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Effect of boron fertilizer on yield and quality seed production of two varieties of carrot

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Abstract: An experiment was conducted at the Horticulture Farm, Bangladesh Agricultural University, Mymensingh during October, 2010 to June, 2011 to study the effects of boron fertilizer on the yield and quality seed production of carrot. There were two varieties, viz., Brasilia Agroflora and Prima Agroflora and five different levels of boron fertilizer viz. 0, 1, 2, 3 and 4 kg B/ha were used to seed production of carrot. The experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. Boron fertilizer was significantly influenced on most of the parameters studied. Boron level 3 kg B/ha gave the highest seed yield (1769.11 kg/ha) which was followed by (1721.36 kg/ha) seed yield by the boron level of 4 kg B/ha and 0 kg B/ha gave the lowest seed yield (1371.93 kg/ha). Between the two varieties of carrot Brasilia Agroflora gave the highest seed yield (1639.79 kg/ha) and the lowest yield (1542.17 kg/ha) for Prima Agroflora. Combined effect of boron fertilizer and variety found highly significant effect. The highest seed yield (1857.78 kg/ha) was obtained from the treatment combination of the variety Brasilia Agroflora and boron fertilizer level 3 kg B/ha and the lowest (1348.02 kg/ha) obtained from the variety Prima Agroflora and without (control) boron fertilizer.
Key words: Boron fertilizer, variety, quality carrot seed, yield

Introduction

Carrot is a very important root crop from nutritional point of view. It plays a vital role to protect the blindness of children providing vitamin A. In Bangladesh there is no recommended variety of carrot for seed production. Many countries have developed good quality high yielding varieties through introduction. For the development of suitable varieties, it is essential to evaluate the characters of the available germplasm properly and conserve the collected materials for future use. Almost entire production of carrot in Bangladesh depends on imported seeds. The seeds are relatively expensive which are not always available in time for sowing. So, cultivation of good quality carrot falls in an uncertainty. This situation also restricts its production. To save the foreign currency and to increase carrot production, timely supply of quality seed in desired quantity should be ensured. This is possible through the improvement of seed production. Hence, the genetic information on yield and yield contributing characters of the crop species are assessed for its improvement.

Adequate supply of micronutrients is essential for maximizing the seed yield of carrot (Mitra *et al*., 1990). Boron increases the stability of plant cells and is involved in the reproductive phase of plants. Its inadequacy is often associated with sterility and malformation of reproductive organs (Katyal and Randhawa, 1983). The use of high yielding varieties of crops and high levels of fertilizers resulted severe micronutrient deficiency in different agro-ecological regions of Bangladesh. The deficiency of B in Bangladesh was most prevalent (Haque, 2002). It is one of the major limiting factors for carrot seed production. Hence, management of boron deserves special attention for successful carrot seed production. Mishra and Yadav (1989) reported that boron possibly plays a key role in plant metabolism and is also essential for the fast growing meristamatic tissue. It is also required for pollen growth and flower formation. Homutescu *et al*. (1993) studied the influence of microelement boron on the production of carrots where the carrot variety Chantenay was treated with boric acid. It was concluded that boron increased the yields by 5.31-23.47%. In the above context, the study entitled, effect of boron fertilizer on quality seed production of two varieties of carrot was undertaken to find out the optimum dose of boron fertilizer and select carrot variety for production of quality seeds.

Materials and Methods

The experiment was conducted at Horticulture Farm, BAU, Mymensingh to study the effect of boron fertilizer on the yield and quality seed production of two varieties of carrot during the period from October, 2010 to May 2011. The treatments of the experiment consisting of two varieties of carrot viz. Brasilia Agroflora and Prima Agroflora and five different levels of boron fertilizer viz. B_0 = 0 kg B/ha, B_1 = 1 kg B/ha, B_2 = 2 kg B/ha, B_3 = 3 kg B/ha, and B_4 = 4 kg B/ha were used. The unit plot size was 1m×1m; total number of treatments: 5×2 = 10; total number of unit plots: 10×3 = 30; total number of plants per plot =16; date of steckling transplanting: 3 January, 2011. Date of harvesting: 10 April to 15 May, 2011. The selected land was medium high and the texture of soil was clay loam. The two factor experiment was laid out following a Randomized Complete Block Design (RCBD) with three replications. The experimental plot was prepared by good tillage and fertilized with recommended doses of manure and fertilizers. Boron fertilizer was given in different level according to treatment after plot preparation. The seeds of varieties were collected from USDA-Alliums project, BAU, Mymensingh. All intercultural operations were done as and when needed. Seeds were sown uniformly in rows on 20 October, 2010. When the plants were 75 days old, they were transplanted at main field. Data were recorded on vegetative growth and flowering behavior, umbel characteristics, yield and quality contributing characteristics of carrot from five randomly selected plants of each plot and were analyzed statistically by MSTAT computer programme. The difference between the treatment means was judged by least significant difference (LSD) test.

Results and Discussion

Most of the studied characteristics were significantly influenced due to the levels of boron fertilizer on carrot seed production.

Effect of carrot variety: Carrot variety showed insignificant difference on flowering behavior, umbel characteristics, yield and quality contributing

characteristics of carrot. The maximum plant height at harvest (118.19 cm), days to 50 % flowering (67.09 days), days to 50 % fruit set (87.22 days), days required from flower to fruit set (18.07 days), number of primary umbels per plant (10.67) and secondary umbels per plant (14.92), diameter of main umbel (10.94 cm), primary umbel (10.97 cm) and secondary umbel (7.66 cm), seed yield in main umbel (6.46 g), primary umbel (6.04 g), secondary umbel (4.43 g) and 1000-seed weight (1.19 g) were obtained from the plots in carrot variety Brasilia Agroflora while the minimum values on all the above mentioned parameters were found in variety Prima Agroflora (Table 1, 2 & 3).

Table 1. Main effect of boron fertilizers and variety on vegetative growth and flowering behaviour of carrot

Treatments	Plant height at harvest (cm)	Days to 50% flowering	Days to 50% fruit set	Days required (flower to fruit set)
Variety				
V_1	118.19	67.09	87.22	18.07
V_2	106.72	63.27	84.48	15.86
LSD 5%	-	-	-	-
LSD 1%	-	-	-	-
Level of sign.	NS	NS	NS	NS
Boron				
B_0	98.53	60.76	81.36	13.94
B_1	108.17	64.62	84.45	15.51
B_2	115.02	65.08	86.99	18.20
B_3	121.10	68.07	90.22	19.14
B_4	119.47	67.37	86.21	18.02
LSD 5%	10.75	5.097	4.209	2.997
LSD 1%	14.49	6.869	5.673	4.039
Level of sign.	**	**	**	**

V_1 = Brasilia Agroflora, V_2 = Prima Agroflora, B_0 = 0 Kg B/ha, B_1 = 1 Kg B/ha, B_2 = 2 Kg B/ha, B_3 = 3 Kg B/ha, B_4 = 4 Kg B/ha, ** Significant at 1% level, NS: Not Significant

Table 2. Main effect of boron fertilizers and variety on umbel characteristics of carrot

Treatments	No. of primary umbels/ plant	No. of secondary umbels/ plant	Diameter of primary umbel (cm)	Diameter of secondary umbel (cm)	Diameter of main umbel (cm)
Variety					
V_1	10.67	14.92	10.97	7.66	10.94
V_2	9.89	13.11	10.49	7.33	10.54
LSD 5%	-	-	-	-	-
LSD 1%	-	-	-	-	-
Level of sign.	NS	NS	NS	NS	NS
Boron					
B_0	9.63	10.72	9.31	6.59	9.55
B_1	10.05	12.21	10.30	7.26	10.25
B_2	10.31	13.71	10.83	7.60	10.83
B_3	11.01	17.51	11.77	8.06	12.04
B_4	10.38	15.94	11.44	7.95	11.04
LSD 5%	1.179	2.604	1.240	1.023	1.226
LSD 1%	-	3.509	1.671	1.378	1.652
Level of sign.	*	**	**	**	**

V_1 = Brasilia Agroflora, V_2 = Prima Agroflora, B_0 = 0 Kg B/ha, B_1 = 1 Kg B/ha, B_2 = 2 Kg B/ha, B_3 = 3 Kg B/ha, B_4 = 4 Kg B/ha, * Significant at 5% level, ** Significant at 1% level, NS: Not Significant

Table 3. Main effect of boron fertilizers and variety on seed yield and quality contributing characteristics of carrot

Treatments	Seed yield in primary umbel (g)	Seed yield in secondary umbel (g)	Seed yield in main umbel (g)	1000-seed weight (g)	Seed yield/ plant (g)	Seed yield (kg/ha)	Seed germination (%)
Variety							
V_1	6.04	4.43	6.46	1.19	19.60	1639.79	81.07
V_2	5.80	4.33	5.96	1.13	18.20	1542.17	80.75
LSD 5%	-	-	-	-	-	-	-
LSD 1%	-	-	-	-	-	-	-
Level of sign.	NS	NS	NS	NS	NS	NS	NS
Boron							
B_0	4.65	3.44	4.81	0.96	15.47	1371.93	76.23
B_1	6.10	4.04	6.15	1.12	17.64	1461.98	79.45
B_2	6.07	4.91	6.59	1.16	19.95	1630.50	82.22
B_3	6.46	4.90	7.01	1.34	21.16	1769.11	83.93
B_4	6.33	4.61	6.48	1.22	20.27	1721.36	82.71
LSD 5%	1.316	1.074	1.388	0.091	1.802	140.30	3.690
LSD 1%	1.774	1.447	1.871	0.123	2.429	189.00	4.973
Level of sign.	**	**	**	**	**	**	**

V_1 = Brasilia Agroflora, V_2 = Prima Agroflora, B_0 = 0 Kg B/ha, B_1 = 1 Kg B/ha, B_2 = 2 Kg B/ha, B_3 = 3 Kg B/ha, B_4 = 4 Kg B/ha, ** Significant at 1% level, NS: Not Significant

Wide difference was observed as to the seed yield per plant between the varieties. Brasilia Agroflora gave the highest (19.60 g) seed yield per plant and Prima Agroflora showed in lowest (18.20 g) per plant (Table 3). This might be due to higher umbel size, number of flower per umbel, number of seeds per umbel and 1000 seed weight. The highest per cent of seed germination (81.07 %) was exhibited in Brasilia Agroflora and the lowest was observed in Prima Agroflora (80.75 %). This might be due to higher 1000 seed weight which enhanced the speed of germination. This result is in agreement with the findings of Shantha *et al.* (1998). They found 80.2 % seed germination in carrot seed from primary umbel. When seed yield was considered, the variety Brasilia Agroflora produced the highest amount (1639.79 kg) while the lowest (1542.17 kg) was obtained from the variety Prima Agroflora (Table 3). This might be due to the fact that the variety Brasilia Agroflora had a good genetic potential which enhanced more cell division and cell elongation resulting best performance. This result agrees with Mohanty (1998); Mohanty and Prusti (2001) who reported that seed yields vary with the cultivars.

Effect of boron fertilizer: Boron fertilizer showed highly significant of all the parameters assessed. The highest plant height at harvest (121.10 cm), days to 50 % flowering (68.07 days), 50 % fruit set (90.22 days), days required from flower to fruit set (19.14 days), number of primary umbels per plant (11.01) and secondary umbels per plant (17.51), diameter of main umbel (12.04 cm), primary umbel (11.77 cm) and secondary umbel (8.06 cm), seed yield in main umbel (7.01 g), primary umbel (6.46 g) and umbel (4.90 g), 1000-seed weight (1.34 g), seed yield per plant (21.16 g) and % germination (83.93) were obtained in boron fertilizer level 3 kg B/ha while the lowest values of all the above mentioned parameters were found from control level (control) 0 kg B/ha (Table 1, 2 & 3). The highest yield per hectare (1769.11 kg) was also found in boron level 3 Kg B/ha and the lowest (1371.93 kg) from 0 kg B/ha (Table 3). It may be due to proper dose of boron plants have more reserve food materials and store in the seeds resulting, the seeds became bolder that enhance the speed of germination process and higher yield per unit area. The 3 kg B/ha level of boron, crop got sufficient nutrient which cause them to get more food and nutrients and as a result of which each plant showed better performance in respect of individual character. On the contrary, the control plot had boron deficiency which causes them less yield production. Deficiency of boron causes problem in carrot seed production. It affects pollen viability, hampers seed formation and development. Thus, yield and quality of seeds are affected (Sharma *et al*., 1999).

Table 4. Combined effect of variety and boron fertilizer on vegetative growth and flowering behaviour of carrot

Treatment combinations (Variety× Boron)	Plant height at harvest (cm)	Days to 50% flowering	Days to 50% fruit set	Days required from flower to fruit set
V_1B_0	100.97	62.31	83.50	14.85
V_1B_1	113.79	66.54	85.25	16.63
V_1B_2	121.25	65.19	88.30	19.43
V_1B_3	129.39	71.98	91.66	20.15
V_1B_4	125.55	69.42	87.38	19.29
V_2B_0	96.08	59.20	79.23	13.04
V_2B_1	102.54	62.69	83.65	14.39
V_2B_2	108.78	64.97	85.68	16.97
V_2B_3	112.80	64.16	88.78	18.13
V_2B_4	113.39	65.32	85.03	16.75
LSD 5%	7.603	3.604	2.976	2.119
LSD 1%	10.250	4.857	4.011	2.856
Level of significance	**	**	**	**

V_1 = Brasilia Agroflora, V_2 = Prima Agroflora, B_0 = 0 Kg B/ha, B_1 = 1 Kg B/ha, B_2 = 2 Kg B/ha, B_3 = 3 Kg B/ha, B_4 = 4 Kg B/ha, ** Significant at 1% level

Table 5. Combined effect of variety and boron fertilizer on umbel characteristics of carrot

Treatment combinations (Variety× Boron)	No. of primary umbels/ plant	No. of secondary umbels/ plant	Diameter of primary umbel (cm)	Diameter of secondary umbel (cm)	Diameter of main umbel (cm)
V_1B_0	9.87	11.24	9.41	6.64	9.75
V_1B_1	10.71	12.95	10.69	7.57	10.17
V_1B_2	10.61	14.88	11.15	7.60	11.10
V_1B_3	11.44	18.72	12.03	8.36	12.49
V_1B_4	10.69	16.81	11.57	8.13	11.18
V_2B_0	9.39	10.20	9.21	6.55	9.35
V_2B_1	9.39	11.48	9.91	6.96	10.34
V_2B_2	10.01	12.53	10.52	7.59	10.55
V_2B_3	10.58	16.31	11.51	7.81	11.58
V_2B_4	10.07	15.07	11.30	7.76	10.89
LSD 5%	0.834	1.841	0.877	0.723	0.867
LSD 1%	1.124	2.481	1.182	0.975	1.168
Level of significance	**	**	**	**	**

V_1 = Brasilia Agroflora, V_2 = Prima Agroflora, B_0 = 0 Kg B/ha, B_1 = 1 Kg B/ha, B_2 = 2 Kg B/ha, B_3 = 3 Kg B/ha,B_4 = 4 Kg B/ha, ** Significant at 1% level

Table 6. Combined effect of variety and boron fertilizer on plant growth and seed yield contributing characteristics of carrot

Treatment combinations (Variety× Boron)	Seed yield in primary umbel (g)	Seed yield in secondary umbel (g)	Seed yield in main umbel (g)	1000-seed weight (g)	Seed yield / plant (g)	Seed yield / ha (kg)	Seed germination (%)
V_1B_0	4.87	3.58	5.14	0.97	16.03	1395.85	76.46
V_1B_1	6.31	4.09	6.34	1.13	18.58	1519.51	49.77
V_1B_2	5.98	5.01	6.74	1.18	20.16	1661.98	81.65
V_1B_3	6.64	4.95	7.25	1.41	22.27	1857.78	84.31
V_1B_4	6.42	4.50	6.12	1.25	20.93	1763.79	83.15
V_2B_0	4.44	3.31	4.47	0.94	14.90	1348.02	75.99
V_2B_1	5.88	3.99	5.96	1.11	16.70	1404.44	79.13
V_2B_2	6.16	4.80	6.44	1.13	19.74	1599.02	82.79
V_2B_3	6.28	4.84	6.77	1.27	20.05	1680.43	83.56
V_2B_4	6.24	4.72	6.15	1.18	19.61	1678.92	82.27
LSD 5%	0.931	0.759	0.982	0.065	1.274	99.180	2.609
LSD 1%	1.254	1.023	1.323	0.087	1.717	133.70	3.517
Level of significance	**	**	**	**	**	**	**

V_1 = Brasilia Agroflora, V_2 = Prima Agroflora, B_0 = 0 Kg B/ha, B_1 = 1 Kg B/ha, B_2 = 2 Kg B/ha, B_3 = 3 Kg B/ha, B_4 = 4 Kg B/ha, ** Significant at 1% level

Combined effect of variety and boron fertilizer : The combined effect of boron fertilizer and variety were found highly significant difference of all the parameters studied. The maximum seed yield per plant (22.27 g) was produced by the combination of variety Brasilia Agroflora (V_1) and the boron level B_3 (V_1B_3) and the minimum yields (14.90 g) was observed in the combination of variety Prima Agroflora (V_2) and control treatment (V_2B_0). The maximum seed yield per hectare (1857.78 kg) was produced by the combination of variety V_1 and the boron dose B_3 (V_1B_3) and the minimum yields (1348.02 kg) were observed in the combination of variety V_2 and control treatment ($V_2B_{0;}$ Table 6). The maximum weight of 1000 seeds (1.41 g) and seed germination (84.31 %) were also recorded in the combination of V_1B_3 and the minimum weight of 1000 seeds (0.94 g) and % seed germination (75.99) were also recorded in the combination of V_2B_0 (Table 4, 5 & 6). So, carrot variety of Brasilia Agroflora (V_1) with the level of boron fertilizer 3 kg B/ha may be used in carrot seed production to get maximum yield.

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