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Effect of boron and plant spacing on growth and yield of tomato (*Solanum lycopersicon* L.) CV. Pusa ruby

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Abstract
Different factors affect the successful production of tomato crop but boron and plant spacing is the most important factors for vegetative growth, plant population and flowering, fruiting per unit area is also important and responsible for increasing the yield of tomato entitled "Effect of boron and plant spacing on growth and yield of tomato (*Solanum lycopersicon* L.) C_V Pusa ruby". Have been conducted at the research farm of AKS University, Sherganj Satna. During Kharif season of 2015-16. Under irrigation to assess the response of tomato to boron (B) fertilizer rates and spacing's. The treatments consisted of four levels of boron (0 kg, 1 kg, 2 kg and 3 kg/ha) and three levels of spacing's (row to row 90 cm. and plant to plant 50, 60, 170 cm.). Experiment was laid out in Randomized block design with three replications. The results of the experiment showed application of boron use of spacing's had significantly. Influence on the most parameters such as Plant height (cm), numbers of branch/plant, day to first flowering, day to 50% flowering, No. of flower/cluster, day to first fruit set, No. of fruit/cluster, fruit length, fruit diameter, average fruit weight, No. of fruit/plant, fruit yield/plant, fruit yield/plot and fruit yield/ha. 2 kg/ha boron. Experiment comprises of three spacing's viz. 90 x 50 cm, 90 x 60 cm and 90 x 70 cm had significantly. Increase on the most parameters such as plant height (cm), numbers of branch/plant, day to first flowering, day to 50% flowering, No. of flower/cluster, day to first fruit set, No. of fruit/cluster, fruit length, fruit diameter, average fruit weight, No. of fruit/plant, fruit yield/plant, fruit yield/plot, fruit yield/ha on wider spacing's 90 x 60 cm.

Keywords: Tomato (*Solanum lycopersicon* L.), Pusa ruby, boron, spacing, growth & yield

1. Introduction
Tomato (*Solanum lycopersicon* L.) is one of the most widely grown vegetable in the world and ranked first in preserved and processed vegetables. It is said to be native of Western South America and belongs to family solanaceae. The genus Solanum consists of annual or short lived perennial herbaceous plants. Tomato is a typical day neutral plant and is mainly self-pollinated but a certain percentage of cross-pollination also occurs. It is a warm season crop, reasonably resistance to heat and drought and grows under wide range of soil and climatic conditions. Tomato fruits are consumed as raw or cooked besides large quantity of tomato are used to make soup, ketchup, sauce, salad, chutneys, paste and powder etc. Tomato is important and remunerative vegetable in India. It is rich source of minerals, and vitamins and organic acids; Tomato fruit provides 3-4% total sugar, 4-7% total solids, 15-30mg/100g ascorbic acid 7.5-10 mg/100g. titratable acidity and 20-50 mg/100g.fruit weight of lycopene Uttar Pradesh, Maharashtra, Karnataka, Bihar, and Orissa. Boron deficiency affects the growing points of roots and youngest leaves. The leaves become wrinkled and curled with light green colour. Its deficiency affects translocation of sugar, starch, nitrogen and phosphorus, synthesis of amino acids and proteins (Stanley *et al*., 1995) [8]. There is less incidence of diseases and pests and sometimes has the advantage of staking. Mechanically harvested and processing tomatoes should be planted at close spacing. Hybrids are planted at wider spacing from row-to-row and close spacing of plant-to-plant to facilitate mechanization.

Materials and Methods: The present research works "Effect of boron and plant spacing on growth and yield of tomato (*Solanum lycopersicon* L.)" have been undertaken in the Department of Horticulture, AKS University, Satna (M.P.) during 2015-2016. Experiment has been conducted at the farm of AKS University, Satna M.P. (80°21' to 81°23' east longitude and 23°58' to 25°12' north latitude). The experimental plot was located about 2000 meters East of

AKS University, Campus. The experiment was arranged in a factorial randomized block design with 12 treatment splitted in two factorial *i.e.,* four levels of boron and three plant spacing with 3 replications. The randomized of the treatment was done with the help of random number table as shown in the plant of layout *viz.,* Crop - Tomato**,** Design - Factorial Randomized block design, Replication - 3, Treatment - 12**,** Total No. of plots - 36, Plot size (meter) - 2.75×2.75, Distance between replications - 0.75 m., Distance between plots - 0.5 m, Distance between row to row - 90 cm., Distance between plant to plant - 50, 60 and 70cm. Net experimental area - (8.25×33) =272.25 m.^{2}.

Treatment combinations

B_0S_1	B_1S_1	B_2S_1 B_3S_1
B_0S_2	B_1S_2	B_2S_2 B_3S_2
B_0S_3	B_1S_3	B_2S_3 B_3S_3

Results: The present research work entitled "Effect of boron and plant spacing on growth and yield of tomato (*Solanum lycopersicon* L.)*"* have been undertaken in the Department of Horticulture, AKS University, Satna (M.P.) during 2015-2016. Data on different parameters were analyzed statistically and results have been presented in tables and figures.

(i) Plant height 30 (DAT): Data collected in connection with height of the plant in (cm) as affected by different levels of boron and plant spacing. Critical analysis of data portrayed in above table obviously indicated that application of boron @ 2kg/ha caused beneficial response on height of plant at 30 DAT and all the treatments were differed significantly. Maximum Plant height i.e. 44.96 cm. was recorded when Boron was applied @ 2kg/ha. An examination of data presented in above table indicated that use of different plant spacing's proved to be beneficial and height of the plant he affected significantly due to use of plant spacing and maximum plant height 43 cm was recorded with S_2 spacing (90X60) was used.

(ii) Plant height 60 days (DAT): Data assembled on account of height of the plant in (cm) as affected by different levels of boron and plant spacing. Data displayed in above table due to use of different levels of boron. Causes striking effect on height of the plant at 60 DAT and improved height i.e. 60.70 cm was recorded by the incorporate of boron @ 2 kg/ha. Data referred in above table mark out that height of the plant was affected by the use of plant spacing. Different spacing's differed significantly and maximum height of plant i.e. 58.05 cm was noted when S_2 (90x60 cm) plant spacing was used.

(iii) Plant height 90 days (DAT): Data collected in connection with height of the plant in (cm) as affected by different levels of boron and plant spacing. Plant height was significantly affected by different level of boron @ 0 kg, 1 kg, 2kg and 3 kg per hectare at 90 days after transplanting (DAT). Maximum plant height was obtained when boron @ 2kg/ha. Was used and minimum plant height 72.87 cm was recorded in control (0 kg/ha). Plant height was significantly affected by different plant spacing (90x50) (90x60) and (90x70) cm proved to be beneficial and height of the plant affected significantly due to use of S_2 spacing followed by S_3.

(iv) Plant height 120 days (DAT): Data collected on account of plant height in (cm) as affected by different levels of boron and plant spacing. Critical analysis of data portrayed in above table obviously indicated that application of boron @ 2kg/ha caused beneficial response on height of plant at 120 DAT and treatments were differed significantly. Maximum plant height i.e. 179.18 cm. was recorded when boron was applied @ 2kg/ha. An examination of data presented in above table indicated that use of different plant spacing's proved to be beneficial and height of the plant affected significantly due to use of S_2 spacing.

(v) Number of branches per plant at 60 (DAT): Data assemble on account of number of branches per plant as affected by different levels of boron and plant spacing. Number of branches per plant the main effect of boron revealed that there was significant difference in number of branches per plant due to different levels of boron used. The number of branches per plant was gradually increased with increasing levels of boron. Application of boron @ 2kg/ha caused beneficial response on number of branches per plant at 120 DAT and treatment were differed significantly. Maximum number of branches per plant i.e. 3.09 was recorded when boron was applied @ 2kg/ha. Number of branches per plant the main effect of spacing revealed that there was significant difference in number of branches per plant due to different plant spacing used. The number of branches per plant was gradually increased with increasing plant spacing. Number of branches per plant affected significantly due to use of S_2 plant spacing.

(vi) Number of branches per plant 90 (DAT): Data collected in connection with number of branches per plant as affected by different levels of boron, plant spacing. Critical analysis of data portrayed in above table obviously indicated that application of boron @ 2kg/ha caused beneficial response on number of branches per plant at 90 DAT and treatments were differed significantly. Maximum number of branches per plant i.e.6.58 was recorded when boron was applied @ 2kg/ha. An examination of data presented in above table indicated that use of different plant spacing's proved to be beneficial and number of branches per plant affected significantly due to use of S_2 plant spacing.

(vii) Number of branches per plant 120 (DAT): Data collected in relation to number of branches per plant as affected by different levels of boron, plant spacing and their interactions have been displayed in table No. 1.

Table 1: Table showing Number of branches/plant of tomato as influenced by different levels of boron and plant spacing at 60 after transplanting.

Number of branch/plant at 60 day	
Levels of Boron	**Number of branch**
B_0 (0 kg/ha)	2.58
B_1 (1 kg/ha)	2.62
B_2 (2 kg/ha)	3.09
B_3 (3 kg/ha)	2.72
SEm±	0.08
CD (P=0.05)	0.22
Plant spacing	
S_1 (90x50 cm)	2.58
S_2 (90x60 cm)	2.95
S_3 (90x70 cm)	2.72
SEm±	0.07
CD (P=0.05)	0.19

(viii) Days to first flowering: Data collected in connection days to first flowering as affected by different levels of boron and plant spacing have been displayed in table No. 2.

Table 2: Table showing Days to first flowering of tomato as influenced by levels of boron and plant spacing.

Days to first flowering	
Levels of Boron	**first flowering**
B_0 (0 kg/ha)	30.55
B_1 (1 kg/ha)	30.17
B_2 (2 kg/ha)	25.44
B_3 (3 kg/ha)	28.71
SEm±	1.02
CD (P=0.05)	2.98
Plant spacing	
S_1 (90x50 cm)	35.94
S_2 (90x60 cm)	23.34
S_3 (90x70 cm)	26.88
SEm±	0.88
CD (P=0.05)	2.58

(ix) Days to 50% flowering: Data collected in connection with days to 50% flowering was affected by different levels of boron and plant spacing. Days taken to 50% flowering varied significantly due application of boron. Application of boron @ 2kg/ha caused beneficial response on days to 50% flowering and treatments were differed significantly. Minimum days to 50% flowering i.e.34.85 (days) was recorded when boron was applied @ 2kg/ha. Days taken to 50% flowering varied significantly due use of different plant spacing's proved to be beneficial and days to 50% flowering affected significantly due to use of S_2 plant spacing.

(x) Number of flower/cluster: Data collected in connection number of flower/cluster as affected by different levels of boron and plant spacing. Critical analysis of data portrayed in above table obviously indicated that application of boron @ 2kg/ha caused beneficial response on number of flower/cluster and treatments were differed significantly. Maximum number of flower/cluster i.e. 8.25 was recorded when boron was applied @ 2kg/ha. An examination of data presented in above table indicated that use of different plant spacing's proved to be beneficial and number of flower/cluster affected significantly due to use of S_2 plant spacing.

(xi) Days to first fruit set: Data collected in connection days to first fruit set as affected by different levels of boron and plant spacing. Result on the effect of boron had significant effect on the Days to first fruit set by application of boron @ 2kg/ha caused beneficial response on days to first fruit set and treatments were differed significantly. Maximum days to first fruit set i.e. 29.08 (days) was recorded when boron was applied @ 2kg/ha. Result on the effect of boron had significant effect on the Days to first fruit set by use of different plant spacing's proved to be beneficial and days to first fruit set affected significantly due to use of S_2 plant spacing.

(xii) Number of fruits/cluster: Data collected in connection number of fruits/cluster as affected by different levels of boron, plant spacing and their interactions have been displayed in graphically represented in Fig. No. 1.

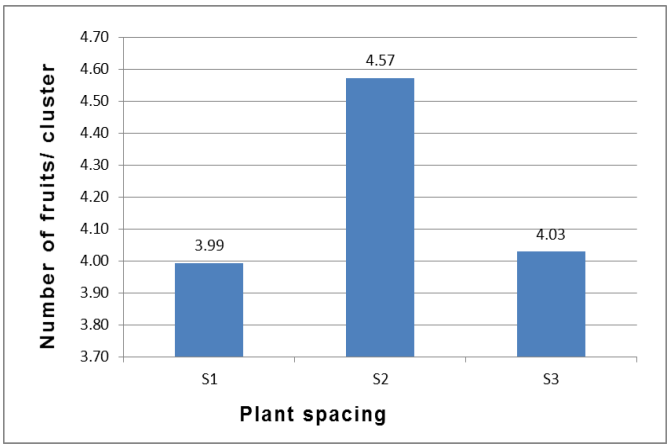

Fig 1: Number of fruits/ cluster of tomato as influenced by different plant spacing

(xiii) Fruit length (cm): Data collected with reference to fruit length (cm) as affected by different levels of boron and plant spacing. Critical analysis of data portrayed in obviously indicated that application of boron @ 2kg/ha caused beneficial response on fruit length (cm) and all the treatments were differed significantly. Maximum fruit length (cm) i.e. 5.03 was recorded when boron was applied @ 2kg/ha. An examination of data presented in above table indicated that use of different plant spacing's proved to be beneficial and fruit length (cm) affected significantly due to use of S_2 plant spacing.

(xiv) Fruit Diameter (cm): Data assembled on account of fruit diameter (cm) as affected by different levels of boron and plant spacing. Critical analysis of data portrayed in obviously indicated that application of boron @ 2kg/ha caused beneficial response on fruit diameter (cm) and all the treatments were differed significantly. Maximum fruit diameter (cm) i.e. 4.61 was recorded when boron was applied @ 2kg/ha. An examination of data presented in above table indicated that use of different plant spacing's proved to be beneficial and fruit diameter (cm) affected significantly due to use of S_2 plant spacing.

(xv) Average fruit weight (g): Data collected in connection average fruit weight (g) as affected by different levels of boron and plant spacing. Critical analysis of data portrayed in obviously indicated that application of boron @ 2kg/ha caused beneficial response on average fruit weight (g) and treatments were differed significantly. Maximum fruit weight (g) i.e. 59.35 was recorded when boron was applied @ 2kg/ha. An examination of data presented in above table indicated that use of different plant spacing's proved to be beneficial and fruit weight (g) affected significantly due to use of S_2 plant spacing.

(xvi) Number of fruits/plant: Data assembled on account of number of fruits/plant as affected by different levels of boron and plant spacing. Critical analysis of data portrayed in obviously indicated that application of boron @ 2kg/ha caused beneficial response on number of fruits/plant and all the treatments were differed significantly. Maximum number of fruits/plant i.e. 28.25 was recorded when boron was applied @ 2kg/ha. An examination of data presented in above table indicated that use of different plant spacing's proved to be beneficial and number of fruits/plant affected significantly due to use of S_2 plant spacing.

(xvii) Fruit yield/plant (kg): Data collected in connection fruit yield/plant (kg) as affected by different levels of boron and plant spacing have been displayed in graphically represented in Fig. No.2.

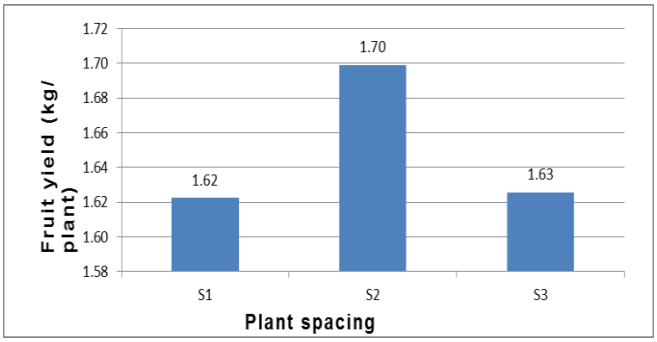

Fig 20: Fruits/ Yield of tomato as influenced by different plant spacing

(xviii) Fruit yield/plot (kg): Data collected in connection fruit yield/plot (kg) as affected by different levels of boron and plant spacing. Critical analysis of data portrayed in obviously indicated that application of boron @ 2kg/ha caused beneficial response on fruit yield/plot and treatments were differed significantly. Maximum fruit yield/plot i.e.18.43 kg was recorded when boron was applied @ 2kg/ha. An examination of data presented in above table indicated that use of different plant spacing's proved to be beneficial and fruit yield/plot affected significantly due to use of S_2 plant spacing.

(xix) Fruit yield/hectare (tone): Data collected in connection fruit yield/hectare (tone) as affected by different levels of boron and plant spacing. Critical analysis of data portrayed in obviously indicated that application of boron @ 2kg/ha caused beneficial response on fruit yield/hectare and treatments were differed significantly. Maximum fruit yield/hectare i.e. 23.10 was recorded when boron was applied @ 2kg/ha. An examination of data presented in above table indicated that use of different plant spacing's proved to be beneficial and fruit yield/hectare affected significantly due to use of S_2 plant spacing.

Discussion

Growth, yield and yield attributes; Effect of boron: In the present investigation it is evident that the increase doses of boron only up to 2 kg/ha significantly the tomato crop. The higher dose of 2 kg/ha given significantly more growth and yield attributes, yield and quality content the over the lower boron levels it was observed that the boron dose of 2 kg/ha has given higher values of all these characters over 3 kg B/ha The beneficial effect of applied of boron may be due to the fact that application of boron maintained the boron requirement of the plant by supplying sufficient amount of nutrients essential for their growth, boron is indirectly associate with the vegetative growth of the plant, this help in the development of cell and cell division, Quack cell enlargement and cell formation result in quack growth, The production of more carbohydrate induce fruit setting and ultimately Increase the yield, The plant which supply lower doses of boron could not maintained growth The vegetative development was checked and fruit setting started at an early stage. On the over hard the vegetative stage of plant was produced by the high doses of boron and such plants bear the fruits in the stage, but due to the maintenance of boron supply the fruit setting were attributed up to the last stage. The plant with limited supply of boron exhausted their energy at an early stage and thus were reduced in the latter stage of growth, such plant could not maintain their growth after one are two picking and they began to Pell yellow due to the shortage of boron supply, The beneficial effect of boron was also reported by Shah (2006) [5], Oyinlola (2004) [3], Amarchandra and Verma (2003) [1], Cardozo *et al.*, (2001) [2], Prasad *et al.*, (1997) [4] reported that increasing doses of boron 2 kg/ha significantly increased fruit yield.

Effect of plant spacing: The height of plant was influenced significantly due to the plant spacing, The significant in plant height increase in plant height was noted under widest spacing (90×50cm) followed by (90×60cm) and (90×70cm), However at 90 days after transplanting the plant height was also significantly highest due to spacing (90×60cm) spacing over the closer spacing, In very dense stands, both enter plant and intra plant competition for moisture, light and nutrition were significantly serves to reduce height of plant, On the other hand widest spacing gave most favorable condition. The fruit yield per plant was found significant highest with the widest spacing (90X60cm) followed by (90X70cm) and then (90X50cm), It may be attributed to the higher percentage of fruit set, high fruit retention, increase in diameter and fruit weight and more number of fruit per plant under widest over closest plant spacing, Consequently the yield per hectare was also recorded highest with the widest plant spacing 90×60cm. It was due to more favorable condition and other physiological and yield parameters. The above results are in conformity with the findings of Singh *et al*. (2002) [6], and Singh *et al.* (2005) [7] the phonological characters were not influenced up to significant extent due to plant spacing's,

Summary and Conclusions: The experiment was carried out at the Horticulture field, AKS University, Satna during 2015-16 to study the effect of boron viz.,- 0kg (control), 1kg, 2kg and 3kg and three plant spacing viz., 90×50 cm, 90×60 cm and 90×70 cm on tomato. The experiment was laid out in a Randomized Block Design (with factorial concept) with three replications. The plot size was 7.56m2 (2.75m × 2.75m). Altogether 12 treatment combinations were there in the experiment. Harvesting was done when crop was matured. Growth characters - The plant height and Number of branches/plant were increased with the age of plants from 30 to 120 DAT, at every stage of growth, these parameter increased significantly when 2 kg/ha boron was applied. Thereafter the declining trend was noted when the B level was higher than 2 kg/ha to 3 kg/ha boron. Boron application affected most of the parameters studied. The level of boron 2 kg/ ha gave highest plant height (44.96cm, 60.70cm 87.41cm and 179.18cm at 30,60, 90 and 120 days after transplanting), number of branch/plant (3.09, 6.58, and 9.48 during at 60, 90 and 120 days after transplanting), Days to first flowering (25.44), days to 50% flowering (34.85), Number of flower/cluster (8.24), Days to first fruit set (29.08) Number of fruits/ cluster (4.78), Number of fruits /plant (28.25), fruit length (4.61cm), fruit Diameter(5.03cm), Average fruit weight (59.35g), fruit yield /plant (1.73kg), fruit yield /plot (18.43 kg) and fruit yield /ha (23.10 t). The widest plant spacing (90×60cm) enhanced the plant height significantly 171.35 over the closer spacing (157.11 to 149.59 cm), however, the branches and flower cluster per plant and flower per cluster did not deviate significantly due to spacing (90X60), Application of boron only up to 2 kg/ha enhanced

the number of fruits per plant, size and weight of fruit yield per plant up to some extent, Further increase in boron level up to 3 kg/ha decline all the parameters. The widest plant spacing (90×60cm) result in significantly highest number of fruits (27.81) fruit length (4.95 cm/fruit) fruit weight (58.42 g/fruit), and fruit yield (1.70 kg/plant) over the closer spacing (90×70 and 90×50cm)

Conclusion: On the basis of above information dealt earlier the following specific conclusions are being warranted. Application of 2kg/ ha boron produced significantly large amount of tomato yield *i.e.* 23.10 t/ha. Plant spacing 90×60 cm produced significantly large amount of tomato fruit yield i.e. 22.58 t/ha.

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