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RESEARCH PAPER

Effect of micronutrients on growth and yield of cabbage (*Brassica oleracea* var. *capitata*)

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Abstract : The present experiment was carried out during the winter 2017 at experimental farm College of Horticulture, SDAU, Jagudan (Gujarat). The experiment was laid out in Randomized Block Design with factorial concept and it has twenty four treatments cominations *viz.*, stages of micronutrient application (S) *i.e.* s_1 - at seedling stage (15 DAS), s_2 - after transplanting (20 and 35 DAT) and s_3 - at seedling stage (15 DAS) and after transplanting (20 and 35 DAT) and the second factor was micronutrients with eight levels *viz.*, m_0 - Zn 0 ppm + B 0 ppm + Mo 0 ppm, m_1 - Zn 0 ppm + B 0 ppm + Mo 50 ppm, m_2 - Zn 0 ppm + B 200 ppm + Mo 0 ppm, m_3 - Zn 0 ppm + B 200 ppm + Mo 50 ppm, m_4 - Zn 1000 ppm + B 0 ppm + Mo 0 ppm, m_5 - Zn 1000 ppm + B 0 ppm + Mo 50 ppm, m_6 - Zn 1000 ppm + B 200 ppm + Mo 0 ppm, m_7 - Zn 1000 ppm + B 200 ppm + Mo 50 ppm and they were replicated thrice. The results indicates that micronutrient application at seedling stage (15 DAS) and after transplanting (20 and 35 DAT) gave maximum plant height at 20, 35 DAT and at harvest. As far as yield parameter is concerned average weight of head, yield per plot and yield per hectare was observed higher due to this treatment. Higher dose of micronutrient application was found *i.e.* @ Zn 1000 ppm + B 200 ppm + Mo 50 ppm superior for growth parameters *i.e.* plant height at 20, 35 DAT and at harvest, number of leaves, leaf area 45 DAT, average weight of head, yield per plot and yield per hectare.

Key Words : Cabbage, Micronutrients, Growth, Yield

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INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata*) is one of the important leafy vegetable of cole group and used as salad, cooked, pickling as well as dehydrated vegetable. The word "Cabbage" is derived from the French word "coboche" mean head. The cabbage belongs to brassicaceae family. The "Sauerkraut" is favorite food in Russia, Germany and U.S.A. which is made by fermenting chopped, ground or sliced cabbage in its juice with little salt added to it and from the nutritional point of view, it ranks very high. The particular flavour in the cabbage head is due to the glycoside 'sinigrin' which contain sulphur also. It is a rich source of vitamin A, B, C and also contains minerals which has cooling effect and helps in preventing constipation, increase appetite, speed up digestion and very useful for patients of diabetes.

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The availability of the essential micronutrients to plants is often poorly related to the total quantity of the particular element in the soil. Iron and zinc are the most abundant metal to be found in living organisms, where it plays a major structural, catalytic and co-catalytic role in enzyme. Zinc involved in many enzymatic activities and IAA formation to increase flower number and fruit set imbalance use of it disruption of metabolic processes such as transpiration, photosynthesis and enzyme activities related to metabolism (Sainju *et al.,* 2003 and Cakmak, 2000). Boron imparts the role in cell wall formation and stability maintenance of structural and functional integrity of biological membranes, movement of sugar or energy into growing parts of plants, pollination, seed set and adequate boron is also required for effective nitrogen fixation in plants (Hakala *et al.,* 2006). Molybdenum stimulates the photosynthesis and increase the metabolic process (Chattopadhyay and Mukhopadhyay, 2003).

Cabbage is a nutrients responsive crop. So that, the judicious application of macro and micronutrients along with required dose of organic manures is essential for getting high yield of quality produce. The foliar application of micronutrients reduces the cost owing to the lesser quantities required nutrients and better absorption. Nutrition is one of the most important factors which govern the productivity and quality of cabbage. It is reported that, the use of micro-nutrients plays an important role in enhancing the translocation of carbohydrates from the site of synthesis to the storage organ and also helps in increasing yield and quality of cabbage (Jany *et al.,* 2008). So, the present experiment was framed to harness the higher economic returns along with maximum yield.

MATERIAL AND METHODS

The present experiment was carried out in open field condition during *Rabi* season, 2017 at College farm, College of Horticulture, S.D. Agricultural University, Jagudan, Dist. Mehsana (Gujarat) on Golden Acre variety of cabbage. It was laid out in Randomized Block Design with factorial concept (FRBD) having two factor *viz.,* stage of application of micronutrients [03 stages of application] and micronutrients [eight levels] thus, making twenty four treatment combinations.

The commercial formulations of micronutrients available in the market in powder form. Foliar spray of zinc sulphate, borax and ammonium molybdate, in aqueous form by using fresh solution at each spray. Preparation of spray solution of 1000 ppm Zn, 200 ppm B and 50 ppm Mo weighed 4.76 g of zinc sulphate hepta hydrate, 1.82 g borax and 0.1 g ammonium molybdate, respectively (on the basis of their equivalent weight), dissolved separately in one litre of water. Spray was done with micro sprayer and the leaves were wetted thoroughly with a fine mist.

Observations were recorded on ten randomly selected plants from each treatments on plant height at 20, 35 DAT and at harvest (cm), number of leaves per plant at harvest leaf area at 45 DAT, average weight of head (kg), yield per plot (kg) and yield (t) per hectare and obtained results were subjected to statistical analysis as per the as per the Randomized Block Design (RBD) described by Panse and Sukhatme (1985). Standard cultural package of practices were followed during the period of investigation except treatments.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Plant height at 20, 35 DAT and at harvest:

Data (Table 1) revealed that individual effect of stage of micronutrient application and micronutrients were found significant. Maximum plant height at 20 DAT (13.06 cm) and 35 DAT (18.82 cm) were recorded with application of micronutrients at seedling stage and after transplanting (s_3), which was at par with treatment s_2. Highest plant height was obtained when the foliar application of micronutrient mixture twice than the single application. It may be due to getting the sufficient amount of these nutrients stimulated enzymatic activities, leading to an improvement in biochemical process like photosynthesis, respiration and protein synthesis. Micronutrients involves in different physiological process like enzyme activation, electron transport, chlorophyll formation and stomatal regulation *etc.* These results are in conformity with the finding of Mehraj *et al.* (2015) in okra.

Statistically significant maximum plant height at 20 DAT (14.92 cm), 35 DAT (21.61 cm) and at harvest (23.65 cm) were observed with application of Zn 1000 ppm + B 200 ppm + Mo 50 ppm (m_7) which were at par with treatment $m_{6,}$ and m_5. However, minimum plant height at 20, 35 DAT and at harvest was observed when no application of micronutrients treatment (m_0). Increase plant height by application of micronutrients might be due to that zinc is directly involving in photosynthesis and play vital role in shoot production, Boron plays major role in synthesis of cell wall, occurrence of cell division, transportation of carbohydrates and hormone activation that helping in the root and shoots growth of the plant. The similar result was also reported with the application of micronutrient through foliar sprays by Ain *et al.* (2016) in broccoli. It could be revealed that, the combined foliar application of different micronutrients might have accelerated the rate of metabolic activities in the plant system that might have resulted in increasing height of the plant. The similar results were also reported with the application of micronutrient mixture through foliar sprays by Sharma *et al*. (2005); Kanujia *et al.* (2006); Nandi and Nayak (2008); Kotecha *et al.* (2011) and Devi *et al.* (2012) in cabbage, Chaudhary and Mukherjee (1999) and Patel (2002) in cauliflower and Basavarajeswari *et al.* (2008) in tomato.

Number of leaves per plant at harvest and leaf area (cm^2) at 45 DAT:

Results (Table 2) pertaining to the effect of stage of micronutrient application, micronutrients and its interaction on number of leaves per plant at harvest and leaf area (cm^2) at 45 DAT showed that maximum number of leaves per plant (18.04) and leaf area (1097.82 cm^2) at 45 DAT in treatment m_7 (Zn 1000 ppm + B 200 ppm + Mo 50 ppm). However, minimum number of leaves per plant at harvest (14.30) at 45 DAT was observed with the application of Zn 0 ppm + B 0 ppm + Mo 50 ppm (m_1) and leaf area (802.21cm^2) with no micronutrient application (m_0). Increase in number of leaves may be due to the result of availability of required quantity of essential plant nutrients at various growth stages leading to hastening the metabolic processes of plant that might have resulted in production of more number of leaves. Similar results were also reported by Narayanmma *et al.* (2007); Nandi and Nayak (2008) and Kotecha *et al.*

Table 1: Effect of micronutrients and their stage of application on plant height (cm) at 20, 35 DAT and at harvest

Treatment	Plant height at 20 DAT	Plant height at 35 DAT	Plant height at harvest
Factor A : Micronutrients (M)			
m_0: Zn 0 + B 0 + Mo 0	10.22	16.42	19.80
m_1: Zn 0 + B 0 + Mo 50	10.70	16.46	20.28
m_2: Zn 0 + B 200 + Mo 0	12.12	16.92	20.30
m_3: Zn 0 + B 200 + Mo 50	13.33	17.68	22.49
m_4: Zn 1000 + B 0 + Mo 0	11.90	18.00	21.07
m_5: Zn 1000 + B 0 + Mo 50	14.09	20.38	22.89
m_6: Zn 1000 + B 200 + Mo 0	14.37	20.51	23.08
m_7: Zn 1000 + B 200 + Mo 50	14.92	21.61	23.65
S.E.±	0.30	0.44	0.51
C.D. (P=0.05)	0.87	1.26	1.45
Factor B : Stage of micronutrients application (S)			
s_1: At seedling stage (15 DAS)	12.35	17.94	21.58
s_2: After transplanting stage (20 and 35 DAT)	12.71	18.73	21.68
s_3: At seedling stage (15 DAS) and After transplanting stage (20 and 35 DAT)	13.06	18.82	21.83
S.E.±	0.19	0.27	0.31
C.D. (P=0.05)	0.53	0.77	NS
Interaction : (S x M)			
S.E.±	0.53	0.76	0.88
C.D. (P=0.05)	NS	NS	NS
C. V. (%)	7.18	7.15	7.06

*DAT-Days after transplanting NS= Non-significant

Table 2: Effect of micronutrients and their stage of application on various growth parameters

Treatments	Initiation of head after transplanting	Edible maturity of head after transplanting	Number of leaves per plant at harvest	Leaf area (cm^2) at 45 DAT
Factor A : Micronutrients (M)				
m_0: Zn 0 + B 0 + Mo 0	49.53	74.26	14.32	802.21
m_1: Zn 0 + B 0 + Mo 50	50.62	75.51	14.30	934.58
m_2: Zn 0 + B 200 + Mo 0	50.04	72.74	15.28	934.22
m_3: Zn 0 + B 200 + Mo 50	51.10	72.73	17.32	901.32
m_4: Zn 1000 + B 0 + Mo 0	49.48	73.53	16.16	962.29
m_5: Zn 1000 + B 0 + Mo 50	50.47	72.06	17.27	981.41
m_6: Zn 1000 + B 200 + Mo 0	49.22	72.61	17.12	1084.75
m_7: Zn 1000 + B 200 + Mo 50	46.83	70.48	18.04	1097.82
S.E.±	0.89	1.05	0.39	24.64
C.D. (P=0.05)	NS	NS	1.10	70.14
Factor B : Stage of micronutrients application (S)				
s_1: At seedling stage (15 DAS)	50.73	72.40	16.06	947.52
s_2: After transplanting stage (20 and 35 DAT)	49.40	73.16	16.04	969.52
s_3: At seedling stage (15 DAS) and After transplanting stage (20 and 35 DAT)	48.85	73.41	16.57	969.93
S.E.±	0.55	0.64	0.24	15.09
C.D. (P=0.05)	NS	NS	NS	NS
Interaction : (S x M)				
S.E.±	1.55	1.82	0.67	42.68
C.D. (P=0.05)	NS	NS	NS	NS
C. V. (%)	5.41	4.32	7.12	7.68

*DAT-Days after transplanting NS= Non-significant

(2011) in cabbage, Patel (2002) and Kumar *et al.* (2012) in cauliflower. Increase in leaf area may be due to combined application of Zn, B and Mo that accelerated photosynthesis process and translocation of metabolites then development as well as elongation of new cells. These findings are in accordance with earlier reported by Kotecha *et al.* (2011) in cabbage and Patel (2002) in cauliflower.

Average weight of head (kg), yield per plot (kg) and yield/ha (t):

Among stage of application, Table 3 revealed that maximum average weight of cabbage head (0.728 kg), yield per plot (9.11 kg) and yield per hectare (28.91 t) was recorded with micronutrient application at seedling stage and after transplanting (s_3), while minimum weight of head (0.575 kg) observed in micronutrient application at seedling stage (s_1) and yield per plot (8.51 kg), yield per hectare (27.00 t) was observed in micronutrient application after transplanting (s_2). The repeated application of micronutrients like zinc increased plant activities in chlorophyll formation, it also influenced the cell division, meristematic activity of plant tissues and expansion of cell and formation of cell wall by active synthesis of aromatic amino acid *i.e.,* tryptophan, which is precursor of IAA and it is responsible to stimulate plant growth by cell elongation and cell division (Choudhary and Mukherjee, 1999).

However, among micronutrient applications, significantly maximum average weight of cabbage head (0.767 kg), yield per plot (10.27 kg) and yield per hectare (32.61 t) was recorded with application of micronutrient Zn 1000 ppm + B 200 ppm + Mo 50 ppm (m_7), however, it was statistically at par with treatment (m_6). Minimum average weight of head (0.557 kg), yield per plot (7.36 kg) and yield per hectare (23.37 t) was recorded with no application of micronutrient treatment (m_0). Improvement in yield characters as a result of foliar application of micronutrients might be due to the foliar application of combined nutrients consist Zn, which accelerated and stimulated the physiological forms and functions of cell, tissue and whole plant resulted in increase the yield

Table 3: Effect of micronutrients and their stage of application on yield parameters

Treatments	Weight of head (kg)	Yield per plot (kg)	Yield per hectare (t)
Factor A : Micronutrients (M)			
m_0: Zn 0 + B 0 + Mo 0	0.557	7.36	23.37
m_1: Zn 0 + B 0 + Mo 50	0.607	7.60	24.11
m_2: Zn 0 + B 200 + Mo 0	0.622	8.22	26.09
m_3: Zn 0 + B 200 + Mo 50	0.671	8.52	26.80
m_4: Zn 1000 + B 0 + Mo 0	0.639	8.90	28.25
m_5: Zn 1000 + B 0 + Mo 50	0.711	9.35	29.67
m_6: Zn 1000 + B 200 + Mo 0	0.713	9.98	31.67
m_7: Zn 1000 + B 200 + Mo 50	0.767	10.27	32.61
S.E.±	0.019	0.25	0.84
C.D. (P=0.05)	0.054	0.71	2.38
Factor B : Stage of micronutrients application (S)			
s_1: At seedling stage (15 DAS)	0.575	8.71	27.55
s_2: After transplanting stage (20 and 35 DAT)	0.680	8.51	27.00
s_3: At seedling stage (15 DAS) and After transplanting stage (20 and 35 DAT)	0.728	9.11	28.91
S.E.±	0.012	0.15	0.51
C.D. (P=0.05)	0.033	0.44	1.46
Interaction : (S x M)			
S.E.±	0.033	0.43	1.45
C.D. (P=0.05)	NS	NS	NS
C. V. (%)	8.53	8.58	9.01

*DAT-Days after transplanting NS= Non-significant

parameters of cauliflower. Promotive effects of molybdenum on vegetative growth which ultimately lead to more photosynthesis activities while, application of boron, enhanced carbohydrate and nitrogen metabolism of pectic substances. Molybdenum had significant effect on yield characters may be due to the increase of the estimated attributed in leaves. In addition, the promotion in plant weight reflected in a significant increase of curd yield. Furthermore the stimulatory effect of molybdenum application could be due to the increase of the metabolic pools required for the synthesis of saccharides, along with the enhanced photosynthetic capacity (Mohamed El-Sayed *et al.*, 2011). These finding corroborate with the result obtained by Sharma *et al.* (2005) and Nandi and Nayak (2008) in cabbage, Mehrotra and Mishra (1974) in cauliflower.

Conclusion:

It could be concluded that for successful cultivation of cabbage to obtaini better growth and yield as well as higher economic return, spray of micronutrient @ Zn 1000 ppm + B 200 ppm + Mo 50 ppm at seedling stage (15 DAS) and 20 and 35 DAT for getting.

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