Effect of Nitrogen With or Without Zinc and Manganese on Growth, Yield and Quality of Guava [*Psidium guajava* (L.)] var. Gwalior-27

THESIS

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MASTER OF SCIENCE

In

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(HORTICULTURE)

By

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CERTIFICATE – I

This is to certify that the thesis entitled **“Effect of nitrogen with or without zinc and manganese on growth, yield and quality of guava [*Psidium guajava* (L.)] var. Gwalior-27”** submitted in partial fulfilment of the requirement of the degree of **Master of Science in Agriculture (Department of Horticulture)** of the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior is a record of the bonafide research work carried out by **Mr. Jagdish Chandra Ganava** under my guidance and supervision. The subject of the thesis has been approved by Student’s Advisory Committee and the Director of Instruction.

No part of the thesis has been submitted for any degree or diploma (Certificate awarded etc.) or has been published/published part has been fully acknowledged. All the assistance and help received during the course of investigation has been acknowledged by him.

Place : Gwalior
Date :

(Dr. K.S. Tomar)
Chairman
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Thesis approved by the Student’s Advisory Committee

Chairman	**(Dr. K.S. Tomar)**	________________
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Member	**(Dr. (Mrs.) Asha Arora)**	________________
Member	**(Dr. N.S. Bhadauria)**	________________
Member	**(Dr. V.B. Singh)**	________________

CERTIFICATE – II

This is to certify that the thesis entitled **"Effect of nitrogen with or without zinc and manganese on growth, yield and quality of guava [*Psidium guajava* (L.)] var. Gwalior-27"** submitted by **Mr. Jagdish Chandra Ganava** to the **Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior** in partial fulfilment of the requirements for the degree of **Master of Science in Agriculture** in the **Department of Horticulture, College of Agriculture, Gwalior** has been, after evaluation, approved by the External Examiner and by the Student's Advisory Committee after an oral examination of the same.

Place : Gwalior
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CHAPTER-I
INTRODUCTION

Guava (*Psidium guajava* L.) is the most popular fruit in the tropical and sub-tropical parts of India because of its low cost of cultivation, more tolerance to drought and semiarid conditions as well as salinity problems and wide adaptability to varying soil and climatic conditions. It has gained considerable prominence owing to its high nutritive value, easy availability at moderate price with pleasant aroma and good flavour of fruits. Guava is a good source of calcium and iron, fair source of phosphorus and rich source of vitamin C and pectin. Guava fruits are also used for many preparations like jam, jelly and RTS beverage.

It is grown over an area of 1.51 lakh hectares in India with an annual production of 18 lakh tonnes accounting for 4.10 and 4.09 per cent of area and production of fruits, respectively.

Different nutrients play important role in improving the yield and quality of fruits to a great extent. It has been noticed that guava suffers severely from deficiency of micronutrients specially zinc and manganese which reduce the quality of guava fruits, however, very little work has been done on these micronutrients in respect of growth, yield and quality of guava. The response of guava plant to these micronutrients may vary from region to region. In view of above facts the present investigation was, therefore, carried out at Pomology Orchard, College of Agriculture, Gwalior to know the effect of nitrogen with and without zinc and manganese application on the growth, yield and quality of guava with the following objectives:

1. To find out the optimum dose of nitrogen.
2. To study the suitable concentration of zinc spray.
3. To determine the suitable concentration of manganese spray.
4. To find out the suitable combination of nitrogen and zinc or manganese for better growth, yield and quality of guava.

CHAPTER-II
REVIEW OF LITERATURE

In this chapter, an attempt has been made to review the research work done so far in India and abroad by different workers on the effect of nitrogen with and without zinc and manganese on growth, yield and quality of guava [*Psidium guajava* (L.)].

Effect of nitrogen:

Nitrogen plays a key role in the nutrition of plants. It is the chief growth stimulating essential element and is important for maintaining vigour and health of tree. Nitrogen is a vital component of the protoplasm, chlorophyll molecule and amino acids from which protein as well as nucleic acids are made. Nitrogenous compounds comprise about 40-50 per cent of dry matter of living substances of plant cells, Because of these reasons nitrogen is required in relatively large quantities in connection with all growth process in plant. It also helps in the utilization of phosphorus, potassium and other elements. Nitrogen deficiency is manifested by stunted growth, pale green to yellowish leaves of the plants. The older leaves are most affected by nitrogen deficiency, as it is a relatively mobile element and is withdrawn from the old leaves and translocated to the young leaves

Howard and Sprague (1949) stated that nitrogen a constituent of both chlorophyll and protoplasm is vitally essential for energy transformation within the plant and for the development of its cellular contents.

Gardner *et al.* (1952) opined that nitrogenous fertilizers increase vigorous vegetative growth in fruit trees and show remarkable effect on the setting of fruits especially.

Tiwari *et al.* (1968) reported that application of nitrogen stimulated growth, increased flower number and fruit yield.

Arora and Singh (1970) reported that spray of urea at 1 or 2 per cent level on guava var. Allahabad Safeda enhanced total fruit yield, weight of fruit, length of fruit, diameter of fruit, vitamin C (mg), TSS (%), reducing sugar, non-reducing sugars and pectin content.

Singh and Singh (1970) observed significant effect of nitrogen levels (0.0 kg, 0.90 kg, 1.36 kg and 1.82 kg/plant) on size and weight of guava fruits as they amplified with the increase in nitrogen dose. However, both the higher doses did not show any significant difference.

Rajput and Singh (1973) observed positive response of N application on fruit development and yield.

Singh and Rajput (1977) reported that urea spray in mid-July and mid-January on guava trees at 4% level was most effective. TSS, reducing and total sugar contents were highest in over-ripe fruit but ascorbic acid and pectin contents were highest in ripe fruits.

Shikhamany *et al.* (1978) reported that nitrogen application increased the rainy season yield by augmenting fruit weight while the dry season yield was raised by an increased number of fruits on the fertilized trees. The total fruit yield was highest (108 kg/tree) in trees receiving the highest N rate (3 g/cm trunk circumference).

Anonymous (1980) recommended 430 g nitrogen per tree of guava in Madhya Pradesh soils. While Singh (1982) found 400 g nitrogen sufficient for guava plant in Madhya Pradesh.

Lekhi (1983) reported that the different doses of nitrogen 0 g, 200 g, 425 g, 850 g per plant did not show any significant difference on growth and yield of guava var. Gwalior 27. However, he observed a marginal increase in length and girth of tertiary shoots, percent fruit set, number of fruits, length and diameter of fruits, weight and yield of fruits with the increase in nitrogen doses.

Singh *et al.* (1983) reported that 3% urea spray significantly increased fruit weight (108.35 g), fruit length (6.36 cm), fruit width (6.25 cm), TSS (13.10%), ascorbic acid (175.21 mg/100 g), reducing sugar (4.25%), total sugar (7.12%) and decreased fruit acidity (0.42%).

Singh (1985) reported that the foliar application of 4 or 6% urea, increased the length of the terminal shoot, the leaf area/shoot, fruit retention, fruit weight, diameter and fruit yield/tree and reduced the duration of flowering. Mean yields were 56, 62.2 and 67.3 kg/tree for the control, 4% and 6% treatments, respectively. Urea treatment also improved fruit quality by increasing the TSS, sugar, ascorbic acid and pectin contents and reducing fruit acidity.

Sharma (1985) reported a significant improvement in length and girth of tertiary shoots, per cent fruit set, number of fruits, length and diameter of fruit, weight and yield of fruits with increase in dose of nitrogen up to 650 g nitrogen per plant.

Singh (1986) reported non-significant effect of nitrogen on vegetative growth and yield of guava plants with the application of nitrogen. However, he reported a marginal effect on different vegetative and yield components with the increase in nitrogen dose.

Mitra (1987) studied the effect of nitrogen levels (0, 130 and 260 g/plant/year) on guava and reported that the highest dose of nitrogen (260 g/plant) improved the fruit weight by about 21 per cent.

Shanmugavelu (1987) reported that urea spray at 1 or 2% increased vitamin C and TSS content of the guava fruit.

Dahshan and Ali (1990) reported that the soil application of N, P, and K in the ratio of 4:1:3 with a net amount of 600 g N per tree annually during growing season in four equal split doses along with farmyard manure markedly improved the growth parameters, yield and fruit quality of guava.

Ghosh (1991) reported that application of higher dose of nitrogen (225 g) per tree gave significantly more number of fruits per tree, higher yield per plant, T.S.S. and total sugar content over lower dose of nitrogen (100 g/plant).

Tassar *et al.* (1992) reported that application of 400 g N/tree in rainy season resulted in the longest terminal shoot length (18.66 cm), highest fruit yield (134.45 kg/tree) and best fruit quality. In the winter season application of 600 g N/tree resulted in the longest terminal shoot length (16.95 cm) and highest fruit TSS and acidity, whereas application of 400 g N/tree resulted in the highest fruit yield (102.65 kg/tree) and ascorbic acid and total sugar contents.

Ali *et al.* (1993) reported that urea treatment had no effect on yield but significantly increased fruit weight and breadth compared with the control. Highest fruit weight and breadth were obtained with the 2 per cent urea treatment and this treatment also resulted highest fruit yield, TSS and total sugar contents and lowest acidity.

Singh and Singh (1995) reported maximum length of terminal shoot, number of leaves and leaf area per shoot obtained with the foliar application of 4 per cent urea and it also significantly improved fruit yield.

Kumar *et al.* (1996) observed that the highest tree volume was obtained at 300 g N. The highest yield was also recorded at 300 g while, maximum was at 600 g N. Fruit weight increased slightly while, TSS, ascorbic acid, reducing sugar and pectin contents increased significantly up to 600 g. The acidity of the juice significantly reduced to N application. The result showed that for 7-8 years old trees, 600 g N/tree/year was optimum N dose to achieve high fruit yield and good fruit quality of guava.

Ahmad *et al.* (1998) observed significant increase in all the reproductive and phsyiochemical parameters up to 2 per cent urea. Beyond 2 per cent, an autoinhibitory effect in terms of marginal leaf burning, poor fruit setting, lesser yield and physiochemichal characters were observed. The highest fruit retention (39.6%), yield per tree (40.2 kg), average fruit weight (230.5 g), T.S.S. (14.6%), ascorbic acid (280.5 mg/100 g) and pectin (0.88%) with lowest acidity (0.30%) were observed with 2 per cent urea concentration.

Tomar *et al.* (1999) reported that highest yield was obtained from foliar application of 2% N while, highest TSS and sugar percentage occurred with application of 1% nitrogen.

Lal and Sen (2001) reported that the TSS, ascorbic acid, reducing sugar, total sugar, non reducing sugar, TSS: acid ratio and pectin content in fruit were generally increased when 0, 300, and 600 g N/tree were supplied for two years.

Bhatia *et al.* (2001) reported that all N levels (300, 600 and 900 gm N/tree) gave significantly higher values for all parameters compared with the control. Nitrogen at 600 g/plant was identified as the best treatment, as it gave high values for fruit weight (125 g), yield (49.8 kg/plant), total soluble solids (10.8%), acidity (0.50%) and ascorbic acid (197 mg/100 pulp).

Dubey *et al.* (2001) reported that spray of 15 per cent urea significantly increased terminal shoot length, fruit yield, length and diameter of fruit, weight of fruit, TSS, total sugar and vitamin C content. Acidity content of fruits decreased with urea spray up to 15 per cent.

Normand and Habib (2001) indicated that NPK fertilizer application induced a rapid floriferous flush in strawberry guava (*Psidium cattleianum*), thereby modifying its natural phenological cycle. Nitrogen was the trigger of this flush, enhancing the proportion of flushing branches. The amount of fertilizer and the leaf nitrogen content had no effect on the flush characteristics. The phenological stage of the plant had a strong influence on the response to fertilizer, with a more intense and less variable flush when fertilizer was applied after a 3 month resting period than just after a harvest. This suggested that the carbohydrate availability within the plant was involved in the response.

Medeiros *et al.* (2004) evaluated the effect of the application of nitrogen (N) fertilizer on the different physical characteristics (weight and the longitudinal and transverse diameter) of guava fruits collected from the field. Results showed that the application of N fertilizer provided an increment in the weight and longitudinal diameter of the guava fruits and that there was no observed change in the transverse fruit diameter.

Al Qurashi (2005) investigated the effect of foliar spraying of N:P:K at 18:18:18, 10:44:10 and 10:10:35 ppm on the growth and nutrition of guava. All foliar fertilizers increased the growth parameters compared to the control. The growth parameters increased more with N:P:K at 18:18:18 ppm than the others. Leaf N, P, K and Mn contents increased with foliar fertilizers compared to the untreated control.

Lima *et al.* (2008) evaluated yield and physical and chemical characteristics of 'Paluma' guava fruit under influence of nitrogen and potassium fertilization. Higher doses of N and K induced higher yields. Nevertheless, fertilization with 200 kg of N+100 kg of K per hectare improved fruit quality, delaying ascorbic acid breakdown and conserving pulp firmness. Main changes took place at maturity stages 4 and 5, when the fruit should present ideal conditions for consumption, namely the increase on soluble solids and soluble sugars content.

Silva *et al.* (2008) studied the effects of irrigation and nitrogen fertilizer on the chemical properties of the fruits of guava cv. Paluma. The nitrogen rates consisted of 50, 100, 150 and 200 kg/ha. The total soluble solids content of the guava fruit decreased as the nitrogen rate increased. The nitrogen rate had marked effect on fruit pH, which varied from 3.37 to 4.40.

Effect of zinc:

Mansour and Sied (1981) reported that foliar spray of zinc at 0.5 and 1.0 per cent concentrations increased fruit set, reduced pre-harvest abscission and increased yield; at picking time fruit characters were good.

Babu *et al.* (1982) reported that zinc regulated the semi-permeability of cell wall thus mobilizing more water into fruits, thereby increasing the size of fruit.

Singh and Chhonkar (1983) recorded significant increase in total soluble solids, reducing sugar and ascorbic acid content in 'Mrig-bahar' guava pulp with foliar spray of 0.4 per cent zinc sulphate solution over control.

Ghosh (1986) reported that foliar application of 0.3% Zn significantly increased the length of fruit, TSS and total sugar while reduced the acidity content in guava fruit.

Pandey *et al.* (1988) reported that foliar application of 0.4 per cent $ZnSO_4$ resulted in significant increase in size of fruit, weight per fruit, yield of fruit per tree, total soluble solids, total sugar while it decreased the acidity content in guava fruit over control.

Sharma *et al.* (1991) reported that foliar application of 0.6 per cent zinc sulphate resulted in significantly highest fruit set (71.96%), fruit weight (165.8 g), number of fruits (498.6/plant), yield (82.39 kg/plant), total soluble solids (11.25%) and ascorbic acid (127.67 mg/100 g) and lowest acidity content in guava fruit (0.36%).

Dahiya *et al.* (1993) reported that foliar spray of zinc sulphate (0.4%) significantly increased the fruit set, breadth of fruit, weight per fruit, total soluble solids and fruit yield per tree as compared to control.

Sharma and Bhattachharayya (1994) observed an increase in vegetative growth due to the foliar spray of Zn.

Kundu and Mitra (1999) reported that the foliar spray of 0.3 per cent Zn on guava produced more percent of fruit set, yield per plant, weight per fruit, diameter of fruit, total soluble solids, total sugar and ascorbic acid and less acidity content over control.

Singh and Brahmachari (1999) conducted an experiment to assess the physico-chemical quality of guava fruit under the influence of two levels of zinc (0.5 and 1.0 per cent $ZnSO_4$). The size of fruits (length and breadth), total soluble solids, total sugar and ascorbic acid content of the fruit pulp were enhanced markedly by the application of zinc. Application of 1.0 per cent $ZnSO_4$ resulted in significant reduction in acidity content in guava fruit over 0.5% $ZnSO_4$ and control.

Balakrishnan (2000) assessed the effect of foliar application of micronutrients on vegetative growth, yield and quality of guava. Foliar spray of 1.0 per cent $ZnSO_4$ $7H_2O$ resulted in increase in number of shoots per twig, length of shoot, number of flowers per shoot, fruit set, total soluble solids, ascorbic acid, total sugar and fruit yield per plant over control, but increase in number of flowers per shoot, fruit set, total soluble solids, ascorbic acid and fruit yield was observed significant.

Indrayan *et al.* (2000) studied the effect of Zn deficiency on pigment composition, nutrient content and photosynthetic activity in field grown fruit trees and identified Zn deficiency in sweet orange based on the visible symptoms in 15 year old trees in Tamil Nadu. Zinc deficiency affected the chlorophyll contents.

Balakrishnan (2001) studied the influence of foliar application of micronutrients on guava. The foliar spray of 0.5 per cent $ZnSO_4$ significantly increased the number of flowers per plant, fruit set, fruit yield per tree, total soluble solids and ascorbic acid. The quality character like acidity remained unchanged due to foliar spray of zinc. The foliar spray of 0.5 per cent $ZnSO_4$, although, increased the number of shoots per twig and length of shoot over control but differences were non-significant.

Bhatia *et al.* (2001) reported that guava responded to zinc up to 0.75 per cent concentration in respect of fruit weight and fruit yield per plant.

Das *et al.* (2001) sprayed the guava trees with 0.5 or 1.0 per cent aqueous solution of zinc sulphate or with water (control) 25-27 days after fruit set and fruits were analysed after 15, 54 and 93 days of spray. Both concentrations of $ZnSO_4$ had elevated total, reducing and non-reducing sugars content of the fruits over control and at a higher rate with the higher concentration. The treatment also increased the weight of fruits but the specific gravity did not change much.

Lal and Sen (2001) conducted a field experiment in Rajasthan to determine the effects of different level of zinc (0, 2 and 4 g/plant) on the fruit quality of guava cv. Allahabad Safeda. The total soluble solids, ascorbic acid, reducing sugar non-reducing sugar, total sugar and pectin content, as well as TSS:acid ratio and pH in fruits linearly increased whereas acidity decreased with increasing rates of Zn.

Lal and Sen (2002) reported significant influence of foliar application of zinc (0, 2 and 4 g/plant) on most of the parameters related to flowering, fruiting, yield attributes and yield of guava.

Natale *et al.* (2002) evaluated height, foliar area, dry matter, nutritional status and soil nutrients after 135 days and observed the greatest plant development with 2 mg zinc/dm^3. Doses of 4 mg zinc/dm^3 or greater resulted in a significant reduction in growth and accumulation of macronutrients.

Prasad *et al.* (2005) studied the effect of various chemicals on the physicochemical qualities of rainy season guava cv. Allahabad Safeda. Spraying of 0.8% borax resulted in maximum contents of ascorbic acid, nonreducing sugar and total sugar, sugar acid ratio, total income and net profit, whereas, minimum acidity was estimated by the same treatment. Maximum total soluble solids content of fruit was recorded under borax treatment and minimum was registered under the control. The reducing sugar was maximum under zinc sulfate spray, whereas 0.8% borax was found equally effective.

Sarolia *et al.* (2007) conducted an experiment on guava cv. Sardar involving the foliar application of 0.3, 0.4 and 0.5 per cent zinc sulphate and ferrous sulphate with their possible combination and control trees were sprayed with water alone. Zinc sulphate and iron sulphate spray improved the vegetative growth of guava trees obtained in terms of length of terminal shoot, shoot diameter and number of leaves per shoot. The fruit maturity period was significantly reduced under the influence of various spray treatments. The yield of guava fruits was also increased significantly by spray treatment. In general it was observed that application of zinc and iron in the form of zinc sulphate and ferrous sulphate sprays of 0.5 and 0.4 per cent concentration, respectively on guava trees were beneficial to obtain promising results.

Pal *et al.* (2008) evaluated the effect of foliar application of nutrients on the yield and quality of guava cv. Sardar Fruit size, in terms of both length and breadth, was significantly increased by foliar application of nutrients. The maximum value of both characters was recorded under 2.0% urea. However, 1.0% urea was at par with 0.4% $ZnSO_4$ for increasing the fruit size. The weight and volume were maximum under 2.0% urea, followed by 1.0% urea and 0.4% $ZnSO_4$. Guava yield was maximum under 2.0% urea, which was closely followed by 1.0% urea. Maximum reduction in acidity was recorded under 0.2% $ZnSO_4$ which was at par with 0.1% borax. Ascorbic acid content was significantly increased by all treatments over the control. Maximum value (277.76 mg/100 g fruit) was observed upon application of 0.2% $ZnSO_4$, which was at par with 0.4% concentration.

Effect of manganese:

Ghosh (1986) observed significant increase in length of fruit and total sugar while decrease in acidity content in guava fruit with foliar spray of 0.3 per cent Mn over control. Whereas, the number of fruits per plant, weight per fruit, diameter of fruit and fruit yield were increased with the foliar spray of 0.3 per cent Mn but did not touch the level of significance.

Plessis and Koen (1990) recommended the soil application of Mn (as manganese sulphate) at 200 g/100 litres of water in guava.

Indrayan *et al.* (2000) reported on the basis of chlorophyll fluorescence induction curves that Mn deficiency affected the chlorophyll content in field grown fruit trees and it also affected the ratio of variable to maximum fluorescence.

Lal and Sen (2001) studied the effect of Mn fertilization on fruit quality of guava cv. Allahabad Safeda. They recorded linear increase in total soluble solids, ascorbic acid, pH and TSS:acid ratio of fruits with increase in dose of Mn from 0 to 4 g/plant, whereas acidity showed a decrease. The maximum reducing sugar, non-reducing sugar, total sugar and pectin were recorded at the higher dose of Mn (4 g/plant).

Lal and Sen (2002) conducted a field experiment in Udaipur, Rajasthan to investigate the effect of foliar application of Mn (0, 2 and 4 g/tree) on flowering, fruiting, yield attributes and yield of guava cv Allahabad Safeda. Most of the parameters were significantly affected by the foliar application of Mn.

Salvador *et al.* (2003) conducted experiments to determine the effect of Mn on the growth and mineral composition of young guava seedlings and they reported that the total dry matter production, Ca, Mg and Fe contents were affected by manganese.

Effect of Interaction of zinc×manganese:

Ghosh (1986) reported that foliar application of 0.3 per cent zinc in combination with 0.3 per cent Mn and 0.3 per cent Mg significantly increased the weight per fruit, length and diameter of fruit, fruit yield per plant and total soluble solids while decreased the acidity content in guava fruit as compared to alone application of Mg, Zn and Mn including control.

Balakrishnan (2000) reported that the application of all micronutrients individually or in combination significantly increased the growth and yield of guava compared to the control. The combination of all the micronutrients, Zn at 0.25% + Fe at 0.25% + Mg at 0.25% + borax at 0.1%, resulted in the highest number of shoots per twig (5.97), length of shoot (16.60 cm), number of leaves (13.15), number of flowers per shoot (19.38), fruit set (83.11%), chlorophyll content (3.03 mg/g), total soluble solids (14.15 degrees brix), total sugars (10.28%), vitamin C [ascorbic acid] content (160.08 mg/100 g) and fruit yield (70.15 kg/tree) compared to the control. The control treatment had the highest acidity percentage (0.75%), while the above combination gave the lowest (0.56%).

Lal and Sen (2002) reported that combined application of 4 g each Zn and Mn per tree as foliar spray along with soil application of 600g N/tree resulted in significantly highest number of fruits (327/tree) and yield (76.97 kg/tree) over control (no N, Zn and Mn application).

Bhatnagar and Chandra (2003) at Bikaner reported deficiency of manganese and zinc in orchard on the basis of analysis of leaf samples of guava fruit and they observed positive and significant correlation between manganese and zinc.

Effect of interaction of nitrogen×zinc×manganese:

Lal *et al.* (2000) conducted an field experiment to study the effect on N, Zn and Mn fertilizers in relation to yield and leaf nutrient content of guava. Application of N at 600 g per plant per year significantly enhanced the fruit yield of guava, and N and Mn content of leaves, while it reduced the P, K and Zn content of leaves. Foliar spray of Zn at 4 g per plant per year significantly increased the yield and Zn content of guava leaves. However, it reduced significantly the Mn content of leaves. Similarly, foliar spray of Mn at 4 g per plant per year significantly increased the fruit yield, N and Zn content of leaves, while it decreased Zn content of guava leaves.

Singh and Gupta (2000) evaluated the status of micro and secondary nutrients in two different locations of guava orchards and adjoining non-cultivated area's. Both adjoining non-cultivated soil profiles had sufficient amount of Zn, Cu, Mn and Fe while SO4-S was found deficient. The guava plantation depleted Zn and Fe in higher amounts than Mn and both the orchard soil profiles became deficient in Zn and Fe although tree leaves did not show their deficiency symptoms. The depletion of Cu and SO4-S was not observed even after 11 and 18 years of guava plantation at both locations. The concentration of micro-nutrients decreased with increase in the depth of soil profiles.

Lal and Sen (2001) supplied fifteen-year-old grafted and uniform guava cv. Allahabad Safeda plants with 0, 300 and 600 g N/plant; and 0, 2 and 4 g Zn and Mn/plant in a field experiment conducted in Rajasthan, India to determine the effects of N, Zn and Mn on the fruit quality of guava. The total soluble solids, ascorbic acid, reducing sugar, non-reducing sugar, total sugar and pectin content, as well as TSS:acid ratio and pH in fruits linearly increased whereas acidity decreased with increasing rates of N, Zn and Mn.

Lal and Sen (2002) investigated the effect of N (0, 300 and 600 g/tree) by soil application, Zn (0, 2 and 4 g/tree) and Mn (0, 2 and 4 g/tree) both by foliar spray on flowering, fruiting, yield attributes and yield of guava cv. Allahabad Safeda. Most of the parameters were significantly affected by the application of N, Zn and Mn. The earliest fruit maturity (131.33 days) and the highest number of fruits (327.00/tree) and yield (76.97 kg/tree) were recorded at treatment combination of (600 g N+4 g Zn+4 g Mn/tree), while the latest fruit maturity (172.67 days) and the lowest number of fruits (243.33/tree) and yield (41.18 kg/tree) were recorded under the control (no N, Zn and Mg applications).

CHAPTER-III
MATERIAL AND METHODS

The details of material and methods and techniques used in the experiment have been described below:

Experimental site:

The experiment was conducted in the guava orchards of Pomology section, College of Agriculture, Gwalior (M.P.).

Climatic conditions:

Gwalior is situated in the north of Madhya Pradesh at an attitude of 226.6 metres from sea level with latitude and longitude 26º13' N and 78º14' E, respectively. This tract enjoys a subtropical climate with extreme of temperatures both in summer (maximum temperature more than 46ºC) as well as in winter (minimum temperature less than 2ºC). Severe frost is of rare occurrence but cold waves are experienced from middle of December up to the end of January. The average annual rainfall is in between 760 to 1060 mm mostly distributed from middle June to the end of September with scanty rains during winters. The meteorological data regarding minimum and maximum temperature, relative humidity and total rainfall as recorded during June 2009 to February 2010 in the Meteorological observatory of the Research Farm, College of Agriculture, Gwalior are given in the Table 3.1 and depicted graphically in Fig. 1.

Table 3.1. Meteorological data during fruiting season, 2009-10

Month & Year	Monthly temperature (°C)		Mean relative humidity (%)	Monthly rainfall (mm)
	Max.	Min.		
June 2009	42.975	26.275	46.45	0
July 2009	37.2	27.4	71.51	94.2
August 2009	34.9	26.76	67.13	91.7
September 2009	34.625	24.05	63.27	133.7
October 2009	29.04	18.54	59.55	0
November 2009	28.23	10.55	63.89	0
December 2009	25.2	10.25	65.55	0
January 2010	22.62	7.8	66.11	0
February 2010	25.18	9.3	54.18	0

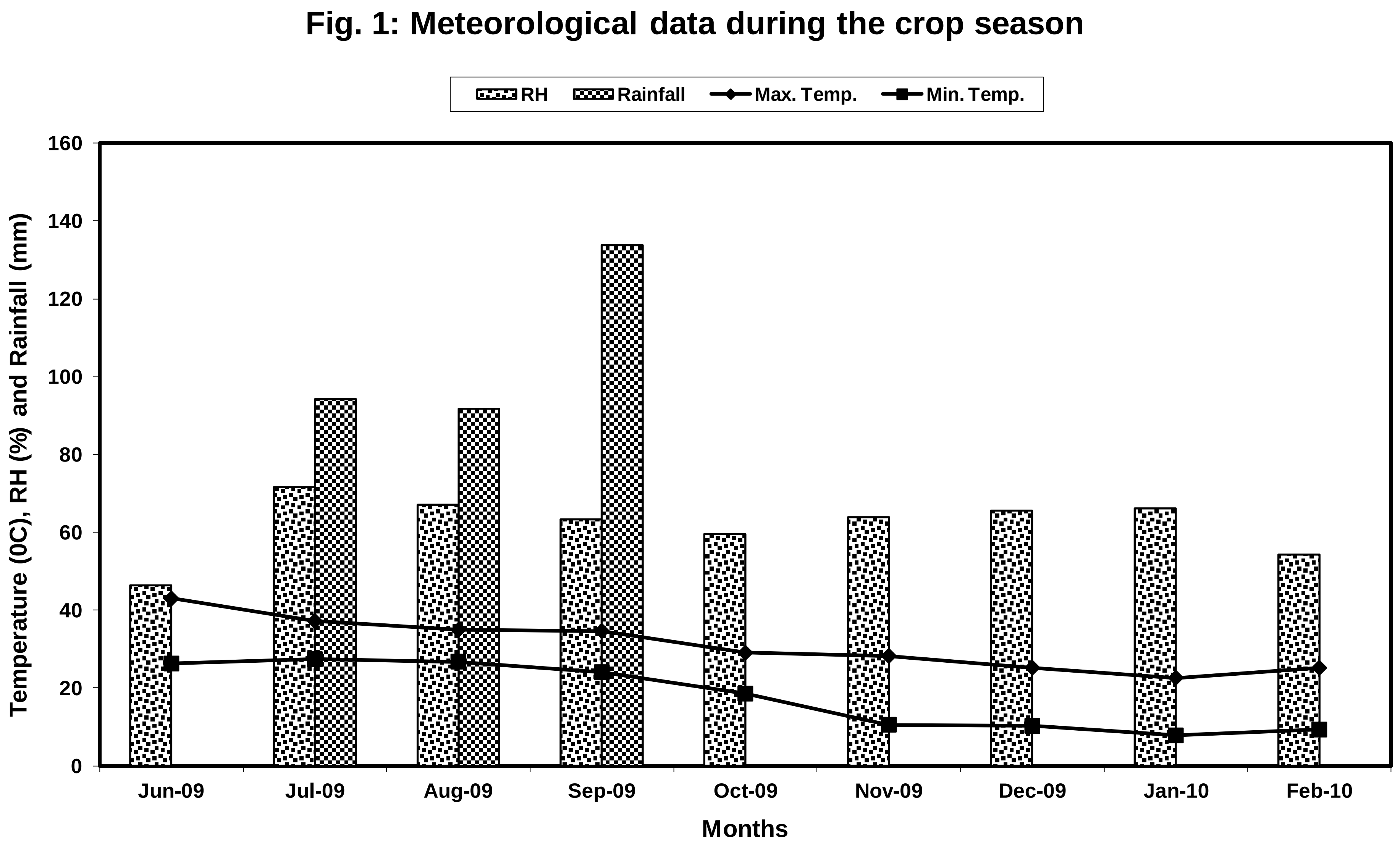


Fig. 1: Meteorological data during the crop season
RH
Rainfall
Max. Temp.
Min. Temp.
160
140
120
100
80
60
40
20
0
Temperature (0C), RH (%) and Rainfall (mm)
Jun-09
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Months

Soil characteristics:

The soil of experimental area was sandy loam having good drainage. To evaluate the basic fertility level, soil samples were taken randomly prior to the application of treatments and analysed for mechanical and chemical composition of soil. Soil samples were taken before starting the experiment. The values of various components are furnished in the Table 3.2.

Table 3.2: Mechanical and chemical composition of experimental site

S. No.	Attributes	Values obtained	Method of determination
	A. Mechanical properties		
	Soil texture %		
	Sand	56.40	International Pipette method (Piper, 1950)
	Silt	18.90	
	Clay	24.60	
	B. Chemical Properties		
1	Organic carbon (%)	0.54	Walkley-Black Method
2	Available nitrogen (kg/ha)	276	Alkaline permanganate method (Subbiah and Asiza, 1956)
3	Available phosphorus (kg/ha)	36	Olsen's method (Olsen *et al.* 1954)
4	Available potash (kg/ha)	329	By flame photometer
5	PH	7.6	Blackman's pH meter
6	EC (mm mhos/cm)	0.30	Conductivity meter

Method of soil sampling:

Soil samples were taken with the help of 60 cm augar from 0 to 30 cm and 30 to 60 cm depth of soil, before treatment application. The samples from each replication were mixed and a representative sample of each treatment was analysed in the laboratory.

Experimental details:

Eight years old seventy-five uniform plants of guava variety Gwalior-27, growing in orchard area of Pomology section, College of Agriculture, Gwalior, were selected for the study.

Description of the variety selected:

Variety Gwalior-27 is a clonal selection from Allahabad Safeda variety of guava. Fruits of this variety are rounded. Physico-chemical characters of this variety as described by Tripathi *et al.* (1971) are as follows:

Average diameter of fruit (cm)	-	7.38
Average length of fruit (cm)	-	7.65
Average weight of fruit (g)	-	225.00
Colour of the skin	-	Light yellow
Colour of the flash	-	Straw white
Number of seeds/fruit	-	303
Thickness (cm)	-	1.40
Total acidity (%)	-	0.26
TSS (%)	-	12.60
Sugar acid ratio	-	48.4
Vitamin-'C' (mg/100 g)	-	172
Ash (%)	-	0.86
Fe (mg/100 g)	-	0.95
P (mg/100 g)	-	41
Ca (mg/100 g)	-	20

Details of experiment:

The experimental details are presented as follows:

Layout	-	Randomized Block Design
Number of replication	-	3
Number of treatments	-	25 (combination of 5 level of each nitrogen and micronutrients (Zn and Mn))
Number of trees	-	75
Plot size	-	One tree unit per treatment
Planting distance	-	5m × 5m
Plant age	-	8 years
Variety	-	Gwalior-27

Details of treatment:

Two factors were taken in this experiment. These are described below:

(A) Nitrogen levels:

1.	0 g N/plant (control)	N_0
2.	600 g N/plant	N_1
3.	750 g N/plant	N_2
4.	900 g N/plant	N_3
5.	1000 g N/plant	N_4

(B) Micronutrient (Mn and Zn) concentrations:

1.	No spray	C_0
2.	0.2% $MnSO_4$/plant	M_1
3.	0.3% $MnSO_4$/plant	M_2
4.	0.4% $ZnSO_4$/plant	Z_1
5.	0.6% $ZnSO_4$/plant	Z_2

Treatment combinations:

The above treatment formed the following nine combinations:

N_0C_0	N_0M_1	N_0M_2	N_0Z_1	N_0Z_2
N_1C_0	N_1M_1	N_1M_2	N_1Z_1	N_1Z_2
N_2C_0	N_2M_1	N_2M_2	N_2Z_1	N_2Z_2
N_3C_0	N_3M_1	N_3M_2	N_3Z_1	N_3Z_2
N_4C_0	N_4M_1	N_4M_2	N_4Z_1	N_4Z_2

Application of nitrogen:

Nitrogen was applied in the form of urea as soil application in split doses before flowering and after fruit setting.

Foliar spray of Zn and Mn:

Zinc and manganese were applied in the form of zinc sulphate and manganese sulphate respectively. Before making solution of $ZnSO_4$ and $MnSO_4$ and their requirement was worked out on the basis of a water spray trial on a few plants of guava of same age growing in the orchard. The quantities of chemicals i.e. 20 and 30 g $MnSO_4$ and 40 and 60g $ZnSO_4$ per plant were calculated as per the requirement for each treatment separately.

The solutions of $ZnSO_4$ and $MnSO_4$ were prepared one hour before their spray. For this the volumetric flasks of 500 ml capacity were used. The weighed amount of chemical was dissolved in distilled water slowly and slowly by the continuous process of shaking the volumetric flasks. Finally, the volume of solutions was made up by adding distilled water to raise the level of solution in the volumetric flask up to the mark.

Aqueous solution of $ZnSO_4$ and $MnSO_4$ in varying concentrations having adhesive agent "Teepol" (0.2%) was sprayed separately twice (first before flowering (July) and second at fruit growth (September)) in Mrig-bahar season crop with the help of hand automizer. The spraying was done till the solution started dripping from the foliage.

Observations to be recorded:

Vegetative characters:

Observations on the following vegetative characters were recorded on the basis of five selected tertiary shoots from all the sides of each tree:

1. **Length of tertiary shoot**
2. **Girth of tertiary shoot**

Yield and yield attributing character:

Five fruits per tree were collected randomly and observations on diameter (vertical and horizontal) of fruit, weight per fruit, number of fruits per plant, number of seeds per fruit and seed pulp ratio were recorded. The yield per tree was determined by weighing the fruits harvested at different picking.

Fruit quality:

For qualitative analysis, five healthy fruits were taken treatment wise from each replication at full maturity stage. All the collected fruit samples were washed with running tap water and rubbed with muslin cloth to remove the dirt and dust. A homogenous sample was prepared after crushing the fruits. This sample was used to determine the following quality parameters:

1. **Total soluble solids**
2. **Ascorbic acid (Vitamin C)**
3. **Acidity**
4. **Sugars: a) Reducing sugar b) Total sugar**

Method of chemical analysis:

1. Total soluble solids (TSS):

For determining the TSS, a drop of sample (juice) is placed on the prism of hand refrectometer and the percentage of dry substance in it read directly.

2. Acidity:

For the estimation of acidity 10 g of fruit pulp from composite sample was blended with 100 ml of distilled water in a mixer for 5 minutes and boiled for one hour. It was filtered and filterate was titrated against N/10 NaOH solution using phenolphthalein as indicator. The results were expressed as percentage citric acid on fresh weight basis using formula given below:

Acid per cent =

$$\frac{\text{Titre} \times \text{Normality of alkali} \times \text{volume made up} \times \text{equivalent weight of acid} \times 100}{\text{Volume of sample taken for estimation} \times \text{weight of sample taken} \times 1000}$$

3. Ascorbic acid:

Ascorbic acid (Vitamin C) was estimated by the method recommended by A.O.A.C. (1984). 10 g of fruit extract from composite sample was blended in a mixer with 4% oxalic acid and made up to known volume and filtered. An aliquot of the filtrate was titrated against standard solution of 2,6-dicholorphenol-indophenol dye until pink colour persisted at least for 15 seconds. Results have been reported as mg/100 g of pulp.

Ascorbic acid (mg/100 g) = $\frac{\text{Titre} \times \text{Dye factor} \times \text{Volume made up} \times 100}{\text{Volume of filtrate taken} \times \text{Wt. of sample taken}}$

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

4. Sugars:

Sugars were determined by the volumetric method as described by Ranganna (1977). For this 50 g freshly extracted pulp of guava and 200 ml of distilled water were stirred well and poured in a 500 ml volumetric flask. The conical flask was rinsed 2 to 3 times with distilled water and the rinsing were transferred to 500 ml volumetric flask. The 2 ml neutral lead acetate solution was added, and excess of it was neutralized with 2.3 ml potassium oxalate and

the volume was made up to 500 ml with distilled water. The mixture was stirred well, allowed to stand for some time and then filtered.

(a) Reducing sugar:

The clear filterate so obtained as under sugars was titrated against a diluted boiling mixture of 5 ml each of Fehling A and Fehling B solutions, using methylene blue as an indicator. The brick red colour marked its end point. The reducing sugar percentage was calculated using the following formula.

$$\text{Factor for Fehling solution (g of invert sugar)} = \frac{\text{Titre} \times 2.5}{1000}$$

$$\text{Reducing sugar (\%)} = \frac{\text{mg of invert sugar} \times \text{dilution} \times 100}{\text{Titre} \times \text{Weight/ of sample} \times 100}$$

(b) Total sugars:

Total sugars were estimated by taking 100 ml of clear filterate as obtained under sugars in 250 volumetric flask. To this 5 g of citric acid wasadded and kept on hot plate to boil for 10 minutes for hydrolysis. After hydrolysis, the solution was neutralized with 1N NaOH. The mixture was then transferred to 250 ml volumetric flask and the volume was made up to the mark. It was then titrated against a diluted boiling mixture of 5 ml each of Fehling A and Fehling B solutions, using methylene blue as an indicator as was done for reducing sugar and the total sugar percentage was calculated by using the following formula.

$$\text{Total sugar (\%) as invert sugar} = \frac{\text{mg of invert sugar} \times \text{dilution} \times 100}{\text{Titre} \times \text{Weight/ of sample} \times 100}$$

Statistical analysis:

In order to see the significance of results, experimental data recorded on vegetative growth, yield and quality of guava were statistically analysed. The skeleton of analysis of variance table is presented below:

Table 3.3. Skeleton of analysis of variance

Sources of variation	d.f.	SS	MSS	'F' test value
Replication	**3**			
Nitrogen	**4**			
Zinc & Manganese	**4**			
Interaction	**16**			
Error	**48**			
Total	**74**			

The 'F' test applied to judge the overall significance of various treatment effects in general and comparison of individual treatment was made with the help of critical difference at 5 per cent level.

Standard error of mean = S.E.(m) = $\pm\sqrt{\frac{\text{E.M.S.}}{\text{N}}}$

Where, E.M.S. is the error mean square and 'N' is the number of observations on which the mean is based.

Critical difference (C.D.) = S.E.(m) × $\sqrt{2}$ **× 't' tabulated value at 5% level.**

Graphical representations:

Suitable graphical illustrations of the data have also been given at appropriate places in the text.

CHAPTER-IV
RESULTS

Effect of different levels of nitrogen, zinc and manganese was assessed on the growth, yield and quality of Guava cv. Gwalior-27 in the present investigation conducted at Pomology Orchard, College of Agriculture, Gwalior during the year 2009-10. The experimental field was regularly visited and the important observations were recorded periodically. The results are depicted by suitable graphs and the data of the final observations are reported below under suitable headings. The analysis of variance table is given in Appendix I to III. The results obtained are detailed here as follows:

A. Vegetative growth:

1. Girth of tertiary shoot:

Girth of tertiary shoot was significantly influenced by only the main effect of micronutrients (manganese and zinc) (Table 4.1 & Appendix I). All the levels of manganese and zinc except 0.2% $MnSO_4$ significantly increased the girth of tertiary shoot over control (no spray). Spray of zinc sulphate at 0.6% concentration resulted in significantly highest girth of tertiary shoot (0.786 mm) over rest of the concentration zinc sulphate, manganese sulphate and control.

Table 4.1: Girth of tertiary shoot (mm) as affected by different levels of nitrogen, manganese, zinc and their combinations

Level of nitrogen	Level of zinc & manganese					Mean
	No spray	0.2% $MnSO_4$	0.3% $MnSO_4$	0.4% $ZnSO_4$	0.6% $ZnSO_4$	
0 g/plant	0.693	0.721	0.721	0.713	0.754	**0.720**
600 g/plant	0.710	0.737	0.743	0.751	0.770	**0.742**
750 g/plant	0.704	0.737	0.765	0.772	0.798	**0.755**
900 g/plant	0.712	0.751	0.773	0.778	0.817	**0.766**
1000 g/plant	0.729	0.771	0.787	0.792	0.792	**0.774**
Mean	**0.710**	**0.743**	**0.757**	**0.761**	**0.786**	

	Nitrogen	Zinc & Manganese	Interaction
S.E.(m)±	0.015	0.015	0.033
C.D. (at 5%)	NS	0.042	NS

2. Length of tertiary shoot:

A perusal of Appendix-I revealed that the levels of both, nitrogen and micronutrients caused significant differences in the length of tertiary shoot individually and in combination.

Scrutiny of data summarized in Table 4.2 and depicted through Fig. 2 revealed successive increase in the length of tertiary shoot with corresponding increase in the level of nitrogen up to 1000 g per plant. Various increases in length of tertiary shoot with increasing levels of nitrogen were, however, substantial, but consistently significant except the difference between 750 and 900 g N/plant. As a result, 1000 g N/plant exhibited the longest tertiary shoot. The increase in length of tertiary shoot with the highest level of nitrogen (1000 g/plant) over no application of nitrogen was 25.25 per cent.

Application of $MnSO_4$ at 0.2 and 0.3% and $ZnSO_4$ at 0.4 and 0.6% concentrations recorded longer tertiary shoot over no spray. Foliar application of $ZnSO_4$ at 0.6% concentration resulted in significantly longest tertiary shoot over rest of the treatments. Further, spray of 0.3% $MnSO_4$ and 0.4% $ZnSO_4$ was equally effective in terms of increasing length of tertiary shoot.

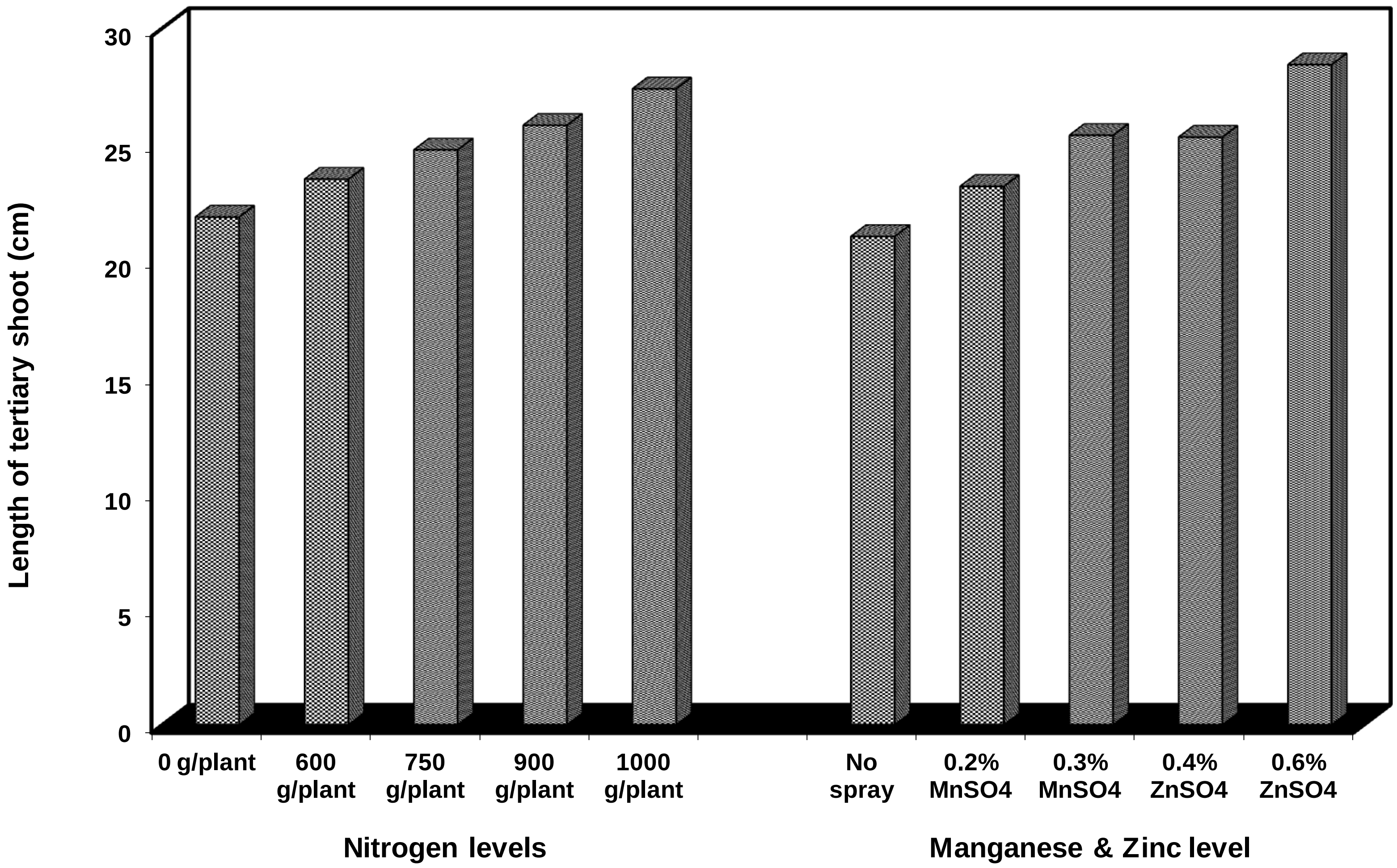
Table 4.2: Length of tertiary shoot (cm) as affected by different levels of nitrogen, manganese, zinc and their combinations

Level of nitrogen	Level of zinc & manganese					Mean
	No spray	0.2% $MnSO_4$	0.3% $MnSO_4$	0.4% $ZnSO_4$	0.6% $ZnSO_4$	
0 g/plant	18.85	20.65	22.03	22.87	24.88	**21.86**
600 g/plant	21.90	20.81	24.05	24.69	25.99	**23.49**
750 g/plant	21.02	23.55	25.49	25.29	28.42	**24.75**
900 g/plant	23.05	24.64	26.01	25.35	29.99	**25.81**
1000 g/plant	20.28	26.23	29.30	28.28	32.82	**27.38**
Mean	**21.02**	**23.18**	**25.38**	**25.30**	**28.42**	

	Nitrogen	Zinc & Manganese	Interaction
S.E.(m)±	0.38	0.38	0.85
C.D. (at 5%)	1.08	1.08	2.42

Interaction effect of level of nitrogen and micronutrients on the length of tertiary shoot was significant (Table 4.2). The tertiary shoot length was significantly higher with 1000 g N and 0.6% $ZnSO_4$/plant. Increasing nitrogen levels up to 1000 g/plant resulted in increase in the length of tertiary shoot at each concentration of $MnSO_4$ and $ZnSO_4$ and vice-versa. Thus, the treatment combination of 1000 g N/plant and 0.6% $ZnSO_4$/plant was found significantly superior to rest of the treatment combinations.

Fig. 2: Length of tertiary shoot (cm) as affected by different levels of nitrogen, manganese, zinc and their combinations



B. Fruit development characters:

1. Diameter of fruit (vertical):

The analysis of variance (Appendix-I) shows that the levels of nitrogen, zinc and manganese affected the vertical diameter (length) of fruit significantly. However, the effect of interaction of both the elements on the length of fruit was not statistically significant.

The vertical diameter of guava fruit increased significantly with the application of nitrogen at any level over control (except 600 g/plant). Application of nitrogen at 1000 g/plant produced same length of fruit as noted under the application of 900 g N/plant and both these level of nitrogen being at par to 750 g N/plant and produced significantly longest fruit over 600 g N/plant and control (Table 4.3 and Fig. 3).

Table 4.3: Diameter of fruit (vertical in cm) as affected by different levels of nitrogen, manganese, zinc and their combinations

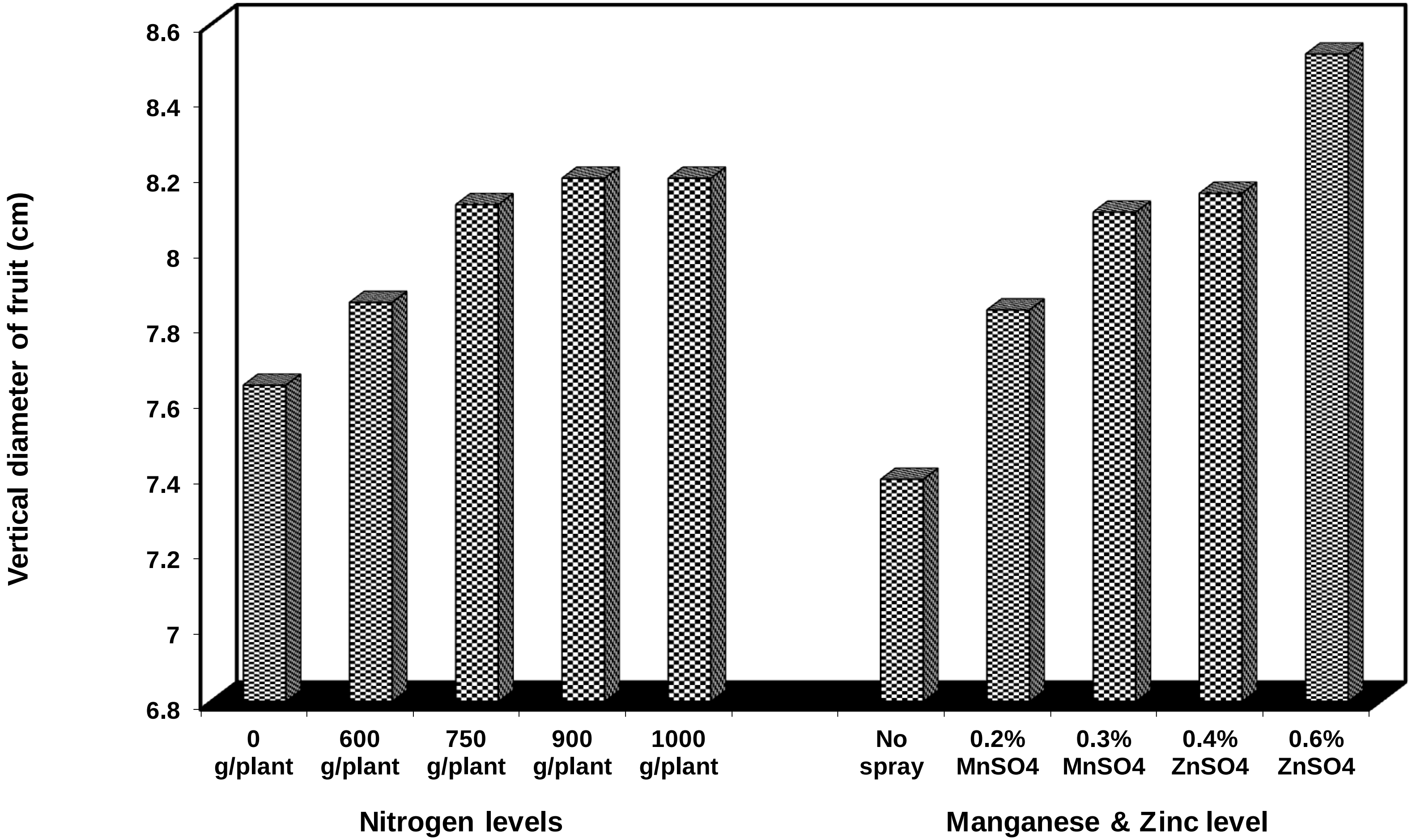
Level of nitrogen	Level of zinc & manganese					Mean
	No spray	0.2% $MnSO_4$	0.3% $MnSO_4$	0.4% $ZnSO_4$	0.6% $ZnSO_4$	
0 g/plant	6.90	7.56	7.62	7.80	8.33	**7.64**
600 g/plant	7.13	7.85	7.83	8.10	8.36	**7.86**
750 g/plant	7.38	7.84	8.73	8.15	8.51	**8.12**
900 g/plant	7.74	8.05	8.16	8.33	8.66	**8.19**
1000 g/plant	7.79	7.90	8.17	8.36	8.74	**8.19**
Mean	**7.39**	**7.84**	**8.10**	**8.15**	**8.52**	

	Nitrogen	Zinc & Manganese	Interaction
S.E.(m)±	0.12	0.12	0.26
C.D. (at 5%)	0.33	0.33	NS

The vertical diameter of fruit increased significantly with the spray of $MnSO_4$ and $ZnSO_4$ at any concentration over control (Table 4.3). Spray of $ZnSO_4$ at 0.6% concentration resulted in significantly longest fruit over other treatments of micronutrients. Further, the sprays of $MnSO_4$ at any concentration and $ZnSO_4$ at lower concentration were found at par to each other.

The interaction effect of nitrogen and micronutrients was not found significant. However, the maximum length of fruit (8.74 cm) was registered with the combination of 1000 g N/plant and 0.6% $ZnSO_4$.

Fig. 3: Vertical diameter of fruit (cm) as affected by different levels of nitrogen, manganese, zinc and their combinations



2. Diameter of fruit (horizontal):

The analysis of variance (Appendix I) indicated that the level of nitrogen and micronutrients (Zn and Mn) affected the horizontal diameter of fruit significantly. The interaction of both the variables did not produce any significant impact on this parameter.

Application of nitrogen at higher levels enhanced diameter of fruits significantly over no application (Table 4.4). Furthermore, application of nitrogen at 750, 900 and 1000 g/plant were found equally effective.

An examination of data presented in Table 4.4 and depicted in Fig. 4 revealed significant improvement in the diameter of fruit due to both concentrations of zinc and manganese. Foliar spray of $ZnSO_4$ at 0.6% being at par with 0.4% concentration resulted in significantly widest fruit (8.49 cm) over spray of $MnSO_4$ at both concentrations and control.

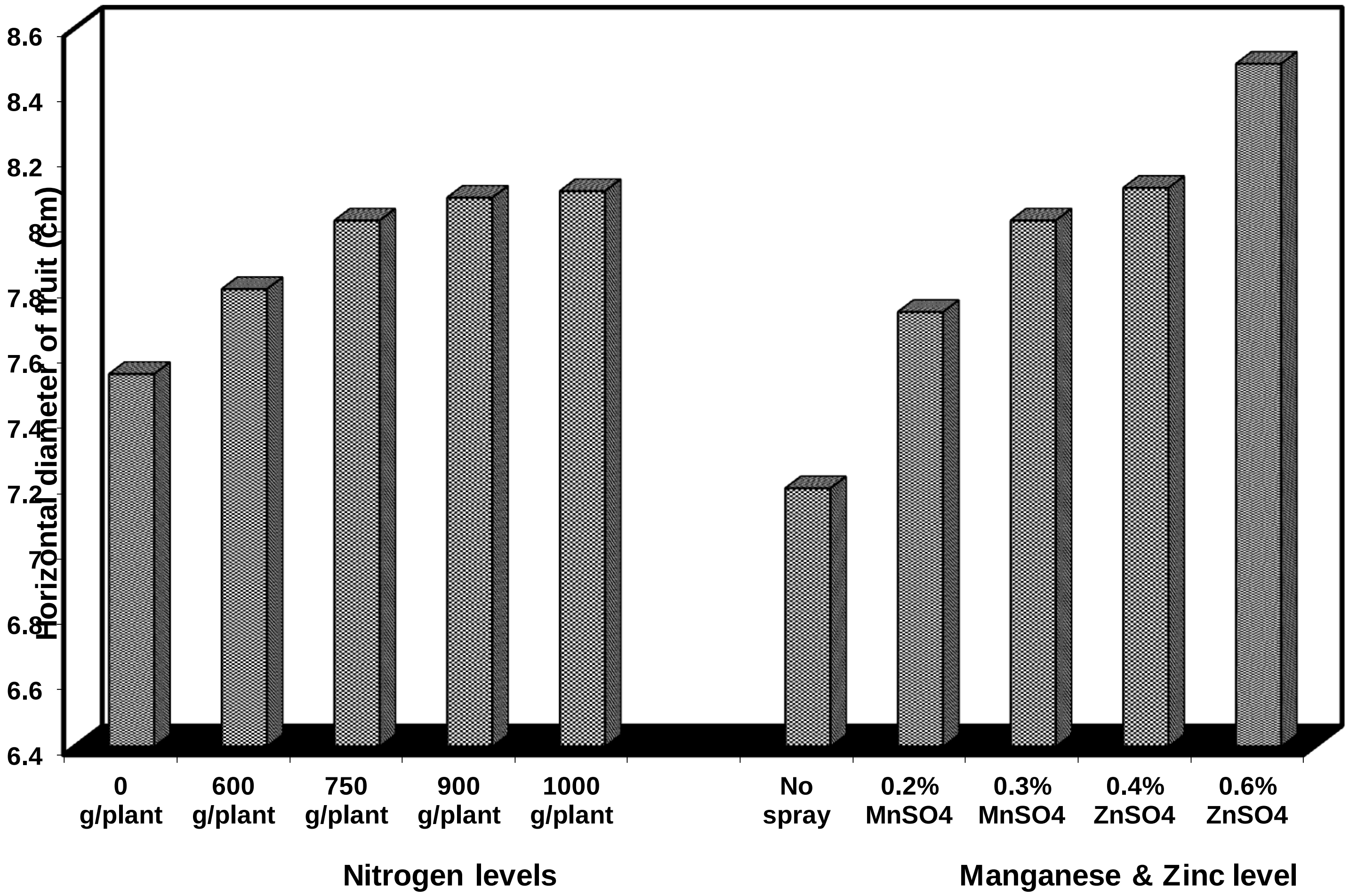
Table 4.4: Diameter of fruit (horizontal in cm) as affected by different levels of nitrogen, manganese, zinc and their combinations

Level of nitrogen	Level of zinc & manganese					Mean
	No spray	0.2% $MnSO_4$	0.3% $MnSO_4$	0.4% $ZnSO_4$	0.6% $ZnSO_4$	
0 g/plant	6.76	7.49	7.54	7.67	8.24	**7.54**
600 g/plant	7.04	7.66	7.80	8.16	8.35	**7.80**
750 g/plant	7.19	7.73	8.53	8.11	8.49	**8.01**
900 g/plant	7.42	7.99	8.08	8.28	8.61	**8.08**
1000 g/plant	7.54	7.79	8.10	8.34	8.75	**8.10**
Mean	**7.19**	**7.73**	**8.01**	**8.11**	**8.49**	

	Nitrogen	Zinc & Manganese	Interaction
S.E.(m)±	0.14	0.14	0.31
C.D. (at 5%)	0.40	0.40	NS

Appendix I revealed non-significant impact of the interaction between level of nitrogen and micronutrients on the horizontal diameter of fruit. However, the maximum diameter of fruit (8.75 cm) was recorded with the application of 1000 g N/plant along with spray of $ZnSO_4$ at 0.6% concentration.

Fig. 4: Horizontal diameter of fruit (cm) as affected by different levels of nitrogen, manganese, zinc and their combinations



C. Fruit quality characters (Physical):

1. Weight of fruit (g):

The analysis of variance (Appendix I) indicated that the level of nitrogen and micronutrients (Zn and Mn) affected the weight per fruit significantly. The interaction of both the experimental variables did not produce any significant impact on this parameter.

All the treatments of nitrogen significantly improved the weight of fruit over control (Table 4.5 and Fig. 5). Application of nitrogen at 1000 g/plant being at par with 900 g/plant produced significantly more weight per fruit over 750, 600 and 0 g N/plant.

Table 4.5: Fruit weight (g) as affected by different levels of nitrogen, manganese, zinc and their combinations

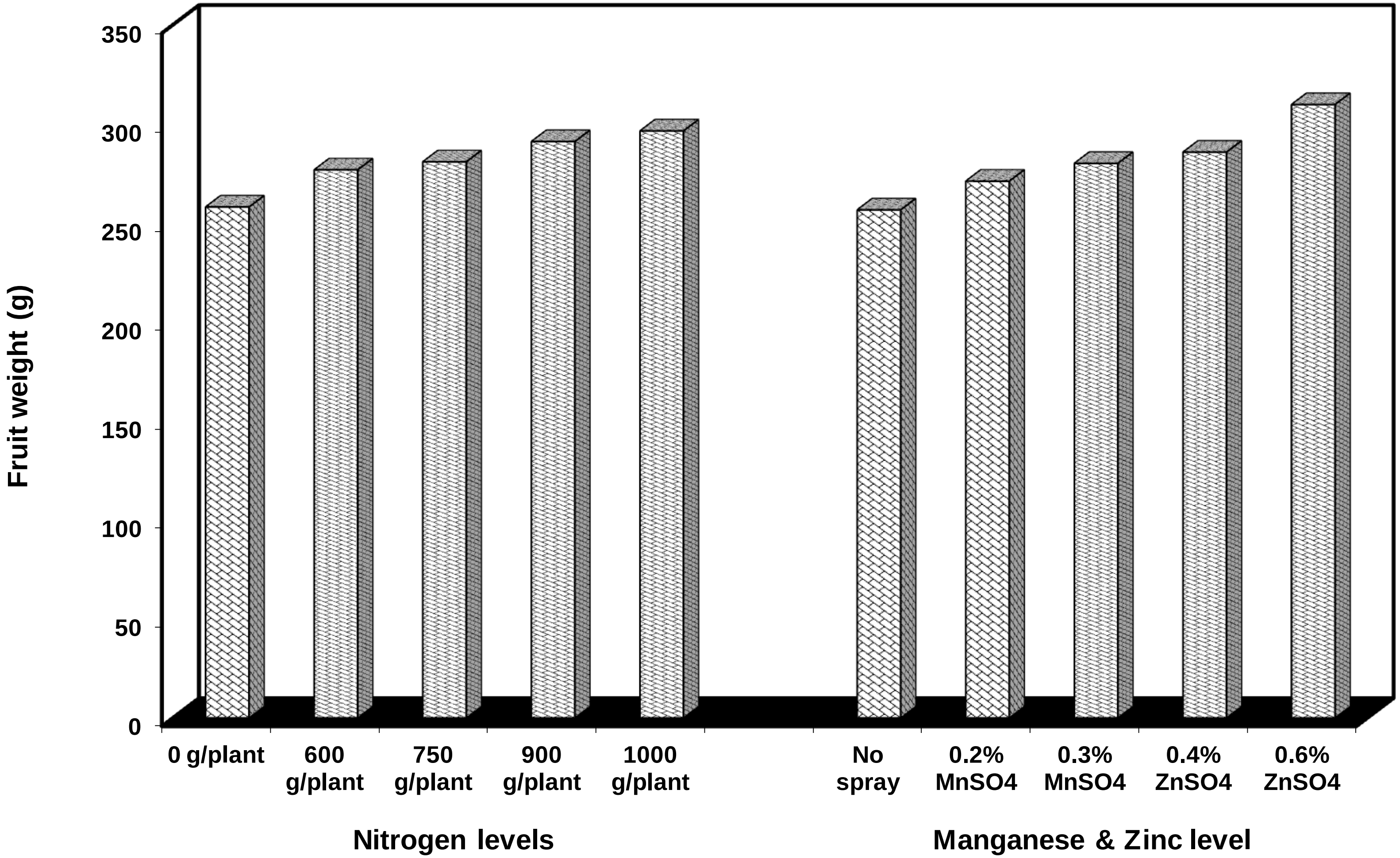
Level of nitrogen	Level of zinc & manganese					Mean
	No spray	0.2% MnSO4	0.3% $MnSO_4$	0.4% $ZnSO_4$	0.6% $ZnSO_4$	
0 g/plant	242.15	250.56	254.91	256.94	285.36	**257.98**
600 g/plant	251.43	271.44	276.73	287.10	296.96	**276.73**
750 g/plant	256.50	271.01	281.01	285.65	309.72	**280.78**
900 g/plant	263.32	279.56	291.02	298.41	322.77	**291.02**
1000 g/plant	269.12	282.46	296.38	300.15	333.79	**296.38**
Mean	**256.50**	**271.01**	**280.01**	**285.65**	**309.72**	

	Nitrogen	Zinc & Manganese	Interaction
S.E.(m)±	5.46	5.46	12.20
C.D. (at 5%)	15.55	15.55	NS

Foliar application of $MnSO_4$ at 0.3% and $ZnSO_4$ at 0.4 and 0.6% produced heavier fruit over control. Among the treatments of $MnSO_4$ and $ZnSO_4$, 0.6% $ZnSO_4$ resulted in significantly highest fruit weight (309.72 g).

Interaction of nitrogen and micronutrients was not significant (Table 4.5). However, maximum fruit weight (333.79 g) was recorded with 1000 g N/plant + 0.6% $ZnSO_4$.

Fig. 5: Fruit weight (g) as affected by different levels of nitrogen, manganese, zinc and their combinations



2. Number of seed per fruit:

The number of seeds per fruit was recorded and presented in Table 4.6 and depicted through Fig. 6. Application of nitrogen at any level significantly increased the number of fruits over control. The maximum number of seeds per fruit (350.16) was recorded with 1000 g N/plant. This treatment was found significantly superior to rest of the treatments.

Number of seeds per fruit differed significantly due to the foliar spray of zinc and manganese. All the concentrations of both the micronutrients except 0.2% $MnSO_4$ resulted higher seeds per fruit over no spray. Spray of 0.6% $ZnSO_4$ per plant recorded significantly higher number of seeds per fruit over spray of micronutrients at any applied remaining concentrations.

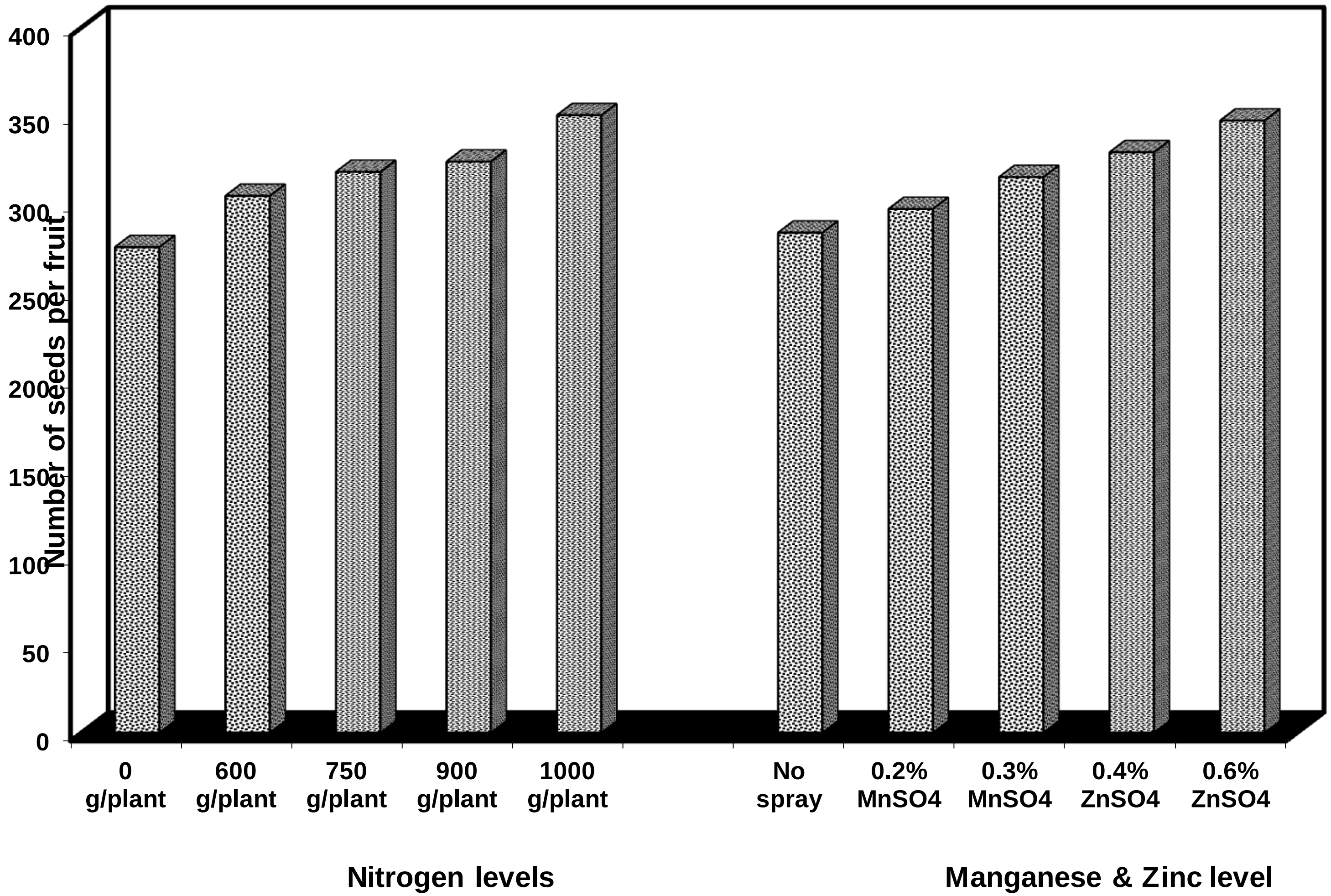
Response of the guava in terms of number of seeds per fruit was found same under combination of any level of nitrogen and micronutrients.

Table 4.6: Number of seeds per fruit as affected by different levels of nitrogen, manganese, zinc and their combinations

Level of nitrogen	**Level of zinc & manganese**					**Mean**
	No spray	**0.2% $MnSO_4$**	**0.3% $MnSO_4$**	**0.4% $ZnSO_4$**	**0.6% $ZnSO_4$**	
0 g/plant	261.03	267.54	271.38	286.08	290.39	**275.28**
600 g/plant	274.96	278.32	305.19	328.32	335.10	**304.38**
750 g/plant	284.39	301.35	322.42	333.12	348.60	**317.97**
900 g/plant	290.04	300.86	324.14	332.16	372.00	**323.84**
1000 g/plant	306.99	336.72	351.95	365.82	389.30	**350.16**
Mean	**283.48**	**296.96**	**315.02**	**329.10**	**347.08**	

	Nitrogen	**Zinc & Manganese**	**Interaction**
S.E.(m)±	5.07	5.07	11.34
C.D. (at 5%)	14.46	14.46	NS

Fig. 6: Number of seeds per fruit as affected by different levels of nitrogen, manganese, zinc and their combinations



3. Number of fruits per plant:

Analysis of variance (Appendix II) clearly reveals that number of fruits per plant was affected significantly by treatments of nitrogen, zinc and manganese, separately as well as jointly.

The data summarized in Table 4.7 and depicted in Fig. 7 reveal significant increase in the number of fruits per plant with the application of nitrogen at any level over control. Application of nitrogen at 1000 g/plant resulted in significantly highest number of fruits per plant over rest of the doses.

Foliar application of $MnSO_4$ and $ZnSO_4$ at any concentration recorded significantly higher number of fruits per plant over no spray of micronutrients (Table 4.7). Spray of $ZnSO_4$ at 0.6% concentration exhibited significantly highest number of fruits per plant (367.97) as compared to the rest of the concentrations of micronutrients.

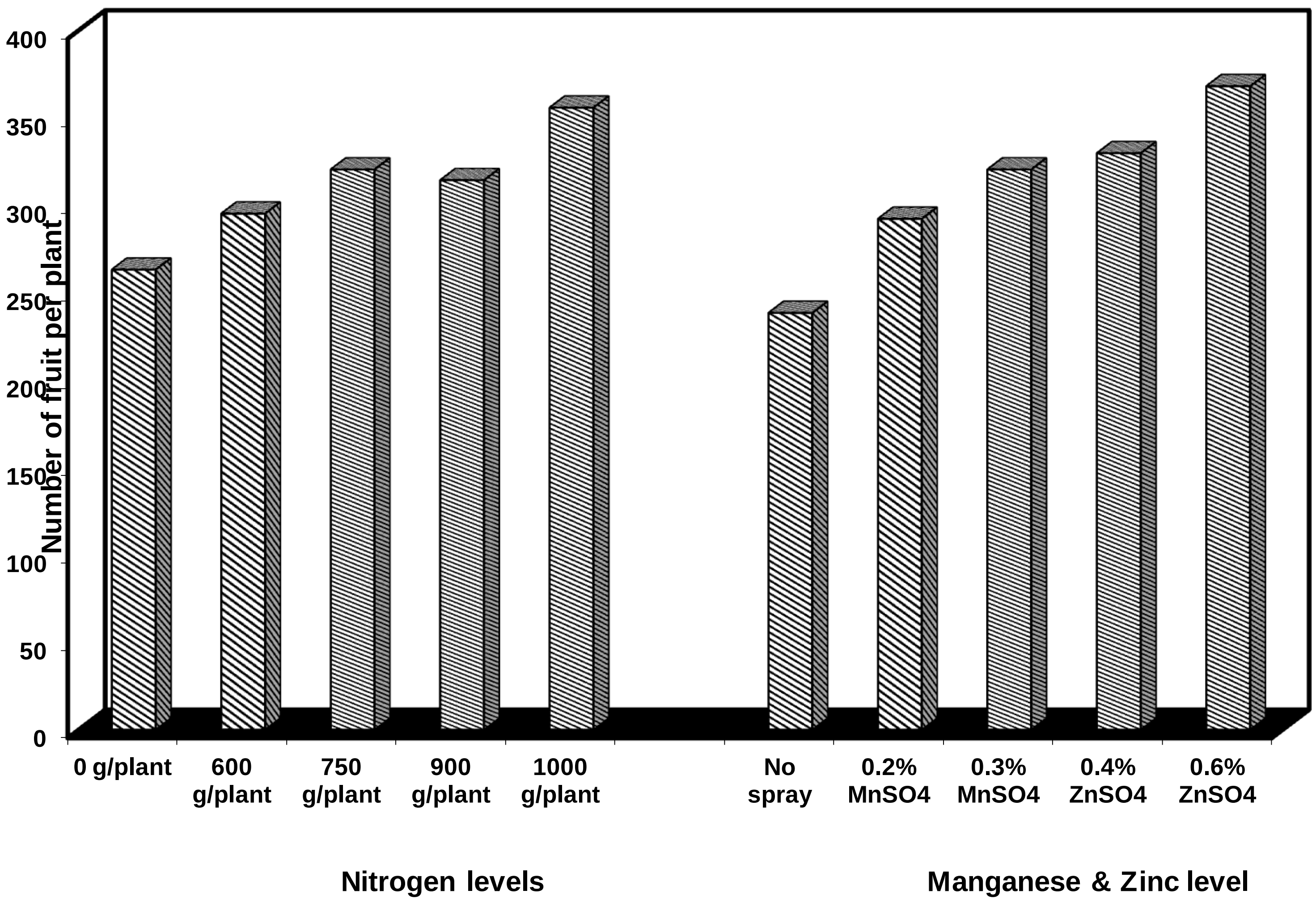
Spray of $ZnSO_4$ at 0.6% in conjunction with 1000 g N/plant produced significantly higher number of fruits (435.10/plant) as compared to the combination of other levels of nitrogen and micronutrients.

Table 4.7: Number of fruit per plant as affected by different levels of nitrogen, manganese, zinc and their combinations

Level of nitrogen	Level of zinc & manganese					Mean
	No spray	0.2% $MnSO_4$	0.3% $MnSO_4$	0.4% $ZnSO_4$	0.6% $ZnSO_4$	
0 g/plant	219.45	259.35	263.07	283.10	290.39	**263.07**
600 g/plant	231.16	269.80	295.85	324.90	353.71	**295.09**
750 g/plant	239.09	292.13	372.89	329.65	367.96	**320.34**
900 g/plant	243.84	291.65	314.21	328.70	392.66	**314.21**
1000 g/plant	258.09	347.70	355.70	381.90	435.10	**355.70**
Mean	**238.32**	**292.13**	**320.35**	**329.65**	**367.97**	

	Nitrogen	Zinc & Manganese	Interaction
S.E.(m)±	3.74	3.74	8.37
C.D. (at 5%)	10.67	10.67	23.86

Fig. 7: Number of fruit per plant as affected by different levels of nitrogen, manganese, zinc and their combinations



4. Seed pulp ratio (percentage of pulp in fruit):

Percentage of pulp in fruits significantly varied due to fertilization through nitrogen (Table 4.8 and Fig. 8). Nitrogen fertilization significantly improved the percentage of pulp in fruits. Application of nitrogen at 750, 900 and 1000 g/plant was found at par to each other. However, nitrogen at 1000 g/plant recorded significantly higher percentage of pulp per fruit over 600 g/plant and control.

Application of $MnSO_4$ at any concentration was not found effective in increasing percentage of pulp per fruit. But spray of $ZnSO_4$ at both the concentrations significantly increased the seed pulp ratio over no spray and 0.2% $MnSO_4$.

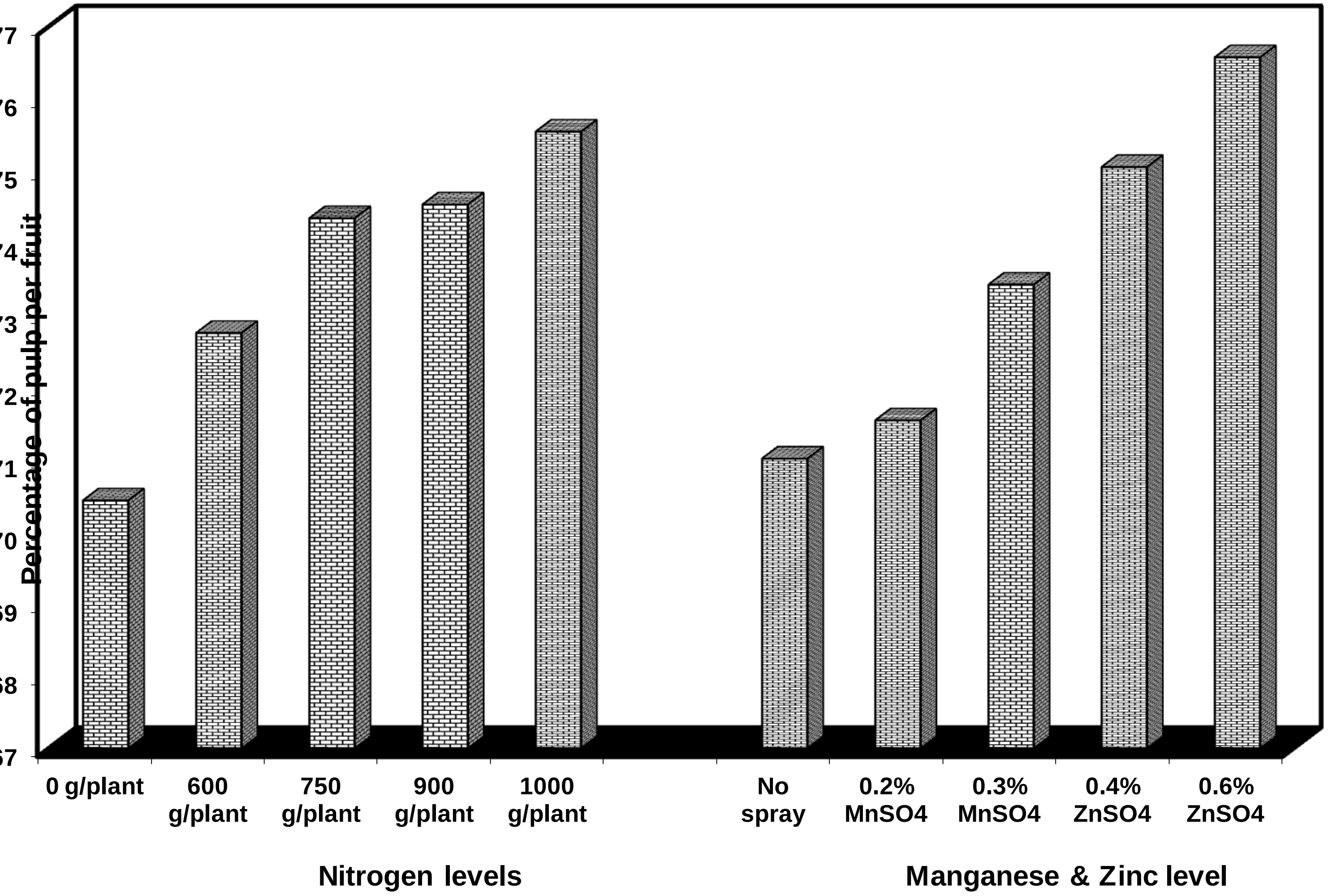
Both the experimental variables did not interact to each other in respect of seed pulp ratio. However, maximum percentage of pulp per fruit (79.75) was recorded with the application of 1000 g N/plant through soil and 0.6% $ZnSO_4$ through foliar.

Table 4.8: Percentage of pulp per fruit as affected by different levels of nitrogen, manganese, zinc and their combinations

Level of nitrogen	Level of zinc & manganese					Mean
	No spray	0.2% $MnSO_4$	0.3% $MnSO_4$	0.4% $ZnSO_4$	0.6% $ZnSO_4$	
0 g/plant	70.11	69.34	69.95	70.22	72.54	**70.43**
600 g/plant	70.75	71.10	72.78	73.97	75.14	**72.75**
750 g/plant	71.18	72.15	74.18	76.47	77.72	**74.34**
900 g/plant	71.57	72.15	74.76	76.47	77.72	**74.53**
1000 g/plant	71.42	72.98	75.45	78.10	79.75	**75.54**
Mean	**71.01**	**71.54**	**73.42**	**75.05**	**76.57**	

	Nitrogen	Zinc & Manganese	Interaction
S.E.(m)±	1.04	1.04	2.32
C.D. (at 5%)	2.96	2.96	NS

Fig. 8: Percentage of pulp per fruit as affected by different levels of nitrogen, manganese, zinc and their combinations



5. Yield of guava fruits/plant:

A perusal of Appendix II revealed that the levels of both nitrogen and micronutrients caused significant differences in yield of guava fruits per plant individually and in combination.

Increasing dose of nitrogen from 0 to 1000 g/plant enhanced the yield of guava fruits per plant significantly. The lowest fruit yield was found to be 57.49 kg/plant at zero level of nitrogen, whereas the highest fruit yield of 64.78 kg/plant was recorded at the maximum level of nitrogen (1000 g/plant). That means the fruit yield increase being round about 12.68 per cent due to 1000 N/plant over no nitrogen (Table 4.9 and Fig. 9).

Foliar application of $MnSO_4$ and $ZnSO_4$ at different concentrations augmented the fruit yield/plant significantly over no spray. As a result, the lowest fruit yield of 53.62 kg/plant was recorded from unsprayed plants, whereas maximum fruit yield (66.87 kg/plant) was obtained with highest tested concentration of $ZnSO_4$ (0.6%). Furthermore, spray of $ZnSO_4$ at 0.6% resulted in significantly highest fruit yield per plant as compared to other treatments of micronutrients.

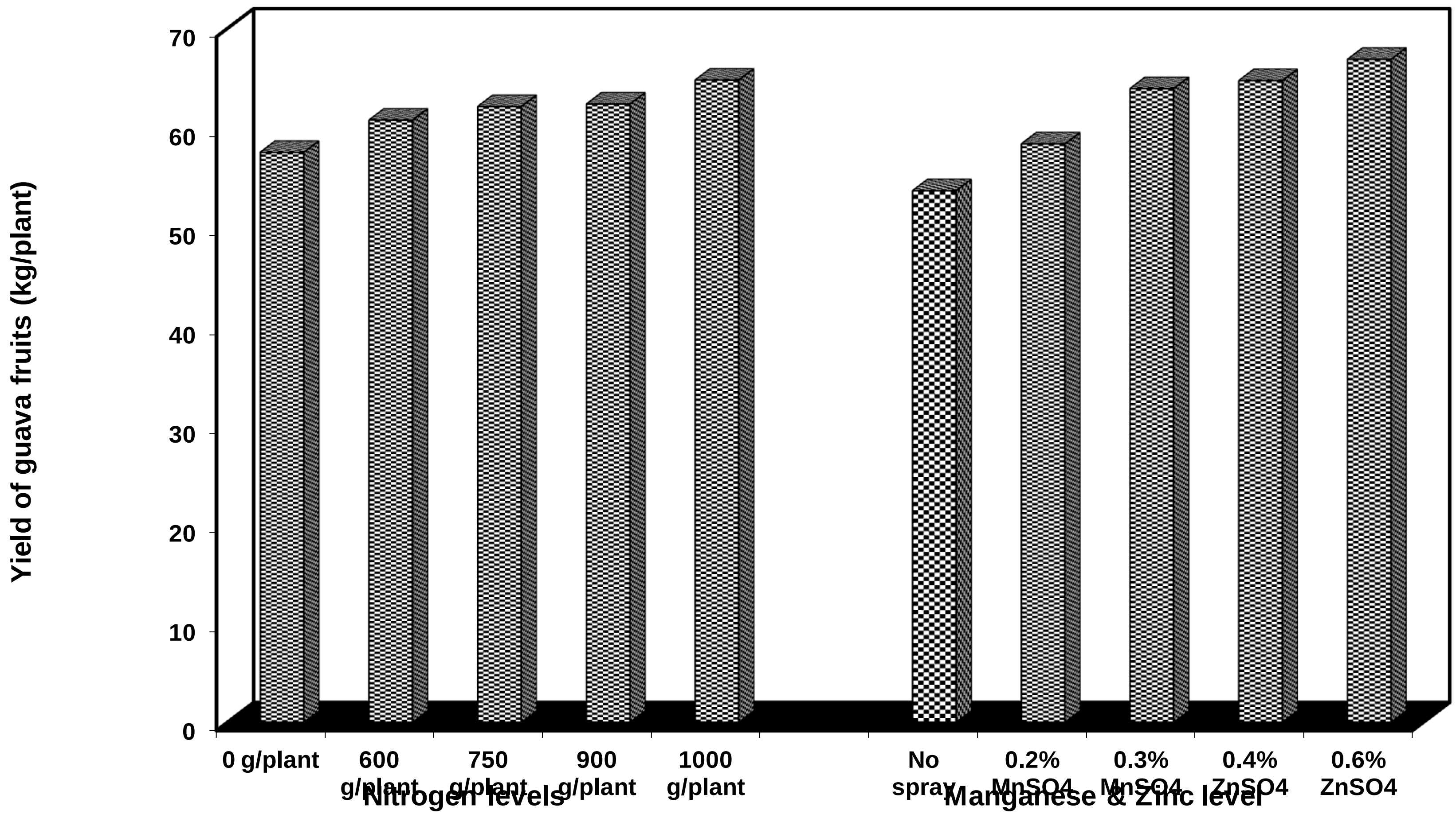
The interaction effect between nitrogen and zinc and manganese was also significant. Treatment combination 1000 g N + 0.6% $ZnSO_4$/plant resulted in significantly highest yield of guava fruit (72.76 kg/plant). However, this treatment combination was found at par with 1000 g N + 0.4% $ZnSO_4$/plant and 900 g N + 0.6% $ZnSO_4$/plant.

Table 4.9: Yield of guava fruits (kg) per plant as affected by different levels of nitrogen, manganese, zinc and their combinations

Level of nitrogen	Level of zinc & manganese					Mean
	No spray	0.2% $MnSO_4$	0.3% $MnSO_4$	0.4% $ZnSO_4$	0.6% $ZnSO_4$	
0 g/plant	52.42	56.32	60.44	59.63	58.65	**57.49**
600 g/plant	53.62	57.75	62.89	64.24	65.21	**60.74**
750 g/plant	54.42	58.60	64.10	64.94	68.49	**62.11**
900 g/plant	54.42	58.60	64.60	64.94	69.25	**62.36**
1000 g/plant	53.25	60.44	67.60	69.84	72.76	**64.78**
Mean	**53.62**	**58.34**	**63.92**	**64.72**	**66.87**	

	Nitrogen	Zinc & Manganese	Interaction
S.E.(m)±	0.63	0.63	1.41
C.D. (at 5%)	1.80	1.80	4.03

Fig. 9: Yield of guava fruits per plant as affected by different levels of nitrogen, manganese, zinc and their combinations



D. Quality characters (chemical):

(i) Total soluble solids:

The level of both nitrogen and micronutrients produced highly significant effects on total soluble solids in the guava fruits singly as well as jointly (Appendix III).

The total soluble solids in guava fruits showed significant improvement with the application of nitrogen irrespective of its dose (Table 4.10 and Fig. 10). All the levels of nitrogen from 0 to 1000 g/plant differed significantly among themselves and the increasing levels of this nutrient were associated with the corresponding increase in total soluble solids in guava fruits. Application of 1000 g N/plant resulted significantly in highest TSS (8.62%) over rest of the doses.

The sprays of $ZnSO_4$ and $MnSO_4$ also produced marked effect on this character. From the data of Table 4.10 it may be noted that the application of $MnSO_4$ at 0.2 and 0.3% and $ZnSO_4$ at 0.4 and 0.6% per plant resulted into significantly more total soluble solids in guava fruits in comparison to that in control where no spray was given. But, out of the two concentrations of each micronutrients, the 0.6% of $ZnSO_4$ was significantly more effective than the other concentrations as the total soluble solids in guava fruits was the maximum (8.44%).

It is evident from the data on interaction between different levels of nitrogen and micronutrients that the combination of the highest levels of nitrogen (1000 g/plant) and $ZnSO_4$ (0.6%) produced the maximum total soluble solids (9.93%) in guava fruits (Table 4.10). This percentage was more than two times of the minimum percentage of total soluble solids (4.54% annexed with control). Data further indicates that 1000 g N + 0.6% $ZnSO_4$/plant significantly recorded maximum total soluble solids over rest of the treatment combinations.

Table 4.10: Total soluble solids (%) as affected by different levels of nitrogen, manganese, zinc and their combinations

Level of nitrogen	Level of zinc & manganese					Mean
	No spray	0.2% $MnSO_4$	0.3% $MnSO_4$	0.4% $ZnSO_4$	0.6% $ZnSO_4$	
0 g/plant	4.54	5.38	5.90	6.99	6.67	**5.90**
600 g/plant	5.80	6.75	6.87	6.89	8.03	**6.87**
750 g/plant	6.20	6.77	8.49	7.64	8.44	**7.51**
900 g/plant	6.48	6.96	7.68	8.12	9.15	**7.68**
1000 g/plant	7.99	7.99	8.62	8.58	9.93	**8.62**
Mean	**6.20**	**6.77**	**7.51**	**7.64**	**8.44**	

	Nitrogen	Zinc & Manganese	Interaction
S.E.(m)±	0.09	0.09	0.20
C.D. (at 5%)	0.26	0.26	0.57

2. Titrable acidity:

The value of mean sum of squares corresponding to main as well as interaction effect (Appendix III) indicated that titrable acid content was significantly influenced by all effects.

The data given in Table 4.11 showed that application of 1000 g N/plant decreased the titrable acid content over 600, 750 and 900 g N/plant and control. Data further indicated that the application of 600 g N/plant recorded same percentage of titrable acid with that of control.

Table 4.11: Acidity in term of citric acid (%) as affected by different levels of nitrogen, manganese, zinc and their combinations

Level of nitrogen	Level of zinc & manganese					Mean
	No spray	0.2% $MnSO_4$	0.3% $MnSO_4$	0.4% $ZnSO_4$	0.6% $ZnSO_4$	
0 g/plant	0.57	0.55	0.55	0.57	0.52	**0.55**
600 g/plant	0.62	0.54	0.54	0.50	0.53	**0.55**
750 g/plant	0.56	0.56	0.45	0.52	0.46	**0.51**
900 g/plant	0.54	0.59	0.52	0.54	0.43	**0.52**
1000 g/plant	0.53	0.56	0.49	0.49	0.38	**0.49**
Mean	**0.57**	**0.56**	**0.51**	**0.52**	**0.46**	

	Nitrogen	Zinc & Manganese	Interaction
S.E.(m)±	0.01	0.01	0.02
C.D. (at 5%)	0.02	0.02	0.05

Fig. 10: Total soluble solids as affected by different levels of nitrogen, manganese, zinc and their combinations

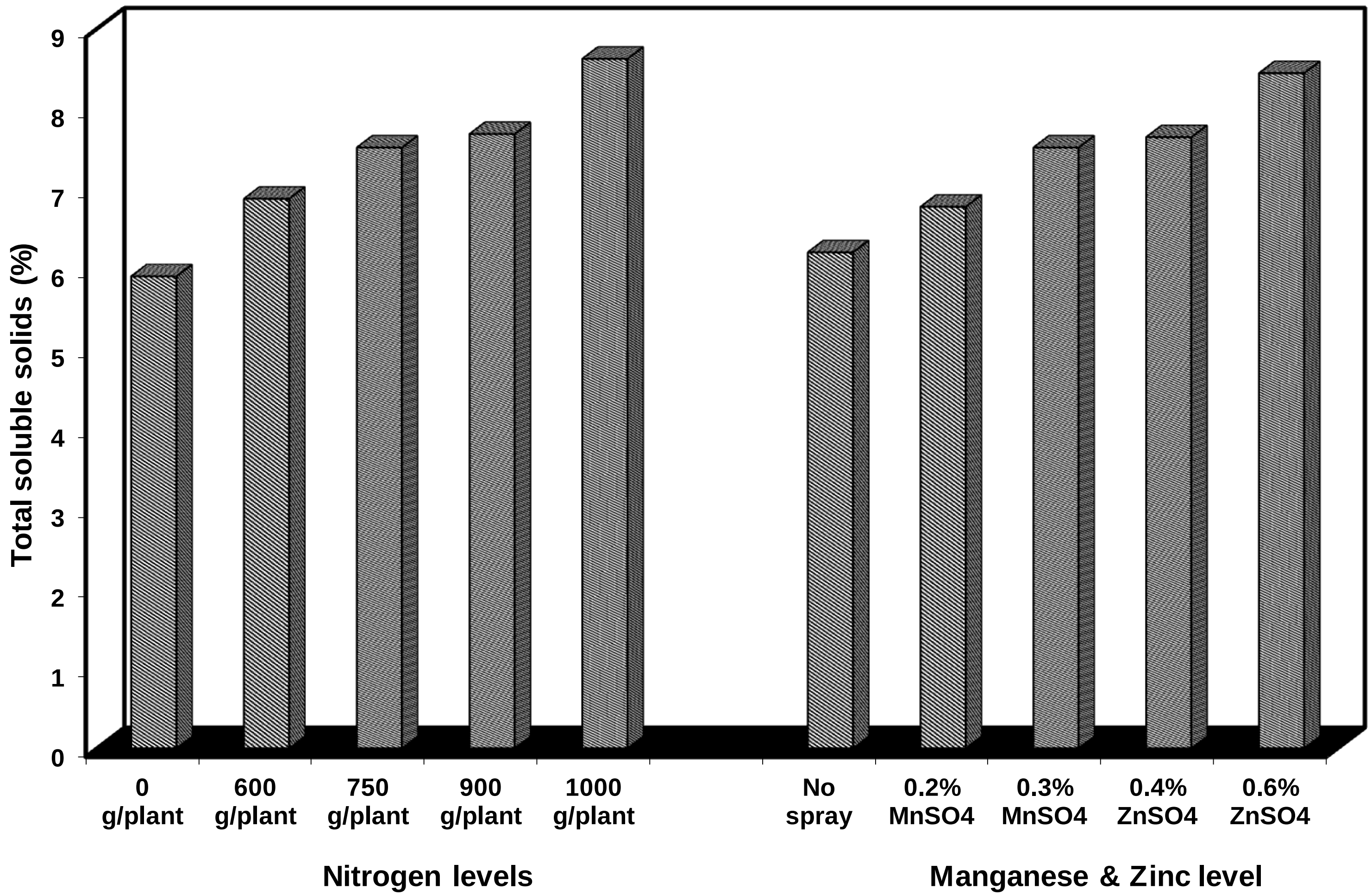
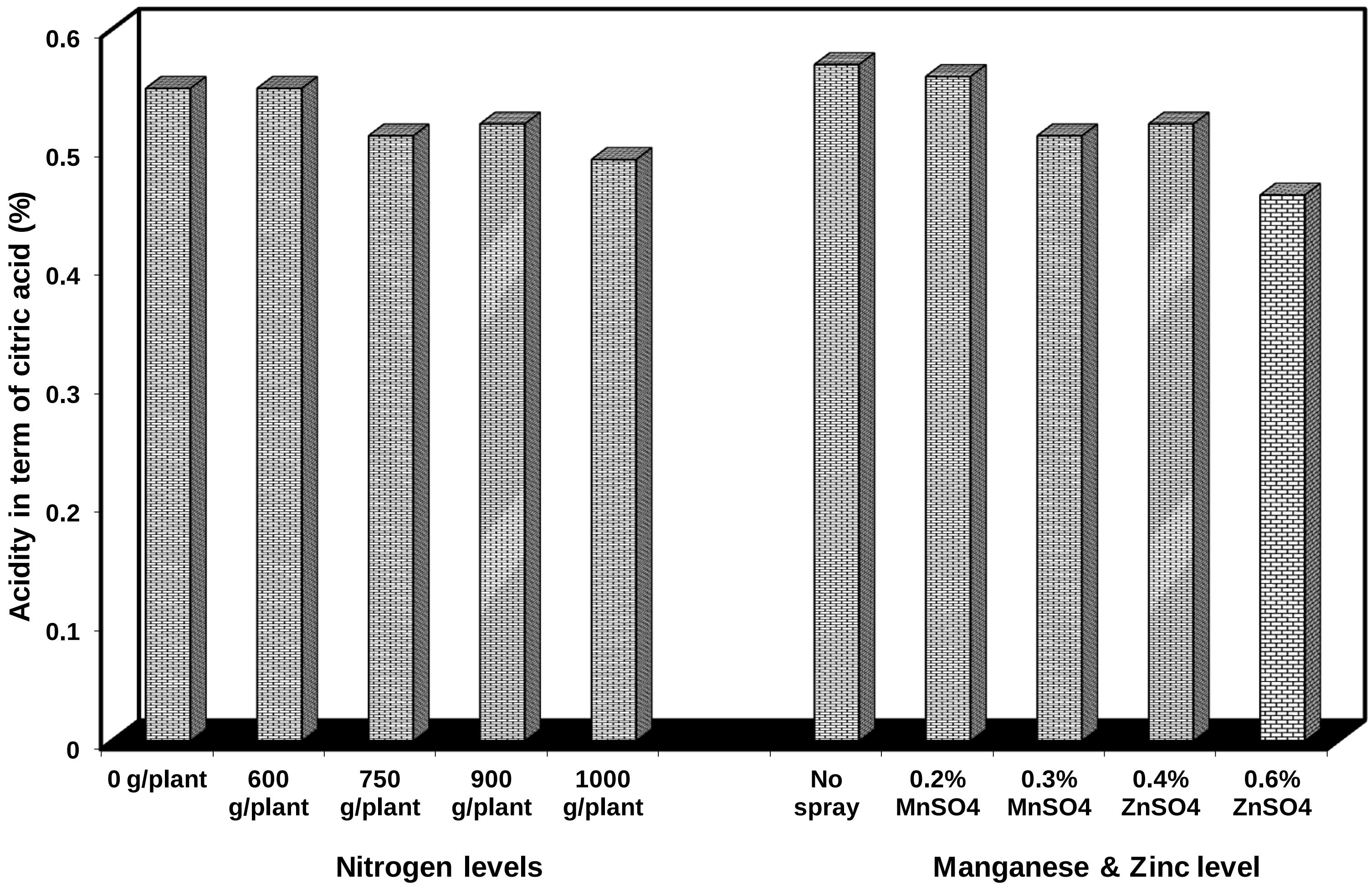


Fig. 11: Acidity in term of citric acid as affected by different levels of nitrogen, manganese, zinc and their combinations



Spray of micronutrients significantly reduced the titrable acid percentage of edible portion of guava fruits. The spray of $ZnSO_4$ @ 0.6% produced significantly minimum titrable acid (0.46%) as compared to rest of the concentrations of both micronutrients (Fig. 11).

The interaction effect between nitrogen and micronutrients was also significant. The treatment combination of 1000 g N and 0.6% $ZnSO_4$/plant significantly exhibited minimum titrable acid percentage (0.38%) in comparison to rest of the treatment combinations.

3. Ascorbic acid (Vitamin C):

An examination of Appendix III exhibited that nitrogen and micronutrients treatments produced significant variation in Vitamin C. The interaction of both nutrients was not significant.

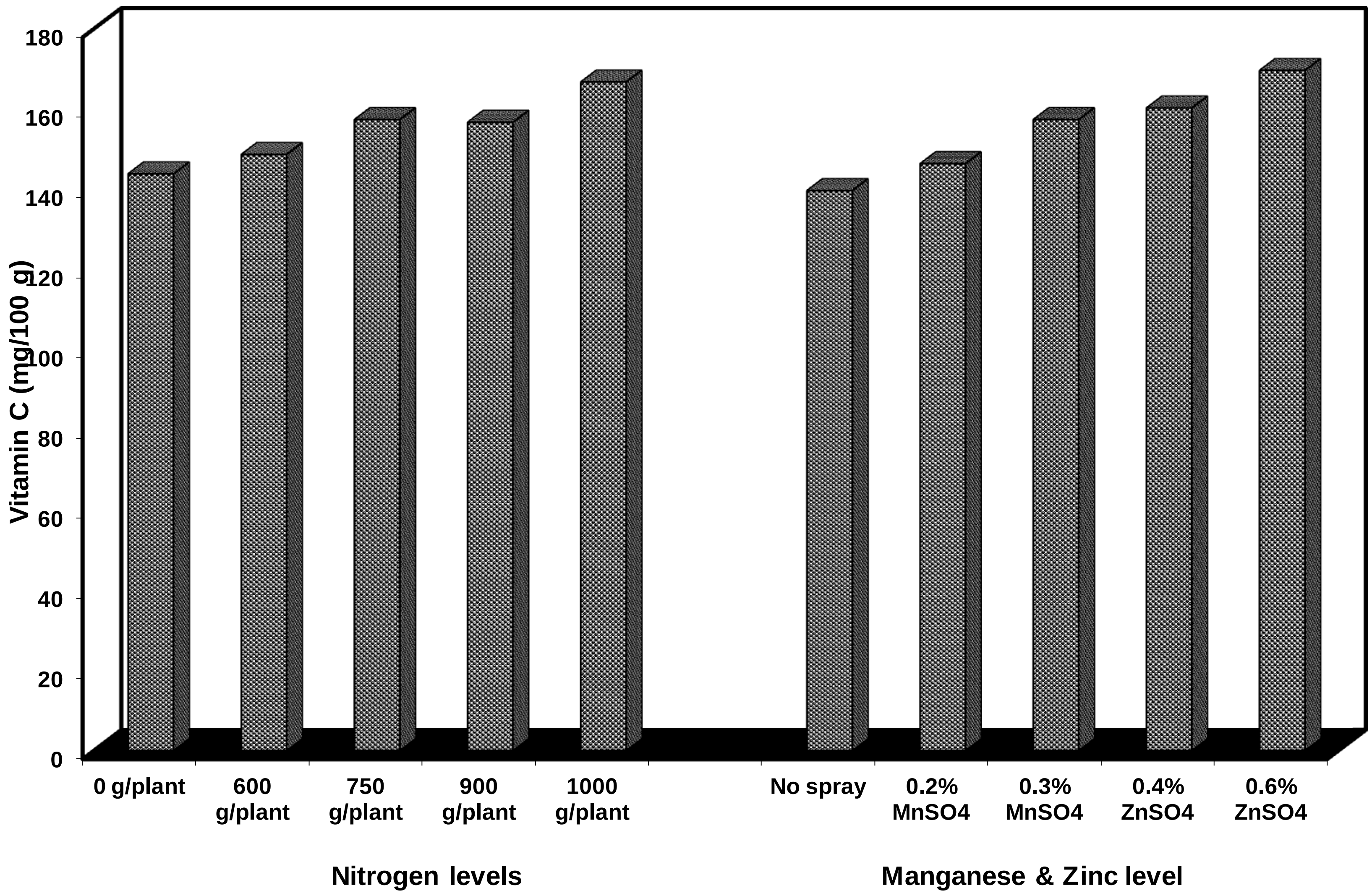
Ascorbic acid content increased significantly with the application of nitrogen over control (Table 4.12). The highest dose of nitrogen i.e. 1000 g/plant, recorded highest ascorbic acid content (166.66 mg/100 g), which was significantly higher over that recorded under rest of the doses (Fig. 12).

Table 4.12: Ascorbic acid (Vitamin C) (mg/100 g) as affected by different levels of nitrogen, manganese, zinc and their combinations

Level of nitrogen	Level of zinc & manganese					Mean
	No spray	0.2% $MnSO_4$	0.3% $MnSO_4$	0.4% $ZnSO_4$	0.6% $ZnSO_4$	
0 g/plant	131.15	140.70	143.77	147.68	155.58	**143.78**
600 g/plant	137.54	138.45	148.61	160.62	157.81	**148.60**
750 g/plant	139.61	146.30	170.85	160.19	169.55	**157.30**
900 g/plant	140.30	144.75	156.62	163.23	178.20	**156.62**
1000 g/plant	149.45	161.31	166.65	169.24	186.63	**166.66**
Mean	**139.61**	**146.30**	**157.30**	**160.19**	**169.55**	

	Nitrogen	Zinc & Manganese	Interaction
S.E.(m)±	3.00	3.00	6.71
C.D. (at 5%)	8.56	8.56	NS

Fig. 12: Ascorbic acid (Vitamin C) as affected by different levels of nitrogen, manganese, zinc and their combinations



Like nitrogen, spray of micronutrients also resulted in significant improvement in the Vitamin C. Spray of $MnSO_4$ at lower concentration was not found effective in increasing ascorbic acid content, but higher concentration of $MnSO_4$ 0.3% and both concentrations of $ZnSO_4$ significantly increased the ascorbic content over no spray. Among the treatment of micronutrients, 0.6% $ZnSO_4$ resulted in significantly highest ascorbic acid content (169.55 mg/100 g).

The data presented in Table 4.12 indicates that the interaction of both the experimental variables did not have significant effect on the Vitamin C. However, the maximum ascorbic acid was recorded with 1000 g N + 0.6% $ZnSO_4$/plant.

4. Reducing sugar (%):

The reducing sugar content significantly varied due to nitrogen, zinc and manganese levels, but did not alter due to their interaction (Appendix III).

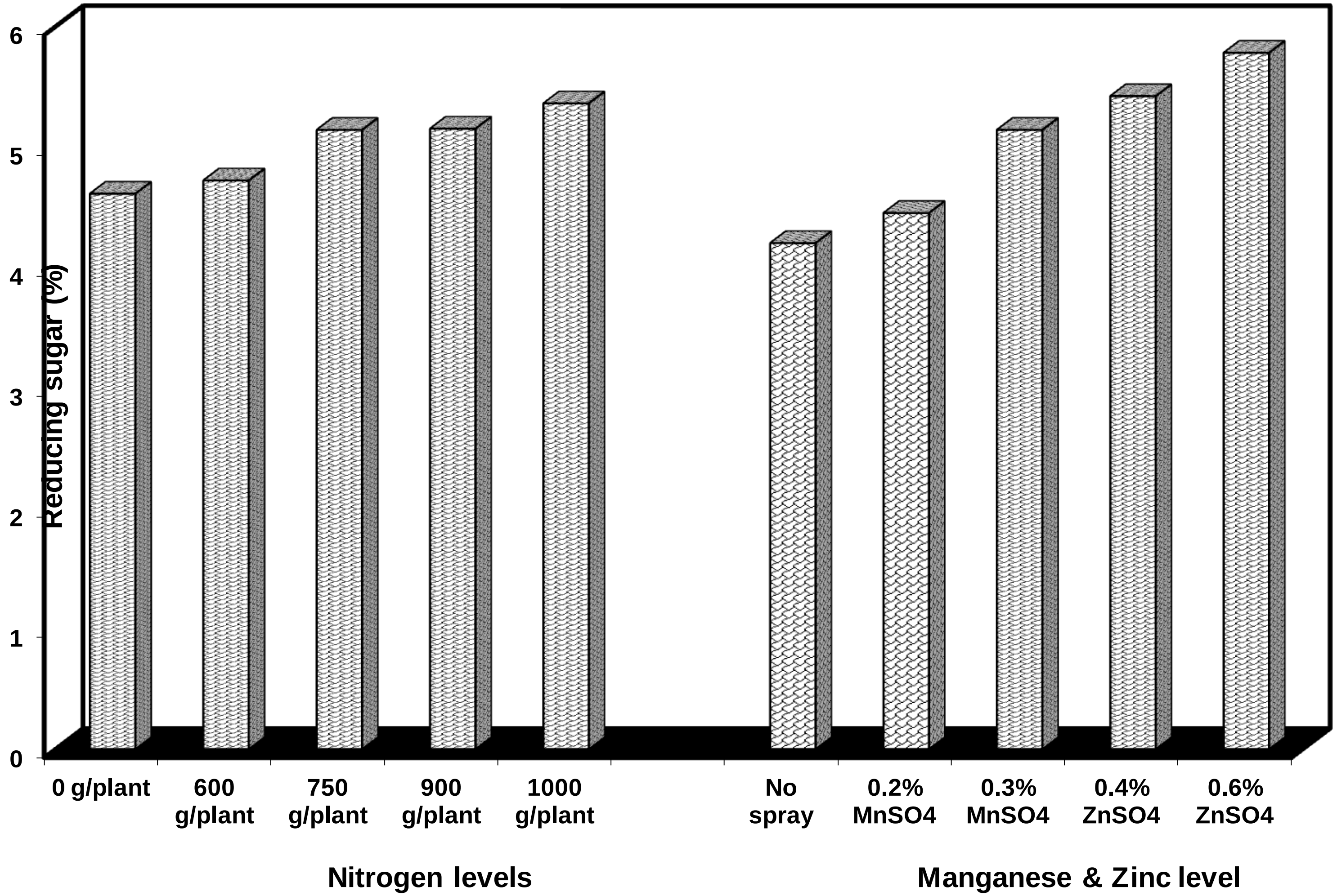
The highest content of reducing sugar (5.36%) was noted under the influence of highest level of N (1000 g/plant) as compared to lower levels, which had reducing sugar content of 4.72 to 5.15 per cent. Whereas, control had lowest reducing sugar content (4.61%).

Table 4.13: Reducing sugar (%) as affected by different levels of nitrogen, manganese, zinc and their combinations

Level of nitrogen	Level of zinc & manganese					Mean
	No spray	0.2% $MnSO_4$	0.3% $MnSO_4$	0.4% $ZnSO_4$	0.6% $ZnSO_4$	
0 g/plant	3.95	4.07	4.60	4.91	5.51	**4.61**
600 g/plant	3.84	4.34	4.72	5.16	5.54	**4.72**
750 g/plant	4.20	4.45	5.87	5.42	5.77	**5.14**
900 g/plant	4.47	4.55	5.15	5.72	5.85	**5.15**
1000 g/plant	4.54	4.82	5.37	5.89	6.20	**5.36**
Mean	**4.20**	**4.45**	**5.14**	**5.42**	**5.78**	

	Nitrogen	Zinc & Manganese	Interaction
S.E.(m)±	0.09	0.09	0.19
C.D. (at 5%)	0.25	0.25	NS

Fig. 13: Reducing sugar (%) as affected by different levels of nitrogen, manganese, zinc and their combinations



Increasing concentrations of Mn and Zn produced higher reducing sugar content (Table 4.13). Foliar spray of $ZnSO_4$ (0.6%) resulted in highest content of reducing sugar, and the treatment was significantly superior to lower concentration of $ZnSO_4$ (0.4%) and both concentrations of $MnSO_4$ (0.2 and 0.3%) including control. Lower concentration of $MnSO_4$ was found comparable to no spray in respect of this quality character (Fig. 13).

Both the variables did not interact to each other in respect of reducing sugar.

5. Total sugar:

A perusal of Appendix III revealed that the level of both, nitrogen and micronutrients caused significant differences in the total sugar singly but not jointly.

The differences in the total sugar among different level of nitrogen were significant (Table 4.14 and Fig. 14). Total sugar increased significantly with the application of nitrogen at higher levels over control. Thus, the maximum total sugar (12.80%) was registered with 1000 g N/plant.

Data presented in table under reference showed that the highest total sugar was obtained with the spray of 0.6% $ZnSO_4$ and this was found significantly superior to other treatments of micronutrients.

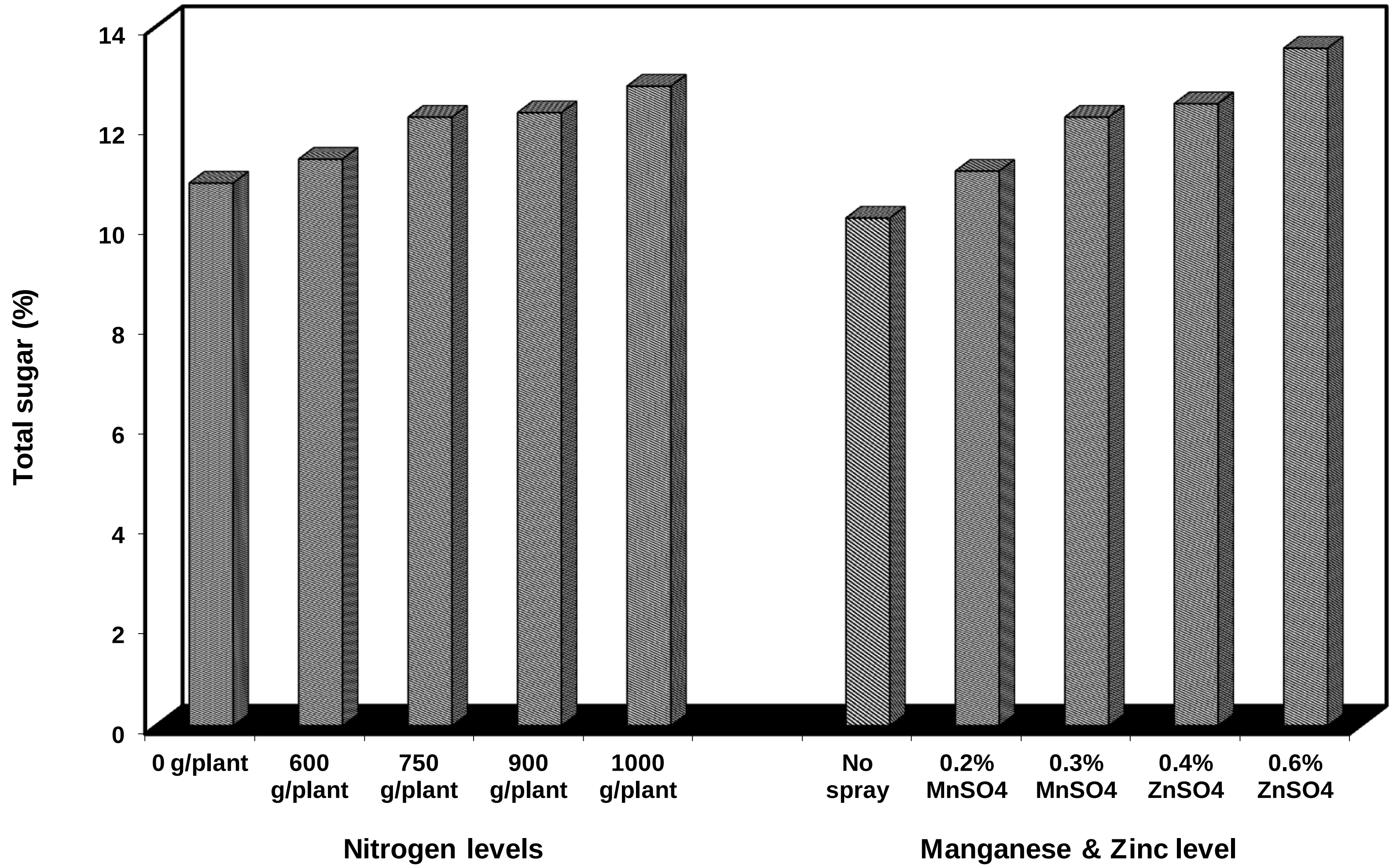
Both the variables did not interact to each other in respect of total sugar.

Table 4.14: Total sugar (%) as affected by different levels of nitrogen, manganese, zinc and their combinations

Level of nitrogen	Level of zinc & manganese					Mean
	No spray	0.2% $MnSO_4$	0.3% $MnSO_4$	0.4% $ZnSO_4$	0.6% $ZnSO_4$	
0 g/plant	9.60	10.12	10.86	11.19	12.52	**10.86**
600 g/plant	8.95	10.70	11.34	12.44	13.26	**11.34**
750 g/plant	10.16	11.10	13.62	12.45	13.56	**12.18**
900 g/plant	10.84	11.46	12.27	12.69	14.09	**12.27**
1000 g/plant	11.24	12.13	12.80	13.48	14.35	**12.80**
Mean	**10.16**	**11.10**	**12.18**	**12.45**	**13.56**	

	Nitrogen	Zinc & Manganese	Interaction
S.E.(m)±	0.25	0.25	0.57
C.D. (at 5%)	0.72	0.72	NS

Fig. 14: Total sugar (%) as affected by different levels of nitrogen, manganese, zinc and their combinations



CHAPTER-V
DISCUSSION

The results of the present investigation "Effect of nitrogen with and without zinc and manganese on growth, yield and quality of guava (*Psidium guajava* L.) var. Gwalior-27" as presented in the preceding chapter are discussed here with the help of findings of several workers in India and abroad pertaining to the subject as reviewed in chapter II. In this discussion, an attempt has been made to establish the relationship amongst the growth manifestations, fruit yield and quality of produce as affected by different treatments under study.

Growth parameters:

The plant growth parameter length of tertiary shoot was improved significantly by N application. However, girth of tertiary shoot improved marginally but not significantly with the nitrogen fertilization. Application of nitrogen at any level significantly increased the length of tertiary shoot over control. As a result, the best plant growth is expressed at the highest level of nitrogen (1000 g/plant). The increase in length of tertiary shoot of guava using different levels of nitrogen was also reported by Sharma (1985), Tassar *et al.* (1989), Dubey *et al.* (2001) and Al Qurashi (2005).

The improvement in growth characters of guava might be due to the well established fact that nitrogen is an important constituent of chlorophyll, proteins and amino-acids. With greater supply of nitrogen the synthesis of amino acids and chlorophyll an accelerated which eventually promoted the growth characters. The beneficial effect of nitrogen on growth characters may be due to the fact that it increases the production of green leaves, which helps synthesis of carbohydrates, protein, etc. for building up of new tissues. Therefore, the supply of additional nitrogen might be the basic reason for improving growth characters.

Reference to Table 4.1 and 4.2 will make it clear that the plant growth as judged by length and girth of tertiary shoot was improved significantly by foliar spray of Zn and Mn. Spray of 0.6% $ZnSO_4$ resulted in significantly longest and widest tertiary shoot over other concentrations of both micronutrients. These results are clearly indicative of growth promoting effect of zinc and manganese when applied as foliar spray before flowering and at fruit growth time. The foliar spray of Zn and Mn might have induced synthesis of chlorophyll and thus leads to increase in chlorophyll content in plants sprayed with higher concentration of Zn and Mn, which in turn resulted in higher vegetative growth. Improvement in vegetative growth was observed earlier with Zn and Mn (Sharma and Bhattachharayya, 1994, Balakrishnan, 2000 and Sarolia *et al.,* 2007).

Fruit yield and yield attributing characters:

On reviewing the data computed in Table 4.9 it is observed that there was substantial improvement in fruit production with nitrogen fertilization. All the four doses of this nutrient (600, 750, 900 and 1000 g/plant), tested, increased the yield of fruit significantly over control. The significant maximum benefit in fruit yield was accrued with the application of 1000 g N/plant.

The weight of fruit per plant is governed mainly by the number of fruits per plant and the weight per fruit. In the present investigation, the effect of level of nitrogen was significant on the number of fruits per plant which showed increase with successive increase in the level of nitrogen from 0 g to 1000 g/plant. The weight per fruit in the present study also showed significant improvement due to application of nitrogen. The maximum number of fruits per plant and weight per fruit was recorded by the highest dose of nitrogen (1000 g/plant). The size of fruit as determined by the vertical diameter (length) and horizontal diameter of fruit also exhibited positive response of nitrogen fertilization. Again, application of 1000 g N/plant resulted in significantly longest and widest fruits over other doses of nitrogen and control.

Since, the maximum values of these parameters were registered with the highest dose of nitrogen (1000 g/plant), it is clear that yield of guava fruits per plant was the maximum at 1000 g N/plant due to the highest weight per fruit and number of fruits per plant. The beneficial effects on yield and yield attributing characters by the higher levels of nitrogen were due to the fact that N increased that efficiency of metabolic process of the tree and the indirectly of fruit. The increase in length and diameter of fruit, fruit weight and yield per plant was due to accumulation of more food material in the tree that led to an efficient utilization for the development of fruit. Better nutrition and healthy growth of treated guava trees brought about an increase in yield per plant.

The results of present investigation are in agreement with the findings of Singh *et al.* (1983), Sharma (1985), Tassar *et al.* (1989), Kumar *et al.* (1996), Taran (1996), Ahmad *et al.* (1998), Bhatia *et al.* (2001), Dubey *et al.* (2001), Medeiros *et al.* (2004) and Lima *et al.* (2008) who reported the response of guava to nitrogen in augmenting the yield and yield attributing characters to a certain level of its application.

Different yield attributing characters viz., length of fruit, diameter of fruits, weight per fruit and number of seeds per fruit, number of fruits per plant and seed pulp ratio varied significantly due to Zn and Mn concentrations. The plant sprayed with water had significantly the lowest value of all these parameters and these characters were improved with the spray of zinc sulphate and manganese sulphate being the maximum under the highest concentration of both micronutrients but $ZnSO_4$ @ 0.6% proved superior to o.3% $MnSO_4$ and other lower concentrations of both micronutrients. Zinc was reported to regulate the semi-permeability of cell wall, thus mobilizing more water into the fruits, thereby increasing the size of the fruit (Babu *et al.*, 1982).

Heavier fruits under zinc treatment might be due to the high level of auxin in the various part of the fruit maintained by zinc application. The present finding also finds support from the work of Pandey *et al.* (1988), Sharma *et al.* (1991), Dahiya *et al.* (1993), Kundu and Mitra (1999), Singh and Brahmachari (1999), Bhatia *et al.* (2001), Das *et al.* (2001), Lal and Sen (2002), Sarolia *et al.* (2007) and Pal *et al.* (2008) in guava. Increase in mean weight of fruit due to manganese spray is in accordance with the work of Lal and Sen (2002) in guava. Increase in yield attributes due to foliar application of zinc has also been reported by Sherif *et al.* (2000) and Balakrishnan (2001b).

Guava cv. Gwalior-27 produced the lowest fruit yield (53.62 kg/plant) when plant was not sprayed at all. But fruit yield was maximum (63.92 and 66.87 kg/plant) in plants sprayed with 0.3% $MnSO_4$ and 0.6% $ZnSO_4$ and proved significantly superior to corresponding lower concentration, respectively. Spray of 0.6% $ZnSO_4$ proved significantly superior among all the concentrations of both the nutrients and produced highest fruit yield per plant. Since the maximum value of yield attributing traits, length and diameter of fruits, weight per fruit, number of fruits per plant, number of seeds per fruit and percentage of pulp per fruit was registered with the foliar spray of $ZnSO_4$ 0.6%. Thus, it is clear that fruit yield in kg per plant was maximum at $ZnSO_4$ 0.6% due to widest, longest and heaviest fruits and highest fruits per plant along with highest percentage of pulp. Favourable effect of zinc spray on yield have earlier been also reported by Mansour and Sied (1981), Pandey *et al.* (1988), Sharma *et al.* (1991), Dahiya *et al.* (1993), Kundu and Mitra (1999), Balakrishnan (2000), Lal *et al.* (2000), Sherif *et al.* (2000), Balakrishnan (2001a & b), Bhatia *et al.* (2001), Sarolia *et al.* (2007) and Pal *et al.* (2008) in guava. Increase in yield with Mn spray finds support from the findings of Lal *et al.* (2000) and Lal and Sen (2002) in guava.

Fruit quality parameters:

Fruit quality parameters were also influenced by different doses of N. All the levels of nitrogen differed significantly among themselves and the increasing levels of nitrogen was associated with corresponding increase in total soluble solids, ascorbic acid, reducing sugar and total sugar. There was slow and significant decrease in titrable acidity with increasing level of nitrogen.

Beneficial effects of nitrogen in increasing total soluble solids, ascorbic acid, reducing and total sugar content of guava were also reported by Singh *et al.* (1983), Ghosh (1991), Singh *et al.* (1992), Kumar *et al.* (1996), Lal and Sen (2001), Dubey *et al.* (2001), Umashankar *et al.* (2002), Lima *et al.* (2008) and Silva *et al.* (2008).

Different quality characters viz., T.S.S., acidity, ascorbic acid, reducing sugar and total sugar significantly varied due to varying $ZnSO_4$ as well as $MnSO_4$ concentrations. Quality characters like total soluble solids, ascorbic acid, reducing sugar and total sugar were significantly increased by the foliar application of zinc and manganese. The foliar spray of zinc reduced acidity content in fruit and reduction was relatively more marked with 0.6% than 0.4% $ZnSO_4$ solution and with 0.2 and 0.3% $MnSO_4$. The titrable acidity was reduced with the spray of micronutrients and minimum content was recorded with 0.6% $ZnSO_4$.

The acids under the influence of chemicals might have either been fastly converted into sugars and their derivatives by the reactions involving reversal of glycolytic pathway or might be used in respiration or both. The increase in T.S.S. and different fractions of sugar under the influence of micronutrients might be due to hydrolysis of complex polysaccharides into simple sugars, synthesis of metabolites and rapid translocation of photosynthetic products and minerals from other parts of plant to developing fruits. Higher level of sugars in Zn and Mn treated plant fruits might be possible cause behind increase in ascorbic acid content because it is synthesized from sugar. It is also possible that treatments reduced the activities of degrading enzymes. Several workers (Singh and Chhonkar, 1983; Pandey *et al.*, 1988; Ghosh, 1986; Sharma *et al.,* 1991; Dahiya *et al.,* 1993; Kundu and Mitra, 1999; Singh and Brahmachari, 1999; Balakrishnan, 2000; Balakrishnan, 2001a & b; Bhatia *et al.*, 2001; Lal and Sen, 2001; Das *et al.,* 2004; Prasad *et al.,* 2005 and Pal *et al.,* 2008) observed that spraying with Zn improved the fruit quality of guava. The beneficial effect of Mn in increasing total soluble solids, reducing sugar, total sugar, T.S.S./acid ratio and ascorbic acid content of guava fruit were also reported by Lal and Sen (2001). Decrease in acidity content by manganese spray has previously been shown by Ghosh (1986) and Lal and Sen (2001).

Effect of interaction:

The interaction effect of nitrogen and micronutrients on length of tertiary shoot, number of fruit per plant, yield of fruit, TSS and titrable acidity was found significant. Spray of 0.6% $ZnSO_4$ along with 1000 g N/plant recorded significantly longer tertiary shoot (32.82 cm), more number of fruits per plant (435.10), higher fruit yield/plant (72.76 kg), higher TSS (9.93%) and lowest acidity content (0.38%) over all remaining treatment combinations. The highest yield under the treatment combination 1000 g N + 0.6% $ZnSO_4$/plant was mainly due to maximum number of fruits per plant under this treatment combination. Similar findings were also reported by Lal *et al.* (2000), Lal and Sen (2001) and Lal and Sen (2002).

CHAPTER-VI

SUMMARY, CONCLUSION AND SUGGESTIONS

The investigation entitled "Effect of nitrogen with and without zinc and manganese on growth, yield and quality of guava (*Psidium guajava* L.) var. Gwalior-27" was carried out at the Pomology Orchard of College of Agriculture, Gwalior during the winter season of 2009-10. Randomized block design with three replications was utilized for the experiment. Eight year old guava plants were selected for the experiment. Treatment consisted of twenty five combinations of five levels each of nitrogen (0, 600, 750, 900 and 1000 g/plant) and micronutrients (no spray, 0.2% $MnSO_4$, 0.3% $MnSO_4$, 0.4% $ZnSO_4$ and 0.6% $ZnSO_4$). Nitrogen was applied in the form of urea in the first week of August, micronutrients were applied in the form of $MnSO_4$ and $ZnSO_4$ (neutralized with lime) before flowering and at fruit growth time. Observations on girth and length of tertiary shoot, fruit diameter (vertical and horizontal), fruit weight, number of seeds/fruit, number of fruits/plant, seed pulp ratio, fruit yield per plant, TSS, acidity, vitamin C, reducing sugar and total sugar were recorded. Results obtained have been summarized below:

Effect of nitrogen:

- **The growth parameter, length of tertiary shoot was affected significantly by the dose of nitrogen; however, girth of tertiary shoot was not influenced by nitrogen fertilization. Application of 1000 g N/plant significantly augmented the length of tertiary shoot over rest of the doses.**
- **Prominent fruit yield components like vertical and horizontal diameter of fruit, fruit weight, number of seeds per fruit, number of fruits per plant and seed pulp ratio showed direct relationship with the dose of nitrogen applied. The highest values of these traits were significantly registered with the highest dose of nitrogen (1000 g/plant). However, this treatment was found at par with 900 g N/plant in respect of horizontal fruit diameter, fruit weight and seed pulp ratio.**
- **Yield of guava fruit per plant increased significantly with the application of each level of nitrogen over control. The production of fruits per plant**

was enhanced by 3.21, 3.62, 5.96 and 11.95 per cent with 1000 g N/plant compared with 900, 750, 600 g N/plant and control respectively.

- **The quality characters like total soluble solids, ascorbic acid, reducing sugar and total sugar increased significantly due to nitrogen fertilization. Application of 1000 g N/plant significantly increased all these quality characters over most of the lower levels of N and control. But application of 1000 g N/plant significantly decreased the titrable acidity over rest of the levels.**

Effect of micronutrients:

- **Significant effect of micronutrients was noticed on girth and length of tertiary shoots. Spray of 0.6% $ZnSO_4$ resulted in significantly widest and longest tertiary shoot over other treatments of micronutrients including control.**
- **Fruit development parameters like fruit diameter (vertical and horizontal), fruit weight, number of seeds per fruit, number of fruits per plant and seed pulp ratio increased significantly with the spray of micronutrients. The highest value of all these parameters was registered with the spray of 0.6% $ZnSO_4$. However, this treatment was found at par with 0.4% $ZnSO_4$ in respect of horizontal diameter of fruit and seed pulp ratio and also with 0.3% $MnSO_4$ in respect of seed pulp ratio.**
- **Spray of micronutrients exhibited favourable effect on fruit yield per plant. Both concentrations of each micronutrient increased the fruit yield of guava significantly over no spray. Spray of 0.6% $ZnSO_4$ enhanced the fruit yield significantly over rest of the treatments.**
- **Fruit quality parameters, Total soluble solids, vitamin C, reducing and total sugar increased with the spray of $MnSO_4$ and $ZnSO_4$ at any concentration. Highest value of all these quality parameters was annexed with spray of 0.6% $ZnSO_4$ which was found significantly superior to rest of the treatments. Like nitrogen, application of 0.6% $ZnSO_4$ also significantly reduced the titrable acidity as compared to rest of the concentrations including control.**

Interaction effect:

- **The interaction effect of nitrogen and micronutrients on length of tertiary shoot, number of fruit per plant, yield of fruit, TSS and titrable acidity was found significant. Spray of 0.6% $ZnSO_4$ along with 1000 g N/plant recorded significantly longer tertiary shoot (32.82 cm), more number of fruits per plant (435.10), higher fruit yield/plant (72.76 kg), higher TSS (9.93%) and lowest acidity content (0.38%) over all remaining treatment combinations.**

Conclusion:

With a view to draw definite conclusion from the results of present investigation, the fruit yield has been the major consideration. It is inferred that the crop of guava may be fertilized, at least, with 1000 g N/plant and sprayed with 0.6% $ZnSO_4$ under the Gwalior conditions.

Suggestions for further work:

1. **Since this was the first year of the investigation, hence this trial should be repeated again to confirm the results of the present experiment.**
2. **Few more levels of nitrogen with micronutrients should also be added in the investigation to obtain their optimum level.**

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APPENDIX-I

Mean sum of squares for girth and length of tertiary shoot, fruit diameter (vertical and horizontal) and fruit weight

S.V.	d.f.	Girth of tertiary shoot (mm)	Length of tertiary shoot (cm)	Fruit diameter (vertical in cm)	Fruit diameter (horizontal in cm)	Fruit weight (g)
Replication	2	0.0012	1.8973	0.3521	0.4216	93.0245
Nitrogen level	4	0.006876	67.3791**	0.89339**	0.83932*	3315.182**
Manganese & Zinc level	4	0.011811*	114.4094**	2.62874**	3.5059**	5799.376**
Interaction	16	0.000373	5.27097**	0.107849	0.073316	70.5905
Error	48	0.003262	2.167093	0.20571	0.293283	446.3705
Total	74					

APPENDIX-II

Mean sum of squares for number of seed and fruit per plant, seed pulp ratio and fruit yield per plant

S.V.	d.f.	Number of seeds/fruit	Number of fruits/plant	Seed pulp ratio (% of pulp)	Fruit yield (kg/plant)
Replication	2	179.3189	150.4667	15.7934	1.0349
Nitrogen level	4	11290.758**	17389.26**	59.7110**	106.877**
Manganese & Zinc level	4	9541.3090**	34910.68**	82.099**	439.070**
Interaction	16	269.718692	1217.392**	3.278558	11.6657*
Error	48	385.941221	210.0506	16.17201	5.990466
Total	74				

APPENDIX-III

Mean sum of squares for quality parameters

S.V.	d.f.	TSS (%)	Acidity (%)	Vitamin C (%)	Reducing sugar (%)	Total sugar (%)
Replication	2	0.08496	0.00098	89.2345	0.2146	1.8937
Nitrogen level	4	15.3178**	0.01021**	1161.7938**	1.5209**	9.0530**
Manganese & Zinc level	4	11.085**	0.0261**	2084.3518**	6.5438**	25.4844**
Interaction	16	0.4788**	0.0038**	79.16337	0.124064	0.615912
Error	48	0.120684	0.001031	135.1462	0.113108	0.959647
Total	74					

VITA

The author of the thesis Jagdish Chandra Ganava S/o Shri Harish Chandra Ganava was born on 14th January, 1983 at Amarpura, Ratlam, M.P.

He acquired his High School level education in 2001 from Higher Secondary School, Sarwan, Ratlam with 49.60 per cent marks. After that he passed Higher Secondary in 2003 scoring 62.8 per cent marks from Boys Higher Secondary School, Sailana, Ratlam.

He completed his B.Sc. (Ag.) from R.A.K. College of Agriculture, Sehore in 2008 achieving 67.1 per cent marks.

After completing graduation he was selected for M.Sc. (Ag.) degree program in Horticulture and was admitted in College of Agriculture, Gwalior (M.P.). He has passed all required courses in M.Sc. by obtaining approximately 71.00 percent marks.

During all the period of his education, from schooling to post graduation he was very sincere and honest towards his studies.

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