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Gurkirat Singh Sidhu
Student, Department of
Agriculture, GSSDGS Khalsa
College, Patiala, Punjab, India

Harpreet Kaur
Assistant Professor, Department
of Agriculture, GSSDGS Khalsa
College, Patiala, Punjab, India

Growth and yield of broccoli (*Brassica oleracea* L. var. *italica*) as influenced by different micronutrients under open field conditions

Gurkirat Singh Sidhu and Harpreet Kaur

Abstract

The field experiment entitled “Growth and yield of Broccoli (*Brassica oleracea* L. var. *italica*) as influenced by different micronutrients under open field conditions” was carried out at the Campus for Research and Advanced Studies, G.S.S.D.G.S. Khalsa College, Patiala during the *rabi* season of 2021-2022. The experiment was laid out in randomized block design comprising of ten treatments and three replications. The results revealed that different treatments of micronutrients recorded significantly superior in growth and yield characters. All the growth parameters like plant height at harvest (49.65 cm), No. of leaves plant⁻¹ (21.16 cm), leaf length at harvest (36.48 cm), leaf breadth at harvest (25.51 cm), and plant spread (58.77 cm) were significantly maximum in treatment T₇ (Manganese 2 kg ha⁻¹ + Molybdenum 0.5 kg ha⁻¹ + Boron 1.5 kg ha⁻¹ + Zinc 2.5 kg ha⁻¹) and yield parameters such as curd length (19.97 cm), curd diameter (17.33 cm), curd weight (318.24 g), and curd yield (153.15 q ha⁻¹) were maximum in T₇ (2 kg ha⁻¹ Manganese + 0.5 kg ha⁻¹ Molybdenum + 1.5 Kg ha⁻¹ Boron + 2.5 kg ha⁻¹ Zinc). The economics parameters like gross return and net return was higher in treatment T₇ (Manganese 2 kg ha⁻¹ + Molybdenum 0.5 kg ha⁻¹ + Boron 1.5 kg ha⁻¹ + Zinc 2.5 kg ha⁻¹) while the benefit cost ratio (2.70) was highest in treatment T₇ (Manganese 2 kg ha⁻¹ + Molybdenum 0.5 kg ha⁻¹ + Boron 1.5 kg ha⁻¹ + Zinc 2.5 kg ha⁻¹).

Keywords: Broccoli, zinc, boron, molybdenum, manganese

Introduction

Broccoli (*Brassica oleracea* var. *L italica*) belongs to the family Cruciferae and is an important cole crop after cabbage and cauliflower. It is having a chromosome number 2n = 18. Broccoli is one of the oldest European vegetables and is widely grown throughout the world, including in tropical, sub-tropical and temperate regions. The origin of the broccoli crop is from the coastal area of the Mediterranean Sea. Broccoli is an Italian vegetable that was cultivated in Italy in ancient Roman times (Decoteau, 2002) ^[1].

Broccoli is also reported to have medicinal properties to cure heart diseases and diabetes. Broccoli has compounds like sulforaphane, indole, and phytochemicals found in broccoli, which are reported to have anticancerous properties. Broccoli also contains a certain amount of goitrogens, the naturally occurring substances that can interfere with the functioning of thyroid gland. Broccoli has 89.1 percent moisture, 3.6 g of protein, 5.9 g of carbs, 2500 international units of vitamin A, 0.10 mg of thiamine, 113 mg of vitamin C, 1.3 mg of calcium, and 78 mg of phosphorus per 100 gm of the edible portion (Dhaliwal 2017) ^[2].

Micronutrients are essential for healthy plant growth and crop production. These are required in minute quantities as an economical source for correcting nutrient deficiencies and improving plant health. Horticultural crops suffer widely from micronutrients. Besides the essential macronutrients, micronutrients like molybdenum, boron, copper, iron, manganese and zinc are also essential for plant growth and metabolism. They are vitally connected with chlorophyll formation, protein synthesis and as an oxidation-reduction agent in a biological system and act as an integral part of the enzyme system (Singh *et al.* 2018) ^[7].

Material and Methods

The experiment was performed during winter season of 2021-2022 at the Campus for Research and Advanced Studies, G.S.S.D.G.S. Khalsa College, Patiala (Punjab). The soil of field experiment was clayey having pH 7.8, organic carbon 0.74%, available N, P₂O₅ and K₂O with medium nitrogen and phosphorus and low potash availability. The treatments consists of ten different nutrient management combinations *viz.* T₁ Control, T₂ Boron 1.5 kg ha⁻¹, T₃

Corresponding Author:
Harpreet Kaur
Assistant Professor, Department
of Agriculture, GSSDGS Khalsa
College, Patiala, Punjab, India

Manganese 2 kg ha⁻¹, T₄ Molybdenum 0.5 kg ha⁻¹, T₅ Zinc 2.5 kg ha⁻¹, T₆ Boron 1.5 kg ha⁻¹ + Manganese 2 kg ha⁻¹, T₇ Manganese 2 kg ha⁻¹ + Molybdenum 0.5 kg ha⁻¹ + Boron 1.5 kg ha⁻¹ + Zinc 2.5 kg ha⁻¹, T₈ Manganese 2 kg ha⁻¹ + Molybdenum 0.5 kg ha⁻¹, T₉ Boron 1.5 kg ha⁻¹ + Manganese 2 kg ha⁻¹ + Zinc 2.5 kg ha⁻¹, T₁₀ Boron 1.5 kg ha⁻¹ + Zinc 2.5 kg ha⁻¹. The experiment was laid out in randomized block design with three replications. The Broccoli nursery was one month old and these seedlings were transplanted on 12th November, 2021 with recommended spacing of 45 × 45 cm. The application of micronutrients were applied during field preparation in all treatment plots before 2 days transplanting.

Table 1: Details of layout

Experimental design	Randomised block Design (RBD)
No of replications	3
No of treatments	10
Total number of plots	30
Seed rate	500 g ha ⁻¹
Spacing	45 × 45 cm
Gross plot size	3.15 × 3.15 m ²
Net plot size	2.7 × 2.7 m ²
Variety	Palam Samridhi

Table 2: Treatments Details

T ₁	Control
T ₂	Boron 1.5 kg ha ⁻¹
T ₃	Manganese 2 kg ha ⁻¹
T ₄	Molybdenum 0.5 kg ha ⁻¹
T ₅	Zinc 2.5 kg ha ⁻¹
T ₆	Boron 1.5 kg ha ⁻¹ + Manganese 2 kg ha ⁻¹
T ₇	Manganese 2 kg ha ⁻¹ + Molybdenum 0.5 kg ha ⁻¹ + Boron 1.5 kg ha ⁻¹ + Zinc 2.5 kg ha ⁻¹
T ₈	Manganese 2 kg ha ⁻¹ + Molybdenum 0.5 kg ha ⁻¹
T ₉	Boron 1.5 kg ha ⁻¹ + Manganese 2 kg ha ⁻¹ + Zinc 2.5 kg ha ⁻¹
T ₁₀	Boron 1.5 kg ha ⁻¹ + Zinc 2.5 kg ha ⁻¹

Result and Discussions

Growth parameters

The data on growth parameters (Table 3) reveals that the growth parameters of the crop were significantly best with treatment T₇ i.e. (Manganese 2 kg ha⁻¹ + Molybdenum 0.5 kg ha⁻¹ + Boron 1.5 kg ha⁻¹ + Zinc 2.5 kg ha⁻¹) recorded higher values of plant height (49.65 cm), number of leaves plant⁻¹ (21.16), leaf length (36.48 cm), leaf breadth (25.51 cm) and plant spread (58.77 cm) which was at par with treatment T₉ (Boron 1.5 kg ha⁻¹ + Manganese 2 kg ha⁻¹ + Zinc 2.5 kg ha⁻¹) i.e. plant height (48.46 cm), number of leaves plant⁻¹ (19.74), leaf length (35.19 cm), leaf breadth (24.37 cm) and plant spread (57.39 cm). The treatment T₁ (control) was

significantly shows lower results in the growth parameters of broccoli. The present study shows that the micronutrients plays an important role in growth parameters of broccoli. The micronutrients helps in synthesis of chlorophyll, also involved in synthesis of plant growth hormones like IAA which increase the vegetative growth of plants. It also increased the availability of the nutrients present in soil. The findings revealed that the combination of different micronutrients significantly increased the plant height at different stages of vegetative growth. Similar findings had been observed by Dhotra *et al.* (2018) [3] in broccoli, Singh *et al.* (2018) [7], Farag *et al.* (2022) [4] in cauliflower.

Table 3: Effect of different micronutrients on growth parameters of broccoli.

Treatment	Plant Height (cm)	No. of Leaves plant ⁻¹	Leaf Length (cm)	Leaf Breadth (cm)	Plant Spread (cm)
T ₁	39.56	13.25	26.54	17.36	47.23
T ₂	45.48	16.61	30.99	21.37	52.51
T ₃	44.45	15.47	29.62	19.97	51.56
T ₄	44.58	15.91	30.19	20.92	52.24
T ₅	45.73	16.95	31.59	21.86	53.37
T ₆	47.62	17.67	32.92	23.42	56.48
T ₇	49.65	21.16	36.48	25.51	58.77
T ₈	46.63	17.53	32.53	22.99	54.44
T ₉	48.46	19.74	35.19	24.37	57.39
T ₁₀	47.51	18.23	33.99	23.53	56.96
S.E(m) ±	0.91	0.72	0.90	0.74	0.74
CD (5%)	2.06	1.63	2.05	1.67	1.68

Yield Parameters

The data on yield parameters (Table 4) revealed that the yield parameters of the crop were significantly best by different nutrient management i.e. T₇ (Manganese 2 kg ha⁻¹ + Molybdenum 0.5 kg ha⁻¹ + Boron 1.5 kg ha⁻¹ + Zinc 2.5 kg ha⁻¹) recorded higher values of curd length (19.97 cm), curd diameter (17.33 cm), curd weight (318.24 g), total yield (157.15 q ha⁻¹) which was at par with treatment T₉ (Manganese 2 kg ha⁻¹ + Boron 1.5 kg ha⁻¹ + Zinc 2.5 kg ha⁻¹)

i.e. curd length (19.09 cm), curd diameter (16.20 cm), curd weight (315.32 g), total yield (153.40 q ha⁻¹). The yield parameters increased as a result of more leaves, which may increase chlorophyll synthesis, increased photosynthetic activity, which raises food accumulation, increased use of amino acids and better use of plant nutrients, particularly nitrogen and phosphorus, during the later stages of crop growth. That showed that the combined levels with optimum dose of micronutrients helps in steady uptake of nutrients

which tends to increase the vegetative growth of plants. Due to the better vegetative growth and the highest curd weight of broccoli has been achieved. These results were also revealed by Singh *et al.* (2018)^[7], Pankaj *et al.* (2018)^[5] in broccoli, and Ranjan *et al.* (2019)^[6] in cauliflower.

Table 4: Effect of different micronutrients on yield parameters of broccoli.

Treatment	Curd length (cm)	Curd Diameter (cm)	Curd Weight (g)	Total yield (q)
T ₁	14.35	11.07	198.17	97.92
T ₂	16.82	13.98	286.90	141.51
T ₃	15.86	13.05	278.27	137.41
T ₄	16.21	13.54	281.11	138.81
T ₅	17.11	14.48	292.36	144.37
T ₆	18.29	15.17	296.45	146.39
T ₇	19.97	17.33	318.24	157.15
T ₈	17.49	14.78	293.81	145.09
T ₉	19.09	16.20	315.32	153.40
T ₁₀	18.84	15.59	303.61	149.93
S.E(m) ±	0.59	0.70	1.52	1.03
CD (5%)	1.34	1.58	3.44	2.87

Conclusion

On the basis of present inspection, it has been concluded that the treatment T₇ (Manganese 2 kg ha⁻¹ + Molybdenum 0.5 kg ha⁻¹ + Boron 1.5 kg ha⁻¹ + Zinc 2.5 kg ha⁻¹) was found to be the best treatment combination in growth and yield parameters of Broccoli. Among 10 treatments, it has been concluded that the combined levels of optimum dose of micronutrients showed the best results in vegetative growth and yield parameters of broccoli. Micronutrients also increased the availability of other nutrients which are essential for plant growth. Micronutrients was involved in the synthesis of plant growth hormones like – IAA which increases the enzymatic activities in plant which helped in better vegetative growth of broccoli.

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