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# Effect of micronutrients on growth, flowering and yield of bitter gourd (*Momordica charantia*) cv. CO 1

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**Abstract**
Present investigation was carried out to study the effect of micronutrients along with magnesium on growth, flowering and yield of bitter gourd. Seven treatment combinations involving the micronutrients *viz*., Zn, Fe, B and Cu and magnesium were imposed with three replications in randomized block design during two seasons *viz*., August 2016 and January 2017. Results showed that, among the treatments, foliar application of $ZnSO_4$+ $FeSO_4$+ $MgSO_4$ each @ 0.5% at 35 and 45 DAS recorded significantly maximum mean values for morphological and growth parameters like, vine length, number of nodes, total leaf area per plant, leaf area index, physiological and biochemical characters like chlorophyll content and soluble protein, reproductive characters like number of female flowers, sex ratio and fruit set percentage and yield attributes. For days taken to first female flower appearance and nodes to first female flower production, non significant results were obtained.

**Keywords:** Micronutrients, bitter gourd, growth, flowering, yield

## Introduction

Bitter gourd (*Momordica charantia* L.) is one of the important vegetable crops belonging to the family Cucurbitaceae. It can be canned, pickled and used as when required. Among the cucurbitaceous vegetables, fruit of bitter gourd records the highest calorific value. In terms of medicinal properties, bitter gourd ranks first among the cucurbits due to higher nutritive value being rich in all the essential vitamins and minerals. Micronutrients are usually required in minute quantities, nevertheless, are vital to the growth of plant (Benepal, 1967) [2]. Micronutrients such as iron, zinc, boron, manganese, etc., have been reported to play a vital role in modifying the growth and development of many horticultural crops. They improve general condition of plants and are known to act as catalyst in promoting organic reactions taking place in plant. Foliar application of micronutrients to crop plants is gaining popularity in increasing crop yield and quality of improving the shelf life of the produce. Similarly, the influence of micronutrients on growth, development and yield of bitter gourd are of immense magnitude. It is realized that productivity of crop is being adversely affected in different areas due to deficiencies of micro nutrients (Bose and Tripathi, 1996) [4]. To overcome the micronutrient deficiency and to improve the productivity and quality, there is an urgent need to study the effectiveness of micronutrients in bitter gourd. Hence, the present investigation was made to study the effect of foliar application of micronutrients on growth, yield and of bitter gourd.

## Materials and methods

The field experiment was carried out to study the response of micronutrients on yield and yield of bitter gourd (*Momordica charantia* L.) cv. CO 1 at the experimental field of College Orchard, Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during 10.8.2016 (I season) and 16.1. 2017 (II season) (2 seasons). It is situated at an elevation of 426.72 m, between $11^o$ N latitude and $77^0$ E longitude. The soil type is sandy clay loam with a pH of 7.8 and EC of 0.52 $dsm^{-1}$.The soil available N, P and K was 177 kg, 16 kg and 1235 kg per ha respectively.

Field experiments were laid out with seven treatments in a randomized block design (RBD) with three replications. The treatments included the foliar spray of $ZnSO_4$, $FeSO_4$ and $MgSO_4$ each @ 0.5%, $CuSO_4$ @ 0.1% and Boric acid @ 0.3% at 35 DAS and 35 and 45 DAS in different combinations with a control (without any spray) as given in table 1.

**Table 1:** Treatment details of the experiment.

| Treatment No. | Treatment details |
|---|---|
| $T_1$ | Foliar spray of $ZnSO_4$+ $FeSO_4$+ $MgSO_4$ each @ 0.5% at 35 DAS |
| $T_2$ | Foliar spray of $ZnSO_4$ + $FeSO_4$+ $MgSO_4$ each @ 0.5% + $CuSO_4$ @ 0.1% at 35 DAS |
| $T_3$ | Foliar spray of $ZnSO_4$+ $FeSO_4$+ $MgSO_4$ each @ 0.5% + $CuSO_4$ @ 0.1% + Boric acid @ 0.3 % at 35 DAS |
| $T_4$ | Foliar spray of $ZnSO_4$ + $FeSO_4$+ $MgSO_4$ each @ 0.5% at 35 and 45 DAS |
| $T_5$ | Foliar spray of $ZnSO_4$ + $FeSO_4$+ $MgSO_4$ each @ 0.5% + $CuSO_4$ @ 0.1% at 35 and 45 DAS |
| $T_6$ | Foliar spray of $ZnSO_4$ + $FeSO_4$+ $MgSO_4$ each @ 0.5% + $CuSO_4$ @ 0.1% + Boric acid @ 0.3% at 35 and 45 DAS |
| $T_7$ | Control (without any spray) |

DAS- Days after sowing

AR grade of $ZnSO_4$, $FeSO_4$, $MgSO_4$, $CuSO_4$ and Boric acid were used for foliar spraying. For all the treatments, recommended dose of fertilizers were applied as common. All the recommended agronomical practices were followed for the crop. Spraying was done using knapsack sprayer and the leaves were wetted thoroughly with fine mist. During the course of investigation, observations such as growth, physiological and biochemical, reproductive and yield characters of the crop were recorded in both the seasons. Five plants were selected at random in each treatment per replication and utilized for recording observations on the following characters like vine length (cm), number of nodes per plant, total leaf area per plant ($cm^2$) and leaf area index at 90 DAS. Chlorophyll content (mg $g^{-1}$) and soluble protein (mg $g^{-1}$) were estimated in leaves at 45, 60 and 90 DAS. Days to first female flower appearance, nodes to first female flower appearance, number of female flowers, sex ratio, fruit set percentage (%), number of fruits per plant, yield per plant (kg) and estimated yield per hectare (t) were recorded. The statistical analysis for the observations recorded was performed according to the method suggested by Panse and Sukhatme (1985) [11]. The critical difference was worked out at five per cent (0.05) probability. The pooled analysis was carried out over the seasons.

## Results and discussion

The results of the present investigation indicated that the growth, physiological and biochemical, reproductive and yield characters of bitter gourd were significantly influenced by foliar application of micronutrients and magnesium.

## Effect of micronutrients on growth attributes

Table 2 represents the data on growth attributes as influenced by various treatments. Among the treatments, the highest vine length was registered in $T_4$ (foliar spray of $ZnSO_4$ + $FeSO_4$+ $MgSO_4$ each @ 0.5% at 35 and 45 DAS) with mean value of 560.75 cm, followed by $T_1$ (foliar spray of $ZnSO_4$ + $FeSO_4$+ $MgSO_4$ each @ 0.5% at 35 DAS) with 547.54 cm. The lowest vine length (498.67 cm) was recorded in $T_7$ (control). The improvement in vine length might be due to the fact that zinc plays a crucial role in regulating auxin concentration in plants that enhanced the absorption of essential elements by increasing the cation exchange capacity of roots. It also improved photosynthesis during which food was manufactured by plants. Similar findings were reported by Bairwa and Fageia (2008) [1] in bottle gourd. The improvement in vine length as a result of foliar feeding of magnesium and micronutrients might be due to the enhanced photosynthetic and other metabolic activities, deposition of photo assimilates, translocation of carbohydrates, improvement in physiological and other metabolites, which led to increase in various plant metabolites responsible for cell division and elongation as opined by Hatwar *et al*. (2003) [6] in chilli. These results are in agreement with the findings of Narayanamma *et al*. (2009) [10] in bitter gourd.

The highest number of nodes was recorded in $T_4$ (foliar spray of $ZnSO_4$ + $FeSO_4$+ $MgSO_4$ each @ 0.5% at 35 and 45 DAS) with a mean value of 155.69, which was followed by $T_1$ (foliar spray of $ZnSO_4$ + $FeSO_4$+ $MgSO_4$ each @ 0.5% at 35 DAS) with a mean value of 146.76. The lowest number of nodes per plant was observed in $T_7$ (control) with a mean value of 124.55.

Among the treatments, significantly higher leaf area was registered in $T_4$ (foliar spray of $ZnSO_4$ + $FeSO_4$+ $MgSO_4$ each @ 0.5% at 35 and 45 DAS) with 3760.25 $cm^2$ than control followed by $T_1$ (foliar spray of $ZnSO_4$ + $FeSO_4$+ $MgSO_4$ each @ 0.5% at 35) with 3749.70 $cm^2$. The lowest leaf area (3715.80 $cm^2$) was recorded in $T_7$ (control). There was a significant response to leaf area index with the foliar spray of $ZnSO_4$ + $FeSO_4$+ $MgSO_4$ each @ 0.5% at 35 and 45 DAS ($T_4$) when compared to control. It registered a highest mean value of 1.253 which was on par with $T_1$ (1.250). The lowest leaf area index was recorded in $T_7$ (control) with a mean value of 1.232. The significant increase in leaf area and leaf area index might be due to the beneficial effect of zinc, which plays an important role in synthesis of tryptophan which is a precursor of IAA. It stimulates leaf growth of plants by activating physiological processes of cell elongation and cell division leading to increased leaf area of plant. This finding is in conformity with Lashkari *et al*. (2007) [9] in cauliflower. Iron is an essential component of several dehydrogenase, proteinase and peptidase enzymes and promotes growth hormones closely associated with growth. All these factors contributed to cell multiplication, cell division and cell differentiation resulting in increased photosynthesis and translocation of food material which enhanced the leaf area and leaf area index. Iron is a component of ferrodoxin, an electron transferring protein and is associated with chloroplast. It helps in photosynthesis which might have resulted in better vegetative growth. These results confirm the findings of Satpute *et al*. (2013) [14] in okra. Increase in plant growth characters *viz*., plant height, number of nodes per plant and leaf area per plant by the application of micronutrients might be due to their involvement in chlorophyll formation, which might have helped to favour cell division, meristematic activity in apical tissue, expansion of cell and formation of new cell wall. These results get support from the findings of Joshi *et al*. (2015) [7].

**Table 2:** Effect of micronutrient spray on growth attributes in bitter gourd cv. CO 1 at 90 DAS (Mean of two seasons)

| Treatment | Vine length (cm) | Number of nodes plant$^{-1}$ | Total leaf area plant$^{-1}$ (cm$^2$) | leaf area index |
|---|---|---|---|---|
| $T_1$ | 547.54 | 146.76 | 3749.70 | 1.250 |
| $T_2$ | 514.63 | 130.10 | 3724.89 | 1.242 |
| $T_3$ | 523.70 | 133.42 | 3718.02 | 1.239 |
| $T_4$ | 560.75 | 155.69 | 3760.25 | 1.253 |
| $T_5$ | 529.35 | 135.33 | 3735.74 | 1.245 |
| $T_6$ | 536.70 | 138.13 | 3732.77 | 1.245 |
| $T_7$ | 498.67 | 124.55 | 3715.80 | 1.232 |
| S. Ed. | 3.34 | 1.32 | 0.71 | 0.0003 |
| CD (P=0.05) | 6.87 | 2.71 | 1.46 | 0.0006 |

**Effect of micronutrients on physiological and biochemical parameters in leaves**

Table 3 represents the data on physiological and biochemical attributes as influenced by various treatments. The total chlorophyll content exhibited progressive increase from 45 to 60 DAS in both seasons and then it declined gradually towards maturity (at 90 DAS). The mean performance of both the seasons showed that, among the different treatments, $T_4$ with foliar spray of $ZnSO_4$ + $FeSO_4$+ $MgSO_4$ each @ 0.5% at 35 and 45 DAS recorded significantly higher total chlorophyll content of 1.30, 2.38 and 2.20 mg g$^{-1}$ of fresh weight than control at 45, 60 and 90 DAS respectively. The lowest total chlorophyll content was noticed in $T_7$ (control) with 0.87, 1.94 and 1.39 mg g$^{-1}$ of fresh weight during 45, 60 and 90 DAS respectively. It was evident from the present study, that the chlorophyll, a vital basic pigment for augmenting the available light for photosynthetic function, was conditioned by the foliar application of micronutrients. The encouraging effect of iron application on $CO_2$ assimilation and photosynthetic pigments is due to the association of iron with chlorophyll formation (Rout and Sahoo, 2015) [13]. Zinc deficiency in plants affect photosynthesis due to altered chloroplast pigments (Kosesakal and Unal, 2009) [8]. In our study, application of zinc sulphate might have strengthened the chloroplast pigment like chlorophyll and this might be the reason for increased chlorophyll in bitter gourd leaves. The mean data for both the seasons showed that the soluble protein content increased gradually from 45 to 90 DAS. The soluble protein content was maximum (2.33, 5.81 and 8.71 mg g$^{-1}$) in $T_4$ (foliar spray of $ZnSO_4$ + $FeSO_4$+ $MgSO_4$ each @ 0.5% at 35 and 45 DAS) followed by $T_1$ (foliar spray of $ZnSO_4$ + $FeSO_4$+ $MgSO_4$ each @ 0.5% at 35 DAS) with 2.29, 5.62 and 8.56 mg g$^{-1}$ at 45, 60 and 90 DAS respectively. The lowest soluble protein content was noticed in $T_7$ (control) with 1.81, 4.75 and 7.69 mg g$^{-1}$ at 45, 60 and 90 DAS respectively. Since magnesium activates a large number of enzymes in the plant, its simultaneous supply increases the rate of mineral nitrogen transformation into proteins (Pessarakli, 2002) [12]. These might be the reason for the increased soluble protein attained in our study by the application of magnesium sulphate as a source of magnesium. With regards to zinc, it is required as structural and catalytic components of protein and enzymes for normal growth and development (Broadley *et al*., 2007) [5].

**Table 3:** Effect of micronutrient spray on biochemical characters in bitter gourd leaves cv. CO 1 (Mean of two seasons)

| Treatment | Total chlorophyll content (mg g$^{-1}$) | | | Soluble protein (mg g$^{-1}$) | | |
|---|---|---|---|---|---|---|
| | 45 DAS | 60 DAS | 90 DAS | 45 DAS | 60 DAS | 90 DAS |
| $T_1$ | 1.27 | 2.28 | 1.99 | 2.29 | 5.62 | 8.56 |
| $T_2$ | 1.06 | 2.19 | 1.48 | 2.09 | 5.13 | 8.01 |
| $T_3$ | 1.19 | 2.00 | 1.57 | 2.30 | 5.23 | 8.27 |
| $T_4$ | 1.30 | 2.38 | 2.20 | 2.33 | 5.81 | 8.71 |
| $T_5$ | 1.05 | 2.09 | 1.69 | 2.18 | 5.32 | 8.15 |
| $T_6$ | 1.22 | 2.22 | 1.74 | 2.28 | 5.43 | 8.39 |
| $T_7$ | 0.87 | 1.94 | 1.39 | 1.81 | 4.75 | 7.69 |
| S. Ed. | 0.04 | 0.03 | 0.02 | 0.03 | 0.02 | 0.02 |
| CD (P=0.05) | 0.09 | 0.07 | 0.05 | 0.08 | 0.05 | 0.04 |

**Effect of micronutrients on reproductive characters**

Data on reproductive characters as influenced by various treatments are given in table 4. The Application of micronutrients produced more number of female flowers per plant, low sex ratio and highest fruit set percentage. The number of female flowers per plant was significantly increased by the foliar application of micronutrients. Among the different combinations, highest number of female flowers and fruit set percentage and lowest sex ratio were recorded in the treatment $T_4$ (foliar spray of $ZnSO_4$ + $FeSO_4$+ $MgSO_4$ each @ 0.5% at 35 and 45 DAS) with a mean of 34.61 plant$^{-1}$, 77.75 % and 1:10.77. Lowest was noticed in $T_7$ (control) with a mean value of 24.42 plant$^{-1}$, 71.35% and 1:15.52 respectively. Better photo assimilates and hormonal balance would have helped the micronutrient sprayed plants for macro and microgenesis and differentiation of axillary buds into reproductive ones. It might be also due to the fact that the plants received zinc and iron produced larger canopy development associated with profuse branching and more leaf area resulting in accumulation of higher amount of photosynthates which showed the positive effect of yield contributing characters *viz*., flowering, fruit set and reduction in fruit drop which reflected the fruit yield. Bharad *et al*. (2007) [3] observed similar results in chilli. Nitrogen metabolism is strictly related to the presence of magnesium in the chlorophyll and its role as a co-factor of the activity of enzymes responsible for the remobilization and transportation of metabolites (nitrogen among others) from the vegetative plant parts to the reproductive part (Pessarakli, 2002) [12]. This might be the reason for the increased number of flowers in bitter gourd in this study. Application of micronutrients did not show any significant variation for days to first female flower production and node number for first female flower appearance in bitter gourd in the present study. This might be due to the reason that the micronutrients were sprayed during the days that were very close to the emergence of these traits that failed in the expression.

**Table 4:** Effect of micronutrient spray on reproductive characters in bitter gourd cv. CO 1 (Mean of two seasons)

| Treatment | Days to first female flower appearance | Nodes to first female flower appearance | No. of female flowers plant$^{-1}$ | Sex ratio | Fruit set percentage (%) |
|---|---|---|---|---|---|
| $T_1$ | 42.33 | 30.57 | 31.53 | 1:11.45 | 75.50 |
| $T_2$ | 42.17 | 29.96 | 26.09 | 1:12.29 | 74.12 |
| $T_3$ | 42.17 | 30.53 | 26.89 | 1:13.53 | 74.95 |
| $T_4$ | 42.67 | 30.52 | 34.61 | 1:10.77 | 77.75 |
| $T_5$ | 42.50 | 30.43 | 27.67 | 1:13.25 | 77.52 |
| $T_6$ | 43.00 | 30.49 | 28.56 | 1:12.12 | 77.68 |
| $T_7$ | 42.33 | 29.10 | 24.42 | 1:15.52 | 71.35 |
| S. Ed. | 0.59 | 0.43 | 0.43 | 0.19 | 1.78 |
| CD (P=0.05) | $1.22^{NS}$ | $0.88^{NS}$ | 0.90 | 0.38 | 3.67 |

### Effect of micronutrients on yield

Data on yield characters as influenced by various treatments are given in table 5. The response of bitter gourd under different combinations of micronutrients spray was found to have significant effect for number of fruits per plant, yield per plant and estimated yield per hectare in bitter gourd. The treatment $T_4$ (foliar spray of $ZnSO_4$ + $FeSO_4$+ $MgSO_4$ each @ 0.5% at 35 and 45 DAS) recorded the highest number of fruits per plant, yield per plant and estimated yield per hectare with a mean of 26.86, 2.40 kg and 23.94 t and lowest in $T_7$ (control) with a mean value of 17.42, 1.43 kg and 14.29 t respectively. Increased yield due to the micronutrient applications might be due to enhance photosynthesis activity, accumulation of carbohydrates and its favourable effect on vegetative growth, retention of flowers and fruits leading to increased production. These results are in agreement with the findings of Satpute *et al*. (2013) [14] in okra.

**Table 5:** Effect of micronutrient spray on number of fruits plant$^{-1}$, yield plant$^{-1}$ (kg) and estimated yield (t ha$^{-1}$) in bitter gourd cv. CO 1 (Mean of two seasons)

| Treatment | Fruits plant$^{-1}$ | Yield plant$^{-1}$ (kg) | Estimated yield (t ha$^{-1}$) |
|---|---|---|---|
| $T_1$ | 23.79 | 2.15 | 21.66 |
| $T_2$ | 19.34 | 1.58 | 15.80 |
| $T_3$ | 20.14 | 1.81 | 18.07 |
| $T_4$ | 26.86 | 2.40 | 23.94 |
| $T_5$ | 21.43 | 1.95 | 19.51 |
| $T_6$ | 22.18 | 2.03 | 20.28 |
| $T_7$ | 17.42 | 1.43 | 14.29 |
| S. Ed. | 0.30 | 0.03 | 0.30 |
| CD (P=0.05) | 0.62 | 0.07 | 0.62 |

### Conclusion

While considering the overall performance, the treatment $T_4$ (foliar spray of $ZnSO_4$+ $FeSO_4$+ $MgSO_4$ each @ 0.5% at 35 and 45 DAS) registered highest values for growth and yield attributes in bitter gourd and thus it can be concluded that this can be recommended to farmers for improving the growth and yield of bitter gourd.

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