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# Growth and Yield of Cabbage as Influenced by Micronutrient Mixture in a Sandy Clay Loam Soil

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

The objective of the present study is to study the effect of various micronutrient mixtures on the growth and yield parameters of cabbage. Randomized Block Design (RBD) was used in the present study with twelve treatments and three replications. The field experiment was carried out in the farmer's field at Boluvampatti, Coimbatore (Tamil Nadu) during March to June 2023. A field experiment was conducted where three different ratios of micronutrient mixtures were applied at four different levels (15 kg $ha^{-1}$,20 kg $ha^{-1}$, 25 kg $ha^{-1}$ 30 kg $ha^{-1}$). The influence of the micronutrient mixture on the growth and yield parameters were investigated. The results revealed a positive and significant effect of the micronutrient mixture on the cabbage. The maximum plant height (34.1cm),

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Plant spread (63.9cm), no of loose leaves (22), whole plant weight (1.37kg), stem length (9.5cm), stem diameter ( 7.5 cm), root weight (28.36 g), root length (26.4) , loose leaves weight (420g), head weight (900g), yield (54 t ha $^{-1}$) and Dry matter content ( 5.42 t ha $^{-1}$ ) were observed in treatment $t_4$ where ratio 1 of micronutrient was applied @ 30 kg ha$^{-1}$). The results revealed positive effect of micronutrient mixture on cabbage. The yield increase over control for Ratio 1 of micronutrient mixture @ 30 kg ha$^{-1}$ was 164.70% over the control followed by Ratio 3 of micronutrient mixture @ 30 kg ha$^{-1}$ (147.05%).

*Keywords: Cabbage; growth attributes; head yield; yield parameters.*

## 1. INTRODUCTION

Micronutrients are crucial for healthy plant nutrition even though they are used in much lesser amounts than other critical elements. Micronutrients can significantly increase the output of horticultural crops and enhance the quality and shelf life of horticultural produce [1]. Micronutrients plays a major role in plant metabolism, nutritional control, chlorophyll generation, reproductive growth, flower retention, fruit and seed development [2]. Intensified agricultural practises, imbalanced fertiliser applications, particularly NPK, nutrient depletion, and a lack of replenishment are the main causes of micronutrient deficiencies [3]. The deficiency of calcium, magnesium, manganese, boron, and molybdenum has a greater impact on cole crops [4]. The deficiency of micronutrient has become a major threat to the productivity, stability and sustainability of crops in many Indian soils. According to [5] 44, 33, 15, 13, 8 and 6% of the samples collected and analysed from different states of India were deficient in available Zn, B, Fe, Mo, Cu and Mn respectively.

Cabbage is one of the most important leafy vegetables consumed globally in terms of area, production, and availability. The edible portion of the cabbage plant is known as 'head' that is comprised of numerous thick and overlapping smooth leaves [6]. It occupies an important place among the cole crops due to its high nutritive value and very low fat and calories content [7]. Cabbage is highly nutritious and rich in vitamin C, fibre, and vitamin K [8]. It has high medicinal value as it keeps inflammation in check, improves digestion and reduces blood pressure [9]. India produces 9606 MT of cabbage from 413 hectares of area with an average productivity of 23.25 MT ha $^{-1}$whereas in Tamil Nadu 257.02 T of cabbage is produced from 3.79 ha of area with an average productivity of 67.81 T ha $^{-1}$ [10].

Judicious use of micronutrients is essential for vegetable cultivation to get maximum yield of high quality produce. Currently, it is widely recognised that micronutrients (Fe, Zn, Mn, B, Mo) applied as foliar sprays might improve cabbage's yield, quality, and shelf life. A well-balanced supply of these micronutrients has the ability to improve the crop's quality and growth traits. The deficiency of calcium, magnesium, manganese, boron, and molybdenum has a greater impact on cole crops.

Compared to other countries production of cabbage in India is incredibly poor. The imbalance use of chemical fertilizers especially N,P and K and no consideration of the micronutrients led to the low yield and productivity in cabbage. Application of micronutrients along with organics and NPK fertilizers has a positive effect on soil health by improving the physical properties like texture, structure, soil aeration, soil colour and biological properties including microbial activity [6]. Inclusion of micronutrients is essential as it plays an important role in biochemical and physiological properties. The balanced supply of these micronutrients have a potential to increase the growth characteristics and quality of the crop to match the national and international standards [7]. The micronutrients present at deficient level in soil may become a yield- limiting component for cabbage cultivation; hence the use of micronutrients mixture may be required for profitable and sustainable cabbage production. Keeping this in view, the study was carried out to evaluate the effect of micronutrient mixture on growth and yield parameters of cabbage.

## 2. MATERIALS AND METHODS

### 2.1 Experimental Site and Soil

The experiment was conducted in farmer's field at Boluvampatti, Coimbatore during Kharif season 2022-2023. The soil of the experimental site was sandy clay loam. The soil was alkaline in soil reaction with an EC of 0.43 dS m$^{-1}$, low organic carbon (0.45 %) and low organic matter

(0.77 %). The available nitrogen (206.5 kg $ha^{-1}$) was low whereas available phosphorous (36.7 kg $ha^{-1}$) and available potassium (398 kg $ha^{-1}$) were high. The available zinc, iron, manganese, copper and boron were 0.718, 0.723, 6.99, 2.16 and 5.37 mg $kg^{-1}$ respectively.

## 2.2 Experimental Design and Treatments

The experiment was laid out in Randomised Block Design with three replications comprising of 12 treatment combinations. The size of each unit plot was 5 m x 4 m. The treatments comprised of three Micronutrient Mixtures as $R_1$,$R_2$ and $R_3$ each at four levels as : $T_1 = R_1L_1$ $R_1L_1$, $T_2 = R_1L_2$, $T_3 = R_1L_3$, $T_4 = R_1L_4$ , $T_5 = R_2L_1$, $T_6 = R_2L_2$, $T_7 = R_2L_3$, $T_8 = R_2L_4$, $T_9 = R_3L_1$ ,$T_{10} = R_3L_2$, $T_{11} = R_3L_3$ and $T_{12} = R_3L_4$ ( R = Ratio ; L= Level). The doses of level 1, level 2, level 3 and level 4 were 15 kg $ha^{-1}$, 20 kg $ha^{-1}$, 25 kg $ha^{-1}$, 30 kg $ha^{-1}$ respectively.

The sources of Zn, B, Cu, Fe, Mn and Mo were Zinc Sulphate, Borax, Copper sulphate, Iron sulphate, Manganese sulphate and sodium molybdate, respectively. The calculated quantities of Micronutrient sources were mixed thoroughly with FYM in the ratio 1:50 and incubated for 30 days.

**List 1. Treatment details**

| Treatments | Levels |
|---|---|
| $T_1$ | $R_1L_1$ |
| $T_2$ | $R_1L_2$ |
| $T_3$ | $R_1L_3$ |
| $T_4$ | $R_1L_4$ |
| $T_5$ | $R_2L_1$ |
| $T_6$ | $R_2L_2$ |
| $T_7$ | $R_2L_3$ |
| $T_8$ | $R_2L_4$ |
| $T_9$ | $R_3L_1$ |
| $T_{10}$ | $R_3L_2$ |
| $T_{11}$ | $R_3L_3$ |
| $T_{12}$ | $R_3L_4$ |

## 2.3 Land Preparation, Transplantation of Seedlings and Intercultural Operations

The experimental field was prepared in the first week of March, 2023 by deep and cross ploughing followed by laddering. The weeds and stubbles were removed, the land was levelled and the soil was turned into good tilth. The micronutrient mixture was applied basally and thirty days old healthy cabbage seedlings of Saint variety were transplanted in the experimental field on 8 March 2023, with a spacing of 45 cm x 30 cm. Throughout the growing season, standard management practices were followed as per Crop Production Guide, 2020, TNAU. Basal dose of 20 t $ha^{-1}$ of FYM , 50 kg N, 125 kg P and 25 kg K $ha^{-1}$ were applied. Weeding was done thrice and mulching was done to improve aeration and for the conservation of the soil moisture. Irrigation was given through drip irrigation whenever required.

## 2.4 Harvest of Crop and Data Collection

The crop was harvested on 6 June 2023, when the heads were firmly compacted and 80% of the cabbage was matured. The compactness of the cabbage head was verified before harvesting by pressing with the thumb. The crop was harvested along with the roots manually without causing damage to the roots and the leaves. The yield of individual plot was converted into yield per hectare.

Data were obtained from ten randomly selected plants at 30, 45, 60, and 75 days, as well as during harvest for plant height, plant spread, and the number of loose leaves as characteristics to be evaluated. During harvesting, final data from the sample plants were collected for the following parameters: weight of the whole plant, stem length, stem diameter, root length, root weight, head weight, head diameter, yield of head per plot, yield per hectare, and dry matter content. Plant height was measured using a scale from the base of the plant to the tip at three stages viz., 30 DAT, 60 DAT and at harvest. The plant height was calculated using the average of five plants in every plot and expressed in centimeters (cm). The plants were chosen randomly from each treatment, and the fresh weight of the herbage was measured by removing any adherent soil from the roots and expressed as grams per plant. Plant spread was recorded by measuring the width of the canopy with the scale and was expressed in cms. For calculating the weight of the whole plant, the entire plant was taken along with the roots and the weight was measured using a weighing balance and was expressed in kgs. Stem length was measured by using a scale. Stem diameter was measured by using a thread and the length of the thread was measured by using a scale. Root length was measured by using a scale and root weight and head weight was measured by using a weighing

balance. To determine the dry matter content, 100 g of chopped head was taken from each plot and dried in the sun. It was then oven dried at 70°C to ensure constant weight. The percentage dry matter in head (%DMH) was then computed. The% DMH was calculated using the formula below.

$$\%\ \text{DMH} = (\text{Dry weight of the head} \div \text{Fresh weight of head}) \times 100$$

## 2.5 Data Analysis

The data for the various parameters obtained from the experiment were statistically analyzed by GRAPES software. To detect differences between treatments that were statistically significant via analysis of variance (ANOVA), Duncan's multiple range test (DMRT) were used at the 5 % level of significance (p=0.05) [11].

## 3. RESULTS AND DISCUSSION

The different ratio of micronutrients mixture at different levels significantly influenced the plant growth parameters and yield of cabbage.

## 3.1 Growth Attributes

### 3.1.1 Plant height, plant spread and number of loose leaves per plant

Plant height was recorded at 30 DAT, 60 DAT and at harvest stages. The combination of different micronutrients in various ratios applied at different levels had a significant effect on cabbage growth parameters. At all the stages, the highest plant height was recorded by the treatment T4 at all the three stages as 19.4 cm, 32.4 cm, 34.1cm at 30 DAT, 60 DAT and at harvest stages respectively where the Ratio 1 of micronutrient mixture was applied @ 30 kg/ha while the shortest height was observed in the control (14.5, 20.8 and 27.4 cm at 30 DAT, 60 DAT and at harvest stages respectively). It was observed that there was an increase in the plant height with the increase in the levels of the micronutrient mixtures applied. The results revealed that the ratio 1 is more effective in increasing the plant height. This may be due to the higher content of boron present in it which implies that Boron has a significant effect on plant height. Application of micronutrient mixture had a substantial impact on the spread of cabbage plants at various growth stages as well (Fig. 3). The treatment $T_4$ recorded a maximum plant spread at all three stages (44.5, 53.8 and 63.9 cm at 30 DAT, 60 DAT and at harvest stages respectively), where the micronutrient mixture Ratio 1 was applied at 30 kg $ha^{-1}$. The maximum number of loose leaves were recorded for $T_4$ at 30 DAT, 60 DAT and at harvest stages (14,17 and 22 at 30 DAT, 60 DAT and at harvest stages respectively). This implies that there was a significant increase in the number of loose leaves with the increase in the levels of the various ratios of micronutrient mixtures. The Ratio 1 of micronutrient mixture produced significant effect in terms of the plant height, plant spread and number of loose leaves due to the higher content of boron and zinc present in it which might have increased the photosynthesis and other metabolic activities, resulting in a rise in biological processes such as cell elongation and cell division. Zn and B plays a major role in biosynthesis of hormones which in turn enhances the growth attributes [12]. Many findings showed that in tomato [13], cauliflower [14], knol khol [15], french bean [16], brinjal [17], green gram [18], onion [19] an improvement in growth parameters is observed with the application of micronutrients.

### 3.1.2 Whole plant weight, stem length and stem diameter

The results revealed that the treatment combinations of micronutrients in various ratios showed significant variation in the growth attributes of the cabbage plant in terms of total plant weight, stem length, and stem diameter (Fig. 4). The treatment T4 showed the maximum value in terms of whole plant weight (1.37 kg), stem length (9.5 cm) and stem diameter (7.5 cm) followed by $T_8$ (1.3 kg, 8.9 cm and 7.3 cm respectively) and the lowest value was recorded in the control treatment. The whole plant weight ranged from 0.75 to 1.37 kg with the highest in $T_4$ and lowest in control. A similar trend was followed in the case of stem length and stem diameter also. The stem length ranged from 4.6 to 9.5 with the highest in $T_4$ and lowest in control. Stem diameter ranged from 5.4 to 7.5 and $T_4$ recorded the highest stem length and the lowest in control. This may be due to the higher content of B, Zn and optimum level of Mo present in the Ratio 1 of micronutrient mixture. The availability of micronutrients promotes photosynthesis, while the partitioning of photosynthates promotes growth, resulting in increased stalk length and diameter. These results also support the findings of [6] which states that foliar application of Boron significantly increased the whole plant height, stem length and stem diameter in cabbage.


**Fig. 1. Micronutrient mixture on plant height at different growth stages of cabbage**
*R: Ratio; L : Level*

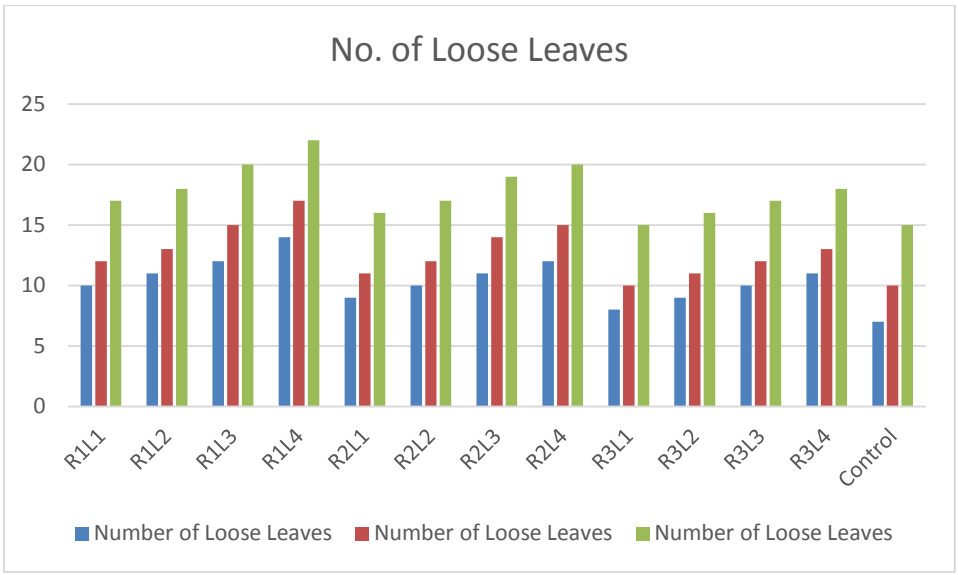


**Fig. 2. Micronutrient mixture on loose leaves at different growth stages of cabbage**
*R: Ratio ; L : Level*

## 3.2 Yield Parameters

### 3.2.1 Head weight and head diameter

The diameter and weight of the marketable cabbage head varied significantly in response to micronutrient application. The highest head weight (900 g) and head diameter (29.8 cm) were obtained with the application of Ratio 1 of micronutrient mixture while the minimum head weight (320 g) and head diameter (16.8 cm) was recorded with the control. The head weight ranged from 320 to 900 g whereas the head diameter ranged from 16.8 to 28.8 cm with the highest value recorded by $T_4$ and the lowest in control in both the cases. The cabbage head weight was increased by the micronutrient mixture in the sequence of $R_1L_4$ (900 g) > $R_2L_4$ (840 g) > $R_1L_3$ (820 g) >$R_2L_3$ (800 g). The micronutrient mixture increased the head diameter in the sequence of $R_1L_4$ (29.8 cm) > $R_2L_4$(27.2 cm)> $R_1L_3$ (26.9 cm) (Table 1). This may be due to the higher levels of B and Zn and optimum levels of Mo present in the Ratio 1 of micronutrient mixture. The findings of [9] supports the present results.

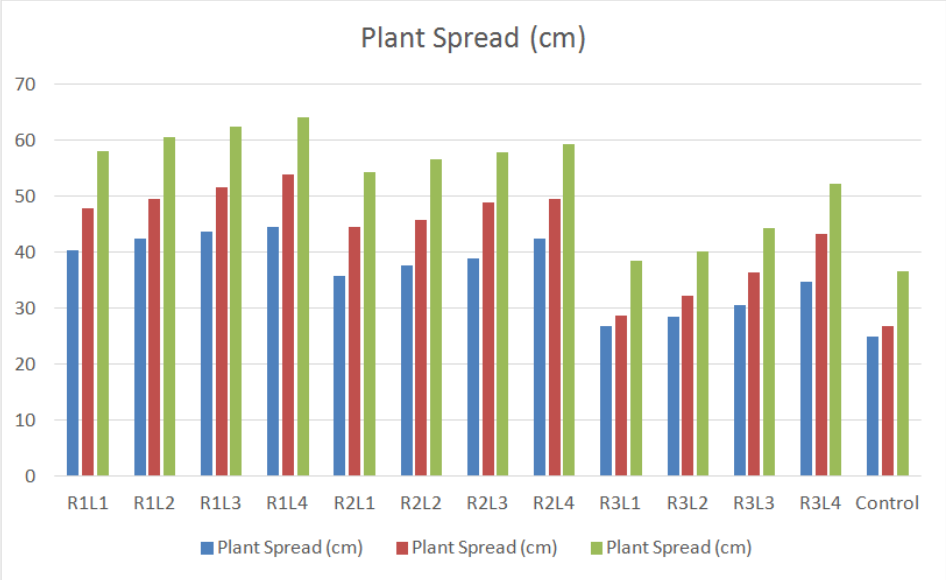


**Fig. 3. Micronutrient mixture on plant spread at different growth stages of cabbage**
*R: Ratio ; L : Level*

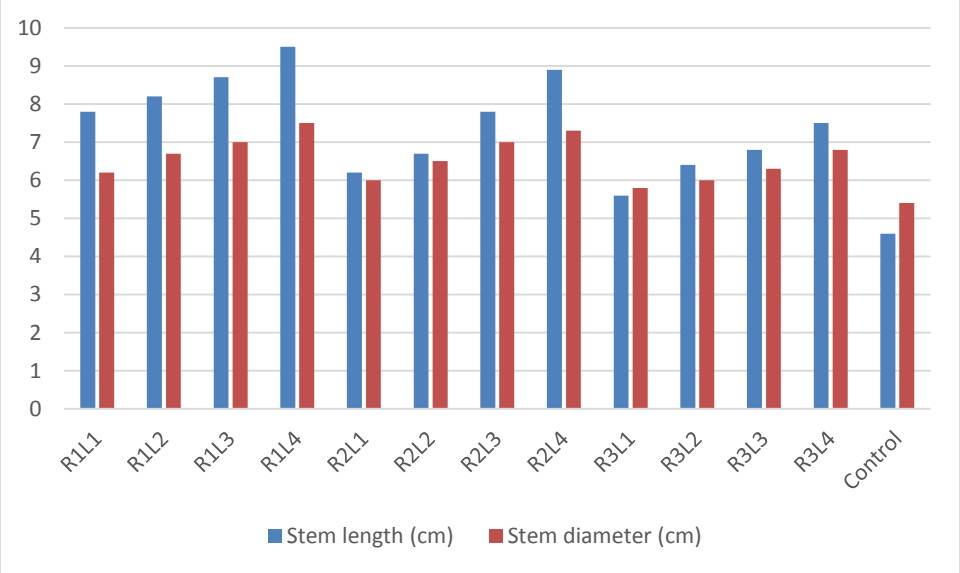


**Fig. 4. Micronutrient mixture on stem length and stem diameter at different growth stages of cabbage**
*R: Ratio ; L : Level*

### 3.2.2 Head yield and percent dry matter content

Different ratios of micronutrient mixtures applied at various levels was found to have a significant impact with respect to cabbage yield and dry matter content (Table 1). Cabbage yield ranged from 27.8 to 56.8 t $ha^{-1}$ where the highest yield was obtained for the treatment $T_4$ (56.8 t $ha^{-1}$)where the micronutrient mixture Ratio 1 was applied @ 30 kg $ha^{-1}$and the minimum yield was recorded in the control plot (27.8 t $ha^{-1}$) . The yield was increased by the micronutrient mixture in the sequence of $R_1L_4$ (56.8 t $ha^{-1}$) > $R_2L_4$ (53.8 t $ha^{-1}$) > $R_1L_3$ (52.2 t $ha^{-1}$) > $R_2L_3$ (51.4 t $ha^{-1}$). The impact of application of micronutrient combinations to yield enhancement can be attributed to improved availability of essential plant nutrients during critical growth phases as a result of which the rate and efficiency of metabolic activities increases, resulting in high assimilation of proteins and carbohydrates, which

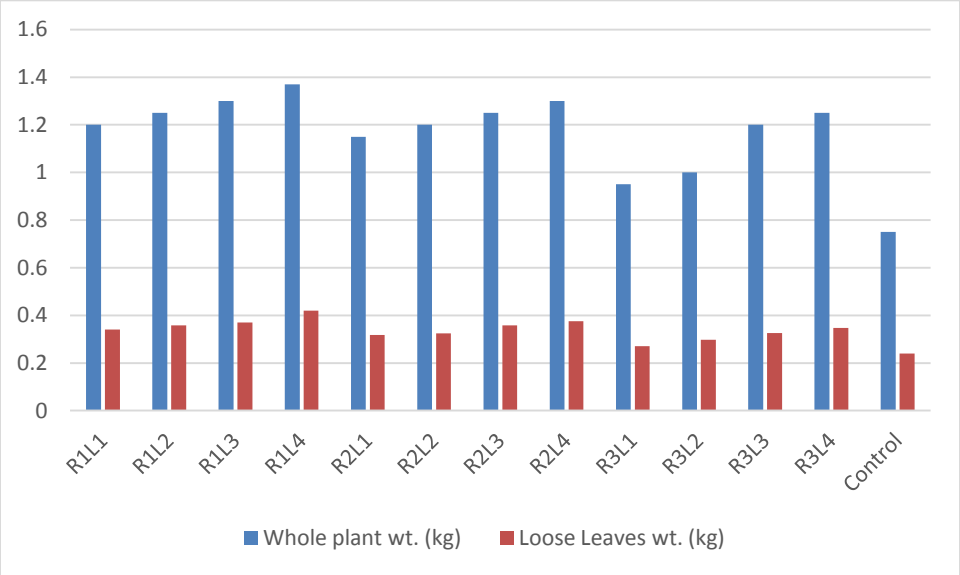


**Fig. 5. Micronutrient mixture on whole plant weight and loose leaves weight at different growth stages of Cabbage**

*R: Ratio ; L : Level*

**Table 1. Head yield and percent dry matter content in different treatment**

| Treatment | Head weight (g) | Head diameter (cm) | Yield (t ha$^{-1}$) | Percentage dry matter head |
|---|---|---|---|---|
| $R_1L_1$ | 740 | 24.8 | 44.4 | 4.02 |
| $R_1L_2$ | 780 | 25.4 | 46.8 | 4.24 |
| $R_1L_3$ | 820 | 26.9 | 52.2 | 4.72 |
| $R_1L_4$ | 900 | 29.8 | 56.8 | 5.24 |
| $R_2L_1$ | 680 | 19.1 | 38.8 | 3.85 |
| $R_2L_2$ | 750 | 20.8 | 45.2 | 4.12 |
| $R_2L_3$ | 800 | 22.2 | 51.4 | 4.35 |
| $R_2L_4$ | 840 | 27.2 | 53.8 | 4.76 |
| $R_3L_1$ | 480 | 17.9 | 34.8 | 3.46 |
| $R_3L_2$ | 560 | 18.5 | 38.4 | 3.58 |
| $R_3L_3$ | 670 | 19.2 | 46.1 | 3.75 |
| $R_3L_4$ | 760 | 20.5 | 49.6 | 3.71 |
| Control | 320 | 16.8 | 27.8 | 3.19 |
| SE | 14.688 | 0.471 | 0.763 | 0.095 |
| CD(p=0.05) | 30.315 | 0.972 | 1.575 | 0.196 |

*R: Ratio ; L : Level*

aids in greater nutrient absorption by plants, resulting in higher yields. The outcomes obtained lend supports with the reports of [20]. The study's findings also revealed that the micronutrient mixture has a substantial impact on percentage dry matter head of cabbage as well. The percent dry matter head ranged from 2.84 to 5.42 t ha$^{-1}$ with the highest value obtained with the treatment $T_4$ (5.42 t ha$^{-1}$) where the ratio 1 of the micronutrient mixture was applied at the rate of 30 kg ha$^{-1}$ and the lowest value for control (2.84 t ha$^{-1}$). The percentage dry matter head was increased by the micronutrient mixture in the sequence of $R_1L_4$(5.42 %)> $R_2L_4$(4.76 %)>$R_1L_3$(4.72 %)>$R_2L_3$(4.35 %) (Table 1). The increase in the dry matter production may be due to the higher content of Zinc and Boron present in the micronutrient mixture which plays a major role in growth and development of the cabbage, translocation of more photosynthates towards sink and consequent accumulation of more dry matter in edible heads. The lowest value of the dry matter content was recorded for the control plot. This findings supports the results of [21]. Many findings showed that in french bean [22], broccoli [23], brinjal [24], Lentil [25] , tomato [26],

chickpea [27], potato [28], onion [29] an improvement in yield attributes with the application of micronutrients.

## 4. CONCLUSION

Based on the results of the field experiment, it can be concluded that the application of Ratio 1 of micronutrient mixture @ level 4 ( 30 kg $ha^{-1}$) has a significant and positive effect on the growth and yield attributes of cabbage variety 'Saint'. This particular treatment demonstrated remarkable effectiveness in promoting higher growth and yield in Cabbage. Therefore, the micronutrient mixture of ratio 1 having more quantities of B and Zn @ 30 kg $ha^{-1}$ may be considered as effective dose for better crop performance and increased yield in cabbage cultivation.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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