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Effect of phosphorus and boron on yield and biochemical parameters of tomato (*Lycopersicum esculentum* Mill.)

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Abstract
The effect of phosphorus and boron on the yield of tomato (*Lycopersicum esculentum* Mill.) were investigated at the Field Experimentation Centre of the Department of Biological sciences. Sam Higginbottom University of Agriculture, Technology and Sciences. Allahabad (UP). During the period from February 2018 to May 2018 to find out the effect of P and B on the yield of tomato. Tomato with 16 treatments and 3 replications were laid out in Randomized Block Design. This research is based on application and effect of P and B on yield parameters number of flowers per cluster, number of fruit clusters per plant, number of fruits per plant, fruit width, individual fruit weight, weight of fruit per plant, fruit yield per plot were found in 6g P and 2g B per m^2. The combination of the doses of phosphorus T_{11} (6g P/m^2) with boron (2g B/m^2) may be recommended for tomato cultivation. This combination significantly produced the highest fruit yield in tomato.

Keywords: Phosphorus; boron; yield; tomato

Introduction
Tomato (*Lycopersicum esculentum* Mill.) belongs to family Solanaceae. it is one of the most popular, important and widely used vegetable crops as ranked number two vegetable of the world after potato (Dorais *et al.*, 2008; Olaniyi *et al.*, 2010) [6, 12]**.** It is considered a perennial crop, but for commercial productions it is cultivated as an annual crop (Mohamed *et al.*, 2010). Fertilizer play important role in tomato yield and quality. Macro essential nutrient (N, P, K) and some micro nutrient such as (B, Cu, and Zn) are very important for enzymatic reactions with in plant body such as the making of RNA and DNA, protein formation, synthesis of cell wall, occurrence of flowering and fruit formation, important part of growth hormone, while their deficiency affected the growth and quality of plants. (Tisdale *et al.*, 1985) [19]. Boron is very essential for growth, yield and quality of tomato. It helps in the development of cell wall, occurrence of cell division, formation of vascular bundle (phloem) and transport of CH_2O (sugar) foliar application of boron resulted increase in setting of fruit, yield of fruit in plant like plums, almond and grapes. (Chaudhary, 2006) [4]. Plants with deficient of boron have leaves thickened, wilted and curled form, petioles thickened, cracked one with watery condition. Fruits, tuber, roots are discoloured, cracked or rotted one (Tisdale *et al.*, 1985) [19].
Phosphorus and boron are the most important nutrient elements for tomato production. Optimum level of P application increases the vegetative growth, yield and yield attributes and each nutrient element had a positive effect on vegetative growth as well as yields (Rahman *et al.*, 1996; Shil *et al.*, 1997) [16]. Boron is another important element for tomato as fruit vegetable. A positive correlation was observed between boron and flower bud, number of flowers and weight of fruit in tomato (Bose *et al.*, 2002) [3].
Micronutrient deficiencies are not only hampering crop productivity but also are deteriorating quality. The low micronutrient feed and food stuffs are causing health hazards in human beings and animals. Micronutrient acts as catalyst in the uptake and use of certain macronutrients (Phillips, 2004) [14]. Fruit size and quality as well as quality of some crops, are improved with micronutrient (Zn and B) use.
Boron is another important micro nutrient required for good quality and high yield of crops (Dale and Krystyna, 1998) [5]. It is involved in the synthesis and integrity of cell wall, cell wall lignification, metabolism of RNA, carbohydrate, phenol and Indole Acetic Acid (IAA), respiration and cell membrane integrity (Parr and Loughman, 1983) [13].

Boron increases the fruit set percentage by promoting pollen germination and elongation of pollen tube (Abdalla, 2006) [1]. Boron content also influences calcium metabolism and its deficiency declines the calcium associated with pectin constituents (Yamaguchi *et al.*, 1986) [21]. Boron deficiency results in wilting and leaf drop (Zekri and Obreza, 2003) [22] and adversely affect the quality and yield of many vegetables especially tomato (Imtiaz *et al.*, 2010) [9]. Its requirements of plants can be satisfied by both foliar and soil application during growing season, especially during reproductive growth stage (Sajid, 2009) [17].

Materials and Methods

The present experiment was undertaken at field of Department of Biological Sciences, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences Allahabad, Uttar Pradesh, INDIA during *rabi* 2017-18. Tomato variety (Balvan), a local variety. The single factor experiment was laid out in the Randomized Block Design (RBD) with 3 replications. The entire experimental plot was divided in to 3 blocks each containing 16-unit plots. In total, there were 48-unit plots. The selected treatments were randomly assigned to each unit plot so as allocated one treatment once in each block. The unit plot was 1 m x 1 m in size with a distance between the blocks was 30 cm and that between unit plots was 30 cm. and recommended package of practices were followed to raise the crop. With different Combinations of Phosphorus and Boron for proper yield of tomato. Over all 15 treatments. Tomato seedlings were raised in one seedbed. The size of seed bed was 2m x l m. 10 grams of seeds were sown in seedbed on 28th January 2018. After sowing, the seeds were covered with light soil to a depth of about 0.6 cm. Complete germination of the seeds took place within 7-8 days of' sowing. Shading by mat (chatai) was provided over the seedbed to protect the young seedlings from the scorching sunshine or heavy rain. Weeding, mulching, and water management were done from time to time as and when needed. No chemical fertilizer was used in the seedbed. Different yield and Biochemical parameters have been recorded & stastically analysed during the course of study.

Treatments of the experiment

The experiment considered of two factors. The levels of each factor are as follows

Factor A: It included four levels of phosphorus which are mentioned below.

Phosphorus level	Notation
0g/m^2	P_0
3g/m^2	P_1
6g/m^2	P_2
9g/m^2	P_3

Factor B: It included four levels of boron which are mentioned below.

Boron level	Notation
0g/m^2	B_0
1g/m^2	B_1
2g/m^2	B_2
3g/m^2	B_3

Combined effect of phosphorus and boron which are mentioned below with Notation

Results

Fruits yield and its components

1) **Days to first flowering:** Days to first flowering was increased with the increasing boron and phosphorous dose. Increased boron rates delayed flowering of the plants. The plant fertilized with 3g. Phosphorous and 0.7g boron produced early flowering (32.66 days) in T_5. Followed by control T_0. and flowering was lasted in T_{15} (39.83 days) was occurred in 9g phosphorous and 3g of boron followed by T_{10} with (37.86 days) The application of recommended rates of P with farmyard manure and vermicompost was superior in terms of yield per plant, yield/ha, number of fruits per plant, Average of tomato fruit weight, number of fruits per inflorescence, and TSS [total soluble solids] content Vermicompost with N, P and K induced early flowering, whereas early picking was obtained with the application of vermicompost and Phosphorous (Shula *et al.* 2006) [18].

Number of flowers per inflorescence statistically significant. The maximum number of flowers per inflorescence observed in T_{11} (7.60) and T_{15} (7.20) compared to other treatments and control T_0 (4.20)

2) **Number of fruits per plant:** Number of fruits per plant statistically significant. And it is varied from highest in T_{10} (5.3) and lower in control T_0 (3.3) the increased yield was not due to larger fruits, but to an increase in the number of fruits. (Felipe and Casanova 2000) [7].
3) **Fruit width (cm):** Fruit width (cm) statistically significant. highest in T_{10} (5.24cm) and T_{15} (5.02 cm) and lesser in control T_0 (3.78 cm) evaluated that Mycorrhizal infection and high soil P conditions improved total flower production, fruit mass, in tomato. (Poulton *et al.* 2002) [15].
4) **Fruit yield (kg):** Fruit yield (kg) per plot statistically significant. Highest in T_{11}(1.73 kg) followed by T_{14} (1.60 kg) and minimum in T_0 with (0.81kg) (Amar Chandra and Verma 2003) [2].

Biochemical contents

Biochemical components of plant like chlorophyll (mg/g), carotenoid total soluble solids (^{0}Brix) and total chlorophyll (mg/g) ascorbic acid of plant**.**

5) **Chlorophyll (mg/g):** The maximum chlorophyll(mg/g) content observed in T_{11}(2.21mg/g) followed by T_9(1.93mg/g) and lesser in T_0 with (1.20mg/g) The effects of phosphorous and boron help plants to increasing chlorophyll contents, were confirmed in cucumber, radish, and cowpea by (Farouk *et al*., 2011); (El-Tantawy 2009).
6) **Carotenoid (mg/g/Fr. Wt):** The maximum carotenoid content observed in T_{15}(3.67) and followed by T_{11}(3.45) and minimum in T_0(2.08)
7) **Total soluble solids (^{0}Brix):** The maximum total soluble solids (^{0}Brix) observed inT_8(5.17) followed by T_7 and T_{11} with same TSS content (5.13) reducing sugars and total soluble sugars were also affected by low nutrient supply of phosphatic fertilizers (Hu-Fan Rong 2004) [8] recommended dose of nitrogen and phosphorous show highest total soluble solids content in TLB111 variety of tomato. (Mishra *et al.* 2004) [10].

Ascorbic acid: The maximum ascorbic acid was observed in T_8 (16.33) followed by T_{13} (15.76) and minimum in T_0 with (12.03) recommended dose of nitrogen and phosphorous show highest ascorbic acid and acidity in TLB 182 variety of tomato. (Mishra *et al.* 2004) [10].

Table 1: Effect of Boran on fruit yield and its components

Treatments	Days to first flowering	Number of flowers per inflorescence	Number of fruits per plant	Fruit width(cm)	Fruit yield (kg)
T_0 - P_0B_0	29.66^{f}	4.20^{D}	3.60^{bc}	3.78^{H}	0.81^{G}
T_1 - P_1B_0	32.40^{Ef}	6.00^{bc}	4.80^{A}	3.91^{gh}	0.89^{Fg}
T_2- P_2B_0	32.60^{ef}	5.96^{bc}	4.83^{A}	4.23^{efg}	1.06^{Defg}
T_3- P_3B_0	33.46^{de}	5.56^{cd}	4.63^{ab}	4.56^{cde}	1.10^{def}
T_4- P_0B_1	33.06^{def}	6.20^{bc}	4.46^{ab}	4.05^{fgh}	1.03^{efg}
T_5- P_0B_2	32.26^{ef}	6.20^{bc}	5.03^{a}	4.65^{bcd}	1.03^{efg}
T_6- P_0B_3	34.06^{cde}	6.13b^{c}	4.76^{a}	4.39^{def}	1.00^{efg}
T_7- P_1B_1	34.33^{Bcde}	6.50^{abc}	5.13^{A}	4.65^{bcd}	1.12^{cdef}
T_8- P_1B_2	33.46^{de}	5.91^{bc}	4.83^{a}	4.90^{Abc}	1.40^{bc}
T_9- P_1B_3	32.53^{ef}	6.97^{Ab}	4.96^{a}	4.87^{abc}	1.18^{cde}
T_{10}- P_2B_1	37.86^{Ab}	6.40^{abc}	4.76^{a}	4.02^{fgh}	1.50^{ab}
T_{11}- P_2B_2	37.28^{abc}	7.60^{a}	5.33^{a}	5.24^{a}	1.73^{a}
T_{12}- P_2B_3	36.60^{abcd}	6.86^{abc}	4.95^{a}	4.46^{de}	1.08^{defg}
T_{13}- P_3B_1	33.40^{d}	6.06^{bc}	3.33^{C}	4.60^{cbe}	1.33^{bcd}
T_{14}- P_3B_2	35.13^{bcde}	6.56^{abc}	5.20^{a}	4.65^{bcd}	0.93^{efg}
T_{15}- P_3B_3	39.83^{a}	7.20^{Ab}	4.96^{a}	5.02^{ab}	1.60^{ab}
Mean	34.24	7.2	4.72	4.49	1.17
C.V	6.232	13.247	13.803	5.206	14.331
CD (5%)	3.566	1.385	1.088	0.396	0.283

Table 2: Effect of Boran on Biochemical contents

Treatments	Chlorophyll (mg/g)	Carotenoid content (µg/ fresh leaf)	Total soluble solids(^{0}Brix)	Ascorbic acid content (µg/ gram)
T_0 - P_0B_0	1.20^{H}	2.08^{i}	3.66^{fg}	12.03^{G}
T_1 - P_1B_0	1.83^{cd}	2.30^{hi}	3.36^{G}	13.33^{defg}
T_2- P_2B_0	1.47^{fg}	2.71^{def}	3.86^{f}	13.16^{efg}
T_3- P_3B_0	1.79^{d}	2.51^{fgh}	3.56f^{g}	13.96^{cdef}
T_4- P_0B_1	1.42^{g}	2.63^{efg}	4.33^{de}	14.26^{cdef}
T_5- P_0B_2	1.49^{fg}	2.36^{ghi}	3.76^{fg}	14.19^{Cdef}
T_6- P_0B_3	1.84^{Cd}	2.75^{def}	4.40^{d}	15.26^{Abc}
T_7- P_1B_1	1.55^{ef}	2.74^{def}	5.13^{ab}	12.93^{fg}
T_8- P_1B_2	1.50^{fg}	2.97^{Cd}	5.17^{A}	16.33^{A}
T_9- P_1B_3	1.93^{b}	3.24^{bc}	4.70^{Bcd}	14.46^{bcde}
T_{10}- P_2B_1	1.58^{e}	2.64^{efg}	4.46^{d}	13.43^{def}
T_{11}- P_2B_2	2.21^{a}	3.45^{Ab}	4.60^{Cd}	14.33^{cde}
T_{12}- P_2B_3	1.54^{ef}	2.83^{de}	3.90^{ef}	14.56^{bcd}
T_{13}- P_3B_1	1.81^{cd}	2.99^{cd}	5.03^{abc}	15.76^{ab}
T_{14}- P_3B_2	1.88^{bc}	3.32^{b}	5.13^{ab}	15.33^{abc}
T_{15}- P_3B_3	1.84^{cd}	3.67^{a}	4.36^{d}	15.00^{abc}
Mean	1.68	2.82	4.33	14.27
C.V	2.992	6.702	6.479	5.765
CD (5%)	0.081	0.319	0.460	1.379

Discussion

The experiment consisted of two factors, (i) four different doses of phosphorus (P) viz., 0, 3, 6, 9 g/m^2, (ii) four different doses of boron (B) viz., 0, 1, 2, 3g/m^2. The experiment consisting of 16 treatment combinations was laid out in Randomized Block Design (RBD) with three replications. The size of each unit plot was 1 m x 1 m and the date of transplanting was 5th march 2018. Five plants were randomly selected in each plot to record the data on growth, yield and yield contributing characters. The collected data were statistically analyzed and the difference between means was evaluated Randomized block design.

Phosphorus and boron played an important role on the yield and yield contributing characters of tomato. The results of the experiment revealed that all the characters studied were significantly influenced by different doses of phosphorus and boron except days to first flowering. It was evident that there was an increasing response of all the parameters with the increasing levels of phosphorus and boron upto certain level 6gram phosphorous and 2gram boron (T_{10}). and then it was declined. The highest fresh matter accumulation and dry matter accumulation of plant, chlorophyll 'a' chlorophyll 'b' and total chlorophyll, flower clusters per plant, flowers per cluster, number of fruits per plant, fruit width, individual fruit weight, weight of fruit per plant, fruit yield per plot were found from 6g P and 2g B per plot. Plants fertilized with 6g P and 2g B produced the highest fruit yields per plot (1.73kg).

Conclusion

In respect of all the yield parameters number of flowers per cluster, number of fruit clusters per plant, number of fruits per plant, fruit width, individual fruit weight, weight of fruit per plant, fruit yield per plot were found in T_{11} (6g P and 2g B per m^2).

The combination of the doses of phosphorus T_{11} (6g P/m^2) with boron (2g B/m^2) may be recommended for tomato cultivation. This combination significantly produced the highest fruit yield in tomato.

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