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Studies on the Soil Application of Micronutrients and Its Influence on Growth, Yield and Quality of Chow Chow (*Sechium edule* (Jacq) Swartz)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Chow chow is one of the major vegetable crops being cultivated under hill region of Tamil Nadu. It gives regular income upto eight months under rainfed conditions. Prevalence of micronutrient deficiency in chowchow reduce the yield and quality during past one decade and forcing many farmers switch to other crops. In order to increase the yield of chowchow, an investigation was carried out from November 2020 to June, 2021 to study the effect of soil application of micronutrients and its positive influence on plant growth and yield at Horticultural Research Station, Thandiyankudisai, Perumbarai, Dindigul district, Tamil Nadu. The micronutrients were applied two months after the planting. The results of the experiment reveals that, the micronutrients application

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of $ZnSO_4$ 20kg + $FeSO_4$ 20kg + $MgSO_4$ 25kg + Borax 10kg +$CuSO_4$ 2.5kg +Mo 1kg recorded the highest values for number of fruits (19.59/ vine), fruit length (11.43cm), fruit diameter (12.38cm), fruit weight (362.67g), yield per vine (7.11kg) and yield per hectare (32.90 t).

Keywords: Chow chow; Sechium edule; micronutrients; nutrients; growth; quality.

1. INTRODUCTION

Chowchow (*Sechium edule* (Jacq) Swartz) is cultivated in subtropical areas such as Tamil Nadu, Karnataka, West Bengal, Uttarakhand, Himachal Pradesh, and the entire North Eastern hill (NEH) regions (NHB, 2022). In the eastern Himalayas, chowchow is grown in the kitchen gardens of tribal communities and serves as an important component of their daily diet. It is known by various names, including chayote, Irish, and air potato. Chowchow is a commonly grown commercial crop in hilly regions due to its resilience and abundant fruiting with minimal care. It thrives in high rainfall conditions. This herbaceous perennial plant is a monoecious climber and vine with an edible tuberous root. It produces numerous large fruits, each containing a single seed that is viviparous. The main method of propagation is through seeds (whole fruit with seed) [1].

Micronutrients play a crucial role in nutrient absorption and balance. Iron, zinc, manganese, copper, and boron are important micronutrient elements with specific and essential physiological functions in plants. Although they are required in small quantities for normal growth and development, micronutrients are equally important in crop nutrition. Plants grown in micronutrient-deficient soils experience similar reductions in productivity as those grown in soils deficient in macronutrients. Micronutrient deficiencies have become a major issue in recent years due to intensive cropping, soil erosion, leaching, and liming of soil [2]. Achieving improved growth, yield, and quality of chowchow vegetables requires a balanced application of nutrients. Nutrients can be applied either in the soil or through foliar application, with the main advantage of foliar application being the immediate availability of nutrients to plants. Micronutrients also play a role in nutrient absorption and balance [3]. Iron, zinc, manganese, copper, and boron are important micronutrients with specific and essential physiological functions in plants.

Zinc is involved in the activity of various enzymes, including dehydrogenase, aldolase, isomerase, proteinase, peptidase, and phosphohydrolase [4]. It directly participates in the synthesis of indole acetic acid (IAA) and protein [5]. Zinc deficiency symptoms manifest as interveinal chlorosis in young leaves. Boron, on the other hand, aids in water absorption and carbohydrate metabolism [6]. It contributes to the translocation of carbohydrates, DNA formation in meristems, cell division and elongation, active salt absorption, and photosynthesis. Boron indirectly influences the metabolic activity of nitrogen, phosphorus, fat, and hormones. Additionally, boron plays a role in flowering and fruit formation [7]. Boron deficiency causes hypertrophy, degeneration, and disintegration of meristematic tissue in cambium cells. Insufficient boron leads to sterility, reduced fruit size, and lower yield [8]. Boron deficiency also affects the synthesis of amino acids and proteins, as well as the translocation of sugar, starch, nitrogen, and phosphorus. Iron is involved in enzyme and chlorophyll synthesis. It is a component of various flavoproteins and participates in oxidation-reduction processes, such as nitrate, sulfate, and nitrogen fixation [9]. Prolonged iron deficiency results in chlorotic symptoms in the entire leaf, including the veins. The crop may exhibit a bleached appearance, become dry, and eventually die [10].

The soils in the hill region have low pH levels and are deficient in many micronutrients, primarily due to continuous cropping in the same soil. The yield potential of the crop has declined over the past decade due to various factors, like nutrients, and diseases [11], abiotic stresses. Chowchow fields in lower Pulney hills encountered micronutrient deficiencies as the farmers don't apply the nutrients enough during crop growing cycle. Therefore, this work was carried out to know the influence of soil application of micronutrients on chowchow yield and quality.

2. MATERIALS AND METHODS

The present study was conducted at the Horticultural Research Station of Tamil Nadu Agricultural University in Thadiyankudisai, Perumbarai, Dindigul district hill region from November 2020 to June 2021. The research station is situated at an altitude of 996 meters, with a latitude of 10°17' north and a longitude of

Table 1. Application of micronutrients

Treatments	Composition
T1	: $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg
T2	: $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg
T3	: $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + +Cu SO_4 2.5kg
T4	: $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Mo 1kg
T5	: $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg
T6	: $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg +Mo 1kg
T7	: Humic acid drenching 10% @ 500ml/plant
T8	: Control

77°42' east. The area receives an annual rainfall of 1400 mm, which is distributed between the months of April and December.

To prepare the field, thorough soil tillage was carried out to achieve a fine tilth. Pits measuring 1.5 cubic feet were dug at a spacing of 2.4 x 1.8 meters. Each pit was enriched with 10 kg of farmyard manure, 250 g of urea, 500 g of superphosphate, and 500 g of muriate of potash. Sprouted entire fruits were then planted at a rate of two per pit. The vines were allowed to trail on an overhead bower. Initially, the field was irrigated once every seven days until April, after which it relied on rainfall for water supply.

The experiment involved the application of micronutrients to the soil as described in Table 1.

2.1 Experimental Plan

The experiment utilized a randomized block design with three replications. Within each replication, five plants were randomly selected and tagged for different treatments in the middle rows. The tagged plants were assessed for specific parameters, and the average value of these parameters was recorded as one replication. The mean values of the three replications were then calculated, yielding a pooled mean for each specific parameter in each treatment.

The micronutrients were applied via foliar application seven times at specific intervals: on the 60th, 75th, 90th, 105th, 120th, 135th, and 150th day after sowing. Various observations were made, including the number of days to male flowering, days to female flowering, number of fruits, fruit length (cm), fruit diameter (cm), fruit weight (g), fruit yield per plant (kg), and fruit yield per hectare (tons). These observations were recorded and documented for further analysis.

2.2 Statistical Analyses

The collected data was subjected to statistical analysis following the procedure outlined by [12]. The AGRES package was utilized to determine the variance of various parameters, and significance was assessed at both the 1% and 5% levels. Non-significant results were denoted as NS.

3. RESULTS AND DISCUSSION

Micronutrients play a crucial role in promoting the growth and development of plants, acting as catalysts in various stages. When it comes to vegetable crops, which are often grown seasonally, the application of micronutrients has been shown to have positive effects. The observations recorded are presented in the Table 2. The results of the experiment revealed that 61.30 days taken for male flower anthesis with the application of $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg +Mo 1kg followed by $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg (60.21). The higher days taken for female flower anthesis (64.79) recorded with the application of $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg +Mo 1kg followed by $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg (64.29. similar results are found in bitter gourd [13].

Combined application of $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg +Mo 1kg (T6) recorded the highest fruit length (11.43cm) followed by $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg (10.81 cm).

Iron plays a crucial role in promoting various growth characteristics in plants. It is a component of ferredoxin, an electron transport protein, and is closely associated with chloroplast function. Its involvement in photosynthesis contributes to better vegetative growth. Additionally, both boron and molybdenum contribute to the growth of meristematic tissues, which ultimately leads to increased vegetative growth and positively impacts the economic parts of the plant [14]. The fruit diameter varied significantly among the treatments from 7.50cm to 12.38cm. The higher fruit diameter of 12.38cm was found with the application of $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg +Mo 1kg followed by 11.65cm with the application of $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg. Similar results were obtained in [15].

Fruit weight was enormously influenced by the application of micronutrients. It ranged from 210g to 362.67g. The maximum fruit weight of 362.67g was observed with the application of $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg +Mo 1kg (T6) followed by 351.33g with the application of $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg. In the previous studies in bitter gourd [2], similar impact of micronutrients was observed. Micronutrients might have helped in translocation of storage reserves like carbohydrate from the site of synthesis to the storage organs which led to increase in fruit weight.

Number of fruits per vine is also equally increased by the micronutrient applications. It ranged from 16.43 to 19.59 nos. The maximum number of fruits per vine 19.59 was observed with the application of $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg +Mo 1kg (T6) followed by 19.23nos. With the application of $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg. The application of micronutrients has shown to contribute to an increase in plant growth characteristics, such as the number of fruits per vine and fruit weight. This effect may be attributed to their involvement in chlorophyll formation, which supports cell division, meristematic activity in apical tissue, and cell expansion. Furthermore, the increased number of fruits may be attributed to the influence of boron and molybdenum in acid soils of the hill region, specifically in terms of female flower production and fruit set.

The treatments applied in the study demonstrated a positive and significant impact on crop yield. The yield of the crop exhibited a linear increase with higher fruit weight and a greater number of fruits per vine. The application of micronutrients had a significant impact on both the yield per vine and per hectare. The treatments greatly influenced the yield per vine from 2.50kg to 7.11kg. The maximum yield per vine 7.11kg was observed with the application of $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg +Mo 1kg (T6) followed by 6.70nos. With the application of $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg. The possible involvement of micronutrients in the physiological aspects during plant growth like cell respiration, phosphorylation, photosynthesis and protein synthesis would have positively influenced the yield [16].

Application of micronutrients greatly influenced the yield per hectare. It ranged from 10.67t to 32.90t (Table 3). The maximum yield per hectare 32.93kg was observed with the application of $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg +Mo 1kg (T6) followed by 31.39t with the application of $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg.

The increase in yield per vine and yield per hectare can be attributed to several factors, including a higher number of female flower production, an increased number of fruits, and higher fruit weight. This increase is likely due to the efficient translocation of photosynthetic assimilates to the fruits [3]. The quality of the fruits was assessed by measuring the total soluble solids (TSS), which represents the sugar content in the fruits. The application of various micronutrients significantly increased the TSS content compared to the control group (which had a TSS content of 3.80). The application of micronutrients had a notable impact on enhancing the total soluble solids content of the fruits (Fig. 1). The maximum TSS of 4.39 brix was recorded in $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg +Mo 1kg. The next higher TSS content (4.29brix) was found with application of $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg. Micronutrients influence on TSS was also observed in amaranthus and tomato [14].

The application of micronutrients greatly influenced the mosaic disease incidence (Table 3). The per cent disease index ranged from 70.00 to 75.50t. The low per cent disease index of 70.00 was observed with the application of $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg +Mo 1kg followed by 70.33 PDI with the application of $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg.

Table 2. Soil application of micronutrients and humic acid on chow-chow growth and yield attributes

Treatments	Days to male flowering (days)	Days to female flowering (days)	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	No. of fruits per vine
T_1-ZnSo$_4$ @ 20kg+ FeSo$_4$@20kg+ MgSo$_4$ @25kg/ha	57.57	61.93	9.21	9.80	298.00	16.43
T_2-ZnSo$_4$ @ 20kg+ FeSo$_4$@20kg+ MgSo$_4$ @25kg+Bo@10kg/ha	58.57	62.44	9.42	10.19	313.33	16.94
T_3-ZnSo$_4$ @ 20kg+ FeSo$_4$@20kg+ MgSo$_4$ @25kg+Mo @1kg/ha	59.18	63.12	10.22	10.49	325.67	17.21
T_4-ZnSo$_4$ @ 20kg+ FeSo$_4$@20kg+ MgSo$_4$ @25kg+CuSo$_4$@2.5kg/ha	59.68	63.95	10.40	11.18	338.67	18.22
T_5-ZnSo$_4$ @ 20kg+ FeSo$_4$@20kg+ MgSo$_4$ @25kg+Bo@10kg+ Mo @1kg /ha	60.21	64.29	10.81	11.65	351.33	19.23
T_6-ZnSo$_4$ @ 20kg+ FeSo$_4$@20kg+ MgSo$_4$ @25kg+Bo@10kg+ Mo @1kg + CuSo$_4$@2.5kg /ha	61.30	64.79	11.43	12.38	362.67	19.59
T_7-Humic acid drenching 10% @500ml/plant	59.35	63.37	10.33	10.73	331.33	17.36
T8: Control	55.10	60.00	7.00	7.50	210.00	11.00
S.Ed.	0.092	0.095	0.072	0.093	2.117	0.084
CD	0.184	0.190	0.144	0.186	4.234	0.168

Table 3. Soil application of micronutrients and humic acid on yield and per cent disease index of mosaic disease incidence

Treatments	Yield per vine (kg)	Yield per hectare (tonnes)	Incidence of CMV (%)
T_1-ZnSo$_4$ @ 20kg+ FeSo$_4$@20kg+ MgSo$_4$ @25kg/ha	4.897	22.67	73.67
T_2-ZnSo$_4$ @ 20kg+ FeSo$_4$@20kg+ MgSo$_4$ @25kg+Bo@10kg/ha	5.308	24.57	72.33
T_3-ZnSo$_4$ @ 20kg+ FeSo$_4$@20kg+ MgSo$_4$ @25kg+Mo @1kg/ha	5.606	25.95	72.67
T_4-ZnSo$_4$ @ 20kg+ FeSo$_4$@20kg+ MgSo$_4$ @25kg+CuSo$_4$@2.5kg/ha	6.174	28.58	71.33
T_5-ZnSo$_4$ @ 20kg+ FeSo$_4$@20kg+ MgSo$_4$ @25kg+Bo@10kg+ Mo @1kg /ha	6.760	31.39	70.33
T_6-ZnSo$_4$ @ 20kg+ FeSo$_4$@20kg+ MgSo$_4$ @25kg+Bo@10kg+ Mo @1kg + CuSo$_4$@2.5kg /ha	7.108	32.90	70.00
T_7-Humic acid drenching 10% @500ml/plant	5.754	26.64	72.33
T8: Control	2.50	10.67	75.50
S.Ed.	0.098	1.20	0.078
CD	0.196	2.40	0.156

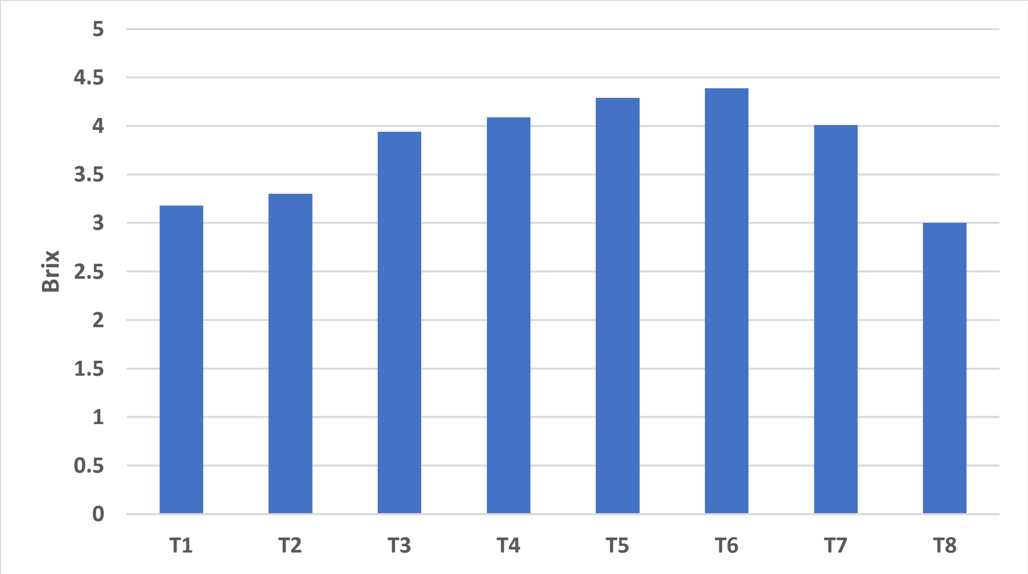

Fig. 1. Use of micronutrients and humic acid on TSS (ºBrix)

4. CONCLUSION

Chow is the important vegetable crop being cultivated in different states of India. Alleviation of micronutrient deficiency is prerequisite for sustainable soil health. Application of nutrients through soil benefit both the crop and soil. It was found that the soil application micronutrients $ZnSO_4$ 20kg + Fe SO_4 20kg + Mg SO_4 25kg + Borax 1kg+Cu SO_4 2.5kg +Mo 1kg in mosaic disease occurred field positively influenced the plant growth, yield attributes and chowchow quality.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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