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Impact of foliar spray of micronutrients on growth, yield and quality of broccoli (*Brassica oleracea* var. *italica*) cv. Pusa KTS-1

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Abstract

Requirement of micronutrients *i.e.*, ammonium molybdate, boric acid, copper sulphate, ferrous sulphate and zinc sulphate for amelioration of growth, yield and quality parameters of broccoli (*Brassica oleracea* var. *italica*) cv. Pusa KTS-1 was studied under field condition. Each micronutrient consisted of three different concentrations (C) 0.20%, 0.40% and 0.60% and applied as foliar feeding to broccoli crop along with control. First spraying of broccoli plants was done on 25th day of planting and subsequently 2nd and 3rd at 45th day and 65th days after transplanting. The result clearly indicated the positive influence of applying micronutrients on yielding maximum plant spread, stalk length, root length, curd yield, ascorbic acid %, reducing sugar %, TSS %, carbohydrate % and minimum days to 50% days to maturity with respect to control. The treatment (T_{15}) zinc sulphate @ 0.60% exhibited highest value of plant spread, stalk length, root length and ascorbic acid content. Foliar application of (T_7) copper sulphate @ 0.40% resulted in minimum number of days to 50% maturity (72.36). However, treatment (T_5) boric acid @ 0.40% resulted in maximum pooled value of curd yield (135.05 q/ha), TSS% and carbohydrate %. Foliar application of (T_2) ammonium molybdate @ 0.40% recorded the maximum pooled value of reducing sugar content (0.81%). Thus, foliar application can be promising approach to maximise broccoli growth and productivity.

Keywords: Broccoli, growth, micronutrients, yield and quality

Introduction

Vegetable production is one of man's basic skills. Among the vegetables, China is the top world producer of broccoli (*Brassica oleracea* L. var. *italica*) followed by India, USA, Spain, Italy, France, Mexico, Poland, Pakistan and United Kingdom (FAO statistics, 2017) [5]. Although, in India broccoli is under-utilized food crop, mainly confined to limited area especially near the big cities. It is rich source of vitamin A and C. It also contains appreciable amount of minerals like phosphorus, potash, calcium, sodium and iron.

Most of the agricultural soils of the world are reported to be inadequate in one or more of the essential nutrients to render healthy plant. Even acidity, alkalinity, salinity, anthropogenic processes and erosion may lead to soil degradation. This deficiency of soil nutrients could be overcome by applying soil or foliar fertilizers or amendments. Foliar application can be considered one of the easier and effective methods, to deliver the needed nutrients to plants in adequate concentrations and improve plant nutritional status as well as increase the crop yield and its quality (Smolen, 2012) [11]. Foliar applications of nutrients like molybdenum, zinc, copper and boron are advantageous compare to soil application, as it furnishes rapid availability of nutrients, enhances immediate uptake of applied nutrients, rule out problem of soil fixation, supplement when immediate response needed and last but not the least, provide nutrients that may not be readily available for root uptake. It is learn that Molybdenum act as catalyst of enzyme activity in the plant. It also affects nitrogen metabolism, protein synthesis and sulphur metabolism. B (boron) is foremost important in affecting growth and yield of Cole crops. The foliar application of zinc, boron, iron and manganese has beneficial role in improving the productivity and quality of crops due to their involvement as a catalyst of various enzymes and other physiologically active molecule (Alloway and Brain, 2008) [2]. However, soil concentration of iron, boron and zinc are more than the plant requirement but these nutrients cannot be readily absorbed by plants. Thus, foliar application can be promising approach to maximise broccoli growth and productivity.

Keeping these in view, the present investigation was conducted to know the effect of foliar spray of micronutrients on the growth, yield and quality of broccoli variety (cv. Pusa KTS-1).

Materials and methods

The field experiment was conducted during the winter season of 2015-2016 and 2016-2017 at the Vegetable Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh. The field experiment was laid out in randomized block design with three replications. The five micronutrient *viz.*, ammonium molybdate {$(NH_4)_2MoO_4$)} boric acid (H_3BO_3), copper sulphate ($CuSO_4$), ferrous sulphate ($FeSO_4$) and zinc sulphate ($ZnSO_4$) consisted of three different concentrations (C) 0.20%, 0.40% and 0.60% and were applied as foliar feeding to broccoli variety (cv. Pusa KTS-1) along with control. The experimental site lies almost in the middle of Indo-Gangetic alluvial plain. The soil samples were analysed for molybdenum (2.7 ppm) and boron (0.30 mg/Kg) concentration using thiosynate method and hot water extraction, respectively. A spacing of 50×40 cm was followed in the plot size of 3m×2m. Spraying was done in the morning (about 9.30 A.M.), when the dewdrops have evaporated. First spraying was done on 25th day of planting and subsequently 2nd and 3rd at 45th day and 65th days after transplanting. Spraying was done with the help of hand sprayer. Observations on plant spread (cm), stalk length (cm) and root length (cm) were recorded by randomly selecting five plants from each plot, while days to 50% curd maturity and yield recorded based on plot. Other quality parameters such as ascorbic acid, reducing sugar, carbohydrate and TSS% were estimated using respective standard method. Results were analysed using analysis of variance (ANOVA) to know the significant differences among the treatments.

Result and discussion

From the finding (Table 1), (T_{15}) zinc sulphate @ 0.60% (39.51 cm) exhibited maximum plant spread, at 30 DAT followed by (T_{13}) zinc sulphate @ 0.20% (38.40 cm) and (T_{14}) zinc sulphate @ 0.40% (38.43 cm) while, at 60 DAT it was maximum in treatment (T_{15}) zinc sulphate @ 0.60% (40.50 cm) followed by (T_{14}) zinc sulphate @ 0.40% (39.45cm) and (T_{13}) zinc sulphate @ 0.20% (39.39) whereas, at harvesting stage the plant spread was again highest with (T_{15}) zinc sulphate @ 0.60% (63.86 cm) stage followed by (T_3) ammonium molybdate @ 0.60% (60.85) and (T_{14}) zinc sulphate @ 0.40% (60.82 cm). This observation indicated the positive influence of foliar spray of different micronutrients on plant spread of broccoli in comparison to control. Zn is important for the formation and activity of chlorophyll and in the functioning of several enzymes and the growth hormone like auxin. However, the auxin availability to the plant could have increased the inter-nodal length coupled with more apical dominance which eventually might have helpful for maximum plant spread. The results are in accordance with the earlier findings of Nkoa *et al.* (2002) [8] and Yildirim *et al.* (2007) [12] in broccoli and Rajawat (2011) [9] in the cabbage

The pooled analysis revealed that, highest stalk length was observed in treatment (T_{15}) zinc sulphate @ 0.60% (6.08 cm) at 30 DAT followed by (T_9) copper sulphate @ 0.60% (5.53 cm) and (T_{14}) zinc sulphate @ 0.40% (5.50 cm) while, at 60 DAT, it was maximum with treatment (T_{15}) zinc sulphate @ 0.60% (13.48 cm) followed by (T_2) ammonium molybdate @ 0.40% (13.01 cm) and (T_8) copper sulphate @ 0.40% (12.94) whereas, at harvesting stage the leaf width was highest with (T_{14}) zinc sulphate @ 0.40% (18.73 cm) followed by (T_{13}) zinc sulphate @ 0.20% (17.93 cm) and (T_{15}) zinc sulphate @ 0.60% (17.92 cm). The minimum pooled stalk length was observed in (T_0) control (3.07, 9.17 and 15.93 cm) at 30 DAT, 60 DAT and harvest stage, respectively. Similar finding has been reported by Agarwal and Ahmed (2007) [1].

Longest root length was noted in foliar spray of (T_{15}) zinc sulphate @ 0.60% (16.40 cm) followed by (T_{14}) zinc sulphate @ 0.40% (15.87 cm) and (T_{13}) zinc sulphate @ 0.20% (14.99 cm), while minimum value of root length was observed in control (T_0) (11.61 cm). At 5% level of significance zinc sulphate @ 0.60% (T_{15}) was significantly superior to rest of the treatment except (T_{14}) zinc sulphate @ 0.40% which was found at par. Similar result was in agreement with finding of Kumar (2009) [7] and Sharma (2012) [10] in broccoli for positive influence of zinc sulphate on root length.

Treatment (T_7) copper sulphate @ 0.40% (72.36) was exhibited minimum number of days to 50% curd maturity followed by (T_5) boric acid @ 0.40% (75.91) and (T_6) boric acid @ 0.60% (76.10). At 5% level of significance application of (T_7) copper sulphate @ 0.20% was significantly superior to rest of the treatment. Chaudhari *et al.* (2017) [4] revealed that the effect of foliar spray of micronutrient was non-significant for days to first curd initiation and days taken to marketable yield.

Application of (T_5) boric acid @ 0.40% recorded maximum pooled value of total yield (135.05 q/ha) followed by (T_{15}) zinc sulphate @ 0.60% (134.98 q/ha), (T_2) ammonium molybdate @ 0.20% (131.66 q/ha) and (T_4) boric acid @ 0.20% (131.38 q/ha). At 5% level of significance (T_5) boric acid @ 0.60% recorded significantly superior total yield with respect to all studied treatments except (T_{15}) zinc sulphate @ 0.60% application which was at par. The obtained results indicate that zinc and boron are a notable nutrient for harvesting an adequate yield of broccoli florets, especially in the soils with low or middle boron and Zn-content, respectively. Similar finding was reported by Chaudhari *et al.* (2017) [4] in cauliflower, Blevins *et al.* (1998) [3] and in broccoli.

The maximum pooled value of ascorbic acid content was recorded with treatment (T_{15}) zinc sulphate @ 0.60% (86.29 mg) followed by the (T_5) boric acid @ 0.40% (84.34 mg) and (T_2) ammonium molybdate @ 0.40% (84.28 mg), which were significantly superior to other treatments at 5% level of significance. However, all the treatments recorded higher ascorbic acid content as compared to the control. The lowest ascorbic acid was recorded with (T_0) control (80.97 mg). Similar finding was obtained by Kotecha *et al.* (2016) [6] in cabbage.

Pooled analysis revealed that the range of carbohydrate content in response to foliar spray of micronutrients recorded greater carbohydrate% in treatment in (T_5) % boric acid @ 0.40% followed by (T_6) boric acid @ 0.60%**.** Similar finding was also reported by Sharma (2012) [10]. Foliar application of (T_2) ammonium molybdate @ 0.40% recorded the maximum pooled value of reducing sugar content (0.81%) followed by (T_5) boric acid @ 0.40% (0.80%), (T_4) boric acid @ 0.20% (0.77%) and (T_6) boric acid @ 0.60% (0.74%) which was significantly superior to the other treatments. The lowest reducing sugar content was recorded in control (0.65%). At 5% level of significance, treatments (T_2) ammonium molybdate @ 0.40%, (T_5) boric acid @ 0.40%, (T_4) boric acid

@ 0.20% and (T_{15}) zinc sulphate @ 0.60% (0.79%) were at par.

Application of (T_5) boric acid @ 0.40% lead to increased TSS%, over other treatments and control followed by the (T_2) ammonium molybdate @ 0.40%, (T_6) boric acid @ 0.60% and (T_{15}) zinc sulphate @ 0.60%. The lowest TSS% was recorded with (T_0) control during both season. The pooled analysis of TSS revealed that (T_5) boric acid @ 0.40% produced maximum TSS% (7.52) over the other treatments. This result was in agreement with the findings of Sharma (2012) [10] in broccoli.

Table 1: Effect of foliar spray of micronutrients on growth, yield and quality attributes of broccoli (*Brassica oleracea var. italica*) cv. Pusa KTS-1 at harvest stage under Varanasi region.

Treatments	Plant spread (cm)			Stalk length (cm)			Root length (cm)	Days to 50 % curd maturity	Yield (q/ha)	Ascorbic acid (mg/100g)	Reducing sugar (%)	TSS (%)	Carbohydrate (%)
	30 DAT	60 DAT	Harvest stage	30 DAT	60 DAT	Harvest stage							
Control (T_0)	16.52	34.16	54.91	3.07	9.17	15.93	11.61	89.43	124.50	80.97	0.65	6.59	32.99
Ammonium Molybdate @ 0.20% (T_1)	18.46	36.37	58.69	5.08	11.86	17.49	13.62	85.48	128.93	82.03	0.68	6.79	34.29
Ammonium Molybdate @ 0.40% (T_2)	21.47	38.45	62.44	4.13	13.01	17.37	13.78	80.89	131.66	84.28	0.81	7.28	37.42
Ammonium Molybdate @0.60% (T_3)	19.47	37.48	60.85	4.91	11.80	16.43	13.89	78.58	125.55	83.18	0.68	7.04	36.47
Boric Acid @ 0.20% (T_4)	19.36	36.49	57.89	4.15	11.75	16.93	13.91	77.52	131.38	81.67	0.77	6.68	36.32
Boric Acid@ 0.40% (T_5)	20.67	37.51	60.80	4.05	12.75	16.45	14.93	75.91	135.05	84.34	0.80	7.52	39.83
Boric Acid @ 0.60% (T_6)	20.48	37.51	57.86	5.02	11.88	15.51	12.92	76.10	128.93	83.48	0.74	7.20	38.28
T_7 (Copper sulphate @ 0.20%)	18.42	35.56	55.99	4.05	11.93	15.53	12.85	72.36	124.88	81.70	0.58	6.42	32.48
T_8 (Copper sulphate @ 0.40%)	19.38	36.52	56.74	4.04	12.94	15.39	13.44	78.40	127.42	82.58	0.72	6.99	34.56
T_9 (Copper sulphate @ 0.60%)	18.48	36.57	56.95	5.53	9.91	15.48	13.95	77.63	124.38	81.05	0.62	6.61	31.56
T_{10} (Ferrous sulphate @ 0.20%)	19.46	35.47	55.89	4.29	11.89	15.15	12.94	79.39	125.96	81.02	0.61	6.54	33.94
T_{11} (Ferrous sulphate @ 0.40%)	18.38	36.52	56.95	4.10	12.03	15.99	14.08	78.46	124.99	81.99	0.62	7.01	32.60
T_{12} (Ferrous sulphate @ 0.60%)	19.38	36.56	59.93	3.91	12.00	16.47	14.90	77.43	127.89	82.26	0.71	7.23	34.51
T_{13} (Zinc sulphate @ 0.20%)	19.54	39.39	58.89	5.04	12.35	17.93	14.99	78.28	128.47	83.49	0.66	6.77	33.25
T_{14} (Zinc sulphate @ 0.40%)	20.39	39.45	60.82	5.50	12.08	18.73	15.87	78.97	128.88	84.01	0.72	7.04	34.60
T_{15} (Zinc sulphate @ 0.60%)	22.59	40.50	63.86	6.03	13.48	17.92	16.40	77.47	134.98	86.29	0.77	7.15	36.48
SEm±	0.78	0.82	1.65	0.70	0.72	0.87	0.82	0.98	0.89	0.20	0.01	0.04	0.83
CD (*P*=0.05)	1.58	1.65	3.30	1.41	1.44	1.75	1.65	1.97	1.78	0.39	0.03	0.09	1.66

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