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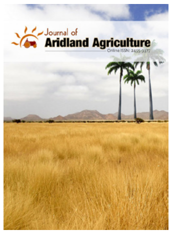
Research Article



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Effect of boron on the yield of wheat (*Triticum aestivum* L.) under center pivot sprinkler irrigation system in the West Desert of Iraq

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ABSTRACT

Two field experiments were conducted under field conditions under a sprinkler irrigation system in the West desert of Iraq, Al-Qaim Area, 400 km west of Baghdad. Underground water was used as a source of irrigation water to study the effect of different rates and different times of boron application on wheat cv. Ibaa99. RCBD with five treatments and three replications was used in this study. Boron dose was 2 kg/ha for soil application method and 0.30 kg/ha for foliar application method. Boron treatments were: 0 (control T1), 2 kg B ha^{-1} at sowing time (T2), 2 kg B ha^{-1} at 30 days after sowing (T3), 0.3 kg B ha^{-1} foliar application at 60 days after sowing (T4) and 0.3 kg B ha^{-1} for foliar application at 90 days after sowing (T5). Most boron treatments gave a significant increase as compared with control in morphological, physiological and productivity characters of wheat crop. The results revealed that B application treatment at 30 days after sowing time increased significantly the 1000 grains weight (17.6%) while T5 treatment increased significantly the chlorophyll content (12.41%) over control. In most cases, B application treatment at 60 days after sowing time showed the best results and increased significantly the plant height (5.24%), leaf area (9.18%), number of grains $spike^{-1}$ (30.9 %), number of spike m^{-2} (18.8%), spike length (65.6%), Grains yield (34.6%) over control. There was evidence that the best dose of boron was 0.3 kg B ha^{-1} and the best time of B application to the foliage was at 60 days after sowing.

KEY WORDS: Wheat, boron, wheat yield, dry areas, west desert

INTRODUCTION

Wheat crop is one of the most important and strategic grain crops in the world. It has an economical importance. In addition, wheat grains contain high levels from protein, starch, substantial amounts of essential vitamins, minerals and trace elements etc. Iraq is suffering from high deficient in food production, especially wheat production. There are a lot of problems facing wheat agriculture In Iraq, one of these problems is: few farmers use micronutrients to increase the productivity of the crops including wheat. Each micronutrient has its own function in plant growth.

In a study (Ejaz *et al.* 2011) on the issue of water use efficiency in case of its limitations, agriculture, where drought problems are one of the most important problems that limit grain production worldwide. Effective water management, and there are factors that impede the growth of plants and their abilities to photosynthesis by disturbing the balance between production, including reactive oxygen species and antioxidant defense, and causing the accumulation of reactive oxygen species that stimulate oxidative stress of proteins, membrane fats and other cellular components, and a number of methods have been used to enhance the efficiency of use. Water and reducing the harmful impact of water stress on crop plants through proper plant nutrition is a good strategy to enhance water use efficiency and productivity in crop plants. Plant nutrients have been found to play a very important role in enhancing water use efficiency in light of limited water supplies, and the use of efficient techniques possible in improving Efficient use of water, some

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macronutrients (nitrogen, phosphorous, potassium, calcium, and magnesium), and micronutrients (zinc, boron, iron, manganese, molybdenum and chloride) and the importance of these nutrients and their role in improving water use efficiency in crop plants.

The drought stress is a dangerous abiotic factor in nutrient acquisition via roots and limiting production of cereal crops in least developed countries in Asia, and that balanced fertilization can improve photosynthetic activity by stabilizing activity. superoxide dismutase, improve proline, abscisic acid, improve proline, and show higher activities of SOD, compared to ineffective genotypes by accumulation of larger nutrients through taller and thinner root system with high efficiency. Under severe drought with low nutritional status, the rate of photosynthesis, especially water use efficiency (WUE) increases genotype efficiency in ineffective parameters, and thus, the physiological and morphological parameters lead to better performance through efficient use of water. Under drought, use of NPK soil along with foliar spray of zinc (Zn), boron (B) and manganese (Mn) increases the grain yield as well as the grain's micronutrient concentration. The rate of photosynthesis, pollen vigor, number of fertile outgrowths, and number of grains per spike are increased by late foliar application of these micronutrients, and this indicates that by increasing foliar application of zinc (Zn), boron (B), and manganese (Mn) when it can reduce the adverse effects of drought that often occur during the late stages of cereal production in least developed countries in Asia, and it can be concluded that soil application of zinc, especially in the flowering stage, is a stress-reducing approach. These findings are highly relevant to farmers' practices, the manufacture of fertilizers that expand service, and put pressure on drought in Asian coastal fields, and there are a few recommendations aimed at expanding scientific knowledge to create more room to support drought mitigation.

Sidhu and Kumar (2018) explained in the study of the effect of adding boron to soils in limestone soils suffering from boron deficiency, three soils of varying calcium carbonate content, 0.75% (soil 1), 2.6% (soil 2), and 5.7%,(Soil 3) collected from various sites of Ludhiana, Bathinda and Shri Muktsar Sahib, Punjab, India. Transactions consist of six levels of Soil cleansing boron. 0.5, 0.75, 1.0, 1.25, 1.5 and 2.0 mg B kg^{-1} and the yield of green fodder and dry matter production increased significantly at 0.75 mg with kg B 1 soil treatment level in the first plots while these were Significantly at 1.0 mg B kgi1 level of soil treatment in all types of soil in the second and third stage, the fourth mind. Of all the three limestone soils, I soils have the least soil Calcium carbonate was the best soil in terms of average yield in comparison To Soil II and Soil III. The combined effect of boron level and soil was significant The effect on the yield of alfalfa. There was a significant increase in dry root mean Biomass at 1.0 mg B kg at soil level above control then remained insignificant

With other high levels of boron applied to the soil. Means dry root the biomass decreased significantly in the soil, at 0.75%, 2.6% and 5.7%, Calcium carbonate levels. It is considered an easily soluble fraction The available fraction of B for plant uptake consists of 0.47-0.62% in soil I,0.31 - 0.43% in soil 2 and 0.24 - 0.34% in soil III of total boron.

Faisal and Farooq (2019) considered that the wheat crop system is one of the most important crop systems in South Asia, and the sustainability of this system is threatened due to several factors, including the lack of micronutrients, especially zinc (Zn), boron (B) and manganese (Mn) as one of the main problems., Continuous rotation of rice and wheat, unbalanced use of fertilizers and little / no use of micronutrients, unbalanced fertilizer use leads to depletion of organic matter and degradation of soil structure resulting in decreased efficiency of macro, micro and micronutrients (Zn, B and Mn) and The ability of plants to absorb nutrients and utilize them with several plant factors such as root geometry, root filaments, transport kinetics parameter and root secretions, crop management and application can help microelements in correcting micronutrient deficiency and enhancing grain concentration.

Use Spray Irrigation Systems in wide range in the west desert of Iraq may help us to conduct our study under desert conditions. Two separate field experiments were conducted under center-pivot sprinkler irrigation system in west desert of Iraq to study the effect of B application on morphological, physiological and productivity characters of wheat crop. To find the best:

1) Method of B application to wheat crop
2) Application time with B to wheat crop.

Experimental Site

Al-Anbar province locates in west of Iraq in desert area, latitude 33.3786 and longitude 43.7158 (22 N., long. 43 deg. 49 E) and occupied an area of 140000 km^2 (32% of Iraq area). Two field experiments with wheat crop were conducted under field conditions under sprinkler irrigation system in west desert of Iraq, Al-Qaim Area, 400 km west of Baghdad (Figure 1). Underground water was used as a source of irrigation water. Both experiments were conducted under the fourth axle of the irrigation system. Soil was plowed and cultivated well. The seedbed was prepared well for the whole site of both experiments. Experiments soil and irrigation water samples tested and analyzed before conducting the experiments, According to Page (1982) and Sarkar *et al.* (2007), soil samples were taken in depth of 0-20 cm.

Fertilizer Treatments

DAP fertilizer N: P (12:38) was applied at rate of 200 kg/ha as N and P_2O_5 in the form of urea and single superphosphate respectively. Potassium sulfate (K_2O 42%) was applied at rate of 130 kg/ha. Both fertilizers were added to all plots including controls pre planting. N fertilizer (urea 46% N) was given to both experiments (72kg/ha) in three batches during the growth stages through the irrigation system (Table 1). Boron dose, Borax ($Na_2B_4O_7$ $10H_2O$, analytical reagent grade with 10.5% B was used a source of B fertilizer. Boron dose was 2 kg/ha for soil application method and 0.30 kg/ha for foliar application method.

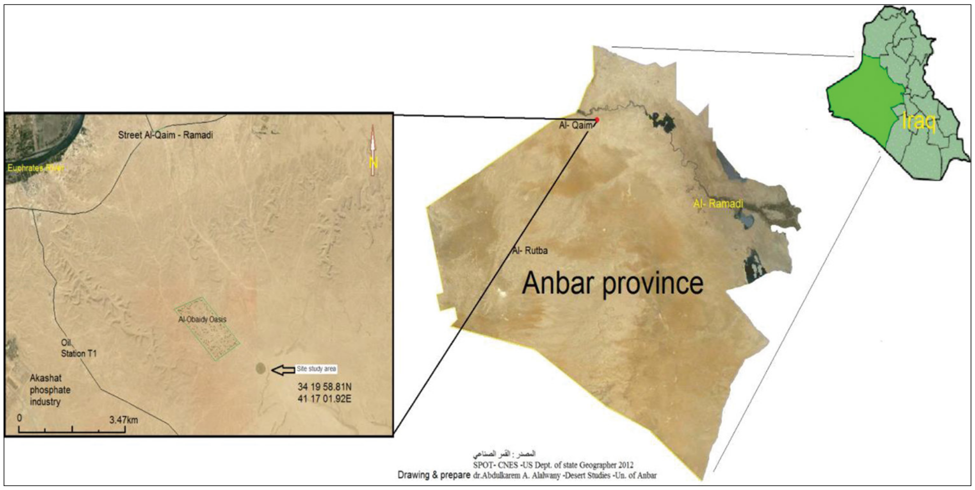

Figure 1: The experimental site in west desert of Iraq

Table 1: The time table of some agricultural operations

No.	Agricultural operations	Rate
1	Spraying with Humic acid (pH 4-6, O.M. 25%, K_2O 3%) through irrigation system	8 l/ha
2	First dose of urea fertilizer (N 46%) through irrigation system	32 kg/ha
3	Spraying with Hort Green (soluble fertilizer N: *P* (17:44) through irrigation system	5kg/ha
4	Second dose of urea fertilizer (N 46%) through irrigation system	20 kg/ha
5	Third dose of urea fertilizer (N 46%) through irrigation system	20 kg/ha
6	Primo Nutrient (N: P_2O_5:K_2O: MgO 20:20:20:3) through irrigation system	0.250 kg/ha
7	Spraying with Humic acid (N 3%, K_2O 6%, O.M. 15%, volvic acid 3%) through irrigation system	0.50 kg/ha

Table 2: The randomized distribution for the treatments in each experiment

Experiment 1		
B1	B2	B3
T1	T4	T2
T3	T1	T5
T4	T3	T1
T2	T5	T4
T5	T2	T3
Experiment 2		
B1	B2	B3
T4	T2	T5
T2	T1	T3
T5	T3	T1
T1	T4	T2
T3	T5	T4

Experimental Design

Each experiment was conducted in randomized complete block design (RCBD) with three replicates. Size of plot was 3x5m^2. (Figure 2). All the treatments were arranged and signed randomly in each block (replicate) (Table 2). There were five treatments in each experiment to test the hypothesis proposed for B nutrition in wheat crop:

T1 = Control (No addition)
T2 = 2kg B/ha at sowing stage (broadcasting).
T3 = 2kg B/ha at 30 days after sowing (broadcasting).
T4 = 0.300 kg B/ha at 60 days after sowing (spray).
T5= 0.300 kg B/ha at 90 days after sowing (spray).

One meter as a space was left surrounding each plot to avoid any risk for transferring spraying solution from plot to each other (Figure 2). Ibaa 99 wheat variety was chosen in this study. On November 15, 2018 wheat seeds were sown by hand according to recommended rate (160 kg/ha). Thirty, 60 and 90 days were chosen because those means: crown root initiation, maximum tillering and pre flowering stage respectively. As the quantity of borax needed for soil application was very small 3 gm/plot, it was mixed well with sufficient quantity of finely ground dry soil and the mixture spread uniformly all over the specified experimental plots for treatments T2 and T3 (Sarkar *et al*., 2007). Solutions were prepared one day before the treatments. Plastic hand sprayer (5 liters) was used for this purpose. On 15th, January, 2019 (60 days after sowing), foliage of plots for treatment (T4) for both experiments were sprayed with 0.300 kg B/ha. And on 15th, February, 2019 (90 days after sowing) plots of treatment (T5) for both experiments were also sprayed with same concentration of Boron, Figure 2, Project team during Field work to prepare for the cultivation of the crop.

Measurements

To test the effect of B on wheat growth to see the differences among the treatments, on 25th March, 2019 (130 days after sowing) data for some morphological characters like plant height and leaf area was measured and collected by selecting 10 plants from each replication randomly in a zigzag fashion and then averaged per each plant for each character. Leaf area for flag leaf was measured and calculated according to Thomas (1975).

Leaf area (cm^2) = Leaf length (cm) X Leaf width (cm) X 0.95, At the same day, the leaf chlorophyll content was determined using Portable Chlorophyll Meter (CCM-220 plus). The SPAD

Figure 2: Project team during Field work to prepare for the cultivation of the crop within the sectors of experience

reading was taken from the flag leaf by selecting 10 plants from each replication randomly in a zigzag fashion. Each value was the mean of 3 replications. On 18th May 2019, one-meter square area from center of each plot was chosen and harvested by hand individually and separately to measure and calculate the following parameters: number of grains per spike, total weight of 1000 grains, spike length, number of spikes per meter square and total grains yield (t ha^{-1}).

Agricultural Operations

Irrigation water continued from underground water through the pivot irrigation system. Irrigation water was given more than 40 times. Hand weeding was done at 21 days after sowing. The most important agricultural operations were given to whole experiments through the irrigation system as described in Table 1. Table 3 shows some weather conditions in the field area during November, 2018 to February, 2019.

Statistical Analysis

The collected data analyzed statistically and adjusted with (LSD) at 5% level of significance (Steel, 1980).

RESULTS

Tables 4 & 5, show results of soil and water analysis for both experiments (in same site) according to Black (1965), Blake *et al.* (1986) and Blak and Hartge (1986). Most boron treatments resulted in a significant improvement in all studied parameters (Tables 6-13).

Plant Height

Boron application has increased plant height in all the treatments as compared to control (Table 6). Maximum plant height (64.42 cm) was significantly achieved with the application of 0.3 kg B ha^{-1} to the foliage at 60 days after sowing time (T4) (5.24 % increase over control). Data showed that minimum value in plant height per plant (61.21, 62.06 cm) was observed in control and in treatment where B was applied at sowing time (T2).

Table 3: Weather conditions from 15th November, as extracted from the records of the official metrological sub-station Al-Qaim field station

Month	Temperature ^{0}C Max. Min.	Rainfall (mm)
November, from 15-21,	20.4 10	13.7
22-30,	18.8 9	
December,	17.8 6.4	37
January First week	15.9 4.4	40.8
Second week	12.6-2.4	
Third week	18.5 4	
Fourth week	17.3 7.1	
February First week	16.9 6.4	16.5
Second week	17.7 6.9	
Third week	19 6.7	
Fourth week	22.4 8.3	

Chlorophyll Content

Generally higher values were observed in treatment (T5) where 0.3 kg B/ha was applied to the foliage at 90 days after sowing time (12.41 % increase over control) (Table 7). Minimum chlorophyll content was observed in control and treatment (T2) where 0.3 kg B/ha was applied at 30 days after sowing time. T5 alone in both experiments recorded significant increase compared with control treatment.

Leaf Area

In general, boron application has increased leaf area per plant for the flag leaves in all the treatments as compared to control (Table 8). Maximum leaf area per plant (41.17 cm^2) was

Table 4: Some chemical and physical characters of soil pre planting

Characters	Soil depth 0-20 cm	Unit
EC	3.21	dsm^{-1}
pH	7.6	-
Gypsum	43.24	gm kg^{-1}
NO_2	0.108	Ppm
NO_3-N	17.4	Ppm
Na	176.9	Ppm
Cl	403.6	Ppm
K	21.9	Ppm
SO_4	416.3	Ppm
HCO_3	376.2	Ppm
Ca	260.7	Ppm
TDS	1750	Ppm
Bulk density	1.58	mg m^{-3}
Texture	SCL*	-
Very fine	180.65	gm kg^{-1}
Fine	192.16	gm kg^{-1}
Medium	107.80	gm kg^{-1}
Coarse	79.22	gm kg^{-1}
Very Coarse	21.17	gm kg^{-1}
TOTAL SAND	581.00	gm kg^{-1}
Fine	116.97	gm kg^{-1}
Medium	27.60	gm kg^{-1}
Coarse	49.33	gm kg^{-1}
TOTAL SILT	193.90	gm kg^{-1}
CLAY	225.10	gm kg^{-1}

* SCL = sandy clay loam

Table 5: Some chemical characters of irrigation water

Characters	Value	Unit
EC	2.1	dsm^{-1}
pH	7.2	-
NO_2	0.05	Ppm
NO_3-N	19	Ppm
Na	150.8	Ppm
Cl	292.1	Ppm
K	15.4	Ppm
SO_4	445.3	Ppm
HCO_3	109.8	Ppm
Ca	215.0	Ppm
TDS	1283	Ppm

achieved with the application of 0.3 kg B ha^{-1} at 60 days after sowing time (T4) (9.18 % increase over control). Data showed that minimum value in leaf area per plant (37.71, 37.86 cm^2) was observed in control and in treatment where B was applied at sowing time (T2). The leaf area was observed with wide range varied from 37.71 cm^2 to 41.17 cm^2 at 130 days after sowing time.

Number of Grains per Spike

B application improved number of grains $spike^{-1}$ in all four stages for both experiments, but B application at 60 days after sowing time (T4) has significantly increased number of grains per spike from 37 to 48.42 grains by 30.9% as compared to control (Table 9).

1000 Grains Weight

Data presented in Table 10 revealed that maximum 1000 grains weight was obtained by the application of B at 30 days after sowing time (T3) (34.3 gm) followed by B application at 60 days after sowing stage (T4) (34.1 gm). Both T3 and T4 treatments had significant difference with control in both experiments. The lowest 1000 grains weight was observed in control treatment (T1) (29.3 gm).

Number of Spike m^{-2}

Boron application significantly increased number of spike m^{-2} over control in treatment T4 for both experiments (Table 11). Maximum number of spike was observed in treatment (T4) (363.5 spike) where 0.3 kg B ha^{-1} was applied by spraying to the foliage at 60 days after sowing time (18.8% increase over control). Data showed that minimum number of spikes was observed in control (306 spike) and in treatment (T2) where B was applied at sowing stage (332 spike). In general, there was no significant difference between boron treatments (T2, T3 and T5) in both experiments.

Table 6: Effect of boron and its time of application on plant height (cm) of wheat

Treatments	Experiment 1	Experiment 2	Mean	% increase over control
T1=Control (no addition)	61.12	61.30	61.21	-
T2=2 kg boron/ha at sowing	62.01	62.11	62.06	1.39
T3=2 kg boron/ha 30 days after sowing	63.88	63.14	63.51	3.76
T4=0.3 kg boron/ha 60 days after sowing	65.68	63.16	64.42	5.24
T5=0.3 kg boron/ha 90 days after sowing	64.62	62.18	63.40	3.58
LSD at 5%	2.002	2.130	-	-

Table 7: Effect of boron and its time of application on chlorophyll content (SPAD value) in flag leaf of wheat

Treatments	Experiment 1	Experiment 2	Mean	% increase over control
T1=Control (no addition)	30.07	31.01	30.54	-
T2=2 kg boron/ha at sowing	32.01	31.64	31.83	4.22
T3=2 kg boron/ha 30 days after sowing	32.47	31.33	31.90	4.45
T4=0.3 kg boron/ha 60 days after sowing	32.38	32.75	32.57	6.65
T5=0.3 kg boron/ha 90 days after sowing	35.27	33.39	34.33	12.41
LSD at 5%	3.07	1.88	-	-

Table 8: Effect of boron and its time of application on flag leaf area (cm2) of wheat

Treatments	Experiment 1	Experiment 2	Mean	% increase over control
T1=Control (no addition)	36.75	38.67	37.71	-
T2=2 kg boron/ha at sowing	37.80	37.92	37.86	0.40
T3=2 kg boron/ha 30 days after sowing	37.43	38.79	38.11	1.06
T4=0.3 kg boron/ha 60 days after sowing	44.80	37.53	41.17	9.18
T5=0.3 kg boron/ha 90 days after sowing	38.29	43.00	40.65	7.80
LSD at 5%	3.66	2.46	-	-

Table 9: Effect of boron and its time of application on number of grains spike^{-1} of wheat

Treatments	Experiment 1	Experiment 2	Mean	% increase over control
T1=Control (no addition)	35.33	38.67	37.00	-
T2=2 kg boron/ha at sowing	39.50	41.10	40.30	8.9
T3=2 kg boron/ha 30 days after sowing	43.37	43.00	43.19	16.7
T4=0.3 kg boron/ha 60 days after sowing	47.50	49.33	48.42	30.9
T5=0.3 kg boron/ha 90 days after sowing	40.30	42.33	41.32	11.7
LSD at 5%	9.11	5.87	-	-

Table 10: Effect of boron and its time of application on 1000 grains weight (gm) of wheat

Treatments	Experiment 1	Experiment 2	Mean	% increase over control
T1=Control (no addition)	28.70	29.80	29.30	-
T2=2 kg boron/ha at sowing	30.60	32.60	31.60	7.8
T3=2 kg boron/ha 30 days after sowing	28.80	35.80	34.3	17.1
T4=0.3 kg boron/ha 60 days after sowing	33.90	34.30	34.1	16.4
T5=0.3 kg boron/ha 90 days after sowing	31.07	32.80	31.9	8.9
LSD at 5%	2.30	3.63	-	-

Table 11: Effect of boron and its time of application on number of spike^{-2} of wheat

Treatments	Experiment 1	Experiment 2	Mean	% increase over control
T1 = Control (no addition)	302	310.0	306.0	-
T2 = 2 kg boron/ha at sowing	335	329.0	332.0	8.5
T3 = 2 kg boron/ha 30 days after sowing	341	345.7	343.4	12.2
T4 = 0.3 kg boron/ha 60 days after sowing	366	361.0	363.5	18.8
T5 = 0.3 kg boron/ha 90 days after sowing	326	350.0	338.0	10.5
LSD at 5%	39.94	31.59	-	-

Table 12: Effect of boron and its time of application on spike length (cm) of wheat

Treatments	Experiment 1	Experiment 2	Mean	% increase over control
T1 = Control (no addition)	6.9	5.9	6.4	-
T2 = 2 kg boron/ha at sowing	7.5	7.3	7.4	15.6
T3 = 2 kg boron/ha 30 days after sowing	7.1	7.2	7.2	12.5
T4 = 0.3 kg boron/ha 60 days after sowing	10.3	10.8	10.6	65.6
T5 = 0.3 kg boron/ha 90 days after sowing	8.7	9.0	8.9	39.0
LSD at 5%	1.74	2.25	-	-

Table 13: Effect of boron and its time of application on grain yield (ton ha^{-1}) of wheat

Treatments	Experiment 1	Experiment 2	Mean	% increase over control
T1 = Control (no addition)	3.608	3.661	3.634	-
T2 = 2 kg boron/ha at sowing	3.971	4.081	4.026	10.8
T3 = 2 kg boron/ha 30 days after sowing	4.467	4.496	4.482	23.3
T4 = 0.3 kg boron/ha 60 days after sowing	4.881	4.902	4.892	34.6
T5 = 0.3 kg boron/ha 90 days after sowing	4.112	4.147	4.130	13.6
LSD at 5%	0.298	0.315	-	-

Spike Length

Similarly spike length was significantly increased with application of boron in treatments T4 and T5 compared with control. Maximum spike length (10.6 cm) was observed with spraying of 0.3 kg B ha^{-1} on foliage of wheat at 60 days after sowing (T4) (65.6% increase over control). The lowest length was observed in control treatment (6.4 cm) (Table 12).

Grain Yield

Wheat grain yield was significantly increased by the boron application over control in both experiments (Table 13). The significantly highest grain yield of 4.892 t ha^{-1} was obtained with spraying of 0.3 kg B ha^{-1} on foliage of wheat at 60 days after sowing (T4) (34.6% increase over control), followed by 4.482 t ha^{-1} with application of 2 kg B ha^{-1} at 30 days after sowing (T3) (23.3% increase over control). The lowest increase over control were 10.8 and 13.6 % were recorded with applied 2 kg B ha^{-1} (T2) at sowing and 0.3 kg B ha^{-1} at 90 days after sowing (T5).

DISCUSSION

Under desert conditions with underground irrigation water, most boron treatments, gave significant increase in morphological, physiological and productivity characters of wheat crop as compared with control. it is found in most cases that wheat crop was more response to foliar application with boron at 60 days after sowing than the application in early or late stages, this gives an important suggestion to give boron in the right dose, in the right time and in the right way. Indeed, boron was supplied with two methods in this study: direct broadcasting to the soil, and by foliar sprays. This depending on many factors: nature of soil, growth stage of crop, B dose and application time. Most researchers working in this issue observed an edge for foliar spray over the soil application. This is mainly due to three reasons: foliar spray requires a lower rate than soil application, it ensures uniform spread over the crop canopy and crops respond immediately for rapid recover (Mortvedt, 2000). Indeed, boron treatments increased grains yield from 3.634 t ha^{-1} to 4.892 t ha^{-1}, this achievement (34.6 % increase over control) was in corroboration with the findings of Halder *et al.* (2007). The higher yield of wheat as obtained with B treatments agree well to the findings of Ahmed *et al.* (2008) and Debnath *et al.* (2011). Boron is necessary for reproductive growth.

Huang *et al.* (2000) found that boron deficiency limits reproductive growth more than vegetative growth for cereal such as wheat. The higher yield of wheat as obtained with B treatments agrees also with other findings in Bangladesh (Ahmed *et al.*, 2008; Debnath *et al.*, 2011) and in Thailand (Rerkasem *et al.*, 1989).

This study gave an indicator that control treatments resulted low grains number per spike compared with boron treatments, because boron is required for normal development of reproductive tissues and deficiency results in low grain set or poor seed quality (Dell *et al.*, 2002). These findings are in agreement with Rerkasem *et al.* (1993) who found that B deficiency depresses grain yield mainly through male sterility, causing grain set to fail. Moreover, grain set of wheat is closely correlated with B concentration in the ear (Rerkasem & Lordkaew, 1992). This may be due to provision of B is one of the essential micronutrients at growing stage to enhance the accumulation of assimilate in leaves and thus resulting higher grains yield of wheat compared with control treatment, it is probably because of B has its role in grain formation (Asad & Rafique, 2000). These results are also in agreement with Hussain and Yasin (2004) and Khan *et al.* (2006) who reported significant increase in 1000 grains weight with foliar application of micronutrients. The reason for increased growth characters in wheat crop (e.g. plant height, leaf area etc.) seems to be presence of B at required stages of plant growth. Indeed, these investigations indicated vital and important role for B like any major plant nutrient (e.g. nitrogen). The ability of B in increasing chlorophyll content in leaves may be related to the vital role of boron in increasing translocation of some nutrient elements like N and P.

CONCLUSIONS

Boron increased quantity of wheat yield for Ibaa99 variety under desert conditions. There was evidence that the best dose of boron was 0.3 kg B ha^{-1} and the best time of B application was at 60 days after sowing. Further work is needed under field conditions to test effect of boron on more varieties in wide range of experiments.

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