

**EFFECT OF FOLIAR SPRAY OF MICRONUTRIENTS  
ON GROWTH, YIELD AND QUALITY OF  
POMEGRANATE (cv. BHAGWA) UNDER CENTRAL  
DRY ZONE OF KARNATAKA**

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**AUGUST, 2015**

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**FRUIT SCIENCE**

By

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**AUGUST, 2015**

**AFFECTIONATELY DEDICATED**

**TO**

**MY EVER LOVING PARENTS,**

**BROTHER AND SISTER**

**DEPARTMENT OF FRUIT SCIENCE**  
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**CERTIFICATE**

This is to certify that the thesis entitled “EFFECT OF FOLIAR SPRAY OF MICRONUTRIENTS ON GROWTH, YIELD AND QUALITY OF POMEGRANATE (cv. BHAGWA) UNDER CENTRAL DRY ZONE OF KARNATAKA” submitted in partial fulfillment of the requirement for the award of degree of **MASTER OF SCIENCE (Horticulture)** in **FRUIT SCIENCE** to the University of Agricultural and Horticultural Sciences, Shivamogga is a record of *bonafide* research work carried out by **Mr. SANTHOSH, P.V.** ID.No. **MH2TAC013** under my guidance and supervision and that no part of the thesis has been submitted for the award of any degree, diploma, associateship, fellowship or any other similar titles.

**MUDIGERE**  
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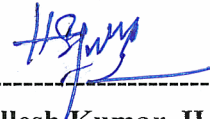
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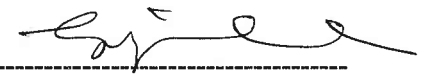
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MUDIGERE

AUGUST, 2015

*Santhosh P.V.*  
**(SANTHOSH P.V.)**

**EFFECT OF FOLIAR SPRAY OF MICRONUTRIENTS ON GROWTH,  
YIELD AND QUALITY OF POMEGRANATE (cv. BHAGWA) UNDER  
CENTRAL DRY ZONE OF KARNATAKA**

**SANTHOSH, P. V. (MH2TAC013)**

**ABSTRACT**

A field experiment was conducted in the farmer's field of Alur village, Hiriyur taluk of Chitradurga district on pomegranate cv. Bhagwa during 2014-15 to study the 'Effect of foliar spray of micronutrients on growth, yield and quality of pomegranate cv. Bhagwa under central dry zone of Karnataka' in Hasth bahar season. The experiment was laid out in randomized block design with 12 treatments replicated thrice. Among the different treatments the foliar spray of Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1% (T<sub>11</sub>) has recorded the highest fruit volume (255.00 ml), fruit diameter (9.64 cm), fruit weight (292.67 g), number of fruits per tree (61.00), yield per tree (17.77 kg) and yield per hectare (15.98 tonnes) and with respect to quality parameters high TSS (15.23 °Brix), lower titratable acidity (0.33 %), higher TSS/TA ratio (46.17), reducing sugar (12.71 %) and total sugars (14.65 %) compared to control which recorded lower yield (13.10 kg) and yield parameters. The foliar spray of Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1% (T<sub>11</sub>) has also registered better quality parameters such as maximum fruit firmness (81.98 Newton), peel thickness (3.66 mm), lowest physiological loss in weight (12.88 %) and maximum shelf life (30.33 days), whereas highest physiological loss in weight (18.98 %) and minimum shelf life (19.67 days) was recorded in control. It has also registered the maximum cost: benefit ratio (3.95) compared to control.

AUGUST, 2015

Department of Fruit Science  
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Major advisor

**Dr. B. S. Shivakumara**

ಕರ್ನಾಟಕದ ಮಧ್ಯ ಒಣ ವಲಯದಲ್ಲಿ ದಾಳಿಂಚೆ ಬೆಳೆಯ ಬೆಳವಣಿಗೆ, ಇಳುವರಿ ಮತ್ತು  
ಗುಣಮಟ್ಟದ ನಿಯತಾಂಕಗಳ ಮೇಲೆ ಲಘು ಪೋಷಕಾಂಶಗಳ ಸಿಂಪರಣೆಯ ಪರಿಣಾಮ

ಸಂತೋಷ್, ಪಿ. ವಿ. (MH2TAC013)

### ಸಾರಾಂಶ

೨೦೧೪ - ೧೫ ನೇ ಸಾಲಿನಲ್ಲಿ ಚಿತ್ರಧುರ್ಗ ಜಿಲ್ಲೆಯ ಹಿರಿಯೂರು ತಾಲ್ಲೂಕು ಆಲೂರು ಗ್ರಾಮದಲ್ಲಿ ದಾಳಿಂಚೆ (ಭಾಗ್ಯ) ತಾಕಿನಲ್ಲಿ ಬೆಳವಣಿಗೆ, ಹಣ್ಣುಗಳ ಇಳುವರಿ ಮತ್ತು ಗುಣಮಟ್ಟದ ನಿಯತಾಂಕಗಳ ಮೇಲೆ ಲಘು ಪೋಷಕಾಂಶಗಳ ಸಿಂಪರಣೆ ಮಾಡುವುದರಿಂದಾಗುವ ಪರಿಣಾಮದ ಬಗ್ಗೆ ಅಧ್ಯಯನ ಮಾಡಲು ಒಂದು ಕ್ಷೇತ್ರ ಪ್ರಯೋಗ ಕೈಗೊಳ್ಳಲಾಯಿತು. ಈ ಸಂಶೋಧನೆಯಲ್ಲಿ ಐದು ರೀತಿಯ ಲಘು ಪೋಷಕಾಂಶಗಳನ್ನು (ಬೋರಾಕ್ಸ್, ಮ್ಯಾಂಗನೀಸ್ ಸಲ್ಫೇಟ್, ಜಿಂಕ್ ಸಲ್ಫೇಟ್, ಐರನ್ ಸಲ್ಫೇಟ್, ಸೋಡಿಯಂ ಮೊಲಿಬ್ಡೇಟ್ ಹಾಗೂ ಇವೆಲ್ಲದರ ಮಿಶ್ರಣ) ಬಳಸಲಾಯಿತು. ವಿವಿಧ ಲಘು ಪೋಷಕಾಂಶಗಳ ವೈಕಿ, ಬೋರಾಕ್ಸ್ 0.೧ % + ಮ್ಯಾಂಗನೀಸ್ ಸಲ್ಫೇಟ್ 0.೨೫ % + ಜಿಂಕ್ ಸಲ್ಫೇಟ್ 0.೫ % + ಐರನ್ ಸಲ್ಫೇಟ್ 0.೫ % + ಸೋಡಿಯಂ ಮೊಲಿಬ್ಡೇಟ್ 0.೧ % ಬಳಸಿದಾಗ ದಾಳಿಂಚೆ ಹಣ್ಣಿನಲ್ಲಿ ಗರಿಷ್ಠ ಗಾತ್ರ (೨೫೫.00 ಮಿಲಿ), ಹಣ್ಣಿನ ವ್ಯಾಸ (೯.೬೪ ಸೆಂ. ಮೀ.), ಹಣ್ಣಿನ ತೂಕ (೨೯೨.೬೭ ಗ್ರಾಂ), ಹಣ್ಣಿನ ಸಂಖ್ಯೆ (೬೧.00), ಹಣ್ಣಿನ ಇಳುವರಿ ಪ್ರತಿ ಮರಕ್ಕೆ (೧೭.೭೭ ಕೆ. ಜಿ) ಹಾಗೂ ಪ್ರತಿ ಹೆಕ್ಟೇರ್ಗೆ (೧೫.೯೮ ಟ / ಹೆ) ದಾಖಲಾಗಿದೆ, ಮತ್ತು ಇದೇ ಉಪಚಾರಗಳಲ್ಲಿ ಗುಣಮಟ್ಟದ ಅಂಶಗಳಾದ ಗರಿಷ್ಠ ಟಿಎಸ್ಎಸ್ (೧೫.೨೩ 'ಬ್ರಿಕ್ಸ್), ಕಡಿಮೆ ಪಥಕ್ರಮಗೊಳಿಸಬಲ್ಲ ಆಮ್ಲ (೦.೩೩ ಶೇ), ಗರಿಷ್ಠ ಟಿಎಸ್ಎಸ್ ಆಮ್ಲ ಅನುಪಾತ (೪೬.೧೭) ಮತ್ತು ಒಟ್ಟು ಸಕ್ಕರೆಯ ಅಂಶ (ಶೇ. ೧೪.೬೫) ದಾಖಲಾಗಿದೆ. ಆದರೆ ಕಡಿಮೆ ಹಣ್ಣಿನ ಇಳುವರಿ (೧೩.೧೦ ಕೆ. ಜಿ) ಮತ್ತು ಇಳುವರಿಯ ನಿಯತಾಂಕಗಳನ್ನು ಸಿಂಪರಣೆ ಮಾಡದೆ ಇರುವ ಚಿಕಿತ್ಸೆಯಲ್ಲಿ ಗುರುತಿಸಲಾಗಿದೆ. ಬೋರಾಕ್ಸ್ 0.೧ % + ಮ್ಯಾಂಗನೀಸ್ ಸಲ್ಫೇಟ್ 0.೨೫ % + ಜಿಂಕ್ ಸಲ್ಫೇಟ್ ೦.೫ % + ಐರನ್ ಸಲ್ಫೇಟ್ 0.೫ % + ಸೋಡಿಯಂ ಮೊಲಿಬ್ಡೇಟ್ 0.೧ % ಸಿಂಪರಣೆ ಮಾಡುವುದರಿಂದ ಕಡಿಮೆ ತೂಕದ ನಷ್ಟ (ಶೇ. ೧೨.೮೮) ಮತ್ತು ಧೀರ್ಘಕಾಲಿಕ ಶೇಕರಣಾ ಅವಧಿಯು (೩೦.೩೩ ದಿನಗಳು) ಹಾಗೂ ವೆಚ್ಚ: ಪ್ರಯೋಜನದ ಅನುಪಾತ (೩.೯೫) ಕಂಡುಬಂದಿದೆ. ಆದರೆ ಗರಿಷ್ಠ ತೂಕದ ನಷ್ಟ (ಶೇ. ೧೮.೯೮) ಮತ್ತು ಕಡಿಮೆ ಶೇಕರಣಾ ಅವಧಿಯು (೧೯.೬೭ ದಿನಗಳು) ಸಿಂಪರಣೆ ಮಾಡದೆ ಇರುವ ಚಿಕಿತ್ಸೆಯಲ್ಲಿ ಗುರುತಿಸಲಾಗಿದೆ.

ಆಗಸ್ಟ್, ೨೦೧೫

ಹಣ್ಣು ಶಾಸ್ತ್ರ ವಿಭಾಗ

ತೋಟಗಾರಿಕಾ ಮಹಾವಿದ್ಯಾಲಯ, ಮೂಡಿಗೆರೆ

  
ಮುಖ್ಯ ಸಲಹೆಗಾರರು

ಡಾ. ಬಿ. ಎಸ್. ಶಿವಕುಮಾರ

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# **INTRODUCTION**

## I INTRODUCTION

Pomegranate (*Punica granatum* L.) belongs to family Punicaceae, regarded as 'fruit of paradise', an ancient favorite fruit of tropical and sub-tropical regions of the world. The fruit is symbolic of 'plenty' and also referred as seed apple. The fruit rind, seeds and pulp comprises of rich medicinal properties. The fruit juice contains tannin (ilagic acid), anthocyanin, polyphenolic and antioxidants A, E and C which plays major role in maintenance of heart blood vessels and proper blood circulation. The punicologin content of juice brings down the octarial flakes of blood and there by controls the blood pressure. It also minimizes the risks of arthritis, alzamir cancer, piles and fistula, stomach ache, decency, diarrhoea and constipation problems in human beings. Among the nutritional aspects pomegranate is a rich source of carbohydrate (14.5%), protein (1.6%), calcium (10mg/100g), phosphorus (70 mg/ 100g), iron (0.3 mg/100g) and vitamin C (65 mg/100 g), besides its calorific value of 65Kcals/100g. Hence this fruit is referred as 'Elixir of life' (Patil and Manjunath, 2014).

Present global pomegranate consumption ranks 18<sup>th</sup> place annually and expected to move on to 10<sup>th</sup> place within the decade in view of its innumerable nutraceutical importance. India ranks first in pomegranate acreage and is the leading pomegranate producer, with nearly 50 percent of world's production. The total area under cultivation of pomegranate in India is 113.20 thousand hectare with a production of 745.00 thousand tonnes and productivity of 6.6 MT/ hectare. Among the states Maharashtra is the leading pomegranate producer followed by Karnataka, Andhra Pradesh, Gujarat and Tamil Nadu. In Karnataka, pomegranate is commercially cultivated in Vijayapur, Belgaum, Koppal, Chitradurga, Bagalkot and Tumkur districts.

Pomegranate production is governed by several factors like climate, soil and irrigation status, varieties, pest and disease situation and nutritional status of soil as well as plant. Deficiency of various nutrients causes drastic reduction in growth, yield and quality of pomegranate. Among the nutrients, micronutrients though require in small quantities their importance in growth, yield and quality of pomegranate is quite essential.

Plant roots are unable to absorb these micronutrients adequately from the dry top soil, therefore foliar application for better results deserves attention.

The requirement of micronutrients (boron, iron, copper, zinc, manganese, chloride and molybdenum) is quite essential in plant metabolism and imparting quality to the fruits of pomegranate is remarkable. Similar trend can be observed in many horticultural crops (Raja, 2009).

Zinc is very much involved in chlorophyll synthesis, water regulation and energy metabolism in plants. It is also required for the maintenance of auxin in an active state for its involvement in the synthesis of tryptophan and structural integrity of ribosome. Accumulation of soluble nitrogen compounds, such as amino acids, amides and hindering the nitrogen metabolism in plants is the major striking character of zinc deficiency (Chundawat, 1997).

The requirement of boron in the fertilization process is quite important during blossoming stage in view of its role of the reproductive organs (anthers, style, stigma and ovary), pollen germination and growth of pollen tube. Boron is also plays important role in cell division in the meristematic tissues of growing points and cambial activity. Boron also plays an important role in flowering, fruit setting and seed formation.

Iron is involved in the production of chlorophyll besides being a component of many enzymes associated with energy transfer, nitrogen reduction, nitrogen fixation and cytochromes (iron containing electron carriers) and flavo enzymes.

Manganese is also a prominent component of chloroplasts and particularly involved in Hill's reaction of photosynthesis. It also involved in the activation of numerous enzymes concerned with the carbohydrate metabolism, phosphorylation reactions and citric acid cycle apart from respiration and nitrogen metabolism in plants.

Molybdenum is involved in enzyme systems relating to nitrogen fixation, nitrogen metabolism and protein synthesis. It also acts as an activator of some dehydrogenases and phosphatases and as cofactor in the synthesis of ascorbic acid.

Foliar application of micronutrients is found to be effective 6 to 20 times than that of soil application (Anees *et al.*, 2011). Various experiments have been conducted earlier on foliar spray of micronutrients in different fruit crops have shown significant response to improve yield and quality of fruits crops (Kumar and Verma, 2004). Micronutrients like (zinc, boron, manganese, iron and molybdenum) has got direct impact on fruit shape and colour, aril colour, quality of juice in coloured varieties of pomegranate cv. Bhagwa which is the only variety having export potentiality. In view of this present experiment “Effect of foliar spray of micronutrients on growth, yield and quality of pomegranate (cv. Bhagwa) under central dry zone of Karnataka” has been designed with the following objectives.

- 1) To study the effect of micronutrients on growth and yield of pomegranate.
- 2) To study the effect of micronutrients on quality and post harvest traits.
- 3) To workout the economics.

# **REVIEW OF LITERATURE**

## II REVIEW OF LITERATURE

Pomegranate is one of the important fruit crop grown in tropical and sub-tropical regions. Supply of nutrients at critical growth stages of plant is very important to attain proper growth, yield and quality of pomegranate. The micronutrient deficiencies in fruit crops has increased markedly in recent years due to intensive cropping system, soil erosion and use of marginal lands for crop production. The supplementing of different micronutrients especially zinc, boron, iron, manganese and molybdenum through foliar application responds quickly and there by helps to minimize the deficiency symptoms resulting in improved growth, yield and quality of pomegranate.

Different micronutrients role is quite important in obtaining in quality fruits of which boron can benefit vegetative growth, fertilization process, fruit set, sugar transportation and resistance to disease infestation, also zinc play an important role in the photosynthesis, protein synthesis, nitrogen metabolism and role in enzyme system. Iron is another element which involves in the production of chlorophyll and is also a component of many enzymes associated with energy transfer, nitrogen reduction and fixation. The importance of manganese is necessary in photosynthesis (Hill's reaction), nitrogen metabolism and carbohydrate metabolism. The association of molybdenum in enzyme systems relating to nitrogen fixation, nitrogen metabolism and protein synthesis is equally important in deciding growth and development of crop.

The research on foliar application of micronutrients on pomegranate production is very limited hence the work done on other fruit crops in the similar aspects has been reviewed in this chapter.

### **2.1 The effect of micronutrients on growth and yield of fruit crops**

#### **2.1.1 Pomegranate**

Khorsandi *et al.* (2009) reported that application of zinc (0.4%) increased the phytoestrogen content of the seed. The foliar fertigation of zinc improves marketable fruit yield and quality attributes of pomegranate and the zinc concentration in leaf and fruit juice content in all cultivars.

Hasani *et al.* (2012) reported that foliar spray of manganese and zinc had positive significant effects on the fruit yield (8.1 kg/tree), Weight of 100 arils (33.5 g), fruit diameter (8.20 cm) and leaf area (592.4 mm<sup>2</sup>).

Eaida *et al.* (2013) reported that 60 mg/l manganese with 3% zinc has recorded the highest fruit set (50.55%), fruit weight (187.97g) in the first and second season respectively.

### **2.1.2 Mango**

Dutta (2004) revealed that 4000 ppm of boric acid was significantly increases the panicle length (29.15cm), per cent of hermaphrodite flowers (30.85%) and 500 ppm of boric acid was significantly increases the fruit weight of mango (280g).

Nehete *et al.* (2011) revealed that ZnSO<sub>4</sub> 1% +FeSO<sub>4</sub> 1% +Borax 0.5% significantly increased the number of fruits per tree (168.00), average fruit weight (0.295 kg) and yield per tree (49.54 kg) in cv. Kesar

Bhatt *et al.* (2012) reported that foliar application of potassium, calcium, zinc and boron enhanced yield of mango. The results revealed that the trees sprayed with 0.5% borax showed maximum fruit yield (28.52 kg/tree), fruit weight (167.29 g), fruit volume (164.52 ml).

### **2.1.3 Banana**

Combination of foliar sprays with ZnSO<sub>4</sub> (0.5 %), FeSO<sub>4</sub> (0.2 %), CuSO<sub>4</sub> (0.2 %) and H<sub>3</sub>BO<sub>3</sub> (0.1 %) at three, five and seven months after planting on growth and yield of cv. Robusta has resulted in (30 kg) bunch weight (Kumar and Jeyakumar, 2002).

Two sprays of micronutrient mixture 1 % (zinc + boron + iron) to the leaves on both the sides just before flowering by using a hand sprayer resulted in the early maturity (106 days), maximum length (21.95 cm) and girth (16.20 cm) of finger in cv. Ardhapuri (Yadlode and Kadam, 2008a).

Foliar application of micronutrients mixture 1% (zinc + boron + iron) affected on weight of mature finger (145.30 g), maximum length (21.90 cm) and girth (15.50 cm) of fingers, weight of ripe finger (137.49 g), in cv. Grand Naine (Yadlod and Kadam, 2008b).

Jeyabaskaran and Pandey (2008) reported that the soil applied with iron influenced the bunch weight (16.3kg) more than the foliar spray, but the foliar sprayed zinc or boron was more effective in increasing bunch weights (16.3kg), pseudostem girth (101cm), total number of leaves (35), leaf length (132.2cm), leaf breadth (67.80cm) total leaf area (14.6m<sup>2</sup>), total number of fingers (242) and total number of hands (15.00) than soil applied zinc or boron.

Foliar application of ZnSO<sub>4</sub> (0.5 %), FeSO<sub>4</sub> (0.2 %), CuSO<sub>4</sub> (0.2 %) and borax (0.1 %) at 3<sup>rd</sup>, 5<sup>th</sup> and 7<sup>th</sup> month after planting is recommended to get higher yield (40.75 t/ha) in banana (Thangaselvabai *et al.*, 2009).

The maximum weight of mature finger (178.75 g), ripe finger (170.50 g) was found with two sprays of 1.0 per cent micronutrient mixture (zinc + boron + iron) which were significantly superior over all the treatments in cv. Ardhapuri (Yadlod and Kadam, 2009).

Yadlod *et al.* (2009) reported that the maximum weight of mature finger (185.60 g) was found in two sprays of micronutrient mixtures 1 % (zinc + boron + iron) followed by one spray micronutrient mixture (180.82 g). It was found that application of IAA 80 ppm, GA<sub>3</sub> 80 ppm and two sprays of micronutrient mixtures (1 %) were effective for physical characters of cv. Shrimanti.

Yadav *et al.* (2009) reported that the nutritional status of leaf were significantly influenced by the various treatments of micronutrients consistently, the higher nitrogen content (3.09%), potassium content (2.98%), boron content (28.00ppm), zinc (25.32ppm) iron content (22.00 ppm) and copper content (13.31 ppm) were observed in banana leaf in plant treated with chelated iron with common application of MnSO<sub>4</sub>, CuSO<sub>4</sub>, and borax.

Patel *et al.* (2010) reported that the foliar application of ZnSO<sub>4</sub> (0.5 %) + FeSO<sub>4</sub> (0.5 %) recorded the maximum values for bunch weight (23.85 kg), bunch length (93.50 cm), bunch girth (114 cm), number of hands per bunch (11.70) and yield (149.078 t/ha) of cv. Basrai.

The combined application of FeSO<sub>4</sub> (0.5 %) + ZnSO<sub>4</sub> (0.5 %) at three, five and seven month after planting of suckers in cv. Martaman recorded the maximum bunch weight (16.30 kg), hands (9.21/bunch), number of fingers (129.21/bunch), yield (40.75 t/ha), finger length (14.80 cm), finger breadth (13.10 cm) and days to ripening (8.1 days), (Pathak *et al.*, 2011).

#### **2.1.4 Grapes**

Sindhu *et al.* (1999) observed that in grapes, the maximum bunch weight (300g) and yield (25 t/ha) were found in vines which received 1.5 per cent urea and 0.5 per cent spray ZnSO<sub>4</sub>, respectively.

Rana and Sharma (1999) revealed that the growth, yield, weight of cluster, volume of cluster, weight of berry and volume of berry were increased with 0.05 per cent of FeSO<sub>4</sub> spray in grapes.

Prabhu and Singaram (2001) revealed that the combined foliar application of ZnSO<sub>4</sub> (0.5 %) and borax (0.2 %) increased the weight of cluster (245 g/cluster), volume of cluster (173 ml) and weight of berry (3.01 g) in cv. Muscat.

Janaki *et al.* (2002) revealed that the combined application of 2.0 kg boron plus 0.2 per cent foliar spray registered the maximum yield of 24.6 tons per hectare in winter and 26.15 tons per hectare in summer season.

Subramoniam *et al.* (2006) reported that recommended dose of N, P and K fertilizer along with foliar spray ZnSO<sub>4</sub> (0.2%) + boric acid (0.2%) + FeSO<sub>4</sub> (0.2%) + MnSO<sub>4</sub> (0.2%) + MgSO<sub>4</sub> (0.2%) + CaCl<sub>2</sub> (0.5%) + KNO<sub>3</sub> (0.5%) + urea (1%) at blooming and 15 days after blooming stages was best in grapes variety Thompson

Seedless. Application of NPK + micronutrient recorded the fresh fruit weight (20.20 t/ha), bunch weight (605.37g), number of berries per bunch (238.00).

### 2.1.5 Citrus

Manna *et al.* (1985) reported that application of zinc along with other micronutrients was less effective in increasing zinc concentration of the leaves as compared to foliar application of zinc alone. The foliar application of micronutrients did not affect the level of N, P and K in the leaves of sweet orange cv. Blood Red. None of the treatments was able to affect fruit yield significantly.

Monga and Josan (2000) revealed that the micronutrient sprays increased the concentration of respective micronutrient without affecting the level of N, P, and K in the leaves. However, the increase in zinc content was more when sprayed with zinc alone rather than in combination with iron and manganese. Fruit yield was maximum under zinc sulphate (0.3%) in Kinnow mandarin.

Ram and Bose (2000) reported that effect of foliar application of magnesium and micronutrients on growth and yield of mandarin orange (*Citrus reticulata* Blanco). The plants treated with magnesium (2%) with combination of copper (0.4%), zinc (0.5%), boron (0.1%), iron (0.25%) produced the maximum number of fruits (442/plant).

Dhinesh and Yadav (2005) reported that maximum number of fruits (380/plant) was recorded from the mandarin trees sprayed with zinc and manganese, whereas minimum (335/plant) was recorded in control and the highest productivity was also recorded with zinc and manganese spray.

Tariq *et al.* (2007) obtained the maximum fruit yield when the citrus cv. Blood red was foliar sprayed with zinc  $0.4 \text{ kg ha}^{-1}$ , magnesium  $0.2 \text{ kg ha}^{-1}$  and boron  $0.04 \text{ kg ha}^{-1}$  along with nitrogen  $1.56 \text{ kg ha}^{-1}$  and surfactant  $0.4 \text{ kg ha}^{-1}$  in 400 litre of water. Minimum per cent peel was obtained with boron alone and maximum fruit size and maximum zinc content in leaf was recorded with zinc + boron combination, maximum fruit volume with zinc + manganese.

Dhinesh *et al.* (2007) revealed that the number of fruits per tree varied significantly and ranged from 126.25 to 246.00. The maximum number of fruit (246.00) was recorded from the trees sprayed with zinc and manganese whereas minimum (126.25) from control. Maximum fruit weight (140.05g), fruit volume (154.50ml) and fruit length (62.40mm) were recorded from the trees sprayed with magnesium (0.5%), zinc (0.5%) and manganese (0.5%) in Kinnow mandarin.

Khurshid and Khattak (2008) revealed that application of micronutrients significantly increased zinc, iron, manganese and copper concentrations in leaves, compared with control. Zinc treatments significantly increased yield (90.02 kg/tree).

Sajida *et al.* (2010) reported that the maximum fruit yield per tree was obtained with high concentration of zinc (1.0%) and low concentrations of boron (0.02%) were applied to the plants of sweet orange cv. Blood orange. The low concentration of Zn (0.5%) and high concentration of B (0.04%) were positively reduced the per cent dieback, per cent chlorosis and per cent rosette per tree.

Ashraf *et al.* (2013) reported that the foliar application of 2, 4-D (10mg/lit), salicylic acid (10mg/lit), potassium (0.25%) and zinc (0.25%) significantly increase the fruit weight, number of fruits per plant and reducing the fruit drop.

### **2.1.6 Guava**

Bhatia *et al.* (2001) reported the effect of micronutrients on cv. L-49 with K<sub>2</sub>SO<sub>4</sub> (0.5, 1.0 and 1.5 %), ZnSO<sub>4</sub> (0.5, 0.75 and 1.0 %), H<sub>3</sub>BO<sub>3</sub> (0.3, 0.5 and 1.0 %) and water (control). The increased fruit weight and the yield (73.0 kg/tree) were observed in the treatment with H<sub>3</sub>BO<sub>3</sub> at 1.0 per cent.

The maximum fruit retention (57.27 %), fruit length (6.07 cm), fruit width (5.92 cm), fruit weight (98.48 g) and fruit yield (48.63 kg/tree) were recorded with foliar application of borax (0.4 %) followed by zinc sulphate (0.8%) in cv. L-49 (Yadav *et al.*, 2011).

Goswami *et al.* (2012) reported that the effect of pre-harvest application of micronutrients on yield of cv. Sardar and observed the size of the fruit comprises length, diameter and volume were maximum under fruits collected from trees sprayed with zinc sulphate (0.4%). The maximum fruit weight was observed under boric acid (0.4%) and it was at par with zinc sulphate at (0.4%).

### **2.1.7 Sapota**

Saraswathy *et al.* (2004) indicated that, the sapota trees supplied with zinc sulphate 50 g and borax 25 g per tree (soil) and two foliar sprays of zinc sulphate at 0.5 per cent and borax at 0.3 per cent registered the highest value for growth and yield parameters. With the application of borax or zinc sulphate, single or in combination, resulted in remarkable improvement in yield of sapota with the treatment having nutrient combinations with zinc sulphate at 50 g + borax at 25 g per tree, borax at 0.3 per cent with zinc sulphate at 0.05 per cent over the control.

### **2.1.8 Papaya**

Jeyakumar *et al.* (2002) reported the influence of foliar application of zinc and boron on fruit yield in cv. Co-5. Staggered applications of zinc sulphate (0.5 %) in combination with borax (0.1 %) at four and eight months after planting found to increase in plant growth and fruit yield (38 kg/plant).

Singh *et al.* (2008) revealed that the micronutrients application of borax at 0.05%+ zinc sulphate at 0.25% was considered as the best which caused the maximum fruit yield (37.20 kg/ plant) in cv. Ranchi.

Shekar *et al.* (2010) reported that maximum plant height (2.21m), plant girth (29.77cm), fruit length (25cm), fruit width (13.17cm) and fruit yield (40.4 kg/plant) in papaya were recorded with the foliar application of copper sulphate 0.25 per cent, manganese sulphate 0.25 per cent along with borax 0.1 per cent.

### **2.1.9 Ber**

Kamble *et al.* (1994) concluded that foliar applications of iron, zinc, manganese, and boron increased the fruit weight and yield on ber. Applications of zinc sulphate (0.4 %), iron sulphate (0.4 %) and boric acid (0.2 %) gave the best results when sprayed in August or September, whereas in the July or October applications were found less effective.

Deepa *et al.* (2008) reported the effect of micronutrient sprays on fruit yield in cv. Umran. The maximum yield (94.5 kg/tree) was recorded with application of 0.4% zinc sulphate, while minimum yield (62.25 kg/tree) was recorded with control.

Meena *et al.* (2008) reported that the foliar application of ferrous sulphate (0.9 %) at pea nut stage produced maximum average fruit weight (32.70 g), fruit length (5.03 cm), fruit breadth (3.52 cm), pulp weight (30.74 g), stone weight (1.96 g), pulp to stone ratio (15.69) and fruit yield (99.17 kg tree) followed by 0.3, 0.6 per cent spray and lowest was recorded in control in cv. Gola.

Dayal *et al.* (2010) reported that effect of nitrogen, phosphorus and zinc on growth and yield of cv. Gola under arid and semi- arid conditions. The maximum fruit length (3.13cm), fruit diameter (3.18cm), fruit weight (21.55g), fruit volume (20.67ml) and yield of fruits (38.05 kg/tree) were recorded in foliar application of 0.6% zinc sulphate, whereas minimum values were found under control.

Kumar and Shukla (2010) reported maximum fruit set (7.7%), minimum fruit drop (20.8%) and maximum fruit yield (7.29 t/ha) with foliar spray of 0.6% borax and 0.4% zinc sulphate combination.

### **2.1.10 Datepalm**

The results indicated that the boric acid 1500 ppm increased yield in terms of pulp weight (0.996g), pulp to seed ratio (0.989), fruit length (1cm) and diameter of the fruits (1cm) in cv. 'Shahany' (Khayyat *et al.*, 2007).

### **2.1.11 Aonla**

Khan *et al.* (2009) reported in aonla that the maximum fruit retention, yield, size, weight and volume of fruits were obtained with foliar application of ZnSo<sub>4</sub> (0.5%) + Thiourea (0.1%), closely followed by borax (0.25%) + thiourea (0.1%).

Singh *et al.* (2012) reported the minimum fruit drop (56.84 and 50.22%), maximum length of fruit (4.01 and 4.10cm), breadth (4.31 and 4.35 cm), weight (46.85 and 47.34g) and pulp content (44.66 and 45.16g) were obtained under the foliar spray of zinc at 0.6%. Zinc at its higher concentrations proved the best treatment in improving the yield of cv. Banarasi.

### **2.1.12 Litchi**

Saraswat *et al.* (2006) reported that the maximum number of inflorescence per tree (414.00), along with maximum fruit set per panicle (238.00) were recorded from the treatment combination of NAA at 20ppm and zinc sulphate at 0.6%. Maximum fruit retention (7.43%), bigger size fruits (3.99cm) and highest yield (143.41kg/plant) in the litchi fruits was also observed in that treatment.

Pathak and Mitra (2008) reported the effect of phosphorous, potassium, sulphur, zinc and boron on litchi. Plant receiving 400g P<sub>2</sub>O<sub>5</sub>, 700g K<sub>2</sub>O and 7g boron per plant per year showed the maximum yield (74.52 kg/plant) and aril weight (14.90g) per fruit.

### **2.1.13 Peach**

Yadav *et al.* (2013) reported that foliar application of 0.1% H<sub>3</sub>Bo<sub>3</sub>, ZnSo<sub>4</sub> 0.5% and FeSo<sub>4</sub> 0.5% was found promising in terms of fruit length (5.59cm), fruit diameter (5.08cm), fruit volume (44.57ml), firmness (12.3lb/inch). Further this treatment was also found best in maximum fruit retention (74.14%), average fruit weight (51.60g) as well as fruit yield (25.39kg/tree) in cv. Sharabat.

### **2.1.14 Pineapple**

Kar *et al.* (2002) reported that the foliar application of zinc 0.6% induced maximum fruit weight (2.29 kg) followed by zinc at 0.4% (2.07 kg). Zinc and boron at various levels as well as their combinations also significantly increased the size of fruit, followed by length and breadth. The pulp weight, peel weight and pulp to peel ratio were significantly increased with treatments of zinc at 0.6% followed by zinc 0.4% levels.

### **2.1.15 Plum**

Hassan *et al.* (2010) revealed that the effect of foliar spray with Aminofert (20% amino acids, 12% organic acids, and 3.6% chelated micro-elements), gibberellins and a mixture of chelated (iron, zinc and manganese) alone or in combination (GA3 + Aminofert or GA3 + a mixture of chelated iron, zinc and manganese) on fruit set (8.53%), yield (142kg/tree) as well as fruit characteristics such as fruit thickness (1.86cm), fruit weight (54.40g), fruit size (56.47cm<sup>3</sup>), polar diameter (4.60cm), Equatorial diameter (4.46cm), number of fruits per tree (2544) and zinc (50ppm), manganese (48.00ppm) and iron (99.00 pm) content present in leaf 'Hollywood' plum trees.

## **2.2 The effect of micronutrients on quality and post-harvest traits of fruit crops**

### **2.2.1 Pomegranate**

Khorsandi *et al.* (2009) reported that application of zinc (0.4%) increased the phytoestrogen content of the seed. The foliar fertigation of zinc improves marketable fruit yield and quality attributes of pomegranate and increased the zinc concentration in leaf and fruit juice content in all cultivars.

Hasani *et al.* (2012) reported that effects of zinc and manganese as foliar spray on pomegranate fruit quality. Foliar spray of manganese and zinc had positive significant effects on the aril per peel ratio (1.88%), TSS (15.73<sup>0</sup> Brix), juice content of arils (68.2%), anthocyanin index (0.328).

Mir *et al.* (2012) reported that the foliar application of zinc, manganese and boron proved the superior with respect to biochemical characters particularly total soluble solids (15.85 °Brix), total sugars (9.78 %), ascorbic acid (13.48 mg/100ml) and anthocyanin content (20.36 mg/ 100ml) in pomegranate fruits.

### **2.2.2 Mango**

Dutta (2004) revealed that 500 ppm of boric acid was significantly increases the TSS (18.8%), total sugar (14.36%) of the mango fruit.

Anees *et al.* (2011) in cv. Dusehri has revealed that trees sprayed with 0.4% FeSO<sub>4</sub>+ 0.8% H<sub>3</sub>BO<sub>3</sub>+ 0.8% ZnSO<sub>4</sub> showed the maximum pulp weight (169.2g), total soluble solids(27.9 °Brix), ascorbic acid (150.3 mg/100ml) and non-reducing sugars (8.83%) and less stone weight (28.13g) along with low acidity (0.178%).

Nehete *et al.* (2011) revealed that the zinc sulphate 1% + iron sulphate 1% + borax 0.5% significantly increased fruit quality in terms of TSS (19.00%), total sugars (16.67%), reducing sugar (6.03%) and ascorbic acid (32.80 mg/100 g pulp) in cv. Kesar.

Bhatt *et al.* (2012) reported that the trees sprayed with 0.5% borax showed maximum TSS (15.67° Brix), reducing sugar (6.42%), non-reducing sugar (9.29%) and ascorbic acid content (34.05%). While with regard to maintenance of post-harvest fruit quality in mango, the minimum physiological loss in weight (16.83%) was recorded in 1% Ca (NO<sub>3</sub>)<sub>2</sub> followed by CaCl<sub>2</sub> (1.2%) up to the end of 12<sup>th</sup> day.

### **2.2.3 Banana**

Foliar spray of micronutrients at 3<sup>rd</sup>, 5<sup>th</sup> and 7<sup>th</sup> months after planting with ZnSO<sub>4</sub>(0.5 %), FeSO<sub>4</sub> (0.2 %), CuSO<sub>4</sub> (0.2 %) and H<sub>3</sub>BO<sub>3</sub> (0.1 %) on quality of cv. Robusta reported the highest total soluble solids (26.66 °Brix) in ripe fruits (Kumar and Jeyakumar, 2002).

Micronutrients mixture (zinc + boron + iron) 1.0 per cent in two sprays affected on pulp to peel ratio (2.87), maximum reducing sugar (12.97 %) and non-reducing sugar (3.58 %) on cv. Grand Naine (Yadlod and Kadam, 2008b).

Jeyabaskaran and Pandey (2008) reported that the fruit quality parameters like TSS (30.4<sup>0</sup> Brix) and acidity (0.32%) were significantly influenced by the soil and foliar application of micronutrients in banana under high soil P<sup>H</sup> condition.

Foliar application of ZnSO<sub>4</sub> (0.5 %), FeSO<sub>4</sub> (0.2 %), CuSO<sub>4</sub> (0.2 %) and H<sub>3</sub>BO<sub>3</sub> (0.1 %) at 3<sup>rd</sup>, 5<sup>th</sup> and 7<sup>th</sup> month after planting is recommended to get high quality fruits in banana (Thangaselvabai *et al.*, 2009).

The maximum total sugar (16.00 %) and reducing sugar (12.75 %) was found with two sprays of 1.0 per cent micronutrient mixture (zinc + boron + iron) which were significantly superior. Maximum pulp to peel ratio (2.80) was found in one spray of 1.0 per cent micronutrient mixture in cv. Ardhapuri (Yadlod and Kadam, 2009).

Yadlod *et al.* (2009) reported that the maximum non-reducing sugar (3.84 %) was found in two sprays of micronutrient mixtures 1 % (zinc + boron + iron) followed by one spray micronutrient mixture. It was found that application of IAA 80 ppm, GA<sub>3</sub> 80 ppm and two sprays of (1 %) micronutrient mixtures were effective for chemical characters of cv. Shrimanti.

Yadlod and Kadam (2010) reported that the maximum total sugar (15.90 %) and reducing sugar (12.09 %) was observed in GA<sub>3</sub> 80 ppm and two sprays of 1.0 per cent micronutrient mixture (zinc + boron + iron), respectively in cv. Basrai.

Patel *et al.* (2010) reported that the foliar application of ZnSO<sub>4</sub> (0.5 %) + FeSO<sub>4</sub> (0.5 %) treatments effectively increased the ascorbic acid (25 mg/100g) and total soluble solids (22.03<sup>0</sup>B) in banana fruits.

The combined application of FeSO<sub>4</sub> (0.5 %) + ZnSO<sub>4</sub> (0.5 %) at three, five and seven month after planting of suckers in cv. Martaman showed significant increase in the

quality parameters like sugar to acid ratio (47.70), non-reducing sugar (10.04 %) and titratable acidity (0.36 %). Application of  $\text{FeSO}_4$  (0.5 %) alone showed considerable improvement on total soluble solids (25.53 °Brix), reducing sugar (6.57 %) and total sugar (17.24 %) content of pulp (Pathak *et al.*, 2011).

#### **2.2.4 Grapes**

Sindhu *et al.* (1999) observed in grapes that, the maximum total soluble solids (18.2%) of fruit were found in vines which received 1.5 per cent urea and 0.5 per cent zinc sulphate spray, respectively. Acidity decreased with increase in concentrations of urea and zinc sulphate spray.

Rana and Sharma (1999) revealed that juice per cent, specific gravity of juice and total soluble solids were increased with 0.05 per cent of  $\text{FeSO}_4$  spray in grapes. However, pH of juice, acidity, total sugars, reducing sugars, non-reducing sugars and TSS to acid ratio were not affected by iron sprays.

Prabhu and Singaram (2001) revealed that the combined foliar application of  $\text{ZnSO}_4$  (0.5 %) and  $\text{H}_3\text{BO}_3$  (0.2 %) increased the quality characters with higher juice per cent, total soluble solids, total sugars and lower acidity in cv. Muscat.

Janaki *et al.* (2002) revealed that the combined application of 2.0 kg boron soil application + 0.2 per cent foliar spray increased the brix and total sugar of berries and reducing acidity in the fruits of cv. Muscat.

Subramoniam *et al.* (2006) in grapes variety Thompson Seedless reported that application of NPK + micronutrient significantly increased the quality of fruits such as juice content (76.85%), TSS (19.50%), acidity (0.90g/l), specific gravity (1.15gc/c), total sugar (12.80%), TSS/acidity ratio (28.43).

#### **2.2.5 Citrus**

Monga and Josan (2000) reported the effect of micronutrients on quality of Kinnow mandarin. The juice content (44.2%) and total soluble solids (12.20%) were

maximum under zinc sulphate (0.3%) treatment and acidity decreased in all treatments compared to the control.

Ram and Bose (2000) reported that the juice content of mandarin orange fruits was recorded maximum (46.37%) with magnesium + copper+ zinc +boron, followed by zinc (46.23%) and boron treated plants (42.78%). Combined application of magnesium + copper + zinc + iron + boron resulted in maximum concentration of (7.22%) of total and reducing sugars (3.03%) in fresh fruits. The non-reducing sugar content was maximum with magnesium + copper + zinc + boron and acidity of fruits varied between 0.84% and 1.43%.

Sajida and Hafeez (2000) revealed that effect of foliar application of zinc, manganese and boron in combination with urea on the quality of sweet orange. Application of manganese significantly increased the fruit colour and fruit juice.

Afzal *et al.* (2002) revealed that the highest juice percentage (50.13%), were noted in application of  $\text{CuSO}_4$ ,  $\text{MnSO}_4$ ,  $\text{FeSO}_4$  and 100gm  $\text{ZnSO}_4$  per plant. The same treatment produced maximum TSS (12.30%). The lowest acidity (0.60%) and peel thickness (0.43cm) were recorded in 60gm in each  $\text{CuSO}_4$ ,  $\text{MnSO}_4$ , and  $\text{FeSO}_4$  in kinnow mandarin (*Citrus reticulata* Blanco).

Tariq *et al.* (2007) obtained the maximum fruit quality when zinc  $0.4 \text{ kg ha}^{-1}$ , magnesium  $0.2 \text{ kg ha}^{-1}$  and boron  $0.04 \text{ kg ha}^{-1}$  was foliar sprayed along with nitrogen  $1.56 \text{ kg ha}^{-1}$  and surfactant  $0.4 \text{ kg ha}^{-1}$  in 400 litre of water. The minimum per cent peel and percent juice in sweet oranges was increased significantly by boron alone, reducing sugar by manganese alone through foliar spray and suggested that each micronutrient had different role on the quality of citrus cv. Blood red fruit.

Dhinesh *et al.* (2007) reported that the effect of micronutrients on enhancing the quality of Kinnow mandarin. The trees sprayed with magnesium (0.5%), zinc (0.5%) and manganese (0.5%) improved the quality parameters like TSS (10.85%) but reduces the titratable acidity (0.83%).

Khurshid and Khattak (2008) revealed that manganese treatments significantly increased the total soluble solids (2.94%) and reduced the acidity of fruit juice (11.76%). Other quality parameters such as per cent peel (31.87%), percent pulp (3.62%), and sugar (3.90%) were improved with the application of zinc, iron, copper and manganese.

Sajida *et al.* (2012) revealed that in sweet orange the foliar application of zinc and boron were significantly enhanced the fruit juice content, total soluble solids, ascorbic acid and non-reducing sugar of fruit. However, fruit juice content, TSS, ascorbic acid was observed significantly higher when fruits were treated with high zinc (1%) and low boron (0.02%).

Ashraf *et al.* (2013) reported that the foliar application of 2,4-D (10mg/lit) , salicylic acid (10mg/lit), potassium (0.25%) and zinc (0.25%) significantly increase the juice percentage, TSS, ascorbic acid, acidity and TSS/acid ratio in kinnow fruit.

### **2.2.6 Guava**

Bhatia *et al.* (2001) in cv. L-49 reported that when plants sprayed with  $K_2SO_4$  (0.5, 1.0 and 1.5 %),  $ZnSO_4$  (0.5, 0.75 and 1.0 %),  $H_3BO_3$  (0.3, 0.5 and 1.0 %) and water (control). The total soluble solids (12.2 °Brix) and total sugars (8.2%) were more with  $H_3BO_3$  followed by  $K_2SO_4$ .

The maximum total soluble solids (11.70°Brix), ascorbic acid (172.00 mg/100g), reducing sugar (3.98 %), non-reducing (3.53 %), total sugars (7.51 %) and acidity (0.30 %) were recorded with foliar application of borax (0.4 %) followed by zinc sulphate (0.8%) in cv. L-49 (Yadav *et al.*, 2011).

Goswami *et al.* (2012) reported the effect of pre-harvest application of micronutrients on quality of cv. Sardar. The zinc sulphate at 0.4% improves the physico - chemical parameters at harvest.

### **2.2.9 Ber**

Micronutrient sprays were found effective in reducing the physiological loss in weight compared to control. Micronutrients with copper, iron and zinc at 0.1, 0.2, 0.3 and 0.4 per cent respectively were given as foliar spray. ZnSO<sub>4</sub> at 0.4 per cent conspicuously enhanced post-harvest quality like lowest physiological Loss in Weight (2.15%), high TSS (23.30<sup>0</sup> Brix), acidity (0.29%), ascorbic acid (91.26mg/100g of pulp) and total sugar (15.10%) of ber (Deepa *et al.*, 2008).

### **2.2.10 Aonla**

Shukla (2011) in Indian gooseberry reported that pre-harvest foliar spray of calcium carbonate with boron have increased fruit quality compared to control.

### **2.2.11 Litchi**

Saraswat *et al.* (2006) revealed that the treatment combination of NAA at 20ppm and zinc sulphate at 0.6% increased TSS (19.30<sup>0</sup> Brix) and total sugar (13.24g) content in the litchi fruits.

Pathak and Mitra (2008) reported that litchi plant receiving 400g P<sub>2</sub>O<sub>5</sub>, 700g K<sub>2</sub>O and 7g boron per plant per year showed the maximum total soluble solids (19.23<sup>0</sup> Brix) and reducing sugar contents of fruits (14.90%) were noted by maximum in application of 600g P<sub>2</sub>O<sub>5</sub>, 350g K<sub>2</sub>O, 140g sulphur and 7g boron per plant per year while TSS/acid ratio (52.83) and ascorbic acid content (44.62mg 100g/aril) were noted highest in fruits from the plants receiving 400 g P<sub>2</sub>O<sub>5</sub>, 1050 g K<sub>2</sub>O, 140g sulphur and 7 g boron per plant per year.

### **2.2.12 Pineapple**

Kar *et al.* (2002) reported that effect of zinc and boron on quality traits in pineapple (*Ananas comosus* L.). The highest TSS (15.67%) content was recorded in fruits treated with zinc (0.6%) + boron (0.15%).

### **2.2.13 Plum**

Hassan *et al.* (2010) revealed that the foliar spray with Aminofert (20% amino acids, 12% organic acids, and 3.6% chelated micro-elements), gibberellins, and a mixture of chelated (iron, zinc and manganese) alone or in combination (GA3 + Aminofert or GA3 + a mixture of chelated iron, zinc and manganese) on fruit characteristics increased fruit firmness (6.12 lb/inch<sup>2</sup>), fruit thickness (1.86 cm), TSS (13.43 %), titratable acidity (0.03%) of 'Hollywood' plum trees.

### **2.3 Effect of foliar spray of micronutrients on cost-benefit ratio of important fruit crops**

Meena *et al.* (2008) reported that the foliar application of ferrous sulphate (0.9 %) at pea stage on ber cv. Gola obtained maximum cost benefit ratio (4.409) than the control (3.557) followed by 0.6 per cent (4.347) and 0.3 per cent (3.992) ferrous sulphate spray.

Patel *et al.* (2010) reported that the foliar application of ZnSO<sub>4</sub> (0.5 %) + FeSO<sub>4</sub> (0.5 %) was found to be best treatment for obtaining higher cost benefit ratio in banana cv. Basrai (1:1.94).

Pathak *et al.* (2011) reported that the combined application of FeSO<sub>4</sub> (0.5%) + ZnSO<sub>4</sub> (0.5%) at 3<sup>rd</sup>, 5<sup>th</sup> and 7<sup>th</sup> month after planting of suckers in banana cv. Martaman recorded the highest cost benefit ratio (3.61).

# **MATERIAL AND METHODS**

### **III MATERIAL AND METHODS**

The investigation conducted during 2014-15 in the farmer's field of Alur village, Hiriyr taluk of Chitradurga district, to know the "Effect of foliar spray of micronutrients on growth, yield and quality of pomegranate (cv. Bhagwa) under central dry zone of Karnataka". The details of material used and the methods adopted during the course of investigation are enumerated in this chapter.

#### **3.1 Geographical location of the experimental site**

Alur village (Hiriyr taluk, Chitradurga district, Karnataka state) is situated at 13<sup>0</sup> 57' east latitude and 70<sup>0</sup> 37' east longitude at an elevation of 606.1 meters above the mean sea level (MSL) in the central dry zone (Zone-4) of Karnataka state.

#### **3.2 Weather conditions of the experimental site**

Normally this zone comprises semi arid situations having maximum and minimum temperature ranges between 31.49 °C and 20.91 °C respectively. The major rainfall is received from South-West monsoon between June and September and from North-eastern monsoon between October to December. The annual relative humidity of location is 77.76 per cent in morning and 61.74 per cent in evening respectively. The mean monthly meteorological data indicating the average rainfall received, temperature and relative humidity recorded during the study period are presented in Appendix-I.

#### **3.3 Soil characteristics of the experimental site**

The texture of the soil is sandy clay loam. Before the imposition of the treatments, composite soil sample from experimental site was collected at 0-30 cm depth. Soil sample was air dried, powdered, passed through 2 mm sieve and analyzed for chemical properties.

The soil is having sandy clay loam in texture, alkaline in nature, with pH 8.03 and Electrical Conductivity (EC) was 0.14 dSm<sup>-1</sup>. The micronutrients like manganese, zinc and iron present in the leaf is furnished in Appendix-II.

### **2.2.7 Sapota**

Saraswathy *et al.* (2004) revealed that the sapota trees supplied with zinc sulphate 50 g and borax 25 g per tree (soil) and two foliar sprays of zinc sulphate at 0.5 per cent and borax at 0.3 per cent increased quality parameters. Remarkable improvement in quality of sapota with the treatment having nutrient combinations with zinc sulphate at 50 g + borax at 25 g per tree, borax at 0.3 per cent with zinc sulphate at 0.05 per cent over the control.

### **2.2.8 Papaya**

Jeyakumar *et al.* (2002) reported that staggered application of zinc sulphate (0.5 %) in combination with borax (0.1 %) at four and eight months after planting found to increase the fruit quality in cv. Co-5.

Pauline *et al.* (2004) reported that the effect application of micronutrients boron (0.1 %), iron (0.1 %) and zinc (0.2 %) as foliar spray on cv. Ranchi. The total and reducing sugars were found maximum with the application of iron in both the years. In general, non-reducing sugar was recorded highest with the application of boron + zinc. The acidity content of fruit did not show any set trend with the micronutrient application.

Singh *et al.* (2008) in cv. Ranchi reported that the application of  $H_3BO_3$  at 0.05% +  $ZnSO_4$  at 0.25% was considered as the best which caused the maximum values of qualitative parameters in respect of total soluble solids (6.81<sup>0</sup> Brix), total sugar (6.88%), ascorbic acid (57.11mg/100g),  $\beta$  carotene (3327.14  $\mu$ g/100 g) and TSS- acid ratio (58.41).

Shekar *et al.* (2010) reported that the maximum total sugars (9.72%), ascorbic acid content (58.32%) and TSS (9.60<sup>0</sup>Brix) in papaya were recorded with the foliar application of copper sulphate 0.25 per cent, manganese sulphate 0.25 per cent along with borax 0.1 per cent.

The harvested leaves were brought in polythene bags from field and were cut into small pieces in laboratory. Known weight of sample (100mg) was incubated in 7.0ml DMS at 60<sup>o</sup> c for 2<sup>1</sup>/<sub>2</sub> hours. After the incubation, supernatant was collected by decanting. Then the volume of supernatant was made up to 10ml by using DMS.

The absorbance of extract was measured at 645nm & 663nm by spectrophotometer using DMS as a blank. The chlorophyll 'a', chlorophyll 'b', and total chlorophyll content were calculated by using the following formula.

$$\text{Chlorophyll-a} = [12.7 (A_{663}) - 2.69 (A_{645})] \times \frac{V}{1000 \times W \times a}$$

$$\text{Chlorophyll-b} = [22.9 (A_{645}) - 4.68 (A_{663})] \times \frac{V}{1000 \times W \times a}$$

$$\text{Total chlorophyll} = [20.2 (A_{645}) + 8.02 (A_{663})] \times \frac{V}{1000 \times W \times a}$$

Where

- a - absorbance at specific wavelength (645nm & 663nm)
- v - Volume of the extract (10ml)
- w - Fresh weight of the sample (100mg)
- a - path length of light in cuvette (1cm)
- A<sub>645</sub> - absorbance at 645nm
- A<sub>663</sub> - absorbance at 663nm

### 3.6.2 Yield parameters

From each treatment, five fully ripened fruits were randomly selected for studying the yield attributes where in following physical characters were studied.

### **3.4 Experimental plot**

The present study was conducted on four-year-old plants of pomegranate cv. Bhagwa (Plate 1). Uniformly aged 180 plants spaced 12x10 ft were selected during *hasth bahar* (sept-oct) of 2014. With-holding of water for two months during August-September, 2014, to impose rest to the plants. Thereafter for triggering of flowering is done by irrigating (first irrigation) and manuring of the plants after pruning, and regular irrigations were given once in 7-8 days interval. The treatments were imposed at before flowering, after initiation of flowering and at fruit set (pea nut stage).

### **3.5 Experimental details**

The experiment was laid out in a Randomized Complete Block Design (RCBD) with twelve treatments (Table 1), replicated thrice (Fig 1). Each treatment consisted of five plants from each replication which were selected for recording biometric observations till harvest. The layout of the experiment is given below.

Design	:	RCBD
Replications	:	3
Number of plants per treatment	:	5
Number of treatments	:	12

#### **3.5.1 Preparation of nutrients solution for foliar spray**

Based on the treatment details, micronutrient solutions of different concentration are prepared by dissolving different nutrients in normal water.

##### **3.5.1.1 Preparation of boron solution**

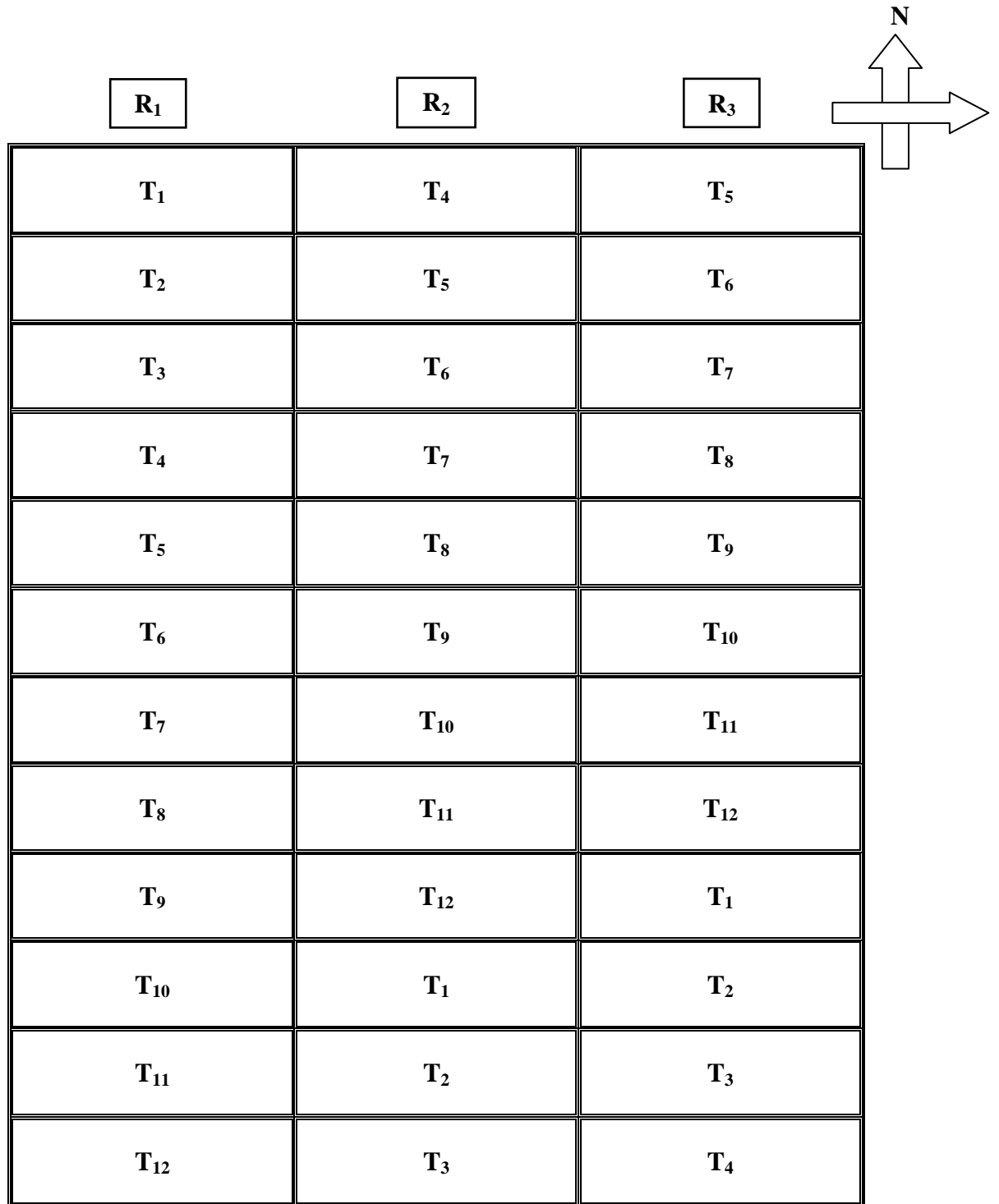
The boron 0.1 per cent solution was prepared by weighing 1 gram of borax and dissolved in 1000 ml of water (1 gram per litre of water). The boron 0.2 per cent solution by weighing 2 gram of borax and dissolved in 1000 ml of water (2 gram per litre of water).



**Plate 1. General view of the experimental plot**

**Table 1. Treatment details**

<b>Number</b>	<b>Treatments</b>
T <sub>1</sub>	Borax 0.1%
T <sub>2</sub>	Borax 0.2%
T <sub>3</sub>	Manganese sulphate 0.25%
T <sub>4</sub>	Manganese sulphate 0.5%
T <sub>5</sub>	Zinc sulphate 0.5%
T <sub>6</sub>	Zinc sulphate 0.8%
T <sub>7</sub>	Ferrous sulphate 0.5%
T <sub>8</sub>	Ferrous sulphate 0.8%
T <sub>9</sub>	Sodium molybdate 0.1%
T <sub>10</sub>	Sodium molybdate 0.2%
T <sub>11</sub>	Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%
T <sub>12</sub>	Control (water spraying)



**Fig. 1. Layout of the experimental plot**

### **3.5.1.2 Preparation of manganese solution**

The manganese 0.25 per cent solution was prepared by weighing 2.5 gram of  $\text{MnSO}_4$  and dissolved in 1000 ml of water (2.5 gram per litre of water). The manganese 0.5 per cent solution by weighing 5 gram of  $\text{MnSO}_4$  and dissolved in 1000 ml of water (5 gram per litre of water).

### **3.5.1.3 Preparation of zinc solution**

The zinc 0.5 per cent solution was prepared by weighing 5 gram of  $\text{ZnSO}_4$  and dissolved in 1000 ml of water (5gram per litre of water). The zinc 0.8 per cent solution by weighing 8 gram of  $\text{ZnSO}_4$  and dissolved in 1000 ml of water (8 gram per litre of water).

### **3.5.1.4 Preparation of iron solution**

The iron 0.5 per cent solution was prepared by weighing 5 gram of  $\text{FeSO}_4$  and dissolved in 1000 ml of water (5 gram per litre of water). The iron 0.8 per cent solution by weighing 8 gram of  $\text{FeSO}_4$  and dissolved in 1000 ml of water (8 gram per litre of water).

### **3.5.1.5 Preparation of molybdenum solution**

The molybdenum 0.1 per cent solution was prepared by weighing 1 gram of sodium molybdate and dissolved in 1000 ml of water (1 gram per litre of water). The molybdenum 0.2 per cent solution was prepared by weighing 2 gram of sodium molybdate and dissolved in 1000 ml of water (2 gram per litre of water).

### **3.5.1.6 Treatment imposition**

The treatments were imposed to pomegranate trees 15 days after first irrigation, when new growth of shoots arises (Plate 2). The micronutrient solutions were prepared by dissolving the borax, manganese sulphate, zinc sulphate, ferrous sulphate and sodium molybdate in the normal water respectively. The foliar spray of micronutrient solutions were given in three intervals of time, once in before flowering, second at full bloom stage and third spray at fruit set stage. Other cultural operations were attended regularly and timely to the effective management of pest and disease during the experiment period.



**Plate 2. Foliar spray of micronutrients on pomegranate cv. Bhagwa**

### **3.6 Observations recorded**

The observations on vegetative growth parameters like leaf fresh and dry weight, leaf area, shoot length (current season) and total leaf chlorophyll content were recorded at 30 and 60 days after first spray. Followed by yield attributes, quality parameters and post harvest observations were recorded after the harvesting of fruits from each treatment.

#### **3.6.1 Growth parameters**

The observations on vegetative growth parameters were recorded at 30 and 60 days after first spray. Five plants were selected randomly in each treatment and in all the three replications and recorded the observations at different intervals.

##### **3.6.1.1 Fresh and dry weight of leaf (g)**

The fresh and dry weight of leaf was calculated by collecting 8 pair of leaves from terminal portion of the shoot. The fresh weight was calculated by weighing the leaves and expressed in g and the dry weight was calculated by drying the leaves in room temperature for ten days and weighed and expressed in g.

##### **3.6.1.2 Leaf area (cm<sup>2</sup>)**

The leaf area was calculated by collecting 8 pair of leaves from terminal portion of the shoot. Leaf area was calculated by using leaf area meter and expressed in cm<sup>2</sup>.

##### **3.6.1.3 Shoot length (cm)**

The current season shoots in all the four directions like (East, West, North and South) were tagged for measuring shoot length from the pruned point and expressed in cm.

##### **3.6.1.4 Total leaf chlorophyll content (mg/g)**

The chlorophyll content of leaf was analyzed by collecting the healthy, 8 pair of leaf from terminal portion of the shoot at fruiting stage. Chlorophyll 'a', chlorophyll 'b' and total chlorophyll contents of leaf tissue was determined by non-destructive method by using dimethyl sulfoxide (DMS) as suggested by Shoaf and Lium (1976).

#### **3.6.2.1 Fruit weight (g)**

Five fruits from each treatment were brought to laboratory and weight of the fruits was recorded in digital analytical balance and expressed in grams (g). The average weight of the five fruits was calculated for statistical analysis.

#### **3.6.2.2 Volume of the fruit (ml)**

Five fruits from each treatment were brought to laboratory and volume of the fruits was recorded by water displacement method and expressed in ml. The average value of the five fruits was calculated for statistical analysis.

#### **3.6.2.3 Diameter of the fruit (cm)**

Fruit diameter was measured with the help of digital vernier calipers at widest middle point where maximum girth was noticed and it was expressed in centimeters.

#### **3.6.2.4 Number of fruits per plant**

The number of fruits per plant was physically counted after maturity then harvested and was expressed as number per tree.

#### **3.6.2.5 Yield per plant (kg)**

The yield of the fruits per plant was recorded at the time of harvest and expressed in kilograms.

#### **3.6.2.6 Yield per hectare (tones)**

The yield per hectare was computed by multiplying the yield per plant with the number of plant that can be accommodated in one hectare and was expressed in tones per hectare.

#### **3.6.3 Fruit quality parameters**

The fruit quality parameters such as total soluble solids, titratable acidity, reducing and non-reducing sugars were recorded from fruits after harvest.

### **3.6.3.2 Reducing sugar (%)**

The reducing sugar content of the fruit was estimated by Anthrone reagent method and expressed in per cent.

### **3.6.3.3 Non-reducing sugar (%)**

The per cent of non-reducing sugars was obtained by subtracting the per cent of reducing sugars from the total sugars and expressed in per cent.

### **3.6.3.4 Total sugar (%)**

The total sugar content of the fruit was estimated by following the method of Ranganna (1977) and expressed in per cent.

### **3.6.3.5 Total Soluble Solids (<sup>0</sup>Brix)**

The total soluble solids was recorded with the extracted juice using a 'Zeiss' digital refractrometer at room temperature and expressed in per cent.

### **3.6.3.6 Titratable acidity (%)**

The total titratable acidity was determined in terms of citric acid by titrating against standard NaOH solution as per A.O.A.C. (Anon., 1960). The total titratable acidity was expressed in terms of citric acid as percentage.

### **3.6.3.7 TSS : TA ratio (%)**

The TSS/TA ratio was calculated by dividing TSS per cent by TA per cent and expressed as per cent.

## **3.6.4 Post harvest traits**

The post harvest traits such as fruit firmness, peel thickness, physiological loss in weight and shelf life were recorded from fruits after harvest.

#### **3.6.4.1 Fruit firmness (Newton)**

Fruit firmness was measured using instrument Anstron and it was expressed in Newton.

#### **3.6.4.2 Peel thickness (mm)**

Peel thickness was measured with the help of digital vernier calipers at widest middle point where maximum girth was noticed and it was expressed in millimeters.

#### **3.6.4.1 Physiological loss in weight (%)**

The initial weight of fruits was recorded on electric top pan balance in each treatment. Thereafter the weights of fruits under each treatment were recorded at four days interval after storage. The cumulative losses in weight were calculated and expressed as per cent physiological loss in weight.

Following is the formula used in calculating PLW

$$PLW = \frac{P_0 - P_1}{P_0}$$

Where,

$P_0$  = initial weight

$P_1$  = weight after 24 hour of storage

#### **3.6.4.2 Shelf life (days)**

Shelf life of fruits was decided based on the appearance and marketability of the fruits. When the fruits attained beyond edible ripe stage and shrivelled, then those fruits were considered to have reached the end of their shelf life (Turner, 1997).

### **3.7 Plant analysis**

The leaf sample analyses to detect the nutrients concentration in the sample and to identify the deficiency or toxicity symptoms. In case of pomegranate leaf, analysis was

carried out before spray and at the time of harvest. 8 pair of leaf growing from terminal portion from non fruiting shoots of the plants selected for analysis.

### **3.7.1 Estimation of micronutrients**

Micronutrients were estimated by directly feeding the Di or tri acid extract of the plant sample to a calibrated atomic absorption spectrometer using respective hollow cathode lamps for each element (Fe, Zn and Mn). Micronutrient concentration was expressed in parts per million (ppm) on dry weight basis.

## **3.8 Economics of cultivation**

### **3.8.1 Cost of cultivation**

The prices of all inputs prevailing at the time of their use, the labour cost were considered to work out the cost of cultivation (Appendix-III).

### **3.8.2 Gross income**

The gross income was worked out based on the prevailing market price of pomegranate fruits.

### **3.8.3 Net income**

The net income per hectare was calculated by using the following formula.

$$\text{NI} = \text{Gross income} - \text{cost of cultivation}$$

### **3.8.4 Cost benefit ratio**

The cost benefit ratio for different treatments was worked out based on the price of inputs used for cultivation and price of marketable produce in local market by using following formula and it is expressed in ratio.

$$\text{Cost: Benefit ratio} = \frac{\text{Net income (₹ ha}^{-1}\text{)}}{\text{Cost of cultivation (₹ ha}^{-1}\text{)}}$$

### **3.9 Statistical analysis of experimental data**

The data on all the growth parameters, yield and quality parameters and nutrient content was tabulated and subjected to statistical analysis using method of analysis of variance (ANOVA) for randomized complete block design (RCBD) by Fisher and Yates (1963). Whenever 'F' test was found significant for comparing the means of two treatments, critical difference (C.D. at 5%) were worked out.

# **EXPERIMENTAL RESULTS**

## IV EXPERIMENTAL RESULTS

The experiment on effect of foliar spray of micronutrients on growth, yield and quality of pomegranate (cv. Bhagwa) under central dry zone of Karnataka was conducted during the year 2014 - 2015 in the farmer's field at Alur village, Hiriyur taluk of Chitradurga district. The results obtained in the present investigation are presented under the following headings.

### 4.1 Effect of foliar spray of micronutrients on growth parameters of pomegranate cv. Bhagwa

The data on effect of foliar spray of micronutrients on growth parameters *viz.*, leaf fresh and dry weight (g), total leaf area (cm<sup>2</sup>), total chlorophyll content in leaf (mg/g), Shoot length (cm) are presented below.

#### 4.1.1 Fresh and dry weight of leaf

The data pertaining to fresh and dry weight of leaf of pomegranate recorded at 30 and 60 days after first spray on pomegranate cv. Bhagwa as influenced by foliar spray of micronutrients was significantly differed among the treatments (Table 2).

The plants received with foliar spray of Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1% (T<sub>11</sub>) recorded maximum leaf fresh and dry weight (0.30g and 0.18g), which was on par with T<sub>6</sub> (0.26g and 0.14g). The minimum leaf fresh and dry weight was observed in T<sub>12</sub> (0.19g and 0.07g) respectively at 30 days after first spray. However similar trend was also observed at 60 days after first spray, where in the maximum leaf fresh and dry weight was observed in T<sub>11</sub> (0.41g and 0.28g), which was followed by T<sub>6</sub> (0.35g and 0.25g). Whereas, the minimum leaf fresh weight of 0.28g and dry weight of 0.17g was recorded in Control-water spraying (T<sub>12</sub>).

#### 4.1.2 Leaf area

The leaf area was recorded at 30 and 60 days after first spray was significantly varied due to foliar spray of micronutrients in pomegranate cv. Bhagwa (Table 3).

**Table 2. Effect of foliar spray of micronutrients on fresh and dry weight of leaf at 30 and 60 days after first spraying in pomegranate cv. Bhagwa**

Treatment	Fresh weight (g)		Dry weight (g)	
	30 <sup>th</sup> day	60 <sup>th</sup> day	30 <sup>th</sup> day	60 <sup>th</sup> day
T <sub>1</sub> - Borax 0.1%	0.20	0.33	0.09	0.20
T <sub>2</sub> - Borax 0.2%	0.24	0.34	0.11	0.22
T <sub>3</sub> - Manganese sulphate 0.25%	0.21	0.31	0.09	0.21
T <sub>4</sub> - Manganese sulphate 0.5%	0.23	0.32	0.11	0.22
T <sub>5</sub> - Zinc sulphate 0.5%	0.25	0.33	0.12	0.23
T <sub>6</sub> - Zinc sulphate 0.8%	0.26	0.35	0.14	0.25
T <sub>7</sub> - Ferrous sulphate 0.5%	0.22	0.32	0.10	0.21
T <sub>8</sub> - Ferrous sulphate 0.8%	0.24	0.34	0.12	0.22
T <sub>9</sub> - Sodium molybdate 0.1%	0.23	0.29	0.09	0.19
T <sub>10</sub> - Sodium molybdate 0.2%	0.24	0.31	0.11	0.20
T <sub>11</sub> - Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%	0.30	0.41	0.18	0.28
T <sub>12</sub> - Control (water spraying)	0.19	0.28	0.07	0.17
S. Em.±	0.02	0.01	0.00	0.01
C.D. at 5%	0.04	0.03	0.01	0.04

The maximum leaf area was noticed in T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%) of 10.77 cm<sup>2</sup> and 13.67 cm<sup>2</sup> at 30 and 60 days after first spray respectively and this was followed by T<sub>6</sub> (10.00 cm<sup>2</sup> and 13.13 cm<sup>2</sup>) at both 30 and 60 days after the first spray. While the minimum leaf area (8.60 cm<sup>2</sup> and 10.63 cm<sup>2</sup>) at 30 and 60 days after first spray was recorded in T<sub>12</sub> (Control-water spraying)

#### **4.1.3 Shoot length**

Significant differences were observed among the treatments for shoot length with foliar spray of micronutrients in pomegranate cv. Bhagwa (Table 3). Where in the maximum shoot length (37.67cm and 50.33cm) was recorded in T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%) at both 30 and 60 days after first spray respectively, which was statistically on par with T<sub>6</sub>(34.00cm and 47.00cm). Whereas, minimum shoot length (28.67cm and 37.33 cm) was observed in T<sub>12</sub> (Control-water spraying) respectively.

#### **4.1.4 Chlorophyll content in leaf**

The data pertaining on chlorophyll – ‘a’, chlorophyll – ‘b’ and total chlorophyll content in leaves (Table 4).

##### **4.1.4.1 Chlorophyll–a**

The chlorophyll ‘a’ content in leaf was significantly differed among the different treatments. Foliar spray of Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1% (T<sub>11</sub>) resulted in significantly maximum chlorophyll – ‘a’ content (1.97mg/g), followed by T<sub>6</sub> (1.62 mg/g). The minimum chlorophyll –‘a’ content (1.20 mg/g) was recorded in T<sub>12</sub> (control-water spraying).

##### **4.1.4.2 Chlorophyll - b**

The chlorophyll - ‘b’ content in leaf was significantly differed among the treatments. Maximum chlorophyll – ‘b’ content (0.66 mg/g) was observed in T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%), followed by

**Table 3. Effect of foliar spray of micronutrients on leaf area and shoot length in pomegranate cv. Bhagwa at 30 and 60 days after first spray**

Treatment	Leaf area (cm <sup>2</sup> )		Shoot length current season (cm)	
	30 <sup>th</sup> day	60 <sup>th</sup> day	30 <sup>th</sup> day	60 <sup>th</sup> day
T <sub>1</sub> - Borax 0.1%	8.70	11.50	31.00	40.00
T <sub>2</sub> - Borax 0.2%	9.27	12.47	32.12	43.67
T <sub>3</sub> - Manganese sulphate 0.25%	9.00	11.43	31.14	39.00
T <sub>4</sub> - Manganese sulphate 0.5%	9.13	12.23	31.33	41.00
T <sub>5</sub> - Zinc sulphate 0.5%	9.37	12.53	32.00	44.33
T <sub>6</sub> - Zinc sulphate 0.8%	10.00	13.13	34.00	47.00
T <sub>7</sub> - Ferrous sulphate 0.5%	9.10	11.40	31.23	40.33
T <sub>8</sub> - Ferrous sulphate 0.8%	9.27	12.70	32.04	42.33
T <sub>9</sub> - Sodium molybdate 0.1%	8.63	10.87	30.12	38.67
T <sub>10</sub> - Sodium molybdate 0.2%	9.27	11.57	30.33	39.67
T <sub>11</sub> - Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%	10.77	13.67	37.67	50.33
T <sub>12</sub> - Control (water spraying)	8.60	10.63	28.67	37.33
S. Em.±	0.21	0.35	1.28	1.98
C.D. at 5%	0.60	1.00	3.68	5.67

**Table 4. Effect of foliar spray of micronutrients on chlorophyll content in leaf of pomegranate cv. Bhagwa**

Treatment	Chlorophyll content in leaf (mg/g)		
	Chlorophyll 'a'	Chlorophyll 'b'	Total Chlorophyll
T <sub>1</sub> - Borax 0.1%	1.42	0.47	1.90
T <sub>2</sub> - Borax 0.2%	1.46	0.50	1.96
T <sub>3</sub> - Manganese sulphate 0.25%	1.38	0.47	1.85
T <sub>4</sub> - Manganese sulphate 0.5%	1.45	0.48	1.93
T <sub>5</sub> - Zinc sulphate 0.5%	1.55	0.51	2.06
T <sub>6</sub> - Zinc sulphate 0.8%	1.62	0.56	2.20
T <sub>7</sub> - Ferrous sulphate 0.5%	1.48	0.49	1.96
T <sub>8</sub> - Ferrous sulphate 0.8%	1.51	0.54	2.05
T <sub>9</sub> - Sodium molybdate 0.1%	1.33	0.35	1.68
T <sub>10</sub> - Sodium molybdate 0.2%	1.38	0.41	1.80
T <sub>11</sub> - Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%	1.97	0.66	2.63
T <sub>12</sub> - Control (water spraying)	1.20	0.33	1.52
S. Em.±	0.06	0.03	0.09
C.D. at 5%	0.18	0.09	0.24

T<sub>6</sub> (0.56 mg/g). The minimum chlorophyll – ‘b’ content (0.33 mg/g) was recorded in T<sub>12</sub> (control-water spraying).

#### **4.1.4.3 Total Chlorophyll**

The total chlorophyll content in leaf was significantly differed among the treatments. Highest total chlorophyll content of 2.63 mg/g was noticed in T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%), which was followed by T<sub>6</sub> (2.20 mg/g). The minimum total chlorophyll content (1.52 mg/g) was recorded in T<sub>12</sub> (control-water spraying).

## **4.2 Effect of foliar spray of micronutrients on yield and yield attributes of pomegranate cv. Bhagwa**

The data on effect of foliar spray of micronutrients on yield and yield attributes of pomegranate cv. Bhagwa *viz.*, fruit weight, volume of the fruit, diameter of the fruit, fruit length, number of fruits per plant, yield per plant and yield per hectare are presented below.

### **4.2.1 Fruit weight**

The weight of fruit differed significantly among the treatments (Table 5) (Plate 3). Significantly the maximum fruit weight (292.67g) was recorded in T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%), which was followed by T<sub>6</sub> (265.00g). Significantly the lowest fruit weight (238.33g) was recorded in T<sub>12</sub> (control-water spraying).

### **4.2.2 Volume of the fruit**

There was a significant difference among the treatments for fruit volume (Table 5) (Plate 3). The maximum volume of the fruit (255.00 ml) was recorded in treatment T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%), which was followed by T<sub>6</sub> (233.33 ml). However the minimum volume of the fruit (193.33 ml) was recorded in T<sub>12</sub> (control-water spraying).

**Table 5. Effect of foliar spray of micronutrients on yield attributes of pomegranate cv. Bhagwa**

<b>Treatment</b>	<b>Fruit weight (g)</b>	<b>Fruit volume (ml)</b>	<b>Fruit diameter (cm)</b>
T <sub>1</sub> - Borax 0.1%	247.63	206.67	8.12
T <sub>2</sub> - Borax 0.2%	259.67	219.33	8.68
T <sub>3</sub> - Manganese sulphate 0.25%	244.00	203.33	8.32
T <sub>4</sub> - Manganese sulphate 0.5%	245.67	204.67	8.42
T <sub>5</sub> - Zinc sulphate 0.5%	256.00	214.67	8.45
T <sub>6</sub> - Zinc sulphate 0.8%	265.00	233.33	8.81
T <sub>7</sub> - Ferrous sulphate 0.5%	240.67	201.00	8.59
T <sub>8</sub> - Ferrous sulphate 0.8%	248.33	206.67	8.61
T <sub>9</sub> - Sodium molybdate 0.1%	242.67	198.00	8.03
T <sub>10</sub> - Sodium molybdate 0.2%	243.00	203.67	8.23
T <sub>11</sub> - Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%	292.67	255.00	9.64
T <sub>12</sub> - Control (water spraying)	238.33	193.33	7.03
S. Em.±	4.10	5.24	0.33
C.D. at 5%	11.75	15.35	0.98



**Plate 3. Effect of foliar spray of micronutrients on fruit characters of pomegranate cv. Bhagwa**

### **4.2.3 Diameter of the fruit**

Significant differences among the treatments was reported for fruit diameter (Table 5) (Plate 3). The maximum fruit diameter (9.64cm) was recorded in treatment T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%), which was statistically on par with T<sub>6</sub> (8.81cm). However the minimum diameter of the fruit (7.03cm) was recorded in T<sub>12</sub> (control-water spraying)

### **4.2.4 Number of fruits per plant**

The number of fruits per plant did not varied significantly among the treatments (Table 6). The maximum number of fruits per plant (61.00) was noticed in T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%), which was followed by T<sub>6</sub> (59.67).The minimum number of fruits per plant (55.00) was recorded in T<sub>12</sub> (control-water spraying)

### **4.2.5 Yield per plant**

There was a significant difference in yield per plant between the treatments (Table 6). The highest yield per plant (17.77kg) was obtained in T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%), which was followed by T<sub>6</sub> (15.77kg). The minimum yield per plant (13.10kg) was recorded in T<sub>12</sub> (control-water spraying).

### **4.2.6 Total yield per hectare**

There was a significant difference in yield per hectare between the treatments (Table 6). The highest yield (15.98t/ha) was obtained in treatment T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%), which was followed by T<sub>6</sub> (14.15t/ha). While, the minimum fruit yield (11.77t/ha) was obtained in T<sub>12</sub> (control-water spraying).

**Table 6. Effect of foliar spray of micronutrients on yield of pomegranate cv. Bhagwa**

<b>Treatment</b>	<b>Number of fruits per plant</b>	<b>Yield per plant (kg)</b>	<b>Yield per hectare (t)</b>
T <sub>1</sub> - Borax 0.1%	57.67	14.23	12.77
T <sub>2</sub> - Borax 0.2%	59.00	15.30	13.73
T <sub>3</sub> - Manganese sulphate 0.25%	57.67	14.04	12.60
T <sub>4</sub> - Manganese sulphate 0.5%	58.67	14.37	12.87
T <sub>5</sub> - Zinc sulphate 0.5%	58.33	14.90	13.37
T <sub>6</sub> - Zinc sulphate 0.8%	59.67	15.77	14.15
T <sub>7</sub> - Ferrous sulphate 0.5%	57.00	13.67	12.27
T <sub>8</sub> - Ferrous sulphate 0.8%	58.00	14.37	12.92
T <sub>9</sub> - Sodium molybdate 0.1%	55.67	13.45	12.07
T <sub>10</sub> - Sodium molybdate 0.2%	56.67	13.74	12.33
T <sub>11</sub> - Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%	61.00	17.77	15.98
T <sub>12</sub> - Control (water spraying)	55.00	13.10	11.77
S. Em.±	1.48	0.48	0.43
C.D. at 5%	NS	1.41	1.26

### **4.3 Effect of foliar spray of micronutrients on quality parameters of pomegranate cv. Bhagwa**

#### **4.3.1 Reducing sugar**

Significant difference was noticed for reducing sugar content of fruit due to foliar spray of micronutrients on pomegranate cv. Bhagwa (Table 7). The higher reducing sugar (12.71 %) was recorded in T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%), which was followed by T<sub>2</sub> (11.60%). The lowest level of reducing sugar (9.34%) was observed in T<sub>12</sub> (control-water spraying).

#### **4.3.2 Non-reducing sugar**

The non-reducing sugar content of fruits did not varied significantly among the treatments (Table 7). The highest per cent of non- reducing sugar (1.96%) was recorded in T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%). While, the lowest non- reducing sugar (1.81%) was recorded in T<sub>12</sub> (control-water spraying).

#### **4.3.3 Total sugars**

The significant difference was noticed in total sugar content with the foliar spray of micronutrients on pomegranate cv. Bhagwa (Table 7). Among the treatments, the highest total sugar (14.65%) was recorded in T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%), which was statistically on par with T<sub>2</sub> (13.81%). While, the lowest total sugars (11.14%) was recorded in T<sub>12</sub> (control-water spraying).

#### **4.3.4 Total soluble solids**

The significant difference was noticed in the total soluble solids with the foliar spray of micronutrients on pomegranate cv. Bhagwa (Table 8). The highest level of total soluble solids (15.23 °Brix) in T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%), which was statistically on par with T<sub>2</sub> (14.70 °Brix).

**Table 7. Effect of foliar spray of micronutrients on sugar content of pomegranate cv. Bhagwa**

<b>Treatment</b>	<b>Reducing sugar (%)</b>	<b>Non-reducing sugar (%)</b>	<b>Total sugars (%)</b>
T <sub>1</sub> - Borax 0.1%	11.41	2.27	13.68
T <sub>2</sub> - Borax 0.2%	11.60	2.21	13.81
T <sub>3</sub> - Manganese sulphate 0.25%	10.64	1.67	12.64
T <sub>4</sub> - Manganese sulphate 0.5%	11.11	1.63	12.32
T <sub>5</sub> - Zinc sulphate 0.5%	11.21	2.41	13.61
T <sub>6</sub> - Zinc sulphate 0.8%	11.42	2.32	13.74
T <sub>7</sub> - Ferrous sulphate 0.5%	11.22	1.82	13.04
T <sub>8</sub> - Ferrous sulphate 0.8%	11.35	1.87	13.22
T <sub>9</sub> - Sodium molybdate 0.1%	10.32	1.41	11.73
T <sub>10</sub> - Sodium molybdate 0.2%	10.68	1.45	12.13
T <sub>11</sub> - Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%	12.71	1.96	14.65
T <sub>12</sub> - Control (water spraying)	9.34	1.81	11.14
S. Em.±	0.22	0.34	0.25
C.D. at 5%	0.63	NS	0.73

However, the lowest level of TSS (12.60 °Brix) was recorded in T<sub>12</sub> (control-water spraying).

#### **4.3.5 Titratable acidity**

The significant difference was noticed in the titratable acidity with the foliar spray of micronutrients on pomegranate cv. Bhagwa (Table 8). Among the treatments, the highest titratable acidity (0.62%) was recorded in T<sub>12</sub> (control-water spraying), which was followed by T<sub>9</sub> (0.45%). While the lowest titratable acidity (0.33%) was recorded in T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%).

#### **4.3.6 TSS / TA ratio**

The TSS/TA ratio of the fruits differed significantly between the treatments (Table 8). The maximum TSS/TA (46.17%) was observed in T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%), which was statistically on par with T<sub>2</sub> (39.03%). While, the lowest TSS/TA (20.35%) was observed in T<sub>12</sub> (control-water spraying).

### **4.4 Effect of foliar spray of micronutrients on post-harvest parameters of pomegranate cv. Bhagwa**

#### **4.4.1 Fruit firmness**

The maximum fruit firmness (81.98 Newton) was obtained in T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%), which was followed by T<sub>6</sub> (79.98 Newton). While, the minimum fruit firmness (71.84 Newton) was recorded in T<sub>12</sub> (control-water spraying) (Table 9).

#### **4.4.2 Peel thickness**

There was significant difference among the different treatments for peel thickness (Table 9). The maximum peel thickness (3.66mm) was recorded in treatment T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%), which were statistically on par with T<sub>6</sub> (3.45mm). However the minimum peel thickness (2.86mm) was recorded in T<sub>12</sub> (control-water spraying).

**Table 8. Effect of foliar spray of micronutrients on TSS, TA and TSS/TA of pomegranate cv. Bhagwa**

<b>Treatment</b>	<b>TSS (°Brix)</b>	<b>TA (%)</b>	<b>TSS/TA ratio (%)</b>
T <sub>1</sub> - Borax 0.1%	14.67	0.43	34.13
T <sub>2</sub> - Borax 0.2%	14.83	0.38	39.03
T <sub>3</sub> - Manganese sulphate 0.25%	13.73	0.44	31.22
T <sub>4</sub> - Manganese sulphate 0.5%	13.87	0.42	33.03
T <sub>5</sub> - Zinc sulphate 0.5%	14.60	0.40	36.52
T <sub>6</sub> - Zinc sulphate 0.8%	14.70	0.39	37.68
T <sub>7</sub> - Ferrous sulphate 0.5%	14.53	0.41	35.41
T <sub>8</sub> - Ferrous sulphate 0.8%	14.67	0.42	34.94
T <sub>9</sub> - Sodium molybdate 0.1%	13.60	0.45	30.23
T <sub>10</sub> - Sodium molybdate 0.2%	13.50	0.43	31.39
T <sub>11</sub> - Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%	15.23	0.33	46.17
T <sub>12</sub> - Control (water spraying)	12.60	0.62	20.35
S. Em.±	0.19	0.04	3.41
C.D. at 5%	0.55	0.11	10.01

**Table 9. Effect of foliar spray of micronutrients on fruit firmness and peel thickness of pomegranate cv. Bhagwa**

<b>Treatment</b>	<b>Fruit firmness (Newton)</b>	<b>Peel thickness (mm)</b>
T <sub>1</sub> - Borax 0.1%	75.23	3.04
T <sub>2</sub> - Borax 0.2%	77.08	3.15
T <sub>3</sub> - Manganese sulphate 0.25%	74.21	3.05
T <sub>4</sub> - Manganese sulphate 0.5%	75.30	3.17
T <sub>5</sub> - Zinc sulphate 0.5%	77.41	3.16
T <sub>6</sub> - Zinc sulphate 0.8%	79.98	3.45
T <sub>7</sub> - Ferrous sulphate 0.5%	75.12	3.10
T <sub>8</sub> - Ferrous sulphate 0.8%	76.33	3.24
T <sub>9</sub> - Sodium molybdate 0.1%	73.21	3.01
T <sub>10</sub> - Sodium molybdate 0.2%	74.01	3.12
T <sub>11</sub> - Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%	81.98	3.66
T <sub>12</sub> - Control (water spraying)	71.84	2.86
S. Em.±	0.53	0.11
C.D. at 5%	1.57	0.32

#### **4.4.3 Physiological loss in weight**

There was significant difference between the treatments was noticed with respect to physiological loss in weight (Table 10). The lowest PLW (12.88%) was observed in T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%), which was on par with T<sub>6</sub> (14.15%). The highest PLW (18.98%) in T<sub>12</sub> (control-water spraying).

#### **4.4.4 Shelf life**

Significant difference was observed between the treatments on shelf life of fruits (Table 10) (Plate 4). The maximum shelf life (30.33 days) was reported in T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%), which was followed by T<sub>6</sub> (27.00 days). Whereas, the minimum shelf life (19.67 days) was recorded in T<sub>12</sub> (control-water spraying).

### **4.5 Effect of foliar spray of micronutrients on nutrient content of pomegranate leaf**

#### **4.5.1 Manganese content in leaf**

Manganese content in the leaf varied significantly among different treatments with foliar spray of micronutrients on pomegranate cv. Bhagwa (Table 11). The maximum manganese content in leaf (134.90ppm) was recorded in T<sub>4</sub> (Manganese 0.5%). Which was statistically on par with T<sub>3</sub> (129.33ppm). While, the minimum manganese content (70.20ppm) in the leaf was recorded in the T<sub>12</sub> (control-water spraying).

#### **4.5.2 Zinc content in leaf**

Zinc content in the leaf varied significantly among different treatments with foliar spray of micronutrients on pomegranate cv. Bhagwa (Table 11). The maximum zinc content in leaf (115.74ppm) was recorded in T<sub>6</sub> (Zinc 0.8%). Which was followed by T<sub>5</sub> (109.53ppm). While, the minimum zinc content (52.50ppm) in the leaf was recorded in the T<sub>12</sub> (control-water spraying).

**Table 10. Effect of foliar spray of micronutrients on physiological loss in weight and shelf life of pomegranate cv. Bhagwa**

Treatment	Physiological loss in weight (%)					Mean	Shelf life (days)
	4 days	8 days	12 days	16 days	20 days		
T <sub>1</sub> - Borax 0.1%	6.23	11.40	13.36	22.42	30.14	16.71	23.00
T <sub>2</sub> - Borax 0.2%	6.00	10.51	12.35	20.24	29.14	15.64	25.67
T <sub>3</sub> - Manganese sulphate 0.25%	6.44	11.48	14.22	21.50	30.48	16.82	22.00
T <sub>4</sub> - Manganese sulphate 0.5%	5.70	10.46	13.32	20.43	29.14	15.81	25.33
T <sub>5</sub> - Zinc sulphate 0.5%	6.43	11.12	12.34	20.23	28.14	15.65	25.00
T <sub>6</sub> - Zinc sulphate 0.8%	5.28	9.60	11.42	18.33	26.13	14.15	27.00
T <sub>7</sub> - Ferrous sulphate 0.5%	6.40	11.49	12.43	22.60	30.45	16.67	23.67
T <sub>8</sub> - Ferrous sulphate 0.8%	5.99	10.47	12.82	20.47	27.34	15.41	26.00
T <sub>9</sub> - Sodium molybdate 0.1%	7.22	11.40	14.43	23.23	32.26	17.73	21.67
T <sub>10</sub> - Sodium molybdate 0.2%	6.27	10.51	13.22	22.43	30.64	16.61	24.00
T <sub>11</sub> - Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%	4.35	6.37	11.33	17.34	25.01	12.88	30.33
T <sub>12</sub> - Control (water spraying)	8.27	12.46	15.43	24.52	34.24	18.98	19.67
S. Em.±	0.48	0.36	0.48	0.44	0.44		0.64
C.D. at 5%	1.38	1.02	1.37	1.26	1.26		1.85



Plate 4. Shelf life studies under laboratory condition

**Table 11. Effect of foliar spray of micronutrients on nutrient content in leaf of pomegranate cv. Bhagwa**

Treatment	Nutrient content (ppm) in leaf		
	Manganese	Zinc	Iron
T <sub>1</sub> - Borax 0.1%	74.67	63.33	57.33
T <sub>2</sub> - Borax 0.2%	78.00	71.00	60.00
T <sub>3</sub> - Manganese sulphate 0.25%	129.33	60.00	75.00
T <sub>4</sub> - Manganese sulphate 0.5%	134.90	69.67	82.00
T <sub>5</sub> - Zinc sulphate 0.5%	84.00	109.53	74.67
T <sub>6</sub> - Zinc sulphate 0.8%	87.33	115.74	83.33
T <sub>7</sub> - Ferrous sulphate 0.5%	78.33	71.00	99.40
T <sub>8</sub> - Ferrous sulphate 0.8%	90.67	74.67	107.10
T <sub>9</sub> - Sodium molybdate 0.1%	74.00	58.33	51.33
T <sub>10</sub> - Sodium molybdate 0.2%	78.33	62.67	57.33
T <sub>11</sub> - Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%	112.23	102.47	90.67
T <sub>12</sub> - Control (water spraying)	70.20	52.50	45.70
S. Em.±	3.57	2.37	3.88
C.D. at 5%	10.48	6.96	11.38

### 4.5.3 Iron content in leaf

Iron content in the leaf varied significantly among different treatments with foliar spray of micronutrients on pomegranate cv. Bhagwa (Table 11). The maximum iron content in leaf (107.10ppm) was recorded in T<sub>8</sub> (Iron 0.8%). Which was statistically on par with T<sub>7</sub> (99.40ppm). While, the minimum iron content (45.70ppm) in the leaf was recorded in the T<sub>12</sub> (control-water spraying).

### 4.6 Cost: benefit ratio

The cost: benefit ratio in pomegranate cv. Bhagwa due to the influence of foliar spray of micronutrients is presented in Table 12 and 13.

The foliar spray of Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1% (T<sub>11</sub>) resulted in maximum net income (₹.7, 65,253 ha<sup>-1</sup>) and gross income (₹.9, 58,800 ha<sup>-1</sup>), which was followed by T<sub>6</sub> (₹.6, 58,547 ha<sup>-1</sup>) and (₹.8, 49,000 ha<sup>-1</sup>) respectively, whereas it was minimum (₹.5, 20,599 ha<sup>-1</sup> and ₹.7, 06, 200 ha<sup>-1</sup>) in T<sub>12</sub> (control-water spraying).

The maximum cost: benefit ratio (3.95) was observed from the treatment T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%), which was followed by treatment T<sub>6</sub> (3.45), While the minimum cost: benefit ratio (2.77) was recorded in T<sub>9</sub> (Sodium molybdate 0.1%).



**Table 13. Effect of foliar spray of micronutrients on economics of pomegranate cv. Bhagwa**

<b>Treatment</b>	<b>Total cost of cultivation (₹)</b>	<b>Fruit yield (t/ha)</b>	<b>Gross income (₹)</b>	<b>Net income (₹)</b>	<b>Cost : benefit ratio</b>
T <sub>1</sub> - Borax 0.1%	189471	12.77	766200	576729	3.04
T <sub>2</sub> - Borax 0.2%	189741	13.73	823800	634059	3.34
T <sub>3</sub> - Manganese sulphate 0.25%	189741	12.60	756000	566259	2.98
T <sub>4</sub> - Manganese sulphate 0.5%	190281	12.87	772200	581919	3.05
T <sub>5</sub> - Zinc sulphate 0.5%	189984	13.37	802200	612216	3.22
T <sub>6</sub> - Zinc sulphate 0.8%	190453	14.15	849000	658547	3.45
T <sub>7</sub> - Ferrous sulphate 0.5%	189403	12.27	736200	546797	2.88
T <sub>8</sub> - Ferrous sulphate 0.8%	189525	12.92	775200	585675	3.09
T <sub>9</sub> - Sodium molybdate 0.1%	191752	12.07	724200	532448	2.77
T <sub>10</sub> - Sodium molybdate 0.2%	194304	12.33	739800	545496	2.80
T <sub>11</sub> - Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%	193547	15.98	958800	765253	3.95
T <sub>12</sub> - Control (water spraying)	185601	11.77	706200	520599	2.80

# **DISCUSSION**

## V DISCUSSION

Nutrient requirement of pomegranate at critical growth stages is very important to attain better growth, yield and quality of fruits. Micronutrients play a major role in crop production due to their essentiality in plant metabolism and adverse effects that manifest due to their deficiency, in addition of affecting the growth, micronutrients also play a major role in disease resistance in cultivated crop species. They can tremendously boost horticultural crop yield and improve quality and post-harvest life of horticultural produce. Keeping this in view, an attempt was made to know the “Effect of foliar spray of micronutrients on growth, yield and quality of pomegranate cv. Bhagwa under central dry zone of Karnataka”. The results on effect of foliar spray of micronutrients are discussed in this chapter with the available scientific reasoning and supportive literature.

### **5.1 Effect of foliar spray of micronutrients on growth parameters of pomegranate cv. Bhagwa**

The results of various growth parameters *viz.*, fresh and dry weight of leaf, total leaf area (cm<sup>2</sup>), total chlorophyll content in leaf (mg/g), shoot length (cm) due to the effect of foliar spray of micronutrients during the crop growth are discussed.

#### **5.1.1 Fresh and dry weight of leaf**

In the present study, the foliar spray of micronutrients significantly influenced the leaf fresh and dry weight of pomegranate cv. Bhagwa. However the application of micronutrient mixture (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%) recorded the maximum fresh and dry weight of leaf (0.41g and 0.28g) and minimum leaf fresh and dry weight (0.28g and 0.17g) was recorded in T<sub>12</sub> (control – water spraying). These observations are in conformity with those of Eaida *et al.* (2013) in pomegranate.

Pathak *et al.* (2011) reported that improvement in growth might be due to combined effect of micronutrients helps in enhancement of photosynthetic and other metabolic activities which lead to an increase in various plant metabolites responsible for

cell division and cell elongation. Boron increases photo synthetic activity and respiration in plants and thus improves growth.

### **5.1.2 Total leaf area**

The total leaf area differed significantly due to the foliar spray of different micronutrients over the control.

The treatment T<sub>11</sub> application of (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%) resulted in the maximum leaf area (10.77cm<sup>2</sup> and 13.67cm<sup>2</sup>) at 30 and 60 days after first spray. Whereas, the minimum leaf area (8.60cm<sup>2</sup> and 10.63cm<sup>2</sup>) at 30 and 60 days after first spray were recorded in T<sub>12</sub> (control – water spraying). These results were similar with the earlier findings of Eaida *et al.* (2013) in pomegranate. This might be due to the use of micronutrients that play an important role in synthesis of auxins especially by zinc that increase cell division and increase the content of chlorophyll in the leaf, which resulted to increase the leaf area.

Dayal *et al.* (2010) reported that foliar application of zinc sulphate greatly influenced vegetative growth of ber plants *i.e.* shoot length, number of leaves /shoot and leaf area, this might be due to zinc plays major role in plant growth, development and increased the efficiency of metabolic and physiological processes of plant.

### **5.1.3 Shoot length (current season)**

The shoot length significantly differed among the treatments at all the stages of crop growth. The plants sprayed with Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1% recorded the maximum shoot length (37.67cm and 50.33cm) and minimum shoot length (28.67cm and 37.33cm) was observed in T<sub>12</sub> (control – water spraying) at 30 and 60 days after first spray respectively. The increase in growth parameters such as shoot length in the present investigation might be due to the foliar spray of micronutrients that results in immediate increase in the photosynthetic compounds inside the plant tissue which might be involved in the synthesis of tryptophan which is a precursor of IAA, so ultimately increases the vegetative growth of the plant.

Similar results were found by Yadav *et al.* (2010) in banana and Khan *et al.* (2009) in aonla.

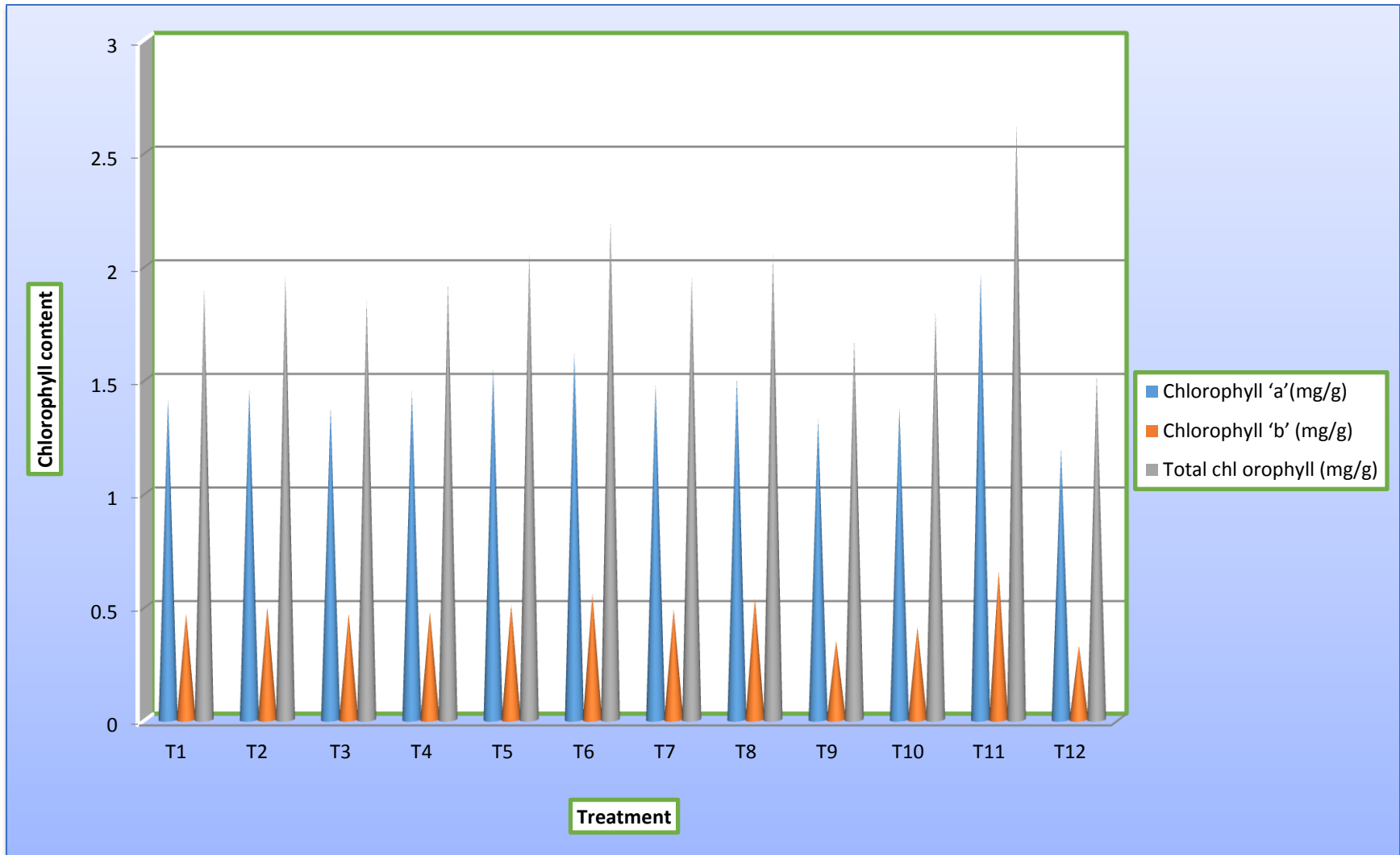
Further increase in the plant height and pseudostem girth was also due to application of proper dose of micronutrients, because they have important functioning role in chlorophyll synthesis and development of cells in meristematic tissues. Thus results are in confirmation with Shekar *et al.* (2010) in papaya.

Combination of micronutrients which helps to increase the plant growth like plant height, canopy spread might be due to zinc which is activator of enzyme, involve in the protein synthesis and had direct effect on the level of auxin in the plant, similar findings by Ram and Bose (2000) in citrus.

#### **5.1.4 Chlorophyll content**

The leaf chlorophyll content was significantly influenced by foliar spray of micronutrients (Fig 2). The maximum chlorophyll 'a', chlorophyll 'b' and total leaf chlorophyll content (1.97, 0.66 and 2.63 mg/g) was recorded in T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%) as foliar spray and the lowest (1.20, 0.33 and 1.52 mg/g) chlorophyll content was recorded in T<sub>12</sub> (control-water spraying). These observations are in conformity with those of Eaida *et al.* (2013) in pomegranate.

This might be due to the use of micronutrients and their role in the representation of critical auxins that increase cell division and increase the content of chlorophyll in the leaf, which works to increase the leaf area. Also due to that micronutrients helps in building the chlorophyll through its direct impact in the composition of amino acids and carbohydrates and energy compounds used in the construction of chlorophyll, as well as importance in building the necessary RNA in protein synthesis and stimulate the enzymes that participate in biological processes for the formation of chlorophyll reported by Eaida *et al.* (2013) in pomegranate.



**Fig. 2. Effect of foliar spray of micronutrients on chlorophyll content in leaf of pomegranate cv. Bhagwa**

## **5.2 Effect of foliar spray of micronutrients on yield and yield attributes of pomegranate cv. Bhagwa**

### **5.2.1 Fruit volume and fruit diameter**

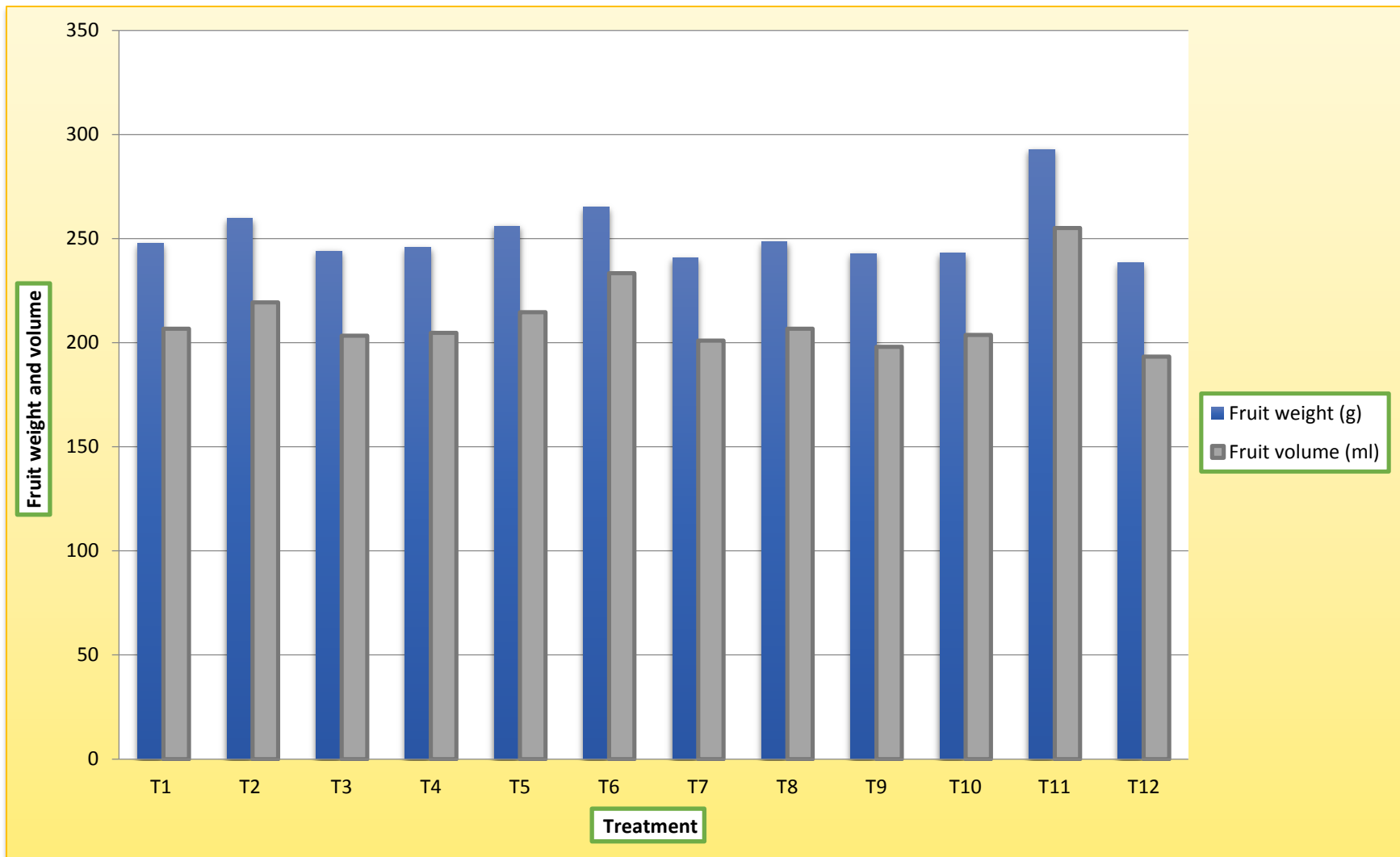
The foliar spray of micronutrients had significant influences on the fruit volume and diameter among the treatments (Fig 3). The highest fruit volume and diameter (255.00 ml and 9.64cm) was noticed in T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%) as foliar spray and the lowest fruit volume and diameter (193.33 ml and 7.03cm) was recorded in the treatment T<sub>12</sub> (control-water spraying). The similar result was also obtained by Hasani *et al.* (2012) in pomegranate, Shekhar *et al.* (2010) in papaya, Yadav *et al.* (2013) in banana and Yadav (2013) in peach.

The increase in fruit volume might be due to increase in cell size and intercellular space. The increase in size of fruit as a result of foliar application of micronutrients might be because it improved the internal physiology of developing fruit in terms of better supply of water, nutrients and other compounds vital for their proper growth and development reported by Yadav *et al.* (2013) in peach.

Dayal *et al.* (2010) the foliar application of zinc sulphate which influences the fruit length, diameter, fruit volume, fruit yield might be due to zinc play an important role in nitrogen and phosphorus metabolism, synthesis of growth regulating substances, oxidation and metabolic activity, which also increase the yield ultimately in ber plants. This might be due to foliar application of micronutrients which helps in multiplication and enlargement of cells and more accumulation of food materials like sugars and water in expanded cells. These results are in corroborated with the findings of Jayabaskaran and Pandey (2008).

### **5.2.2 Weight of fruit**

Fruit weight is an important yield contributing trait, which would improve the yield per unit area and thereby fetching a higher profit to the farmers. The results pertaining to weight showed that (Fig 3), the maximum fruit weight (292.67 g) was



**Fig. 3. Effect of foliar spray of micronutrients on yield attributes of pomegranate cv. Bhagwa**

obtained in T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%) as foliar spray, While the lowest fruit weight (238.33 g) was recorded in T<sub>12</sub> (control-water spraying). Similar result was also obtained by Hasani *et al.* (2008) and Eaida *et al.* (2013) in pomegranate, Nehete *et al.* (2011) in mango and Pathak *et al.* (2011) in banana.

Nehete *et al.* (2011) opined that the possible reason for increase in fruit weight in mango by the micronutrients might be due to faster loading and mobilization of photo assimilates to fruits and involvement in cell division and cell expansion which ultimately reflected into more weight of fruit in treated plants.

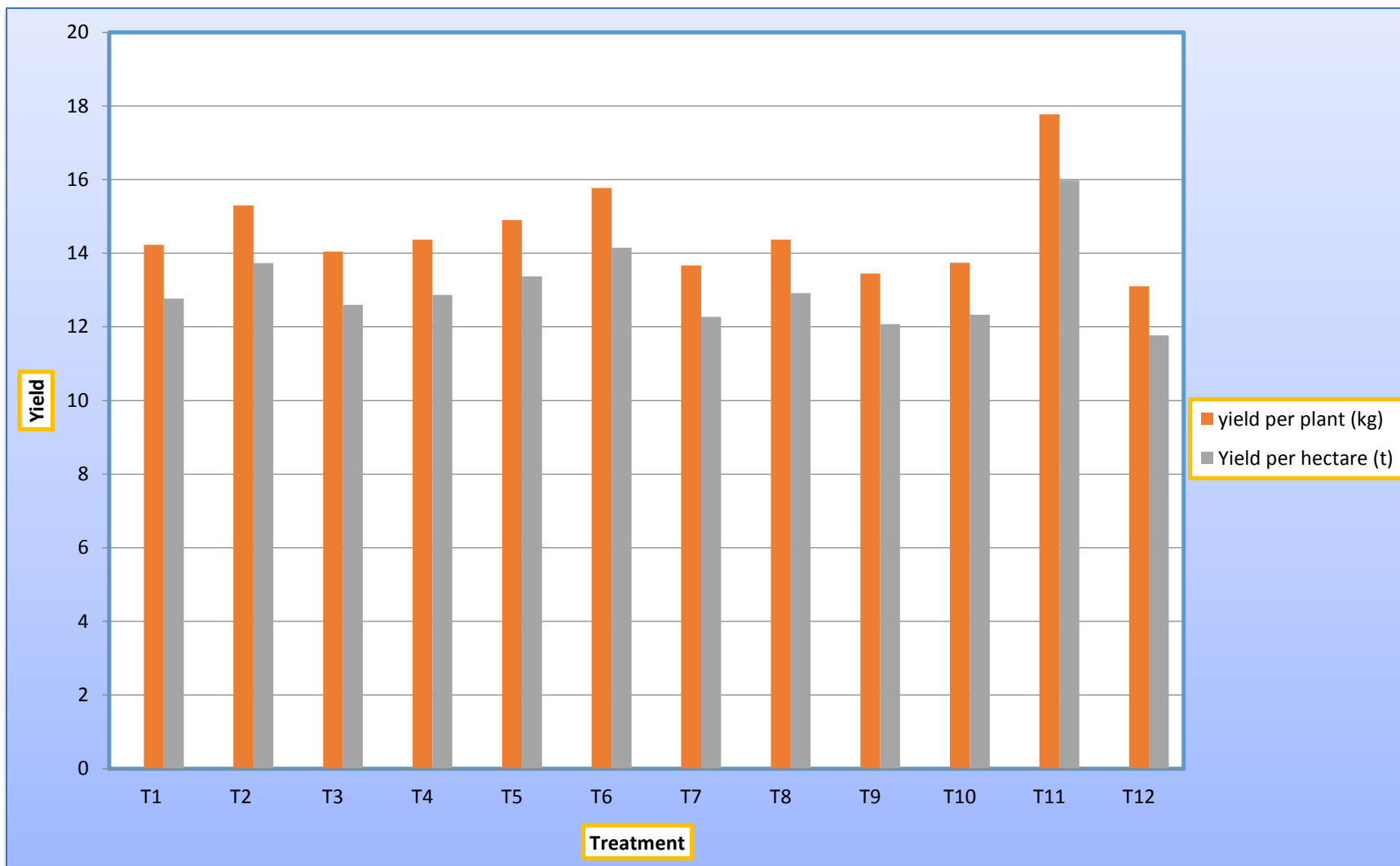
The increase in fruit weight in mango with the spray of borax was due to the involvement in hormonal metabolism, increase in cell division and expansion of cell. Boron is also known to stimulate rapid mobilization of water and sugar in the fruit. These results are in close conformity with the findings of Bhatt *et al.* (2012) and Yadlod and Kadam (2008a).

### **5.2.3 Number of fruits per plant**

The number of fruits per plant did not varied significantly among the treatments. The maximum number of fruits per plant (61.00) was obtained in treatment T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%) as foliar spray, While the lowest number of fruits per plant (55.00) was recorded in T<sub>12</sub> (control-water spraying).

### **5.2.4 Yield per plant and yield per hectare**

The results obtained in the experiment with foliar spray of micronutrients on yield per plant and yield per hectare differed significantly (Fig 4). The maximum yield per plant and yield per hectare (17.77 kg and 15.98 t/ha) was obtained in treatment T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%) as foliar spray, while the minimum fruit yield and yield per hectare (13.10 kg and 11.77 t/ha) was obtained in T<sub>12</sub> (control-water spraying). The similar result was also obtained by Hasani



**Fig. 4. Effect of foliar spray of micronutrients on yield of pomegranate cv. Bhagwa**

*et al.* (2012) and Eaida *et al.* (2013) in pomegranate, Shekhar *et al.* (2010) in papaya and Nehete *et al.* (2011) in mango.

The significant increase in fruit yield is a cumulative effect of increase in number of fruits because of reduction in fruit drop and higher fruit weight by the direct and indirect effect of foliar spray of micronutrients in mango cv. Kesar. Promotion of starch formation followed by rapid transportation of carbohydrates in plants activated by zinc and boron are well established. Foliar spray of micronutrients might have effected the physiological processes resulting into higher production reported Nehete *et al.* (2011) in mango.

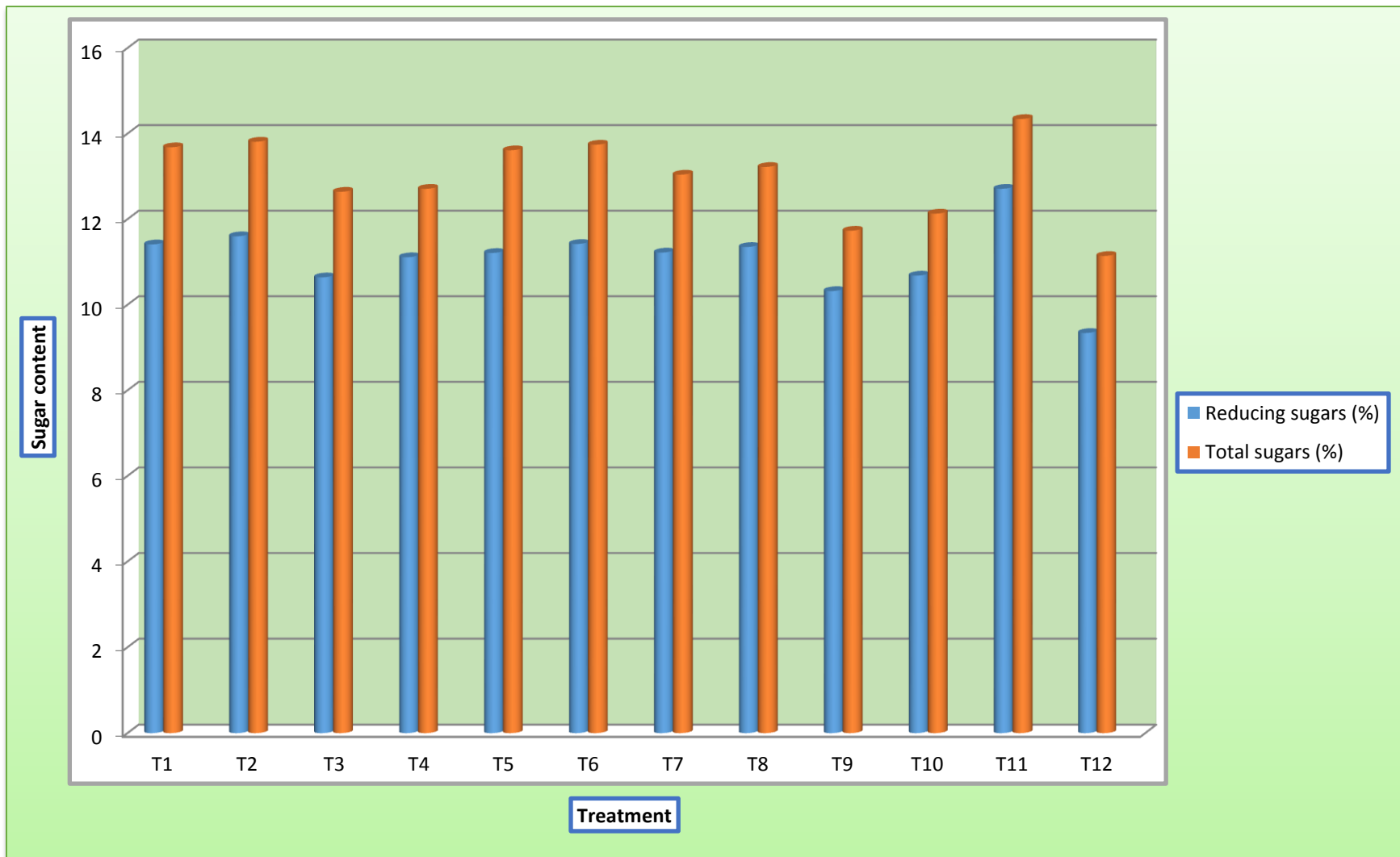
It is possibly due to their directly or indirectly involvement in setting, retention and growth and development of fruit, their activity improved number of fruits and average fruit weight reported Shekhar *et al.* (2013) in papaya.

Yadav *et al.* (2013) opined that in peach trees the combination of all the applied micronutrients significantly increased the yield of plants due to the beneficial roles of boron in pollination, zinc in growth promoting substances and iron in electron transport chain.

### **5.3 Effect of foliar spray of micronutrients on fruit quality of pomegranate cv. Bhagwa**

#### **5.3.1 Reducing, non-reducing and total sugars**

The results obtained from the study on effect of foliar spray of micronutrients on reducing sugar and total sugars of fruit differed significantly (Fig 5). The results obtained on non-reducing sugar were not altered significantly by the foliar spray of micronutrients. Among the different treatments T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%), showed increase in reducing sugar and total sugars (12.71% and 14.65%) respectively, while the decreased reducing sugar and total sugars (9.34% and 11.14%) was recorded in T<sub>12</sub> (control –water spraying). The similar result was obtained by Nehete *et al.* (2011) and Anees *et al.* (2011) in mango.



**Fig. 5. Effect of foliar spray of micronutrients on sugar content of pomegranate cv. Bhagwa**

The significant improvement in reducing sugar might be due to formation and translocation of carbohydrate which improves the fruit quality reported by Pathak *et al.* (2008) in banana. This might be due to involvement of micronutrients in translocation of more sugars to fruits reported by Shekhar *et al.* (2010) in papaya.

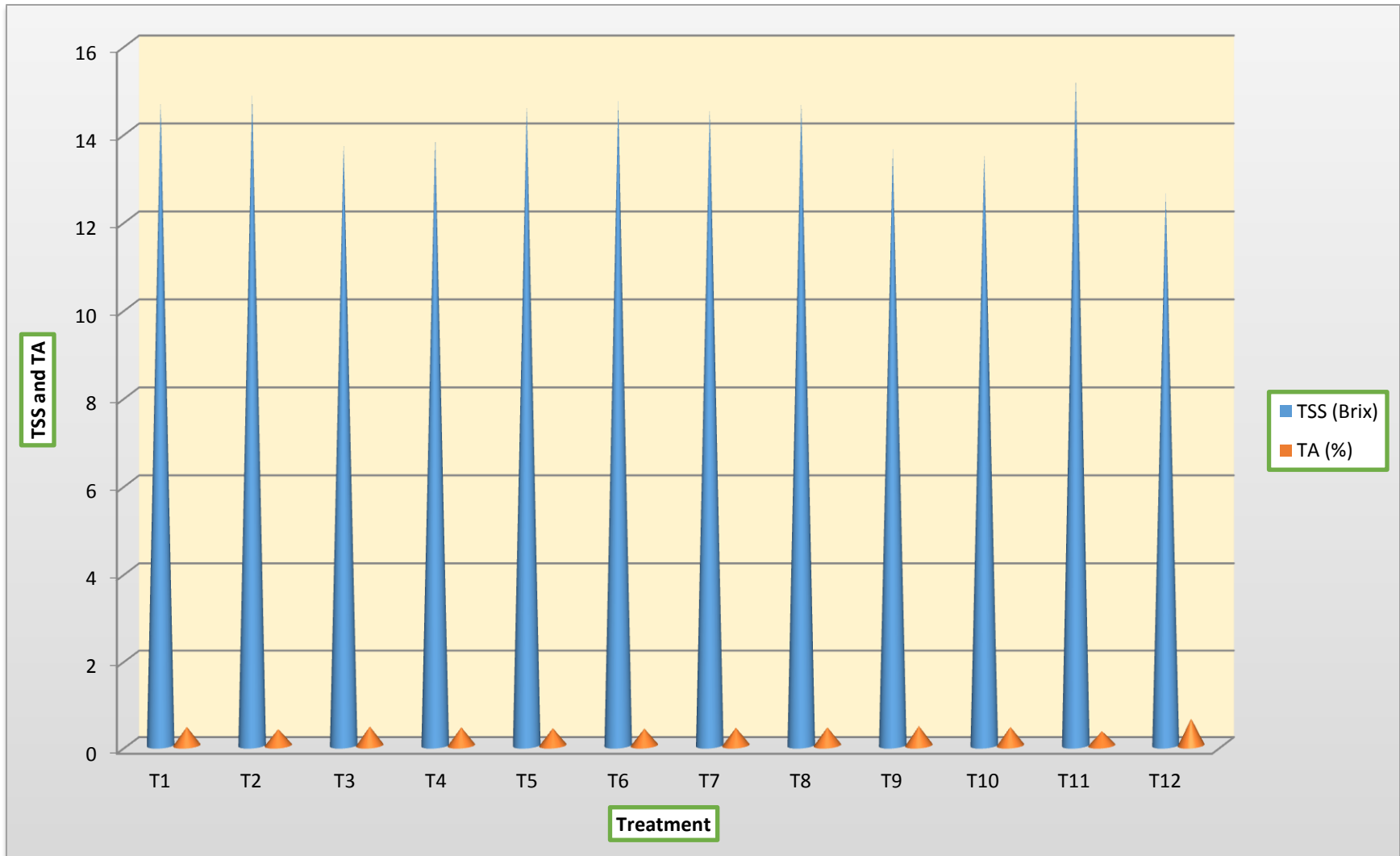
Combination of micronutrient sprays proved highly helpful in the process of photosynthesis and mobilization of food material leading to the accumulation of quality constituents like carbohydrate which ultimately promoted the quality attributes and quick metabolic transformation of starch and pectin into soluble compounds and rapid transformation of sugars from leaves to developing fruits reported by Nehete *et al.* (2011) in mango.

### **5.3.2 Total soluble solids, titratable acidity and TSS/TA ratio**

The total soluble solids (TSS), titratable acidity (TA) and TSS/TA ratio of fruits was significantly differed among the treatments (Fig 6). The higher total soluble solids and TSS/TA ratio (15.23 °Brix and 46.17%) was observed in the treatment T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%), while the lowest TSS and TSS/TA ratio (12.60 °Brix and 20.35%) was recorded in T<sub>12</sub> (control–water spraying). The lowest acidity (0.33%) was recorded in treatment T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%), while the increase in acidity (0.62%) in treatment T<sub>12</sub> (control –water spraying). The reduction in acidity might be due to more accumulation of sugars in the fruit. The similar results were obtained by Eiada *et al.* (2013) and Hasani *et al.* (2012) in pomegranate.

Increase in the TSS might be due to more rapid translocation of sugars from leaves to developing fruits. Boron facilitates the sugar transport within the plant and it was also reported by Yadav *et al.* (2013) in peach that borate reacted with sugar to form a sugar borate complex, which was more easily able to transverse membrane.

Micronutrients are believed to stimulate the function of numbers of enzymes and manganese is responsible for accumulation of carbohydrates from photosynthesis process where boron is believed to increase the translocation of food material in the plant system



**Fig. 6. Effect of foliar spray of micronutrients on quality parameters of pomegranate cv. Bhagwa**

and translocation of more metabolites to fruit. These results are in agreements with findings of Shekhar *et al.* (2010).

As manganese regulates the enzymatic activity, it would have activated the enzymes involved in the conversion of polysaccharide into simple sugars that increased the TSS of fruit reported by Dhinesh and Yadav (2005) in citrus.

Regulatory role of zinc is mediated through auxin induced cell enlargement accumulating water and solutes in the vacuole and the influence of boron in translocation of sugars might account for the increase of TSS content in fruits harvested from the plants sprayed with zinc and boron as well as their combination, similar results reported by Kar *et al.* (2002) in pineapple.

#### **5.4 Effect of foliar spray of micronutrients on fruit firmness and peel thickness of pomegranate cv. Bhagwa**

##### **5.4.1 Fruit firmness and peel thickness**

The effect of foliar spray of micronutrients showed significant differences with respect to fruit firmness and peel thickness. Among the different treatments the maximum fruit firmness and peel thickness (81.98 Newton and 3.66 mm) was recorded in T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%) as foliar spray, while the lowest fruit firmness and peel thickness (71.84 Newton and 2.86 mm) was recorded in T<sub>12</sub> (control-water spraying). The similar result was also obtained by Hasani *et al.* (2012) in pomegranate and Anees *et al.* (2011) in mango.

The improved in firmness and peel thickness of fruit is the result of foliar application of micronutrients in present investigation might be because it improved the internal physiology of developing fruit in terms of better supply of water, nutrients and other compounds vital for their proper growth and development reported by Yadav *et al.* (2013) in peach. The maximum amount of pulp content was might be due to foliar application of zinc and boron might have made rapid synthesis of metabolites particularly carbohydrates and their translocation to the fruits causing relatively greater pulp content similar results reported by Singh *et al.* (2012) in aonla.

## **5.5 Effect of foliar spray of micronutrients on post-harvest parameters of pomegranate cv. Bhagwa**

### **5.5.1 Physiological loss in weight**

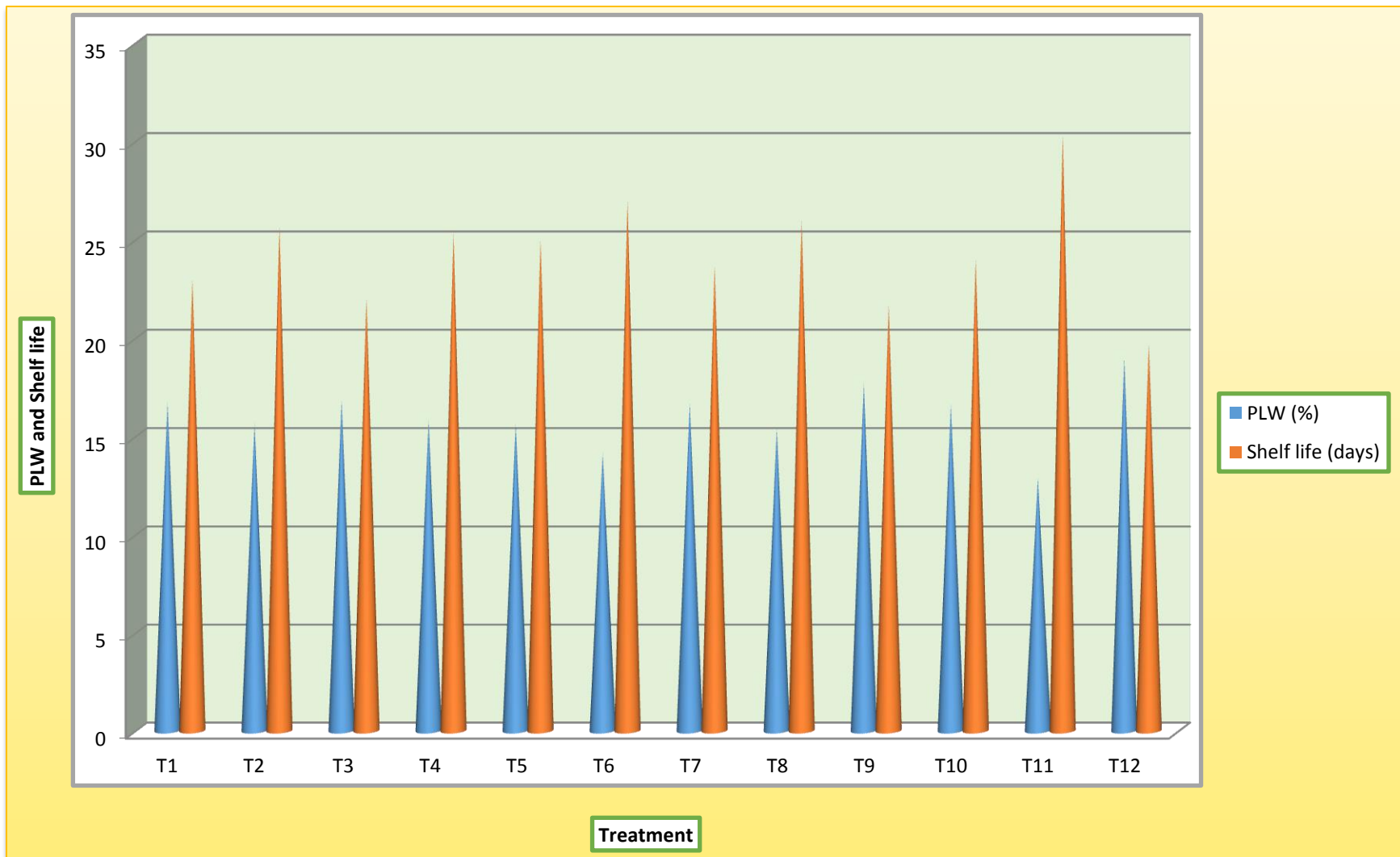
The result pertaining to physiological loss in weight (PLW) differed significantly among the treatments (Fig 7). The least physiological loss in weight (12.88 %) was noticed in T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%), while the highest PLW (18.98%) was recorded in T<sub>12</sub> (control-water spraying). Similar results were recorded in mango by Bhatt *et al.* (2012). The increase in the transpiration changes with progress of storage period might be responsible for high PLW of fruits. The decrease in weight loss by the application of micronutrients may be due to its role in the maintenance of fruit firmness, retardation of respiratory rates as well as transpiration and delayed senescence.

The decrease in physiological loss in weight of fruit might be due to a raised energy requirement at the time of ripening where the splitting of ATP occurs and resulting elevation of ADP level accelerates respiration. This increase in respiration might ultimately lead to pronounced loss in weight of fruit, reported by Deepa *et al.* (2008) in ber.

### **5.5.2 Shelf life**

The result pertaining to shelf life differed significantly among the treatments (Fig 7). The maximum shelf life (30.33 days) was observed in T<sub>11</sub> (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%) and minimum shelf life (19.67 days) was observed in T<sub>12</sub> (control-water spraying). Similar results were observed by Hassan *et al.* (2010) in plum and Pathak *et al.* (2011) in banana. This might be due to biochemical reaction inside the fruit tissues in terms of cell division and application micronutrients helps to synthesis of growth substance and metabolism.

The improvement in shelf life with the application of micronutrients might be due to its role in the maintenance of fruit firmness, retardation of respiration rates as well as transpiration and delayed senescence reported by Bhatt *et al.* (2012) in mango.



**Fig. 7. Effect of foliar spray of micronutrients on PLW and shelf life of pomegranate cv. Bhagwa**

## **5.7 Effect of foliar spray of micronutrients on nutrient content in leaf of pomegranate cv. Bhagwa**

### **5.7.1 Nutrient content in leaf (ppm)**

Manganese, zinc and iron content in the leaf was positively increased with foliar spray of micronutrients. In the present investigation the plants supplied with foliar spray of T<sub>4</sub> (Manganese 0.5%) increased the manganese status of pomegranate leaves and exhibited maximum manganese content (134.90ppm) over the control (T<sub>12</sub> –water spraying). Zinc content in the leaf was increased with foliar spray of T<sub>6</sub> (Zinc 0.8%) of pomegranate leaves exhibited maximum zinc content (115.74ppm) over the control (T<sub>12</sub>- water spraying). Iron content in the leaf was increased with foliar spray of T<sub>8</sub> (Iron 0.8%) of pomegranate leaves exhibited maximum iron content (107.10ppm) over the control (T<sub>12</sub>- water spraying). Similar results were reported by Hasani *et al.* (2012) in pomegranate and Nehete *et al.* (2011) in mango. Micronutrients spray on the leaves of sweet oranges increased the concentration of the respective nutrients in the leaves. The combination with zinc and manganese increased the fruit yield considerably, due to the interactions among the micronutrients.

Increase in leaves nutrient content may be due to its readily available nutrients and maximum absorption from nutrient source and less translocation to the other parts of the plant similar results were reported by Sajida and Hafeez (2000).

## **5.8 Economics**

The cost benefit ratio differed significantly due to treatments effects and compared to control and data is presented in the Table 12 and 13.

The treatment T<sub>11</sub> (foliar spray of Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%) had a maximum cost benefit ratio of (3.95) which was followed by T<sub>6</sub> (3.45), while the minimum cost benefit ratio (2.77) was recorded in T<sub>9</sub> (Sodium molybdate 0.1%). This might be due to reduced cost of cultivation and increased yield of pomegranate.

### **Future line of work**

Pomegranate being a high remunerative crop to the grower, wide scope to study the effect of both macro and micronutrients on the yield levels of pomegranate with different combinations and their importance in pest and disease resistance. The following studies may be initiated to study

- 1) The effect of both combination of macro and micronutrients on yield and quality of pomegranate.
- 2) Effect of different levels of micronutrients with respective occurrence of pest and diseases needs to be studied.

# **SUMMARY**

## VI SUMMARY

The field experiment was carried out at farmer's field of Alur village, Hiriyr taluk and Chitradurga district, to study the effect of foliar spray of micronutrients on growth, yield and quality of pomegranate (cv. Bhagwa) under central dry zone of Karnataka during 2014-15 and the results obtained on various characters are summarized in this chapter.

The foliar spray of (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%) recorded maximum fresh leaf weight (0.30g and 0.41g), dry leaf weight (0.07g and 0.17g) and leaf area (10.77cm<sup>2</sup> and 13.67cm<sup>2</sup>) at 30 and 60 days after first spray respectively. However similar trend was also found in case of shoot length with the maximum of 37.67cm and 50.33cm at both 30 and 60 days after first spray.

The foliar spray of (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%) recorded the maximum chlorophyll 'a', chlorophyll 'b' and total chlorophyll (1.97, 0.66 and 2.63mg/g) content in leaf respectively.

The maximum fruit weight (292.67g), fruit volume (255.00ml) and fruit diameter (9.64cm) was recorded in the foliar spray of (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%).

The maximum number of fruits per plant (61.00), yield per plant (17.77 kg) and yield per hectare (15.98t) was recorded in the foliar spray of (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%).

Among the different treatments, the foliar spray of (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%) showed increased reducing, non-reducing and total sugars (12.71%, 1.96% and 14.65%) respectively.

The higher total soluble solids (15.23 °Brix) and TSS/TA ratio (46.17%) was observed in the foliar spray of (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron

0.5% + Molybdenum 0.1%). However the higher titratable acidity (0.62%) was observed in the control (water spraying).

Among the different treatments, the higher fruit firmness (81.98 Newton) and peel thickness (3.66 mm) was recorded in the foliar spray of (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%).

The least physiological loss in weight (PLW) (12.88%) and maximum shelf life (30.33days) was noticed in the foliar spray of (Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1%).

Manganese content in the leaf was positively increased with foliar spray of micronutrients. In the present investigation the plants supplied with (Manganese 0.5%) (T<sub>4</sub>) increased the manganese status in leaf and exhibited maximum manganese (134.90 ppm).

Zinc content in the leaf was positively increased with foliar spray of micronutrients. In the present investigation the plants supplied with (Zinc 0.8%) (T<sub>6</sub>) increased the zinc status in leaf and exhibited maximum zinc (115.74 ppm).

Iron content in the leaf was positively increased with foliar spray of micronutrients. In the present investigation the plants supplied with (Iron 0.8%) (T<sub>8</sub>) increased the iron status in leaf and exhibited maximum iron (107.10 ppm).

### **Practical application of the findings**

The plants treated with foliar spray of Borax 0.1% + Manganese 0.25% + Zinc 0.5% + Iron 0.5% + Molybdenum 0.1% (T<sub>11</sub>) influenced on improved growth, increased yield, better quality and highest cost: benefit ratio as against the (T<sub>12</sub>) (Control –water spraying) of pomegranate cv. Bhagwa under central dry zone of Karnataka.

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# **APPENDICES**

## APPENDIX - I

Mean monthly meteorological data for the year 2014-2015 recorded at meteorological observatory of Agriculture Research Station, Hiriyr, Chitradurga District.

Months	Rainfall (mm)	Temperature ( <sup>0</sup> C)		Relative humidity (%)	
		Maximum	Minimum	Morning	Evening
April, 2014	158.00	36.06	21.60	86.57	63.13
May, 2014	43.40	35.34	21.79	84.52	63.39
June, 2014	2.40	33.69	22.34	92.00	70.30
July, 2014	11.80	30.87	20.70	89.19	62.45
August, 2014	116.30	30.93	20.34	76.84	62.23
September, 2014	71.40	31.71	27.38	82.97	68.10
October, 2014	24.40	32.01	21.59	78.32	60.48
November, 2014	84.00	30.65	19.04	71.10	44.33
December, 2014	1.40	30.22	17.45	71.74	52.71
January, 2015	0.00	31.57	17.26	91.10	73.13
February, 2015	5.00	33.02	19.64	45.36	60.18
March, 2015	9.00	35.40	21.85	63.42	60.52
<b>Mean/ Total</b>	527.10	31.49	20.91	77.76	61.74

## APPENDIX - II

### Physical and chemical properties of soil of the experimental site.

<b>PARTICULARS</b>	<b>VALUES</b>	<b>METHOD ADOPTED</b>
<b>Physical properties</b>		
<b>Soil type</b>	sandy clay loam	International pipette method (Piper, 1966)
<b>Chemical properties</b>		
<b>Soil pH (1:2.5 ratio)</b>	8.03	pH meter (Jackson, 1973)
<b>EC (dS/m at 25<sup>0</sup> C)</b>	0.14	Conductivity bridge (Jackson, 1973)
<b>Manganese content in leaf (ppm)</b>	55.0	Atomic absorption spectrometer
<b>Zinc content in leaf (ppm)</b>	42.4	Atomic absorption spectrometer
<b>Iron content in leaf (ppm)</b>	38.6	Atomic absorption spectrometer

## APPENDIX – III

### Cost of cultivation for pomegranate cv. Bhagwa.

No.	Materials/works	Pomegranate
		Hectare (900 pl.)
<b>I.</b>	<b>Inputs</b>	
1	Fertilizers (600: 250: 250 g NPK/plant)	
	a. Urea @ ₹6.25/kg	7331
	b. Rock phosphate @ ₹8.4/kg	10500
	c. MOP @ ₹ 16.88/kg	6330
2	Plant protection chemicals	20000
3	Plant protection equipments cost	5000
<b>II</b>	<b>Labour charges</b>	
1	Spraying of micronutrients -20 labour	3600
2	Irrigation, watch and ward	70000
3	Weeding and fertilizer application -30 labours	5400
4	Training and pruning	27000
5	Plant protection measures - 25 labours	4500
6	Harvesting-33 labours	5940
<b>III.</b>	<b>Other expenses</b>	
1	Misc. expenses (Land rent and others)	20000
	<b>Total (Rs.)</b>	<b>185601</b>

Note: Price of pomegranate/ Marketable price @ ₹ 60/kg.

## APPENDIX-IV

### List of symbols and abbreviations

Symbols	Abbreviations
%	Per cent
@	At
<sup>0</sup> C	Degree centigrade
CD	Critical difference
Cm	Centimeter
cm <sup>2</sup>	Centimeter square
cv.	Cultivar
<i>et al.</i>	Et alii (and other)
G	Gram
Ha	Hectare
<i>i.e.</i>	That is
Kg	Kilogram
m <sup>2</sup>	Meter square
Mg	Milligram
ml	Milliliter
Mm	Millimeter
Ppm	Parts per million
S.Em.	Standard Error of Mean
S.D	Standard deviation
<i>viz.</i>	As follows
Meq	Mili equivalent