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# Effect of Different Micronutrient Combinations on Plant Growth and Plant Establishment of Acid Lime (*Citrus aurantifolia* Swingle) c.v. Vikram

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**ABSTRACT: To analyze the plant establishment and vegetative growth of acid lime c.v. Vikram and to standardize the doses of different micronutrient combinations, an experiment entitled, "Effect of different micronutrient combinations on plant growth and plant establishment of acid lime (*Citrus aurantifolia* Swingle) c.v. Vikram" was carried out during the year 2020-2021 in an open field, Central Research Farm, Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. The experimental field was laid out in a Randomized Block Design (RBD) with 11 treatments of different micronutrient combinations and three replications. The levels of micronutrients included $ZnSO_4$ (0.5%, 1%, 1.5%, 2%), $FeSO_4$ (0.5%, 1%, 1.5%, 2%) and Borax (0.5%, 1%, 1.5%, 2%). The variety used in this experiment was Vikram. The experiment comprised 10 foliar applications by varying the concentrations of the above said micronutrients in combinations along with control. The experiment results revealed that the imposition of different treatment combinations had a significant effect on improving vegetative growth and establishment of the acid lime plants. From the present investigation it was concluded that $T_{10}$ $ZnSO_4$ (0.5%) + FeSO4(0.5%) + Borax(2%) was found significantly superior over all other treatments, which resulted in highest survival percentage and vegetative growth parameters like survival percentage (100% ), mortality per cent (0.00%), plant height (cm) (41.88), number of leaves per plant (102.99), number of branches per plant (15.48), stem girth (2.23cm), plant spread (64.76cm), leaf area (6.60cm$^2$), Leaf area index (0.0026LAI) and chlorophyll (64.67SPAD). The treatments with high Zinc and Boron content and less iron content survived the most. Previous studies revealed that the synergistic effect of combinations of Zn, B and Fe resulted in better vegetative growth and establishment as a whole. The methods used for the experiment to be accomplished are meter scale for measuring plant height, vernier calipers for measuring stem girth, SPAD chlorophyll meter for measuring the chlorophyll content and manual graph paper for getting the leaf area. Since this is based on one season trail therefore, further evaluation trails are needed to substantiate the findings. As because this variety is from MAU, Parbhani, which is in tropical zone of India, there is a need of detailed research on it and screen it in all sorts of regions and climatic circumstances to achieve the optimum growth and development of the crop.**

**Keywords**: Citrus, Micronutrients, $ZnSO_4$, $FeSO_4$, Borax, FYM, plant growth, plant establishment.

## INTRODUCTION

Acid lime (*Citrus aurantifolia* Swingle) is one of the most widely and commercially grown fruit crop in tropical and sub-tropical region of India. Probably in India, the crop originated and then spread to the Middle East and other tropical and subtropical countries. It belongs to the family Rutaceae. The major cultivar grown widely is Kagzi lime. In India, acid lime is mainly grown in the states of Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Madhya Pradesh, Bihar, Assam, Jharkhand and Chhattisgarh. Its chromosome number is 18 (2n=2X=18).

Basically, citrus is a mesophyte tree and called as fruit of godly tree. India is the 4th largest producer of citrus fruit in the world. It is, otherwise, called as Mexican lime, Kagzi lime, West Indian lime or Key lime. In

India, locally it is called as Nimbu.

Acid lime trees grown in tropical and sub-tropical conditions to give out continuous flushes of growth, both vegetative as well as reproductive throughout the year until manipulated externally into a concentrated bloom in for a particular season. Acid lime trees flower three times in a year *viz.*, from January- February, June-July and September-October known as Ambe, Mrig and Hasthe bahar respectively. For the fruits of the Ambe, Mrig and Hasth bahar, the flowering becomes available from June-July, November-December and April-May months, respectively. The percentage of flowering of Ambe, Mrig and Hasth bahar is 47 %, 36 % and 17 %, respectively Tagad *et al.*, (2018).

The area under acid lime cultivation in India is 255.20 thousand hectares with production of 2523.50 thousand million tons and productivity 9.9 million tons, while in Maharashtra, it is cultivated on 45.00 thousand hectares with production of 246.00 thousand MT with 5.5 MT productivity. In Maharashtra, Ahmednagar, Solapur, Akola, Jalgaon, Pune, Nagpur, Beed, Jalna and Aurangabad are the major acid lime cultivating districts Tagad *et al.*, (2018).

There exist five main groups of cultivated limes such as small fruited acid limes, large fruited acid limes, sweet limes, Australian limes and lime hybrids. Out of the above said five, *Citrus aurantifolia* comes under small fruited acid limes. Among all the lime species, acid lime is the tenderest. Its appealing appearance, deep aroma of peel and excellent taste gives a major position to acid lime which is grown widely throughout the world (Babu, 2001).

*Citrus aurantifolia* is a shrubby tree to 5m (16ft) with many thorns. Its trunk that rarely grows straight, has a lot of branches and they often originate quite down on the trunk. The leaves are ovate, 2.5-9 cm long, resembling the leaves of orange fruit (the scientific name *aurantifolia* refers to the resemblance of orange, *Citrus aurantium*).Small petiole wings are present. The flowers are 2.5cm in diameter, yellowish white with light purple tingle on margins.

Some of the important acid lime cultivars are Pramalini, Vikram, Chakradhar, PKM-1 or Jai Devi, Sai Sharbati and Balaji. Out of the above, the selected cultivar for the thesis work to be conducted is Vikram. Vikram is a MAU, Parbhani released variety of acid lime. It can be grown in offseason also. The fruit is medium sized. Heavy fruiting is seen in this variety. It has high bunch bearing habit. The fruit colour is golden. Moreover, highest TSS content and juice content is recorded in the Vikram cultivar of acid lime. Above all, this cultivar is most suitable and easily grown under the agro-climatic situations of Prayagraj.

Micronutrients can tremendously boost horticultural crop yield and quality. In general Zn and Fe deficiency are regular in all citrus crops. However, these can be corrected through use of organic matter and spray of zinc sulphate and ferrous sulphate during the active growth period of the Acid lime tree. Application of micronutrients either through foliar spray is important in flowering and quality fruit production Tagad *et al.*, (2018). The improvement in plant growth and development could be due to the involvement of micronutrients in the synthesis of many compounds which are essential for plant growth and development and also act as an activator for many enzymes (Ram and Bose, 2000). It is essential for the formation of chlorophyll and function of normal photosynthesis (Papadakis *et al*., 2005). The higher fruit retention in Zn treated trees may be ascribed to an increase in the synthesis of IAA which consequently improves the endogenous level of auxin at abscission zone to avoid fruit drop (Razzaq *et al.*, 2013).

Foliar feeding is one of the ways for this goal, for the nutrients are applied directly to the site of their metabolism and are not subjected to any loss as in case of soil application. It was observed that foliar application of $ZnSO_4$ (0.5%) and Boric acid (0.3%) at fruit set stage showed the significant increase of plant height and also increase the tree spread and stem girth in Feutrelly's Early (*Citrus reticulate* Blanco). (Ahmad *et al.*, 2012). Zinc increase the flowering, fruit set, fruit size and control the fruit drop and ultimately increase the yield. Iron escalates the manufacture of more carbohydrate in the leaves which increase in flowering, fruit set, fruit size, control the fruit drop and ultimately it increases the yield of plants Jagtap *et al*., (2013). It was reported that the leaf nutrient status of mango increased with application of Zn (0.1 and 0.2%), Mn (0.1 and 0.2%) and Fe (0.1 and 0.2%). Application of Zn improved the leaf N and Zn content while Fe improved P and Fe and Mn improved the Mn and K contents (Dutta and Dhua, 2002).

Analyzing the previous studies, there is a need to get a suitable combination of micronutrients for a proper growth of the crop in the given climatic situation. To check the effect of the foliar sprays of micronutrients for enhancing the overall vegetative growth of the crop, the present research trail was laid out and which was undertaken in Central Field of Horticulture Department, Horticulture Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences. The advantages of the present study was the perfect establishment of MAU released variety in Prayagraj conditions and a suitable micronutrient combination which can be further carried out for research to get the yield of the crop in the above said prevailing conditions.

## MATERIALS AND METHODS

The experimental work entitled in the abstract was carried out in Central Field, Horticulture Research Farm, the Department of Horticulture, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj 2020-2021. The method employed during the course of investigation and materials utilized have greater significance in the research program. The details of materials used and technique employed in carrying out the investigation described below.

The experiment was accomplished at the Horticulture Research Farm, Department of Horticulture, SHUATS, Prayagraj is situated in the agro climatic zone (Sub-tropical belt) of Uttar Pradesh state. Geographically, Allahabad is located at of 200 15' North latitude, 600 3' East longitude and at an altitude of 678 meters above mean sea level (MSL).

The Prayagraj district is under subtropical belt in the South-East of Uttar Pradesh state, that experiences extremely hot summer and fairly cold winter. The maximum temperature of the location is as high as 46°C – 48°C and seldom falls as low as 4°C – 5°C. The range of relative humidity is between 20 to 94 per cent. The average rainfall is mostly around 1013.4 mm annually in this area.

The soil chemical analysis revealed that soil was sandy loam in texture, acidic in reaction (pH 6.20) medium in organic carbon (0.70%) and potassium (112.50 kg/ha), low in available phosphorus (18.0 kg/ha). The electrical conductivity of the soil was 0.15 dS/m.

There were 10 treatment combinations with three replications. The details of the treatments are being shown in Table 1. Crop variety 'Vikram' was transplanted manually on 17$^{th}$ of October, 2020. The crop spacing was maintained as prescribed for the particular treatments. The combinations of the mentioned treatments were applied at 30, 60, 90, 120, 150 and 180 (DAT) days after planting. The observations on survival and mortality percentage and growth parameters *viz.* plant height, number of leaves per plant, number of branches per plant , plant spread, stem girth, leaf area, leaf area index and chlorophyll content were taken successfully.

**Table 1: Treatments combinations.**

| Treatment notation | Treatment combinations |
|---|---|
| $T_0$ | Control |
| $T_1$ | $ZnSO_4$(0.5%) + $FeSO_4$(0.5%) + Borax(0.5%) |
| $T_2$ | $ZnSO_4$(1%) + $FeSO_4$(0.5%) + Borax(0.5%) |
| $T_3$ | $ZnSO_4$(1.5%) + $FeSO_4$(0.5%) + Borax(0.5%) |
| $T_4$ | $ZnSO_4$(2%) + $FeSO_4$(0.5%) + Borax(0.5%) |
| $T_5$ | $ZnSO_4$(0.5%) + $FeSO_4$(1%) + Borax(0.5%) |
| $T_6$ | $ZnSO_4$(0.5%) + $FeSO_4$(1.5%) + Borax(0.5%) |
| $T_7$ | $ZnSO_4$(0.5%) + $FeSO_4$(2%) + Borax(0.5%) |
| $T_8$ | $ZnSO_4$(0.5%) + $FeSO_4$(0.5%) + Borax(1%) |
| $T_9$ | $ZnSO_4$(0.5%) + $FeSO_4$(0.5%) + Borax(1.5%) |
| $T_{10}$ | $ZnSO_4$(0.5%) + $FeSO_4$(0.5%) + Borax(2%) |

## RESULTS AND DISCUSSION

The survival percentage was calculated in each treatment which was selected in each plant and the data so obtained were subjected to statistical computation, ANOVA. The application on leaves (foliar) of micronutrients mainly affected survival % is given in Table 2 and Fig. 1. The data shows that foliar application of different levels of micronutrients viz., Zinc sulphate (0.5%, 1%, 1.5%, 2%), Borax (0.5%, 1%, 1.5%, 2%) and Ferrous sulphate (0.5%, 1%, 1.5%, 2%) have significant effect on survival percentage as compared to control ($T_0$). The data pertaining to the survival percentage indicates that the differences were significant when the CD value was greater than the treatment difference. The maximum survival percentage (100%) of acid lime were recorded in $T_{10,}$ $T_9$, $T_5$, $T_4$, $T_3$, $T_2$ and $T_1$ which were significantly superior over $T_6$, $T_7$, $T_8$ and control. This was the growth trend observed during the experiment in acid lime. The maximum survival percentage in the mentioned treatments may be due to optimum combination of micronutrients or growing climatic conditions which resulted in greater vegetative emergence of plant as a whole. Ample doses of boron, zinc and iron in combinations might have increased the enzymatic activities *viz.* zinc helping in protein synthesis, boron in cell wall formation and iron in chlorophyll synthesis, thus metabolizing the biological processes such as photosynthesis leading to good green flush in the plants. The treatments with more B and Zn and less of Fe survived the most. The results are in support with Ram and Bose (2000).

The mortality per cent was calculated in each treatment which were selected in each plant and the data so obtained were subjected in statistical computation, ANOVA. Data presented in Table 2 and Fig. 1 reveal that foliar application of micronutrient significantly influenced mortality per cent. The data shows that foliar application of different levels of micronutrients viz., Zinc sulphate (0.5%, 1%, 1.5%, 2%), Borax (0.5%, 1%, 1.5%, 2%) and Ferrous sulphate (0.5%, 1%, 1.5%, 2%) have significant effect on mortality per cent as compared to control ($T_0$). The data pertaining to the mortality percentage indicates that the differences were significant when the CD value was greater than the treatment difference. The minimum mortality percentage (0%) of acid lime was recorded in $T_{10,}$ $T_9$, $T_5$, $T_4$, $T_3$, $T_2$ and $T_1$ and the maximum mortality percentage was recorded in $T_0$ (control) i.e. 33% followed up by $T_6$, $T_7$ and $T_8$ (11.11%). This was the growth trend observed during the experiment in acid lime. The minimum mortality percentage in most of the treatments was due to correct dose of micronutrients which have boosted up their metabolism in proper way.

The maximum mortality percentage in the mentioned treatments may be due to higher dose of iron which resulted in iron toxicity causing cellular damage and decreasing the ability of roots to grow and ultimately death of the plant. The results are in support with Ram and Bose (2000).

**Table 2: Effect of different micronutrient combinations on survival and mortality percentage of acid lime (*Citrus aurantifolia* Swingle) c.v. Vikram.**

| Treatment Notations | Treatment Combinations | Survival Percentage (%) | Mortality Percentage (%) |
|---|---|---|---|
| $T_0$ | Control | 66.67 | 33.33 |
| $T_1$ | $ZnSO_4$(0.5%) + $FeSO_4$(0.5%) + Borax(0.5%) | 100.00 | 0.00 |
| $T_2$ | $ZnSO_4$(1%) + $FeSO_4$(0.5%) + Borax(0.5%) | 100.00 | 0.00 |
| $T_3$ | $ZnSO_4$(1.5%) + $FeSO_4$(0.5%) + Borax(0.5%) | 100.00 | 0.00 |
| $T_4$ | $ZnSO_4$(2%) + $FeSO_4$(0.5%) + Borax(0.5%) | 100.00 | 0.00 |
| $T_5$ | $ZnSO_4$(0.5%) + $FeSO_4$(1%) + Borax(0.5%) | 100.00 | 0.00 |
| $T_6$ | $ZnSO_4$(0.5%) + $FeSO_4$(1.5%) + Borax(0.5%) | 88.89 | 11.11 |
| $T_7$ | $ZnSO_4$(0.5%) + $FeSO_4$(2%) + Borax(0.5%) | 88.89 | 11.11 |
| $T_8$ | $ZnSO_4$(0.5%) + $FeSO_4$(0.5%) + Borax(1%) | 88.89 | 11.11 |
| $T_9$ | $ZnSO_4$(0.5%) + $FeSO_4$(0.5%) + Borax(1.5%) | 100.00 | 0.00 |
| $T_{10}$ | $ZnSO_4$(0.5%) + $FeSO_4$(0.5%) + Borax(2%) | 100.00 | 0.00 |
| | **F-test** | **S** | **S** |
| | **SE.d (±)** | **2.13** | **0.88** |
| | **CD (5 %)** | **4.45** | **1.84** |

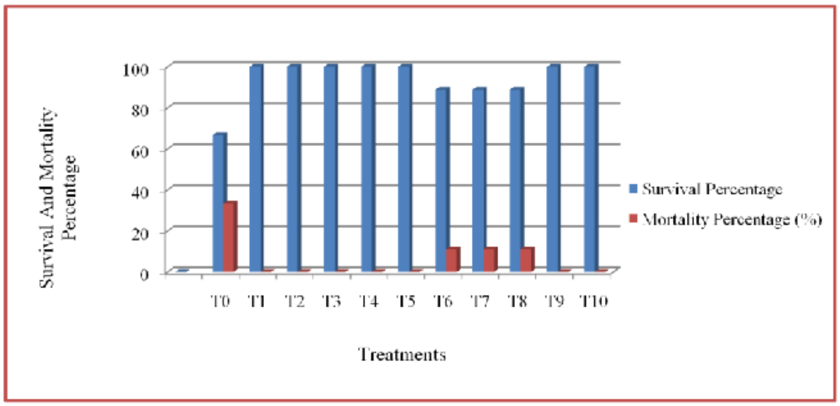


**Fig. 1.** Effect of different micronutrient combinations on survival and mortality percentage of acid lime (*Citrus aurantifolia* Swingle) c.v. Vikram.

The plant height at 30, 60, 90, 120, 150 and 180 DAT was measured in each treatment which were selected in each plant and the data so obtained were subjected in statistical computation, ANOVA. Data presented in Table 3 and Fig. 2 reveal that foliar application of micronutrient significantly influenced plant height. The data shows that foliar application of different levels of micronutrients viz., Zinc sulphate (0.5%, 1%, 1.5%, 2%), Borax (0.5%, 1%, 1.5%, 2%) and Ferrous sulphate (0.5%, 1%, 1.5%, 2%) have significant effect on plant height (cm) as compared to control ($T_0$). The data pertaining to the plant height indicates that the differences were significant when the CD value was greater than the treatment difference. The maximum value ($T_{10}$) was found significantly superior over all the treatments, when the CD value was subtracted from the same, followed up by $T_5$, $T_3$, $T_8$, $T_9$, $T_1$, $T_2$, $T_4$, $T_7$, $T_6$ and control. This was the growth trend observed during the experiment in acid lime. The maximum plant height in $T_{10}$ might be due to optimum combination of micronutrients or growing climatic conditions leading to structural and functional integrity of biological membranes which are, however, essential for the stability of the plant as a whole. The applied combinations of micronutrients *viz.* Zn, Fe and B might have helped the plant move oxygen throughout the roots, leaves, and other parts of the plant, producing the green color that made us know our plant is healthy. The results are in support with Singh *et al.*, (2008).

The number of leaves per plant at 30, 60, 90, 120, 150 and 180 DAT was counted in each treatment which were selected in each plant and the data so obtained were subjected in statistical computation, ANOVA. Data presented in Table 3 and Fig. 2 reveal that foliar application of micronutrient significantly influenced number of leaves per plant. The data shows that foliar application of different levels of micronutrients viz., Zinc sulphate (0.5%, 1%, 1.5%, 2%), Borax (0.5%, 1%, 1.5%, 2%) and Ferrous sulphate (0.5%, 1%, 1.5%, 2%) have significant effect on number of leaves per plant as compared to control ($T_0$). The data pertaining to the number of leaves per plant indicates that the differences were significant when the CD value was greater than the treatment difference. The value ($T_5$)

was found at par at 30, 60, 90, 120, 150 and 180 DAT, when the CD value was subtracted from the maximum value i.e. $T_{10}$ and the rest are significantly superior over the minimum values *viz.* $T_7$, $T_6$, $T_4$, $T_2$ and control. This was the growth trend observed during the experiment in acid lime. Proper dose of micronutrients in combinations might have helped the plant to produce good amount of chlorophyll and proper movement of sugar and energy to growing plant parts. So, ultimately it resulted in good vegetative flush. The results are in support with Dawood *et al.*, (2001); El-Saida (2001) ; Gurjar *et al.*, (2015).

The number of branches per plant at 30, 60, 90, 120, 150 and 180 DAT was counted in each treatments which were selected in each plant and the data so obtained were subjected in statistical computation, ANOVA. Data presented in Table 3 and Fig. 2 reveal that foliar application of micronutrient significantly influenced number of branches per plant. The data shows that foliar application of different levels of micronutrients viz., Zinc sulphate (0.5%, 1%, 1.5%, 2%), Borax (0.5%, 1%, 1.5%, 2%) and Ferrous sulphate (0.5%, 1%, 1.5%, 2%) have significant effect on number of branches per plant as compared to control ($T_0$). The data pertaining to the number of leaves per plant indicates that the differences were significant when the CD value was greater than the treatment difference. The value ($T_5$) was found at par at 30, 60, 90, 120, 150 and 180 DAT, when the CD value was subtracted from the maximum value i.e. $T_{10}$ and the rest are significantly superior over the minimum values *viz.* $T_7$, $T_6$, $T_4$, $T_2$ and control. This was the growth trend observed during the experiment in acid lime. The applied combinations of micronutrients *viz.* Zn, Fe and B might have helped the plant move oxygen throughout the roots, leaves, branches and other parts of the plant, producing the green color that made us know our plant is healthy. The results are in support with Dawood *et al.*, (2001) ; Gurjar *et al.*, (2015).

The stem girth (cm) at 30, 60, 90, 120, 150 and 180 DAT was measured in each treatment which were selected in each plant and the data so obtained were subjected in statistical computation, ANOVA. Data presented in Table 3 and Fig. 2 reveal the foliar application of micronutrient significantly influenced stem girth. The data shows that foliar application of different levels of micronutrients viz., Zinc sulphate (0.5%, 1%, 1.5%, 2%), Borax (0.5%, 1%, 1.5%, 2%) and Ferrous sulphate (0.5%, 1%, 1.5%, 2%) have significant effect on stem girth (cm) as compared to control ($T_0$). The data pertaining to the stem girth indicates that the differences were significant when the CD value was greater than the treatment difference. The value ($T_5$) was found at par at 30, 60, 90, 120, 150 and 180 DAT, when the CD value was subtracted from the maximum value i.e. $T_{10}$ and the rest are significantly superior over the minimum values *viz.* $T_7$, $T_6$, $T_4$, $T_2$ and control. This was the growth trend observed during the experiment in acid lime. The maximum stem girth in $T_{10}$ might be due to optimum combination of micronutrients or growing climatic conditions leading to structural and functional integrity of biological membranes which are, however, essential for the stability of the plant as a whole. The treatments with more B and Zn and less of Fe have reported the best vegetative growth of higher stem girth with good green flush. The results are in support with Ram and Bose (2000) ; Singh *et al*., (2008).

The plant spread (E-W & N-S) at 30, 60, 90, 120, 150 and 180 DAT was measured in each treatment which were selected in each direction and the data so obtained were subjected in statistical computation, ANOVA. Data presented in Table 3 and Fig. 2 reveal that foliar application of micronutrient significantly influenced plant spread (E-W & N-S). The data shows that foliar application of different levels of micronutrients viz., Zinc sulphate (0.5%, 1%, 1.5%, 2%), Borax (0.5%, 1%, 1.5%, 2%) and Ferrous sulphate (0.5%, 1%, 1.5%, 2%) have significant effect on plant spread (cm) (E-W & N-S) as compared to control ($T_0$). The data pertaining to plant spread indicates that the differences were significant when the CD value was greater than the treatment difference. The value ($T_5$) was found at par at 30, 60, 90, 120, 150 and 180 DAT, when the CD value was subtracted from the maximum value i.e. $T_{10}$ and the rest are significantly superior over the minimum values *viz.* $T_7$, $T_6$, $T_4$, $T_2$ and control. This was the growth trend observed during the experiment in acid lime. Increase in the number of leaves and branches lead to greater plant spread due to optimum combinations of micronutrients *viz.* zinc helping in protein synthesis, boron in cell wall formation and iron in chlorophyll synthesis, thus metabolizing the biological processes such as photosynthesis leading to good green flush in the plants. The results are in support with Prasad *et al.*, (2013); Jagtap *et al.*, (2013) ; Deshmukh *et al.*, (2015).

The leaf area was measured in each treatment with a selected leaf and the data so obtained were subjected in statistical computation as shown in ANOVA. Data presented in Table 3 and Fig. 2 reveal that foliar application of micronutrient significantly influenced leaf area. The data shows that foliar application of different levels of micronutrients *viz.*, Zinc sulphate (0.5%, 1%, 1.5%, 2%), Borax (0.5%, 1%, 1.5%, 2%) and Ferrous sulphate (0.5%, 1%, 1.5%, 2%) have significant effect on leaf area as compared to control ($T_0$). The data pertaining to leaf area indicates that the differences were significant when the CD value was greater than the treatment difference. The value ($T_5$) was found at par at 30, 60, 90, 120, 150 and 180 DAT, when the CD value was subtracted from the maximum value i.e. $T_{10}$ and the rest are significantly superior over the minimum values *viz.* $T_7$, $T_6$, $T_4$, $T_2$ and control. This was the growth trend observed during the experiment in acid lime. Due to optimum combinations of micronutrients *viz.* zinc helping in protein synthesis, boron in cell wall formation and iron in chlorophyll synthesis, thus metabolizing the biological processes such as photosynthesis might have determined rates of energy and material exchange between plant canopies and the atmosphere which lead to greater leaf area and good green flush in the plants. The treatments with more B and Zn and less of Fe have reported the best vegetative growth with good green flush and wider leaf area. The results are in support with Obaid and Al-Hadethi (2013).

Data presented in Table 3 and Fig. 2 reveal that foliar application of micronutrient significantly influenced Leaf area index (LAI). The data shows that foliar application of different levels of micronutrients viz., Zinc sulphate (0.5%, 1%, 1.5%, 2%), Borax (0.5%, 1%, 1.5%, 2%) and Ferrous sulphate (0.5%, 1%, 1.5%, 2%) have significant effect on Leaf area index (LAI) as compared to control ($T_0$). The data pertaining to leaf area index indicates that the differences were significant when the CD value was greater than the treatment difference. The value ($T_5$) was found at par at 30, 60, 90, 120, 150 and 180 DAT, when the CD value was subtracted from the maximum value i.e. $T_{10}$ and the rest are significantly superior over the minimum values *viz.* $T_7$, $T_6$, $T_4$, $T_2$ and control. This was the growth trend observed during the experiment in acid lime. Due to optimum combinations of micronutrients *viz.* zinc helping in protein synthesis, boron in cell wall formation and iron in chlorophyll synthesis, thus metabolizing the biological processes such as photosynthesis might have determined rates of energy and material exchange between plant canopies and the atmosphere which lead to greater leaf area index and good green flush in the plants. The treatments with more B and Zn and less of Fe have reported the best vegetative growth with good green flush and greater leaf area index. The results are in support with Obaid and Al-Hadethi (2013).

**Table 3: Effect of different micronutrient combinations on growth parameters of acid lime (*Citrus aurantifolia* Swingle) c.v. Vikram.**

| Treatment Symbols | Treatment combinations | Growth Parameters | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Plant Height | No. of Leaves per plant | No. of Branches per plant | Plant spread | Stem Girth | Leaf Area | Leaf Area Index (LAI) | Chlorophyll Content (%) |
| $T_0$ | Control | 30.64 | 77.47 | 11.11 | 49.00 | 1.47 | 3.23 | 0.0017 | 43.63 |
| $T_1$ | $ZnSO_4$(0.5%) + $FeSO_4$(0.5%) + Borax(0.5%) | 38.06 | 90.01 | 12.85 | 55.56 | 1.55 | 4.60 | 0.0019 | 58.15 |
| $T_2$ | $ZnSO_4$(1%) + $FeSO_4$(0.5%) + Borax(0.5%) | 36.05 | 89.16 | 13.18 | 52.53 | 1.58 | 4.38 | 0.0020 | 56.42 |
| $T_3$ | $ZnSO_4$(1.5%) + $FeSO_4$(0.5%) + Borax(0.5%) | 40.10 | 98.75 | 14.36 | 60.33 | 2.10 | 6.23 | 0.0023 | 54.32 |
| $T_4$ | $ZnSO_4$(2%) + $FeSO_4$(0.5%) + Borax(0.5%) | 37.40 | 86.75 | 13.45 | 54.47 | 1.71 | 6.16 | 0.0022 | 55.39 |
| $T_5$ | $ZnSO_4$(0.5%) + $FeSO_4$(1%) + Borax(0.5%) | 41.19 | 102.92 | 15.38 | 63.27 | 2.17 | 6.43 | 0.0020 | 63.08 |
| $T_6$ | $ZnSO_4$(0.5%) + $FeSO_4$(1.5%) + Borax(0.5%) | 35.33 | 94.39 | 14.06 | 58.77 | 1.76 | 5.82 | 0.0021 | 55.96 |
| $T_7$ | $ZnSO_4$(0.5%) + $FeSO_4$(2%) + Borax(0.5%) | 35.43 | 88.11 | 14.14 | 56.77 | 1.64 | 5.45 | 0.0020 | 55.64 |
| $T_8$ | $ZnSO_4$(0.5%) + $FeSO_4$(0.5%) + Borax(1%) | 34.95 | 90.04 | 13.75 | 53.73 | 1.65 | 5.24 | 0.0022 | 56.65 |
| $T_9$ | $ZnSO_4$(0.5%) + $FeSO_4$(0.5%) + Borax(1.5%) | 35.40 | 92.97 | 14.22 | 56.76 | 1.64 | 5.42 | 0.0021 | 54.47 |
| $T_{10}$ | $ZnSO_4$(0.5%) + $FeSO_4$(0.5%) + Borax(2%) | 41.88 | 102.99 | 15.48 | 64.76 | 2.23 | 6.60 | 0.0026 | 64.67 |
| | **F-test** | **S** | **S** | **S** | **S** | **S** | **S** | **S** | **S** |
| | **SE.d (±)** | **0.569** | **2.368** | **0.348** | **0.307** | **0.031** | **0.089** | **0.0012** | **3.483** |
| | **CD (5 %)** | **1.187** | **4.941** | **0.726** | **0.640** | **0.065** | **0.185** | **0.0023** | **7.265** |

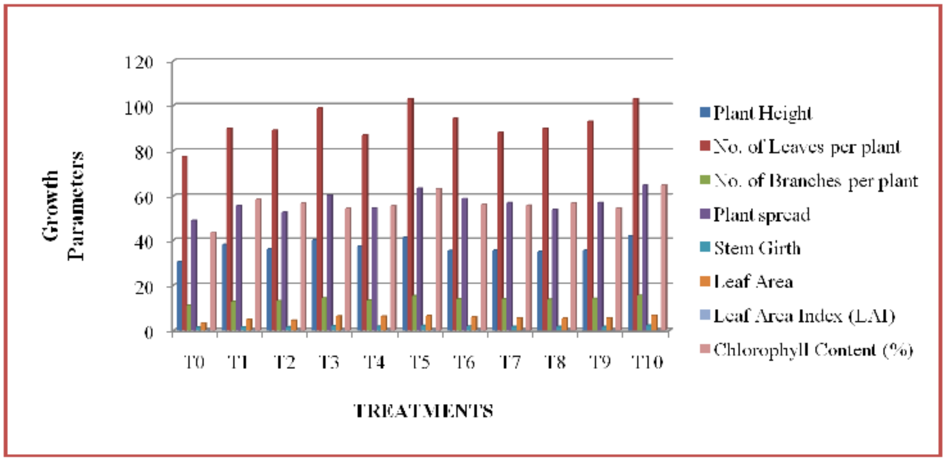


**Fig. 2.** Effect of different micronutrient combinations on growth parameters of acid lime (*Citrus aurantifolia* Swingle) c.v. Vikram.

Data presented in Table 3 and Fig. 2 reveal that foliar application of micronutrient significantly chlorophyll SPAD. The data shows that foliar application of different levels of micronutrients viz., Zinc sulphate (0.5%, 1%, 1.5%, 2%), Borax (0.5%, 1%, 1.5%, 2%) and Ferrous sulphate (0.5%, 1%, 1.5%, 2%) have significant effect on chlorophyll SPAD as compared to control ($T_0$). The maximum chlorophyll (64.67SPAD) were recorded under application of $T_{10}$ $ZnSO_4$(0.5%) + $FeSO_4$(0.5%) + Borax(2%) followed by $T_5$ $ZnSO_4$(0.5%) + $FeSO_4$(1%) + Borax(0.5%) and $T_3$ $ZnSO_4$(1.5%) + $FeSO_4$(0.5%) + Borax(0.5%) and the minimum chlorophyll (43.63 SPAD) were recorded under control. The data pertaining to chlorophyll SPAD indicates that the differences were significant when the CD value was greater than the treatment difference. The value ($T_5$) was found at par at 30, 60, 90, 120, 150 and 180 DAT, when the CD value was subtracted from the maximum value i.e. $T_{10}$ and the rest are significantly superior over the minimum values *viz.* $T_7$, $T_6$, $T_4$, $T_2$ and control. Zinc alone plays a vital role in chlorophyll synthesis. However, the combinations of Zn, B and Fe might have significantly increased the chlorophyll content of the leaves. Increase in the chlorophyll SPAD might be due to growing climatic conditions or variation in micronutrient combinations applied. The treatments with more B and Zn and less of Fe have reported the best vegetative growth with good green flush and greater chlorophyll SPAD content. The results are in support with Pestana *et al.*, (2002); Papadakis *et al.*, (2005); Razzaq *et al.*, (2013); Boaretto *et al.*, (2001).

## CONCLUSION

From the present investigation it may be concluded that $T_{10}$ $ZnSO_4$(0.5%) + $FeSO_4$(0.5%) + B(2%) resulted in highest survival percentage and vegetative growth parameters like survival percentage (100% ), mortality per cent (0.00%), plant height (cm) (41.88), number of leaves per plant (102.99), number of branches per plant (15.48), stem girth (2.23cm), plant spread (64.76cm), leaf area (6.60cm$^2$), Leaf area index (0.0026LAI) and chlorophyll (64.67SPAD).

Moreover, the treatments $T_9$, $T_5$, $T_4$, $T_3$, $T_2$ and $T_1$ also showed 100% survivability due to higher zinc and boron content and lesser iron content and the other treatments including the control died mostly due to iron toxicity and environmental conditions.

Hence, for better growth and establishment it is recommended to apply the foliar application of proper dose of micronutrients at initial stage of acid lime seedlings under Prayagraj agro-climatic conditions. Since this is based on one season trail therefore, further evaluation trails are needed to substantiate the findings.

## FUTURE SCOPE

The application of suitable combination of micronutrients or growing climatic conditions lead to structural and functional integrity of biological membranes which are, however, essential for the stability of the plant as a whole. The applied combinations of micronutrients *viz.* Zn, Fe and B might have helped the plant move oxygen throughout the roots, leaves, and other parts of the plant, producing the green color that made us know our plant is healthy. As acid lime plants are accessible year-round, with a peak season in June-July, these above said applications may stimulate vegetative development, resulting in a higher yield in the future. As a result, both producers and sellers will see higher returns or profits.

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**Conflict of Interest.** As a Corresponding Author, I Anurag Anshuman Mishra, confirm that none of the others have any conflicts of interest associated with this publication.

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