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The Effect of Boron, Humic Acid and Interference on Water Productivity and Yield of Cauliflower (Brassica Oleracea)

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Abstract : **An experiment has been carried out at field in Gardmalla/Qushtapa with reading GPS (longitude 440035E, Latitude 360023N) ,414 meter above sea level, 15.5 Km far Southern of Erbil city during the Winter season of 2017 to test the effect of application humic acid in soil and spraying boron on the growth and productivity of water on cauliflower. Factorial experiment 3 (humic acid) (0, 10 and 20 kg ha-1 using) × 4 (boron foliar) (0, 0.5, 1.0, and 2.0 kg B ha-1) using solid snow cultivars in RCBD with three replicates.**

Planting solid snow cultivars was done on 10/7/2017 (seeding date), 10 /8 /2017 (transfer to field) and 22/12/ 2017 picking or harvesting date. Irrigation water was applied at 35% depletion to the depth of total plant root and calculate the depth of water applied up to field capacity. Irrigation system is surface flow irrigation through line pipe provided with meter gages for measuring water applied.

The results show that the application of boron and humic acid increase significantly all growth and yield parameters of cauliflower improved the highest values of leaf length (cm), leaf width (cm) and chlorophyll content (mg/cm2), recorded 47.67 cm, 28.45 cm and 40.66 mg/cm2; 75.39 cm, 37.55 cm and 43.11 mg/cm2 and 80.0 cm, 40.29 cm and 47.33 mg/cm2 in treatment 2 kg ha-1 of boron foliar and 0, 10 and 20 kg ha-1 of humic acid addition, respectively. The values of curd weight (kg), curd diameter (cm) and total yield (Mg/ha) values were 0.97 kg, 19.45 cm and 25.38 Mg/ha; 1.33 kg, 22.33 cm and 32.66 Mg/ha and 1.40 kg, 23.78 cm and 36.53 Mg/ha in treatment 2 kg ha-1 of boron foliar and 0, 10 and 20 kg ha-1 of humic acid application, respectively. Values of water productivity (Kg/m3) ranged between 6.25 to 12.18 Kg fresh (green) curd m-3 water applied.

Key word: Boron Foliar, Humic Acid, Water Productivity, Cauliflower

I. INTRODUCTION

Micronutrients are defined as substances that are crucial for crop growth; however, they are used in lower amounts as compared the macronutrient, such as N, P and K [1],[2] have reported that foliar application of microelements improves the effectiveness of macronutrient. All around the world, boron shortage is more common than the shortage of other micro elements [3]. As well as boron's taking part in growth of the plant, boron also takes part in many physiological and biochemical incidents that occur in plant. [4] listed the roles of boron as; 1. the functions of boron on sugar transmission, 2. cell-wall synthesis, 3. lignifications, 4. cell wall structure, 5. carbohydrate metabolism, 6. RNA metabolism, 7- respiration, 8. indole acetic acid (IAA) metabolism, 9. phenol metabolism and 10. membranes [5]. Boron shortage can be observed in the soil which is the lack of organic substance, moisture content and high in lime has generally thin texture. The higher lime content and reaction in soil decrease boron intake. [6] , [7] , [8] . Due to these reasons, plants are unable to benefit from boron in the soil. When B level in the soil gets 1.0 ppm and gets enough 1.5 ppm, it has toxic effects. Therefore, an application with precision scale can be applied in fertilization.

[9] study the effects of foliar applications of boron humate and calcium humate are investigated on yield, quality and biochemical content of cauliflower. Effects of boron humate and calcium humate applications on vitamin C, pH, total soluble solid dry matters, % dry matter, plant height, curd diameter, curd yield, number of leaves and mineral composition of plants were investigated.

Soil organic matter is one of the important soil components that affects soil reactions such as form of ion uptake by plants [10]. OM also effect plant growth by increasing the improvement of photosynthesis system, micro and macro element uptake and changing in growth of root cells [11]. Vegetables are the important components of our daily diet and they serve as the rich sources of nutrients, vitamins and minerals. Cauliflower is of Cyprus and Mediterranean origin. It is cultivated extensively in tropical and temperate regions of the world viz., China, Germany, India, Indonesia,

Japan, Korea, Poland, Russia, Taiwan, Turkey, Ukraine, USA, Uzbekistan, Iraq and several other countries, this study was conducted to investigate:

1. The effect of foliar application of boron on yield and yield components of cauliflower.
2. The effect of soil application of humic acid on quality parameters of cauliflower and water productivity.
3. The interaction of foliar application of boron and humic acid in yield of cauliflower and water productivity.

II. Material and Methods

Field experiment has been carried out at Gardmalla/Qushtapa with reading GPS (longitude 440035E, Latitude 360023N) ,414 meter above sea level, 15.5 Km far Southern of Erbil city. The texture of the soil is silt clay loam during season 2017. Some soil characteristics (Table 1) were determined according to Black (1965a,b). The mean rainfall is 30.2 mm during Cauliflower growing season. This study includes the following treatments:

1. Four treatments included 4 rates of boron 0, 0.5, 1.0, and 2.0 kg B ha^{-1} using boric acid (17%B). These rates were applied in different split applications namely 2, 4, 6, and 8 treatments.
2. Three levels of humic acid (H_0= 0.0, H_1=10, H_2=20) kg ha^{-1} using.

The experimental treatments arranged in Randomize Complete Block Design with three replicates. The main plots were assigned to humic acid treatments, whereas a fertilization boron treatment was assigned to the sub plots**.** Planting solid snow cultivars was done on 10 / 7/2017 (seeding date), 10 /8 /2017 (transportation to field) and 22 / 12/ 2017 picking or harvesting date. The area of each plot was 6 m^2 (3×2), plants spaced 0.40 m × 0.80 cm between rows. Plots were separated 2 m from each other. And all agriculture practices for growing wheat were applied as recommended.

The amounts of applied irrigation water (m^3 ha^{-1}) depended gravimetrically methods. Irrigation water was applied at 35% depletion to the depth of total plant root and calculate depth of water applied up to field capacity. Irrigation system was surface flow irrigation through line pipe provided with meter gages for measuring water applied. The amount of water depth was calculated according to [12]

$$\boldsymbol{d = (\theta_{fc} - \theta_w) \times D} \ldots\ldots\ldots\ldots (\mathbf{1})$$

Where:

d = Depth of water added

D = The irrigation root zone depth (cm)

θ_{fc} = Soil moisture at field capacity (cm^3 cm^{-3})

θ_w = Soil moisture before irrigation (cm^3 cm^{-3})

Table1. Some Physical and Chemical Characteristics of Studies Soil

Physical Characteristic		Value	Unite
Texture	Sand	184	g kg^{-1}
	Silt	450	
	Clay	366	
	Silt clayloam		
Bulk Density	1.31		*Mg* m^{-3}
Particle density	2.64		*Mg* m^{-3}
Water Content 0.33 bar	32%		
Water Content 15 bar	19%		
Chemical properties			
pH	7.5		
EC	0.8		dSm^{-1}
O.M	14		g kg^{-1}
Total (N)	11		*mg* L^{-1}
Available (P)	7.5		
Available (K)	340		
Equivalent $CaCO_3$	330		g kg^{-1}
Active $CaCO_3$	15.2		
CEC	29.3		Cmolc kg^{-1}

At harvest time, a sub sample of 10 plants has been taken from each plot to measure number of leaves per plant, leaf length (cm); leaf width (cm); chlorophyll content (mg/cm2); curd weight (kg); curd diameter (cm). Total yield calculated from one meter area and then converted to Mg/ha, also water productivity is determine according to [12] as following equation:

$$water\ productivity = \frac{yield\ (kgh^{-1})}{Total\ water\ applied\ (mm)} \ldots\ldots (2)$$

The Statistical Package for the Social Science (SPSS, IBM 2007)[13] program is used of the effect of differences factors in study parameters. LSD (0.05) test is used to significant as compared between the percentages in this study.

III. Results and Discussion

Results of number of leaves per plant, leaf length (cm), leaf width (cm) and chlorophyll content (mg/cm^2) are increased significantly with the amount of boron applied and humic acid addition (Table 2) and improved the highest values of number of leaves per plant, leaf length (cm), leaf width (cm) and chlorophyll content (mg/cm^2) recorded 26.33, 28.47 and 30.33 leaves per plant in 0, 10 and 20 kg ha^{-1} of humic acid addition + 2 kg ha^{-1} of boron foliar, respectively. And recorded 47.67 cm, 28.45 cm and 40.66 mg/cm^2; 75.39 cm, 37.55 cm and 43.11 mg/cm^2 and 80.0 cm, 40.29 cm and 47.33 mg/cm^2 in treatment 2 kg ha^{-1} of boron foliar and 0, 10 and 20 kg ha^{-1} of humic acid addition, respectively. This can be due to the role of boron fertilization in plant physiology especially at flowering and grain filling.[2] good nodules formation [14] and due to proper management for the crop. And the role of humic acid in increase the growth of plant and efficiency in uptake the necessary nutrients. In other hand, because the available of nutrients in organic fertilizer (humic acid) this mean, to increasing the amount absorbed by plants and transferd to curd.

Table 2. The Effects of Humic Acid and Boron Application on Parameters Growth of Cauliflower and Chlorophyll Content

Humic Acid kg ha^{-1}	Boron kg ha^{-1}	Number of Leaves/plant	Leaf Length (cm)	Leaf Width (cm)	Chlorophyll Content (mg/cm^2)
0	0	18.45	37.67	24.33	37.15
	0.5	22.67	40.42	25.89	38.74
	1	25.88	43.12	26.45	39.11
	2	26.33	47.67	28.45	40.66
10	0	21.67	67.87	31.23	41.32
	0.5	24.33	70.22	34.23	42.45
	1	27.21	73.16	36.41	42.78
	2	28.47	75.39	37.55	43.11
20	0	24.11	71.22	37.74	44.27
	0.5	26.32	74.29	38.75	45.65
	1	29.65	76.78	39.44	46.86
	2	30.33	80.00	40.29	47.33
LSD (0.05)	Boron	0.58	1.21	0.86	0.14
	Humic Acid	1.01	1.98	1.52	0.93
	Boron× Humic Acid	1.34	2.88	2.13	1.05

Results of yield Cauliflower parameters and WUE (Table 3) indicate the importance of boron application for good yield and better utilization of water, this can be attributed to the role of micronutrients and humic acid fertilization in improving crop resistance to water stress and other stresses [15]. The values of curd weight (kg), curd diameter (cm) and total yield (*Mg*/ha) recorded 0.97 kg, 19.45 cm and 25.38 *Mg*/ha; 1.33 gm, 22.33 cm and 32.66 *Mg*/ha and 1.40 gm, 23.78 cm and 36.53 *Mg*/ha in treatment 2 kg ha^{-1} of boron foliar and 0, 10 and 20 kg ha^{-1} of humic acid application, respectively as compared with the control treatment (0.0 kg ha^{-1} of boron foliar and 0 kg ha^{-1} of humic acid addition) recorded 0.85 kg, 18.31 cm and 24.37 *Mg*/ha, respectively.

Table 3. The Effect of Humic Acid and Boron Application on Yield Parameters of Cauliflower and Water Productivity

Humic Acid kg ha^{-1}	Boron kg ha^{-1}	Curd Weight (kg)	Curd Diameter (cm)	Total Yield *Mg* /ha	Water Productivity Kg/m^3
0	0	0.85	18.31	24.37	6.25
	0.5	0.88	18.62	24.86	6.30
	1	0.92	19.21	25.00	6.33
	2	0.97	19.45	25.38	6.43
10	0	0.95	20.10	27.65	8.13
	0.5	1.09	20.67	28.86	8.49
	1	1.12	21.46	30.33	8.92
	2	1.33	22.33	32.66	9.61
20	0	1.20	20.37	31.17	10.39
	0.5	1.29	21.34	33.11	11.04
	1	1.33	22.56	34.45	11.48
	2	1.40	23.78	36.53	12.18
LSD (0.05)	Boron	0.12	0.76	0.42	0.13
	Humic Acid	0.19	1.38	1.26	1.46
	Boron× Humic	0.27	1.92	1.64	2.17

Values of water productivity (Kg/m^3) range between 6.25 to 12.18 Kg fresh (green) curd m^{-3} water applied.

Studies of the water requirements of cauliflower are almost limited in Iraq, especially in the Kurdistan region. In this study found that the water requirement of cauliflower = 395 mm (0 kg ha^{-1} of humic acid addition) to decreases to 340 mm and 300 mm when addition humic acid 10 and 20 kg ha^{-1}, respectively. This gives an idea about the role of the organic fertilization (humic acid) to reduce the values of the depth of water added as well as reducing the water requirement of the crop. This signifies the economic justification for this application.

Therefore, it can be concluded that proper humic acid and boron foliar application with good crop management can achieve good productivity and high WUE under north of Iraq conditions. Thus, the influence of organic matter such as humic acid on availability and movement of nutrient in soil and plant require further investigations.

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