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Response of foliar application of micronutrients and growth regulators on growth and yield attributes of Cabbage in a *Vertisol* of Central plain of C.G

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Abstract
Micronutrient and growth regulators both play an important role in sustaining agricultural production under intensive cultivation and changing scenario of climate. Therefore, study was conducted to find out the effect of foliar application of micronutrients and growth regulators on growth and yield attributes of cabbage in a *Vertisol*. The present investigation was carried out during *Rabi* Season of the years 2017 and 2018 at Instructional Farm, IGKV Raipur (C.G.) with eighteen different combinations of foliar application of micronutrient (B + Mo + Fe + Zn) and growth regulators (GA_3 + NAA) with different micronutrient omission treatments. The present study demonstrates that combined effects of foliar application of micronutrient with growth regulators in Treatment T18 (B + Mo + Fe + Zn + GA + NAA) recorded maximum plant height (27.60 cm), plant spread (62.88 cm^2), head diameter (16.17 cm^2), leaf yield (22 q ha^{-1}) and head yield (455 q ha^{-1}). of cabbage. However, the micronutrients omission i.e. Fe, Mn, Cu, Zn, B and Mo was found to be significantly reduces the plant height, plant spread, leaf and head yield of cabbage. Large reductions in the yield of cabbage were observed with the omission of B (T9) as compared to the other micronutrient omission treatments. This indicates that B (T9) was the most yield limiting micronutrients followed by Fe (T4), Zn (T5) and Cu (T7). However, the foliar application of micronutrient enhances the plant height, fruit diameter, leaf and head yield. Similarly, the foliar fertigation of growth regulators (GA_3 and NAA) may also significantly improve the growth and yield of cabbage. The combined effects of foliar application of micronutrient (100 ppm) with GA_3 (50 ppm) and NAA (80 ppm) in twice (20 and 40 DAT) was found to be most effective for significant increased in growth, and yield attributes of cabbage. Present work recommended that foliar fertigation of micronutrient (B + Mo + Fe + Zn) with growth regulators (GA + NAA) can enhance the growth and yield performance of cabbage and could alter an economical and simple mechanism for quality cabbage production among the farming community.

Keywords: Cabbage, foliar spray, micronutrients, plant growth regulators, yield

Introduction
Cabbage (*Brassica oleraceavar. Capitata* L.), a member of the family Cruciferae, it is popular as winter season vegetable and one of the most important leafy vegetable crop and used as salad, cooked, pickling as well as dehydrated vegetable. The flavour in cabbage is due to presence of a glycoside ‘sinigrin’. To increase the yield of cabbage application of major and micronutrients is helpful. Now a day’s plant growth regulators have been tried to improve growth and ultimately yield. The cabbage head is rich source of vitamin A, B, C and protein contains minerals. It has cooling effect and helps in preventing constipation, increase appetite, speed up digestion and very useful for patients of diabetes. Since micronutrients are costly chemicals, amelioration of such deficiencies through soil application may increase the cost of cultivation whereas foliar applications may reduce the cost owing to the lesser quantities required and better absorption through the foliage. Similarly growth regulators are also becoming very popular for obtaining higher yields in vegetable crops. They help in the synthesis of metabolites as well as translocation of nutrients and assimilation in different parts, which ultimately resulted in higher yields. Plant growth regulators are effective at very low concentration when used at active growth stage i.e., vegetative growth of the crop.

Application of GA_3 with the environmental conditions play important role in modifying the growth and yield of cabbage. Royand Nasiruddin, 2011). Gibberellic acid (GA) and Naphthalene acetic acid (NAA) exhibited beneficial effect in several crops (Thapa *et al.*, 2013) [13]. Due the growth regulators, auxin causes enlargement of plant cell and Gibberellins stimulates cell division, cell enlargement or both (Nickell, 1982) [10].

Materials and Methods

The experiment was laid out at the Instructional Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidhyalaya, Raipur, Chhattisgarh during the Rabi season of the years 2016-17 and 2017-18 with Randomized Complete Block Design (RCBD) with three replications. Each replication consisted of 18 unit plots. The size of each unit plot was 4.5 m x 5.2 m. The gap Between the plots was 50 cm and between the replications was 100 cm. Total of 18 treatments including the untreated control were selected in this investigation which were: T1 = NPK + (Control), T2 = NPK + (Water), T3 = NPK + (All micronutrients (Fe, Mn, Zn, Cu, B and Mo), T4 = NPK + (T3 – Fe), T5 = NPK + (T3 – Zn), T6 = NPK + (T3 – Mn), T7 = NPK + (T3 – Cu), T8 = NPK + (T3 – Mo), T9 = NPK + (T3 – B), T10 = NPK + (S), T11 = NPK + B + Mo, T12 = NPK + B + Mo + Fe, T13 = NPK + B + Mo + Fe + Zn, T14 = NPK + GA + NAA, T15 = NPK + B + Mo + S + GA + NAA, T16 = NPK + B + Mo + GA + NAA, T17 = NPK + B + Mo + Fe + GA + NAA, T18 = NPK + B + Mo + Zn + Fe + GA + NAA. The micronutrients were (Fe, Mn, Cu, Zn, B - 100 ppm and Mo – 50 ppm), with growth regulators (GA_3 – 50 ppm and NAA - 80 ppm) applied twice as foliar application at 20 and 40 DAT. Plants in control plots were no spray. with recommended dose of fertilizers N:P:K at the rate of 130: 80: 60 kg/ha at the time of planting. The data were taken from randomly selected five plants from each plot on various characters *viz*., plant height (cm), plant spread (cm^2), leaf yield (q/ha) and head yield (q/ha). All the data analysis was carried out as per described by Gomez and Gomez (1984) [3].

Research Findings and Discussion

Plant height (cm) at 30, 60 DAT and at harvest

For sustaining the production in higher level, micronutrients play a vital role as enzyme activation and electron transport in photosynthesis and respiration. Similarly growth regulators as signal molecules and regulate the cellular processes to determine the formation of the root, stem, leaf, and flower. The effects of different combinations of micronutrient and growth regulators were non significantly affected the plant height (Table 1 and Fig 1) in different micronutrients omission treatments at 30 DAT, while it was significantly affected at 60 DAT and at harvest in both the years (2017 & 2018). The maximum plant height was recorded as 16.17 and 15.50 cm at 30 DAT in Treatment T18 (B + Mo + Fe + Zn + GA + NAA) and minimum was registered as 13.13 and 13.07 cm at 30 DAT in Treatment T1 (Control) in both the years (2017 & 2018), respectively. Similarly, the pooled mean data of plant height at 30 DAT was also non significantly affected by different combinations of micronutrient and growth regulators. The pooled mean data of plant height was registered maximum (15.83 cm) in Treatment T18 (B + Mo + Fe + Zn + GA + NAA), while minimum plant height (13.10 cm) was recorded in Treatment T1 (Control). The omission of micronutrients namely Fe, Mn, Cu, Zn, B and Mo in treatments T4 (All Micronutrient - Fe), T5 (All Micronutrient - Zn), T6 (All Micronutrient - Mn), T7 (All Micronutrient - Cu), T8 (All Micronutrient - Mo) and T9 (All Micronutrient - B) was found to be significantly reduces the plant height at 30 DAT. Therefore, foliar application of micronutrients and growth regulators in 20 DAT was found to be significantly increases the plant height of cabbage at 30 DAT.

The maximum plant height was recorded as 26.20 and 24.60 cm at 60 DAT in Treatment T18 (B + Mo + Fe + Zn + GA + NAA) and minimum plant height registered as 20.40 and 19.73 cm at 60 DAT in Treatment T1 (Control), in both the years (2017 & 2018), respectively. The pooled mean data of plant height at 60 DAT was also significantly affected by different combinations of micronutrient and growth regulators. Similarly, the pooled mean data of plant height was registered maximum (25.40 cm) in Treatment T18 (B + Mo + Fe + Zn + GA + NAA), while minimum plant height was recorded in Treatment T1 (Control) as 20.07 cm. However, the treatment T3 (All Micronutrient (Fe, Mn, Zn, Cu, B, Mo), and T17 (B + Mo + Fe + GA + NAA) were found to be at par with rest of the treatments. The pooled mean data of plant height indicated that the Omission of micronutrients namely Fe, Mn, Cu, Zn, B and Mo in treatments T4 (All Micronutrient - Fe), T5 (All Micronutrient - Zn), T6 (All Micronutrient - Mn), T7 (All Micronutrient - Cu), T8 (All Micronutrient - Mo) and T9 (All Micronutrient - B) significantly reduce the plant at 60 DAT. Therefore, foliar application of micronutrients and growth regulators in 40 DAT was found to be significantly increases the plant height of cabbage at 60 DAT.

Likewise, plant height of cabbage was recorded maximum as 29.20 and 26.00 cm at harvest in Treatment T18 (B + Mo + Fe + Zn + GA + NAA) and minimum plant height was registered as 21.13 and 21.40 cm at harvest in Treatment T1 (Control), in both the years (2017 & 2018), respectively. Similarly, the pooled mean data of plant height at harvest was also significantly affected by different combinations of micronutrient and growth regulators. The pooled mean data of plant height was found maximum (27.60 cm) in Treatment T18 (B + Mo + Fe + Zn + GA + NAA), while minimum plant height (21.27 cm) was recorded in Treatment T1 (Control). However, the treatment T3 (All Micronutrient (Fe, Mn, Zn, Cu, B, Mo), and T17 (B + Mo + Fe + GA + NAA) were found to be at par with rest of the treatments. The Omission of micronutrients namely Fe, Mn, Cu, Zn, B and Mo in treatments T4 (All Micronutrient - Fe), T5 (All Micronutrient - Zn), T6 (All Micronutrient - Mn), T7 (All Micronutrient - Cu), T8 (All Micronutrient - Mo) and T9 (All Micronutrient - B) was found to be significantly reduced the plant height at harvest. Hence, foliar application of micronutrients and growth regulators was found to be significantly increased the plant height of cabbage. Results revealed that the foliar application of micronutrients and growth regulators in twice (20 and 40 DAT) was found to be most effective for enhancing the plant height of cabbage. These results are in close agreements with the findings of Patel *et al.* (2010), Landve *et al.* (2010) and Kotecha *et al.* (2016) [5].

Application of nutrient in balance and integrated manner along with the foliar application of micronutrients fulfill the nutrient requirement of crops, which might be responsible for better growth and development of the cabbage than that of micronutrient omission treatments. The foliar application of micronutrients is responsible for the enzyme activation and electron transport in photosynthesis, respiration and biological nitrogen fixation, which may lead to enhance in plant height (Hatwar *et al.* 2003; Sarma *et al.* 2005) [4]. The role of gibberellic acid and NAA is well known, which promotes cell elongation and quick cell multiplication and thereby increasing plant height due to increases in length of internodes (Kotecha *et al.* 2016) [5].

Plant spread (cm^2) at 30, 60 DAT and at harvest

The effects of different combinations of foliar application of micronutrient and growth regulators was non significantly affected the plant spread (Table 2 and Fig 2) in different nutrient omission treatments at 30 DAT, while it was significantly affected at 60 DAT and at harvest in both the years (2017 & 2018). The maximum plant spread was recorded as 31.17 and 31.43 cm^2 at 30 DAT in Treatment T18 (B + Mo + Fe + Zn + GA + NAA), and minimum plant spread registered as 29.67 and 27.93 cm^2 at 30 DAT in Treatment T1 (Control), in both the years (2017 & 2018), respectively. The pooled mean data of plant spread at 30 DAT was recorded non significantly maximum (31.30 cm^2) in Treatment T18 (B + Mo + Fe + Zn + GA + NAA), however, minimum plant spread (28.80 cm^2) was recorded in Treatment T1 (Control). The pooled mean data of plant spread indicated that the Omission of micronutrients i.e. Fe, Mn, Cu, Zn, B and Mo in treatments T4 (All Micronutrient - Fe), T5 (All Micronutrient - Zn), T6 (All Micronutrient - Mn), T7 (All Micronutrient - Cu), T8 (All Micronutrient - Mo) and T9 (All Micronutrient - B) significantly reduced the plant spread at 30 DAT. Among the eighteen different treatment combinations the maximum plant spread was recorded as 53.60 and 55.03 cm^2 at 60 DAT in Treatment T18 (B + Mo + Fe + Zn + GA + NAA) and minimum plant spread recorded as 39.07 and 38.90 cm^2 at 60 DAT in Treatment T1 (Control), in both the years (2017 & 2018), respectively. The pooled mean data of plant spread at 60 DAT was found maximum (53.82 cm^2) in Treatment T18 (B + Mo + Fe + Zn + GA + NAA), however, minimum plant spread was recorded in Treatment T1 (Control) as 38.98 cm^2. The pooled mean data of plant spread indicated that the Omission of micronutrients i.e. Fe, Mn, Cu, Zn, B and Mo in treatments T4 (All Micronutrient - Fe), T5 (All Micronutrient - Zn), T6 (All Micronutrient - Mn), T7 (All Micronutrient - Cu), T8 (All Micronutrient - Mo) and T9 (All Micronutrient - B) was significantly reduced the plant at 60 DAT. Therefore, foliar application of micronutrients and growth regulators in 40 DAT was found to be significantly increased the plant height of cabbage at 60 DAT.

The maximum plant spread was recorded as 64.60 and 61.17 cm^2 at harvest in Treatment T18 (B + Mo + Fe + Zn + GA + NAA) and minimum plant spread registered as 49.53 and 48.90 cm^2 at harvest in Treatment T1 (Control), in both the years (2017 & 2018), respectively. The pooled mean data of plant spread was registered maximum (62.88 cm^2) in Treatment T18 (B + Mo + Fe + Zn + GA + NAA), while minimum plant spread (49.22 cm^2) was recorded in Treatment T1 (Control). The pooled mean data of plant spread indicated that the Omission of micronutrients namely Fe, Mn, Cu, Zn, B and Mo in treatments T4 (All Micronutrient - Fe), T5 (All Micronutrient - Zn), T6 (All Micronutrient - Mn), T7 (All Micronutrient - Cu), T8 (All Micronutrient - Mo) and T9 (All Micronutrient - B) significantly reduce the plant spread at harvest. Results revealed that the foliar application of micronutrients and growth regulators in twice (20 and 40 DAT) was found to be more effective for significant increased in plant spread of cabbage at harvest. Our results are also with the line of Landve *et al.* (2010) and Kotecha *et al.* (2016) [5].

The increase in plant growth parameter i.e. plant spread is also associated with the plant height. All the nutritional factors which may lead to enhance the plant height may also enhance the plant spread i.e. balance nutrient application, foliar application of Fe, Zn, B, Mo, GA and NAA than that of micronutrient omission treatments. The increased in plant spread might be due to the role of Fe, Zn, B, in protein and chlorophyll synthesis, enhance meristematic activity of plant tissues, expansion of cells and formation of cell wall. This could be also due to the fact that, substances like gibberellins and NAA had induced nutrient transport from root to the aerial parts of plant, cell division, cell elongation and cell enlargement and found to encourage the plant spread (Bokade *et al.* 2006) [1].

Leaf yield (q ha^{-1})

The effects of different combinations of foliar application of micronutrient and growth regulators were significantly affected the leaf yield (Table 3 and Fig 3) in different micronutrient omission treatments in both the years (2017 & 2018). The leaf yield was recorded maximum as 210 and 232 q ha^{-1} in Treatment T18 (B + Mo + Fe + Zn + GA + NAA) and minimum leaf yield was registered as 168 and 185 q ha^{-1} in Treatment T1 (Control), in both the years (2017 & 2018), respectively. Similarly the pooled mean data of leaf yield was also significantly affected by foliar application of micronutrient and growth regulators. The pooled mean data of leaf yield was registered maximum (221 q ha^{-1}) in Treatment T18 (B + Mo + Fe + Zn + GA + NAA), whereas, the minimum leaf yields (176 q ha^{-1}) was recorded in Treatment T1 (Control). The omission of micronutrients namely Fe, Mn, Cu, Zn, B and Mo in treatments T4 (All Micronutrient - Fe), T5 (All Micronutrient - Zn), T6 (All Micronutrient - Mn), T7 (All Micronutrient - Cu), T8 (All Micronutrient - Mo) and T9 (All Micronutrient - B) was found to be significantly reducing the leaf yield of cabbage. Large reductions in the leaf yield were observed with the omission of B (T9) as compared to the other nutrient omission treatments. The yield reductions were more pronounced with B omission. This indicates that B was the most yield limiting micronutrients followed by Fe, Zn and Cu for cabbage yield. Micronutrients are not applied by farmers as basal dressing. Therefore, the soils are low in available B and Fe than that of other nutrients. Hence, the study revealed that the foliar application of micronutrients along with growth regulators in twice (20 and 40 DAT) was found to be more effective for significant increase in leaf yield of cabbage particularly in treatments T3 (NPK + all micronutrient (Fe, Mn, Zn, Cu, B and Mo), T17 (B + Mo + Fe + GA + NAA) and T18 (B + Mo + Fe + Zn + GA + NAA). The increased in leave yield might be due to the combine effect of micronutrient and plant growth regulator application in improving the crop growth than that of micronutrients omission (Lashkari *et al.* 2007; Singh *et al.* 2014) [6, 12]. The application of micronutrients in optimum level responsible for higher photosynthesis which may increase carbohydrate and sugar accumulation, higher N fixation by Fe and Mo enhance the protein synthesis of cabbage. (Moklikar *et al.* 2018 and Meena *et al.* 2019) [10, 8]. The increase in leave yield with application of growth regulators GA3 and NAA may be due to enhance the activity of apical meristem resulting in more nucleo - protein and carbohydrate synthesis responsible for increasing leaf initiation (Dhengle and Bhosale 2007) [2].

Head yield (q ha^{-1})

The response of different combinations of foliar application of micronutrient and growth regulators were significantly affected the head yield of cabbage (Table 3 and Fig 4) in different micronutrient omission treatments in both the years (2017 & 2018). The maximum head yield was recorded as 462 and 449 q ha^{-1} in Treatment T18 (B + Mo + Fe + Zn + GA + NAA) and minimum head yield was registered as 357 and 339 q ha^{-1} in Treatment T1 (Control), in both the years (2017 & 2018), respectively. Similarly the pooled mean data of head yield was also significantly affected by foliar application of micronutrient and growth regulators. The pooled mean data of head yield was registered maximum (455 q ha^{-1}) in Treatment T18 (B + Mo + Fe + Zn + GA + NAA), whereas, the minimum head yield (348 q ha^{-1}) recorded in Treatment T1 (Control). The omission of micronutrients i.e. Fe, Mn, Cu, Zn, B and Mo in treatments T4 (All Micronutrient - Fe), T5 (All Micronutrient - Zn), T6 (All Micronutrient - Mn), T7 (All Micronutrient - Cu), T8 (All Micronutrient - Mo) and T9 (All Micronutrient - B) was found to be significantly reduces the head yield of cabbage. The yield reductions were more pronounced with B omission. This indicates that B was the most yield limiting micronutrients followed by Fe, Zn and Cu for cabbage yield. Micronutrients are not applied by farmers as basal dressing. Therefore, the soils are low in available B and Fe than that of other nutrients. Hence, the study revealed that the foliar application of micronutrients along with growth regulators in twice (20 and 40 DAT) was found to be more effective for significant Increased in head yield of cabbage (Patel *et al.* 2018 and Moklikar *et al.* 2018) [11, 9]. The increase in yield and yield attributing characters might be due to the synergistic effect of micronutrient and growth regulator on cabbage (Kotecha *et al.* 2016) [5] than that of micronutrient omission plot. The enhancement of yield of cabbage due to micronutrient application may be attributed to the fact that micronutrients play a vital role in plant nutrition uptake and use, and influence various physiological processes like photosynthesis, protein and chlorophyll synthesis, reduce incidence of diseases etc. (Patel *et al.* 2010 and Landve *et al.* 2010). GA_3 application decreased number of days taken for head initiation. It might be due to the more cell division and elongation with increase in photosynthetic activity that could be attributed to better crop yield (Yadav *et al.* 2000) [14]. NAA application causes the improvement in physiological and other metabolic activity which led to an increase in various plant metabolites responsible for actively cell division and elongation results improvement in yield and yield attributes of cabbage (Singh *et al.* 2014 and Patel *et al.* (2018) [13, 11].

Table 1: Effect of foliar application of micronutrient and growth regulator on plant height of cabbage

Treatment	Plant Height (cm) at 30 Days			Plant Height (cm) at 60 Days			Plant Height (cm) at harvest		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
T1 Control (No Spray)	13.13	13.07	13.10	20.40 e	19.73 f	20.07 e	21.13 h	21.40 f	21.27 e
T2 (Water Spray)	13.53	13.27	13.40	21.47 de	20.67 ef	21.07 de	22.00 gh	21.87 ef	21.93 e
T3 (All Micronutrient (Fe, Mn, Zn, Cu, B, Mo)	15.60	15.47	15.53	24.87 ab	24.20 ab	24.53 ab	26.00 bc	26.47 a	26.23 b
T4 (All Micronutrient - Fe)	13.67	14.53	14.10	22.60 cd	21.47 def	22.03 cd	24.93 bcde	23.47 de	24.20 cd
T5 (All Micronutrient - Zn)	14.93	14.13	14.53	21.67 cde	21.73 def	21.70 d	23.67 efg	23.87 d	23.77 d
T6 (All Micronutrient - Mn)	14.60	14.07	14.33	22.40 cde	21.60 def	22.00 cd	23.47 efg	23.93 cd	23.70 d
T7 (All Micronutrient - Cu)	13.53	13.87	13.70	21.53 de	21.60 def	21.57 de	23.33 efg	23.07 def	23.20 d
T8 (All Micronutrient - Mo)	14.40	13.60	14.00	21.80 cde	21.87 cde	21.83 cd	23.80 efg	23.80 d	23.80 d
T9 (All Micronutrient - B)	13.73	14.37	14.05	21.87 cde	21.47 def	21.67 de	23.47 efg	23.33 de	23.40 d
T10 (S)	15.80	13.93	14.87	21.93 cde	21.00 def	21.47 de	23.27 efg	23.07 def	23.17 d
T11 (B+Mo)	14.27	13.60	13.93	22.07 cde	21.87 cde	21.97 cd	24.00 def	23.27de	23.63 d
T12 (B+Mo+Fe)	14.40	13.67	14.03	21.80 cde	21.33 def	21.57 de	23.07 fg	23.60 d	23.33 d
T13 (B+Mo+Fe+Zn)	14.73	14.47	14.60	22.20 cde	22.00 cde	22.10 cd	23.80 efg	23.73 d	23.77 d
T14 (GA+NAA)	14.13	13.93	14.03	22.67 cd	22.40 bcde	22.53 cd	24.20 cdef	23.67 d	23.93 d
T15 (B+Mo+S+GA+NAA)	15.07	14.33	14.70	22.67 cd	22.27 bcde	22.47 cd	24.47 cdef	24.13 cd	24.30 cd
T16 (B+Mo+GA+NAA)	14.67	14.87	14.77	23.73 bc	23.07 abcd	23.40 bc	25.73 bcd	24.73 bcd	25.23 bc
T17 (B+Mo+Fe+GA+NAA)	16.07	15.27	15.67	25.13 ab	23.87 abc	24.50 abc	26.53 b	25.60 abc	26.07 b
T18 (B+Mo+Fe+Zn+GA+NAA)	16.17	15.5	15.83	26.20 a	24.60 a	25.40 a	29.20 a	26.00 ab	27.60 a
S Em (±)	0.683	0.689	0.514	0.725	0.737	0.562	0.636	0.598	0.405
CD (%)	NS	NS	NS	2.084	2.118	1.616	1.827	1.719	1.165

Table 2: Effect of foliar application of micronutrient and growth regulator on plant spread of cabbage

Treatment	Plant spread (cm^2) at 30 Days			Plant spread (cm^2) at 60 Days			Plant spread (cm^2) at harvest		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
T1 Control (No Spray)	29.67	27.93	28.80	39.07 g	38.90 f	38.98 g	49.53 f	48.90 f	49.22 h
T2 (Water Spray)	29.77	28.63	29.20	39.70 g	39.53 ef	39.62 fg	51.33 ef	51.57 ef	51.45 gh
T3 (All Micronutrient (Fe, Mn, Zn, Cu, B, Mo)	31.03	30.67	30.85	50.40 abc	53.87 a	52.13 ab	58.87 bc	57.43 abc	58.15 cd
T4 (All Micronutrient - Fe)	28.97	29.87	29.42	47.77 bcde	48.00 bcd	47.88 bcde	54.93 cde	56.50 bcd	55.72 def
T5 (All Micronutrient - Zn)	28.83	27.87	28.35	46.67 cdef	47.00 bcd	46.83 cde	53.77 ef	52.90 cdef	53.33 fg
T6 (All Micronutrient - Mn)	29.33	28.63	28.98	45.37 def	50.80 ab	48.08 bcd	53.80 ef	52.77 cdef	53.28 fg
T7 (All Micronutrient - Cu)	27.93	27.80	27.87	43.10 fg	48.13 bc	45.62 de	53.47 ef	53.30 cdef	53.38 fg
T8 (All Micronutrient - Mo)	29.57	28.47	29.02	42.83 fg	46.43 bcd	44.63 de	54.13 e	54.18 cde	54.16 efg
T9 (All Micronutrient - B)	29.07	28.20	28.63	45.73 def	42.90 def	44.32 de	53.70 ef	52.97 cdef	53.33 fg
T10 (S)	29.93	28.10	29.02	44.90 def	43.77 cdef	44.33 de	54.23 de	52.40 def	53.32 fg
T11 (B+Mo)	29.53	28.63	29.08	44.53 ef	45.27 cd	44.90 de	53.57 ef	52.90 cdef	53.23 fg
T12 (B+Mo+Fe)	30.30	28.50	29.40	43.50 efg	46.40 bcd	44.95 de	54.63 cde	54.30 cde	54.47 efg
T13 (B+Mo+Fe+Zn)	30.00	27.97	28.98	42.43 fg	45.23 cd	43.83 def	54.73 cde	53.33 cdef	54.03 fg
T14 (GA+NAA)	28.60	29.77	29.18	46.33 cde	46.20 bcd	46.27 de	55.63 cde	53.77 cde	54.70 efg
T15 (B+Mo+S+GA+NAA)	29.33	29.23	29.28	43.10 fg	44.23 cde	43.67 ef	59.17 bc	55.90 cde	57.53 cde

T16 (B+Mo+GA+NAA)	28.50	30.87	29.68	50.03 abcd	51.33 ab	50.68 abc	62.13 ab	56.73 abcd	59.43 bc
T17 (B+Mo+Fe+GA+NAA)	30.20	31.33	30.77	51.73 ab	54.04 a	53.38 a	64.27 a	61.23 a	62.75 ab
T18 (B+Mo+Fe+Zn+GA+NAA)	31.17	31.43	31.30	53.60 a	55.03 a	53.82 a	64.60 a	61.17 ab	62.88 a
S Em (±)	0.081	0.078	0.058	1.614	1.811	1.513	1.620	1.624	1.186
CD (%)	NS	NS	NS	4.638	5.206	4.349	4.655	4.669	3.408

Table 3: Effect of foliar application of micronutrient and growth regulator on yield of leaf and head of cabbage

Treatment	**Leaf Yield (q ha^{-1})**			**Head Yield (q ha^{-1})**		
	2017	**2018**	**Pooled**	**2017**	**2018**	**Pooled**
T1 Control (No Spray)	168 d	185 d	176 f	357 e	339 e	348 g
T2 (Water Spray)	181 cd	199 cd	190 ef	372 de	367 de	370 fg
T3 (All Micronutrient (Fe, Mn, Zn, Cu, B, Mo)	205 ab	230 ab	218 a	441 ab	434 ab	437 ab
T4 (All Micronutrient - Fe)	192 abc	219 abc	205 abcde	419 abcd	397 abcd	408 bcde
T5 (All Micronutrient - Zn)	189 abcd	209 bc	199 bcde	417 abcd	400 abcd	409 bcde
T6 (All Micronutrient - Mn)	196 abc	216 abc	206 abcde	436 abc	417 abcd	427 abc
T7 (All Micronutrient - Cu)	200 abc	214 abc	207 abcde	402 bcde	415 abcd	408 bcde
T8 (All Micronutrient - Mo)	203 abc	220 abc	212 ab	438 ab	423 abc	431 abc
T9 (All Micronutrient - B)	182 bcd	202 cd	192 def	390 cde	369 de	380 efg
T10 (S)	183 bcd	198 cd	190 ef	408 bcd	384 bcde	396 cdef
T11 (B+Mo)	209 a	206 cd	207 abcde	422 abc	429 ab	426 abc
T12 (B+Mo+Fe)	182 bcd	201 cd	192 def	429 abc	407 abcd	418 bcd
T13 (B+Mo+Fe+Zn)	181 cd	205 cd	193 cdef	397 bcde	372 cde	384 def
T14 (GA+NAA)	208 a	210 abc	209 abcd	418 abcd	406 abcd	412 bcde
T15 (B+Mo+S+GA+NAA)	200 abc	220 abc	210 abc	432 abc	408 abcd	420 bc
T16 (B+Mo+GA+NAA)	203 abc	216 abc	209 abcd	426 abc	403 abcd	415 bcd
T17 (B+Mo+Fe+GA+NAA)	209 a	232 ab	221 a	442 ab	437 ab	440 ab
T18 (B+Mo+Fe+Zn+GA+NAA)	210 a	232 ab	221 a	462 a	449 a	455 a
S Em (±)	8.16	7.95	6.03	16.43	18.60	12.20
CD (%)	23.45	22.86	17.35	47.23	53.46	35.05

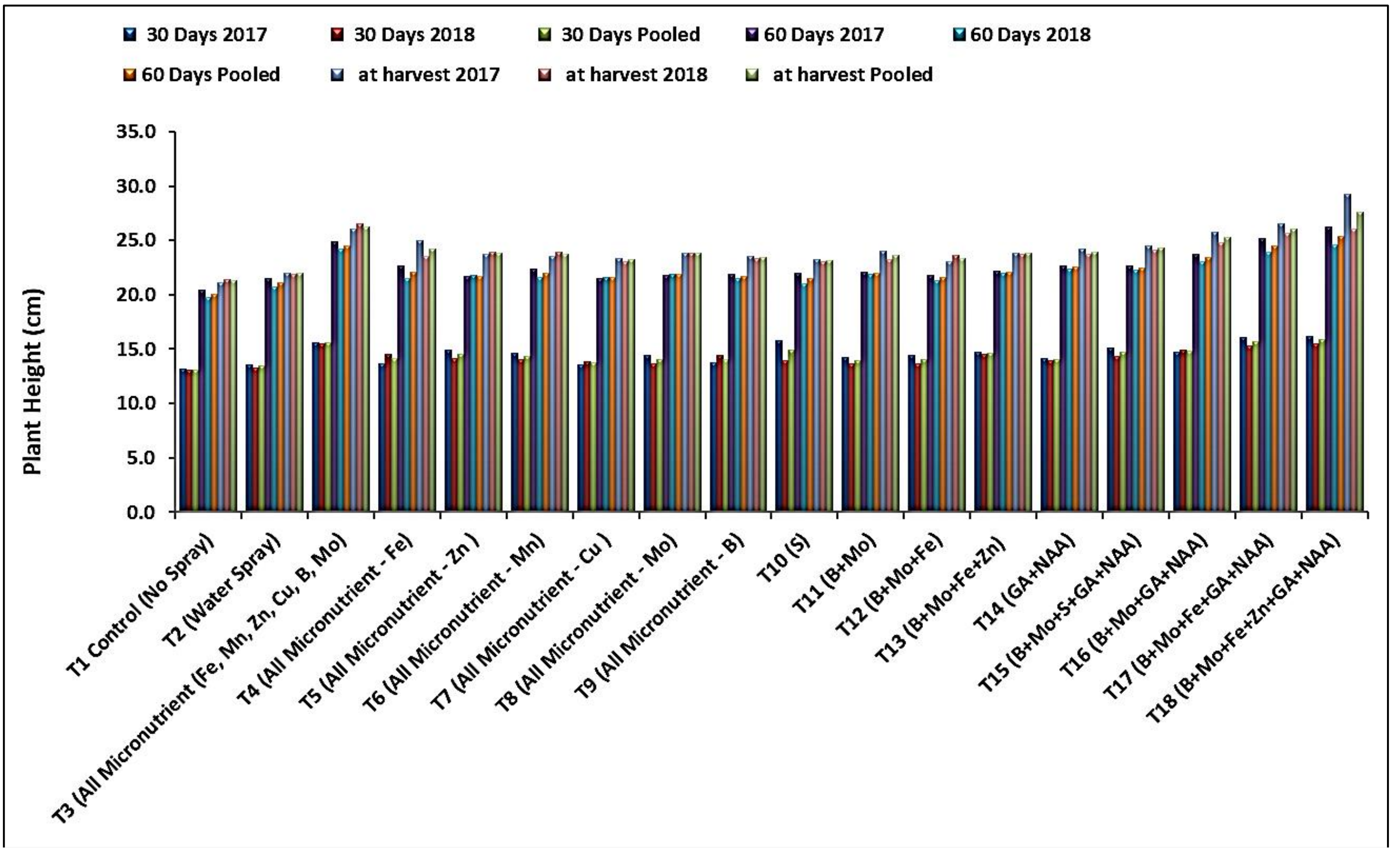

Fig 1: Effect of micronutrient and growth regulator on plant height of cabbage

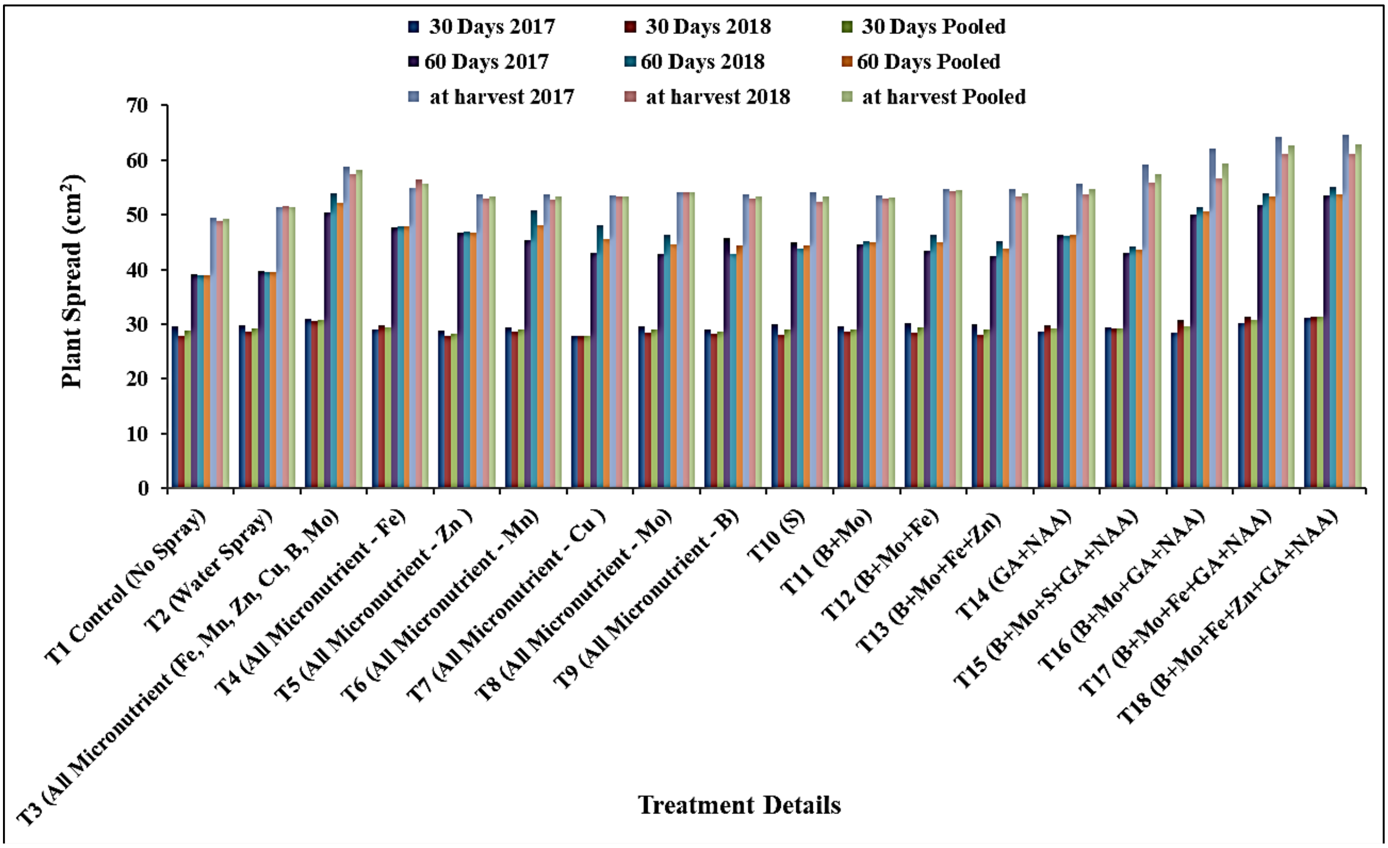

Fig 2: Effect of micronutrient and growth regulator on plant spread of cabbage

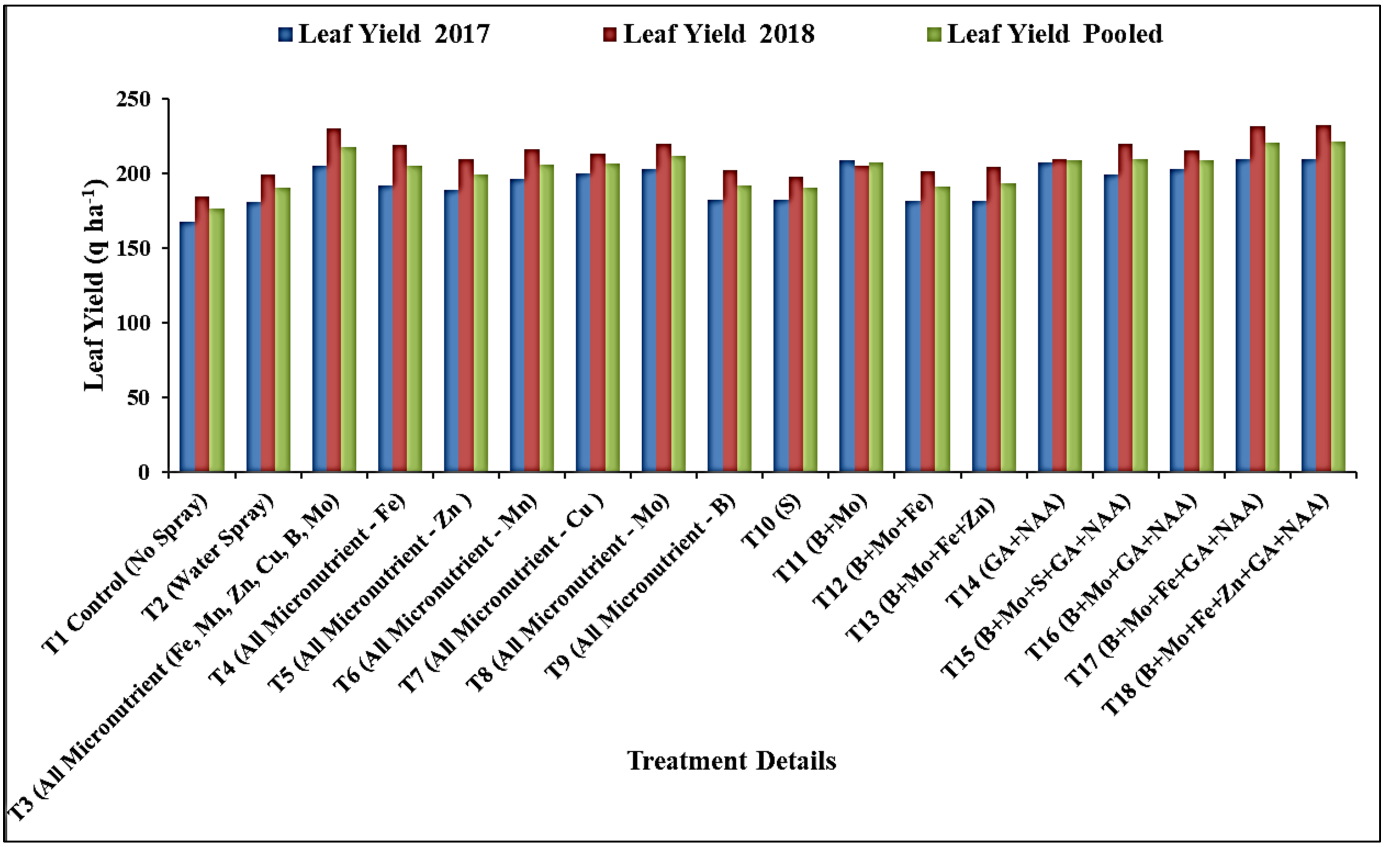

Fig 3: Effect of foliar application of micronutrient and growth regulator on yield of leaf of cabbage

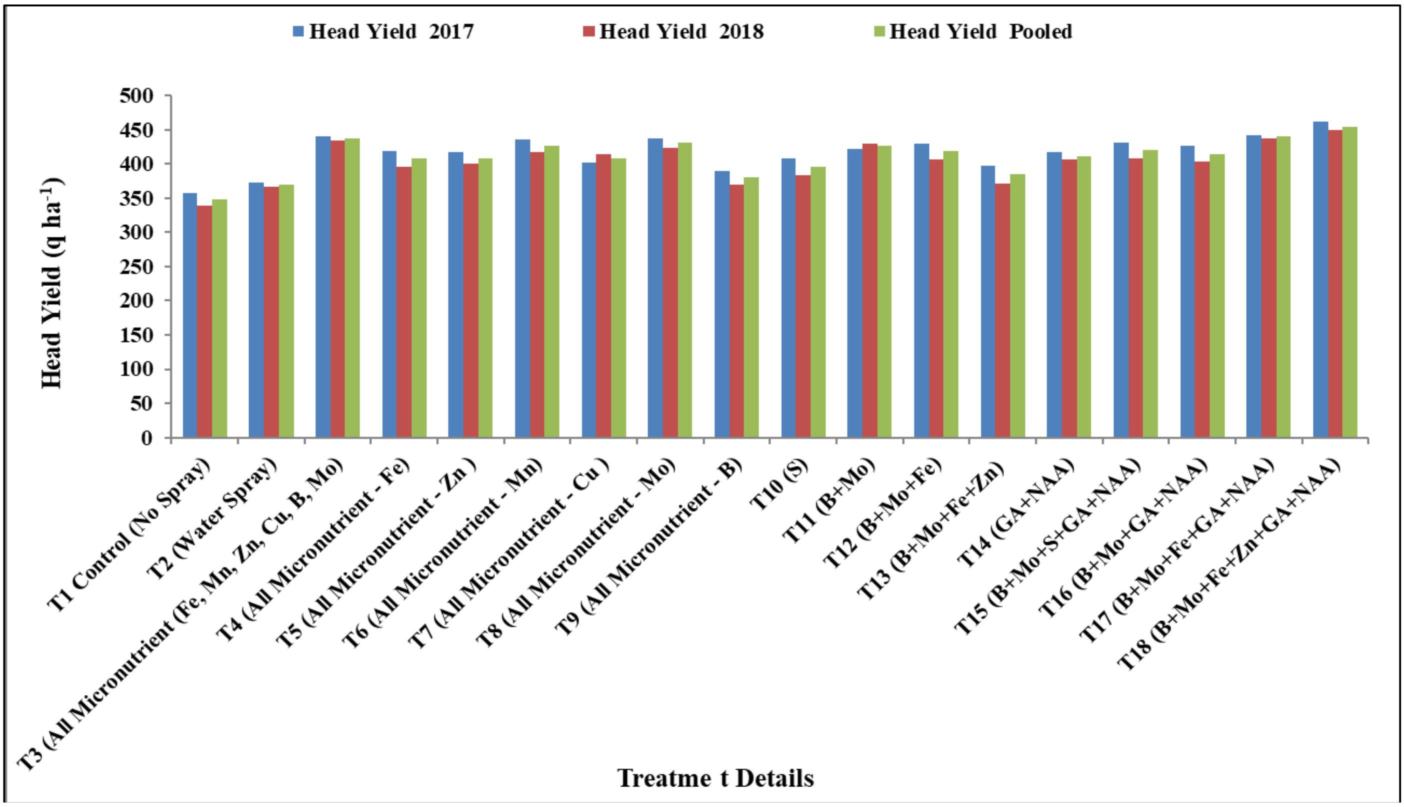

Fig 4: Effect of foliar application of micronutrient and growth regulator on yield of head of cabbage

Conclusion

The present study demonstrates that omission of micronutrients namely Fe, Mn, Cu, Zn, B and Mo significantly reduces the plant height, plant spread, leaf and head yield of cabbage. Hence, the combined effects of foliar application of micronutrient with growth regulators twice (20 and 40 DAT) were found to be most effective for significant maximum increased in growth and yield attributes of cabbage. This work recommended that foliar fertigation of micronutrient (B + Mo + Fe + Zn) with growth regulators (GA_3 + NAA) can enhance the growth and yield performance of cabbage and could alter an economical and simple mechanism for quality cabbage production among the farming community.

References

1. Bokade N, Bhalekar MN, Gupta NS and Despande A. Effect of growth regulators on growth and yield of tomatoin summer. J. Maharashtra agric. Unive. 2006;31(1):64-65.
2. Dhengle RP, Bhosale AM. Effect of plant growth regulators on growth of cabbage(Brassica oleracea L. var. capitata.). Asian J. of Hort 2007;2(2):131-34.
3. Gomaz KA, Gomaz AA. Statistical properties for agricultural research (2nd ed.) John wiley and sons, New York 1984.
4. Hatwar GP, Godane SU, Urkude SM, Gahukar OV. Effect of micronutrients on growth and yield of chilli. J. Soils and Crops 2003;13(1):123-25.
5. Kotecha AV, Dhruve JJ, Patel NJ, Vihol NJ. Influence of micronutrients and growth regulators on the performance of cabbage quality. Adv. Res. J. Crop Improv 2016;7(1):46-51.
6. Lashkari CO, Makwana AN, Meman MA. Effect of zinc and iron on growth and yield of cauliflower (Brassica oleracea var. botrytis Linn.) cv. Snowball-16. The Asian J Hort 2007;2(2):277-279.
7. Lendve VH, Chavan SD, Barkule SR, Bhosale AM. Effect of foliar application of growth regulators on growth of cabbage cv. Pride of India. The Asian Journal of Horticulture 2010;5(2):475-478
8. Meena SL, Aravindakshan K, Arya CK, Meena KK, Meena MK. Effect of bioregulators and boron on growth attributes of cabbage (*Brassica oleracea* var. *capitata* L.) cv. Golden acre. International Journal of Chemical Studies 2019;7(3):1540-1543.
9. Moklikar MS, Waskar DP, Maind MM, Bahiram VK. Studies on Effect of Micro Nutrient on Growth and Yield of Cauli-Flower (Brassica oleracea var. botrotis) cv. Sungro- Anandi. Int. J. Curr. Microbiol. App. Sci 2018;6:2351-2358
10. Nickell LG. Plant gowth regulators, agicultural uses. Springer-Verlag. Berlin, Heidelberg, New York, U.S.A 1982
11. Patel SJ, Desai LJ, Keraliya SJ, Patel CK. Cabbage (*Brassica oleracea* var. *capitata* L.) Yield, Nutrients Uptake and Soil Available Nutrients as Influenced by Nitrogen and Foliar Nutrients Application under South Gujarat Condition. Int. J Pure App. Biosci 2018;6(2):1222-1225
12. Singh M, Rana DKJ, Rawat MS, Rawat SS. Effect of GA3 and kinetin on growth, yield And quality of sprouting broccoli (BRASSICA OLERACEA var. italica) International Journal of Agricultural Extension and Rural Development 2014;1(1):001-004
13. Thapa U, Das R, Mandal AR and Debanath S. Influence of GA3 and NAA on growth, yield and quality attributing characters of sprouting broccoli [*Brassica oleracea* (L.) var. Italica Plenk].Crop Res. (Hisar) 2013;46(1&3):192-195.
14. Yadav BD, Khandelwal SK and Sharma YK. Response of cabbage to foliar application of micronutrients. Indian J of Hort 2009;36(1):47-50.