Bangladesh Agron. J. 2021, 24(1): 129-138

FOLIAR APPLICATION OF BORON AND IRRIGATION LEVELS ON THE PERFORMANCE OF LENTIL

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(**Received:** 05 May 2021, **Accepted:**18 May 2021)

Keywords: Boron, splitting, irrigation, lentil, yield.

Abstract

The experiment was conducted to study the response of lentil to irrigation levels and different methods of boron application in relation to yield and yield contributing characters. Three levels of irrigation *viz.*, I_0: control (No irrigation), I_1: one irrigation at 25 days after sowing (DAS), I_2: two irrigations at 25 DAS and 40 DAS, and four levels of Boron *viz.*, B_0: control (No boron), B_1: 80% recommended dose (RD) as basal + rest 20% as a foliar spray (FS) at pre-flowering (PF), B_2: 60% RD as basal + rest 40% as FS at PF, B_3: 40% RD as basal + rest 60% as FS at PF as treatment variables. It was found that the highest number of pods plant^{-1}, number of seeds pod^{-1}, 1000-seed weight, pod length, seed yield and stover yield was obtained with two irrigations. In contrast, B_3 had a significant effect on the yield contributing characters of lentil. Results also revealed that numerically more seed yield (638.23 kg ha^{-1}) was recorded in I_2B_3. Similar trend was found in case of stover yield (751.26 kg ha^{-1}) and biological yield (1389.4 kg ha^{-1}) from I_2B_3 combinations. These results suggested that combined application of irrigation at 25 and 40 DAS and boron at 40% RD as basal + rest 60% as FS at PF significantly enhanced the crop yields of lentil.

Introduction

In Bangladesh, 176,633 metric tons of lentils from an area of 385399 million hectares were produced during 2017-2018 (BBS, 2018). The poor fertility of the soil and not use of manures and proper fertilizers are considered to be the key reasons for reduced yield of lentil. Physiological processes of plants such as photosynthesis, cell growth and turgidity, etc., are affected directly or indirectly by irrigation (Reddi and Reddi, 1995).Water stress can affect leaf area growth, flowering, pod setting and resulting in low yield. In the growing stage, insufficient water supply can decrease crop quantity and quality (Debaeke and Aboudrare, 2004). Vegetative stage, pre-flowering stage and pod setting stage are critical periods for water use in the lentil cycle. The considerable rise in lentil yield characteristics can be accomplished by using irrigation water, though most farmers in Bangladesh do not use irrigation water both in pulses and lentils (Quah and Jafar, 1994).

The plants require smaller amounts of micronutrients but must be available to plants for better growth and production. Boron (B) is an important for plant growth, development and quality (Pilbeam and Kirkby, 1983; Marschner, 1995; Brown *et al.*, 1999; Dordas *et al.,* 2007). Boron also plays a large role in sugar exchange, nitrogen fastening, protein synthesis, sucrose synthesis, cell wall formation, membrane stability and K^+ movement (Singh *et al.,* 2014). Boron soil deficiency is a major cause of lower crop yields in Bangladesh, India, Nepal and China (Anantawiroon *et al.*, 1997). Boron deficiency results in plant sterility due to malformation of the reproductive tissue that affects pollen germination, resulting in increased flower fall and reduced fruit area (Subasinghe *et al.*, 2003). Irrigation and micronutrient like boron management are very important for maintaining lentil production in dry and nutrient-deficient soil. Thus, the present study was initiated to assess the effects of irrigation and boron on yield performance of lentil.

Materials and Methods

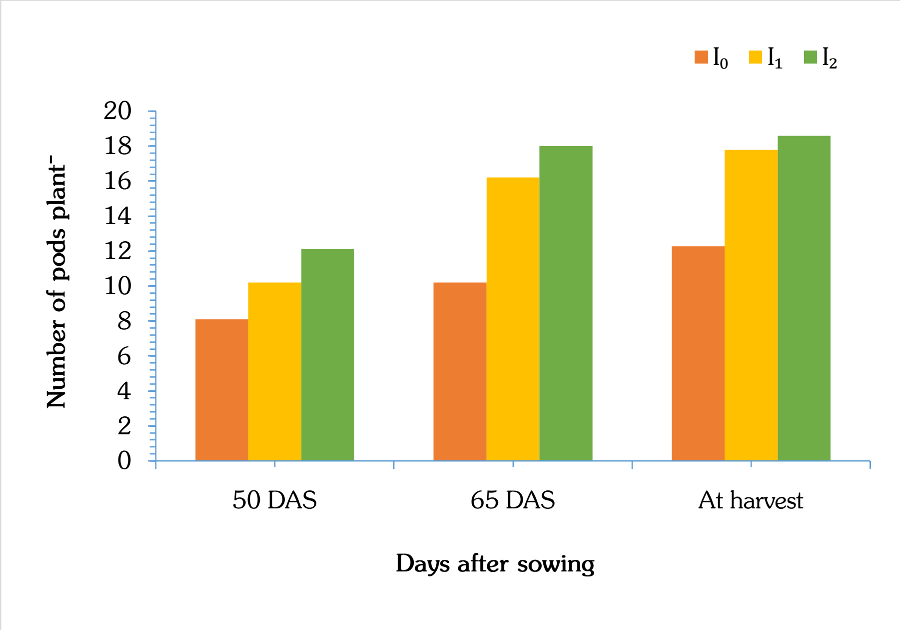
The experiment was conducted during from November 2018 to March 2019 at Agronomy Research Field, Sher-e-Bangla Agricultural University, Dhaka-1207. The soil of the research field was slightly acidic, with low organic matter content before sowing. Lentil var. BARI Mashur 6 seeds were sown on November, 2018. The experiment was laid out in a split-plot design where irrigation treatments in main plot: *viz.*, Control (I_0)(No irrigation), one irrigation (I_1) at 25 days after sowing (DAS), two irrigations (I_2) at 25 and 40 DAS and boron application *viz.*, B_0 = 0 kg B/ha (Control), B_1=80% recommended dose of B as basal + Rest 20% as foliar spray (BF) at pre-flowering (PF), B_2 = 60% RD of B as basal + Rest 40% as FS at PF, B_3= 40% RD of B as basal + Rest 60% as FS at PF in sub-plot. The size of each unit plot was 2.5m× 1.5m. The land was fertilized with urea-TSP, MoP-Boric acid @ 50-90 – 40-8.5 kg ha^{-1}, respectively. Total Urea, TSP and MoP were applied as a basal dose. Boron was applied as boric acid as basal dose and rest amount was applied as a foliar application at before flowering stage. The seeds were treated with Autostin50 WP (Carbendazim group) before sowing to control the seed-borne diseases. The seeds were sown in rows in the furrows having a depth of 2-3 cm. Row to row distance was maintained 30 cm. Data on yield parameters were recorded and analysed using a computer-operated program MSTAT-C, and treatments means were estimated by the Duncan Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

Results and Discussion

Yield contributing parameters

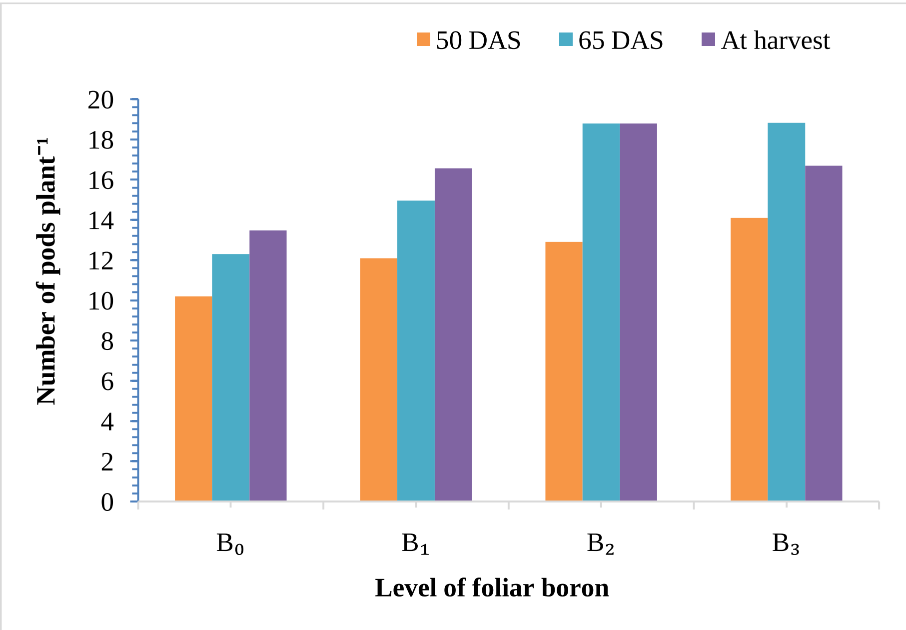
Number of pods plant^{-1}

A significant variation was found in the total number of pods per plant due to different irrigation levels (Figure 1). At harvest, the highest number of pods per plant (18.59) was found in irrigation at the vegetative and reproductive stage (I_2) followed by the treatment of I_1 (17.78). On the other hand, the lowest number of pods per plant (12.28) was also produced in no irrigation treatment. The number of pods per plant of lentil varied significantly due to different levels of boron application (Figure 2). Result showed that the highest number of pods per plant (18.49) was obtained from B_3 (40% recommended dose as basal + rest 60% as a foliar spray at pre-flowering) at 65 days after sowing (DAS). Likewise, the lowest number of pods per plant (13.47) was recorded from B_0 (control) at harvest. The result showed that the maximum number of pods per plant (17.78) was recorded from I_2B_3 at harvest which was statistically similar to others except control. The lowest number of pods per plant (11.56) at harvest was obtained from I_2B_0 treatment (Table 1). Irrigation at higher frequencies may have decreased the plant water stress resulting higher partitioning of food materials into flower primordial which resulted the higher number pod setting in plants. This could be due to the greater role of foliar boron application in the production of indole acetic acid (IAA), which may have resulted in more pods per plant (Taliee and Sayadian, 2000).



I_0 = No irrigation, I_1= 25 DAS I_2 = 25 & 40 DAS

Fig. 1. Effect of irrigation on number of pods plant^{-1}of Lentil at different days after sowing (SE= 0.837, 1.529, 0.2562 at 50, 65 DAS and at harvest respectively).



B_0 =control; B_1 = 80% recommended dose as basal + rest 20% as a foliar spray at pre-flowering; B_2 = 60% RD as basal + rest 40% as FS at PF; B_3 = 40% RD as basal + rest 60% as FS at PF

Fig. 2. Effect of boron on number of pods plant^{-1} of Lentil at different days after sowing (SE = 0.599, 1.5679, 1.220 at 50, 65 DAS and at harvest respectively).

Table 1. Interaction effect of irrigation and boron on number of pods plant^{-1} of lentil at different days after sowing

Treatment combinations	Number of Pods plant^{-1}		
	50 DAS	65 DAS	At harvest
I_0B_0	2.78 bc	13.45 a-c	13.72 a
I_0B_1	2.89 bc	12.78 a-c	13.74 ab
I_0B_2	6.55 a	11.67 a-c	14.52 ab
I_0B_3	5.44 a-c	10.55 bc	12.14 b
I_1B_0	5.33 a-c	15.22 a-c	13.15 ab
I_1B_1	5.78 ab	15.89 a-c	14.67 ab
I_1B_2	2.56 c	14.22 a-c	15.74 ab
I_1B_3	4.11 a-c	20.67 a	16.55 ab
I_2B_o	4.61 a-c	10.23 c	11.56 ab
I_2B_1	4.22 a-c	11.78 a-c	15.26 ab
I_2B_2	5.11 a-c	16.98 a-c	17.77 ab
I_2B_3	5.33 a-c	19.22 ab	17.78 a
SE	1.039	2.715	2.113
CV (%)	12.97	13.46	14.05

Similar letter within the parenthesis do no differ significantly at 5% level of significance according to Duncan's Multiple Range Test

NS = Non-significant, I_0 = No irrigation; I_1= 25 DAS; I_2 = 25 DAS and 40 DAS, B_0 =Control; B_1= 80% recommended dose as basal + rest 20% as a foliar spray at pre-flowering; B_2 = 60% RD as basal + rest 40% as FS at PF; B_3 = 40% RD as basal + rest 60% as FS at PF

Pod length

Significant variation was observed on pod length of lentil due to different levels of irrigation treatments (Table 2). Results revealed that the maximum pod length (1.31cm) was obtained from two irrigation I_2 (at 25 days after sowing and 40 DAS) which was statistically similar to I_1 (25 DAS). However, the lowest pod length (1.26 cm) was recorded from I_0 (control).A substantial difference was also observed on seed length of lentil due to different levels of boron treatments (Table 3). Results showed that the maximum pod length (1.33cm) was obtained from B_1 (80% as recommended dose as basal + rest 20% as a foliar spray at pre-flowering) was statistically similar to B_2 (60% RD as basal + rest 40% as FS at PF), and B_3(40% RD as basal + rest 60% as FS at PF). The lowest pod length (1.20 cm) was recorded from B_0. Pod length was significantly improved by the synergistic effect of different levels of irrigation and boron application (Table 4). Results showed that higher pod length (1.42 cm) was recorded from I_2B_3 combination which was statistically similar to I_2B_2, I_2B_1. However, the lowest pod length (1.23cm) was recorded from I_0B_0 combination which was statistically similar to I_0B_1, I_0B_2, I_0B_3, I_1B_0, I_1B_2 and I_2B_0 respectively. Combinedly, boron application at two spilt and irrigation at optimum levels may have increased the cell division of flowers primordial resulted the vigorous development of pod in onward of growth stage.

Number of seeds pod^{-1}

The number of seeds per pod of lentil, significant variation was observed due to different levels of irrigation treatments (Table 2). Results revealed that the highest number of seeds per pod (1.94) was obtained from I_2 (25 days after sowing and 40 DAS) which was statistically similar to I_1 (25 DAS). On the other hand, the lowest number of seeds per pod (1.61) was acquired from I_0 (without irrigation). A similar result was founded by Roy *et al.* (2016).The substantial influence was also found by different levels of boron application for the number of seeds per pod (Table 3). Result showed that maximum number of seeds per pod (2.00) was recorded from B_3 which was statistically identical to B_1 (1.96). Conversely, the lowest number of seeds per pod (1.74) was collected from B_2 (60% RD as basal + rest 40% as FS at PF). The result of this study was similar to the Pandey and Gupta (2013).The number of seeds pod^{-1} was significantly influenced by the interaction effect of different levels of irrigation and boron application (Table 4). Results showed that the highest number of seed pod^{-1} (2.00) was recorded from I_2B_3 combination which was statistically similar to I_2B_1, I_2B_2, I_2B_1 and I_1B_1 treatment combination. Likewise, the lowest number of seeds per pod (1.40) was recorded from I_0B_0 which was statistically similar to I_0B_2, I_0B_2, I_1B_0 I_0B_3, I_1B_0 and I_2B_0.Islam *et al.* (2018) reported that agronomic bio-fortification through foliar boron application might have enhanced the seed setting that resulted in an increasing number of seeds per pod.

1000-seed weight

The irrigation levels had a significant effect on 1000-seed weight where maximum 1000-seed weight (24.26 g) was recorded from two irrigations (I_2) at 25 and 40 DAS which was significantly similar to I_1 (25 DAS) respectively. The lowest 1000-seed weight (19.61 g) was obtained from I_0 (control). Hossain *et al.,* (2013) was also found a significant increase in 1000-seed weight with two irrigations; one at the pit-flowering stage and another at the fruiting stage. Significant effect was also found by different levels of boron treatments for 1000-seed weight of lentil (Table 3).

Table 2. Effect of irrigation on yield contributing characters of lentil at harvest

Treatments	Yield contributing Characters		
	Pod Length (cm)	Number of seeds pod^{-1}	1000-seed weight (g)
I_0	1.26	1.61	19.61 b
I_1	1.30	1.94	22.84 a
I_2	1.31	1.86	24.26 a
SE	NS	NS	0.725
CV (%)	8.52	12.14	11.29

Similar letter within the parenthesis do no differ significantly at 5% level of significance according to Duncan's Multiple Range Test
NS = Non significant, I_0 = No irrigation; I_1= 25 DAS; I_2 = 25 DAS and 40 DAS

Table 3. Effect of boron on yield contributing characters of lentil at harvest

Treatments	Yield contributing characters		
	Pod length (cm)	Number of seeds pod^{-1}	1000-seed weight (g)
B_0	1.20	1.92 a	21.11b
B_1	1.33	1.96 ab	22.43 ab
B_2	1.29	1.74 b	22.87 a
B_3	1.25	2.00 a	22.53ab
SE	NS	0.065	0.508
CV (%)	8.84	10.33	6.86

Similar letter within the parenthesis do no differ significantly at 5% level of significance according to Duncan's Multiple Range Test

NS = Non significant, B_0=Control; B_1 = 80% recommended dose as basal + Rest 20% as a foliar spray at pre-flowering; B_2 = 60% RD as basal + Rest 40% as FS at PF; B_3 = 40% RD as basal + Rest 60% as FS at PF

Result revealed that the maximum 1000-seed weight (22.87 g) was recorded from B_2 which was statistically similar to B_1 (22.53 g) and B_3 (22.53 g). Similarly, the lowest 1000-seed weight (21.11 g) was obtained from B_0 (control). Maqbool *et al.* (2018) and Vimalan *et al.* (2017) also noted similar results. Weight of 1000-seed was significantly influenced by the interaction effect of different levels of irrigation and boron application (Table 4). Results showed that maximum 1000-seed weight (25.53 g) was recorded from I_2B_2 combination which was statistically identical to $I_1B_1$and similar to I_2B_3. Accordingly, the lowest 1000-seed weight (17.69 g) was recorded from I_0B_0 combination which was statistically similar to I_0B_1 followed by I_0B_2, I_0B_3 and I_1B_0, respectively. Gunasekera *et al.* (2006) noted that by increase in moisture stress intensity, 1000-seed weight decreases. Increased water use efficiency with increasing water stress has also been observed in lentils reflecting the lower soil evaporation component of water use without irrigation. The higher seed weight could be due to the higher mobilization of photosynthates to the developing seeds at higher accumulation boron (Islam *et al.,* 2018).

Table 4. Interaction effect of irrigation and boron on yield contributing parameters of lentil at harvest

Treatment combinations	Yield contributing characters		
	Pod length (cm)	Number of seeds pod^{-1}	1000-seed weight (g)
I_0B_0	1.23 ab	1.40	17.69 e
I_0B_1	1.28 ab	1.40	19.99 de
I_0B_2	1.31 ab	1.67	21.05 cd
I_0B_3	1.22 ab	1.57	20.98 cd
I_1B_0	1.30 ab	1.70	23.01 a-d
I_1B_1	1.22 ab	1.89	23.35 a-c
I_1B_2	1.21 b	1.89	22.37 b-d
I_1B_3	1.30 ab	2.00	23.29 a-c
I_2B_o	1.36 ab	1.69	22.64 b-d
I_2B_1	1.4 a	1.89	23.95 a-c
I_2B_2	1.41 a	1.66	25.53 a
I_2B_3	1.42 a	2.00	24.42 ab
SE	0.066	NS	0.814
CV (%)	8.84	10.33	6.3

Similar letter within the parenthesis do no differ significantly at 5% level of significance according to Duncan's Multiple Range Test

NS = Non-significant, I_0 = No irrigation; I_1= 25 DAS; I_2 = 25 DAS and 40 DAS, B_0 =Control; B_1= 80% recommended dose as basal + rest 20% as a foliar spray at pre-flowering; B_2 = 60% RD as basal + rest 40% as FS at PF; B_3 = 40% RD as basal + rest 60% as FS at PF

Yield characters

Seed yield

Irrigation level exerted a significant result on lentil seed yield (Table 5). The maximum seed yield (570.56 kg ha^{-1}) of lentil was obtained from the treatment I_2 (Irrigation at 25 DAS and 40days after sowing) followed by the treatment I_1 (Irrigation at 25 days after sowing). The lowest seed yield (363.1 kg ha^{-1}) was recorded from I_0 (control). From the result, it was observed that seed yield increased gradually with the irrigation level. Shortage of irrigation water greatly reduced the yield. A similar result was found by Zhang *et al.* (2000). Significant variation was also found by different levels of boron treatment (Table 6). The highest seed yield (583.51 kg ha^{-1}) was recorded from B_3 followed by B_2 and B_1 while lowest seed yield (448.70 kg ha^{-1}) from B_0. Vimalan *et al.* (2017) reported similar result with seed yield of green gram. The interaction of irrigation level and boron had a significant influence on seed yield (Table 7). The maximum seed yield (638.23 kg ha^{-1}) was recorded in from I_2B_3which was statistically different from I_2B_2, I_2B_1, I_2B_0, I_1B_3, I_1B_2, I_1B_1, I_1B_0, I_0B_3 combinations. Likewise, the lowest amount of seed yield (210.67 kg ha^{-1}) was recorded from I_0B_0. The increase in number of irrigation resulted in significant increase in seed yield, which may be attributed from the higher number of pods per plant, number of seeds per pod and 1000-seed weight. Increase in seed yield with increase in number of irrigations has been reported by Panda *et al.* (2004). If micronutrients are applied in conjunction with macronutrients to favorably influence the plant vigor, morphology, and metabolic processes (Valenciano *et al.*, 2011).

Stover yield

Irrigation had a significant variation on stover yield of lentil (Table 5). Result showed that the highest stover yield (573.98 kg ha^{-1}) was obtained from $I_2$and the lowest stover yield (405.14 kg ha^{-1}) was recorded from I_0. The same result was found by Paramjit and Roy (2001). Variation was also found by different levels of boron on stover yield of lentil (Table 6). The result showed that the highest stover yield (598.81 kg ha^{-1}) was recorded from $B_3$and the lowest stover yield (496.31 kg ha^{-1}) from B_0. The combined effect of irrigation and boron showed a significant effect on stover yield of lentil (Table 7). The highest stover yield (751.20 kg ha^{-1}) was recorded from I_2B_3 combination while the lowest stover yield (252.27 kg ha^{-1}) was recorded from I_0B_0 (control). Application of two irrigations recorded significantly higher stover yield than one irrigation which in turn gave significantly higher stover yield than no irrigation in chickpea (Pandey *et al.*, 1984). This variation of results indicated that the increasing irrigation levels were more effective on soil moisture and favorable soil for more to more increase plant height as well as stover yield. The results showed that stover yield directly proportional to the application of irrigation water. It might be due to the morpho-physiological growth performance of plants that depends on optimum level of irrigation, which enhanced dry matter accumulation and finally increased overall yield performance.

Biological yield

A significant effect was observed on biological yield of lentil in different levels of irrigation (Table 5). The maximum biological yield (1167.2 kg ha^{-1}) was recorded from I_1 (25 days after sowing) which was statistically similar to I_2 (25 days after sowing and 40 DAS). The lowest biological yield (768.3 kg ha^{-1}) were obtained from I_0 (no irrigation). Roy *et al.* (2016) mentioned a similar result in chickpea. The biological yield was found significant in respect to boron (Table 6). The result revealed that the highest biological yield (1182.4 kg ha^{-1}) was recorded from B_3 (40% recommended dose as basal + rest 60% as FS at PF) which was significantly different from B_2 (60% RD as basal + rest 40% as FS at PF). Likewise, the lowest biological yield (945.0 kg ha^{-1}) was obtained from B_0 (control).The interaction effect of irrigation and boron had a significant variation on biological yield (Table 7). From the table, it was observed that higher biological yield (1389.4 kg ha^{-1}) was recorded in the combination of I_2B_3 which was statistically incompatible with other treatments. The lowest biological yield (492.9 kg ha^{-1}) was recorded from the combination of I_0B_0 (control).

Harvest index

The harvest index was found significant in different levels of irrigation (Table 5).The highest harvest index (49.85%) was recorded from I_2 (Irrigation at 25 DAS and 40DAS), which was statistically similar to I_1 (25 DAS).There were no significant variations in case of harvest index due to different boron management except control treatment (Table 6). Among the treatments, B_3gave the maximum harvest index (53.34%), which was followed by other treatments except B_0 (control). The combined application of irrigation and boron had a significant variation on harvest index (Table 7). The result showed that the maximum harvest index was calculated from I_2B_3 which was statistically different from other treatments. Likewise, the lowest harvest index (43.24%) was recorded from the combination of I_0B_0 (control).

Table 5. Effect of irrigation on yield and harvest index of lentil at harvest

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
I_0	363.10 b	405.14 b	768.24 b	47.26
I_1	545.00a	552.22 a	1167.22 a	46.69
I_2	570.56 a	573.98 ab	1144.54 a	49.85
SE	2.057	5.467	5.782	NS
CV (%)	14.46	35.48	19.51	16.02

Similar letter within the parenthesis do no differ significantly at 5% level of significance according to Duncan's Multiple Range Test

NS = Non significant, I_0 = No irrigation; I_1= 25 DA; I_2 = 25 DAS and 40 DAS

Table 6. Effect of boron on yield and harvest index of lentil at harvest

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
B_0	448.70 b	496.31	945.01 b	47.48
B_1	466.98 ab	486.90	953.88 b	48.95
B_2	472.44 ab	553.02	1025.46ab	49.06
B_3	583.51 a	598.89	1182.40 a	49.34
SE	4.063	NS	7.266	NS
CV (%)	24.73	28.44	21.23	16.2

Similar letter within the parenthesis do no differ significantly at 5% level of significance according to Duncan's Multiple Range Test

NS = Non-significant, B_0 =Control; B_1= 80% recommended dose as basal + rest 20% as a foliar spray at pre-flowering; B_2 = 60% RD as basal + rest 40% as FS at PF; B_3 = 40% RD as basal + rest 60% as FS at PF

Table 7. Interaction effect of irrigation and boron on yield and harvest index of lentil at harvest

Treatment combinations	Yield and harvest index characters			
	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
I_0B_0	210.67 c	252.27 c	492.94 d	47.36 ab
I_0B_1	268.77 bc	477.57 a-c	846.34 b-d	43.57 ab
I_0B_2	271.03 bc	412.57 bc	783.60 cd	47.34 ab
I_0B_3	372.20 ab	478.17 a-c	950.37bc	49.68 ab
I_1B_0	357.23 ab	711.03 ab	1168.26 a-c	39.13 b
I_1B_1	474.30 a	556.57 a-c	1130.87 a-c	50.78 b
I_1B_2	508.37 ab	653.97 ab	1162.34 a-c	43.73 b
I_1B_3	514.10 a	567.30 ab	1207.40ab	52.51 b
I_2B_o	512.20 a	525.63 a-c	1173.83 a-c	53.85 b
I_2B_1	457.87 ab	426.57 bc	884.44 b-d	51.77 b
I_2B_2	537.93 ab	592.53 ab	1130.46 a-c	47.58 b
I_2B_3	638.23 a	751.20 a	1389.43 a	45.93 a
SE	7.038	8.765	12.585	4.661
CV (%)	24.73	28.44	21.23	16.2

Similar letter within the parenthesis do no differ significantly at 5% level of significance according to Duncan's Multiple Range Test

NS = Non-significant, I_0 = No irrigation; I_1= 25 DAS; I_2 = 25 DAS and 40 DAS, B_0 =Control; B_1= 80% recommended dose as basal + rest 20% as a foliar spray at pre-flowering; B_2 = 60% RD as basal + rest 40% as FS at PF; B_3 = 40% RD as basal + rest 60% as FS at PF

Conclusion

It can be concluded that the irrigation and boron application as foliar spray significantly influenced the seed yield of lentil. Seed yield and yield attributes of lentil were the best in the treatment I_2B_3 (two irrigations at 25 DAS and 40 DAS and Boron at 40% RD as basal + rest 60% B as FS at PF).

Acknowledgement

The authors avail the opportunity to express their sincere thanks and heartfelt gratitude to the Government of the People's Republic of Bangladesh through the Ministry of Science and Technology (MoST) for providing financial support (NST fellowship) for conducting this research.

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