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# Influence of nutrition and elicitation on vegetative, herbage and oil yield in *Ocimum* (*Ocimum sanctum* L.)

**M Lakshmi Madhuri, S Surya Kumari, DV Swami, K Giridhar, DR Salomi Suneetha and K Uma Krishna**

## Abstract
The present investigation entitled "Effect of nutrition, elicitation, extraction intervals on essential oil production and value addition in holy basil (*Ocimum sanctum* L.)" was carried out at College of Horticulture, Venkataramannagudem, Dr. YSR Horticultural University, West Godavari district of Andhra Pradesh during *Kharif* 2018-19 to 2019-20. The study was conducted to ascertain the best nutrient and elicitor levels, pre-processing interval for maximum oil recovery and optimization of *ocimum* based herbal RTS. The study considered three graded levels of nitrogen (Nitrogen 100%, 75% and 50%) with three levels of micronutrients (copper @ 5g, zinc @ 5g, copper and zinc @ 5g each), three elicitor levels (Salicylic acid 50 ppm, 100 ppm and 150 ppm), three pre-processing intervals (immediately after harvest, 24 hrs. and 48 hrs.) and eight blends of herbal RTS (10:5:40:45, 15:5:35:45, 20:5:30:45, 25:5:25:45, 5:10:40:45 5:15:35:45, 5:20:30:45 and 5:25:25:45) consists of ocimum, ginger, lemon and sugar. The study revealed that, quantitative parameters like plant height, number of branches per plant, fresh herb yield per plant, dry herb yield per plant and oil yield were significant with graded levels of nitrogen, micronutrients and salicylic acid at both the cuts.

**Keywords:** Ocimum, nitrogen, salicylic acid and micronutrients

## Introduction
The genus Ocimum is collectively called as "Basil" belongs to the family Lamiaceae (Labiateae) and contains about 50 to 150 species of herbs and shrubs from the tropical regions of Asia, Africa, Central and South America (Gill and Randhawa, 1997).
Tulsi (*Ocimum sanctum* L.) is an aromatic sweet smell scented herb omnipresent throughout India and is worshiped in temples and houses of Hindus. Within ayurveda, Tulsi is known as "The incomparable one" "The mother medicine of nature" and "Queen of herbs". Tulsi is also reversed as an "elixir of life" that is equal for both medicinal and spiritual properties. This considered a potent adoptogen with adaptation to stress and promotion of homeostasis, the herb has a unique combination of pharmacological action, that promote well-being and resilient.
Holy basil is considered as a species with substantial nutritional and fertilization needs. It responds extremely well to nitrogen fertilization (Al-mansour *et al.* 2018). The importance of nitrogen in medicinal and aromatic plants is of utmost, as an integral component of a variety of biochemical compounds such as proteins and nucleic acids, which form the living material (Mahantesh *et al.* 2017). Nitrogen fertilization influences both the quantity and quality of essential oil. Micronutrients, especially Zn, act either as metal component of various enzymes or as functional, structural or regulatory cofactors. Thus, they are associated with saccharide metabolism, photosynthesis and protein synthesis (Marschner, 1995). In plants, Cu plays a vital role in various metabolic processes, namely cell wall metabolism, acts as structural element in regulatory proteins, photosynthetic electron transport and mitochondrial respiration, biosynthesis of plant hormones and as cofactor for a variety of enzymes (Bouazizi *et al.* 2010 and Ke *et al.* 2007), changes membrane integrity and permeability (Yruela, 2005), as well as affects the uptake of other nutrient elements (Bernal *et al.* 2007). In recent years, scientists have been looking for new alternatives to conventional methods for plant protection and simultaneously for improvement in health properties and bioactive compound content. One of these methods is elicitation, which is induction of natural plant resistance mechanisms using biotic or abiotic factors. Salicylic acid (SA) is a phenolic compound, capable of enhancing plant growth and yield in some plants.

SA acts as a potential non-enzymatic antioxidant, plant growth regulator, imparts tolerance against abiotic stressand plays an important role in regulation of a number of plant physiological processes and production of bioactive compounds (Ghasemzadeh *et al.* 2012).

## Materials and Methods

The present investigation was carried out during *kharif* 2018-19 and 2019-20 at college of Horticulture, Dr. Y.S.R. Horticultural University, Venkataramannagudem, West Godavari District, Andhra Pradesh.

**Table 1:** Treatments

| Factor 1 (Levels of nitrogen) | Factor 2 (Levels of micronutrients) | Factor 3 (Levels of SA) |
|---|---|---|
| N1:Nitrogen 100% | M1:Copper @5g | S1:SA 50 ppm |
| N2:Nitrogen 75% | M2:Zinc @5g | S2:SA 100 ppm |
| N3:Nitrogen 50% | M3:Copper @5g + Zinc @5g | S3:SA 150 ppm |

**Table 2:** Treatment combinations

| | | |
|---|---|---|
| T1: N1 M1 S1 | T10: N2 M1 S1 | T19: N3 M1 S1 |
| T2: N1 M1 S2 | T11: N2 M1 S2 | T20: N3 M1 S2 |
| T3: N1 M1 S3 | T12: N2 M1 S3 | T21: N3 M1 S3 |
| T4: N1 M2 S1 | T13: N2 M2 S1 | T22: N3 M2 S1 |
| T5: N1 M2 S2 | T14: N2 M2 S2 | T23: N3 M2 S2 |
| T6: N1 M2 S3 | T15: N2 M2 S3 | T24: N3 M2 S3 |
| T7: N1 M3 S1 | T16: N2 M3 S1 | T25: N3 M3 S1 |
| T8: N1 M3 S2 | T17: N2 M3 S2 | T26: N3 M3 S2 |
| T9: N1 M3 S3 | T18: N2 M3 S3 | T27: N3 M3 S3 |

- Nitrogen 100% @ 120 kg/ha
- Nitrogen 75% @ 90 kg/ha
- Nitrogen 50% @ 60 kg/ha
- The Recommended Dose of Phosphorus and Potassium were applied in the form of MOP and SSP @ 60kg/ha equal splits during last plough as basal dose to all the treatments.

### Quantitative parameters

#### Plant height (cm)

Five plants were randomly selected from each plot and measured at harvest. The plant height was measured from the ground level to the tip of the main shoot and the average was computed and expressed in centimeters.

#### Number of branches per plant

The total branches i.e. primary, secondary and tertiary branches from five randomly selected plants from each plot were counted. The average was computed and expressed as number of branches per plant.

#### Fresh herbage yield per plant (g)

A representative five plants were selected randomly for recording fresh yield at the time of harvest. The mean weight was calculated and expressed in grams.

#### Dry herbage yield per plant (g)

After recording the fresh yield from randomly selected plants, same plants were dried under partial shade till they attained constant weight and dry weight was recorded. The mean dry yield was calculated and expressed in grams.

#### Essential oil recovery (%) plant$^{-1}$

The essential oil content per plant was determined by hydrodistillation according to AOAC (2000) standard method. The essential oil thus obtained was expresses as %.

$$\text{\% oil from fresh herbage} = \frac{\text{Weight difference of flask (g)}}{\text{Weight of fresh sample taken}} \times 100$$

#### Oil yield per hectare (kg)

The oil yield per hectare was computed by multiplying the yield of fresh herbage per hectare with the percentage recovery of oil.

## Results and Discussion

### Quantitative parameters

In the present field experiment, graded levels of nitrogen and micro nutrients as nutrients and salicylic acid for elicitation of essential oil are applied 30 days after transplanting and 15 days after first cut. The observations with different levels of nitrogen, micro nutrients and salicylic acid as elicitor and their interaction effects on quantitative parameters like plant height (cm), number of leaves, number of branches, fresh herb yield per plant (g), dry herb yield per plant (g) and oil yield from herb (kg) were recorded in both the cuts and the pooled data of the study i.e. for *kharif* 2018-19 and 2019-20 are presented in the table 3 to 7 respectively.

#### Plant height (cm)

The pooled data pertaining to plant height in response to graded levels of nitrogen, micro nutrients and salicylic acid as elicitor and their interactions are presented in the table 3.

The plant height was significantly higher (54.75 cm and 49.76 cm) with the application of 100% nitrogen at both the harvests and linear response was observed to nitrogen treatments. Among the micronutrient treatments, Copper and Zinc @ 5g each recorded the maximum plant height (53.66 cm and 47.10 cm) at both the cuts. Among the treatments with salicylic acid as elicitor treatments, SA 100 ppm recorded the highest plant height (52.58 cm and 46.00 cm) at first and second cuts.

The interaction effect of graded levels of nitrogen and micro nutrients with respect to plant height was found to be significant in both the cuts. Maximum plant height (59.32 cm and 52.66 cm) was recorded with 100% nitrogen with combined application of Copper and Zinc @ 5g each. The minimum plant height (45.62 cm and 36.27 cm) was observed with combination of 50% nitrogen with Copper 5g in both the cuts.

The interaction effect of nitrogen and salicylic acid as elicitor on plant height was found to be significant in both the harvests. Among the interaction effects, the highest plant height (58.07 cm and 53.72 cm) was recorded with combination of 100% nitrogen and 100ppm salicylic acid. The lowest plant height (42.29 cm and 37.65 cm) was recorded with combination of 50% nitrogen with 50ppm salicylic acid as elicitor in both the harvests.

The interaction effect of micro nutrients and salicylic acid as elicitor with respect to plant height was found to be significant at both the cuts. Higher plant height (57.93 cm and 49.05 cm) was recorded with combined application of Copper and Zinc @ 5g each and 100ppm salicylic acid. The lowest plant height (46.22 cm) was observed with application of Copper 5g with 50ppm salicylic acid in first cut and application of Copper 5g with 150ppm salicylic acid recorded the lowest plant height (41.28 cm) in second cut.

The interaction effect of the treatment combinations with respect to plant height was found to be significant. The maximum plant height (69.08 cm and 61.96 cm) was recorded at 100% nitrogen with application of Copper and Zinc @ 5g each with 100ppm salicylic acid. The minimum plant height (41.58 cm and 31.30 cm) was recorded with application of 50% nitrogen with Zinc 5g and 50ppm salicylic acid at both the cuts.

Based on the results it can be concluded that, nitrogen considered as an important constituent of amino acids, proteins and chlorophyll enhanced photosynthetic activity, which led to an increase in plant height with the increased level of nitrogen application. Similar results were observed in Japanese mint (Shormin *et al.* 2009) [21].

The increased plant height recorded by foliar application of micronutrients was due to the fact that zinc as an activator of enzyme tryptophan, the precursor of IAA was involved in protein synthesis and had direct effect on the enzymatic regulation which stimulated the growth of plant tissues. The results were in accordance with findings of Ingle *et al*. (1993) [9] in chilli, Chhibba *et al*. (2007) [2] in Fenugreek, Choudhary *et al.* (2014) [4] in garlic, Manna *et al.* (2014) and Kumara *et al.* (2016) [11] in Damask rose plants

Salicylic acid as a prerequisite for the synthesis of auxin**,** in the meristematic tissue of the plant was responsible for increased plant height. SA is believed to be involved in changing the hormonal status of plant responsible for plant height.

The present study also clearly indicated the beneficial impact of SA on crop growth, which might be due to the involvement SA in regulation of several physiological processes in plants such as stomata closure, ion uptake, inhibition of biosynthesis and transpiration (Khan *et al*. 2003 and Shakirova *et al*. 2003) [12, 19].

Similar results were reported by Shams *et al*. (2012) [20] in thyme, Sumathi *et al*. (2012) [24] in patchouli, Hassan *et al*. (2015) [7] in Basil.

**Number of branchesplant$^{-1}$**

The pooled data on number of branchesplant$^{-1}$ at the first cut and second cut are presented in the table 4.

The data indicated that among the nitrogen doses evaluated, significantly maximum number of branchesplant$^{-1}$ (98.68 and 68.05) was observed with application of 100% nitrogen. Among the micronutrient treatments, combined application of Copper and Zinc @ 5g each recorded the maximum number of branchesplant$^{-1}$ (95.35 and 59.97) and salicylic acid as elicitor treatments, SA 100 ppm recorded the maximum number of branchesplant$^{-1}$ (96.07 and 60.82) at first and second cuts.

The maximum number of branchesplant$^{-1}$ (102.48 and 70.95) was recorded 100% nitrogen with combined application of Copper and Zinc @ 5g each. The minimum number of branchesplant$^{-1}$ (82.46) was recorded with combination of 75% nitrogen along with Copper 5g at first cut and combination of 50% nitrogen with Zinc 5g (44.50) at second cut.

The interaction effect of nitrogen and salicylic acid as elicitor with respect to number of branchesplant$^{-1}$ was found to be significant at both the harvests. Among the interaction effects, the maximum number of branchesplant$^{-1}$ (102.56 and 72.26) was recorded with combination of 100% nitrogen and 100ppm salicylic acid as elicitor. The minimum number of branchesplant$^{-1}$ (83.48 and 42.18) was recorded with combination of 50% nitrogen and 50ppm salicylic acid as elicitor at both the cuts.

The interaction of micro nutrients and salicylic acid as elicitor with respect to number of branchesplant$^{-1}$ was found to be significant at both the cuts. Maximum number of branchesplant$^{-1}$ (101.24 and 66.64) was achieved with combined application of Copper and Zinc @ 5g each with 100ppm salicylic acid as elicitor. The minimum number of branchesplant$^{-1}$ (89.61 and 50.66) was obtained with application of Copper @ 5g and 50ppm salicylic acid as elicitor at both the cuts.

The interactions of the nitrogen with micro nutrients and salicylic acid on number of branchesplant$^{-1}$ were found to be significant at both the harvests. Among the interaction effects, maximum number of branchesplant$^{-1}$ (111.36 and 77.00) was recorded with 100% nitrogen in the combined application of Copper and Zinc @ 5g each with 100ppm salicylic acid as elicitor. The minimum number of branchesplant$^{-1}$ (75.76 and 36.10) was recorded with application of 50% nitrogen and Zinc 5g with 50ppm salicylic acid at both the cuts.

Based on the results obtained it could be concluded that, plants applied with higher doses of nitrogen recorded the increased number of branches per plant. The reason might be due to the involvement of nitrogen in the basic reactions of photosynthesis that resulted in production of more number of leaves and branches. The low C: N ratio also encouraged the vegetative growth. Nitrogen being the basic constituent of proteins and nucleic acids was found helpful in increasing the plant growth (Hartmann *et al*. 1981) [6].

The increase in number of branches might be due to involvement of zinc in the synthesis of tryptophan, a precursor of IAA, which is necessary for cell division and cell elongation which in turn promotes the branches in plants. These findings are in conformity with those of Aladakatti *et al*. (2012) [1] in Stevia and Sumathi *et al*. (2012) [24] in Patchouli.

**Fresh herb yield plant$^{-1}$ (g)**

The pooled results presented in Table 5 showed that all the treatments of graded levels of nitrogen with micro nutrients and salicylic acid as elicitor and their treatment combinations had a significant effect on the fresh herb yield per plant at both the cuts.

It is evident from the data that, the fresh herb yield per plant was significantly higher (731.19 g and 528.15 g) with the fertilizer application of 100% nitrogen at both the cuts respectively. Among the micronutrient treatments, combined application of Copper and Zinc @ 5g each recorded the maximum fresh herb yield per plant (618.15 g and 438.21 g) and among the salicylic acid as elicitor treatments, SA 100 ppm recorded the maximum fresh herb yield per plant (620.45 g and 439.57 g) at first and second cuts.

The interaction effect of the nitrogen and micro nutrients with respect to fresh herb yield per plant was found to be significant at both the cuts. The maximum fresh herb yield per plant (769.11 g and 554.46 g) was recorded with combination of 100% nitrogen and combined application of Copper and Zinc @ 5g each. The minimum fresh herb yield per plant (428.58 g) was recorded with combination of 50% nitrogen with Copper 5g at first cut, and the combination of 50% nitrogen with Zinc @ 5g (344.44 g) at second cut.

The interaction effect of the nitrogen and salicylic acid as elicitor on fresh herb yield per plant was found to be significant at both the harvests. Among the interaction effects, the maximum fresh herb yield per plant (740.98 g and 534.28 g) was recorded with combination of 100% nitrogen and

100ppm salicylic acid as elicitor. The minimum fresh herb yield per plant (415.52 g and 337.78 g) was recorded with combination of 50% nitrogen with 50ppm salicylic acid as elicitor at both the cuts.

The interaction of the micro nutrients and salicylic acid as elicitor with respect to fresh herb yield per plant was found to be significant at both the cuts. Among the interaction effects, the maximum fresh herb yield per plant (633.94 g and 450.13 g) was recorded with combined application of Copper and Zinc @ 5g each with 100ppm salicylic acid as elicitor. The minimum fresh herb yield per plant (552.32 g and 410.34 g) was observed with application of Copper 5g and 50ppm salicylic acid as elicitor at both the harvests.

The interaction effects of the nitrogen with micro nutrients and salicylic acid were found to be significant at both the harvests. The maximum fresh herb yield per plant (799.76 g and 569.73 g) was recorded with 100% nitrogen with the combined application of Copper and Zinc @ 5g each with 100ppm salicylic acid. The minimum fresh herb yield per plant (323.83 g and 303.36 g) was recorded with application of 50% nitrogen with Copper @ 5g and 50ppm salicylic acid as elicitor at both the cuts.

This increase in fresh weight of the herb might be due to an increase in plant height, plant spread, number of branches and leaf area per plant with accumulation of proteins and amino acids in structural organs. The present findings are in conformity with findings of Joshi *et al.* (2013) [10] in chrysanthemum. Similar observations were also reported by Magnifico *et al.* (1986) [14] in carnation and Singh *et al.* (2008) [22] in African marigold

The increase in fresh herb yield might be due to the role of zinc in various growth processes like photosynthesis, nitrogen metabolism, protein synthesis, hormone production and regulation of auxin concentration in the plants. These favourable impacts of zinc resulted in taller plants, increase in leaf area, leaf to stem ratio and dry matter production. Nutrient uptake (N, P, K and Zn) is vital in enhancing the leaf yield. The nutrient availability and uptake during the early stages were met by soil application of $ZnSO_4$ and later by foliar sprays at particular phenological stages of the crop that might have reflected in terms of higher green yields (Chhibba *et al*. 2007) [2].

Salicylic acid as foliar application also increases the fresh herb yield by promoting the growth, development, differentiation of cells, tissues of plants and enhancing the plant growth parameters. These findings are in accordance with the results obtained by Chhibba *et al*. (2007) [2] in fenugreek, Laila, (2011) [13] in red amaranth, Sumathi *et al*. (2012) [24] in patchouli and Gajbhiye *et al*. (2013) [5] in lemon grass.

**Dry herb yield plant$^{-1}$ (g)**

The pooled data pertaining to dry herb yield is presented in Table 6. There was significant increase in dry herb yield per plant with graded levels of nitrogen, micro nutrients, salicylic acid as elicitor and the treatment combinations at both the cuts.

The results obtained indicated that significantly higher dry herb yield per plant (306.74 g and 252.16 g) was recorded with the fertilizer application of 100% nitrogen. Among the micronutrient treatments, combined application of Cooper and Zinc @ 5g each recorded the maximum dry herb yield per plant (236.81 g and 232.24 g). Among the salicylic acid as elicitor treatments, SA 100 ppm recorded the maximum dry herb yield per plant (270.71 g and 233.55 g) at first and second cuts. The interaction effect of the nitrogen and micro nutrients with respect to dry herbage yield per plant was found to be significant at both the cuts. Highest dry herb yield per plant (335.41g and 262.50g) was recorded with combination of 100% nitrogen in the combined application of Copper and Zinc @ 5g each at both the cuts. The minimum dry herb yield per plant (200.31 g and 187.04) was recorded with combination of 50% nitrogen with Copper @ 5g at both the cuts.

The interaction effect of the nitrogen and salicylic acid with respect to dry herb yield per plant was found to be significant at both the cuts. Maximum dry herb yield per plant (315.38 g and 254.13 g) was recorded with combination of 100% nitrogen with 100ppm salicylic acid. The minimum dry herb yield per plant (185.08 g and 183.09 g) was recorded with combination of 50% nitrogen and 50ppm salicylic acid at both the cuts.

The interaction effect of the micro nutrients and salicylic acid as elicitor with respect to dry herbage yield per plant was found to be significant. Among the interaction effects, the maximum dry herb yield per plant (286.60 g and 242.61 g) was recorded with combined application of Copper and Zinc @ 5g each with 100ppm salicylic acid. The minimum dry herb yield per plant (239.26 g and 220.57 g) was recorded with application of Zinc 5g with 50ppm salicylic acid at both the cuts

The interaction effect of nitrogen with micro nutrients and salicylic acid as elicitor with respect to dry herb yield per plant was found to be significant at both the cuts. Among the interaction effects, maximum dry herb yield per plant (344.93 g and 270.66 g) was recorded with 100% nitrogen with combined application of Copper and Zinc @ 5g each with 100ppm salicylic acid at both the cuts. The minimum dry herb yield per plant (162.39 g) was recorded with application of 50% nitrogen with Copper @ 5g each with 50ppm salicylic acid at first cut and 50% nitrogen with combined application of Copper and Zinc @ 5 g each and SA 150 ppm at second cut (177.70 g).

The increase in the dry herb yield of the plant might be due to an increase in the availability of nutrients which helps in synthesis of carbohydrates, later they converted into amino acids and proteins which helped in structural development of the plant in terms of number of branches, leaves and leaf area per plant and the excess amounts were accumulated in the plant parts which are responsible for an increase in the dry weight of the plant. The present findings are in conformity with the earlier results reported by Ravindran *et al.* (1986) in marigold, Joshi *et al*. (2013) [10] in chrysanthemum.

The increase with SA might be due to stimulation of dry mass production through enhancement of cell division and cell enlargement (Hayat *et al.* 2005) [8] and chlorophyll accumulation which reflected on vegetative growth of the plants. According to Shakirova *et al.* (2003) [19], the positive effect of salicylic acid on growth and yield is attributed to its influence on other plant hormones. These findings are in accordance with the results obtained by Chhibba *et al*. (2007) [2] in fenugreek, Sumathi *et al*. 2012 [24] in patchouli, Hassan *et al*. 2015 [7] in basil and Sathiyamurthy (2017) [18] in onion.

**Oil yield (kg ha$^{-1}$)**

The pooled data of oil yield are presented in the table 7. Regarding oil yield ha$^{-1}$, it was found that graded levels of nitrogen with micro nutrients, salicylic acid as elicitor and the interactions were significant at both the cuts.

The data indicated that among the nitrogen fertilizer doses evaluated, significantly higher oil yield (8.39 kg ha$^{-1}$ and 6.29 kg ha$^{-1}$) was observed with application of 100% nitrogen at both the cuts. Among the micronutrient treatments, combined application of Copper and Zinc @ 5g each recorded the maximum oil yield (7.46 kgha$^{-1}$ and 5.27 kg ha$^{-1}$) and among salicylic acid as elicitor treatments, SA 100 ppm recorded the maximum oil yield (7.08 kg and 5.01 kg) at both the harvests.

The interaction of nitrogen and micro nutrients, the maximum oil yield (9.18 kg ha$^{-1}$ and 7.09 kg ha$^{-1}$) was recorded with combination of 100% nitrogen with Copper and Zinc @ 5g each. The minimum oil yield (4.71 kg ha$^{-1}$ and 2.61 kg ha$^{-1}$) was recorded with combination of 50% nitrogen and Copper @ 5g at both the cuts.

The interaction of nitrogen and salicylic acid as elicitor with respect to oil yield was found to be significant at both the cuts. Among the interaction effects, maximum oil yield (8.55 kg ha$^{-1}$ and 6.45 kg ha$^{-1}$) was recorded with combination of 100% nitrogen and 100ppm salicylic acid as elicitor. The minimum oil yield (5.04 kg ha$^{-1}$ and 2.94 kg ha$^{-1}$) was recorded with combination of 50% nitrogen and 50ppm salicylic acid as elicitor at both the harvests.

The interactions effects of micro nutrients and salicylic acid as elicitor with respect to oil yield was found to be significant at both the cuts. The maximum oil yield (7.73 kg ha$^{-1}$ and 5.66 kg ha$^{-1}$) was recorded with combined application of Copper and Zinc @ 5g each with 100ppm salicylic acid as elicitor. The minimum oil yield (6.00 kg ha$^{-1}$ and 3.91 kg ha$^{-1}$) was recorded with application of Copper @ 5g with 50ppm salicylic acid as elicitor at both the harvests.

The interaction effect of nitrogen with micro nutrients and salicylic acid as elicitor with respect to oil yield ha$^{-1}$ was found to be significant at both the cuts. Among the interaction effects, the maximum oil yield (9.36 kg ha$^{-1}$ and 7.26 kg ha$^{-1}$) was recorded with 100% nitrogen with the combined application of Copper and Zinc @ 5g each and 100ppm salicylic acid as elicitor. The minimum oil yield (4.03 kg ha$^{-1}$ and 1.93 kg ha$^{-1}$) was recorded with application of 50% nitrogen with Copper @ 5g and 50ppm salicylic acid as elicitor at both the harvests.

The effect of micronutrients on essential oil percentage may be attributed to their effect on enzyme activity and metabolism improvement. Zinc is an essential micronutrient that acts either as a metal component of various enzymes or as a functional, structural or regulatory cofactor associated with saccharide metabolism, photosynthesis, and protein synthesis. Carbon dioxide and glucose are precursors of monoterpene biosynthesis. Saccharides are also a source of energy and reducing power for terpenoid synthesis. As zinc is involved in photosynthesis and saccharide metabolism and as $CO_2$ and glucose are the most likely sources of carbon utilized in terpene biosynthesis, the role of zinc in influencing essential oil accumulation seems particularly important (Srivastava *et al*. 1997) [23]. The results on the effects micronutrient on coriander plants agreed the results obtained by Said-Al-Ahl and Mahmoud (2010) [17] in sweet basil, Mehrab (2014) [16] in lemon balm and Choudhary *et al.* (2015) [3] in fennel crop.

**Table 3:** Influence of nutrients and salicylic acid on plant height

| Pooled data on plant height (cm) (2018-2020) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Treatments** | | **First cut** | | | | **Second cut** | | | |
| | | **M1** | **M2** | **M3** | **Mean** | **M1** | **M2** | **M3** | **Mean** |
| N1 | | 50.38 | 54.32 | 59.32 | 54.75 | 46.73 | 49.90 | 52.66 | 49.76 |
| N2 | | 47.89 | 51.11 | 49.16 | 49.39 | 43.45 | 46.03 | 44.69 | 44.73 |
| N3 | | 45.62 | 45.67 | 52.25 | 47.58 | 36.27 | 37.98 | 43.95 | 39.40 |
| Mean | | 47.96 | 50.37 | 53.66 | | 42.15 | 44.64 | 47.10 | |
| **Treatments** | | **S1** | **S2** | **S3** | **Mean** | **S1** | **S2** | **S3** | **Mean** |
| N1 | | 52.06 | 58.07 | 54.12 | 54.75 | 46.70 | 53.72 | 48.87 | 49.76 |
| N2 | | 50.12 | 49.38 | 48.66 | 49.39 | 45.66 | 44.23 | 44.29 | 44.73 |
| N3 | | 42.29 | 50.30 | 50.95 | 47.85 | 37.65 | 40.05 | 40.50 | 39.40 |
| Mean | | 48.16 | 52.58 | 51.24 | | 43.33 | 46.00 | 44.55 | |
| **Treatments** | | **S1** | **S2** | **S3** | **Mean** | **S1** | **S2** | **S3** | **Mean** |
| M1 | | 46.22 | 48.84 | 48.83 | 47.96 | 42.19 | 42.99 | 41.28 | 42.15 |
| M2 | | 49.41 | 50.98 | 50.71 | 50.37 | 41.88 | 45.97 | 46.07 | 44.64 |
| M3 | | 48.84 | 57.93 | 54.19 | 53.66 | 45.94 | 49.05 | 46.32 | 47.10 |
| Mean | | 48.16 | 52.58 | 51.24 | | 43.33 | 46.00 | 44.55 | |
| **Treatments** | | **S1** | **S2** | **S3** | | **S1** | **S2** | **S3** | |
| N1 | M1 | 48.46 | 54.22 | 48.45 | - | 44.55 | 50.90 | 44.73 | - |
| | M2 | 55.18 | 50.91 | 56.87 | - | 47.53 | 48.31 | 53.87 | - |
| | M3 | 52.54 | 69.08 | 57.04 | - | 48.02 | 61.96 | 48.02 | - |
| N2 | M1 | 48.46 | 47.04 | 48.19 | - | 43.92 | 42.23 | 44.21 | - |
| | M2 | 51.48 | 52.82 | 49.04 | - | 46.82 | 46.42 | 44.86 | - |
| | M3 | 50.43 | 48.29 | 48.76 | - | 46.23 | 44.05 | 43.80 | - |
| N3 | M1 | 41.74 | 45.26 | 49.86 | - | 38.09 | 35.84 | 34.88 | - |
| | M2 | 41.58 | 49.21 | 46.23 | - | 31.30 | 43.17 | 39.47 | - |
| | M3 | 43.56 | 56.43 | 56.77 | - | 43.57 | 41.14 | 47.14 | - |
| **Comparing means** | | **S.Em+** | | **CD @5%** | | **S.Em+** | | **CD @5%** | |
| N | | 0.27 | | 0.77 | | 0.28 | | 0.80 | |
| M | | 0.27 | | 0.77 | | 0.28 | | 0.80 | |
| NM | | 0.47 | | 1.34 | | 0.49 | | 1.40 | |
| S | | 0.27 | | 0.77 | | 0.28 | | 0.80 | |
| NS | | 0.47 | | 1.34 | | 0.49 | | 1.40 | |
| MS | | 0.47 | | 1.34 | | 0.49 | | 1.40 | |
| NMS | | 0.81 | | 2.32 | | 0.85 | | 2.42 | |

| N - Nitrogen (kg ha-1) | Micronutrients (g l-1) | Salicylic acid (ppm) |
|---|---|---|
| Nitrogen 100% | Copper @ 5g | SA 50 ppm |
| Nitrogen 75% | Zinc @ 5g | SA 100 ppm |
| Nitrogen 50% | Copper and Zinc @ 5g each | SA 150 ppm |

**Table 4:** Influence of nutrients and salicylic acid on number of branches plant[-1]

| Pooled data on number of branches plant-1(2018-2020) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Treatments** | | **First cut** | | | | **Second cut** | | | |
| | | **M1** | **M2** | **M3** | **Mean** | **M1** | **M2** | **M3** | **Mean** |
| N1 | | 94.44 | 99.11 | 102.48 | 98.68 | 65.40 | 67.81 | 70.95 | 68.05 |
| N2 | | 82.46 | 94.77 | 99.92 | 92.52 | 46.88 | 59.02 | 63.22 | 56.37 |
| N3 | | 93.70 | 87.58 | 83.64 | 88.31 | 47.73 | 44.50 | 45.73 | 45.98 |
| Mean | | 90.33 | 93.82 | 95.35 | | 53.34 | 57.11 | 59.97 | |
| **Treatments** | | **S1** | **S2** | **S3** | **Mean** | **S1** | **S2** | **S3** | **Mean** |
| N1 | | 96.20 | 102.56 | 97.27 | 98.68 | 61.83 | 72.26 | 70.06 | 68.05 |
| N2 | | 92.42 | 93.27 | 91.86 | 92.52 | 55.90 | 57.20 | 56.03 | 56.37 |
| N3 | | 83.48 | 92.36 | 89.07 | 88.31 | 42.18 | 53.01 | 42.76 | 45.98 |
| Mean | | 90.70 | 96.07 | 92.74 | | 53.30 | 60.82 | 56.28 | |
| **Treatments** | | **S1** | **S2** | **S3** | **Mean** | **S1** | **S2** | **S3** | **Mean** |
| M1 | | 89.61 | 91.13 | 90.26 | 90.33 | 50.66 | 55.35 | 54.00 | 53.34 |
| M2 | | 90.00 | 95.83 | 95.64 | 93.82 | 51.36 | 60.47 | 59.48 | 57.11 |
| M3 | | 92.50 | 101.24 | 92.31 | 95.35 | 57.88 | 66.64 | 55.37 | 59.97 |
| Mean | | 90.70 | 96.07 | 92.74 | | 53.30 | 60.82 | 56.28 | |
| **Treatments** | | **S1** | **S2** | **S3** | | **S1** | **S2** | **S3** | |
| N1 | M1 | 91.20 | 98.96 | 93.16 | | 61.93 | 70.53 | 63.73 | |
| | M2 | 98.83 | 97.36 | 101.13 | | 59.46 | 69.26 | 74.70 | |
| | M3 | 98.56 | 111.36 | 97.53 | | 64.10 | 77.00 | 71.76 | |
| N2 | M1 | 83.73 | 81.76 | 83.10 | | 47.46 | 46.43 | 46.76 | |
| | M2 | 95.40 | 94.93 | 94.00 | | 58.53 | 60.30 | 58.23 | |
| | M3 | 98.13 | 103.13 | 98.50 | | 61.70 | 64.86 | 63.10 | |
| N3 | M1 | 93.90 | 92.66 | 94.53 | | 42.60 | 49.10 | 51.50 | |
| | M2 | 75.76 | 95.20 | 91.80 | | 36.10 | 51.86 | 45.53 | |
| | M3 | 80.80 | 89.23 | 80.90 | | 47.86 | 58.06 | 31.26 | |
| **Comparing means** | | **S.Em+** | | **CD @5%** | | **S.Em+** | | **CD @5%** | |
| N | | 0.78 | | 2.22 | | 1.04 | | 2.96 | |
| M | | 0.78 | | 2.22 | | 1.04 | | 2.96 | |
| NM | | 1.35 | | 3.85 | | 1.80 | | 5.12 | |
| S | | 0.78 | | 2.22 | | 1.04 | | 2.96 | |
| NS | | 1.35 | | 3.85 | | 1.80 | | 5.12 | |
| MS | | 1.35 | | 3.85 | | 1.80 | | 5.12 | |
| NMS | | 2.35 | | 6.67 | | 3.12 | | 8.87 | |


| N - Nitrogen (kg ha-1) | Micronutrients (g l-1) | Salicylic acid (ppm) |
|---|---|---|
| Nitrogen 100% | Copper @ 5g | SA 50 ppm |
| Nitrogen 75% | Zinc @ 5g | SA 100 ppm |
| Nitrogen 50% | Copper and Zinc @ 5g each | SA 150 ppm |


**Table 5:** Influence of nutrients and salicylic acid on fresh herbage yield plant[-1]

| Pooled data on fresh herbage yield plant-1 (g) (2018-2020) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Treatments** | | **First cut** | | | | **Second cut** | | | |
| | | **M1** | **M2** | **M3** | **Mean** | **M1** | **M2** | **M3** | **Mean** |
| N1 | | 694.55 | 729.92 | 769.11 | 731.19 | 493.05 | 536.95 | 554.46 | 528.15 |
| N2 | | 665.54 | 640.45 | 623.16 | 643.05 | 435.60 | 414.07 | 394.02 | 414.56 |
| N3 | | 428.58 | 449.26 | 462.17 | 446.67 | 351.03 | 344.44 | 366.15 | 353.87 |
| Mean | | 596.23 | 606.54 | 618.15 | | 426.56 | 431.82 | 438.21 | |
| **Treatments** | | **S1** | **S2** | **S3** | **Mean** | **S1** | **S2** | **S3** | **Mean** |
| N1 | | 720.53 | 740.98 | 732.06 | 731.19 | 521.41 | 534.28 | 528.77 | 528.15 |
| N2 | | 646.03 | 648.97 | 634.15 | 643.05 | 423.44 | 413.81 | 406.44 | 414.56 |
| N3 | | 415.52 | 471.41 | 453.10 | 446.67 | 337.78 | 370.62 | 353.22 | 353.87 |
| Mean | | 594.03 | 620.45 | 606.44 | | 427.54 | 439.57 | 429.48 | |
| **Treatments** | | **S1** | **S2** | **S3** | **Mean** | **S1** | **S2** | **S3** | **Mean** |
| M1 | | 552.32 | 621.26 | 615.10 | 596.23 | 410.34 | 436.72 | 432.62 | 426.56 |
| M2 | | 614.66 | 606.16 | 598.80 | 606.54 | 436.34 | 431.86 | 427.26 | 431.82 |
| M3 | | 615.10 | 633.94 | 605.41 | 618.15 | 435.95 | 450.13 | 428.55 | 438.21 |
| Mean | | 594.03 | 620.45 | 606.44 | | 427.54 | 439.57 | 429.48 | |
| **Treatments** | | **S1** | **S2** | **S3** | | **S1** | **S2** | **S3** | |
| N1 | M1 | 687.66 | 693.33 | 702.66 | | 480.30 | 497.06 | 501.80 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | M2 | 720.70 | 729.86 | 739.20 | | 531.03 | 536.06 | 543.76 | |
| | M3 | 753.23 | 799.76 | 754.33 | | 552.90 | 569.73 | 540.76 | |
| N2 | M1 | 645.46 | 681.63 | 669.53 | | 447.36 | 431.73 | 427.70 | |
| | M2 | 658.56 | 640.90 | 621.90 | | 419.96 | 414.26 | 408.00 | |
| | M3 | 634.06 | 624.40 | 611.03 | | 403.00 | 395.43 | 383.63 | |
| N3 | M1 | 323.83 | 488.83 | 473.83 | | 303.36 | 381.36 | 368.36 | |
| | M2 | 464.73 | 447.73 | 435.33 | | 358.03 | 345.26 | 330.03 | |
| | M3 | 458.00 | 477.66 | 450.86 | | 351.96 | 385.23 | 361.26 | |
| **Comparing means** | | **S.Em+** | | **CD @5%** | | **S.Em+** | | **CD @5%** | |
| N | | 4.56 | | 12.94 | | 1.85 | | 5.27 | |
| M | | 4.56 | | 12.94 | | 1.85 | | 5.27 | |
| NM | | 7.90 | | 22.42 | | 3.21 | | 9.13 | |
| S | | 4.56 | | 12.94 | | 1.85 | | 5.27 | |
| NS | | 7.90 | | 22.42 | | 3.21 | | 9.13 | |
| MS | | 7.90 | | 22.42 | | 3.21 | | 9.13 | |
| NMS | | 13.68 | | 38.84 | | 5.57 | | 15.82 | |

| N-Nitrogen (kg ha-1) | Micronutrients (g l-1) | Salicylic acid (ppm) |
|---|---|---|
| Nitrogen 100% | Copper @ 5g | SA 50 ppm |
| Nitrogen 75% | Zinc @ 5g | SA 100 ppm |
| Nitrogen 50% | Copper and Zinc @ 5g each | SA 150 ppm |

**Table 6:** Influence of nutrients and salicylic acid on dry herbage yield plant$^{-1}$

| **Pooled data on dry herbage yield plant-1 (g) (2018-2020)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Treatments** | | **First cut** | | | | **Second cut** | | | |
| | | **M1** | **M2** | **M3** | **Mean** | **M1** | **M2** | **M3** | **Mean** |
| N1 | | 288.03 | 296.41 | 335.77 | 306.74 | 240.27 | 253.72 | 262.50 | 252.16 |
| N2 | | 265.53 | 257.64 | 252.85 | 258.67 | 241.37 | 234.95 | 227.42 | 234.58 |
| N3 | | 200.31 | 228.22 | 202.80 | 210.44 | 187.04 | 191.85 | 206.80 | 195.23 |
| Mean | | 251.29 | 260.75 | 263.81 | | 222.89 | 226.84 | 232.24 | |
| **Treatments** | | **S1** | **S2** | **S3** | **Mean** | **S1** | **S2** | **S3** | **Mean** |
| N1 | | 304.10 | 315.38 | 300.73 | 306.74 | 249.61 | 254.13 | 252.75 | 252.16 |
| N2 | | 262.90 | 263.85 | 249.27 | 258.67 | 235.27 | 237.32 | 231.15 | 234.58 |
| N3 | | 185.08 | 232.90 | 213.35 | 210.44 | 183.09 | 209.20 | 193.40 | 195.23 |
| Mean | | 250.69 | 270.71 | 254.45 | | 222.66 | 233.55 | 225.77 | |
| **Treatments** | | **S1** | **S2** | **S3** | **Mean** | **S1** | **S2** | **S3** | **Mean** |
| M1 | | 239.26 | 254.97 | 259.64 | 251.29 | 220.57 | 225.61 | 222.51 | 222.89 |
| M2 | | 262.85 | 270.56 | 248.85 | 260.75 | 222.86 | 232.43 | 225.23 | 226.84 |
| M3 | | 249.96 | 286.60 | 254.86 | 263.81 | 224.54 | 242.61 | 229.56 | 232.24 |
| Mean | | 255.79 | 270.71 | 257.56 | | 222.66 | 233.55 | 225.77 | |
| **Treatments** | | **S1** | **S2** | **S3** | | **S1** | **S2** | **S3** | |
| N1 | M1 | 278.73 | 291.06 | 294.31 | | 236.13 | 238.66 | 246.03 | |
| | M2 | 301.46 | 310.16 | 277.60 | | 246.40 | 253.00 | 261.76 | |
| | M3 | 332.10 | 344.93 | 330.29 | | 266.30 | 270.66 | 250.46 | |
| N2 | M1 | 276.66 | 262.46 | 257.46 | | 238.33 | 249.60 | 236.20 | |
| | M2 | 263.96 | 258.03 | 250.93 | | 237.86 | 234.56 | 232.43 | |
| | M3 | 248.06 | 271.06 | 239.43 | | 229.63 | 227.80 | 224.83 | |
| N3 | M1 | 162.39 | 211.40 | 227.16 | | 187.26 | 188.56 | 185.30 | |
| | M2 | 223.13 | 243.50 | 218.03 | | 184.33 | 209.73 | 181.50 | |
| | M3 | 169.73 | 243.80 | 194.86 | | 177.70 | 229.30 | 213.40 | |
| **Comparing means** | | **S.Em+** | | **CD@5%** | | **S.Em+** | | **CD@5%** | |
| N | | 1.91 | | 5.43 | | 1.23 | | 3.51 | |
| M | | 1.91 | | 5.43 | | 1.23 | | 3.51 | |
| NM | | 3.31 | | 9.41 | | 2.14 | | 6.08 | |
| S | | 1.91 | | 5.43 | | 1.23 | | 3.51 | |
| NS | | 3.31 | | 9.41 | | 2.14 | | 6.08 | |
| MS | | 3.31 | | 9.41 | | 2.14 | | 6.08 | |
| NMS | | 5.74 | | 16.30 | | 3.71 | | 10.53 | |

| N-Nitrogen (kg ha-1) | Micronutrients (g l-1) | Salicylic acid (ppm) |
|---|---|---|
| Nitrogen 100% | Copper @ 5g | SA 50 ppm |
| Nitrogen 75% | Zinc @ 5g | SA 100 ppm |
| Nitrogen 50% | Copper and Zinc @ 5g each | SA 150 ppm |

**Table 7:** Influence of nutrients and salicylic acid on oil yield

| Pooled data on oil yield (kg ha-1) (2018-2020) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Treatments** | | **First cut** | | | | **Second cut** | | | |
| | | **M1** | **M2** | **M3** | **Mean** | **M1** | **M2** | **M3** | **Mean** |
| N1 | | 7.45 | 8.53 | 9.18 | 8.39 | 5.35 | 6.43 | 7.09 | 6.29 |
| N2 | | 6.62 | 7.13 | 7.56 | 7.10 | 4.60 | 5.13 | 5.18 | 4.97 |
| N3 | | 4.71 | 5.52 | 5.64 | 5.29 | 2.61 | 3.42 | 3.54 | 3.19 |
| Mean | | 6.26 | 7.06 | 7.46 | | 4.18 | 4.99 | 5.27 | |
| **Treatments** | | **S1** | **S2** | **S3** | **Mean** | **S1** | **S2** | **S3** | **Mean** |
| N1 | | 8.28 | 8.55 | 8.33 | 8.39 | 6.18 | 6.45 | 6.23 | 6.29 |
| N2 | | 7.00 | 7.15 | 7.16 | 7.10 | 4.60 | 5.15 | 5.16 | 4.97 |
| N3 | | 5.04 | 5.53 | 5.30 | 5.29 | 2.94 | 3.43 | 3.20 | 3.19 |
| Mean | | 6.77 | 7.08 | 6.93 | | 4.57 | 5.01 | 4.86 | |
| **Treatments** | | **S1** | **S2** | **S3** | **Mean** | **S1** | **S2** | **S3** | **Mean** |
| M1 | | 6.00 | 6.46 | 6.32 | 6.26 | 3.91 | 4.40 | 4.25 | 4.18 |
| M2 | | 6.84 | 7.04 | 7.30 | 7.06 | 4.77 | 4.97 | 5.23 | 4.99 |
| M3 | | 7.48 | 7.73 | 7.17 | 7.46 | 5.04 | 5.66 | 5.11 | 5.27 |
| Mean | | 6.77 | 7.08 | 6.93 | | 4.57 | 5.01 | 4.86 | |
| **Treatments** | | **S1** | **S2** | **S3** | | **S1** | **S2** | **S3** | |
| N1 | M1 | 7.50 | 7.80 | 7.06 | | 5.40 | 5.70 | 4.96 | |
| | M2 | 8.30 | 8.50 | 8.80 | | 6.20 | 6.40 | 6.70 | |
| | M3 | 9.06 | 9.36 | 6.13 | | 6.96 | 7.26 | 7.03 | |
| N2 | M1 | 6.46 | 6.63 | 6.76 | | 4.40 | 4.63 | 4.76 | |
| | M2 | 6.96 | 7.10 | 7.33 | | 4.96 | 5.10 | 5.33 | |
| | M3 | 7.56 | 7.73 | 7.40 | | 4 | 5.73 | 5.40 | |
| N3 | M1 | 4.03 | 4.96 | 5.13 | | 1.93 | 2.86 | 3.03 | |
| | M2 | 5.26 | 5.53 | 5.76 | | 3.16 | 3.43 | 3.66 | |
| | M3 | 5.83 | 6.10 | 5.00 | | 3.73 | 4.00 | 2.90 | |
| **Comparing means** | | **S.Em+** | | **CD @5%** | | **S.Em+** | | **CD @5%** | |
| N | | 0.02 | | 0.07 | | 0.02 | | 0.06 | |
| M | | 0.02 | | 0.07 | | 0.02 | | 0.06 | |
| NM | | 0.04 | | 0.12 | | 0.04 | | 0.11 | |
| S | | 0.02 | | 0.07 | | 0.02 | | 0.06 | |
| NS | | 0.04 | | 0.12 | | 0.04 | | 0.11 | |
| MS | | 0.04 | | 0.12 | | 0.04 | | 0.11 | |
| NMS | | 0.07 | | 0.20 | | 0.07 | | 0.20 | |

| **N-Nitrogen (kg ha-1)** | **Micronutrients (g l-1)** | **Salicylic acid (ppm)** |
|---|---|---|
| Nitrogen 100% | Copper @ 5g | SA 50 ppm |
| Nitrogen 75% | Zinc @ 5g | SA 100 ppm |
| Nitrogen 50% | Copper and Zinc @ 5g each | SA 150 ppm |

## Conclusion

From the present investigation it can be recommended that topdressing with 100% nitrogen with foliar spray of Copper and Zinc @ 5g each with SA 100ppm at 30 DAT and immediately after first harvest recorded the maximum herbage yield, essential oil recovery and essential oil yield $ha^{-1}$ in Ocimum.

## References


1. Aladakatti YR, Palled YB, Chetti MB, Halikatti SI, Alagundagi SC, Patil PL. Effect of nitrogen. phosphorus and potassium levels on growth and yield of stevia (*Stevia rebaudiana* Bertoni.). Karnataka journal of agricultural science 2012;25(1):25-29.
2. Chhibba M, Nayyar VK, Kanwar JS. Influence of Mode and Source of Applied Iron on Fenugreek (*Trigonella corniculata* L.). International Journal of Agriculture and Biology 2007;9(2):254-56.
3. Choudhary HD, Sharma SR, Jat RS, Jat G. Effect of soil and foliar application of Zinc and Iron on yield, quality and economics of Fennel. Annals of Plant and Soil Research 2015;17(2):200-03.
4. Choudhary MK, Kavita A, Maurya IB, Singh B, Sharma MK, Hatwal PK. Effect of biofertilizers and micronutrients on growth and yield of garlic (*Allium sativum* L.) var.'G-282'. Progressive Horticulture 2014;46(2):1-21.
5. Gajbhiye B, Momin YD, Puri AN. Effect of FYM and NPK fertilization on growth and quality parameters of lemongrass (*Cymbopogon flexuosus*). Agricultural Science Research Journals 2013;3(4):115-20.
6. Hartmann A, Fu H, Burris RH. Influence of amino acids on nitrogen fixation ability and growth of *Azospirillum* spp. Applied Environmental Microbiology 1981;54:87-93.
7. Hassan MRA, El-Naggar AHM, Shaban EH, Mohamed MEA. Effect of NPK and bio-fertilizers rates on the vegetative growth and oil yield of *Ocimum basillicum* L. plants. Alexendria Science Exchange Journal 2015;36:59-72.
8. Hayat S, Fariduddin Q, Ali B, Ahmad A. Effect of salicylic acid on growth and enzyme activities of wheat seedlings. Acta Agron Hung 2005;53:433-37.
9. Ingle VG, Thakre AU, Badhe SB, Khan MAH. Effect of foliar spray of auxins, micronutrients with urea on fruit drop and yield of chilli cv. CA 960. Punjab Rao Krishi Vidyapeeth Research Journal 1993;17:142-45.
10. Joshi NS, Varu DK, Barad AV, Pathk DM. Performance

of varieties and chemical fertilizers on growth and flowering in chrysanthemum. International Journal of Agricultural Sciences 2013;9(1):182-88.
11. Kumara R, Sharma S, Kaundal M, Sharma S, Thakura S. Response of damask rose (*Rosa damascena* Mill.) to foliar application of magnesium (Mg), copper (Cu) and zinc (Zn) sulphate under western Himalayas. Industrial Crops and Products 2016;83:596-02.
12. Khan AM, Ahmad I. Growth and flowering of *Gladiolus hortulans* L. cv. Wind Song as influenced by various levels of NPK. International Journal of Agriculture and Biology 2003;6(6):1037-39.
13. Laila K, Masum AS, Kond A, Shinya O. Foliar application of salicylic acid improved the growth. yield and leafs bioactive compounds in red amaranth *(Amaranthus tricolor* L.) Japan Texas Agri Life Research 2011;74:77-86.
14. Magnifico N, Talia MAC, Mininni M, Cordella S. Yield, uptake of N, P, K and leaf analysis of carnation cultivar 'Astor' with or without the application of water soluble fertilizers. Colture Protette 1986;14(3):47-54.
15. Manaa A, Gharbi E, Mimouni H, Wasti S, Aschi-Smiti S, Lutts S, Ben Ahmed H. Simultaneous application of salicylic acid and calcium improves salt tolerance in two contrasting tomato (*Solanum lycopersicum*) cultivars. South African Journal of Botany 2014;95:32-39.
16. Mehrab Y. Effects of micronutrients foliar application on essential oils of Lemon balm (*Melissa officinalis* L.). Advances in Environmental Biology 2014;8:1063-68.
17. Said-Al-Ahl HAH, Mahmoud AA. Effect of zinc and/or iron foliar application on growth and essential oil of sweet basil (*Ocimum basilicum* L.) under salt stress. Ozean Journal of Applied Sciences 2010;3(1):97-111.
18. Sathiyamurthy VA, Saraswathi T, Tamilselvi NA, Sobha TTK, Beaulah A, Rohini N, Arumugam T. Effect of salicylic acid on growth. yield and storage quality of onion (*Allium cepa* L.). International Journal of Current Microbiology and Applied Sciences 2017;4:78-86.
19. Shakirova MF, Sakhabutdinova AR, Bezrukova MV, Fathutdinova RA, Fathutdinova DR. Change in the hormonal status of wheat seedling induced by salicylic acid and salinity. Plant Science 2003;164(3):317-22.
20. Shams A, Shakouri MJ, Kapourchal SA, Aslanpour M. Effect of nitrogen and phosphorus fertilizers on yield of *Thymus daenensis* in dry condition. Indian Journal of Science and Technology 2012;5:1916-20.
21. Shormin T, Khan MAH, Alamgir M. Response of different levels of nitrogen fertilizer and water stress on the growth and yield of Japanese mint (*Mentha arvensis* L.). Bangladesh Journal of Scientific and Industrial Research 2009;44(1):137-45.
22. Singh Y, Verma P, Verma JP. Effect of NPK, spacing and MH on floweryield of African marigold (*Tagetes erecta* L.) cv. Pusa Nagangi Gainda. Annals of Horticulture 2008;1(1):27-31.
23. Srivastava NK, Misra A, Sharma S. Effect of zinc deficiency on net photosynthetic rate, 14C partition, and oil accumulation in leaves of peppermint. Photo Synthetica 1997;33(1):71-79.
24. Sumathi M, Shashekal SG, Shankaraiah N, Ravi Kumar P, Kavitha V. Effect of nitrogen and VAM levels on herbage and oil yield of patchouli (*Pogostemon patchouli* Pettle.). International Journal of Advanced Biological Research 2012;2(3):403-11.