Research Article

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Effect of NPK and boron on growth and yield of early cabbage (*Brassica oleracea L. var. capitata*)

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ABSTRACT

The thirteen treatment combinations of NPK and boron fertilizers were evaluated with three replications under randomized block design during July 2023 to December 2023. The results exhibited significant effect of various treatment combinations on growth, yield of cabbage. Maximum plant height (21.20 cm, 31.67 cm and 36.87 cm on 30, 60 DAT and at harvest, respectively), number of non-wrapped leaves per plant (10.53, 14.13 and 17.87 on 30, 60 DAT and at harvest, respectively), leaf area at harvest (288.17 cm^2), leaf length (28.10 cm), leaf width (21.47 cm), plant spread at harvest (71.10 cm), with minimum days taken to head harvest (80.30 DAT) and maximum polar diameter of head (13.80 cm), equatorial diameter of head (15.80 cm), fresh weight of head (931.70 g), yield per plot (13.05 kg) and yield per hectare (230.05 q/ha) were recorded in treatment T13 (NPK 125% + boron 15 kg/ha) compared to rest of treatments, while minimum days taken to head formation (47.83 DAT) was found in T12 (NPK 125% + boron 10 kg/ha). Lowest values for these parameters were recorded under treatment T1 (Control), in which no fertilizers had been applied.

Introduction

Cabbage is the most important cole crop which belongs to the family Brassicaceae and originated in Western Europe and the Mediterranean region. India stands as the world's second-largest producer of cabbage. It can grow easily under wide range of environmental conditions, both temperate and tropical, but cool moist climate is most suitable (Muzimal *et al*., 2011).

It is rich source of vitamins and minerals. It contains, vitamin A (2000 IU), thiamine (0.06 mg), riboflavin (0.03 mg), vitamin C (124 mg), potassium (114 mg), phosphorus (44 mg), calcium (39 mg), sodium (14.1 mg) and iron (0.8 mg) per 100 g edible part (Fageria *et al*., 2003). Cabbage is used for salad, boiled, cooked, cured, pickling and dehydration purposes and its juice is also used as a remedy against poisonous mushrooms has an anti-cancer property and protects against bowl cancer due to the presence of indole-3-carbinal. The leaves are used to recover from ulcers and wounds. Shredded cabbage leaves fermented under pressure (sauerkraut) in their own juice have a curative effect on scurvy disease. It neutralizes acidity and improves digestion and appetite (Katyal and Chadha, 1985).

It is a heavy feeder, especially of nitrogen, so the supply of proper nutrients must be ensured during its cultivation. The crop production system with high yield targets cannot be sustainable unless nutrient inputs to the soil are at least balanced against nutrient removal by crops (Nahar *et al*.,

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2014). Nitrogen is one of the most important nutrients for higher yields and good quality heads. Nitrogen plays an important role in the building up of protoplasm and proteins, which induce cell division and initiate meristematic activities when applied in optimum quantity (Riad *et al.*, 2009). Phosphorus is an important constituent of living and enters in the composition of phospholipids, nucleic acids, nucleoprotein and coenzymes. Phosphorus is also involved in carbohydrate metabolism, enzyme activation, nitrogen uptake and protein synthesis (Singh *et al.,* 2004). Potassium helps in the translocation of accumulations and improves the quality of cabbage head in relation to taste and keeping quality (Rutkauskiene and Poderys, 1999). Boron has a significant role in the vegetables of cruciferous plants. It mainly requires the synthesis of proteins, cell wall development, carbohydrate metabolism, translocation of sugars, hormone regulation, pollen grain germination, pollen tube growth, fruit setting and seed development (Singh, 1991).

Material and Methods

The experimental trial was conducted at open field Hi-tech unit of Horticulture, Department of Horticulture, Rajasthan College of Agriculture, Udaipur from July 2023 to December 2023 situated at 24˚34'50.0556" N latitude and 73˚42'19.8648" E longitude. The soil samples were collected and evaluated for different soil parameters. The seedlings were raised in pro trays. Transplanting of seedling was done at 4 to 5 true leaves stage and light irrigation has been given immediately after transplanting. Treatments applied before the transplanting at the time of plots preparation. Full dose of phosphorus, potassium, boron and half dose of nitrogen was applied as basal and remaining nitrogen dose has been applied 30 days after transplanting. The experiment was layout in a Randomized Block Design (RBD) with three replications. The size of each unit plot was 2.7 m × 2.1 m and R × P was 45 cm × 30 cm. A total of 13 treatments including the untreated control were selected in this investigation which were T_1 = Control, T_2 = NPK 75% + 0 kg Boron/ha, T_3 = NPK 75% + 5 Boron/ha, T_4 = NPK 75% + 10 kg Boron/ha, T_5 = NPK 75% + 15kg Boron/ha, T_6 = NPK 100% + 0 kg Boron/ha, T_7 = NPK 100% + 5 Boron/ha, T_8 = NPK 100% + 10 kg Boron/ha, T_9 = NPK 100% + 15kg Boron/ha, T_{10} = NPK 125% + 0 kg Boron/ha, T_{11} = NPK 125% + 5 Boron/ha, T_{12} = NPK 125% + 10 kg Boron/ha, T_{13} = NPK 125% + 15 kg Boron/ha. The sources of NPK and boron were urea, diammonium phosphate, muriate of potash and boric acid.

Observations were recorded for growth and yield parameters. At 30 days after transplanting (DAT), 60 DAT and at harvest, the height of the plant was measured in cm from the stem's base at ground level to the maximum length of upper leaves from the randomly selected five plants by meter scale. Total number of non-wrapped leaves per plant were counted at 30 DAT, 60 DAT and at harvest and average was worked out. Leaf area was calculated at harvest by third leaf from the top in cm^2 by leaf area meter. Plant spread and leaf length were measured in cm at harvest and the average was calculated and at harvest also, the plant's leaf width was measured in cm and the average value computed. The number of days from the transplant to head formation and head harvest calculated by randomly tagged plant basis and the average values were reported.

On tagged plant's polar diameter was determined using a scale from the stalk end to the crown of one's head, and average was calculated. The diameter between opposite sides at right angles (to the polar diameter) was measured by scale which were used from recording equatorial diameter of head. Fresh weight of head from randomly selected five plants was taken and average head weight was calculated by weight machine. Yield per plot was measured in kg by average from tagged plants of every plot. Yield per hectare was obtained by then total head yield per plot was multiplied by a factor (quintal). The recorded observations were analyzed statistically as per the procedure advocated by Panse and Sukhatme (1985) for drawing inferences.

Results and Discussion

It is evident from the results presented in Table 1 that NPK and boron had imparted significant effects on all the growth parameters. The results showed that maximum plant height at 30 DAT (21.20 cm), at 60 DAT (31.67 cm), at harvest (36.87), number of non-wrapped leaves at 30 DAT (10.53), at 60 DAT (14.13), at harvest (17.87), leaf area (288.17 cm^2), leaf length (28.10 cm), leaf width (21.47) and plant spread (71.10 cm) with minimum days taken to head harvest (80.30 days) were reported with T_{13} (NPK 125 % + boron 15 kg/ha), although treatment T_{12} (NPK 125 % + boron 10 kg/ha) were found best for minimum days taken to head formation. Best performance in almost all the growth parameters was observed by the treatment having maximum doses of fertilizers along with highest boron, which clearly indicated that the behavior of NPK and boron played a significant role on vegetative growth of cabbage. It might be due to fact that available nitrogen is a major component of chlorophyll, the pigment responsible for photosynthesis and increased production of carbohydrates, this abundance of carbohydrates stimulates cell division and elongation, resulting in larger leaf areas and large plant spreading, more leaf length and width as reported by Verma and Nawange (2015) working with cabbage. Phosphorus has significant role in energy storage, cell division and cell enlargement, which enhances the number of leaves and it is also responsible for better growth and development. Potassium plays a key role in stomata regulation, which affects leaf size, shape and

thickness. Boron is a constituent of cell membrane and is essential for cell division, so boron is must for maintaining vegetative growth. These results are in agreement with the findings in broccoli has also been reported by Brahma *et al.* (2002), who observed highest plant height, number of non-wrapped leaves and plant spread by application of higher doses (200:120:80 NPK). Sharma *et al.* (2002) and Nahar *et al.* (2014) also observed maximum leaf length, leaf width, early head formation and early head harvest due to application of highest doses of NPK and boron in cabbage. The findings of Yeshiwas *et al.* (2017), Akand *et al.* (2015) in cabbage, Singh *et al.* (2015) in broccoli and Kumar *et al.* (2012) in cauliflower were in close proximity with the results of current study as they also observed the robust growth with high doses of NPK and boron.

Similarly the significant results on yield and yield attributing parameters were noticed with each increasing dose of NPK and boron up to a level of NPK 125 % +15 kg boron/ ha as compare to control (Table 2 and Fig. 1), therefore maximum values of yield and yield attributes *i.e.* polar diameter (13.80 cm), equatorial diameter of head (15.80 cm), fresh weight of head (931.70 g), yield per plot (13.05 kg) and yield per hectare (230.05 q ha^{-1}) were recorded in treatment T_{13} (NPK 125% + 15 kg boron/ha). Best performance in yield attributes due to application of treatment T_{13} certainly due to availability of major nutrients along with boron which might have accelerated anabolic and catabolic physiological process, resulting more synthesis of chlorophyll, amino acids and effective utilization of carbohydrates resulted in enlargement of head (Raid *et al.*, 2009). The increase photosynthate and food material move to sink and ultimately increased the yield, further head diameter increased with the increase in phosphorus application adequate phosphorus nutrition promotes many aspects of plant physiology fundamental process. (Arif *et al.*, 2005). Potassium also regulates water loss from the plant by maintaining the balance between anabolism, respiration, transpiration and synthesis of amino acid and the accumulation of high molecular carbohydrates necessary for fruit formation and development which leads to increase yield (Yildirim *et al.*, 2009). The beneficial effect of boron on yield might be due to enhanced supply of micronutrients during entire growing season, significant increase in yield attributes and yield as reported by Khadka *et al.* (2005). Similarly Alam and Jahan (2007) reported highest head weight, Basumatary *et al.* (2017) recorded maximum head diameter, head weight and total yield per ha while working with cabbage due to application of NPK and boron. Prasad *et al.* (2009) recorded maximum head length, head width, total head weight, yield per hectare due to application of higher doses of nitrogen and phosphorus in Chinese cabbage. Findings of Meena *et al.* (2017) and Gochar (2016) in cauliflower, Jilani *et al.* (2009) in cucumber, Haque (2006) in cabbage, Katiyar *et al.* (2011) in broccoli were also in same trend as they reported increased yield due to application of higher doses of fertilizers.

Table 1. Effect of NPK and boron on growth parameters of cabbage

	Treatment details	Plant height(cm)			Number of non-wrapped leaves per plant			Leaf area (cm^2)	Leaf length (cm)	Leaf width (cm)	Plant spread (cm)	Days taken to head formation (DAT)	Days taken to head harvest (DAT)
		30 DAT	60 DAT	at final harvest	30 DAT	60 DAT	at final harvest						
T_1	Control	17.10	25.00	32.07	6.70	9.40	11.23	243.60	20.50	14.87	52.97	54.84	92.40
T_2	NPK 75% + Boron 0 kg/ha	17.60	28.13	33.50	7.77	10.57	12.93	262.43	23.27	16.70	61.33	54.07	90.23
T_3	NPK 75% + Boron 5 kg/ha	17.73	28.40	33.83	7.97	11.23	13.43	266.93	25.20	18.10	61.17	54.33	91.43
T_4	NPK 75% + Boron 10 kg/ha	17.67	28.33	33.70	7.90	11.40	13.47	271.80	24.87	17.90	64.60	53.90	89.57

T_5	NPK 75% + Boron 15 kg/ha	18.07	28.57	34.90	8.07	12.17	14.50	273.03	25.63	18.27	65.77	53.57	87.90
T_6	NPK 100% + Boron 0 kg/ha	18.23	29.10	35.47	8.17	12.37	14.97	276.80	25.83	18.60	66.27	53.00	87.57
T_7	NPK 100% + Boron 5 kg/ha	18.63	29.63	35.80	8.43	12.73	15.03	277.23	26.37	19.17	66.73	52.20	86.37
T_8	NPK 100% + Boron 10 kg/ha	18.37	29.27	35.53	8.57	12.47	14.90	281.67	26.93	19.13	68.10	51.13	83.53
T_9	NPK 100% + Boron 15 kg/ha	19.30	30.60	35.93	8.60	13.27	16.53	279.93	27.23	19.37	68.80	52.50	84.70
T_{10}	NPK 125% + Boron 0 kg/ha	18.97	30.33	36.07	9.53	13.33	16.40	283.20	27.37	19.83	68.23	49.93	83.30
T_{11}	NPK 125% + Boron 5 kg/ha	20.30	30.50	36.30	10.33	13.53	17.33	285.07	27.43	20.34	69.50	48.90	81.93
T_{12}	NPK 125% + Boron 10 kg/ha	19.53	30.73	36.23	10.17	13.70	17.47	286.80	27.47	20.80	71.03	47.83	80.50
T_{13}	NPK 125% + Boron 15 kg/ha	21.20	31.67	36.87	10.53	14.13	17.87	288.17	28.10	21.47	71.10	48.33	80.30
	SEm±	0.765	0.632	0.603	0.561	0.505	0.604	2.097	0.677	0.450	1.086	0.604	0.811
	CD at 5%	2.247	1.855	1.771	1.646	1.483	1.773	6.158	1.988	1.321	3.188	1.772	2.381

Table 2. Effect of NPK and boron on yield parameters of cabbage

	Treatment details	Polar diameter of head (cm)	Equatorial diameter of head (cm)	Fresh weight of head (g)	Yield/ plot (kg)	Yield/ ha (q)
T_1	Control	9.00	10.43	493.23	6.90	121.79
T_2	NPK 75% + Boron 0 kg/ha	9.97	11.30	698.77	9.78	172.54
T_3	NPK 75% + Boron 5 kg/ha	9.93	11.73	720.10	10.08	177.80
T_4	NPK 75% + Boron 10 kg/ha	10.20	11.60	733.97	10.28	181.23
T_5	NPK 75% + Boron 15 kg/ha	10.53	12.13	750.83	10.51	185.39
T_6	NPK 100% + Boron 0 kg/ha	11.37	12.27	737.33	10.32	182.06
T_7	NPK 100% + Boron 5 kg/ha	11.83	12.67	786.20	11.01	194.12

T_8	NPK 100% + Boron 10 kg/ha	12.27	12.77	806.67	11.29	199.17
T_9	NPK 100% + Boron 15 kg/ha	12.57	13.60	838.63	11.74	207.07
T_{10}	NPK 125% + Boron 0 kg/ha	12.87	14.37	844.47	11.82	208.51
T_{11}	NPK 125% + Boron 5 kg/ha	12.93	15.33	894.53	12.52	220.87
T_{12}	NPK 125% + Boron 10 kg/ha	13.40	15.43	914.03	12.80	225.69
T_{13}	NPK 125% + Boron 15 kg/ha	13.80	15.80	931.70	13.05	230.05
SEm±		0.429	0.394	14.475	0.203	3.574
CD at 5%		1.260	1.158	42.501	0.597	10.495

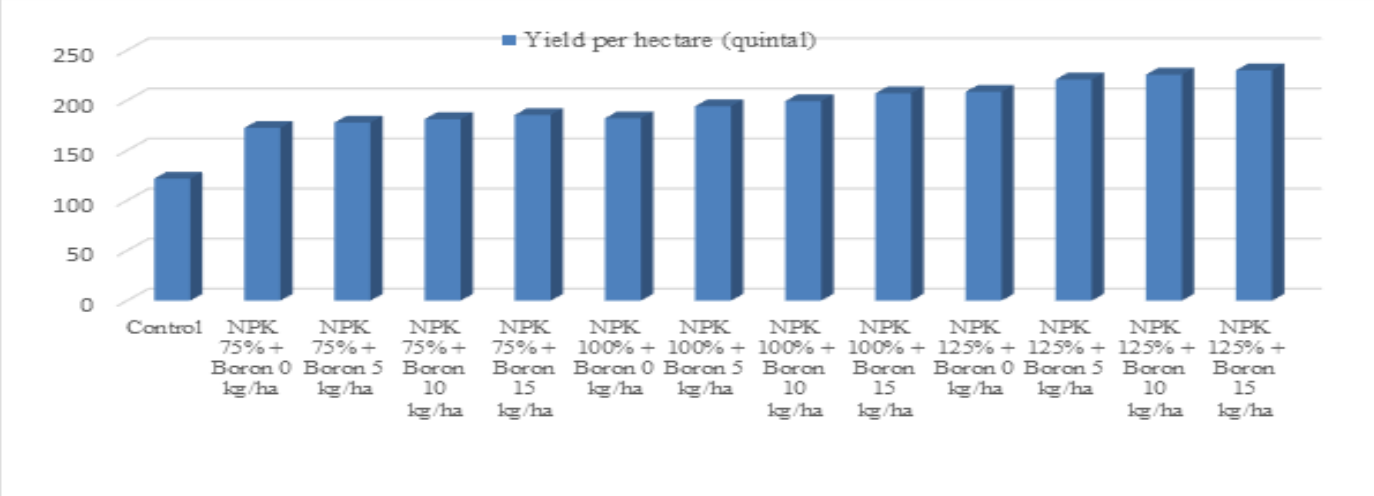

Fig. 1. Effect of NPK and boron on yield of cabbage (q/ ha)

Conclusion

The application of NPK and boron fertilizer treatment T_{13}, which consists of NPK at 125% of the recommended dose and boron at 15 kg per hectare, has been found to be superior in promoting the growth and yield of early cabbage. This treatment demonstrated the most positive impact on various growth parameters, including leaf area, leaf length, leaf width, plant spread. Additionally, the yield attributes, such as head weight and total yield per hectare, were markedly improved with this treatment. The enhanced performance of the T_{13} treatment can be attributed to the synergistic effect of balanced NPK nutrition and the essential micronutrient boron, which plays a crucial role in cell wall formation, membrane integrity, and reproductive development.

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Conflict of Interest

The authors have no conflict of interest.

Data Sharing

All relevant data are within the manuscript.

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