Boron irrigation effect on germination and morphological attributes of *Zea mays* cultivars (*Cv.Afghoee & Cv.Composite*)

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Abstract
The present investigation was mainly intended to evaluate the effect of different concentrations of boron in irrigation water on *Zea mays* cultivars *(Cv.Afghoee & Cv.Composite)*. The results revealed that with increasing boron concentration, the percentage emergence and growth of the seedlings of *Zea mays (Cv.Afghoee & Cv.Composite)* decreased markedly. In case of *Cv.Afghoee* maximum percentage germination (95%) was recorded in treatments T1 (control) and T2 (1ppm B) while minimum germination (65%) occurred in T4 (3ppm B) treatment, while in *Cv.Composite* maximum percentage germination (100%) was observed in T1 and T2 (control & 1 ppm B respectively) treatments and minimum percentage germination (95%) was recorded in T4 (3ppm B) treatment respectively. In the pot experiment all the growth parameters (shoots length, roots lengths, oven dry weight of shoots and roots and numbers of leaves) were significantly affected by varying concentration of Boron. Thus it can be stated that with increasing boron concentration the seed germination and growth of both the cultivars of *Zea mays (Cv.Afghoee & Cv.Composite)* decreased markedly.
Key Words:-
Boron concentration, seedlings emergence, seedling growth, *Zea mays* L.

Introduction

Boron is essential for plants but at low concentration in environment. [1 & 2]. The amount of B in soil could be either the favorite effecter or source of toxicity [3]. Similarly, Boron deficiency may occur due to naturally low concentrations of boron in the soil and it is the second most widespread micronutrient problem and dicotyledon species tend to be more sensitive to Boron deficiency than germinaceous crops [4]. Plants uptake of boron from irrigation water is relatively small [5]. Boron toxicity may occur due to naturally high concentrations in the soil, the over use of B fertilizer or the continued use of irrigation waters high in soluble salts, including Boron. Boron is often found in high concentration in association with saline soils [6]. Irrigation water is the most important contributor to high levels of soil B [7]. The usual criteria for the determination of the quality of irrigation water are the concentration and composition of dissolved constituents in it. Richards [8], has listed various characteristics which determine the quality of irrigation water. Irrigation quality must be considered not only with regards to its immediate effect on soils and crops but also with regard to the welfare of consumers. Pesticides, pathogens and even some naturally, occurring water constituents may not affect the crops directly but may affect animals or humans and so are equally important criteria of water quality [9 & 10]. To illustrate this with an example, let us assume that the goal is for a stream to be used for irrigation of crops. For that to be feasible, the water should have certain quality characteristics including limited boron content. The scientists found that sensitive crops will be protected adequately from the harmful effects of boron if its concentration in irrigation water is maintained at 750 µg/liter or less. Thus, the quality criterion of 750 µg/liter boron can be used to judge, at least partly, the suitability of that water for irrigation. The effects of boron, for example, may vary widely, depending on other chemicals present in water, synergistic action between those chemicals and boron, the type of crop involved, temperature, pH, and other environmental factors. Boron and Ca application had beneficial effect on symbiotic interaction between legume and rhizobia under saline condition [11].

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Materials & Methods

Seed germination

For germination experiment 10 healthy seeds of each cultivar of *Zea mays (Cv.Afghoee & Cv.Composite)* were placed in each of the Petri dish having filter papers containing about 10 ml solution of relevant treatment (T1= control, T2= 1ppm B, T3= 2ppm B, T4= 3 ppm B). Each treatment had 8 replicates. The Petri dishes were arranged in a Randomized Block Design. The emergence of the radical from the seed coat was taken as the index of the germination of the seeds. Germination of seeds was noted daily. The experiment was terminated after ten days,

Seedlings growth

For this experiment 22 cm wide clay pots were used and their central drainage holes were unplugged so that the water drained freely out of these. Garden compost was used as soil culture medium and pots were arranged in a Complete Randomized Block Design in a wire netting house at Botanic Garden, Bahauddin Zakariya University, Multan, Pakistan. Each treatment had 8 replicates. Sowing of *Zea mays* cultivars was done on March 31, 2013. At the two leaves stage only one plant was allowed to grow and the others were removed (Thinning). First harvest was taken after 26 days of sowing, while the second harvest was taken after 30 days of 1st harvest. The data obtained in both the experiments was subjected to ANOVA [12].

Results

Figures I and II show that germination started on 2nd day after the start of experiment. The rate of germination was much faster in T1 and T2 treatments (Control and 1 ppm B treatment) as compared to other treatments. In treatment T 4 (3 ppm B) the rate of germination was *very* low. In case of *Cv. Afghoee* (Fig. I) maximum percentage germination (95%) was recorded in treatments T1 and T2 while minimum germination (65%) occurred in T4 treatment , while in the case of *Cv. Composite (Fig. II)* maximum percentage germination (100%) was observed in T1 and T2 (control & 1 ppm B) treatments and minimum percentage germination (95%) was recorded in T4 (3ppm B) treatments.

Statistical analysis revealed that there were non-significant differences in shoot length under different treatments (Table 3). In case of *Cv. Afghoee* maximum shoot length was observed in T3 treatment (Table 1) and in case of *Cv. Composite* it was observed in T1 treatment (Table 2). Whereas, reverse was observed for root length i.e. *Cv. Afghoee* had more root length at T1 treatment but *Cv. Composite* showed maximum root length at T3 treatment of boron (Table 1 & 2). By applying ANOVA it was concluded that there was only significant variation in root length of both cultivars *(Cv.Afghoee & Cv.Composite)* at harvest II, whereas all other attributes (harvest I, treatments and Interaction) showed non-significant variation with respect to root length (Table 3).

ANOVA for the dry weight of shoot revealed highly significant differences for interaction of cultivars under different treatments whereas all other differences were non-significant. Shoot dry weight of both cultivars *(Cv.Afghoee & Cv.Composite)* at T3 treatment were greatest (Table 1, 2 & 3). Statistical analysis revealed significant variation in dry weight of root among cultivars (H-I, Table 3). Root dry weights of both cultivars (*Cv.Afghoee & Cv.Composite*) were more at T3 treatment Table (1 & 2).

ANOVA revealed highly significant differences in number of leaves among cultivars and their interaction under different treatments. Maximum numbers of leaves of both cultivars *(Cv.Afghoee & Cv.Composite)* were recorded at T2 treatment (Table 1, 2 & 3).

Discussion

The main aim of the experiment was to investigate the effects of different concentrations of boron in irrigation water on seed germination of *Zea mays* cultivars *(Cv.Afghoee & Cv.Composite)*. Different concentrations of boron in irrigation water were applied to both cultivars of Zea mays *(Cv.Afghoee & Cv.Composite)* to investigate their effect on the germination. It was investigated that the *Cv.Afghoee* & *Cv.Composite* respond differently to different concentration of boron in irrigation water. In the present study the plants like *Zea mays* (Cv. *Afghoee* and *Composite)* could not show good growth at high concentration (3 ppm) of boron. However there was significant variation in different growth parameters of both cultivars of Zea mays *(Cv.Afghoee & Cv.Composite)*. These results are in conformity with the work of Nable, [5] and Paull *et al.,* [13], who stated that there were significant differences in plant responses to different soil boron level. The consistent decrease in percentage seed germination with the increase in concentration of boron in the present study is in line with the findings of Yau and Saxena [14] who stated that when plants were subjected to high boron concentration from germination than this might have rendered the effects of boron toxicity more severe than they would have been in the field. The behavior of two plant species was different in different treatments. Results revealed that maximum shoot length was occurred at T3 treatment. This is in accordance with the findings of Yau and Saxena [14] that plant height increased as soil B level increased however when soil B level was increased there was no increase in flag leaf width, length or area as for barley [15]. Similarly, Boron toxicity significantly decreased leaf biomass, RGR_L, organic N, soluble proteins, and NR and NiR activities [16].

From the results it was concluded that shoot dry weight of both cultivars of Zea mays *(Cv.Afghoee & Cv.Composite)* decreased with the increase in concentrations of boron. This is also in accordance with the findings of Yau and Saxena [14] that there was a linear decrease in shoot dry weight at tillering stage with increasing B levels. The results revealed that soil B level had a significant effect on shoot B concentration. According to Yau and Saxena [14], there is a linear increase in shoot B concentration and a linear decrease in shoot dry weight at tillering with increasing Boron levels. Root dry weight of both cultivars *(Cv.Afghoee & Cv.Composite)* almost remained constant and initially there was decrease and then up and down trend in root weight with the passage of time. High concentrations of B in the soil resulted in a significant reduction in yield [17], a problem that is wide spread throughout the cereal growing districts of Southern Australia [16]. Irrigation quality must be considered not only with regards to its immediate effect on soils and crops but also with regard to the welfare of consumers. Boron toxicity may occur due to naturally high concentrations of Boron in the soil, the over use of Boron fertilizer or the continued use of irrigation waters high in soluble salts. Irrigation water is the most important contributor to high levels of soil Boron [7].

Results of this study suggest that Boron has a remarkable effect on various growth parameters of plants and plants growth is retarded by the increase concentration of Boron in soil and irrigation water.

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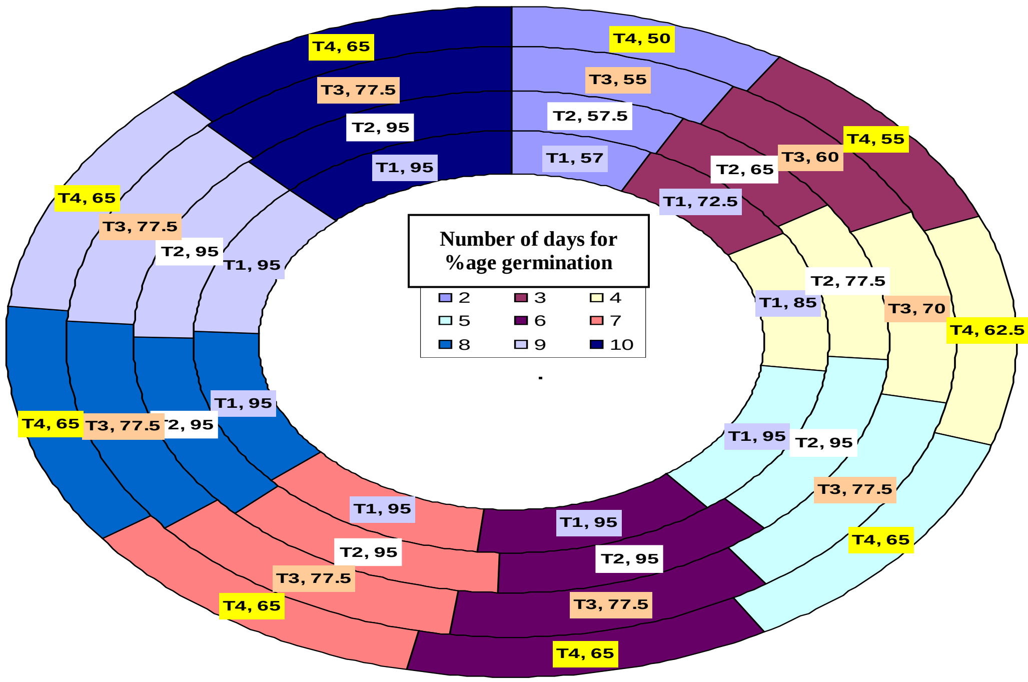

Fig. I: Mean values for %age germination of *Cv. Afghoee* under different concentrations of Boron.

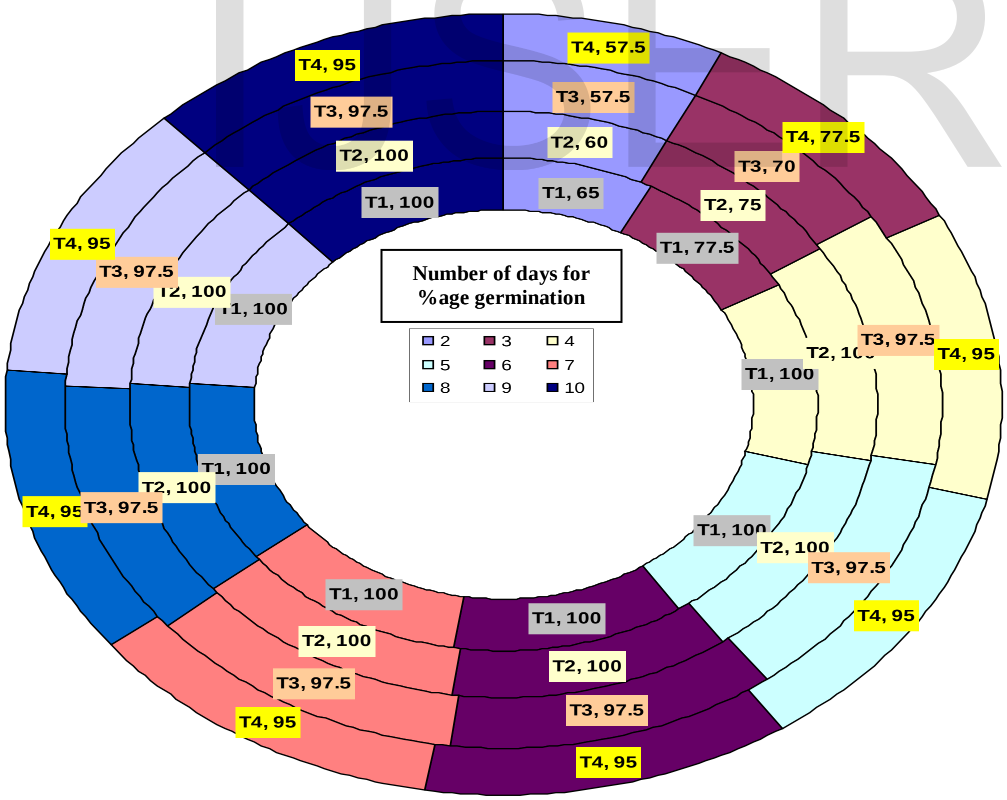

Fig. II: Mean values for %age germination of *Cv. Composite* under different concentrations of Boron.

Table 1: Mean (± S.E) of various growth parameters of Zea mays (*Cv.Afghoee*) under different boron concentrations at harvest 1st and harvest 2nd.

Treatments	Harvests	Shoot lengths (cm)	Root lengths (cm)	Shoot dry weight (gm)	Root dry weight (gm)	Leaves number
T1	**H-I**	52.42 ± 8.87	38.05 ± 2.98	0.93 ± 0.28	1.48 ± 0.08	6.25 ± 0.23
	H-II	80.30 ± 5.07	58.80 ± 0.73	6.21 ± 0.10	3.48 ± 0.06	10.00 ± 0.90
T2	**H-I**	44.92 ± 4.14	37.00 ± 5.10	0.90 ± 0.10	1.30 ± 0.03	6.25 ± 0.23
	H-II	76.20 ± 1.78	58.57 ± 1.84	5.54 ± 1.27	3.56 ± 0.68	10.25 ± 0.63
T3	**H-I**	55.20 ± 5.61	36.57 ± 0.48	0.71 ± 0.21	1.27 ± 0.57	6.50 ± 0.64
	H-II	89.00 ± 1.18	62.30 ± 2.34	4.88 ± 0.67	4.45 ± 2.22	8.75 ± 0.49
T4	**H-I**	52.25 ± 2.09	36.77 ± 4.86	0.53 ± 0.09	1.30 ± 0.02	6.25 ± 0.49
	H-II	82.00 ± 0.29	52.35 ± 2.69	4.78 ± 0.36	2.54 ± 0.09	8.50 ± 0.64

Table 2: Mean (± S.E) of various growth parameters of Zea mays (*Cv.Composite*) under different boron concentrations at harvest 1st and harvest 2nd.

Treatments	Harvests	Shoot lengths (cm)	Root lengths (cm)	Shoot dry weight (gm)	Root dry weight (gm)	Leaves number
T1	**H-I**	56.85 ± 4.32	40.85 ± 0.37	1.28 ± 0.20	1.05 ± 0.52	6.25 ± 0.23
	H-II	80.90 ± 4.25	58.95 ± 2.69	6.04 ± 1.07	3.62 ± 0.02	9.00 ± 1.08
T2	**H-I**	66.1 0± 2.25	39.00 ± 2.50	0.94 ± 0.23	0.88 ± 0.22	6.75 ± 0.63
	H-II	70.57 ± 1.48	56.32 ± 2.01	6.86 ± 1.14	3.62 ± 0.35	10.25 ± 0.49
T3	**H-I**	56.95 ± 3.49	42.47 ± 2.38	0.94 ± 0.15	0.88 ± 0.11	6.75 ± 0.25
	H-II	78.37 ± 3.84	61.10 ± 2.22	4.82 ± 0.36	3.83 ± 0.45	10.00 ± 0.41
T4	**H-I**	48.12 ± 3.37	37.17 ± 1.17	0.72 ± 0.17	0.84 ± 0.28	6.25 ± 0.63
	H-II	69.60 ± 1.19	56.20 ± 1.33	4.76 ± 0.59	3.63 ± 0.08	10.00 ± 0.71

Table 3: Mean squares of average shoots and roots length, shoots & roots dry weight and leaves number of two cultivars of Zea mays L. (*Cv.Afghoee & Cv.Composite*) at H-I & H-II

Source of variation	Degree of freedom	Harvests	Shoot lengths (cm)	Root lengths (cm)	Shoot dry weight (gm)	Root dry weight (gm)	Leaves number
Cultivars	**1**	**H-I**	270.281 N.S	61.605 N.S	0.3202 N.S	1.453 *	0.781**
		H-II	183.36 N.S	0.151*	0.580 N.S	0.2397 N.S	0.125 N.S
Treatments	**3**	**H-I**	57.574 N.S	12.075 N.S	0.028 N.S	0.072 N.S	0.198 N.S
		H-II	115.972 N.S	76.296 N.S	4.89 N.S	1.498 *	1.25 N.S
Interaction	**3**	**H-I**	235.128 N.S	10.671 N.S	0.326 N.S	0.0017 N.S	0.115***
		H-II	28.52 N.S	14.18 N.S	0.995 **	0.996 N.S	1.708 N.S
Error	**24**	**H-I**	89.582	65.927	0.144	0.28	1.0104
		H-II	53.092	44.93	2.576	0.415	2.125

* = Significant at 5% probability , **, *** = Highly significant N.S = Non-significant