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INTEGRATIVE APPROACHES OF MICRONUTRIENTS AND MULCH ON YIELD, QUALITY AND SOIL PROPERTIES OF GUAVA (*PSIDIUM GUAJAVA* L.) CV. HISAR SURKHA

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ABSTRACT

The results of this study indicate that the foliar application of micronutrients combined with mulching significantly enhances plant growth parameters, yield, and quality. Specifically, the treatment T_5 (Zinc@0.3% +Paddy straw@5cm) exhibited the most pronounced benefits. This combination increased leaf area to 58.22 cm², yield to 29.13 kg and fruit count per plant to 203.33. Furthermore, it positively affected quality attributes, resulting in a total sugar content of 7.81%, acidity of 0.22% and ascorbic acid concentration of 155.43 mg. economically, this treatment yielded the highest net return of Rs. 415,610.3, significantly outperforming the control treatment (T_1), which had a net return of Rs. 225,947.7.

Key words : Micronutrients, Mulching, *Psidium guajava*, Foliar application, Fruit quality.

Introduction

Guava (*Psidium guajava* L.) is one of the most important tropical and subtropical fruit crops known as apple of the tropics (Mehta *et al.*, 2018). Guava originated from tropical America stretching Mexico to Peru it has chromosome numbers 2n=22(n=11) (Sarkar *et al.*, 2016). It is successfully grown all over the country but the leading guava growing states are Uttar Pradesh, and Bihar. Guava fruits are rich in dietary fibre and vitamin-c and moderate levels of folic acid (Rajkumar *et al.*, 2017). It also contains some quantities of carbohydrates, sugars and pectin. Guava leaves contain a high concentration of flavonoids and polyphenols associated with potent antioxidant activity (Pandhi *et al.*, 2022). Guava plants often suffer from micronutrient deficiency, leading to lower yield and quality. Foliar feeding of nutrients and organic mulching has become crucial for addressing this issue. This method effectively corrects nutrient deficiencies, leading to increased productivity and improved produce quality. Nutrients like nitrogen, phosphorus, and potassium play a vital role in plant productivity, while micronutrients such as zinc, iron, boron, and calcium are crucial for plant growth, development, and nutrient uptake. Micronutrients like Zinc, Boron, Iron and Copper are especially important for metabolic activities in fruit physiology (Rawat *et al.*, 2010) and (Singh, 2011). Zinc is an essential micronutrient for plants. It is involved in numerous enzymatic reactions and is necessary for the growth and development of plants. Zinc also plays a role in regulating protein and carbohydrate metabolism (Kumar, 2014). Boron is a heavy non-metal micronutrient that has an effect on cell wall structure and plays a major role in cell elongation (pollen tube) and root growth. Boron deficiency commonly results in empty pollen grains, poor pollen vitality, and a reduced number of flowers per plant. Applying boron to foliage leads to a higher increase in fruit set and vegetative growth (Rawat *et al.*, 2010). Iron is the third most limiting nutrient for plant growth and metabolism, primarily due to the low solubility of the oxidized ferric form in aerobic environments Iron is necessary for many enzyme functions and serves as a catalyst for the synthesis of chlorophyll (Samaranayke *et al.*, 2012). Mulching is an important soil management practice that involves covering the soil surface around the base of plants. The role of mulching in conserving soil moisture, maintaining soil fertility, accelerating biological activities, preventing soil degradation, regulating soil temperature, improving soil aeration, increasing organic matter content and controlling weed growth has been well proven (Singh *el al*., 2015). Commonly used mulch materials in fruit orchards include pruned materials, paddy straw, neem leaves and banana leaves. Organic mulches serve as environmentally friendly tools for weed suppression and increasing production (Das *et al*., 2010).

Materials and Methods

The study was conducted at the Agriculture Research Farm, Department of Agriculture, Mata Gujri College, Sri Fatehgarh Sahib, Punjab. The research farm is situated at 30º56' 11.90" N and 76º18'13.18"E, 279 meters above sea level. The climate is subtropical with distinct winter, summer and rainy seasons. Temperature ranges from 4-45ºC and most rainfall occurs from July to September. The study carried 1-year data of 2023-24, including 12 treatments details are T_1 Control, T_2 Paddy straw @5cm, T_3 Neem leaves @ 2cm & banana leaves@ 3cm, T_4 Zinc @ 0.3%, T_5 Zinc@0.3% +Paddy straw@ 5cm , T_6 Zinc @ 0.3% + Neem leaves @ 2cm & banana leaves @ 3cm , T_7 Iron@0.1%, T_8 Iron@0.1% + Paddy straw@5cm, T_9 Iron @ 0.1% + Neem leaves @ 2cm + banana leaves @ 3cm, T_{10} Boron @ 0.2%, T_{11} Boron @ 0.2% + Paddy straw @ 5cm and T_{12} Boron @ 0.2% + Neem leaves @ 2cm & banana leaves @ 3cm each with replicated 3 times. Where, zinc, boron and iron applied by foliar application.

Increment in tree height (%) : A pre-marked bamboo pole was used to measure the tree's height. The height was measured starting from the trunk base (collar region) until the top of the terminal extension shoot, once before applying treatments and after harvest. The increase in height over the growing season was calculated and expressed in a percent increase in tree height. It was computed as:

$$\text{Increment in tree height} = \frac{\text{Tree height}_2 - \text{Tree height}_1}{\text{Tree height}_1} \times 100$$

Where, Tree height$_2$ = Tree height after harvest

Tree height$_1$ = Tree height before application of treatments (September)

Increment in stem girth (%) : Plant stem girth was measured at the beginning and end of the growing season, specifically at a height of (20-25) cm from ground level using a meter scale and the measurements were expressed as a percentage.

Increment in tree spread (%) : The tree's spread was measured in two directions: East-West and North-South. This was done before the start of the experiment and again after harvest (in March) using a measuring tape at the height where the spread was the greatest. The average of the East-West and North-South directions was taken as the spread and the increase in tree spread was then calculated. This increase was expressed as a percentage increase over the initial spread, accounting for increased stem girth and tree height.

Leaf area : The leaf area of various guava cultivars was measured using the leaf area meter (Systronics Leaf Area Meter 211). Ten samples from each treatment were collected to measure leaf area.

Number of fruit per tree : The total amount harvested at different periods from various treatments was counted and totaled regularly.

Fruit yield per tree (kg) : Mature fruits were picked at regular intervals in each treatment separately, and their weight was measured using an electronic scale. Next, the total yield (kg/plant) was computed.

Total sugar : Total sugar is determined by 25 g of fruit pulp taken in a 250 ml volumetric flask and thoroughly homogenized in distilled water. To this 10 ml of 45% saturated lead acetate was added and the contents were shaken and filtered and kept for ten minutes. Thereafter, 10 ml of 22% potassium oxalate was added to precipitate the excess lead and make the final volume 250 ml with distilled water. Then the contents were again filtered and 100 ml of the filtrate was taken in another 250 ml volumetric flask and 5 ml of concentrated hydrochloric acid was added to it. The hydrolysis was carried out by keeping it overnight. The excess of acid was then neutralized by adding saturated sodium hydroxide and the final volume was made to 250 ml with distilled water. The hydrolyzed aliquot was then taken in a burette and titrated against a boiling mixture of 5 ml solution each of Fehling A and Fehling B using methylene blue as an indicator (A. O. A. C., 1980). The end point was indicated by the appearance of brick red colour. Total sugar was expressed in (%) on a fruit weight basis.

Total sugar (%)

$$= \frac{\text{Fehling Factor} \times \text{Volume Made} \times 100}{\text{Titre value} \times \text{Volume of sample taken for estimation}}$$

Titratable acidity : To determine the acidity of the fruit, the juice extracted from 5 g of the sample was first filtered through a muslin cloth. Then, it was diluted to a known volume of 25 mL with distilled water. Subsequently, the diluted juice was titrated against standard NaOH solution, with the aid of Phenolphthalein as an indicator. The endpoint was indicated by the appearance of a light pink color, which was then recorded. The acidity value was expressed as a percentage, representing the concentration of acidity present in the fruit.

Titratable acidity (%)

$$= \frac{1 \times \text{Eq. Wt. of acid} \times \text{Normality of NaOH} \times \text{Titre} \times 100}{10 \times \text{Weight of sample}}$$

Ascorbic acid (mg/100g) : Fruit juice (10 ml) was taken in a conical flask and 3% HPO_3 solution was added to it to make the volume 100 ml. It was then centrifuged to have a clear solution. This solution was then filtered and 10 ml of this aliquot was taken into a flask. The standard dye prepared above was taken into a burette and the aliquot was taken into a burette and the aliquot was titrated against it. The appearance of a light pink colour persisting for a few seconds was considered as the endpoint. Finally, the ascorbic acid content of the sample was calculated by the following formula:

Ascorbic acid (mg/100 g of fruit juice

$$= \frac{\text{Titre} \times \text{Dye factor} \times \text{Volume made up} \times 100}{\text{Weight of sample}}$$

$$\text{Dye factor} = \frac{0.5}{\text{Titre value}}$$

Soil pH : The knowledge of soil pH is of paramount importance as it enables the prediction of soil fertility, the availability of nutrients, and the activity of microorganisms in soil. Soil pH calculated with soil: water (1:2) suspension, with the help of digital pH meter (Jackson, 1967).

Electrical conductivity (dS/m) : 20g of air-dried soil sample was taken, dissolved in 40ml of distilled water and mixed well. Leave it overnight to get the clear supernatant solution. The solution was used to measure the electronic conductivity with the help of an electrical conductivity bridge and expressed in dS/m (Jackson, 1967).

Available nitrogen : The available nitrogen in the soil was estimated using the alkaline potassium permanganate method as described by Subbiah and Asija (1956).

1. 20g of soil samples from each treatment were placed in Kjeldhal distillation flasks and mixed with distilled water.
2. Then, 100 ml of KMnO4 solution and 100 ml of 2.5% NaOH were added and the flask was corked.
3. Next, 25 ml of N/50 H2SO4 was pipetted into a 50 ml conical flask and 3 drops of methyl indicator were added.
4. The delivery tube was then inserted into the flask. Distilled ammonia gas from the distillation flask was passed into the conical flask with water.
5. When about 30 ml of distillate had collected in the flask, excess sulfuric acid was titrated against N/50 NaOH and the reading was recorded.
6. The endpoint was reached when the color changed from pink to yellow. The available nitrogen was calculated based on these readings.

Weight of given soil = 20g

Volume of N/50 H_2SO_4 taken = 25ml

Volume of N/50 NaOH taken =× (titrated value)

Volume of N/50 acid used for NH_3 = 25-x

1 ml of N/50 H_2SO_4 = 0.00028g of N

$$\text{Available Nitrogen} = \frac{(25 - X) \times 0.00028}{\text{Weight of soil taken}} \times 100$$

Available Phosphorous (kg/ha) : The available phosphorus in soil was determined using the Stannous Chloride reduced ammonium molybdate method with Olsen's Extractant (Olsen *et al.*, 1954) and measured on a UV Spectrophotometer at a 660nm wavelength.

Here are the steps used to determine the available phosphorous:

1. 2g of soil sample was placed in a conical flask, and a pinch of Darco G-60 and 50ml of 0.5 M $NaHCO_3$ (Olsen's reagent) at pH 8.5 were added.
2. The flask was shaken for 30 minutes on a mechanical shaker and filtered through a Whatman filter paper.
3. 5ml of the clear and colorless filtrate was transferred into a 25ml volumetric flask.
4. Then, 5ml of ammonium molybdate solution was added drop by drop, which contained 400ml of 10 N HCl/l. The content was slowly shaken to drive out the evolved CO_2. When the frothing completely ceased, distilled water was added to bring the volume to about 22ml.
5. 1ml of freshly diluted solution was added and shaken to make the volume up to 25ml. The intensity of the blue color was then read at a 660nm wavelength.

Additionally, a blank sample was run in the same manner, and a standard curve was prepared as follows:

- A series of 25ml volumetric flasks were taken.

- 0, 0.5, 1.0, 1.5, 2.0, and 2.5ml of a 2mg/l solution were pipetted into each flask.

- 5ml of Olsen's extract was added to each flask, followed by the addition of ammonium molybdate as per Olsen's method.

- The intensity of the blue color was measured, and a standard curve was drawn by plotting concentrations of P in µ against absorbance readings. Calculations:

$$\text{Available P}\left(\text{kg/ha}\right)=\frac{Q\times V\times 2.24\times 10^{6}}{A\times S\times 10^{6}}=\frac{Q\times V\times 2.24}{A\times S}$$

Where,

Q = quantity of P in kg read on X- axis against a sample reading

V = volume of extracting reagent used (ml),

A = volume of aliquot used for colour development (ml) and

S = weight of soil sample (g).

Available Potassium (kg/ha): The available potassium in the soil was determined and calculated using a flame photometer following the procedure outlined by Merwin and Peach in 1951. A 5g soil sample was placed in a 100ml conical flask, and then 25ml of neutral 1 N ammonium acetate solution was added. The mixture was shaken for 5 minutes and then filtered using Whatman filter paper. The potassium concentration in the filtrate was measured using a flame photometer.

Preparation of Standard Curve

The flame photometer readings were recorded for each working standard of potassium (K) after adjusting the blank to zero. A standard curve was then plotted by plotting the readings against the potassium concentrations.

Calculations

$$\text{Available K}\left(\text{kg/ha}\right)=C\times\frac{25}{5}\times 2.24=C\times 11.2$$

Where,

C stands for the concentration (mg/L) of potassium in the sample filtrate obtained on the X-axis, against the reading.

Results

Increment in tree height (%): The statistical analysis of the table indicates that the application of micronutrients, mulching and their combined effect has a notable influence on the increment of tree height of guava trees. It was observed that the highest increment in tree height 2.39% was recorded under the treatment N_1 ($ZnSO_4$@0.3), while the lowest increment in tree height 0.84% was recorded In N_0 (control) as compared to other treatments. Similarly, in the case of mulching the data revealed the highest increment in tree height 1.92% was recorded in M_2 (Neem leaves@2cm and banana leaves@3cm, while the lowest increment in tree height was 0.96% recorded in M_0 (control). Moreover, the results demonstrate the significant impact of combining micronutrients and mulching on the tree height with the highest increment in tree height 2.48% recorded under the treatment N_1M_1 ($ZnSO_4$@0.3%+ Paddy straw @ 5cm) and the lowest increment in tree height 0.33% was recorded in N_0M_0 (control).

Increment in stem girth (%): The data in the table indicates the significant effect of micronutrient, mulching and their combination on the fruit yield of guava trees. Data revealed that the highest increment in stem girth 2.59% was recorded under the treatment N_1 ($ZnSO_4$ @ 0.3%), while the lowest increment in stem girth 0.22% was recorded in N_0 (control). However, in the case of mulching the highest increment in stem girth of M_1 (Paddy straw@5cm) 0.46% was observed and the lowest increment in stem girth of 0.26% was measured in M_0 (control). The combined impact of micronutrients and mulching showed the highest growth 0.63% in stem girth under the treatment N_1M_1 ($ZnSO_4$ @ 0.3% + Paddy straw @ 5cm and the lowest increment in stem girth 0.10% was recorded in N_0M_0 (control).

Increment in tree spread (%) : The data presented shows the impact of different treatments on the spread of trees. The results indicate that micronutrients have a significant effect on tree spread. The treatment N_1 ($ZnSO_4$ @ 0.3%) resulted in the highest tree spread increase of 3.27%, while the control group N_0 showed the lowest increase at 0.97%. Additionally, the use of mulching also affected tree spread, with the highest increase of 2.44% observed in M1 (Paddy straw@5cm) and the lowest increase of 1.28% seen in M_0 (control). When the effects of micronutrients and mulching were combined, the highest tree spread increase of 3.63% was noted in treatment N_1M_1 ($ZnSO_4$@0.3% + Paddy straw@5cm), while the lowest increase of 3.31% was found in N_0M_0 (control). These findings indicate a significant combined effect of micronutrient and mulching on tree spread.

Leaf area (cm^{-2}) : The statistical analysis of the table indicates that the application of micronutrients, mulching, and their combined effect has a notable

Table 1 : Effect of foliar application of micronutrients and mulching on increment in tree height of guava.

Treatment details	Control (M_0)	Paddy straw @ 5cm (M_1)	Neem leaves@2cm and banana leaves@3cm(M_2)	Mean N
Control (N_0)	0.33[c]	0.49[c]	1.7[ab]	**0.84**
$ZnSO_4$@0.3% (N_1)	2.28[ab]	2.48[a*]	2.4[a]	**2.39**
$FeSO_4$@0.1% (N_2)	0.5[c]	1.65[ab]	1.5[b]	**1.22**
Borax@0.2% (N_3)	0.74[c]	2.22[ab]	1.98[ab]	**1.65**
Mean M	**0.96**	**1.69**	**1.92**	
Factors	**C.D. 5%**	**SE(m)**		
Micronutrients(N)	0.44	0.15		
Mulches(M)	0.38	0.13		
Interaction(N × M)	0.76	0.26		

*Same alphabet in a column show no significance difference.

Table 2 : Effect of foliar application of micronutrients and mulching on increment in stem girth of guava.

Treatment details	Control (M_0)	Paddy straw @ 5cm (M_1)	Neem leaves@2cm and banana leaves@3cm(M_2)	Mean N
Control (N_0)	0.10[i]	0.29[ef]	0.25[fg]	**0.22**
$ZnSO_4$@0.3% (N_1)	0.59[ab]	0.63[a*]	0.57[bc]	**0.59**
$FeSO_4$@0.1% (N_2)	0.15[hi]	0.40[d]	0.34[e]	**0.29**
Borax@0.2% (N_3)	0.20[gh]	0.47[c]	0.44[d]	**0.38**
Mean M	**0.26**	**0.46**	**0.39**	
Factors	**C.D.5%**	**SE(m)**		
Micronutrients(N)	0.01	0.004		
Mulches(M)	0.01	0.003		
Interaction(N × M)	0.02	0.006		

*Same alphabet in a column show no significance difference.

Table 3 : Effect of foliar application of micronutrients and mulching on increment in tree spread of guava.

Treatment details	Control (M_0)	Paddy straw @ 5cm (M_1)	Neem leaves@2cm and banana leaves@3cm(M_2)	Mean N
Control (N_0)	0.35[h]	1.37[f]	1.18[f]	**0.97**
$ZnSO_4$@0.3% (N_1)	3.31[b]	3.63[a*]	2.87[c]	**3.27**
$FeSO_4$@0.1% (N_2)	0.58[h]	2[d]	1.71[e]	**1.43**
Borax@0.2% (N_3)	0.88[g]	2.77[c]	2.17[d]	**1.94**
Mean M	**1.28**	**2.44**	**1.98**	
Factors	**C.D.5%**	**SE(m)**		
Micronutrients(N)	0.14	0.05		
Mulches(M)	0.12	0.04		
Interaction(N × M)	0.25	0.08		

*Same alphabet in a column show no significance difference.

influence on the leaf area of guava trees. It was observed that the maximum leaf area of 55.80 cm² was recorded under the N_1 treatment, representing an increase from the minimum leaf area of 50.48 cm² observed in the control group (N_0). Similarly, in the case of mulching, the data revealed that the maximum leaf area of 55.41 cm² was achieved with the application of (M_1) (Paddy straw @5cm), while the minimum leaf area of 52.41 cm² was noted in the control group (M_0). Moreover, the results demonstrate the significant impact of combining micronutrients and mulching on the leaf area, with the N_1M_1 treatment ($ZnSO_4$@0.3% + Paddy straw @5cm) yielding the maximum leaf area of 58.22 cm². This comprehensive analysis underscores the importance of

Table 4 : Effect of foliar application of micronutrients and mulching on leaf area (cm^2) of guava.

Treatment details	Control (M_0)	Paddy straw (M_1)	Neem leaves and banana leaves (M_2)	Mean N
Control (N_0)	44.93^{d}	54.01^{bc}	52.52^{c}	**50.49**
$ZnSO_4$@0.3% (N_1)	56.34^{ab}	58.22^{a*}	52.85^{c}	**55.80**
$FeSO_4$ @0.1% (N_2)	52.14^{c}	55.09^{bc}	52.59^{c}	**53.28**
Boron @0.2% (N_3)	56.22^{ab}	54.34^{bc}	52.70^{c}	**54.42**
Mean M	**52.49**	**55.41**	**52.67**	
Factors	**C.D. 5%**	**SE(m)**		
Micronutrients(N)	1.66	0.56		
Mulches(M)	1.44	0.49		
Interaction(N × M)	2.88	0.98		

*Same alphabet in a column show no significance difference.

Table 5 : Effect of foliar application of micronutrients and mulching on number of fruits per tree of guava.

Treatment details	Control (M_0)	Paddy straw (M_1)	Neem leaves and banana leaves (M_2)	Mean N
Control (N_0)	153.33^{f}	187.67^{cde*}	191^{bcde}	**177.33**
$ZnSO_4$@0.3% (N_1)	199.67^{ab}	203.33^{a}	196.67^{abcd}	**199.89**
$FeSO_4$ @0.1% (N_2)	201^{ab}	198.67^{ab}	186.33^{cde}	**195.33**
Boron @0.2% (N_3)	193^{abcde}	196.67^{abc}	194.33^{abcde}	**194.67**
Mean M	**186.75**	**196.58**	**192.08**	
Factors	**C.D.5%**	**SE(m)**		
Micronutrients(N)	5.30	1.79		
Mulches(M)	4.59	1.56		
Interaction(N × M)	9.19	3.11		

*Same alphabet in a column show no significance difference.

Table 6 : Effect of foliar application of micronutrients and mulching on fruits yield (kg/tree) of guava.

Treatment details	Control (M_0)	Paddy straw (M_1)	Neem leaves and banana leaves (M_2)	Mean N
Control (N_0)	19.17^{d}	26.23^{bc}	26.57^{bc}	**23.99**
$ZnSO_4$@0.3% (N_1)	27.87^{ab}	29.13^{a*}	27.57^{ab}	**28.19**
$FeSO_4$ @0.1% (N_2)	26.2^{bc}	27.27^{abc}	25.43^{c}	**26.30**
Boron @0.2% (N_3)	25.93^{bc}	26.6^{bc}	26.67^{bc}	**26.40**
Mean M	**24.79**	**27.31**	**26.56**	
Factors	**C.D.5%**	**SE(m)**		
Micronutrients(N)	1.03	0.33		
Mulches(M)	0.89	0.30		
Interaction (N × M)	1.78	0.60		

*Same alphabet in a column show no significance difference.

considering both micronutrient application and mulching practices in maximizing the leaf area of guava trees.

Number of fruits per tree : The data in the table indicates the significant effect of micronutrient, mulching and their combination on the number of fruits per tree of guava tree. Data revealed that the micronutrient plays a significant role in several fruits per tree, where the maximum number of fruits *i.e.*, 199.89 was recorded under the treatment N_1 ($ZnSO_4$@ 0.3%). While the minimum number of fruits per tree was recorded in N_0 (control) *i.e.*, 177.33. While in the case of mulching, it was also found significant result. The data revealed the maximum number of fruits per tree was recorded in M_1 (Paddy straw @ 5cm) *i.e.*, 196.58 while the minimum number of fruits per tree was recorded in M_0 (control) *i.e.*, 186.75. The table shows that the combined effect of micronutrients with mulching was found significant. A maximum number of fruits per tree was recorded under the treatment N_1M_1 ($ZnSO_4$ @ 0.3% + Paddy straw @ 5cm) *i.e.*, 203.33. The minimum number of fruits per tree was recorded in N_0M_0 (control) *i.e.*, 153.33 as compared to other treatments.

Fruit yield per tree (kg) : The data about the table indicates the significant effect of micronutrient, mulching and their combination on the fruit yield of guava trees. Data revealed that the micronutrient plays a significant role in fruit yield, where the maximum fruit yield *i.e.*, 28.19kg was recorded under the treatment N_1 ($ZnSO_4$ @ 0.3%). While the minimum fruit yield was recorded in N_0 (control) *i.e.*, 23.99 kg. While in the case of mulching, it was also found significant result. The data revealed the maximum fruit yield was recorded in M_1 (Paddy straw@5cm) *i.e.*, 27. While the minimum fruit yield was recorded in M_0 (control) *i.e.*, 24.79kg. From the table it is clearly shown that the combined effect of micronutrients with mulching was found significant. Maximum fruit yield was recorded under the treatment N_1M_1 ($ZnSO_4$ @ 0.3% + Paddy straw @ 5cm) *i.e.*, 29.13kg. The minimum fruit yield was recorded in N_0M_0 (control) *i.e.*, 19.17kg as compared to other treatments.

Total sugar (%) : The data pertaining to the table indicate the significant effect of micronutrient, mulching and their combination on

Table 7 : Effect of foliar application of micronutrients and mulching on total sugar (%) of guava.

Treatment details	Control (M_0)	Paddy straw (M_1)	Neem leaves and banana leaves (M_2)	Mean N
Control (N_0)	5.38[e]	6.77[d]	6.78[d]	**6.31**
$ZnSO_4$@0.3% (N_1)	7.57[ab*]	7.81[a]	6.99[cd]	**7.46**
$FeSO_4$ @0.1% (N_2)	7.22[bcd]	7.33[bc]	7.25[bcd]	**7.27**
Boron @0.2% (N_3)	7.39[abc]	7.22[bcd]	7.09[bcd]	**7.24**
Mean M	**6.89**	**7.28**	**7.03**	
Factors	**C.D.5%**	**SE(m)**		
Micronutrients(N)	0.25	0.08		
Mulches(M)	0.22	0.07		
Interaction(N × M)	0.43	0.15		

* Same alphabet in a column show no significance difference.

Table 8 : Effect of foliar application of micronutrients and mulching on acidity (%) of guava.

Treatment details	Control (M_0)	Paddy straw (M_1)	Neem leaves and banana leaves (M_2)	Mean A
Control (N_0)	0.33[a*]	0.32[a]	0.28[ab]	**0.31**
$ZnSO_4$@0.3% (N_1)	0.25[b]	0.22[b]	0.25[b]	**0.24**
$FeSO_4$ @0.1% (N_2)	0.24[b]	0.23[b]	0.32[a]	**0.26**
Boron @0.2% (N_3)	0.32[a]	0.23[b]	0.25[b]	**0.27**
Mean B	**0.28**	**0.25**	**0.27**	
Factors	**C.D.**	**SE(m)**		
Micronutrients(N)	0.03	0.01		
Mulches(M)	0.02	0.01		
Interaction(N × M)	0.04	0.01		

*Same alphabet in a column show no significance difference.

Table 9 : Effect of foliar application of micronutrients and mulching on ascorbic acid (mg/100g) of guava.

Treatment details	Control (M_0)	Paddy straw (M_1)	Neem leaves and banana leaves (M_2)	Mean N
Control (N_0)	140.2[e]	149.33[bcd]	146.93[cd]	**145.49**
$ZnSO_4$@0.3% (N_1)	153.97[ab]	155.43[a*]	150.4[bc]	**153.27**
$FeSO_4$ @0.1% (N_2)	145.33[cde]	149.03[bcd]	149.8[bcd]	**148.06**
Boron @0.2% (N_3)	144.8[de]	145.53[cde]	147.47[cd]	**145.93**
Mean M	**146.07**	**149.83**	**148.65**	
Factors	**C.D.**	**SE(m)**		
Micronutrients(N)	2.71	0.92		
Mulches(M)	2.35	0.79		
Interaction(N × M)	4.69	1.59		

*Same alphabet in a column show no significance difference.

the total sugar of guava tree. Data revealed that the micronutrient plays a significant role in total sugar, where the maximum total sugar was recorded under the treatment N_1 ($ZnSO_4$@0.3%) at 7.46%. While the minimum total sugar was recorded in N_0 (control) at 6.31%. While in the case of mulching, it was also found significant result. The data revealed the maximum total sugar was recorded under the treatment M_1 (Paddy straw@5cm) at 7.28% while the minimum total sugar was recorded in M_0 (control) at 6.89%. The result reveals that the combined effect of micronutrient with mulching was found significant. The highest total sugar was observed in N_1M_1 ($ZnSO_4$@0.3%+Paddy straw@5cm) at 7.81% and the minimum total sugar was recorded in N_0M_0 (control) at 5.38%.

Titratable acidity (%) : In terms of titratable acidity, data demonstrated that micronutrients play an important impact, having the lowest titratable acidity reported at 0.24% under treatment N_1 ($ZnSO_4$ @ 0.3%). The highest titratable acidity was found in N_0 (control) at 0.31%. In case of mulching the data revealed that the minimum titratable acidity was recorded at 0.25% for treatment T_2 (Paddy straw@5cm). The highest titratable acidity was reported in T_1 (control) at 0.28%. From the table it is clearly showed that the combined effect of micronutrient with mulching was found significant. Minimum titratable acidity was recorded under the treatment N_1M_1 ($ZnSO_4$@0.3% +Paddy straw@5cm) *i.e.*, 0.22%. While the maximum titratable acidity was recorded in N_0 M_0 (control) *i.e.*, 0.33% as compare to other treatments.

Ascorbic acid (%) : The data also indicates significant difference among the treatment for ascorbic acid. Data revealed that the micronutrient plays significant role in ascorbic acid, where the maximum ascorbic acid was recorded under the treatment N_1 ($ZnSO_4$@0.3%) at 153.27mg/100g. While the mimimum ascorbic acid was recorded in N_0 (control) at 145.49 mg/100g. In the case of mulching it was also found significant result. The data revealed the maximum ascorbic acid was recorded under the treatment M_1 (Paddy straw@5cm) at 149.83mg/100g and the minimum ascorbic acid was recorded in M_0

Table 10 : Effect of foliar application of micronutrients and mulching on available nitrogen (kg/ha) in soil.

Treatment details	Control (M_0)	Paddy straw (M_1)	Neem leaves and banana leaves (M_2)	Mean N
Control (N_0)	250.00[b]	257.67[a]	254[b]	253.89
$ZnSO_4$@0.3% (N_1)	253.33[b]	260[a*]	252.33[b]	255.22
$FeSO_4$ @0.1% (N_2)	250.33[b]	259.67[a]	259.33[a]	256.44
Boron @0.2% (N_3)	251[b]	259.33[a]	253[b]	254.44
Mean M	251.17	259.17	254.67	
Factors	**C.D.**	**SE(d)**	**SE(m)**	
Micronutrients(N)	N/A	0.96	0.68	
Mulches(M)	1.73	0.83	0.58	
Interaction(N × M)	3.46	1.66	1.17	

*Same alphabet in a column show no significance difference.

was recorded in N_2 ($FeSO_4$ @ 0.1%) *i.e.*, 256.44kg. The minimum available nitrogen was recorded in N0 (control) *i.e.*, 253.89 kg. While in the case of mulching it was found significant result. The data revealed the maximum available nitrogen was recorded in M_1 (Paddy straw @ 5cm) *i.e.*, 259.17kg. While the minimum available nitrogen was recorded in M_0 (control) *i.e.*, 251.17 kg. From the table it is clearly showed that the combined effect of micronutrient with mulching was found significant. Maximum available nitrogen was recorded under the treatment N_1M_1 ($ZnSO_4$ @ 0.3% + paddy straw @ 5cm) *i.e.*, 260kg. While the minimum available nitrogen was recorded in N_0M_0 (control) *i.e.*, 250 kg as compare to other treatment.

Table 11 : Effect of foliar application of micronutrients and mulching on economic parameters of guava.

S. no.	Treatments	Total cost of cultivation (Rs/ha)	Gross income (Rs/ha)	Net return (Rs/ha)	B : C ratio
T_1	Control	140519	366466.7	225947.7	1.61
T_2	No micronutrients + Paddy straw@5cm	140819	501581.3	360762.3	2.56
T_3	No micronutrients + Neem leaves@2cm & banana leaves@ 3cm	140719	507954.7	367235.7	2.61
T_4	Zinc@0.3% + No mulch	141119	532810.7	391691.7	2.78
T_5	Zinc@0.3% +Paddy straw@5cm	141419	557029.3	415610.3	2.94
T_6	Zinc@0.3% +Neem leaves@2cm & banana leaves@3cm	141319	527074.7	385755.7	2.73
T_7	Iron@0.1% + No mulch	140899	513690.7	372791.7	2.65
T_8	Iron@0.1% + Paddy straw@5cm	141199	514965.3	373766.3	2.65
T_9	Iron@0.1% + Neem leaves@2cm & banana leaves@3cm	141099	511778.7	370679.7	2.63
T_{10}	Boron@0.2% + No mulch	143063	514965.3	371902.3	2.60
T_{11}	Boron@0.2% + Paddy straw@5cm	143363	527712	384349	2.68
T_{12}	Boron@0.2% + Neem leaves@2cm & banana leaves@3cm	143263	509866.7	366603.7	2.56

(control) at 146.07mg/100g. The combined effect of micronutrients and mulching also found significant with the highest value in N_1M_1 ($ZnSO_4$@0.3%+Paddy straw@5cm) at 155.43mg/100g, which was statistically *at par* with T_4 ($ZnSO_4$@0.3% + control) at 153.97mg/100g.

Available Nitrogen : The data pertaining in the table clearly showed the effect of micronutrient, mulching and their combination on the available nitrogen in soil. Data revealed that the micronutrient found non significant in available nitrogen, where the maximum available nitrogen

Economic attributes : An examination of data among different treatment shows the maximum cost of cultivation was obtained under the treatment T_{11} (Boron@0.2% + Paddy straw @ 5cm) *i.e.*, Rs. 143363. While the minimum cost of cultivation was obtained under the treatment T_1 (control) *i.e.*, 140519 Rs. In case of gross income the maximum gorss income was obtained under the treatment T_5 (Zinc @ 0.3% + Paddy straw @ 5cm) *i.e.*, Rs. 557029.3. While the minimum gross income was obtained under the treatment T_1 (control) *i.e.*, Rs. 366466.7. And the maximum net return was obtained under the treatment T_5 (Zinc @ 0.3% + Paddy straw @ 5cm) *i.e.*, Rs.415610.3. While the minimum net return was obtained under the treatment T_1 (control) *i.e.*, Rs. 225947.7.

Discussion

In case of zinc, it is required in plants for synthesis of enzymes responsible for chlorophyil synthesis, thylakoid synthesis and chloroplast development. It is a component of various favo-protiens, peroxidase, catalase, cytochrome oxidase enzymes and found in ferrodoxin which precipitates in oxidation-reduction reaction eg. NO_4^- and SO_4^{2-} reduction, N-fixation etc. These activities are responsible for increase in vegetative growth attributes like plant height, plant spread, stem girth and leaf area in plants (Bakshi *et al.*, 2014) and (Mor *et al.*, 2024). *Journal of Plant Nutrition*, **47(3)**, 423-432. Mulching has also positive response on vegetative growth of guava by conserving soil moisture near to the root zone.

The production of more number of fruits per tree in the treatment could be due to zinc which act as catalyst in the oxidation and reduction process and is also great importance in the sugar metabolism thus increase the yield per tree and also increase the fruit weight. These findings agree with (Yadav *et al*., 2017). As far as the effect of micronutrients on guava yield and yield efficiency is concerned, the increase in fruit yield with the application of micronutrients may be attributed to increased fruit size, fruit weight and minimum fruit drop resulting from the effects of micronutrients on cell division, cell elongation and translocation of photosynthates and metabolites from leaves and others parts of plants to the developing fruits (Saini *et al*., 2021). The highest fruit yield which was obtained by foliar spray of micronutrients may be attributed to better uptake and mobilization of nutrients to the sink which caused better fruit development (Rajkumar *et al*., 2017).

An association of zinc with the synthesis of auxins in plants played a vital role along with the increase in enzymatic activities. It also acts as a catalyst in the oxidation and reduction process in plants. Guava possesses a climacteric phenomenon which triggers the dramatic changes in respiration. This leads the biochemical reactions including conversion of complex food material *i.e.* starch into simple substances like sugars (Mondal *et al*., 2023). Zn helps in other enzymatic reaction like the transformation of carbohydrates, activity of hexokinase and formation of cellulose and change in sugar are considered due to its action on zymohexose (Dutta and Dhua, 2002).

The highest titratable acidity was observed in T_1 (control) at 0.33%. Such type of results might due to transformation of organic acid into sugar at the time of ripening. Zinc has also shown to have an important role in photosynthesis and enzyme activation, resulting in increasing sugar and decreasing acidity (Bakshi *et al*., 2014).

The increase in ascorbic acid content of fruit juice was due to increase synthesis of catalytic enzymes and co-enzymes which are represented ascorbic acid and synthesized (Kazemi, 2014).

The increase in available nitrogen is mainly attributed to efficient weed control, increase in organic matter content, microbial activity, fast decomposition and mineralization of mulches and high soil moisture under paddy straw mulching (Hussain *et al*., 2020). Paddy straw mulch are used the physical structure of soil is altered. Aeration is increased in soil, which provides better atmosphere for root development (Sharma *et al*., 2019). Mulches also add organic matter to the soil thus increasing the nutrient status in soil solution.

Conclusion

From the results obtained during the present investigation with different treatments of micronutrients and mulching on vegetative growth, yield and quality of guava cv. Hisar Surkha, it is concluded that plants treated with Zinc @ 0.3% +Paddy straw@5cm significantly increased the height of plant, plant spread, number of leaves, leaf area, fruit length, fruit breadth and fruit weight also for biochemical and yield attributes, it was also found superior treatment as compared to all other treatment.

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