***Original Research Article***

**Effect of soil application of zinc sulphate on growth, yield and quality of guava cv. L-49**

**Abstract –** A field study was carried out to determine the effect of soil application of zinc sulphate on growth, yield and quality of guava cv. L-49 during rainy and winter season. Different soil applications were applied i.e. $T_1$ : $ZnSO_4$@ 0 g/plant (Control), $T_2$ : $ZnSO_4$@ 50 g/plant, $T_3$ : $ZnSO_4$@ 75 g/plant, $T_4$ : $ZnSO_4$@ 100 g/plant, $T_5$ : $ZnSO_4$@ 125 g/plant and $T_6$ : $ZnSO_4$@ 150 g/plant with three replications under randomized block design. The results of the study revealed significant increase in growth, yield and quality of guava fruit. However, application of $ZnSO_4$@ 125 g/plant proved to be the best treatment in in increasing the yield, fruit length & fruit breadth, fruit weight, TSS, Ascorbic acid and decreased acidity during rainy and winter seasons. For nutrient analysis, maximum N and Zn content in leaf and fruit was recorded under application of $ZnSO_4$@ 125 g/plant and maximum K content in guava fruit was observed due to application of $ZnSO_4$@ 100 g/plant. Thus, it can be concluded that effect of soil application of zinc sulphate increases the growth, yield and quality of guava fruits.

**Keywords :** L-49, Soil application, yield, TSS.

**Introduction:**

Guava (*Psidium guajava* L.), "Apple of the Tropics" and "Poor Man's Apple" is an important fruit crop of country, not because of large area and production, but due to its wider edapho-climatic adaptability . It is classified under genus Psidium covering about 150 species (Hayes, 1970) but only *Psidium guajava* L. has been commercially exploited. It was introduced in India in the 17$^{th}$ century by Portuguese and became a commercial crop. It is very popular fruit crop and widely grown in tropical and sub-tropical regions up to 1500 m above mean sea-level. It is being cultivated throughout the American tropics, Asia, Africa and Pacific Islands. It is a more income generating crop without much care and input as it is sturdy in nature, prolific in bearing even on marginal lands. It is considered as a multipurpose tree due to its utility as a fruit, fuel, fodder, timber and it is a highly remunerative crop. Although guava is native to Central America

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but now it is cultivated and naturalized throughout the tropics and due to increasing demand; it is also grown in some subtropical regions. Guava is a rich source of sugars, ascorbic acid and pectin. The content of ascorbic acid (Vitamin- C) ranges from 75-260 mg/100 g pulp which varies with cultivar, season, location and stage of maturity. Guava fruits are good source of vitamin A (about 250 IU/100g) and contain appreciable quantities of thiamine, niacin and riboflavin (Gaur *et al*., 2014, a). Micronutrients are required by the plants in small quantities and thus, can be applied more safely and easily through foliar application. Application of micronutrients through foliar fertilization has advantage of lower application rates, uniformity in distribution of fertilizer materials and quick response to applied nutrients (Parmar *et al*., 2014). Among these micronutrients, zinc is most important. Although soil application of zinc is potentially very efficacious but it is very unpopular. Zinc plays an important role in starch metabolism, acts as a cofactor for many enzymes and affects photosynthesis, nucleic acid metabolism and protein biosynthesis. Zinc deficiency can inhibit the growth of fruit trees by impeding photosynthesis, carbon metabolism and respiration, which reduces the yield and quality of fruit. Keeping in view, this experiment has been planned to study the "Effect of soil application of zinc sulphate on growth, yield and quality of guava cv. L-49" with the objective to study the requirement of zinc sulphate in guava.

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**Materials and Methods:**

The present investigation was conducted at Experimental orchard of Department of Horticulture, CCS Haryana Agricultural University, Hisar on 9 year old guava trees during the year 2018-22 for the rainy and winter season guava fruits. L-49 variety was selected as an experimental material to examine the eaffectof soil application of zinc sulphate on growth, yield and quality of guava. The time of application was first fortnight of July. The experiment comprised of total 6 soil applications i.e. $T_1$ : $ZnSO_4$@ 0 g/plant (Control), $T_2$ : $ZnSO_4$@ 50 g/plant, $T_3$ : $ZnSO_4$@ 75 g/plant, $T_4$ : $ZnSO_4$@ 100 g/plant, $T_5$ : $ZnSO_4$@ 125 g/plant and $T_6$ : $ZnSO_4$@ 150 g/plant with three replications under randomized block design. After soil application, the fruits were analyzed for plant height (m), yield (kg/plant), fruit weight (g), fruit length (cm), fruit breadth (cm), TSS (°Brix), acidity (%), ascorbic acid (mg/100 g pulp) and nutrient analysis (soil analysis before starting of the experiment and leaf & fruit analysis for N, P, K, Zn content).

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**Plant height (m) :**The initial and final heights of the trees were measured with the help of measuring pole, upto maximum point of height. Odd type shoots were ignored. The increase in plant height was calculated by the following formula:

$$\text{Plant height (m)} = \frac{\text{Final height} - \text{initial height}}{\text{Initial height}} \times 100$$

**Yield (kg/plant) :** To calculate total fruit yield, the total number of fruits per tree was multiplied with average fruit weight and the value was expressed in kilograms (kg/tree).

**Fruit weight:**Five randomly selected fruits from the tagged branch of the tree were picked and weighed on top pan electric balance. To calculate the average fruit weight the total fruit weight was divided by total number of fruits taken and expressed in grams (g).

**Fruit length and breadth (cm) :**The observations on size of fruits in terms of their length (cm) and diameter (cm) were taken with the help of Vernier Caliper, at the time of fruit harvesting. Then the average length and diameter were calculated and expressed in centimeter (cm).

**TSS (ºBrix) :** The total soluble solids (TSS) was measured by hand refractometer.

**Acidity (%) :** Acidity was estimated by using the method given in A.O.A.C. (1990).

The method is as follows :

**Reagents prepared**

The following reagents were prepared for further use:

1. Sodium hydroxide 0.1 N

2. Phenolphthalein indicator 1 per cent

**Procedure**

Five gram of fruit pulp was mashed in pestle morter using small amount of distilled water. Two ml of filtrate was pipetted out into a beaker and titrated against N/10 sodium hydroxide using phenolphthalein as an indicator. The appearance of light pink color atleast for 15 seconds was the endpoint of the titration. Acidity was expressed in terms of per cent citric acid equivalent after applying the following formula:

$$\text{Acidity (\%)} = \frac{\text{Titrate value x Normality of NaOH x Equivalent weight of citric acid}}{\text{Volume of juice taken (ml) x 1000}} \times 100$$

**Ascorbic acid (mg/100g pulp) :**The ascorbic acid content was estimated by following the standard method suggested by A.O.A.C, (1990).

**Reagents**

a) Metaphosphoric acid solution (3%)

| | |
|---|---|
| Metaphosphoric acid ($HPO_3$) | 15 g |
| Glacial acetic acid | 40 ml |
| Final volume adjusted | 500 ml |

b) 2, 6 dichlorophenol indophenol dye

| | |
|---|---|
| 2, 6-dichlorophenol indophenol dye | 50 mg |
| Sodium bicarbonate | 42 mg |
| Volume adjusted | 200 ml |

c) Standard ascorbic acid solution

50 mg of ascorbic acid ($C_6H_8O_6$) was dissolved in 50 ml metaphosphoric acid (3%).

**Estimation**

Grinding of 5 g of fruit pulp was done using 25 ml of 3 per cent metaphosphoric acid and filtered through muslin cloth. A 2 ml of filtrate was titrated against 2, 6-dichlorophenol dye until a distinctly rose pink colour appeared. Concurrently, 1.0 ml of standard ascorbic acid was also titrated against the dye. The results were manifested as mg of ascorbic acid per 100 g of fruit pulp. It was determined by the given mathematical formula:

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$$\text{Ascorbic acid (mg/100 g fruit pulp)} = \frac{\text{Titrate value x total volume}}{\text{Standard reading x ml of sample}} \times 100$$

**Soil Analysis**

**Collection of soil samples:**

Soil samples were collected at the start as well as at the end of experiment from the area under tree canopy in all four directions and were mixed. Trowel was used for this purpose and kept in clean polythene bags.

**Processingof soil samples:**

Soil samples were air dried in shade for three to four days. These were grinded using wooden mortar and pestle and passed through 2mm sieve to separate out the coarse fragments. Coarse fragments were discarded and fine earth samples were used for analysis.

**Available nitrogen (kg/ha)**

The alkaline permanganate method proposed by Subbiah and Asija (1956) was used for the determination of available nitrigen in soil sample. 2 g soil was taken in 800 ml kjeldahl flask and 20 ml of water and 0.32% $KMnO_4$ solution were added to it. In a conical flask 5 ml of N/50 $H_2SO_4$ was taken and 2-3 drops of methyl red indicator were added to it and the end of delivery tube was dipped into this flask. Tap water was run in the condenser. After this, 100 ml of 2.5% NaOH solution was added into the flask and corked immediately. Heater was switched on. After completion of distillation, conical flask containing distillate was removed first and the heater was switched off. Excess of $H_2SO_4$ was titrated against N/100 NaOH and volume was noted down. A blank was also done simultaneously. Kjeldahl flask was carefully removed after cooling and the contents were drained out.

**Available phosphorus (kg/ha)**

For the determination of available phosphorus, Olsen's method (Olsen *et al.*, 1954) was used. 2 g soil was taken in 100 ml wide mouthed bottle. A pinch of Darco G-60 and 20 ml of 0.5M $NaHCO_3$ were added to it. It was kept on mechanical shaker for 30 minutes and the suspension was filtered through Whatman no. 1 filter paper. 5 ml of filtrate was transferred in 25 ml volumetric flask and 5 ml of ammonium molybdate solution was added to it. It was shaken slowly for 5 minutes till frothing completely ceased. Distilled water was added washing down the sides to about 20 ml volume. After this, 1 ml of freshly diluted $SnCl_2$ solution was added and volume was made up to the mark with the help of distilled water. Contents were mixed and the intensity of blue colour was measured at wavelength of 660 nm using red filter on spectrophotometer.

**Available potassium (kg/ha)**

Available Potassium was determined by neutral normal $NH_4OAC$ solution using flame photometer (Hanway and Heidal, 1952). 5 g of soil was taken in a 100 ml conical flask and 25 ml of neutral Normal $NH_4OAC$ solution was added to it. It was shaken for 5 minutes and filtered through Whatman no. 1 filter paper. Concentration of K was measured using flame photometer.

**Leaf analysis**

Leaf samples were collected during August month from middle of non-fruiting branches. Forty to fifty leaves were taken from each tree. These were grinded using grinder and the powder formed was stored in clean polythene bags. These powdered leaf samples were used for digestion.

**Digestion:** 0.2 g plant sample was taken in 50 ml conical flask. 10 ml of diacid mixture ($H_2SO_4$ and $HClO_4$ in ratio of 9:1 for N,P,K & $HNO_3$ and $HClO_4$ in ratio of 4:1 for Zn, Fe) was added to it and kept overnight. After this, it was kept on hot plate and heated gently at first. Then, it was heated vigorously till it became a clear colourless solution of about 3-4 ml and all the fumes ceased out. It was cooled down and transferred to 50 ml volumetric flask and volume was made to the mark using distilled water. It was then filtered using Whatman no. 1 filter paper and used for analysis.

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**Nitrogen (%)**

Colorimetric or Nessler's method proposed by Lindner in 1944was used for the determination of total nitrogen. 0.2 ml of digested plant material was taken in 25 ml volumetric flask and 5 ml of distilled water was added to it. To it, about 1 ml of 10% NaOH was added to neutralize the

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acidity of solution. After this, 1 ml of 10% sodium silicate was added and the volume was made to about 20 ml. then, 2 ml of Nessler's reafent was added which gave orange colour complex. Volume was made to the mark. Intensity of colour was read on spectrophotometer by using blue filter at 440 nm wavelength. N content was calculated using standard curve.

**Phosphorus (%)**

Vanado-molybdophosphoric yellow color method proposed by Koenig and Johnson (1942) was used for the determination of total phosphorus in plant sample. 2 ml of aliquot was taken in 25 ml volumetric flask and 2-3 drops of 2,4-dinitrophenol indicator were added to it. After this, ammonia solution was added till yellow colour appeared and then 6 N HCl was added till it again became colourless. 5 ml of vanadomolybdate solution was added and the volume was made upto the mark. It was mixed well and the intensity of yellow colour was read on spectrophotometer using blue filter at 440 nm wavelength and P content was calculated using standard curve. A blank was also run simultaneously.

**Potassium (%)**

Flame photometer was used for the determination of Potassium in the acid digest of plant samples. 5 ml of digested plant material was taken in a 25 ml volumetric flask and the volume was made to the mark using distilled water. K concentration was measured using flame photometer. K content of the sample was calculated using the standard curve.

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**Zinc (mg/kg)**

Atomic Absorption Spectrophotometer (AAS) was used for the determination of Zn in the acid digest of plant samples. Diluted solution of the digested plant sample was analysed by using Atomic Absorption Spectrophotometer (AAS).

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**Results and Discussion:**

The initial soil nutrient status was calculated before the start of the experiment (Table 1).

**Table 1. Initial soil nutrients status**

| Properties | Values |
|---|---|
| Available N (Kg/ha) | 125.00 |
| Available P (Kg/ha) | 20.00 |
| Available K (Kg/ha) | 380.0 |

Soil application of zinc was found effective in influencing the growth and yield of guava fruit. The plant height was not affected by the soil application of zinc sulphate. During rainy season, the maximum yield (45.3 kg/plant) of guava fruit was recorded in $T_5$ i.e. $ZnSO_4$ @ 125 g/plant and during winter season the maximum yield (19.3 kg/plant) of guava fruit was recorded in $T_4$ i.e. $ZnSO_4$ @ 100 g/plant which was statistically at par with $ZnSO_4$ @ 100 & 150 g/plant and minimum yield was recorded under control. The total combined yield (64.6 kg/plant) of both rainy and winter seasons was recorded maximum under $T_5$ i.e. $ZnSO_4$ @ 125 g/plant (Table 2). Increase in yield may be due to increase in fruit set per cent, number of fruits, weight of fruits and decrease in fruit drop. Similar findings were reported by Nijjar and Brar (1977) in Kinnow, Khera *et al.* (1985) in citrus and Meena *et al.*(2005), Yadav *et al.*(2011), Jat and Kacha (2014)& Suman *et al.*(2016) in guava.

**Table 2: Growth and yield of guava as influenced by soil application of zinc sulphate**

| $ZnSO_4$ (g/plant) | Plant height (m) | Yield (kg/plant) | | |
|---|---|---|---|---|
| | | Rainy | Winter | Total |
| Control | 5.81 | 35.3 | 14.0 | 49.3 |
| 50 | 6.05 | 40.0 | 17.3 | 57.3 |
| 75 | 6.11 | 41.7 | 17.7 | 59.4 |
| 100 | 6.03 | 44.0 | 19.7 | 63.7 |
| 125 | 6.17 | 45.3 | 19.3 | 64.6 |
| 150 | 6.01 | 44.7 | 19.0 | 63.7 |
| CD (p=0.05) | NS | 1.7 | 1.1 | 2.2 |

The maximum fruit length during rainy season (5.15 cm) and winter season (6.03 cm) was recorded in $T_5$ i.e. $ZnSO_4$ @ 125 g/plant and minimum was recorded under control. The maximum fruit breadth during rainy season (4.63 cm) and winter season (5.49 cm) was recorded under $T_5$ i.e. $ZnSO_4$ @ 125 g/plant and minimum was recorded under control. On the other hand, the maximum fruit weight during rainy season (96.7 g) and winter season (124.7 g) was recorded under $T_5$ i.e. $ZnSO_4$ @ 125 g/plant which was statistically at par with $ZnSO_4$ @ 100 & 150 g/plant and minimum fruit weight was recorded under control (Table 3). The enlargement in fruit size is caused by drawing of photosynthates to the fruit as a consequence of intensification of the sink. An increase in fruit weight was due to accumulation of sugars and high pulp percentage in zinc treated fruits.Similar observations were recorded by Meena *et al.*(2005), Pal *et al.*(2008),Yadav *et al.*(2011), Goswami *et al.*(2012), Trivedi *et al.*

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(2012), Jat and Kacha (2014), Parmar *et al.* (2014), Arshad and Ali (2016) in guava and Sharma *et al.* (2009 b) in ber.

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**Table 3: Fruit length, fruit breadth and fruit weight of guava as influenced by soil application of zinc Sulphate**

| $ZnSO_4$ (g/plant) | Fruit length (cm) | | Fruit breadth(cm) | | Fruit weight (g) | |
|---|---|---|---|---|---|---|
| | Rainy | Winter | Rainy | Winter | Rainy | Winter |
| Control | 4.79 | 5.70 | 4.21 | 4.73 | 85.1 | 107.0 |
| 50 | 5.03 | 5.70 | 4.45 | 4.89 | 91.7 | 117.7 |
| 75 | 5.10 | 5.83 | 4.50 | 5.29 | 93.0 | 121.0 |
| 100 | 5.11 | 5.90 | 4.61 | 5.43 | 95.0 | 122.0 |
| 125 | 5.15 | 6.03 | 4.63 | 5.49 | 96.7 | 124.7 |
| 150 | 5.11 | 6.00 | 4.61 | 5.31 | 95.1 | 123.3 |
| CD (p=0.05) | 0.07 | 0.14 | 0.07 | 0.17 | 1.7 | 2.1 |

However, the maximum TSS during rainy season (10.3°Brix) and winter season (11.2°Brix) was also recorded under $T_5$ i.e. $ZnSO_4$ @ 125 g/plant and the minimum TSS was noted in control. The acidity during rainy and winter season was found non-significant. Similarly, the highest ascorbic acid content during rainy season (175.0 mg/100g pulp) was found under $T_3$ i.e. $ZnSO_4$ @ 75 g/plant and during winter season, the maximum ascorbic acid content (197.7 mg/100g pulp) was noted under $T_5$ i.e. $ZnSO_4$ @ 125 g/plant and minimum ascorbic acid content was found under control (Table 4). As zinc is credited with definite role in the hydrolysis of complex polysaccharides into simple sugars, synthesis of metabolites and rapid translocation of photosynthetic products and minerals from other parts of the plant to the developing fruits ultimately leading to the increase in TSS and the higher ascorbic acid content may be attributed to adequate supply of hexose sugars via photosynthetic activity which increases on application of micronutrients.Similar results were observed by Devi *et al.* (1997) in sweet orange, Meena *et al.*(2005), Yadav *et al.*(2011), Jat and Kacha(2014) in guava and Sharma *et al.*(2009 b) in ber.

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**Table 4: Quality of guava as influenced by soil application of zinc sulphate**

| $ZnSO_4$ (g/plant) | TSS (°Brix) | | Acidity (%) | | Ascorbic acid (mg/100g) | |
|---|---|---|---|---|---|---|
| | Rainy | Winter | Rainy | Winter | Rainy | Winter |
| Control | 9.3 | 9.6 | 0.47 | 0.41 | 151.7 | 182.7 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **50** | **9.9** | **10.4** | **0.46** | **0.42** | **163.7** | **189.3** |
| **75** | **10.0** | **10.7** | **0.46** | **0.42** | **175.0** | **193.7** |
| **100** | **10.1** | **11.1** | **0.44** | **0.41** | **167.3** | **195.0** |
| **125** | **10.3** | **11.2** | **0.46** | **0.40** | **171.7** | **197.7** |
| **150** | **10.2** | **11.1** | **0.47** | **0.41** | **170.7** | **197.0** |
| **CD (p=0.05)** | **0.2** | **0.2** | **NS** | **NS** | **2.9** | **2.5** |

The leaf nutrient content of guava was highly influenced by the soil application of zinc sulphate. The maximum N (1.50 %) and Zn (37.33 mg/kg) content in leaf was recorded under $T_5$ i.e. $ZnSO_4$ @ 125 g/plant and minimum was recorded under control. On the other hand, maximum K (0.77 %) was recorded under $T_4$ i.e. $ZnSO_4$ @ 100 g/plant and minimum was noted under control. The P content of leaf was not much affected by the soil application of zinc sulphate (Table 5). Increase in zinc sulphate leads to increasing nitrogen concentration in soil. The zinc content increased might be due to soil application of zinc sulphate. Similar results were obtained by Amiri *et al.*(2008) in apple.

**Table 5: Leaf nutrient content of guava as influenced by soil application of zinc sulphate**

| **$ZnSO_4$ (g/plant)** | **N (%)** | **P (%)** | **K (%)** | **Zn (mg/kg)** |
|---|---|---|---|---|
| **Control** | **1.21** | **0.24** | **0.60** | **28.77** |
| **50** | **1.4** | **0.28** | **0.71** | **31.33** |
| **75** | **1.41** | **0.39** | **0.74** | **34.00** |
| **100** | **1.45** | **0.31** | **0.77** | **34.77** |
| **125** | **1.50** | **0.30** | **0.75** | **37.33** |
| **150** | **1.49** | **0.32** | **0.76** | **36.00** |
| **CD (p=0.05)** | **0.09** | **N.S** | **0.07** | **1.70** |

The nutrient content of guava fruit was also influenced by soil application of zinc sulphate. The maximum N (3.77 %) and Zn (8.21 mg/kg) content in guava fruit was recorded under $T_5$ i.e. $ZnSO_4$ @ 125 g/plant and minimum was recorded in control. The P and K content of guava fruit were found non significant (Table 6). Increase in zinc sulphate leads to increasing nitrogen concentration in leaf. The maximum zinc concentration may be due to the reason that zinc easily moved down to the soil profile and was efficiently taken up and transported to above ground parts. Similar findings was noted by Nijjar and Brar (1977) in Kinnow, Devi *et al.*(1997) in Sathgudi orange, Pawan (1998) in apple and Kavitha *et al.* (2002) in papaya.

**Table 6: Nutrient content of guava fruit as influenced by soil application of zinc sulphate**

| **$ZnSO_4$ (g/plant)** | **N (%)** | **P (%)** | **K (%)** | **Zn (mg/kg)** |
|---|---|---|---|---|

| $ZnSO_4$ (g/plant) | N (%) | P (%) | K (%) | Zn (mg/kg) |
|---|---|---|---|---|
| Control | 3.11 | 0.27 | 0.59 | 7.09 |
| 50 | 3.51 | 0.31 | 0.71 | 7.71 |
| 75 | 3.63 | 0.30 | 0.72 | 8.17 |
| 100 | 3.61 | 0.33 | 0.75 | 8.13 |
| 125 | 3.77 | 0.32 | 0.76 | 8.21 |
| 150 | 3.76 | 0.29 | 0.74 | 8.20 |
| CD (p=0.05) | 0.23 | N.S | N.S | 0.11 |

**Conclusion:**

Micronutrients like zinc play an important role in growth, fruit retention and development and cause efficient yield improvement. Results revealed that the maximum yield (64.6 kg/plant), TSS (10.3 & 11.2°Brix**)** and ascorbic acid (171.7 & 197.7 mg/100g pulp) during rainy and winter seasons and N and Zn contents in leaves and fruits of guava cv. L-49 were recorded in 125 g $ZnSO_4$. So, there is need to disseminate this soil application of zinc sulphate on guava among the farmers with effective extension methods like front line demonstration and others etc.

**Comment [PKAFO23]:** Name of season??

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