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ORIGINAL ARTICLE

GROWTH AND YIELD OF CAULIFLOWER AS AFFECTED BY BORON AND FERTILIZER TYPE

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Abstract: Synthetic fertilizers can cause environmental problems when used in long term. It is necessary to use other types of materials to fertilize plants. Application of boron to leaves of cauliflower can increase yield. The experiment was conducted in Babylon city, Iraq, to determine effects on growth and yield of cauliflower (*Brassica oleracea* var. *botrytis* L.). The experiment included application of boron at 30 mg.L^{-1}, to foliage, the control was no boron. Also, commercially available liquid urea at 1 g.L^{-1}; humic acid at 5 mL.L^{-1}, Higro Amin-L at 5 mL-L^{-1}, and Maxinim at 5 mL.L^{-1} were applied to soil. Heads were harvested before opening. The interaction between boron and humic acid increased plant height, number of leaves per plant, leaf area per plant, curd diameter, curd weight, total curd yield, dry matter percent of curds, and contributed to the highest percent nitrogen and boron in curds.

Key words: Borax, Organic fertilizer, Urea, Vegetable production

1. Introduction

Cauliflower (*Brassica oleraceae* var. *botrytis* L.) requires balanced and sufficient supply of nutrients for better growth and higher yield. The flower head (curd) contains a good amount of vitamin B and a fair amount of protein, P, K and vitamin A and C [Hassan (2003)]. Boron is an essential micronutrient required for normal plant growth and development, and plants differ widely in their requirements but ranges of deficiency and toxicity are narrow. The B concentration in soil varied widely with soil type and environment [Troeh and Thompson (1993)]. Application of boron to leaves of cauliflower, or addition to soil as borax, improves vegetative growth, benefits nutrient content, and increases yield [Matlob *et al.* (1989), Singh (2003), Adhikary *et al.* (2004), Hegazy and Abdel-bary (2008), Bhat *et al.* (2010), Chander *et al.* (2010), Al-Rashedy (2012), Kamal *et al.* (2013), Al-Habar and Al-Rashidy (2014)].

The beneficial effect of addition of organic matter containing mineral nutrients to soil for improved growth of plant, balanced fertilizers through organic and inorganic sources improve soil health [AL-Taey (2017), Al-Taey and Al-Musawi (2019)]. Macronutrients play a role in growth and development of plants. Nitrogen encourages root development and provides energy by forming ATP and potassium play a role in carbohydrate metabolism, enzyme activation and osmotic regulation [Shaheen *et al.* (2007), Al-Taey and Saadoon (2014)]. Urea increased nitrogen percent in curds of cauliflower [Al-Sahaf *et al.* (2012)]. Addition of vermicompost and foliar application of humic acid increased plant height, number of leaves, curd diameter and curd yield of cauliflower [Srimathi (2015)]. Addition of poultry manure increased number of leaves, average of curd weight and curd yield in cauliflower [Al-Shimmery *et al.* (2016)]. Seaweed extract and rice residuals increased plant height, number of leaves, leaf area and head diameter in broccoli [Manea and Abbas (2018)].

As an alternative to synthetic materials, organic fertilizer can supply soil with adequate levels of macro- and micro-nutrients and folic and humic acids which releases phosphorus and potassium and increases their absorption [Ati and Al-Sahaf (2007), AL-Bayati, *et al.,* (2019), Manae *et al.* (2019)]. Organic fertilizers cause less environmental damage than synthetic fertilizers [Dong-Chu *et al.* (2008)]. Humic acid applied to cauliflower plants increase number of leaves and curd

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weight [Mejwel *et al.* (2013)].

Boron is one of the eight essential micronutrients, deficiency of boron can cause brown-heart of cauliflower and tardy production of small heads, Generally, boron becomes less available to plants with increasing soil pH foliar application a suitable strategy for agricultural application of treatment this deficiency. Use of chemical fertilizers may affect soil health and limit sustainable production of some vegetables. The study was undertaken to determine effects of application of boron, liquid organic fertilizer, or urea on growth and yield of cauliflower.

2. Materials and Methods

This experiment was carried out at the College of Agriculture, University of AL-Qasam Green, Babylon, Iraq, during 2015. Prior to the beginning of the experiment, random soil samples from 0-30 cm were obtained and analyzed at the Department of Horticulture, to determine soil physical and chemical properties (Table 1).

Seeds of the cv. White Cloud were placed in cells of seedling trays containing peat moss on 22 Aug. 2015. Seedlings were fertilized twice with 1 g·L^{-1} of liquid poultry litter extract (4N-1P-5K). Trays were placed in a greenhouse, and irrigated weekly with 1 L of water per tray. In a field the sandy loam soil was prepared by disking once, and furrow beds 2.5 m in length and 0.75 m wide, with 2 beds per plot, were constructed with 0.75 m between treatments. Irrigation tape with 20 cm between emitters, spaced 40 cm between irrigation lines, was placed in the field prior to planting and beds were covered with black polyethylene (150 µ thick).

When seedlings were 10-13 cm in height, and with 4 or 5 true leaves, they were moved to the field on 6 October 2015. Seedlings were planted by hand at distance of 40 cm between plants, there were 16 plants in each plot. Treatments were: application of borax (17.4% boron) at 30 mg.L^{-1} or without boron. Fertilizer treatments were urea 46% at 1 g.L^{-1}; humic acid at 5 mL.L^{-1}; Higro Amino (Ekobjikarim, Ankara, Turkey) at 5 mL-L^{-1} and Mainim (Ekobjikarim) at 5 mL-L^{-1} (Table 2).

Boron was applied to plant leaves, organic liquid fertilizers or urea were added to the soil, the boron and organic fertilizers were added in equal splits at 6 November 2015, 6 December 2015 and 6 January 2016. The experiment was arranged in a split plot within a randomized complete block design with boron as the main plot treatment and fertilizer treatment as the sub-plot with 3 replications. Curds were harvested when they on 10 March 2016. Ten plants were tagged and assessed for: plant height, number of leaves per plant, plant leaf area, curd diameter, curd weight, total curd yield, curd dry matter percent, and percent nitrogen and boron in curds.number leaves per plant, leaf area per plant and head diameter (Table 3).

The interaction of application of boron and fertilizer affected all growth parameters (Table 4).

The plant highest, greatest leaf area per plant, and head diameter were with boron and humic acid. The most leaves per plant was with boron and humic acid and Higro Amin and Maxinim. The lowest number of

Table 1: Physical and chemical properties of the sandy-loam soil.

Clay %	Silt %	Sand %	Exchangeable K (mg.kg^{-1})	Available P (mg.kg^{-1})	Total N (mg.kg^{-1})	Organic matter%	EC (dS.m^{-1})	pH
19	16	65	1.9	9.8	76	1.7	3.95	7.03

Table 2: Characteristics of liquid organic fertilizers.

Material	pH	Organic matter	N	K_2O	Humic or folic acid	Amino acid	Company	Country
Maxinim	5.5	30%	3%	3%	None	None	Ekobjikarim	Turkey
Higro Amin-L	4.0	24%	6%	None	None	9%	Ekobjikarim	Turkey
Humic acid	6.0	25%	None	6%	21%	None	Mil-Tar	Turkey

Table 3: ANOVA responses due to boron spraying, fertilizer, and their interaction on plant height, number of leaves per plant, leaf area per plant and curd diameter.

Source	Plant height (cm)	No. leavesper plant	Leaf areadm^2/plant	Curd diameter(cm)
Boron (B)	ns	*	*	ns
Fertilizer (F)	*	*	*	*
Interaction (B×F)	*	*	*	*

ns, * not significant or significant at $p < 0.05$, ANOVA.

Table 4: Interaction effect[a] due to boron and fertilizers on plant height, number of leaves per plant, leaf area per plant and curd diameter.

Boron	Fertilizer	Plant height (cm)	No. leaves per plant	Leaf area (dm^2/plant)	Curd diameter (cm)
0 ($mg.L^{-1}$)	Urea	46.96 abcd	18.33 cde	32.55 e	42.00 e
	Humic acid	47.90 abc	21.00 ab	47.15 b	47.00 b
	Higroamin	44.10 bcd	19.00 bcd	35.21 d	42.67 de
	Maxinim	45.06 abcd	17.33 e	34.53 d	44.00 cd
30 ($mg.L^{-1}$)	Urea	48.53 ab	20.67 ab	34.59 d	42.33 e
	Humic acid	49.43 a	21.66 a	50.21 a	50.33 a
	Higroamin	44.80 abcd	21.33 a	37.27 c	46.33 b
	Maxinim	44.70 abcd	22.00 a	35.42 d	44.33 c

[a] data in the interaction analyzed with Least Squares Means and means separated with Least Significant Differences.
[b] values followed by the same letter are not different at the 5% levels.

Table 5: ANOVA responses due to application of boron, fertilizer, and their interaction on curd weight, total yield, curd dry matter, N and B percent in curds.

Source	Curd weight(g)	Total yield ($t.ha^{-1}$)	Curd drymatter (%)	N (%)	B (%)
Boron (B)	*	*	*	*	*
Fertilizer (F)	*	*	*	*	*
Interaction (B×F)	*	*	*	*	*

ns, * not significant or significant at $p < 0.05$, ANOVA.

Table 6: Interaction effect[a] due to application of boron and fertilizer on curd weight, total yield, curd dry matter, N and B percentage in curds.

Boron	Fertilizer	Curd weight (g)	Total yield ($t.ha^{-1}$)	Curd dry matter (%)	N (%)	B (%)
0 ($mg.L^{-1}$)	Urea	650 cd	21.77 d	8.21 de	3.52 b	2.06 g
	Humic acid	825 b	27.67 ab	11.11 b	3.19 bc	2.90 b
	Higroamin	700 bcd	23.73 cd	8.91 d	2.83 d	2.37 de
	Maxinim	750 bc	22.26 cd	8.46 de	2.24 e	2.15 fg
30 ($mg.L^{-1}$)	Urea	750 bc	23.73 cd	9.37 cd	3.95 a	2.26 ef
	Humic acid	984 a	29.96 a	13.14 a	3.51 b	3.05 a
	Higroamin	742 bc	24.46 cd	11.09 b	3.45 b	2.54 c
	Maxinim	709 bcd	25.16 bc	10.62 b	2.95 cd	2.41 d

[a] Data in the interaction analyzed with Least Squares Means and means separated with Least Significant Differences.
[b] Values followed by the same letter are not different at the 5% levels.

leaves per plant, leaf area and head diameter were achieved without boron and urea, while the lowest plant height was achieved without boron and higroamin. In brief, plants heights were generally not different, the exception was for the combination of boron and humic acid being taller than no boron and Higroamin. All plants treated with boron and all fertilizers had the same number of leaves and plants treated with boron and urea were similar to those without boron treated with humic acid which was also similar to the no boron and higroamin treatment. Plants with the greatest leaf area and curd diameter were treated with boron and humic acid. Application of boron on number of leaves and leaf area may be attributed to the role of boron in increased cell division and growth, increased uptake of nutrients and transfer of sugars in the plant through cellular membranes [Al-Sahaf (1989), Bhat *et al.* (2010)] leading to increased numbers of leaves, increased length and width of the leaf blade, and increased leaf area per plant. Application of humic acid increased plant height, numbers of leaves, leaf area and head diameter which may be due to supplying soil with humic acids which increase soil nutrients as nitrogen phosphorus, potassium and other, which affects plant growth and development and yields [Ati and Al-Sahaf (2007)]. These results agreed with [Burhan and Al-Taey (2018)] increase nutrient uptake and synthesis of porphyrins in synthesis of chlorophyll [Farhan *et al.* (2008)].

The ANOVA indicated that application of boron or fertilizer and their interaction affected measured variable (Table 5). Application of boron or fertilizer, and their interaction, affected curd weight, total yield, curd percent dry matter, and percent nitrogen and boron in curds (Table 6). The highest curd weight, total yield of curds, curd percent dry matter and percent boron were due to treatment with application of boron and humic

acid. The highest nitrogen percent was for the combination of boron and urea (Table 6).

The lowest head weight, total yield, curd percent dry matter, and percent boron were achieved without boron and urea, while the lowest percent nitrogen was achieved without boron and Maxinim. In brief, Plants with the highest curd weight and curd dry matter were treated with boron and humic acid. Treatments which produced the highest yield were those treated with humic acid with and without boron. Those without boron and treated with humic acid was similar to those treated with boron and Maxinim which were also similar to other treatments with and without boron. Plants with the highest N were treated with boron and urea. Plants with the highest B were treated with boron and humic acid. Better yield for cauliflower can be achieved provided that optimal fertilizer and boron management is followed.

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