Effect of Micronutrient and Organic Fertilizer on Plant Growth and Yield of Broccoli (Brassica Oleracea Var. Italica) CV. Palam Samridhi

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Abstract

Boron and Farm Yard Manure (FYM) has significant role in cell division and development of the plant near the tips of shoots and roots. Hence, the study was conducted to investigate effect of boron and FYM application on plant growth and yield of broccoli (Brassica oleracea Var. Italica) cv. "Palam Samridhi". The study was conducted during 2013-14 and 2014-15 using 10 treatments viz., T_1 (Control), T_2 (Spray of Boron @ 0.3% 20 days after transplanting + 100% of FYM), T_3 (Spray of Boron @ 0.3% 35 days after transplanting + 100% of FYM), T_4 (Spray of Boron @ 0.3% 45 days after transplanting + 100% of FYM), T_5 (Soil application of borax @ 10 kg ha^{-1} + 100% of FYM), T_6 (Soil application of borax @ 12.5 kg ha^{-1} + 100% of FYM), T_7 (Soil application of borax @ 15 kg ha^{-1} + 100% of FYM), T_8 (Soil application of borax @ 10 kg ha^{-1} + 50% of FYM), T_9 (Soil application of borax @ 12.5 kg ha^{-1} + 50% of FYM) and T_{10} (Soil application of borax @ 15 kg ha^{-1} + 50% of FYM). The experiment was designed using Randomized Block Design (RBD) method with three replications. It was found that the boron and FYM application (T_7 - Soil application of borax @ 15 kg ha^{-1} + 100% of FYM) in soil had significantly increased the plant height (67.3 cm), plant spread (4618 cm^2), number of leaves (16), diameter of main curd (16.03 cm), average curd weight of per plant (461 g), number of lateral shoots (6), diameter of lateral shoots (3.2 cm), average weight of lateral shoots (164) and yield (208.1 q/ha).

Keywords – *Broccoli, Yield, Growth parameter, Boron application, FYM*

Boron is much required for cell division and development in the growth regions of the plant near the tips of shoots and roots. It also affects sugar transport and appears to be associated with some of the functions of calcium. Boron affects pollination and

I. INTRODUCTION

Broccoli (*Brassica oleracea var. italica*, family*:* Brassicaceae) which is one of the exotic vegetable introduced in India. The first selection of sprouting broccoli was probably made in Greece and in the pre-Christian era [7]. Broccoli is an edible green plant in the cabbage family whose large, flowering head is eaten as a vegetable [12]. The word broccoli comes from the Italian plural of *broccolo*, which means "the flowering crest of a cabbage", and is the diminutive form of *brocco*, meaning "small nail" or "sprout". Broccoli is often boiled or steamed but may be eaten raw [4]A. Broccoli consists of immature flowering buds which would commonly contain the energy for a plant to fruit it is very high nutrients and often termed as super-food. Broccoli which is nutritious among cole crops being rich in vitamin and minerals and boiling broccoli reduces the levels of suspected anti-carcinogenic compounds, such as sulforaphane [1]. Broccoli has about 14 times more beta-carotene, a precursor of vitamin A than commonly cultivated cabbage [16]. It has high amount of vitamin C and significant amount of potassium, folic acid and several phytochemicals. It can also be a good source of calcium and this can be enhanced if the soil is limed. It has anti carcinogenic properties and has been found useful for number of other diseases. Due to its high levels of vitamin C, beta carotene and fibre broccoli is a powerful antioxidant. High fiber content also believed to be of benefit in case of diabetes. It has as much calcium as milk, and is therefore an important source of nutrition for those with osteoporosis or calcium deficiencies [12].

B. Experimental Design

The experiment was designed using Randomized Block Design (RBD) and SPSS (V. 16.0) Software. In the investigation, 10 treatments were conducted with three replications. The size of each

the development of viable seeds which in turn affect the normal development of fruit. Boron is taken up by plant roots as the neutral molecule $HB_4O_7^-$ and BO_3^-.

II. METHODOLOGY

The experiment was conducted at Research Farm, Chatha, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu during year 2013-2014 and 2014-2015. The Geographical area falls under sub-tropical climate and the place is situated at 32°39'29''N and 74°47'56''E and located at a height of 296 m above the Mean Sea Level. The maximum temperature raises upto 45 ˚C and minimum temperature goes down to 4-5°C. The mean annual rainfall ranges between 1000-1200 mm and large part of it is received during rainy season (July - September).

A. Soil characteristics of the experimental site

Composite surface soil samples (0-15 cm) from different locations were collected. The soil samples were brought in the laboratory and allowed to dry at room temperature. On drying big clods were broken and the soil was grinded with wooden pestle and mortar leaving no aggregates and the soil was finally passed through 2 mm sieve. After sieving, the soil samples were kept in polythene bags separately for analysis. The samples were cleaned, dried and analysed for investigations. The cleaned and dried soil samples were analysed by standard procedure for physico-chemical properties as given in Table 1.

Table 1 Physico-chemical properties of experimental soil

S. No.	Soil Component	Value obtained	Method Adopted
1.	pH	7.2	Glass electrode pH meter [9]
2.	EC (dS/m)	0.45	Solubridge method [9]
3.	CEC (C mol (p^+), per kg)	14.26	Reference as [14]
4.	Organic carbon (%)	0.45	Reference as [19]
8.	Texture	Sandy clay loam	Hydrometer method [5].
9.	Available N (kg/ha)	248.5	Alkaline potassium permanganate method [18]
10.	Available P (kg/ha)	14.4	Olsen's method [13]
11.	Available K (kg/ha)	156.4	Ammonium acetate method [9]
12.	Available B (mg/kg)	0.36	Azomethine – H method [20]

plot was 3 m × 3 m = 9 m^2. However, the spacing between plants was 60 cm × 45 cm. Five plants from each plot were randomly selected and they were labelled. These plants were used for recording all morphological observations in respect of growth and yield of the crop. The details of the observations recorded are as follow: plant height (cm) (60 DAT), plant spread (cm) (60 DAT), number of Leaves per plant (60 DAT), Diameter of the Curd (cm), Curd Weight (g), Number of Lateral shoots, Diameter of Lateral shoots (cm), Total weight of Lateral shoots (g), Total Yield per hectare (q). The obtained data were analyzed statistically using ANOVA.

III. RESULTS AND DISCUSSION

A. Pre- Harvest observations

1. Plant height (cm)

The results pertaining of the role of boron and FYM application on plant height (cm) of broccoli at 60 DAT (Day after transplanting) are presented in table 2. The plant height at 60 DAT found maximum in T_7 (Soil application of borax @ 15 kg ha^{-1} + 100% of FYM) is 67.3 cm followed by 65.7 cm in T_6 (Soil application of borax @ 12.5 kg ha^{-1} + 100% of FYM). The minimum was found in T_1 (control) 58.1 cm. The same trend was reported by [3], [6] in cauliflower.

2. Plant Spread (cm^2)

The data on plant spread which was observed at 60 DAT Day after transplanting is presented in the table 2. At 60 DAT maximum plant spread was found in T_7 (Soil application of borax @ 15 kg ha^{-1} + 100% of FYM) 4618 cm^2. The minimum plant spread 3692 cm^2 was found T_1 (control). These results were found in cauliflower by [3], [6].

3. Number of leaves per plant

The data presented in table 2 clearly showed that the role of boron and FYM application was directly affecting the number of leaves per plant. The maximum number of leaves per plant was recorded significant with application of Soil application of borax @ 15 kg ha^{-1} + 50% of FYM (T_{10}) and T_9 (Soil application of borax @ 12.5 kg ha^{-1} + 50% of FYM), which was recorded (16) leaves. The minimum number of leaves per plant (14.00) was noticed with control. The same trend was reported by [6], [17] while working on cauliflower.

Table 2 Effect of B and FYM application on plant height, plant spread and number of leaves per plant of Broccoli

Notation	Treatments	Plant height (cm)			Plant spread (cm^2)			No. of leaves/plant		
		1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
T_1	Control (Recommended dose of NPK)	57.3	58.8	58.1	3670	3713	3692	14	14	14

T_2	Spray of Boron @ 0.3% applied 20 days after transplanting + Recommended dose of NPK + 100% of FYM	61.7	65.5	63.6	3730	3748	3739	15	16	16
T_3	Spray of Boron @ 0.3% applied 35 days after transplanting + Recommended dose of NPK + 100% of FYM	61.7	66.5	64.1	3887	3913	3900	16	16	16
T_4	Spray of Boron @ 0.3% applied 45 days after transplanting + Recommended dose of NPK + 100% of FYM	61.8	66.0	63.9	3843	3976	3909	15	16	16
T_5	Soil application of Borax @ 10 kg/ha + Recommended dose of NPK + 100% of FYM	63.2	67.7	65.5	4079	4123	4101	16	16	16
T_6	Soil application of Borax @ 12.5 kg/ha + Recommended dose of NPK + 100% of FYM	63.2	68.2	65.7	4415	4441	4428	16	16	16
T_7	Soil application of Borax @ 15 kg/ha + Recommended dose of NPK + 100% of FYM	65.9	68.6	67.3	4610	4625	4618	16	16	16
T_8	Soil application of Borax @ 10 kg/ha + Recommended dose of NPK + 50% of FYM	62.7	66.8	64.7	4110	4174	4142	15	16	16
T_9	Soil application of Borax @ 12.5 kg/ha + Recommended dose of NPK + 50% of FYM	62.3	67.0	64.6	4290	4247	4269	16	16	16
T_{10}	Soil application of Borax @ 15 kg/ha + Recommended dose of NPK + 50% of FYM	62.2	67.3	64.7	4518	4455	4487	16	17	16
	F-Value	2.56	4.39	6.57	5.04	2.42	6.68	3.61	2.28	5.08
	CD (0.05)	3.9	3.9	2.7	441	NS	354	1.0	N.S	1.0
	SE(m) ±	0.50	0.62	0.49	72.31	76.87	68.82	0.17	0.19	0.17
	CV	3.73	3.46	3.59	6.26	8.28	7.34	3.81	4.54	4.21

B. Post-Harvest Observations

1. Number of Lateral shoots

The data presented in table 3 clearly showed that the maximum number of lateral shoots per plant was recorded 6 in T_7 (Soil application of borax @ 15 kg ha^{-1} + 50% of FYM) and the minimum number of lateral shoots per plant (15.00) was noticed with control.

2. Diameter of Lateral shoots (cm)

Boron and FYM application influenced the lateral shoot diameter over control (Table 3). The maximum lateral shoot diameter is 3.2 cm was recorded with T_7 (Soil application of borax @ 15 kg ha^{-1} + 100% of FYM) followed by 3.1 cm in T_6 (Soil application of borax @ 12.5 kg ha^{-1} + 100% of FYM) and T_{10} (Soil application of borax @ 15 kg ha^{-1} + 50% of FYM), which were higher than other. The lowest lateral shoot diameter (2.3 cm) was observed in treatment T_1 (control). This type of result was also reported in broccoli [8] and cabbage [2], [10].

3. Curd Diameter (cm)

Boron and FYM application significantly influenced the curd diameter over control (Table 3). The maximum curd diameter is 16.03 cm was recorded with T_7 (Soil application of borax @ 15 kg ha^{-1} + 100% of FYM) followed by 15.56 cm in T_{10} (Soil application of borax @ 15 kg ha^{-1} + 50% of FYM), which were significantly higher than other. The lowest curd diameter (13.30 cm) was observed in treatment T_1 (control). This type of result was also reported in [8] and cabbage [2], [10].

4. Total weight of Lateral shoots (g)

Table 4 shows that the total weight of lateral shoots was significantly influenced by the different treatment. The treatment T_7 (Soil application of borax @ 15 kg ha^{-1} + 100% of FYM) had significantly the highest weight of lateral shoots (164 g) followed by T_{10} (Soil application FYM) was 160 g. Lowest curd weight 127 g was observed in T_1 (control).

5. Curd Weight (g)

Table 4 shows that the curd weight was significantly influenced by the different treatment. The treatment T_7 (Soil application of borax @ 15 kg ha^{-1} + 100% of FYM) had significantly the highest curd weight (461g) followed by T_{10} (Soil application of borax @ 15 kg ha^{-1} + 50 % of FYM) was 434 g. Lowest curd weight 359 g was observed in T_1 (control). This type of result was also reported in cabbage [2], [10] and cauliflower [11].

Table 3 Effect of B and FYM application on number and diameter of lateral shoots and curd diameter per plant of Broccoli

Notation	Treatments	No. of lateral shoots			Dia. of lateral shoots (cm)			Central head diameter (cm)		
		1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
T_1	Control (Recommended dose of NPK)	5	5	5	2.2	2.4	2.3	13.03	13.56	13.30
T_2	Spray of Boron @ 0.3% applied 20 days after transplanting + Recommended dose of	5	5	5	2.4	2.5	2.4	14.03	14.20	14.11

	NPK + 100% of FYM									
T_3	Spray of Boron @ 0.3% applied 35 days after transplanting + Recommended dose of NPK + 100% of FYM	5	5	5	2.5	2.5	2.5	14.30	14.56	14.43
T_4	Spray of Boron @ 0.3% applied 45 days after transplanting + Recommended dose of NPK + 100% of FYM	5	6	6	2.7	2.8	2.7	14.26	14.63	14.45
T_5	Soil application of Borax @ 10 kg/ha + Recommended dose of NPK + 100% of FYM	5	6	6	2.7	2.9	2.8	14.80	15.03	14.91
T_6	Soil application of Borax @ 12.5 kg/ha + Recommended dose of NPK + 100% of FYM	5	6	6	2.9	3.2	3.1	15.40	15.50	15.45
T_7	Soil application of Borax @ 15 kg/ha + Recommended dose of NPK + 100% of FYM	6	6	6	3.2	3.2	3.2	16.00	16.06	16.03
T_8	Soil application of Borax @ 10 kg/ha + Recommended dose of NPK + 50% of FYM	5	6	6	3.1	3.1	3.1	14.56	14.90	14.73
T_9	Soil application of Borax @ 12.5 kg/ha + Recommended dose of NPK + 50% of FYM	5	6	6	2.8	2.8	2.8	15.23	15.40	15.31
T_{10}	Soil application of Borax @ 15 kg/ha + Recommended dose of NPK + 50% of FYM	5	5	6	3.0	3.1	3.1	15.50	15.63	15.56
	F-Value	0.31	1.02	1.05	2.56	1.86	4.30	10.03	4.88	13.73
	CD (0.05)	N.S	N.S	N.S	0.6	N.S	0.4	0.80	0.99	0.62
	SE(m) ±	0.11	0.12	0.09	0.07	0.07	0.07	0.16	0.16	0.16
	CV	13.31	12.57	12.93	12.88	13.66	13.29	3.21	3.89	3.57

6. Total Yield (q/ha)

The table 4 shows that the treatment T_7 (Soil application of borax @ 15 kg ha^{-1} + 100% of FYM) had significantly more yield per hectare than other treatment (208.1 q ha^{-1}). The yield of treatment T_{10} (Soil application of borax @ 15 kg ha^{-1} + 50 % of FYM) and T_6 (Soil application of borax @ 12.5 kg ha^{-1}) of borax @ 15 kg ha^{-1} + 50 % of+ 100% of FYM) was almost similar 197.8 and 194.9 q ha^{-1}, respectively. The treatment T_1 (control recorded lowest yield per hectare (161.8 q ha^{-1}).]. The increase of total yield might be due to increase in diameter and weight of lateral shoots and main curd was reported by others in cabbage [2], [10] and cauliflower [11], [15].

IV. CONCLUSION

From the present investigation it was concluded that in the field experiment the best treatment combination is application of B in the form borax @ 15.0 kg with recommended dose of NPK and 100 % FYM (T_7) which recorded best results with respect to metric characters like diameter and weight of lateral shoots, central head diameter, head weight and yield. The maximum yield per hectare was recorded in T_7 (208.1 q ha^{-1}) treatment. It is found to be the best treatment combinations to obtain the higher growth parameters and yield in broccoli.

Table 4 Effect of B and FYM application on Total wt. of lateral shoots/plant, Curd weight and Total yield of Broccoli

Notation	Treatments	T wt. of lateral shoot^{-1}plant (g)			Curd weight (g)			Total yield (q ha^{-1})		
		1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
T_1	Control (Recommended dose of NPK)	127	127	127	355	362	359	160.7	163.0	161.8
T_2	Spray of Boron @ 0.3% applied 20 days after transplanting + Recommended dose of NPK + 100% of FYM	136	139	138	362	368	365	166.2	169.3	167.7
T_3	Spray of Boron @ 0.3% applied 35 days after transplanting + Recommended dose of NPK + 100% of FYM	141	141	141	368	375	371	169.1	172.0	170.6
T_4	Spray of Boron @ 0.3% applied 45 days after transplanting + Recommended dose of NPK + 100% of FYM	145	146	146	365	374	369	170.0	173.3	171.6
T_5	Soil application of Borax @ 10 kg/ha + Recommended dose of NPK + 100% of FYM	152	154	153	393	402	398	181.6	185.4	183.5
T_6	Soil application of Borax @ 12.5 kg/ha + Recommended dose of NPK + 100% of FYM	157	158	158	417	439	428	191.1	198.8	194.9

T_7	Soil application of Borax @ 15 kg/ha + Recommended dose of NPK + 100% of FYM	162	165	164	445	477	461	202.3	213.8	208.1
T_8	Soil application of Borax @ 10 kg/ha + Recommended dose of NPK + 50% of FYM	148	150	149	402	430	416	183.3	193.4	188.3
T_9	Soil application of Borax @ 12.5 kg/ha + Recommended dose of NPK + 50% of FYM	153	155	154	412	393	402	182.8	188.1	185.5
T_{10}	Soil application of Borax @ 15 kg/ha + Recommended dose of NPK + 50% of FYM	159	160	160	425	443	434	194.6	201.2	197.8
	F-Value	34.41	5.30	17.96	28.68	8.90	23.25	39.19	14.39	38.30
	CD (0.05)	5.5	14.5	7.5	17	39	20	6.4	12.8	6.8
	SE(m) ±	1.99	2.43	2.07	5.64	7.58	6.37	2.44	3.06	2.71
	CV	2.19	5.67	4.32	2.53	5.56	4.36	2.07	4.00	3.21

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