Bangladesh J. Environ. Sci., Vol. 38, 109-114, 2020 **@ BAED ISSN 1561-9206**

EFFECT OF BORON AND ALUMINIUM ON SEED GERMINATION AND SEEDLING GROWTH OF WHEAT

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ABSTRACT

A Petri dish and hydroponic culture experiment was conducted at Plant Physiology Laboratory, Department of Crop Botany, Bangladesh Agricultural University, Mymensingh during the period from November 2017 to April 2018 to investigate the effect of boron and aluminium and their interactions on seed germination and seedling growth on wheat seedlings. The experiment comprised of two levels of B (0, 40 µM) and Al (0, 200 µM). The treatments combination were 0 µM B + 0 µM Al (control), 0 µM Al + 40 µM B, 200 µM Al + 40 µM B and 0 µM B + 200 µM Al and five wheat varieties *viz*; BARI GOM 23, BARI GOM 24, BARI GOM 28, BARI GOM 27 and BARI GOM 30. The experiment was laid out in two factors Completely Randomized Design with three replications. Application of 0 µM Al + 40 µM B had a higher radicle and plumule length, germination percentages, root length, shoot length, leaf length, leaf sheath length, and fresh and dry mass production in wheat. Results indicated that germination percentage, radicle and plumule length, root and shoot length, leaf length, leaf sheath length, fresh and dry mass plant^{-1} were greater in boron treatment but without aluminium. Application of 0 µM B + 200 µM Al resulted germination percentage, radicle and plumule length, root and shoot length, leaf length, leaf sheath length, fresh and dry mass plant^{-1} were lowest in compare to other treatment. However, Aluminium had profound negative effect on germination percentage, growth and developments of wheat seedlings but boron can ameliorate the aluminium toxicity in every stage of growth and developments of wheat seedlings. Among the varieties, BARI GOM 28 had highest tolerance to aluminium toxicity and positive boron response in respect of growth and development.

Key words: Boron, aluminium, seed germination, seedling growth.

Introduction

The wheat crop is mainly cultivated under rain fed conditions where precipitation is less than 900 mm annually. Wheat is grown both as spring and winter crop. It is widely grown throughout the temperate zones (in Northern Europe up to 60° N) and in some tropical/sub-tropical areas at higher elevations. The major centers are: Europe (131 million t grain, 27 million ha), the former USSR (108 million t grain, 48 million ha), North America (106 million t grain, 42 million ha), China (96 million t grain, 30 million ha) and India (50 million t grain, 23 million ha). Aluminium stress associated with low soil pH affected soils and there are more than one million ha of land with low pH in Bangladesh. On world-wide basis there are nearly 2.6 billion ha of strongly acid soils with Al^{3+} toxicity (Dudal, 1976). Acid soil, by increasing Al^{3+} solubility increases its concentration at the rhizosphere. Al^{3+} toxicity inhibits plant growth by interfering with the regulatory process of root growth and development (Foy and Taylor, 1998). To overcome the situation Al^{3+} tolerant wheat germplasm may be helpful for the expansion of its cultivation in the areas of acid soil. In Bangladesh, the tolerance grade of the existing gene pool of wheat against Al^{3+} toxicity is yet to be determined .Thus, the present work was undertaken to determine the tolerance efficiency of some high yielding varieties of wheat against different levels of Al^{3+} stress with respect to seed germination, root and shoot growth, and dry matter yield at seedling stage. Boron (B) is an essential element for plant growth. Boron has been referred to as one of the apoplastic elements mainly because it is localized in cell walls. However, the real function of B in plant nutrition has not been completely elucidated. Wheat cultivars differ markedly in their sensitivity to B deficiency Boron efficient cultivars of wheat displayed greater ability to absorb B than B-inefficient cultivars when grown under a similar B supply (Subedi *et al.* 1999).

Boron is one of the important micro-nutrients for plants. It is one of the most widely applied micro-nutrients although it is required in small quantity. It's shortage in soil may reduce crop yield to a great extent. Boron is known to play many important functions in plant metabolism. In the absence of boron, proper development of meristematic tissues of plant does not take place. Boron is necessary for cell division, nitrogen and carbohydrate metabolism, salt absorption and water relations in plant. Boron is also required in the translocation of sugars, starches, nitrogen and phosphorus and synthesis of amino acids and proteins (Tisdale *et al.*, 1984). The piece of research work was undertaken to find out the objectives: i) to notice the effects of B and Al^{3+} on germination of wheat cultivars and ii) to trace the effect of B and Al^{3+} on growth and development of wheat seedlings in hydroponic culture.

Materials and Methods

A Petri dish and hydroponic culture experiment was conducted at Plant Physiology Laboratory, Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, during the period from November 2017 to April 2018 to investigate the effect of boron and aluminum on morphological characters and growth of wheat seedlings. The experiment comprised of four levels of concentrations *viz*., 0 µM B + 0 µM Al (control), 0 µM Al + 40 µM B, 200 µM Al + 40 µM B and 0 µM B + 200 µM Al and five wheat varieties *viz*., BARI GOM 23, BARI GOM 24, BARI GOM 28, BARI GOM 27 and BARI GOM 30. Treatments were applied to the seeds on Petri dish. Full nutrient solutions except treatments were applied to the water tank at recommended rates. 200 µM Al and 40 µM Boron solution were also added to the water tank at 5 days interval. The experiment was laid out in two factors completely randomized design with three replications. Data were statistically analyzed for analyses of variance (ANOVA) using the M-STAT Statistical Computer Package Programme in accordance with the principles of Completely Randomized Design (Gomez and Gomez, 1984). Duncan's Multiple Range Test (DMRT) was used to compare variations among the treatments.

Results and Discussion

Application of 0 µM B + 200 µM Al had a profound influence on radicle and plumule length, germination percentages in wheat (Table 1 and Fig. 1). Radicle and plumule length and germination percentage decreased under 0 µM B + 200 µM Al compared to control at 4, 6 and 8 days after sowing indication 0 µM B + 200 µM Al concentration is toxic to wheat seedlings growth and development. The effect of treatment 0 µM Al + 40 µM B on root and shoot length, leaf length, fresh and dry weight was also significant (Tables 2-3). The root and shoot length, leaf length, fresh and dry weight were greater in 0 µM Al + 40 µM B compared to control. Paliwal (1993) who reported that wheat root length decreased when grown in aluminum concentrated solution than control. These results are consistent with Foy and Fleming (1982) who reported that wheat shoot length decreased in aluminum concentrated solution than control.

The effect of variety on radicle and plumule length and germination percentage was significant. The highest radicle length and the highest plumule length were recorded in BARI GOM 28 (Table 1). The lowest radicles length and the lowest plumule length was observed in BARI GOM 27. In genotypes, the highest shoot length was observed in BARI GOM 28 which ensured the highest dry mass $plant^{-1}$ at 15 and 20 DAS. The lowest fresh and dry weight was recorded in BARI GOM 27 (Table 3). The higher dry mass reduction was observed in BARI GOM 27 indicated this variety was susceptible to aluminium. Genotypic variations in root length were also observed by Ma *et al.* (2004) in wheat that supports the present

The interaction effect of radicle and plumule length and germination percentage was significant. The highest radicle length was observed in the treatment combination of BARI GOM 28 with 0 µM Al + 40 µM B at all growth stages while the highest plumule length was observed in the treatment combination of BARI GOM 28 with 0 µM Al + 40 µM B. However the lowest radicle length and the lowest plumule length were observed in the treatment combination of BARI GOM 27 with 0 µM B + 200 µM Al (Table 1). Again the highest germination percentage was recorded in the treatment combination of BARI GOM 28 with 0 µM Al + 40 µM B and the lowest germination percentage was observed in the treatment combination of BARI GOM 27 (Fig. 1). The interaction effect of variety and treatment on root and shoot length, fresh and dry weight plant^{-1} was found as significant (Table 3). The lowest dry mass reduction due to aluminium was observed in BARI GOM 28 indicating this variety more tolerant to aluminium toxicity than others.

Table 1. Effect of treatment, variety and their interaction on length of radical, plumule and length of wheat

Treatment	Radicle length (cm)			Plumule length (cm)			Root length (cm)		
	4 DAS	6 DAS	8 DAS	4 DAS	6 DAS	8 DAS	10 DAS	15 DAS	20 DAS
Effect of treatment									
T_1	4.54b	4.80c	5.15c	2.22c	2.69c	3.49c	7.07b	9.24b	13.96b
T_2	6.09a	6.89a	7.30a	4.13a	4.79a	5.32a	8.14a	9.46a	15.70a
T_3	3.44c	5.75b	6.14b	3.18b	3.83b	4.33b	6.78c	9.16b	11.92c
T_4	2.70d	3.36d	3.72d	1.98d	2.30d	2.77d	6.53d	8.87c	10.28d
$LSD_{0.05}$	0.52	0.11	0.11	0.14	0.12	0.21	0.10	0.11	0.10
Level of sig.	**	**	**	**	**	**	**	**	**
CV%	16.90	2.82	2.65	6.55	4.58	7.19	1.89	1.57	1.04
Effect of variety									
V_1	4.92a	5.80b	6.11b	3.14b	3.55b	4.34b	7.39b	9.37b	13.14b
V_2	3.71c	4.76d	5.31d	2.39e	3.09d	3.49d	6.72c	8.55c	12.30d
V_3	3.17c	3.88e	3.95e	2.59d	3.13cd	3.24e	6.40d	8.40d	10.97e
V_4	4.84ab	6.03a	6.79a	3.36a	4.00a	4.82a	8.36a	11.02a	15.76a
V_5	4.30b	5.51c	5.73c	2.92c	3.24c	4.02c	6.78c	8.57c	12.65c
$LSD_{0.05}$	0.59	0.12	0.12	0.17	0.13	0.24	0.11	0.12	0.11
Level of sig.	**	**	**	**	**	**	**	**	**
CV%	16.90	2.82	2.65	6.55	4.58	7.19	1.89	1.57	1.04
Interaction effect of treatment and variety									
T_1V_1	4.55d-g	5.46e-g	5.70h	2.53fgh	2.82gh	3.75gh	7.14g	9.48d	14.21f
T_1V_2	4.25e-h	4.27h	4.57j	1.89jk	2.42ij	3.15ij	6.62hi	8.59gh	13.43gh
T_1V_3	3.57g-j	3.40j	3.43k	1.59k	2.36ij	2.78jk	6.35jk	8.56gh	12.10i
T_1V_4	5.43cd	5.63e	6.72e	2.72f	3.36ef	4.30ef	8.59c	11.18a	16.55b
T_1V_5	4.90d-f	5.25g	5.31i	2.38gh	2.52ij	3.48hi	6.65h	8.41hi	13.53g
T_2V_1	6.82a	7.45b	8.12b	4.45ab	4.87b	5.79ab	9.18b	10.15c	16.08c
T_2V_2	5.54b-d	6.41cd	6.74e	3.79cd	4.63bc	4.47ef	7.36ef	8.61gh	15.14e
T_2V_3	5.23c-e	5.54ef	5.56h	3.59cde	4.30d	4.77de	7.09g	8.49gh	13.26h
T_2V_4	6.60a-b	7.72a	8.58a	4.60a	5.33a	6.20a	9.58a	11.17a	18.21a
T_2V_5	6.26a-c	7.33b	7.52c	4.24b	4.80b	5.40bc	7.50e	8.86f	15.79d
T_3V_1	5.19c-e	6.54c	6.18g	3.52de	4.26d	4.67e	6.67h	9.19e	12.13i
T_3V_2	2.59j-l	5.31fg	6.43f	2.68fg	3.55ef	4.12fg	6.47hij	8.57gh	11.47k
T_3V_3	2.21kl	4.25h	4.42j	2.57fgh	3.31f	3.16ij	6.15kl	8.38hi	10.10l
T_3V_4	3.80fg-i	6.44cd	7.20d	3.85c	4.45cd	5.19cd	8.14d	11.10a	14.17f
T_3V_5	3.39g-j	6.21d	6.46f	3.31e	3.59e	4.54ef	6.50hij	8.56gh	11.72j
T_4V_1	3.13h-k	3.77i	4.42j	2.07ij	2.26jk	3.14ij	6.58hi	8.65fg	10.14l
T_4V_2	2.47j-l	3.06k	3.50k	1.20l	1.77l	2.23l	6.42ij	8.43gh	9.16n
T_4V_3	1.68l	2.34l	2.40l	2.64fg	2.57hi	2.27l	6.02l	8.18i	8.43o
T_4V_4	3.55gh-j	4.34h	4.66j	2.29hi	2.85g	3.58hi	7.15fg	10.64b	14.13f
T_4V_5	2.66ij-l	3.27jk	3.63k	1.74k	2.05k	2.66kl	6.49hij	8.46gh	9.56m
$LSD_{0.05}$	1.17	0.24	0.24	0.31	0.26	0.47	0.22	0.24	0.22
Level of sig.	*	**	**	**	**	*	**	**	**
CV%	16.90	2.82	2.65	6.55	4.58	7.19	1.89	1.57	1.04

LSD= Least Significant Difference

** = Significant at 1% level of probability, * = Significant at 5% level of probability

T_1 = (0 µM B+ 0 µM Al), T_2 = (0 µM Al+ 40 µM B), T_3 = (200 µM Al+ 40 µM B), T_4 = (0 µM B+ 200 µM Al)

V_1= BARI GOM 23, V_2= BARI GOM 24, V_3= BARI GOM 27, V_4= BARI GOM 28, V_5=BARI GOM 30

Table 2. Effect of treatment, variety and their interaction on length of shoot, leaf and leaf breath of wheat

Treatment	Shoot length (cm)			Leaf length (cm)			Leaf breath length (cm)		
	10 DAS	15 DAS	20 DAS	10 DAS	15 DAS	20 DAS	10 DAS	15 DAS	20 DAS
Effect of treatment									
T_1	4.40b	5.70b	6.18b	10.18b	11.17b	2.80b	4.01b	4.95b	2.80b
T_2	7.04a	8.63a	12.77a	11.39a	11.92a	3.34a	4.84a	5.24a	3.34a
T_3	4.07c	4.85c	6.11b	7.69c	9.52c	2.03c	3.07c	3.81c	2.03c
T_4	3.65d	4.31d	5.36c	7.35d	8.88d	1.63d	2.38d	3.02d	1.63d
$LSD_{0.05}$	0.12	0.11	0.12	0.13	0.16	0.09	0.10	0.14	0.09
Level of sig.	**	**	**	**	**	**	**	**	**
CV%	3.32	2.41	2.11	1.97	2.08	5.16	3.85	4.35	5.16
Effect of variety									
V_1	4.97b	6.31b	7.82b	9.80b	11.64a	13.96b	2.56b	3.81b	4.65b
V_2	4.47d	5.61d	6.97d	8.93d	11.01b	12.66d	2.31c	3.31d	3.92d
V_3	4.17e	5.21e	6.72e	7.78e	10.35c	12.06e	2.12d	3.10e	3.56e
V_4	5.56a	6.46a	8.89a	10.10a	10.00d	15.24a	2.87a	4.13a	5.07a
V_5	4.79c	5.78c	7.61c	9.14c	8.84e	13.43c	2.40c	3.53c	4.07c
$LSD_{0.05}$	0.13	0.12	0.13	0.15	0.18	0.16	0.10	0.11	0.15
Level of sig.	**	**	**	**	**	**	**	**	**
CV%	3.32	2.41	2.11	1.97	2.08	1.45	5.16	3.85	4.35
Interaction effect of treatment and variety									
T_1V_1	4.51fg	6.39e	6.09g	11.39bc	11.72c	15.44d	2.87c	4.22ef	5.48bc
T_1V_2	4.07i	5.37g	5.55h	9.49e	10.97e	13.35f	2.65d	3.64g	4.64de
T_1V_3	3.60jk	4.59i	5.39hij	8.24fg	9.36g	13.45f	2.49de	3.63g	4.50ef
T_1V_4	5.42e	6.50e	7.30e	11.48b	12.48b	18.31a	3.41ab	4.41de	5.49bc
T_1V_5	4.41fgh	5.66f	6.56f	10.30d	11.32d	14.53e	2.60d	4.17f	4.62de
T_2V_1	7.37b	9.27a	13.66b	12.13a	12.62b	17.49b	3.25b	4.92ab	5.62b
T_2V_2	6.63d	8.41cd	11.59d	11.28bc	11.30de	17.28b	3.30b	4.83bc	4.86d
T_2V_3	6.56d	8.24d	11.48d	10.16d	10.42f	16.21c	3.22b	4.62cd	4.41efg
T_2V_4	7.65a	8.69b	14.50a	12.21a	13.40a	18.63a	3.58a	5.14a	6.05a
T_2V_5	7.02c	8.55bc	12.62c	11.15c	11.85c	17.40b	3.36b	4.68c	5.29c
T_3V_1	4.34gh	5.12h	6.24g	8.15g	10.16f	11.51h	2.28fg	3.53gh	4.23fg
T_3V_2	3.75j	4.50ij	5.54h	7.56h	9.35g	10.58i	1.74hi	2.60j	3.58h
T_3V_3	3.44k	4.42ij	5.47hi	6.59i	8.20i	9.35k	1.65hij	2.56j	3.14jk
T_3V_4	4.67f	5.58fg	7.22e	8.52f	10.25f	12.41g	2.36ef	3.62g	4.58de
T_3V_5	4.17hi	4.63i	6.09g	7.65h	9.63g	11.58h	2.14g	3.07i	3.53hi
T_4V_1	3.67jk	4.47ij	5.32hij	7.55h	9.56g	11.40h	1.83h	2.59j	3.28ij
T_4V_2	3.44k	4.15k	5.21ij	7.39h	8.38hi	9.43k	1.54ij	2.19k	2.58l
T_4V_3	3.07l	3.59l	4.54k	6.15j	7.39j	9.22k	1.13k	1.59l	2.21m
T_4V_4	4.52fg	5.06h	6.56f	8.19g	10.43f	11.61h	2.16fg	3.34h	4.18g
T_4V_5	3.56jk	4.28jk	5.19j	7.48h	8.62h	10.22j	1.49j	2.21k	2.85kl
$LSD_{0.05}$	0.26	0.23	0.27	0.28	0.36	0.32	0.21	0.23	0.31
Level of sig.	**	**	**	**	**	**	**	**	**
CV%	3.32	2.41	2.11	1.97	2.08	1.45	5.16	3.85	4.35

LSD= Least Significant Difference
** = Significant at 1% level of probability, * = Significant at 5% level of probability
T_1 = (0 µM B+ 0 µM Al), T_2 = (0 µM Al+ 40 µM B), T_3 = (200 µM Al+ 40 µM B), T_4 = (0 µM B+ 200 µM Al)
V_1= BARI GOM 23, V_2= BARI GOM 24, V_3= BARI GOM 27, V_4= BARI GOM 28, V_5=BARI GOM 30

Table 3. Effect of treatment, variety and their interaction on fresh as well as dry weight of wheat seedling

Treatment	Fresh weight/plant (g)			Dry weight /plant (mg)		
	10 DAS	15 DAS	20 DAS	10 DAS	15 DAS	20 DAS
Effect of treatment						
T_1	213.82b	310.99b	434.89b	77.53b	116.47b	143.50b
T_2	298.45a	355.49a	526.58a	111.51a	132.65a	161.12a
T_3	103.55c	297.93c	422.43c	23.88c	80.91c	113.99c
T_4	73.31d	206.42d	299.39d	11.46d	60.35d	107.26d
$LSD_{0.05}$	9.58	0.57	1.94	0.32	0.53	0.61
Level of sig.	**	**	**	**	**	**
CV%	7.52	0.26	0.62	0.77	0.74	0.62
Effect of variety						
V_1	191.62b	316.81b	479.82b	66.72b	106.25c	146.71b
V_2	148.12d	276.02d	377.57d	46.03d	78.68d	117.83d
V_3	132.63e	192.52e	282.21e	31.76e	66.16e	100.96e
V_4	211.34a	381.85a	534.32a	80.61a	121.83a	166.49a
V_5	177.70c	296.34c	430.19c	55.33c	115.05b	125.35c
$LSD_{0.05}$	10.71	0.63	2.16	0.36	0.59	0.68
Level of sig.	**	**	**	**	**	**
CV%	7.52	0.26	0.62	0.77	0.74	0.62
Interaction effect of treatment and variety						
T_1V_1	282.07cd	342.57g	498.90f	85.14e	105.33f	158.83d
T_1V_2	159.60f	294.83k	404.03j	75.44g	85.60i	135.37gh
T_1V_3	123.73gh	209.80o	299.80n	48.92j	70.21l	109.63k
T_1V_4	300.37bc	390.33b	525.33d	105.40d	128.53d	178.70c
T_1V_5	203.33e	317.40i	446.37g	72.73h	192.67a	134.97h
T_2V_1	295.77bc	378.27d	601.10b	137.73b	162.87c	185.67b
T_2V_2	287.60c	346.60f	442.63gh	81.86f	106.47f	136.67g
T_2V_3	265.83d	261.07m	404.47j	60.18i	80.06j	121.63i
T_2V_4	310.63b	430.80a	647.83a	165.60a	189.60b	206.73a
T_2V_5	332.43a	360.70e	536.87c	112.20c	124.27e	154.90e
T_3V_1	112.87ghi	320.70h	505.80e	30.75l	88.70h	122.63i
T_3V_2	78.97jk	275.83l	383.80k	18.46n	72.39k	106.73l
T_3V_3	91.73ij	196.87q	281.80o	11.77q	65.24n	89.93n
T_3V_4	131.63g	388.57c	524.83d	34.22k	97.14g	145.27f
T_3V_5	102.53hi	307.70j	415.93i	24.21m	81.07j	105.40l
T_4V_1	75.77jk	225.70n	313.50m	13.26p	68.12m	119.70j
T_4V_2	66.33kl	186.80r	279.80o	8.40r	50.26p	92.57m
T_4V_3	49.23l	102.33s	142.77p	6.21s	49.12p	82.63o
T_4V_4	102.73hi	317.70i	439.30h	17.23o	72.07k	135.27h
T_4V_5	72.50jk	199.57p	321.60l	12.20q	62.20o	106.13l
$LSD_{0.05}$	21.42	1.26	4.33	0.71	1.19	1.35
Level of sig.	**	**	**	**	**	**
CV%	7.52	0.26	0.62	0.77	0.74	0.62

LSD= Least Significant Difference
** = Significant at 1% level of probability, * = Significant at 5% level of probability
T_1 = (0 µM B+ 0 µM Al), T_2 = (0 µM Al+ 40 µM B), T_3 = (200 µM Al+ 40 µM B), T_4 = (0 µM B+ 200 µM Al)
V_1= BARI GOM 23, V_2= BARI GOM 24, V_3= BARI GOM 27, V_4= BARI GOM 28, V_5=BARI GOM 30

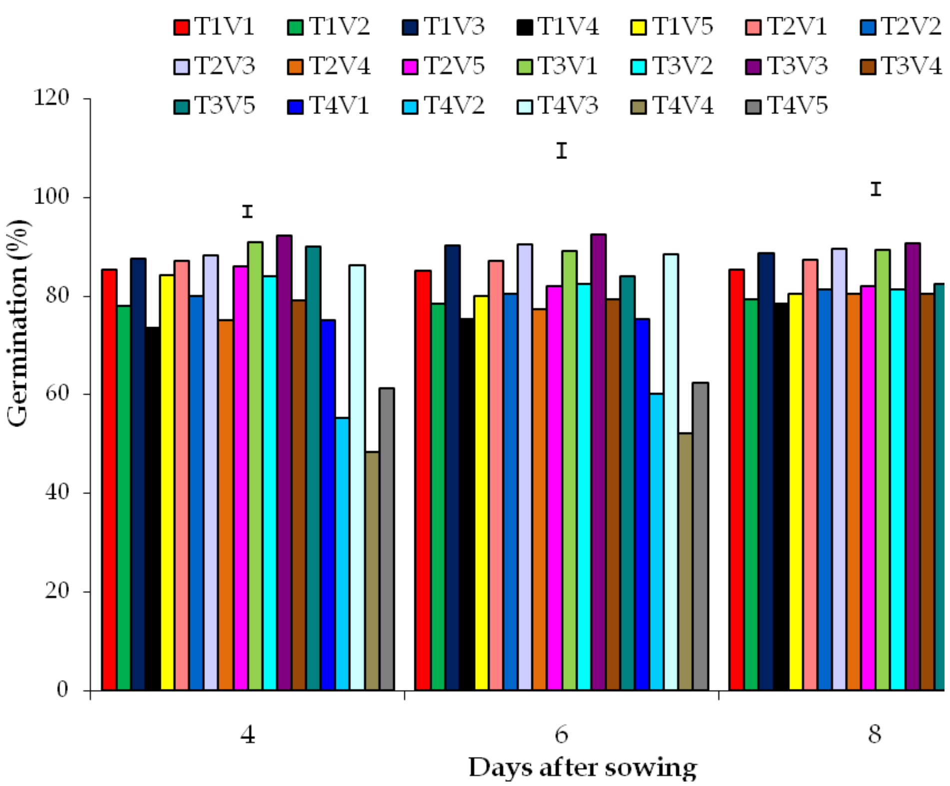

Fig. 1. Interactive effect of treatments and varieties on germination (%) in wheat grown in petri dish

Conclusion

Aluminium had profound negative effect on germination percentage, growth and developments of wheat seedlings but boron can ameliorate the aluminium toxicity in every stage of growth and developments of wheat seedlings. On the other hand, among the varieties, BARI GOM 28 had highest tolerance to aluminium toxicity and positive boron response in respect of growth and development.

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