 hi	14.0 bc	34.5 abc	1.437 ef	87.4 h-l	12.7 e-i	24.7 ab
	1000	0	1.564 b-e	92.0 a	8.0 j	30.8 bc	1.603 c-f	84.7nop	15.4 abc	21.0 a-d
		2.5	1.482 cde	89.5bcd	10.5 ghi	33.5 a-d	1.465 ef	86.9 i-m	13.2 d-h	23.7abc
		5	1.617 b-e	84.3 ij	15.7 ab	32.4 a-d	1.355 f	85.7 k-o	14.4 b-e	22.3 a-d
	2000	0	1.310 e	85.2 hij	14.8 abc	34.8 abc	1.550 def	87.2 h-l	12.9 e-h	24.7 ab
		2.5	1.648 b-e	83.0 j	17.0 a	32.7 a–d	1.372 f	82.7 p	17.4 a	22.7 a-d
		5	1.504 cde	84.5 ij	15.5 ab	29.9 bc	1.437 ef	83.9 op	16.2 ab	20.0bcd

*Values having the same alphabetical letter in common, within each character, do not significantly differ, using the revised L.S.D test at 0.05 level

CONCLUSION

It is concluded that sowing broad bean plants at 10 cm with the application of humic acid at rate 1000 mg l^{-1} and foliar application of boric acid at rate 5 mg l^{-1} was leading to obtain the highest dry seed yield fed^{-1}as average of two experiments, under conditions of Bangar El Sokar region - Borg Al-Arab – Alexandria.

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الملخص العربى

تأثير مسافة الزراعة والتسميد بالهيوميك والبورون على النمو وانتاج وجودة البذور في الفول الرومي

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أجريت تجربتين حقليتين في مزرعة خاصة بمنطقة بنجر السكر– برج العرب– الإسكندرية خلال الموسم الشتوي ٢٠١٥/٢٠١٤، لدراسة تأثير ثلاثة مسافات زراعة(١٠، و٢٠، و٣٠سم)، والمعاملة بثلاثة تركيزات لحمض الهيوميك (صفر، و١٠٠٠، و٢٠٠٠ملليجرام/لتر)، والرش بثلاثة معدلات لحمض البوريك(صفر، ٢,٥ و٥ ملليجرام / لتر)علي صفات النمو الخضري، ومحصول البذور وجودته فيالفول الرومي. أظهرت النتائج بصفة عامة أن مسافات الزراعة كان لها تأثير واضح على كل الصفات المدروسة على الفول الرومي في هذه الدراسة. حيث اعطت مسافة الزراعة الواسعة (٣٠ سم) في التجربة الأولى أعلى القيم المعنوية لمتوسط عددالأفرع/نبات، والكتلة الطازجة/نبات(جم) وإلى زيادة في التبكير ونسبة العقد، بالإضافة الى ذلك فقد حققت أقل القيم لمتوسط ارتفاع النبات(سم)، في التجربتين، بينما حققت مسافة الزراعة الضيقة بين النباتات(١٠ سم) أعلى القيم لمحصول البذور للفدان، ونسبة البذور الجيدة، وذلك في كلا التجربتين.

أدت معاملة نباتات الفول الرومي بحمض الهيوميك الى زيادة معنوية في ارتفاع النبات، وعدد الأفرع/ نبات في التجربة الأولى، من ناحية أخرى أدى إضافة ٢٠٠٠ ملليجرام/ لترمن حمض الهيوميك الى تحقيق أعلى القيم لمتوسط الكتلة الطازجة للنبات يتبعه تركيز ١٠٠٠ ملليجرام/ لتر في كلا التجربتين، وإلى انخفاض في نسبة العقد في التجربة الأولى. كذلك أوضحت النتائجإن استخدام١٠٠٠ ملليجرام/ لترمن حمض الهيوميك كان قد أعطى أعلىالقيم لمتوسط محصول البذور للفدان، ونسبة البذور الجيدة، وأقل قيمة لنسبة البذور الهزيلة في التجربة الأولى.

أظهرت النتائج أن معاملة النباتات بـــ ٢,٥ ملليجرام / لترمن حمض البوريك أعطىأعلى قيم لمتوسط ارتفاع النبات (سم) في التجربة الأولى. كذلك بينت النتائج أن زيادة حمض البوريك من ٠ إلى ٥ ملليجرام / لتر أدى إلى انخفاض الكتلة الطازجة للنبات(جم) في التجربة الثانية، وإلى زيادة في التبكير ونسبة العقد في التجربة الأولى، من ناحية أخرى كانارتفاع تركيز حمض البوريك إلى ٥ ملليجرام / لتر مصحوبا بزيادة في محصول البذور/ الفدان في التجربة الأولى، وزيادة في نسبة البذور الجيدة في التجربة الثانية. بناء على ما سبق يمكن التوصية بزراعة الفول الرومي على مسافة ١٠سم، والرش بحمض الهيوميك بتركيز ١٠٠٠ ملليجرام في اللتر، والرش الورقي بحمض البوريك بتركيز ٥ ملليجرام للتر للحصول على أعلى انتاجية من محصول البذور الجافة للفدان، وبجودة عالية وذلك تحت ظروف منطقة بنجر السكر- ببرج العرب – الاسكندرية.