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Effect of soil and foliar application of boron on growth and seed yield of onion

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Abstract

A field experiment was conducted during *rabi* season, 2015-16 at Research Farm, Chilli and Vegetable Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola with an objective to study the effect of soil and foliar application of boron on growth and seed yield of onion (*cv.* Akola Safed) on Inceptisol in randomized block design with seven treatments and three replications fertilized with different levels of boron fertilizers. The treatments comprised of three levels of basal dose of boron through borax @ 1.5, 3.0 and 5.0 kg ha⁻¹ at the time of planting of onion bulbs and foliar sprays of boron through borax @ 0.1%, 0.2% and 0.3% at buttoning stage (60 DAP). The result revealed that the growth attributing characters such as highest number of tillers per plant (11.85), lowest number of days to attain 50% buttoning stage (27 days after planting), highest number of umbels per plant (12.83) and highest polar diameter (4.06 cm) and equatorial diameter (4.92 cm) were recorded with the soil application of borax @ 3.0 kg ha⁻¹ (T₃). However the significantly highest yield and yield attributing characters *viz.*, umbellate per umbel (227.55), seeds per umbel (680.87), seed weight per umbel (3.46 g), seed yield (14.84 q ha⁻¹) and quality parameters such as test weight – g/1000 seeds (5.18 g) were found most effective with the foliar sprays of borax @ 0.2% at buttoning stage (60 DAP) which was at par with foliar sprays of borax @ 0.3% at buttoning stage (60 DAP) followed by soil application of borax @ 3.0 kg ha⁻¹. It could be concluded that, foliar application of borax @ 0.2% at buttoning stage (60 DAP) or soil application of borax @ 3.0 kg ha⁻¹ at the time of planting of onion bulbs recorded highest seed yield.

Keywords: Boron fertilizers, borax, umbellate, umbel, seed yield

Introduction

Onion (*Allium cepa* L.) which belongs to the family Alliaceae is one of the most important vegetables (Ayoub and Hala, 2013) [5]. In Maharashtra, onion is produced in three season *viz.*, kharif or rainy, late kharif and rabi or winter. Seed has a unique role to increase onion production and good quality seed is the most important input component for productive agriculture. The total annual organised seed production of onion is about 750-800 tonnes against the demand of 4000 tonnes (Singh, 2010) [25]. In Maharashtra there is a demand of 600 tonnes seed per year. While only 300 tonnes of seed is produced. So there is necessary to increase area under seed production programme to produce good quality seeds in large quantity every year which will acts as a source to increase per hectare seed yield of onion. Onion seed is usually produced in the temperate and subtropical countries. In the region where high temperature prevails almost throughout the year, only the early bolting type of onion, requiring relatively little low temperature exposure, can produce seed. Onion is a biennial crop for the purpose of seed production. In one season bulbs are produced from seed and in the second season bulbs are replanted to produce seed. Onion seeds are poor in keeping quality and lose viability within a year. Therefore, it is essential to produce seeds freshly and use the same for bulb production. It is highly cross-pollinated crop which is facilitated by protandrous nature of flowers. Cross-pollination is effected by honey-bees (Bose *et al.*, 1986) [7].

There are two basic systems of production, bulb-to-seed production and seed-to-seed production. Bulb-to-seed production has the advantage that it is possible to select the bulbs to maintain the quality of the seed stock and to discard off-types, e.g., double-bulbs, misshapen bulbs or premature bolters (Brewster, 1994) [7]. On an average onion seed yield of 700 to 900 kg ha⁻¹ can be obtained under good management practices. As large bulbs produce number seed stalks which result in increase in seed yields (Singh, 2001) [26]. Yield and quality of onion seed is greatly affected by the soil fertility and environmental conditions during growth and

development (Anisuzzaman *et al.*, 2009) [4]. The importance of micronutrients has been realized during the past four decades when widespread micronutrient deficiencies were observed in most of the soils in our country, where intensive agriculture is practiced.

Boron (B) deficiency is one of the major constraints to crop production (Sillanpaa, 1982) [24]. B has emerged as an important micronutrient in Indian agriculture, next only to zinc in the context of the spread of its deficiency (Sathya *et al.*, 2009) [22]. About one third of the cultivated soils in India are deficient in B (Gupta *et al.*, 2008) [14]. Sandy, highly leached, calcareous (>8% calcium carbonate), high pH (>7) and recently limed soils are prone to B deficiency (Borkakati and Takkar, 2000; Alloway, 2008) [16, 21]. Boron is absorbed by the plants mainly as boric acid (H_3BO_3). However, it can also be absorbed in some of its anionic forms, *viz.*, dihydrogen borate ($H_2BO_3^-$), monohydrogen borate (HBO_3^{2-}) and borate (BO_3^{3-}), under high pH conditions. Boron has been considered to be functional in the transport of carbohydrates and translocation of sugar is thought to be enhanced by the formation of borate- sugar complexes (Gauch and Dugger, 1954; Price *et al.*, 1972; Marcus- Wyner and Rains, 1982; Katyal and Randhawa, 1983) [13, 21, 18, 16]. Boron is involved in the reproduction of plants and germination of pollen (Wallace, 1961) [30]. Boron is associated with the pollen producing capacity of anther, viability of pollen tubes, pollen germination and growth of pollen tube (Mathew and George, 2013) [19]. B in anthers, stigmas and ovaries may be twice as high in stems of plants (Sywortokin, 1958) [28], suggesting its role in pollen formation and quality of flowers and fruits. Boron also increases nectar production in flowers which attracts pollinating insects (Kumar *et al.* 2014) [20]. Being a less mobile nutrient in plants, boron deficiency symptoms first appear on stem tips, young leaves, flowers and buds (Dobermann and Fairhurst, 2000) [11].

Successful seed production of onion depends on specific environmental conditions. The plant growth and yield of onion seed are greatly influenced by a number of factors which include, among others, optimization of fertilizer application and conservation of soil moisture (Anez, 1996, Dubey and Khan, 1993, Singh *et al.*, 1996) [3, 12].

Materials and Methods

A field experiment was carried out at Research Farm, Chilli and Vegetable Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *rabi* season 2015-16 on Inceptisol soil. The experiment was laid out in Randomized Block Design (RBD) with seven treatments and three replications. The treatments were comprised of three levels of basal dose of boron through borax @ 1.5, 3.0 and 5.0 kg ha⁻¹ at the time of planting of onion bulbs and foliar sprays of boron through borax @ 0.1%, 0.2% and 0.3% at buttoning stage (60 DAP). A total of seven treatments consists of T₁ – Control, T₂ – S. A. of borax @ 1.5 kg ha⁻¹, T₃ – S. A. of borax @ 3.0 kg ha⁻¹, T₄ – S. A. of borax @ 5.0 kg ha⁻¹, T₅ – F. A. of borax @ 0.1% at buttoning stage (60 DAP), T₆ – F. A. of borax @ 0.2% at buttoning stage (60 DAP), T₇ – F. A. of borax @ 0.3% at buttoning stage (60 DAP). The whole experimental plot was divided into three blocks, each of which was then divided into 7 unit plots. The total number of plot was 21. The size of each unit plot was 3 m x 2.10 m. The spaces between blocks and unit plots were 1 m and 0.6 m respectively. In each unit plots, the ridges and furrows were prepared for planting of onion bulbs. The disease free of uniform medium size onion bulbs (var. Akola Safed) about

4.5 to 6.5 cm in diameter was used for planting of bulbs. Before planting, the one third portions of these bulbs were cut and lower bulbs treated with fungicide copper oxychloride (COC) of 0.2% solution and these bulbs were planted on ridges and furrows at the spacing 60 x 30 cm. The planting was done on 13th October, 2015. The basal fertilizer dose of 50: 50: 50 N, P₂O₅ and K₂O kg ha⁻¹ were applied through urea, diammonium phosphate (DAP) and muriate of potash (MOP) after 30 days of planting of onion bulbs and remaining half dose of nitrogen (50 kg N) as top dressed at 60 days after planting of onion bulbs. The treatment wise borax was also applied as basal by mixing with FYM. The foliar spray of borax was carried out at buttoning stage (during anthesis stage) in respective treatments. The spraying was avoided during the period of flowering to maturity stage. Seeds were harvested as per the maturity of umbels from each net plot separately. It was done by cutting off umbels when about 15-20% umbellate was opened. After harvesting of umbels the seeds were dried thoroughly in the sun before threshing. Plot wise threshing, cleaning and weighing operations were done manually. The observations were recorded on growth attributing and yield attributing characters. The data collected from the experimental field was analyzed statistically following the procedure as described by (Panse and Sukhatme, 1985).

S. A. - (Soil application of borax)

F. A. - (Foliar application of borax)

Results and Discussion

(I) Growth attributing characters

The data pertaining to the plants per plot, tillers per plant, days required to 50% buttoning of onion, number of primary and secondary umbels per plant, diameter of umbel (polar and equatorial) as influenced by various treatments of boron are presented in Table 1, Table 2 and Table 3.

(a) Plants per plot

The number of plants per plot varied from 14.00 to 15.00. The plant population is most important for seed production of onion which ultimately influences the seed production. Onion is a highly cross pollinated crops which is facilitated by protandrous of flowers (Singh, 2001) [26].

(b) Tillers per plant

The data revealed that the highest number of tillers per plant (11.85) was recorded with soil application of borax @ 3.0 kg ha⁻¹ (T₃) which was at par with the foliar application of borax @ 0.2% at buttoning stage (60 DAP) (11.73) and 0.3% at buttoning stage (60 DAP) (11.59). Production of branches at the pre- flowering stage ensures the floral primordial initiation and subsequently can contribute to a better yield from the crop by the application of treatments. Hence, soil as well as foliar application of borax increased number of tillers per plant because boron helps in growth of meristematic tissues, which ultimately increase vegetative growth and boron is involved in the cell wall development, cell differentiation and shoot elongation of plants (Sharma *et al.*, 1999) [23].

(c) Buttoning stage

It was observed from the data that the soil application of borax @ 3.0 and 1.5 kg ha⁻¹ showed lowest number of days to attain 50% buttoning stage (27 and 28 days after planting) of bulbs as compared to foliar application of borax @ 0.1%, 0.2% and 0.3% and the control. Plants which did not received

boron were the last to flower among all the treatments. They flowered at 30 days after planting of bulbs. Induction of early flowering due to application of micronutrients was mainly ascribed to the process of plant regulators which have an influence on early flower initiation (Deepika and Pitagi, 2015)^[9].

(d) Umbels per plant

The total umbels consist of number of primary and secondary umbels per plant. The primary umbels are almost higher than the secondary umbels. The significantly highest number of umbels per plant (12.83) was recorded in the treatment of soil application of borax @ 3.0 kg ha⁻¹ (T₃) followed by foliar application of borax @ 0.2% and 0.3%. It is noticed that, the highest primary umbels (8.93) and secondary (3.90) were recorded in the treatment of soil application of borax @ 3.0 kg ha⁻¹ which was statistically at par with the foliar application of borax @ 0.2% and 0.3%. The data indicated that the diameter of umbel i.e. polar diameter (vertical) and equatorial diameter (horizontal) was increased significantly due to the application of borax over control.

(e) Umbel diameter

The result indicated that the highest polar diameter (4.06 cm) and equatorial diameter (4.92 cm) were recorded with the soil application of borax @ 3.0 kg ha⁻¹ (T₃) which was at par with the foliar application of borax @ 0.2% (T₆) and 0.3% (T₇). The number of umbels per plant and umbel diameter was significantly highest in the treatment of soil application of borax @ 3.0 kg ha⁻¹ because due to application of borax 3.0 kg ha⁻¹, crop received sufficient nutrient which cause them to get more food and nutrients as a result plant showed better performance in respect of individual characters. Basal dose and foliar application of boron was inductive to vegetative growth characters to a great extent because boron helps in photosynthesis and growth of meristematic tissues, carbohydrate and auxin metabolism, cell development and differentiation which ultimately increase vegetative growth (Kumar *et al.*, 2014)^[20].

(II) Seed yield attributing characters

The data pertaining to the umbellate per umbel, seeds per umbel, seed weight per umbel as influenced by various treatments of boron are presented in Table 4.

(a) Umbellate per umbel

The significantly highest number of umbellate per umbel (227.55) was recorded with the foliar application of borax @ 0.2% (T₆) which was at par with foliar application of borax @ 0.3% (216.64) (T₇) and soil application of borax @ 3.0 kg ha⁻¹ (207.16) (T₃). The variation in number of flowers per inflorescence might be due to the role of boron in enhancement in translocation of carbohydrate from site of synthesis to storage tissue in plant. The highest number of seeds per umbel (680.87) was recorded in the treatment of foliar application of borax @ 0.2% at buttoning stage (60 DAP) followed by foliar application of borax @ 0.3% (653.08) which was statistically at par with the soil application of borax @ 3.0 kg ha⁻¹ (647.18).

(b) Seeds per umbel

The highest number of seeds per umbel (680.87) was recorded in the treatment of foliar application of borax @ 0.2% at

buttoning stage (60 DAP) followed by foliar application of borax @ 0.3% (653.08) which was statistically at par with the soil application of borax @ 3.0 kg ha⁻¹ (647.18). Because of boron is involved in the reproduction of plants and germination of pollen (Wallace, 1961)^[30]. Boron is associated with the pollen producing capacity of anther, viability of pollen tubes, pollen germination and growth of pollen tube (Mathew and George, 2013)^[19].

(b) Seed weight per umbel

The significantly highest seed weight per umbel (3.46 g) was recorded with the foliar application of borax @ 0.2% (T₆) at buttoning stage followed by foliar application of borax @ 0.3% (3.18 g) (T₇) which was at par with the soil application of borax @ 3.0 kg ha⁻¹ (T₃) (2.79 g). The highest seed weight per umbel was recorded with the foliar application of borax followed by soil application of borax might be due to boron involved in transportation of sugar across cell membranes, cellular differentiation and development, nitrogen metabolism, active salt absorption, water retention etc. (Kumar *et al.*, 2014)^[20]. The mobilization of photosynthates to the developing seeds by application micronutrients might be the reason for increase in seed weight (Sivaiah *et al.*, 2013)^[27].

(III) Seed yield of onion

The data in respect of seed yield per plant and seed yield (q ha⁻¹) as influenced by various treatments are presented in Table 5. Significantly highest seed yield (14.84 q ha⁻¹) was recorded with foliar application of borax @ 0.2% at buttoning stage (60 DAP) (T₆) followed by foliar application of borax @ 0.3% at buttoning stage (12.81 q ha⁻¹) (T₇) which was statistically at par with soil application of borax @ 3.0 kg ha⁻¹ (12.22 q ha⁻¹) (T₃). Foliar applied boron causes increase in seed yield than soil applied boron. Boron is required more at reproductive stage and foliar applied boron is instantly become available to plant as compared to soil applied boron (Padbhushan and Kumar, 2014)^[20]. The improvement in yield can be ascribed to boron as it is directly linked with process of fertilization, pollen producing capacity of anther, viability of pollen grains, pollen germination and pollen tube growth (Agarwal *et al.*, 1981, Dickson, 1978, Vaughan, 1997)^[1, 10, 29]. Similar trend was observed in seed yield per plant because boron on seed yield can be attributed to increasing seed yield per plant (35.99) which was highest in treatment of foliar application of borax @ 0.2% at buttoning (60 DAP) followed by foliar application of borax @ 0.3% at buttoning stage (60 DAP) and at par with soil application of borax @ 3.0 kg ha⁻¹.

(IV) Quality parameters

The data in relation to test weight of seed are reported in Table 6. Test weight of seed consists of weight of 1000 seeds (g). Significantly highest test weight of seeds (5.18 g) was recorded in the treatment of foliar application of borax @ 0.2% (T₆) which was at par with foliar application of borax @ 0.3% (T₇) (4.96 g) and the soil application of borax @ 3.0 kg ha⁻¹ (T₃) (4.81 g). Increase in test weight of seeds might be due to boron application influence cell division, carbohydrate metabolism, sugar and starch formation, which increases size and weight of grain (Kalyani *et al.*, 1993)^[15].

Table 1: Growth attributing characters as influenced by various treatments of boron application

Treatments	Plants / plot	Tillers / plant	Days to 50% buttoning
T ₁ – Control	14.00	9.97	33.67
T ₂ - S. A. of borax @ 1.5 kg ha ⁻¹	14.67	10.35	30.33
T ₃ - S. A. of borax @ 3.0 kg ha ⁻¹	15.00	11.85	27.00
T ₄ - S. A. of borax @ 5.0 kg ha ⁻¹	14.33	10.84	32.00
T ₅ - F. A. of borax @ 0.1% at buttoning stage (60 DAP)	14.67	10.16	31.33
T ₆ - F. A. of borax @ 0.2% at buttoning stage (60 DAP)	14.33	10.35	28.67
T ₇ - F. A. of borax @ 0.3% at buttoning stage (60 DAP)	13.67	10.05	29.33
SE (m)±	0.32	0.20	0.88
CD at 5%	NS	0.62	2.74

S. A. - (Soil application of borax) F. A. - (Foliar application of borax)

Table 2: Umbels per plant as influenced by various treatments of boron application

Treatments	Umbels per plant		
	Primary umbels	Secondary umbels	Total umbels
T ₁ – Control	6.53	2.20	8.73
T ₂ - S. A. of borax @ 1.5 kg ha ⁻¹	7.00	2.47	9.47
T ₃ - S. A. of borax @ 3.0 kg ha ⁻¹	8.93	3.90	12.83
T ₄ - S. A. of borax @ 5.0 kg ha ⁻¹	7.27	2.70	9.97
T ₅ - F. A. of borax @ 0.1% at buttoning stage (60 DAP)	7.40	2.73	10.13
T ₆ - F. A. of borax @ 0.2% at buttoning stage (60 DAP)	8.00	3.63	11.63
T ₇ - F. A. of borax @ 0.3% at buttoning stage (60 DAP)	7.87	3.00	10.87
SE (m)±	0.38	0.36	0.74
CD at 5%	1.11	1.06	2.17

Table 3: Umbel diameter as influenced by various treatments of boron application

Treatments	Umbel diameter (cm)	
	Vertical	Horizontal
T ₁ – Control	3.19	3.83
T ₂ - S. A. of borax @ 1.5 kg ha ⁻¹	3.24	3.90
T ₃ - S. A. of borax @ 3.0 kg ha ⁻¹	4.06	4.92
T ₄ - S. A. of borax @ 5.0 kg ha ⁻¹	3.32	4.10
T ₅ - F. A. of borax @ 0.1% at buttoning stage (60 DAP)	3.41	3.99
T ₆ - F. A. of borax @ 0.2% at buttoning stage (60 DAP)	3.95	4.63
T ₇ - F. A. of borax @ 0.3% at buttoning stage (60 DAP)	3.62	4.37
SE (m)±	0.15	0.18
CD at 5%	0.47	0.57

Table 4: Umbellate per umbel, seeds per umbel and seed weight per umbel as influenced by various treatments

Treatments	Umbellate / umbel	Seeds / umbel	Seed weight / umbel (g)
T ₁ – Control	174.60	365.00	2.03
T ₂ - S. A. of borax @ 1.5 kg ha ⁻¹	182.74	421.30	2.11
T ₃ - S. A. of borax @ 3.0 kg ha ⁻¹	207.16	647.18	2.79
T ₄ - S. A. of borax @ 5.0 kg ha ⁻¹	184.31	486.42	2.14
T ₅ - F. A. of borax @ 0.1% at buttoning stage (60 DAP)	191.11	584.71	2.43
T ₆ - F. A. of borax @ 0.2% at buttoning stage (60 DAP)	227.55	680.87	3.46
T ₇ - F. A. of borax @ 0.3% at buttoning stage (60 DAP)	216.64	653.08	3.18
SE (m)±	13.24	13.71	0.24
CD at 5%	41.26	41.00	0.76

Table 5: Seed yield of onion as influenced by various treatments of boron application

Treatments	Seed yield per plant (g)	Seed yield (q ha ⁻¹)
T ₁ – Control	18.31	7.98
T ₂ - S. A. of borax @ 1.5 kg ha ⁻¹	24.63	10.34
T ₃ - S. A. of borax @ 3.0 kg ha ⁻¹	27.49	12.22
T ₄ - S. A. of borax @ 5.0 kg ha ⁻¹	20.43	11.04
T ₅ - F. A. of borax @ 0.1% at buttoning stage (60 DAP)	24.90	11.36
T ₆ - F. A. of borax @ 0.2% at buttoning stage (60 DAP)	35.99	14.84
T ₇ - F. A. of borax @ 0.3% at buttoning stage (60 DAP)	34.34	12.81
SE (m) ±	3.57	0.98
CD at 5%	11.12	3.06

Table 6: Test weight of seed as influenced by various treatments of boron application

Treatments	Test weight of seeds (g/ 1000 seeds)
T ₁ – Control	3.74
T ₂ - S. A. of borax @ 1.5 kg ha ⁻¹	4.42
T ₃ - S. A. of borax @ 3.0 kg ha ⁻¹	4.81
T ₄ - S. A. of borax @ 5.0 kg ha ⁻¹	4.66
T ₅ - F. A. of borax @ 0.1% at buttoning stage (60 DAP)	4.70
T ₆ - F. A. of borax @ 0.2% at buttoning stage (60 DAP)	5.18
T ₇ - F. A. of borax @ 0.3% at buttoning stage (60 DAP)	4.96
SE (m)±	0.17
CD at 5%	0.50

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