EFFECT OF MICRONUTRIENTS (Zn, Fe AND Mn) ON GROWTH, YIELD AND QUALITY OF ONION (*Allium cepa* L.) cv. 'LOCAL WHITE'

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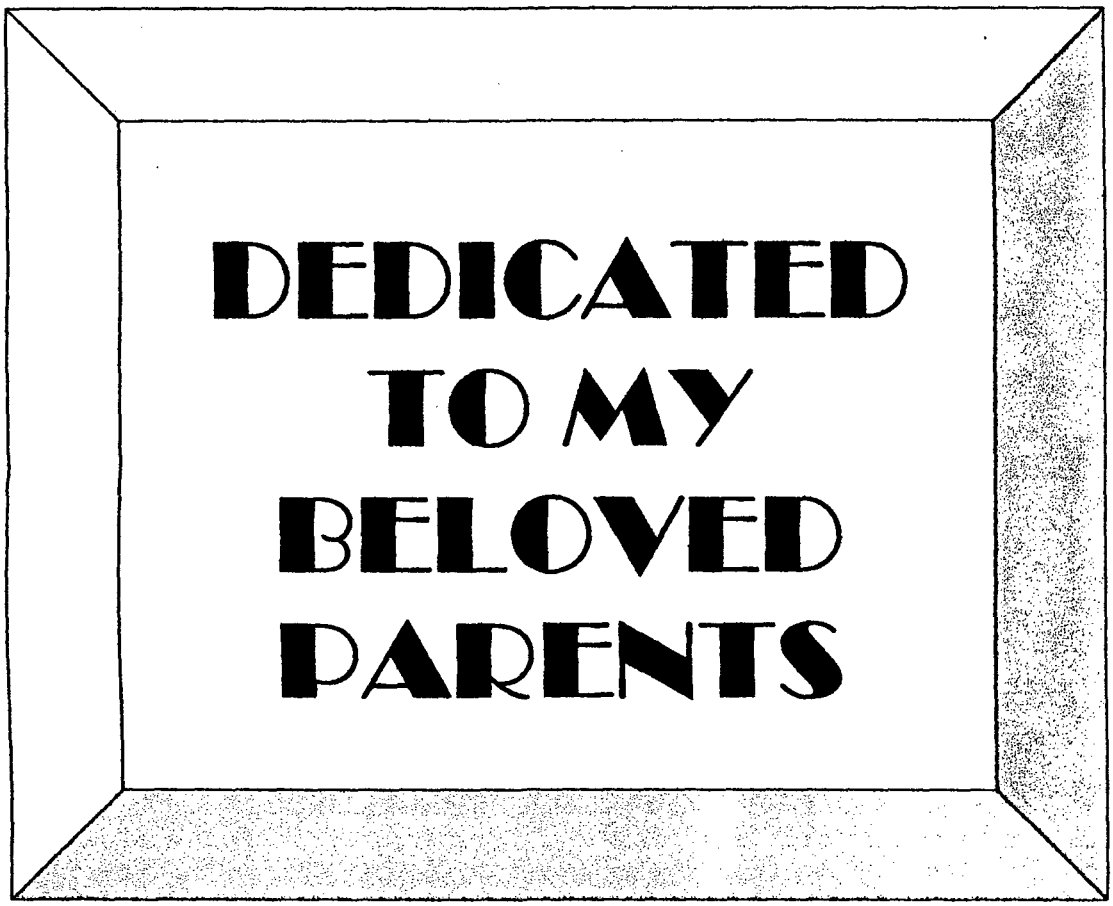
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ABSTRACT

EFFECT OF MICRONUTRIENTS (Zn, Fe AND Mn) ON GROWTH, YIELD AND QUALITY OF ONION (*Allium cepa* L) cv. 'LOCAL WHITE'

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ABSTRACT

The present investigation entitled,"Effect of micronutrients (Zn, Fe and Mn) on growth, yield and quality of onion (*Allium cepa* L.) cv. 'Local White' was laid out in a Randomized Block Design with four replications during *rabi* season of 2000-2001 at the Horticultural Research Farm, Department of Horticulture, B.A.College of Agriculture, Anand Campus, Anand. There were eight treatments, in which each micronutrient was applied as a basal dose @ 10 kg/ha before transplanting alongwith recommended dose of FYM and NPK viz., T_1 (Control), T_2 ($ZnSO_4$), T_3 ($FeSO_4$), T_4 ($MnSO_4$), T_5 ($ZnSO_4$ + $FeSO_4$), T_6 ($ZnSO_4$ + $MnSO_4$), T_7 ($FeSO_4$ + $MnSO_4$) and T_8 ($ZnSO_4$ + $FeSO_4$ + $MnSO_4$).

The soil application of micronutrients (Zn, Fe and Mn) improved growth characters significantly. The treatment T_5 ($ZnSO_4$ + $FeSO_4$) recorded significantly higher plant height (63.65 cm) than the control while significantly higher number of leaves per plant were recorded in the treatment T_8 ($ZnSO_4$ + $FeSO_4$ + $MnSO_4$) than all other treatments. Significantly higher yield contributing attributes like bulb diameter (6.65 cm), bulb weight (160.86 g) and bulb yield (54.112 t/ha) than the control were found in the treatment T_8 ($ZnSO_4$ + $FeSO_4$ + $MnSO_4$). The application of micronutrients (Zn, Fe and Mn) also exerted a great influence on quality attributes of onion. Significantly higher percentage of TSS (16.73%), dry matter content (15.27%) and sulphur content (0.46%) of onion bulbs as compared to control were also recorded in the same treatment T_8 ($ZnSO_4$ + $FeSO_4$ + $MnSO_4$). The overall performance of T_8 ($ZnSO_4$ + $FeSO_4$ + $MnSO_4$) was found to be the best for growth, yield and quality of onion cv. 'Local White' with an ICBR of 1:9.98.

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CERTIFICATE

This is to certify that the thesis entitled, "EFFECT OF MICRONUTRIENTS (Zn, Fe AND Mn) ON GROWTH, YIELD AND QUALITY OF ONION (*Allium cepa* L.) cv. 'LOCAL WHITE' " submitted by **Shri Vikas R. Ahire** in partial fulfilment of the requirements for the award of the degree of **Master of Science (Agriculture)** in **Horticulture** of the Gujarat Agricultural University is a record of bonafide research work carried out by him under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

PLACE : ANAND
DATE : Feb. 26, 2002

(K. P. KIKANI)
MAJOR ADVISOR

CERTIFICATE

This is to certify that I have no objection for supplying to my scientist or worker a copy of thesis or any part of it for rendering service either in library or documentation centre.

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Date : Feb.28 ,2002

DECLARATION

This is to declare that the whole of the research work reported in this thesis in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **HORTICULTURE** by the undersigned is the result of investigation done by me under the direct guidance and supervision of **Dr. K.P. Kikani**, Professor and Head, Department of Horticulture and no part of the work has been submitted for any other degree so far.

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All might not have been mentioned but none is forgotten.

Place : Anand
Date : Feb. 28 ,2002

(VIKAS R. AHIRE)

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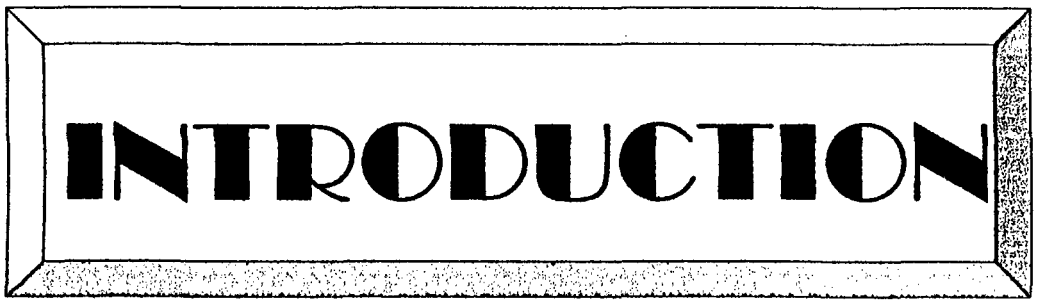

INTRODUCTION

CHAPTER - I

INTRODUCTION

Vegetable crops offer higher yields, income and higher calories as compared to other agronomic crops therefore, growing vegetable crops has been proved to be the most profitable enterprise. It is a boon to small and marginal farmers for higher production in short duration with handsome income. Also, vegetables are natural sources of protective food as they supply nutrients, vitamins and minerals alongwith roughages. However, for maintaining proper physique, recommendations have been made by the dieticians is 295 grams of total vegetable per day per head (Kale *et al.*, 1993). In this context, the production of India is sufficient to provide only about 140 grams vegetables per day per capita (Prasad and Kumar, 1998). However, in countries like Italy, Russia, Japan, USA, UK, Canada and Australia, the consumption of vegetables per capita is very high in comparison to India, as they consume respectively 596, 564, 520, 486, 449, 428 and 346 grams. Low consumption of vegetables in India is a problem as our general people are suffering from several diseases and physiological disorders. Since, the Indian population is predominantly vegetarian, there is an urgent need to increase vegetable production by bringing more area under vegetable growing and adoption of improved technologies. In developing

countries like India, where the pressure of population on land is continuously increasing, there is no scope to increase the area under vegetables therefore, the only way is to increase the production of vegetables with better quality per unit area by scientific crop management.

Amongst different group of vegetables, onion (*Allium cepa* L.) is one of the most important bulb crops grown in India and used since the time immemorial. It is one of the important vegetables grown world wide. It is one of the most widely and commonly used vegetables in different forms and purposes due to its flavour. It is used for flavouring or seasoning the food, both at mature and immature bulb stages, besides used as salad and pickle. To a lesser extent, it is used by processing industry for dehydration in the form of flakes and powder, which are in great demand in the world market.

Onion is an important crop in all countries with world production of about 43.91 million tonnes from an area of 2.58 million hectares (Anon., 1999_a) and is commercially cultivated in a little over hundred countries of the world. However, the total production of onion in India is 5.46 million tonnes from an area of 0.48 million hectares (Anon., 1999_a). In India, major onion growing states are Maharashtra, Gujarat, Karnataka, Tamil Nadu, Orrisa, Madhya Pradesh, Uttar Pradesh and Andhra Pradesh. In Gujarat,

onion occupies an area of about 52,200 hectares with production of 14.62 lakh tonnes (Anon., 1998-99).

Onion bulb is rich in minerals like phosphorus and calcium, and carbohydrates. It also contains proteins and vitamin C.

The pungency in onion odour is formed by enzymatic reactiononly when tissues are damaged. The pungency in onion is due to a volatile oil known as allylpropyl disulphide. Pungency varies with cultivar, growing conditions, stage of maturity and storage conditions. It is maximum just before fall of top in the field. The outer skin colour is due to the presence of quercetin.

Recently in vegetable production, intensive farming with the use of high yielding varieties together with large doses of high analysis NPK fertilizers with prompt plant protection measures is on the increase which is coupled with removal of large amount of nutrients including micronutrients from the soil. In context of the above facts, Gujarat Agricultural University (G.A.U.) has carried out following work in micronutrients (Anon., 1999_b).

Deficiency of Zn, Fe and Mn has been categorized for different soil orders, groups and soil types. In general the deficiency is more pronounced in Entisols and Inceptisols.

The rate of depletion of micronutrients under continuous cropping in '*Goradu*' soil is Zn > Fe > Mn > Cu > Mo.

Zinc sulphate could be applied as a Zn source as it is one of the efficient and economical source among different Zn carriers.

Critical level of Zn in soil ranged from 0.38 to 0.68 ppm for different regions in Gujarat for obtaining response to Zn.

An improvement in yield by 10 to 25 per cent could be obtained due to application of 25 kg zinc sulphate per hectare in different crops.

Amongst different Fe carriers, the water soluble ferrous sulphate is one of the most effective and economical source.

Critical level for obtaining response to Fe application ranged from 4.1 to 5.8 ppm for different regions of Gujarat.

For getting higher yields on Fe deficient soils, application of 50 kg ferrous sulphate per hectare once in three years is recommended.

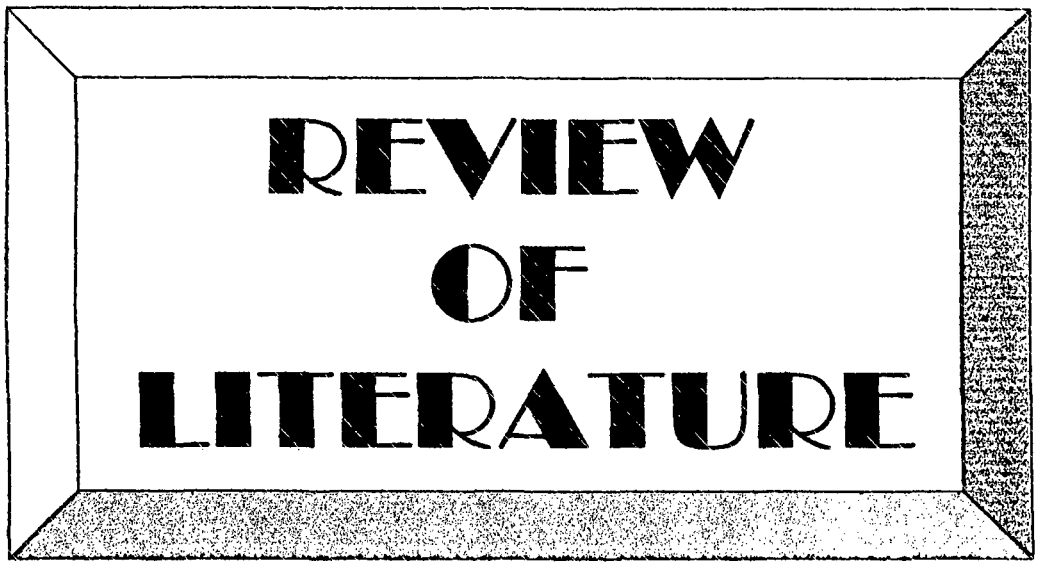
Manganese sulphate is the efficient and effective source of manganese among the different manganese carriers.

Critical level of manganese in soil ranged from 3 to 4 ppm for different regions in Gujarat for obtaining response.

Number of factors like soil reaction, organic matter status, management practices, govern the availability of nutrients from soil to plants. The deficiency of micronutrients is very common in Anand district as the soil is of sandy loam type with high drainage and slightly saline in reaction.

Deficiency of micronutrients causes considerable losses in yield and quality and hence, limiting the productivity of onion crop. The growth, yield and quality of onion bulbs is found to be improved with the supply of micronutrients in adequate amount and in a proper proportion. One of the major reasons for low productivity of onion crop is its poor nutrients management. For higher production and quality of onion, balanced fertilization plays a key role, as the returns from continuous use of only major nutrients has been reducing over the years due to insufficiencies of micronutrients and they are also responsible for efficient utilization of major nutrients. Therefore, considering the importance of micronutrients in onion, the present investigation was conducted to study the effect of micronutrients (Zn, Fe and Mn) on growth, yield and quality of onion (*Allium cepa* L.) cv. "Local White" with the following objectives.

1. To find out the effect of $ZnSO_4$, $FeSO_4$ and $MnSO_4$ application (soil) on vegetative growth, yield and quality of onion.
2. To find out the combined effect of $ZnSO_4$, $FeSO_4$ and $MnSO_4$ application (soil) on vegetative growth, yield and quality of onion.
3. To workout the economy of micronutrients application.


REVIEW
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LITERATURE

CHAPTER – II

REVIEW OF LITERATURE

The growth, yield and quality of any vegetable crop depends on many factors, amongst them recommended dose of NPK, FYM along with micronutrients plays an important role. This is equally true for onion production also, therefore the available literature related to the effect of micronutrients (Zn, Fe and Mn) on growth, yield and quality of onion and other vegetables has been briefly reviewed in this chapter.

2.1 Some fundamental aspects of Zn, Fe and Mn

2.2 Growth characters

2.3 Yield and yield attributes

2.4 Quality attributes

2.1 SOME FUNDAMENTAL ASPECTS OF Zn, Fe AND Mn

2.1.1 Zinc (Zn)

2.1.1.1 *Role of zinc in plants* :

Zinc is essential for several enzyme systems that regulate various metabolic activities in plants. It is involved in auxins production, which are growth regulating substances in plants. Zinc is also vital for the oxidation

process in plant cells and helps in the transformation of carbohydrates and regulates sugar in plants. Under Zn deficient conditions, flowering and fruit development are reduced and maturity is delayed. The end result is lower yield, poor quality and sub-optimal nutrient use efficiency (Gupta, 1995).

2.1.1.2 *Zinc deficiency symptoms* :

The Zn deficiency symptoms as observed by Gupta (1995), common to many crops normally appear in 4-weeks old plants on old as well as emerging new leaves. These are :

Light green, yellow or bleached spots in intervienal area of older leaves. The emerging leaves are smaller in size and often termed as 'little leaf'. The internodal distance in severe deficiency becomes short and 'Rosetting' condition.

2.1.1.3 *Critical limits of zinc in plants* :

The critical limit of zinc was observed in cotton and orange as 200 ppm and for tomato as 526 ppm. Above this limit visual toxic effect was also observed according to Gupta (1995).

2.1.1.4 *Crop uptake and removal of zinc* :

Zinc is absorbed as Zn^{2+} from soil solution through roots. The amount of Zn absorbed depends on soil, crop, variety, yield and climatic conditions along with management practices. The uptake of Zn at economic yield of most of the crops varies between 80 to 980 g/ha (Gupta, 1995).

Cropping systems of 200 to 300 per cent intensity deplete the soil Zn more due to higher production. The amount of Zn absorbed varies with the cropping systems and ranges from 187 to 728 g/ha/year. The utilization of added Zn was more in sandy loam than in loamy sand soil and decreased with increase in Zn levels (Gupta, 1995).

2.1.1.5 *Amelioration of zinc (Zn) deficiency* :

(a) Zinc carriers :

All the Zn carriers i.e. $ZnSO_4.7H_2O$, ZnO, $Zn_3(PO_4)_2$, Zincated superphosphate (Zn-SSP), $ZnSiO_3$ and Zn-frits evaluated in Madhya Pradesh, Haryana, Gujarat and Andhra Pradesh through significantly increased the yield in crops, yet $ZnSO_4$ produced the largest increase. Though Zn-EDTA proved significantly superior to $ZnSO_4$, yet high cost of the former makes it less efficient (Takkar *et al.*, 1989).

Organic manures i.e. 11 t/ha FYM, 5 t/ha poultry manure and 2.5 t/ha piggery manure, were as efficient as 11 kg Zn/ha in meeting the Zn requirement of crops. Efficiency of both manure and Zn increases when they are applied together (Takkar *et al.*, 1989).

(b) Rate of Zn application :

By and large Zn deficiency is ameliorated by soil application of 11 kg/ha to cereals, 8.5 kg/ha to soyabean and sugarcane while 25 kg/ha is recommended every three years for any field crop grown in zinc-deficient soil or 8-10 kg/ha every year (Tandon, 1989).

2.1.2 Iron (Fe)

2.1.2.1 *Role of iron in plants* :

Iron is a constituent of a large number of metabolically active compounds like cytochromes, heme and non-heme enzymes and other functional metalloproteins such as fenodoxin and haemoglobin. The best known note of iron is its catalytic function in biological oxidation and reduction and other metabolic processes in plants like oxidative photophosphorylation during cell respiration. Iron is involved in the formation of chlorophyll even though it is not its constituent. Iron is also known to be involved in carbohydrate metabolism (citric acid, mallic acid

and ascorbic acid). It is related to vitamins, biological nitrogen fixation and Cu, Zn, Mn and Mg metabolism (Malewar and Ismail, 1995). Iron is directly involved in protein synthesis. Plants under iron stress show considerable accumulation of nitrate, amino acids, amides and fall in protein content. Further, iron is required at the level of transcription and translation of nucleic acids.

2.1.2.2 *Iron deficiency symptoms* :

The most easily recognizable symptom of iron deficiency in plant is extensive chlorosis of the leaves. Iron deficiency typically begins to show on younger leaves while most matured and lower leaves show no sign of chlorosis. Interveinal chlorosis with surface of the leaf showing a fine reticulate network of green veins setting off chlorotic areas (occurs commonly, referred to as iron chlorosis) (Malewar and Ismail, 1995).

2.1.2.3 *Critical limits of iron in plants* :

A healthy plant usually contains 100 ppm Fe on dry matter basis (range 50-250 ppm) while less than 50 ppm Fe (25-80 ppm) is considered to be the deficiency limit in plants. In work reported by Dangarwala *et al.* (1983), generally the cash crops were richest in Fe (236-711 ppm) followed

by vegetables (161-321 ppm), fodders (212-421 ppm), legumes (56-160 ppm) and finally cereals (52-109 ppm) (Malewar and Ismail, 1995).

2.1.2.4 *Amelioration of iron (Fe) deficiency* :

(a) Iron carriers and method of application :

Amongst the inorganic Fe carriers, $FeSO_4.7H_2O$ is the most commonly used. Both soil and foliar application of $FeSO_4$ are equally effective in increasing the yield in cereals (Takkar *et al.*, 1989).

(b) Rate of application :

Application of 50 kg ferrous sulphate/ha is recommended every three years for any field crop grown on iron deficient soil or 15-17 kg/ha every year (Tandon, 1989).

(c) Organic manures :

Application of Fe amended organic manures enhanced strikingly the available Fe on both black clay and red soil in Tamilnadu. Green manuring alone as well as foliar application of Fe on sandy soils of Punjab proved strikingly superior to soil application of Fe in combating Fe deficiency (Takkar *et al.*, 1989).

2.1.2.5 *Crop uptake and removal of iron* :

Iron uptake by crops is highest among micronutrients but the amounts absorbed are poorly translocated from the roots to the upper plant parts. Uptake of iron is characterized by factors like selectivity, accumulation and genotype. It takes place either passively or actively. Natural chelating agents seem to play a vital role in augmenting iron supply to crops grown on iron deficient soils. There is a wide variation in uptake and removal of iron by crops. Disparity between soil Fe supply and crop uptake suggest, the involvement of several factors, such as particle size, oxidation of bivalent ions in soils, interaction between micronutrients, soil microbial oxidation-reduction, formation of organic complexes in soils, variation in Fe requirement of crop species and influence of climatic factors on availability of iron (Malewar and Ismail, 1995).

2.1.3 Manganese (Mn)

2.1.3.1 *Role of Mn in plants* :

Manganese is known to activate number of enzymes and it functions as an autocatalyst. It is essential for splitting the water molecule during photosynthesis. It has certain properties similar to magnesium. It is also important in nitrogen metabolism and carbondioxide assimilation.

2.1.3.2 *Manganese deficiency symptoms* :

Manganese deficiency in oat is characterized by 'grey speck' in which the leaf develops grey lessions but the tip remains green, the base dies and the panicle may be empty. In dicots, younger leaves develop chlorotic patches between the veins. In sugarcane it may appear as alternating light green strips between dark green veins.

Mn deficiency is largely associated with high pH of the soil surrounding the roots (*rhizophere*) and is more likely on neutral to alkaline soils, although it may occur on sandy soils poor in Mn or from where Mn have leached, peat or muck soils, heavily limed soils and during cold weather or bad growing conditions following cold or dry periods.

2.1.3.3 *Critical limits of manganese in plants* :

Critical limit of manganese in plants ranges from 20-500 pm while less than 20 ppm is considered to be the deficiency limit in plants and above 500 ppm is considered as toxic level.

2.1.3.4 *Amelioration of manganese* :

(a) Manganese carriers :

Manganese sulphate is the most commonly used inorganic Mn carrier. It is either used for soil application or foliar application.

(b) Rate of application :

In Andhra Pradesh, 0.3% $MnSO_4$ in sprayed in alkaline soils for onion crop. In sugarcane crop, 6.25 kg $MnSO_4$ in 1125 litre water may be sprayed. Soil application of 25 kg $MnSO_4$ can be done in wheat if there is Mn deficiency. Foliar spray of manganese twice a year is very effective for citrus.

2.1.3.5 *Crop uptake and removal of manganese* :

The amount of manganese absorbed by crops varies to a great deal from a few grams to a few kg/ha. Probably soil properties exert a great influence on this. Tea bushes in South India are reported to assimilate 590 g manganese for every 100 kg made tea. On the other hand in the alluvial soils of Gujarat, mean manganese uptake per tonne of dry matter varied from 198 g manganese in pearlmillet to 150 g in bidi tobacco (Dangarwala *et al.*, 1983).

2.2 GROWTH CHARACTERS

Growth is a permanent and irreversible increase in size or volume of the plant with an accompanied increase in dry weight (Verma, 1991). It is due to the formation of new cells at localized region called meristem and increase in size and mass of cell produced.

Maurya and Lal (1975) observed that the efficiency of plant and bulb increased with the advancement of age under the influence of zinc treatments. They also revealed that best results of growth characters were noted under zinc treatment at 3 ppm level on onion cv. 'Poona Red' in sand nutrient culture.

Bhonde *et al.* (1995) conducted an experiment at Nasik on onion cv. 'Agrifound Dark Red' grown during *Kharif* season. They reported that the foliar application of 3 ppm Zn + 1 ppm Cu + 0.5 ppm B at 30 days after transplanting had a significant effect on bulb development.

2.2.1 Plant height

Jawaharlal *et al.* (1986) reported that soil application of $ZnSO_4$ @ 50 kg/ha or $FeSO_4$ @ 50 kg/ha recorded maximum plant height in onion (*Allium cepa* var. *cepa* L.).

Baghel and Sarnaik (1988) observed that the combined foliar spray of Zn at 0.5% and B at 0.2% significantly increased the plant height in onion cv. 'Pusa Red'.

Singh and Tiwari (1989) found that the plant height of onion cv. 'Pusa Red' was highest under 3 ppm Zn sprayed at 90 days after transplanting.

In a pot experiment, seedlings of onion cv. 'Pusa Red' were transplanted in mid-January and foliar sprays of 1-3 ppm Zn, 50-150 ppm Fe and 0.25 ppm B were given at 60 and 70 days after transplanting. Sprays of 3 ppm Zn singly or sprays of 3 ppm Zn + 100 ppm Fe + 0.75 ppm B were most effective for increasing the plant height (Singh and Tiwari, 1995).

Seema (2000) reported that application of sulphur and foliar spray of micronutrients (Zn, Fe, B and Cu) exerted a great influence on growth parameters of onion cv. 'Local White'. Significantly maximum plant height at 75 DAT was recorded under the application of sulphur as gypsum @ 20 kg/ha and foliar spray of $ZnSO_4$ 0.5%.

Similarly, Mallick and Muthukrishnan (1980) studied the effect of micronutrients on tomato and found that zinc (Zn) was highly effective in increasing the plant height by 20 per cent as compared to iron (Fe). Amongst the micronutrients, soil application of Zn was found to be more effective in promoting the growth and development of tomato plant.

Bose and Tripathi (1996) studied the effect of micronutrients on growth of tomato cv. 'Pusa Ruby' and found that the best growth (plant height of 81.56 cm) was observed after combined foliar application of micronutrients (Zn, Mn, Fe, B).

Randhawa *et al.* (1977) reported that in cultivars of okra 'Pusa Sawani' and 'Punjab-13', Zn (as zinc sulphate) at 15 ppm and P (as potassium dihydrogen phosphate) at 60 ppm increased the plant height.

2.2.2 Number of leaves

Katare *et al.* (1971) reported that the spray of various micronutrients (Zn, Mn and Cu) caused significant increase in number of green leaves of onion.

Lal and Maurya (1981) reported that foliar application of copper in the form of copper sulphate at the rate of 1 ppm gave significantly maximum number of leaves per plant with the soil application of 50 kg $ZnSO_4$ or 50 kg $FeSO_4$ in onion var. 'Cepa'.

The combined foliar application of Zn at 0.5% at B at 0.2% significantly increased the number of leaves per plant in onion cv. 'Pusa Red' as compared with water sprayed control (Baghel and Sarnaik, 1988).

Singh and Tiwari (1995) studied the effect of micronutrients on growth of onion (*Allium cepa* L.) variety 'Pusa Red'. They found that foliar sprays of 3 ppm Zn singly or combined with Fe and B were most effective for increasing all the growth parameters (number of leaves) studied at 90 and 120 DAT.

Significantly maximum number of leaves were found under the treatment of soil application of sulphur as gypsum @ 20 kg/ha and foliar spray of $ZnSO_4$ 0.5% at 75 DAT in onion crop cv. 'Local White' (Seema, 2000).

Also, Ibrahim (1989) found that the growth and nutrient uptake responses of pea plants cv. 'Little Marvel' had no significant effects on number of branches when Zn and Fe were applied @ 0.321 and 0.150 chelate/litre foliar spray.

2.3 YIELD AND YIELD ATTRIBUTES

Katare *et al.* (1971) reported that 0.3 per cent foliar application of various micronutrients (Zn, Mn and Cu) caused significant increase in yield of onion.

Maurya and Lal (1975) found that the zinc in the form of zinc sulphate at 1, 2 and 3 ppm, when applied to onion plants in sand nutrient culture increased the yield of onion bulb per pot as compared to control.

Gupta *et al.* (1983) reported that the yield of onion bulbs increased significantly with all Zn levels. They also found that application of 10 ppm Zn enhanced the yield of onion bulbs by 67 per cent over control and 26 per cent over 5 ppm Zn treatment.

Jawaharlal *et al.* (1986) observed that soil application of 50 kg $ZnSO_4$/ha, recorded maximum onion bulb yield of 17.16 t/ha which was closely followed by soil application of 50 kg $FeSO_4$/ha with 17.15 t/ha, which were at par statistically.

Baghel and Sarnaik (1988) revealed that combined foliar spray of Zn at 0.5% and B at 0.2% significantly increased the bulb yield and bulb diameter in onion cv. 'Pusa Red' as compared with the water sprayed (control), here the yield was 17.0% higher than the control, whereas the combined soil application was 15% less effective than the control.

Singh and Tiwari (1989) recorded maximum yield (275 q/ha) when two sprays of 1 ppm Zn, 0.5 ppm B, 1000 ppm Fe were given at 50 and 65 days after transplanting in onion 'Pusa Red'. This treatment was found to be at par with the treatments of Cu 1 ppm and B 0.5 ppm each applied singly.

Singh and Tiwari (1993) investigated the effect of foliar spray of micronutrients on onion cv. 'Pusa Red' during *rabi* season and they found that bulb yield was highest when the crop was given a combined spray of Cu 1 ppm, Zn 3 ppm, B 0.5 ppm and Fe 100 ppm twice at 15 days interval.

Singh and Tiwari (1995) conducted a pot experiment in onion cv. 'Pusa Red' and reported that the weight of bulb, diameter of bulb and yield

were highest with spraying of 3 ppm Zn + 100 ppm Fe + 0.75 ppm B at 120 DAT.

Studies on onion cv. 'Agrifound Dark Red' grown during *kharif* season under Nasik conditions revealed that combined foliar application of 3 ppm Zn, 1 ppm Cu, 0.5 ppm at 30 and 40 days after transplanting gave highest net return to the onion growers as reported by Bhonde *et al.* (1995).

Slimen *et al.* (1999) studied the effect of Fe, Zn, Mn and Cu applied as sulphates ($CuSO_4$ at 1 g/litre and others at 3 g/litre) and B applied as borax (0.7 g/litre) on onion cv. 'Compest 16' yield and nutrient content. The highest yield was obtained by foliar spray of $ZnSO_4$, this treatment increased yield over the control by 23.6 and 27.8% over two seasons, respectively.

Kumar and Das (2000) conducted an experiment to study the effect of Zn (0, 10 and 20 kg/ha) and S (0, 30 and 60 kg/ha) application on their availability in soil in relation to yield and nutrition of onion cv. 'N-53'. The yield of onion was highest (18.04 t/ha) in the treatment Zn @ 10 kg/ha.

Seema (2000) studied the effect of sulphur and foliar spray of micronutrients on growth, yield and quality of onion (*Allium cepa* L.) cv. 'Local White'. Significantly maximum yield of onion bulbs (525.93 q/ha)

was recorded in the treatment of sulphur as gypsum @ 20 kg/ha + foliar spray of $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + Borax 0.2% + $CuSO_4$ 0.2%.

Phor *et al* (1995) reported that the yield increased at increasing rates of zinc in garlic cv. 'HG-1'. The highest yield (number of cloves, weight of 100 cloves and yield/ha) was observed following the application of Zn @ 5 kg/ha.

Mahmood *et al.* (1996) conducted a field experiment in Zn deficient soil on potato crop. They observed that soil application of zinc @ $ZnSO_4$ 12.5 kg/ha gave the highest mean tuber yield of 33.36 t/ha, but it was not significantly different from foliar application of 5 ppm $ZnSO_4$ (32.28 t/ha), whereas in control tuber yield was 26.40 t/ha.

Khomchak *et al.* (1971) found that addition of Zn at 0.02 per cent to irrigation water for tomato plants grown on Zn deficient soils increased the yield by 16.3 per cent.

Mahapatra and Kibi (1971) tried various treatments, these are (a) soaking of tomato seeds in 0.035 per cent Zn solution for 14 hours, (b) soaking + foliar spray of Zn at 1.12 kg/ha, (c) foliar sprays of Zn at 2.24 or 4.48 kg/ha and (d) soil application at 11.20 or 22.40 kg/ha. Maximum fruit production and enhanced P and K absorption were noted under foliar spray

of Zn at 2.24 kg/ha. Soil treatment at the highest rate was as effective on foliar sprays in increasing the yield.

Foliar application of 0.02 and 0.05 per cent $ZnSO_4$ at 30, 50 and 70 days after planting had beneficial effect on yield of tomato cultivar 'Prichard' (Elabdeen and Metwally, 1982).

Reddy *et al.* (1985) assessed the effect of various micronutrients Zn, Cu and B on tomato cv. 'Pusa Ruby' receiving NPK as basal dressing. They reported the highest yield 202.1 q/ha under NPK + 75 kg Zn/ha as against 170.1 q/ha on plots receiving NPK alone (control).

Kumbhar and Deshmukh (1993) studied the effect of soil application of ferrous sulphate on the yield of tomato cv. 'Rupali'. They found that soil application of 80 kg $FeSO_4$/ha was significantly superior in respect of fruit yield. Amongst the different treatments, ferrous sulphate @ 80 kg/ha gave 14.03 per cent higher yield than control and 3.22 per cent higher yield than 40 kg/ha ferrous sulphate treatment.

Reddy and Reddy (1986) reported that treatment with Zn and B each at 500 ppm showed an increased yield in brinjal cv. 'Pusa Purple Round'.

Iyengar and Edward (1988) found that in egg plant (brinjal), all the zinc treatments, except fritted zinc @ 5 kg/ha showed significant response in

yield. Soil application of $ZnSO_4$ and ZnO @ 5 and 10 kg/ha showed similar response. Soil and foliar applications of $ZnSO_4$ alone were equally effective in increasing the yield.

Rawat and Mathpal (1984) found that iron (Fe) and zinc (Zn) when applied to chilli 30 DAT and again 15 days later, increased fruit yield, with Zn at 0.5 per cent having the most beneficial effect.

Nusain (1991) studied the response of chilli to Zn, Fe and B each at 0.1 per cent applied as foliar sprays at 30, 60 and 75 DAT. He found that the highest yield of 13.2 t/ha was obtained with foliar sprays of Zn alone and combination of Zn + B + Fe.

Khan and Soltanpour (1978) found that spraying chloritic plants with $ZnSO_4$ (1% solution) corrected chlorosis symptoms and greatly increased yield in french bean.

Singh *et al.* (1988) reported that the application (0, 10 and 20 kg $ZnSO_4$/ha) to three short duration varieties of pigeonpea (T-21, VPAS-120 and Prabhat) increased yield, content and uptake of Zn.

Hodgon *et al.* (1992) found that in pigeonpea, application of Fe 20 kg/ha to the soil increased grain yield by 414 per cent.

2.4 QUALITY ATTRIBUTES

Maurya and Lal (1975) reported that application of zinc at 1, 2 and 3 ppm significantly increased the TSS of onion bulbs cv. 'Poona Red'.

Palanivel (1981) stated that both soil and foliar application of $ZnSO_4$ and $FeSO_4$ significantly increased the sulphur content of small onion bulbs.

Jawaharlal *et al.* (1986) found that the dry matter production of bulb was maximum in the soil applied $ZnSO_4$ @ 50 kg/ha in onion var. 'Cepa'.

Jawaharlal *et al.* (1988) conducted an experiment to study the effect of Zn and Fe on the quality on onion cv. 'Pusa Red' and reported that highest quality indices viz., TSS and sulphur content were obtained with $FeSO_4$ @ 50 kg/ha applied through soil.

Mishra *et al.* (1990) noted maximum TSS in onion with soil application of borax @ 10 kg/ha which was followed by the dipping of onion seedling roots for 12 hrs in 3% ZnO suspension.

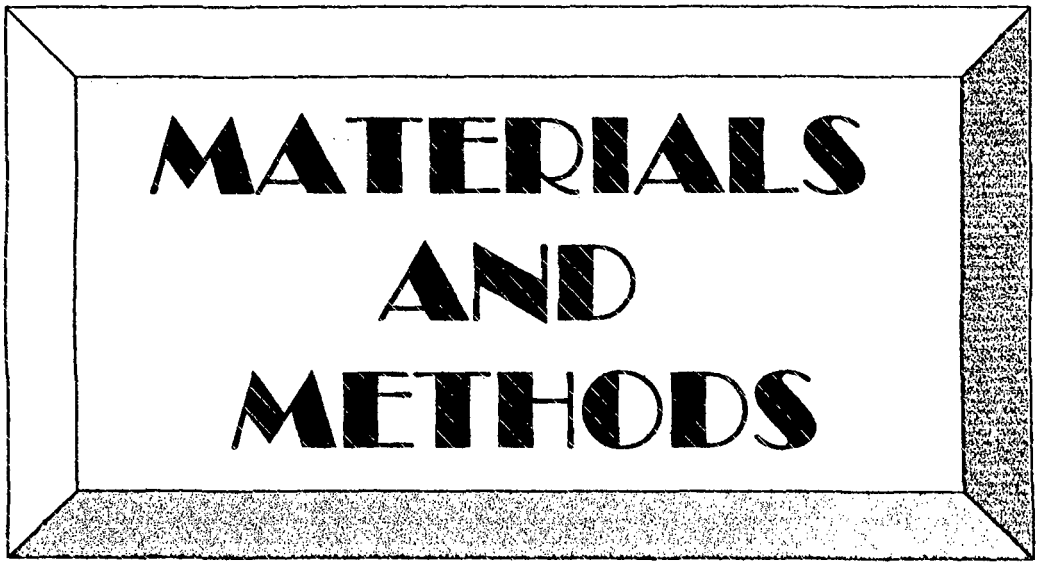
In a field trial on onion cv. 'Pusa Red' receiving combined foliar application of Zn at 0.5% and B at 0.2% significantly increased the percentage of TSS and dry matter content (Baghel and Sarnaik, 1988).

Singh and Tiwari (1993) observed that highest values of TSS were recorded with combined spray of Cu 1 ppm, Zn 3 ppm, B 0.5 ppm and Fe 100 ppm done at 60 and 70 DAT of onion cv. 'Pusa Red'. They also found that zinc at 3 ppm was equally effective with regards to qualitative attributes of onion.

Bhonde *et al.* (1995) revealed that the combination of 3 ppm Zn, 1 ppm Cu and 0.5 ppm B by foliar application had a significant effect on bulb quality instead of single application.

The application of sulphur and micronutrients spray was reported to improve the quality characters of onion bulbs cv. 'Local White'. Maximum TSS was recorded in the treatment of application of sulphur as gypsum @ 20 kg/ha and combined foliar spray of $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + Borax 0.2% + $CuSO_4$ 0.2%. Highest accumulation of dry matter content was recorded in the treatment, application of sulphur as gypsum @ 20 kg/ha and foliar spray of $ZnSO_4$ 0.5% and highest sulphur content in onion bulb was found in treatment, application of sulphur as gypsum @ 20 kg/ha + foliar spray of $FeSO_4$ 0.5% (Seema, 2000).

Thus, it can be concluded from foregoing review of literature that application of micronutrients namely Zn, Fe and Mn are effective for improvements in growth, yield and quality of onion and other crops.


MATERIALS
AND
METHODS

CHAPTER – III

MATERIALS AND METHODS

The details of materials used and techniques adopted during the course of investigation on "Effect of micronutrients (Zn, Fe and Mn) on growth, yield and quality of onion (*Allium cepa* L.) cv. 'Local White'" are described in this chapter.

3.1 GENERAL

An experiment was conducted at Horticultural Research Farm, Department of Horticulture, B.A.College of Agriculture, G.A.U., Anand Campus, Anand during *rabi* season of 2000-2001.

3.1.1 Geographical location of the experimental site

Anand is situated on the 22°-35' North latitude and 72°-55' East longitude and has an elevation of 45 m above the mean sea level.

3.1.2 Soil characteristics

The soil of this area is classified as sandy loam and is locally known as '*Goradu*'. It has good drainage property and it is very deep but rather poor in organic matter. It responds well to irrigation and manuring.

The mechanical analysis and some chemical properties of the experimental field are presented in Table 3.1 and 3.2.

Table 3.1 : Mechanical analysis of the soil

Sr. No.	Particulars	Value in per cent (soil depth 0-15 cm)	Method of analysis
1.	Coarse sand	0.93	International
2.	Fine sand	82.7	Piper method
3.	Silt	10.4	(Piper, 1950)
4.	Clay	5.0	

Table 3.2 : Chemical properties of the soil

Sr. No.	Particulars	Value	Method of analysis
1.	Soil pH (1:2.)	7.6	Blackman's pH meter (Jackson, 1973)
2.	EC (dS/m)	0.27	Solubridge method
3.	Total nitrogen (%)	0.047	Kjeldahl's method (Jackson, 1973)
4.	Available P_2O_5 (kg/ha)	58.94	Olsen's method (Jackson, 1973)
5.	Available K_2O (kg/ha)	398.60	Flame photometric method (Jackson, 1973)

3.1.3 Climate and weather condition

Climate of Anand region is semi-arid and sub-tropical. The winter is cool and dry. October to May are sunny months generally receiving an average of more than eight hours sunshine per day. Temperature during hot weather commences by about middle of February and ends by about middle of June. It ranges from 36.7°C to 46.7°C. Winter sets in the middle of October and continue till the middle of February. Monsoon is warm and moderately humid. It commences by the middle of September. Average rainfall of this region is about 836 mm. Monsoon in this region is often erratic and uncertain, both with respect of total rainfall and its distribution.

The meteorological data on the average monthly maximum and minimum temperature, relative humidity and sunshine hours recorded at the Meteorological Observatory of Anand during experimental period are given in Appendix I.

3.2 EXPERIMENTAL DETAILS

The details of the experiment are given as under.

3.2.1 Design

Randomized Block Design (RBD).

3.2.2 Treatment details

There are total eight treatments as given below :

Sr. No.	Treatments	Details
1.	T_1	NPK + Control
2.	T_2	NPK + $ZnSO_4$ (10 kg/ha)
3.	T_3	NPK + $FeSO_4$ (10 kg/ha)
4.	T_4	NPK + $MnSO_4$ (10 kg/ha)
5.	T_5	NPK + $ZnSO_4$ (10 kg/ha) + $FeSO_4$ (10 kg/ha)
6.	T_6	NPK + $ZnSO_4$ (10 kg/ha) + $MnSO_4$ (10 kg/ha)
7.	T_7	NPK + $FeSO_4$ (10 kg/ha) + $MnSO_4$ (10 kg/ha)
8.	T_8	NPK + $ZnSO_4$ (10 kg/ha) + $FeSO_4$ (10 kg/ha) + $MnSO_4$ (10 kg/ha)

NPK = 75 kg N + 38 kg P_2O_5 + 38 kg K_2O/ha

3.2.3 Plot size : Gross : 3.6 m x 1.8 m = 6.48 Sq.m

Net : 3.4 m x 1.5 m = 5.1 Sq.m.

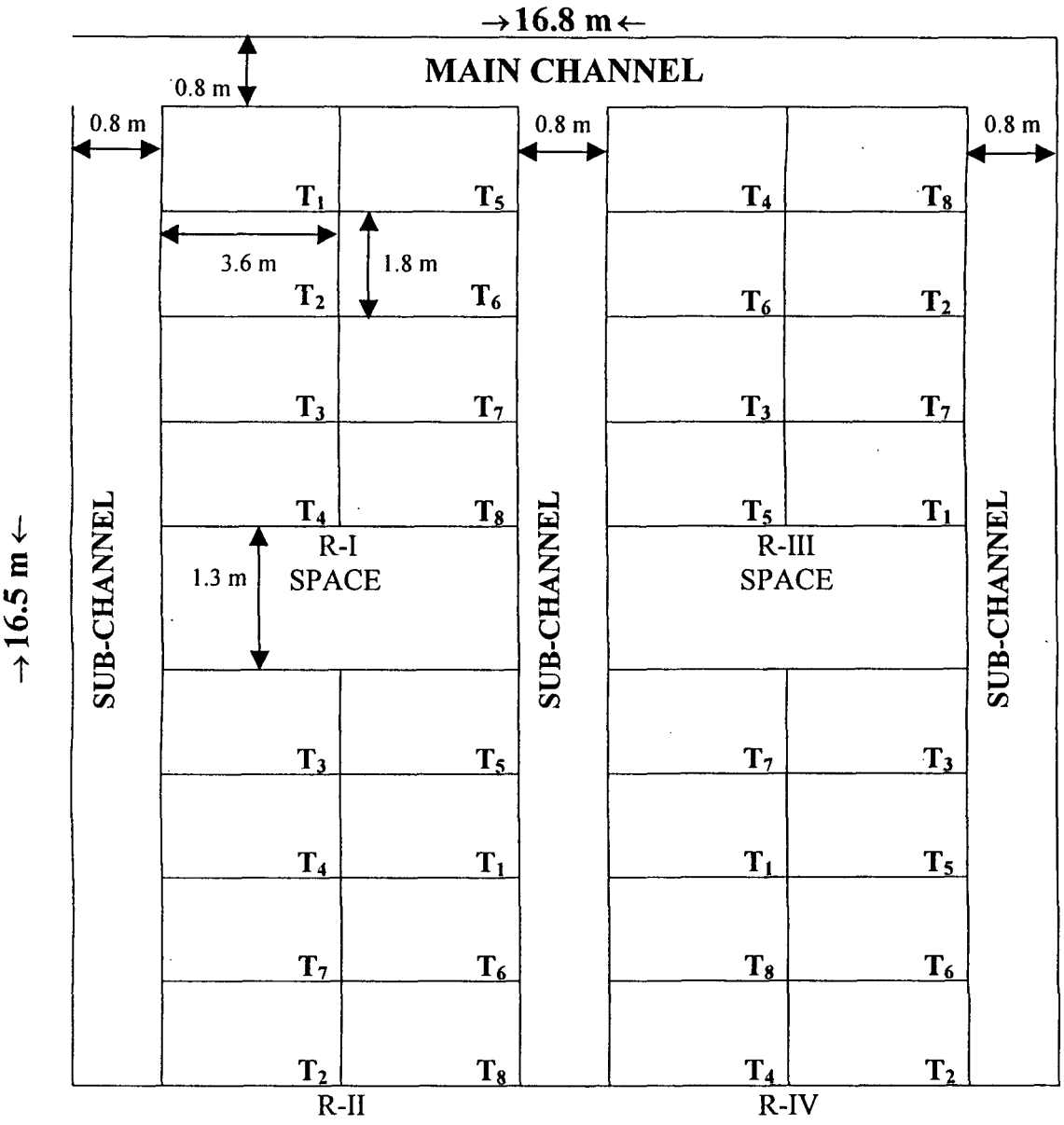
3.2.4 Number of replications : 4 (Four)

3.2.5 Number of plots : 32

3.2.6 Total experimental area : 16.8 m x 16.5 m = 277.2 Sq.m.

3.2.7 Spacing : 15 cm x 10 cm

Fig. 3.1 LAYOUT PLAN OF THE EXPERIMENT



Gross plot : **3.6 x 1.8 = 6.48 m^2**

Net plot : **3.4 x 1.5 = 5.1 m^2**

Total area : **16.8 x 16.5 = 277.2 m^2**

3.2.8 Application of micronutrients

All micronutrients viz., $ZnSO_4$, $FeSO_4$ and $MnSO_4$ were given as a basal dose in the soil.

3.3 CULTIVATION DETAILS

3.3.1 Preparatory cultivation

The experimental land was ploughed once, then worked with cultivator and finally the soil was leveled with the help of plank. Plots were prepared as per the details of the experiment.

3.3.2 Manures and fertilizers

Application of well decomposed farm yard manure was done uniformly to all the experimental plots @ 20 tonnes per hectare.

3.3.2.1 *Recommended dose of fertilizers*

75 kg N + 38 kg P_2O_5 + 38 kg K_2O/ha

The nitrogen was given in the form of urea, half the dose of nitrogen was applied as basal and remaining half was applied in two splits at 30 day interval after transplanting as top dressing. The phosphorus and potash were applied as a basal dose in the form of diammonium phosphate and muriate of potash, respectively.

3.3.3 Transplanting

Six weeks old uniform healthy seedlings of onion cv. 'Local White' were selected for transplanting. Seedlings were transplanted on 19th December, 2000. A light irrigation was given immediately after transplanting aimed at better establishment of the seedlings in the field.

3.3.4 After care

The irrigation was given at 8-10 days interval depending upon the soil moisture condition. Herbicidal spray of Basaline was given 5 days after transplanting. Proper care for weeding, manual inter-cultural operations and plant protection measures were taken throughout the life period of onion crop. No serious insect pest and diseases were observed during the crop period. Thrips and stem phyllium blight disease were observed but controlled with the application of Nuvacron and Dithane M-45.

3.3.5 Harvesting

Storage life of onion depends on the harvesting of onion bulbs at appropriate stage of maturity, as onion may be stored about six months. Irrigation was stopped before two weeks of harvest, when 25-50% top leaves falls. Other tops were made down manually before harvesting the crop and the remaining leaves were also allowed to dry one week before harvest for

hardening of underground bulbs. The bulbs were harvested on 4th April, 2001.

3.4 OBSERVATIONS RECORDED

Five plants were selected at random from the net plot of each treatment to record the observations.

The observations recorded are given below along with the procedure adopted.

3.4.1 Growth

The growth observations in respect of height of plant, number of leaves and stem diameter per plant were recorded.

3.4.1.1 *Plant height (cm)*

Length of the longest leaf upto the tip was measured in centimeter from the ground level at 45, 60 and 75 days after transplanting. Finally, mean height per plant was calculated.

3.4.1.2 *Number of leaves*

The observations on total number of leaves were recorded at 45, 60 and 75 days after transplanting. Finally, average number of leaves per plant were calculated.

3.4.2 Yield

3.4.2.1 *Equatorial diameter of bulb*

The horizontal diameter was recorded upto 1 mm accuracy using vernier caliper in the laboratory. The observational plants were used for the purpose. The mean diameter on the basis of five bulbs was then worked out and expressed in centimetre.

3.4.2.2 *Weight of bulb*

The individual weight per bulb of selected five plants was recorded and the average weight of one bulb was worked out for each treatment and expressed in gram.

3.4.2.3 *Neck thickness of bulb*

The neck thickness of the bulbs of the selected five plants at harvest was measured in centimeter with the help of vernier caliper upto 1 mm accuracy. The mean thickness was then worked out.

3.4.3 Quality

3.4.3.1 *Total soluble solids (TSS)*

Five onion bulbs were cut into pieces from each treatment and five readings were recorded from the extract for the estimation of TSS with the help of Erma made pocket hand refractometer (Ranganna, 1979). The mean value was worked out and expressed in terms of percentage.

3.4.3.2 *Dry matter content*

For the estimation of dry matter accumulation, 100 g of the cut onion slices were kept in oven at 70°C for drying till constant weight. The dry matter accumulation in the onion bulbs was calculated on the basis of final dry weight and was expressed in percentage.

3.4.3.3 *Sulphur content in bulb*

Sulphur content was determined by wet digestion method (Jackson, 1973). The intensity of the colour was measured by colorimetric method (Palaskar *et al.*, 1981).

3.5 STATISTICAL ANALYSIS

The data collected for all the characters were subjected to the statistical analysis by adopting "Analysis of Variance" technique as described by Steel and Torrie (1980).

3.6 ECONOMICS OF THE TREATMENTS

Economics of the treatments were worked out on the basis of purchase price of different chemical fertilizers and manures and other cost involved. While the income was calculated on the basis of prevailing selling price of the onion bulbs.

EXPERIMENTAL RESULTS

CHAPTER – IV

EXPERIMENTAL RESULTS

The present investigation, to study the effect of micronutrients (Zn, Fe and Mn) on growth, yield and quality of onion cv. 'Local White' was conducted during *rabi* season of 2000-2001 at the Horticultural Research Farm, Department of Horticulture, B.A.College of Agriculture, Gujarat Agricultural University, Anand Campus, Anand. The data collected on various characters was analysed statistically and the results pertaining to each character are presented in this chapter.

4.1 GROWTH CHARACTERS

4.1.1 Effect on plant height (cm)

The data on the growth in terms of plant height as influenced by application of micronutrients (Zn, Fe and Mn) are presented in Table 4.1 and graphically depicted in Fig. 4.1.

The perusal of the data revealed that the effect of micronutrients application on plant height of onion at 45 days after transplanting was non-significant however, maximum plant height was recorded in T_3 (50.60 cm) while minimum was recorded in control T_1 (46.96 cm).

Table 4.1 : Effect of micronutrients (Zn, Fe and Mn) on plant height (cm) of onion cv. 'Local White'

Symbol	Treatments	Plant height (cm)		
		45 DAT	60 DAT	75 DAT
T_1	Control	46.96	49.83	53.13
T_2	Zn	48.28	53.90	57.72
T_3	Fe	50.60	52.70	56.89
T_4	Mn	48.90	51.92	55.99
T_5	Zn + Fe	49.27	54.75	63.65
T_6	Zn + Mn	48.75	52.60	57.73
T_7	Fe + Mn	47.82	52.29	57.10
T_8	Zn + Fe + Mn	48.68	52.85	61.21
	S.Em. ±	0.68	0.84	0.70
	C.D. at 5%	NS	2.48	2.05
	C.V. %	2.81	3.20	2.40

DAT – Days after transplanting

Data also revealed that plant height recorded at 60 and 75 days after transplanting was significant with application of micronutrients.

Significantly maximum plant height at 60 days after transplanting was found in the treatment T_5 (54.75 cm) followed by T_2 (53.90 cm), T_8 (52.85 cm), T_3 (52.70 cm) and T_6 (52.60 cm) which were statistically at par with each other whereas lowest plant height was recorded in control T_1 (49.83 cm).

At 75 days after transplanting, significantly maximum plant height was recorded under T_5 (63.65 cm). The second highest plant height was recorded under T_8 (61.21 cm) which differed significantly from rest of all treatments, while it was lowest in control T_1 (53.13 cm).

4.1.2 Effect on number of leaves per plant

The result pertaining to the number of leaves per plant due to application of micronutrients (Zn, Fe and Mn) has been presented in Table 4.2 and showed in Fig. 4.2.

It is seen from data that the differences in number of leaves per plant with micronutrients application at 45 and 60 days after transplanting were found to be non-significant. However, maximum number of leaves at 45 days after transplanting were observed in T_5 (5.76) and minimum in T_4

Table 4.2 : Effect of micronutrients (Zn, Fe and Mn) on number of leaves per plant of onion cv. 'Local White'

Symbol	Treatments	Number of leaves/plant		
		45 DAT	60 DAT	75 DAT
T_1	Control	4.95	5.69	5.94
T_2	Zn	5.32	5.90	6.80
T_3	Fe	5.28	5.75	6.42
T_4	Mn	4.90	5.71	6.21
T_5	Zn + Fe	5.76	5.89	6.64
T_6	Zn + Mn	4.93	5.78	6.59
T_7	Fe + Mn	5.28	5.73	6.50
T_8	Zn + Fe + Mn	5.46	6.13	7.66
	S.Em. ±	0.20	0.11	0.13
	C.D. at 5%	NS	NS	0.38
	C.V. %	7.64	3.77	3.88

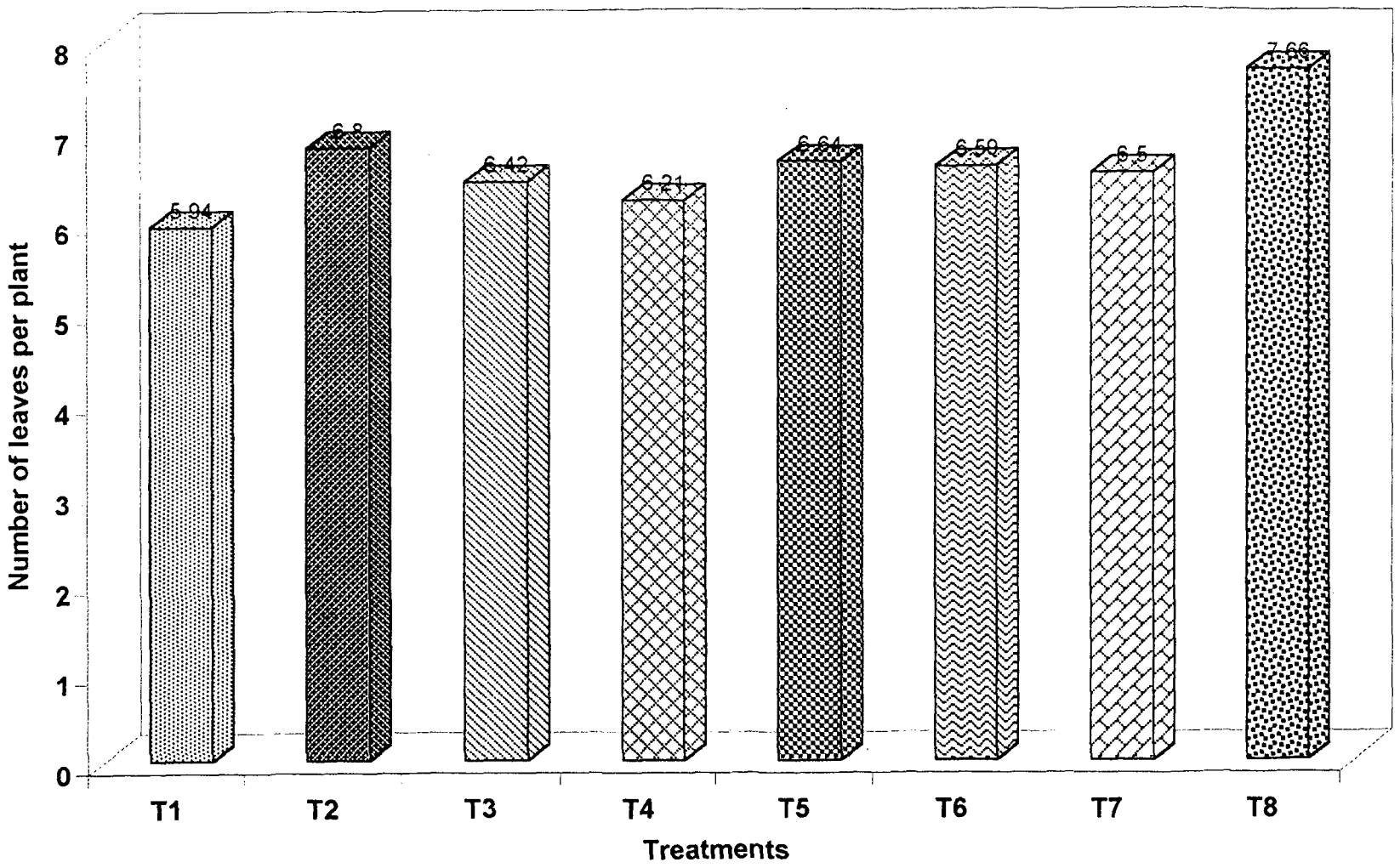


Fig. 4.2 : Effect of micronutrients (Zn, Fe and Mn) on number of leaves per plant at 75 DAT of onion cv. 'Local White'

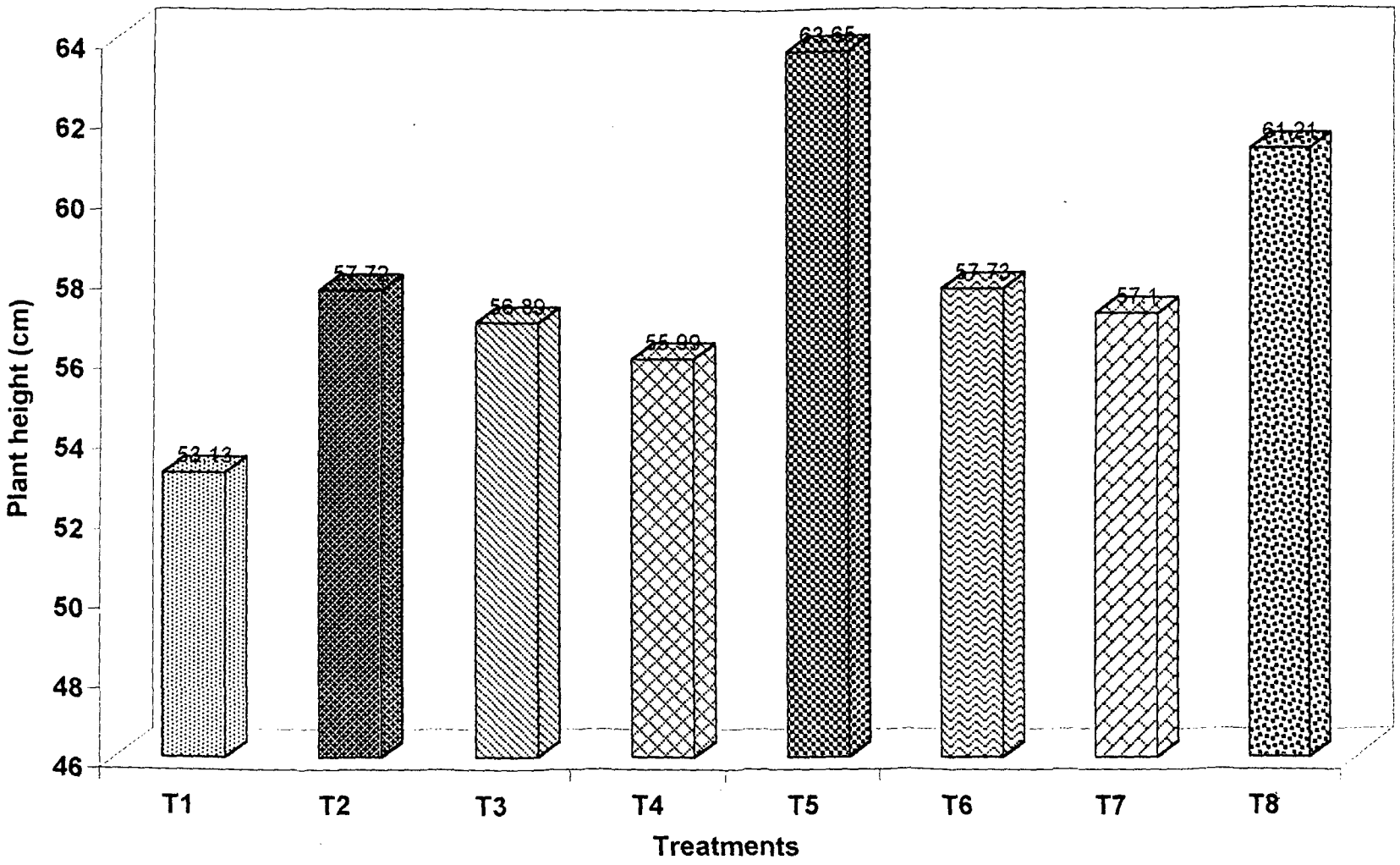


Fig. 4.1 : Effect of micronutrients (Zn, Fe and Mn) on plant height (cm) at 75 DAT of onion cv. 'Local White'

(4.90). At 60 days after transplanting maximum number of leaves were recorded in T_8 (6.13) and minimum in control T_1 (5.69).

It is also seen from data that number of leaves per plant recorded at 75 days after transplanting were found to be significant with application of micronutrients. Significantly maximum number of leaves per plant were recorded in T_8 (7.66) followed by T_2 (6.80) which was at par with T_5 (6.64), T_6 (6.59), T_7 (6.50) and T_3 (6.42) while minimum were recorded in the control T_1 (5.94).

4.2 YIELD ATTRIBUTES

The results obtained pertaining to the yield attributes of onion bulb as influenced by micronutrients (Zn, Fe and Mn) application are given below.

4.2.1 Effect on equatorial bulb diameter (cm)

The effect of micronutrients (Zn, Fe and Mn) application on bulb diameter at harvest was found to be significant. Related data has been shown in Table 4.3 and Fig. 4.3. Significantly maximum bulb diameter was recorded in the treatment T_8 (6.65 cm) which was followed by the treatments T_2 (6.25 cm), T_5 (6.24 cm) and T_6 (6.19 cm) which were statistically at par with each other. Lowest bulbs diameter was recorded in the treatment T_1 (4.57 cm) which is control. It is also observed with the help of data that soil application of micronutrients has increased the bulb diameter.

4.2.2 Effect on bulb weight (g)

The effect of micronutrients (Zn, Fe and Mn) application on bulb weight of onion has been presented in Table 4.4 and showed in Fig. 4.4. It indicate that the effect of micronutrient application on average bulb weight differed significantly. Significantly maximum bulb weight was recorded under the treatment T_8 (160.86 g). The next highest value of bulb weight was recorded under the treatment T_6 (129.74 g) which was at par with treatments

Table 4.3 : Effect of micronutrients (Zn, Fe and Mn) on Equatorial bulb diameter (cm) of onion cv. 'Local White'

Symbol	Treatment	Bulb diameter (cm)
T_1	Control	4.57
T_2	Zn	6.25
T_3	Fe	5.36
T_4	Mn	4.64
T_5	Zn + Fe	6.24
T_6	Zn + Mn	6.19
T_7	Fe + Mn	5.51
T_8	Zn + Fe + Mn	6.65
	S.Em. ±	0.20
	C.D. at 5%	0.59
	C.V. %	7.05

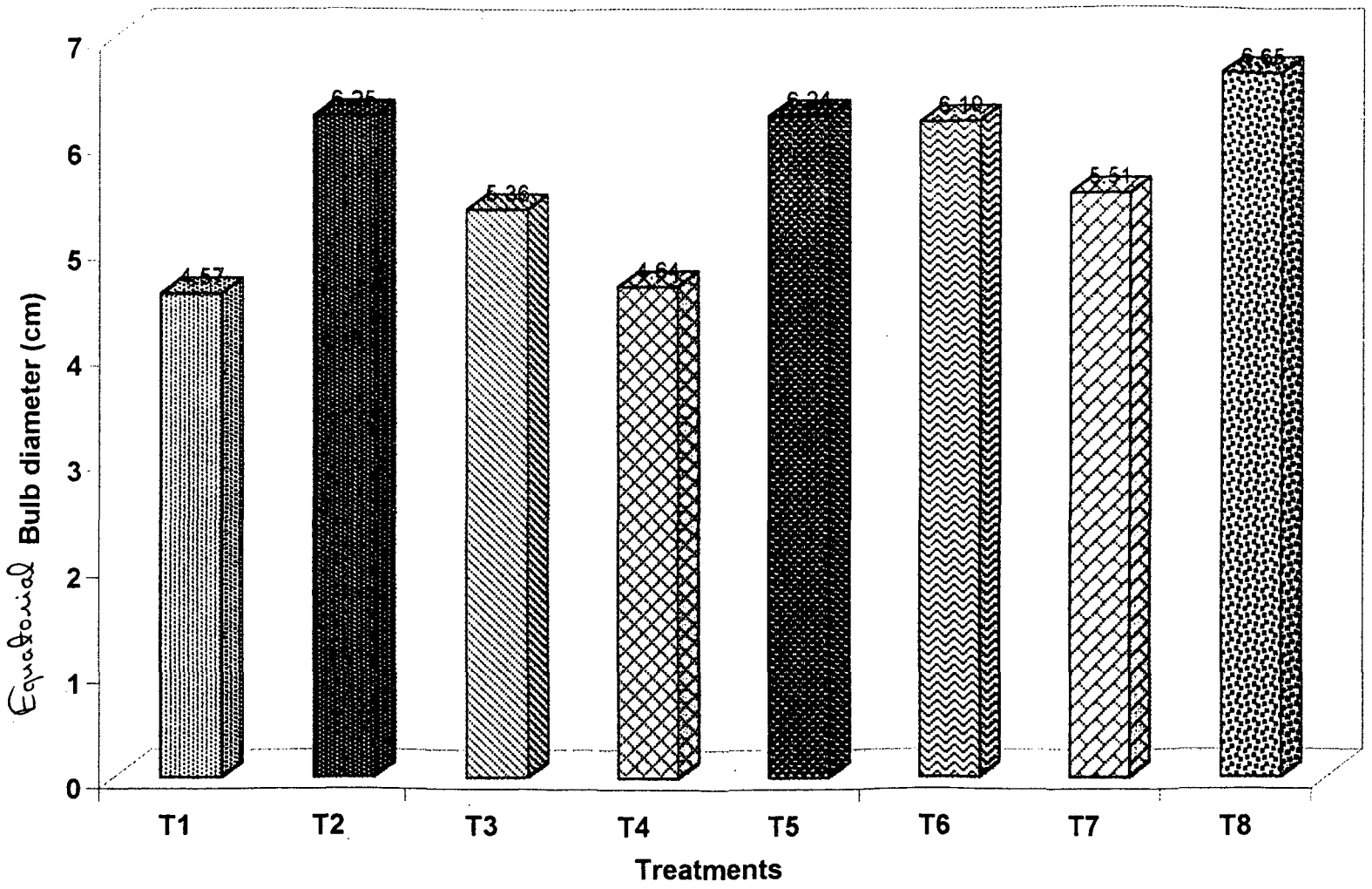


Fig. 4.3 : Effect of micronutrients (Zn, Fe and Mn) on equatorial bulb diameter (cm) of onion cv. 'Local White'

Table 4.4 : Effect of micronutrients (Zn, Fe and Mn) on bulb weight (g) of onion cv. 'Local White'

Symbol	Treatment	Bulb weight (g)
T_1	Control	45.81
T_2	Zn	124.62
T_3	Fe	58.54
T_4	Mn	39.00
T_5	Zn + Fe	119.80
T_6	Zn + Mn	129.74
T_7	Fe + Mn	73.64
T_8	Zn + Fe + Mn	160.86
	S.Em. ±	8.19
	C.D. at 5%	24.09
	C.V. %	19.18

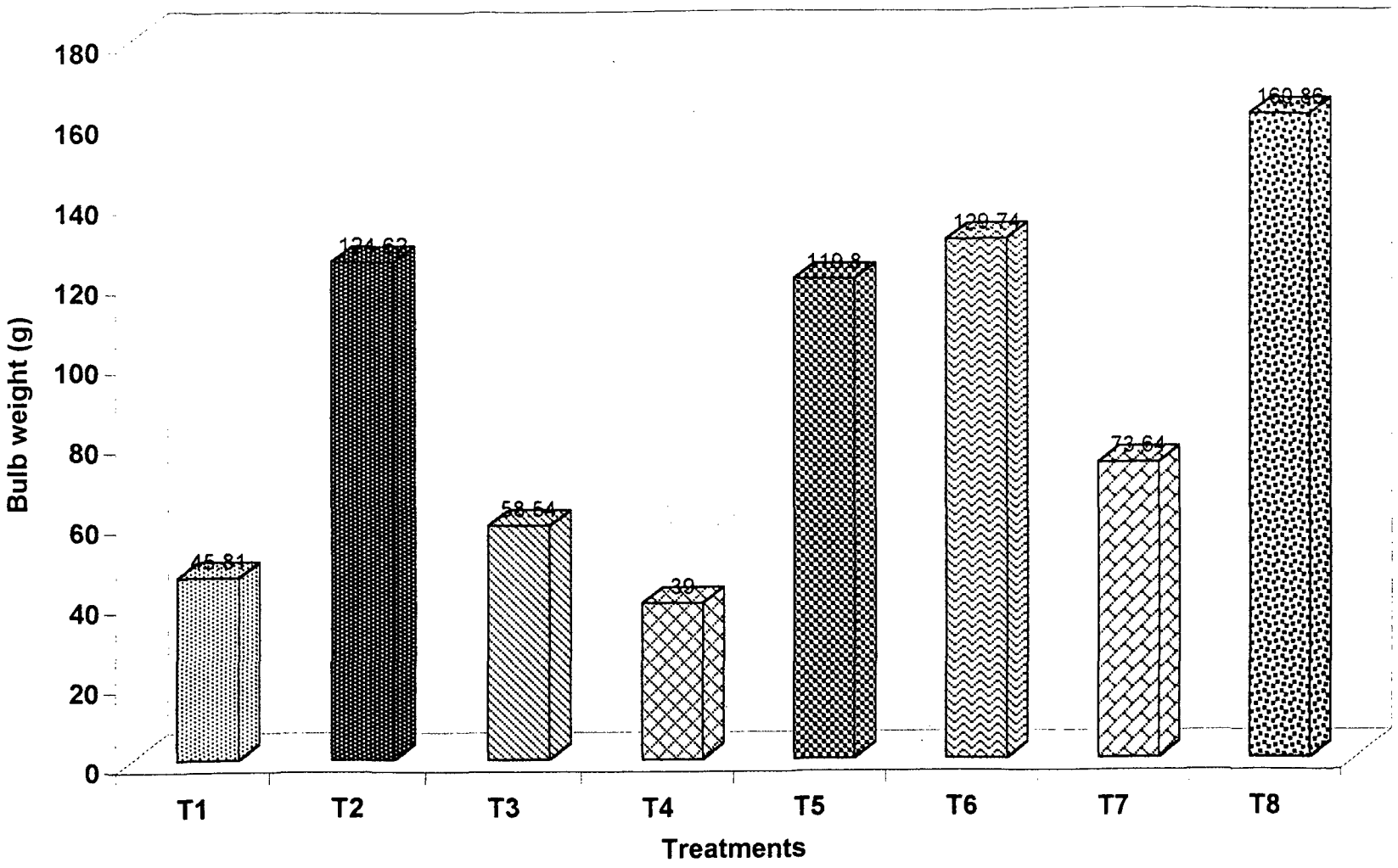


Fig 4.4 : Effect of micronutrients (Zn, Fe and Mn) on bulb weight (g) of onion cv. 'Local White'

T_2 (124.62 g) and T_5 (119.80). Lowest bulb weight was recorded under the treatment T_4 (39.00 g).

4.2.3 Effect on neck thickness (cm)

The data pertaining to the neck thickness of onion bulbs as influenced by micronutrients (Zn, Fe and Mn) application are presented in Table 4.5 and Fig. 4.5. It can be seen from the data that the effect of micronutrients application on the neck thickness was found to be non-significant. However, the maximum neck thickness was recorded in T_2 (0.83 cm) followed by T_1 (0.79 cm) and T_8 (0.74 cm) and the minimum was recorded in treatment T_3 (0.60 cm).

4.3 YIELD OF ONION BULB (t/ha)

The average bulb yield of onion per plot was converted in tonnes per hectare. The data on the total bulb yield of onion per hectare as affected by micronutrients (Zn, Fe and Mn) are presented in Table 4.6 and graphically depicted in Fig. 4.6.

The data showed that there was a significant effect of micronutrients application on the bulb yield of onion crop. Significantly maximum bulb yield was obtained under the treatment T_8 (54.112 t/ha). The next highest

Table 4.5: Effect of micronutrients (Zn, Fe and Mn) on neck thickness (cm) of onion bulbs cv. 'Local White'

Symbol	Treatment	Neck thickness (cm)
T_1	Control	0.79
T_2	Zn	0.83
T_3	Fe	0.60
T_4	Mn	0.69
T_5	Zn + Fe	0.65
T_6	Zn + Mn	0.67
T_7	Fe + Mn	0.63
T_8	Zn + Fe + Mn	0.74
	S.Em. ±	0.05
	C.D. at 5%	NS
	C.V. %	14.75

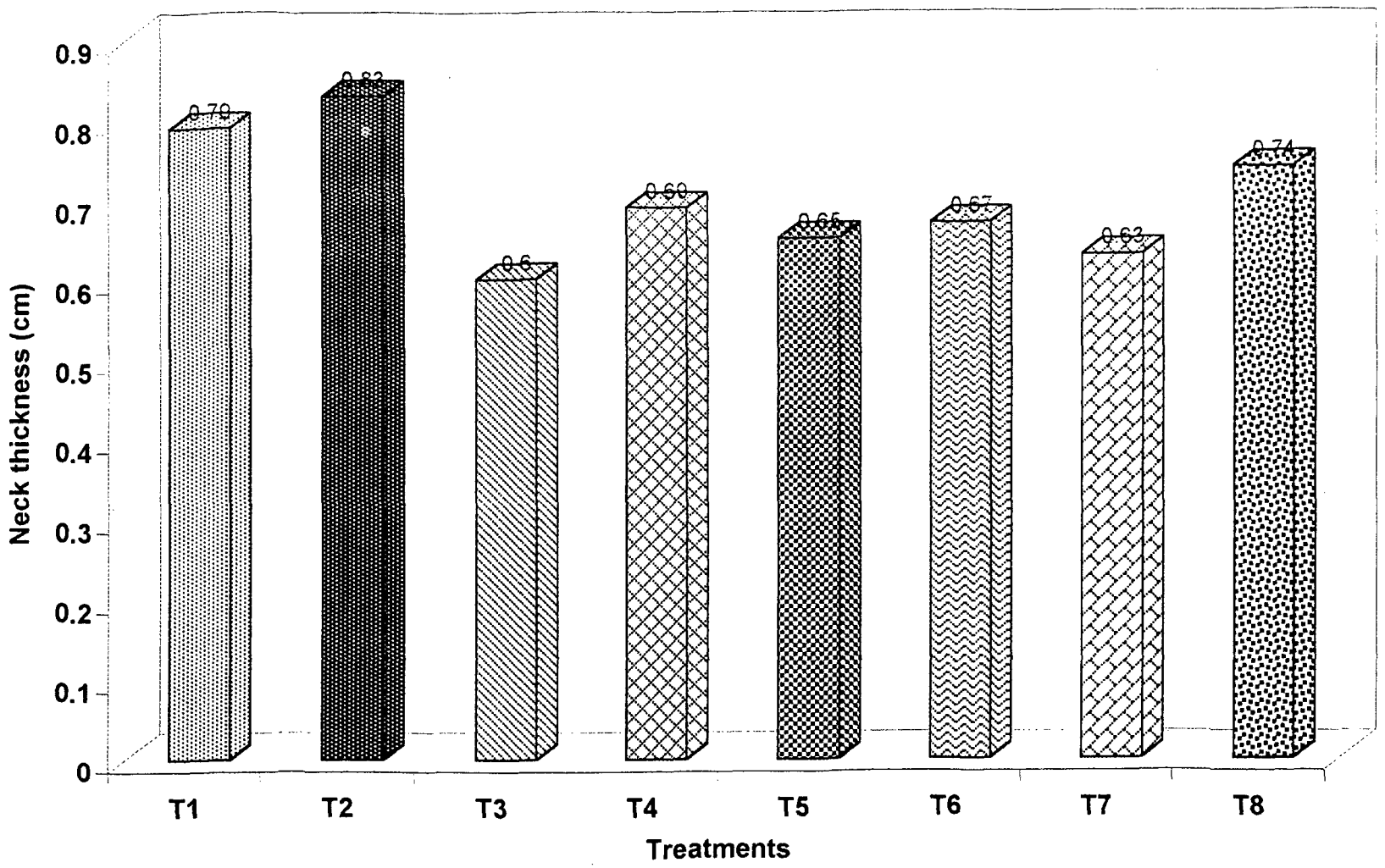


Fig. 4.5 : Effect of micronutrients (Zn, Fe and Mn) on neck thickness (cm) of onion bulbs cv. 'Local White'

Table 4.6 : Effect of micronutrients (Zn, Fe and Mn) on the bulb yield (t/ha) of onion cv. 'Local White'

Symbol	Treatment	Yield (t/ha)
T_1	Control	38.379
T_2	Zn	46.027
T_3	Fe	41.040
T_4	Mn	39.758
T_5	Zn + Fe	42.617
T_6	Zn + Mn	41.470
T_7	Fe + Mn	40.521
T_8	Zn + Fe + Mn	54.112
	S.Em. ±	2.66
	C.D. at 5%	7.83
	C.V. %	12.39

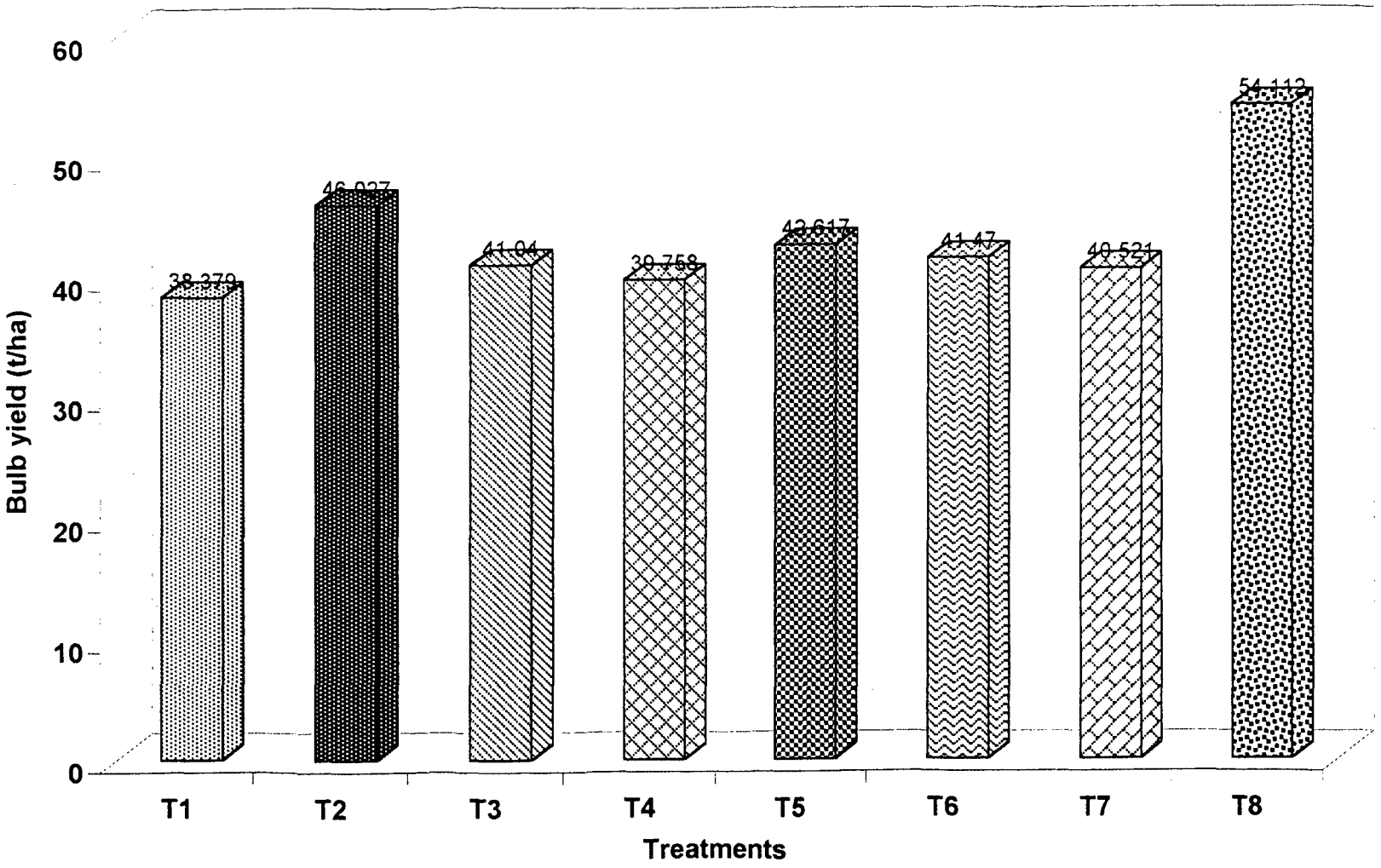


Fig. 4.6 : Effect of micronutrients (Zn, Fe and Mn) on the bulb yield (t/ha) of onion cv. 'Local White'

bulb yield was recorded in the treatment T_2 (46.027 t/ha) which was at par with rest of the treatments. The minimum bulb yield (38.379 t/ha) was recorded under the treatment T_1 (Control).

4.4 QUALITY ATTRIBUTES

The results pertaining to the qualitative attributes of onion as affected by micronutrients (Zn, Fe and Mn) application are given below.

4.4.1 Total soluble solids (%)

The total soluble solids (%) of onion bulbs as influenced by micronutrients (Zn, Fe and Mn) application are shown in data presented in Table 4.7 and graphically depicted in Fig. 4.7. The effect of micronutrients application on the total soluble solids of onion bulbs were found to be significant. Significantly maximum total soluble solids were found in T_8 (16.73%) followed by treatments T_2 (15.74%), T_5 (15.00%), T_7 (14.56%) and T_6 (14.27%) which were at par with each other. Lowest total soluble solids were recorded under the control treatment T_1 (11.66%) as compared to other treatments.

Table 4.7 : Effect of micronutrients (Zn, Fe and Mn) on total soluble solids (%) of onion bulbs cv. 'Local White'

Symbol	Treatment	Total soluble solids (%)
T_1	Control	11.66
T_2	Zn	15.74
T_3	Fe	13.81
T_4	Mn	13.01
T_5	Zn + Fe	15.00
T_6	Zn + Mn	14.27
T_7	Fe + Mn	14.56
T_8	Zn + Fe + Mn	16.73
	S.Em. ±	0.91
	C.D. at 5%	2.68
	C.V. %	12.71

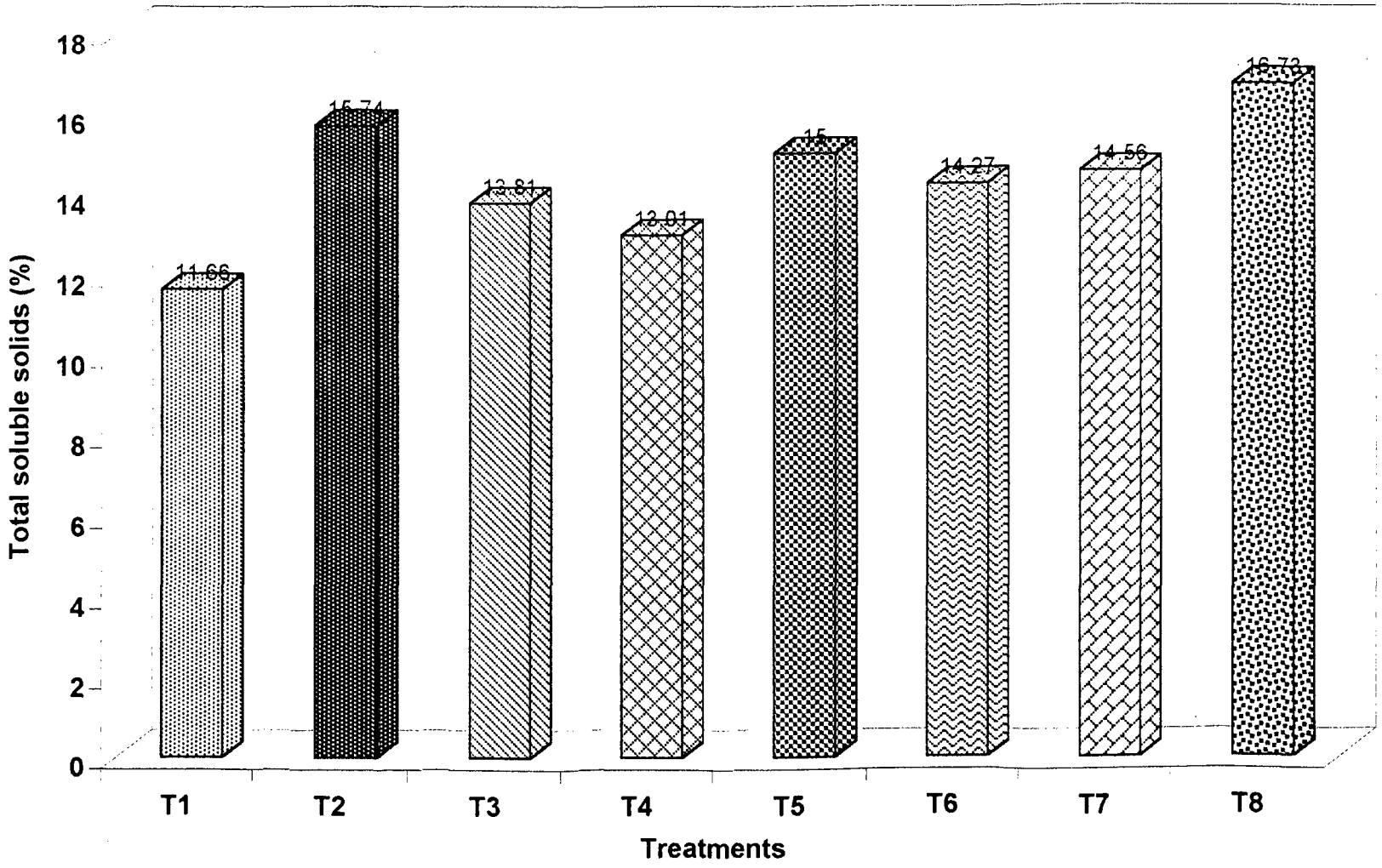
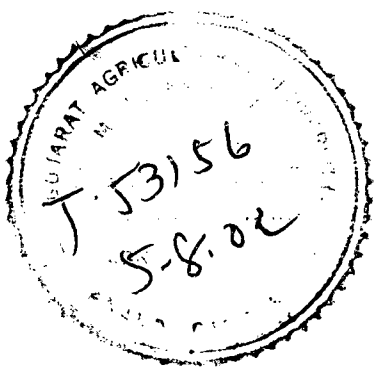


Fig. 4.7: Effect of micronutrients (Zn, Fe and Mn) on total soluble solids (%) of onion bulbs cv. 'Local White'

Table 4.8 : Effect of micronutrients (Zn, Fe and Mn) on dry matter content (%) of onion bulbs cv. 'Local White'

Symbol	Treatment	Dry matter (%)
T_1	Control	12.10
T_2	Zn	13.45
T_3	Fe	13.40
T_4	Mn	13.04
T_5	Zn + Fe	14.01
T_6	Zn + Mn	13.55
T_7	Fe + Mn	13.40
T_8	Zn + Fe + Mn	15.27
	S.Em. ±	0.25
	C.D. at 5%	0.75
	C.V. %	3.84



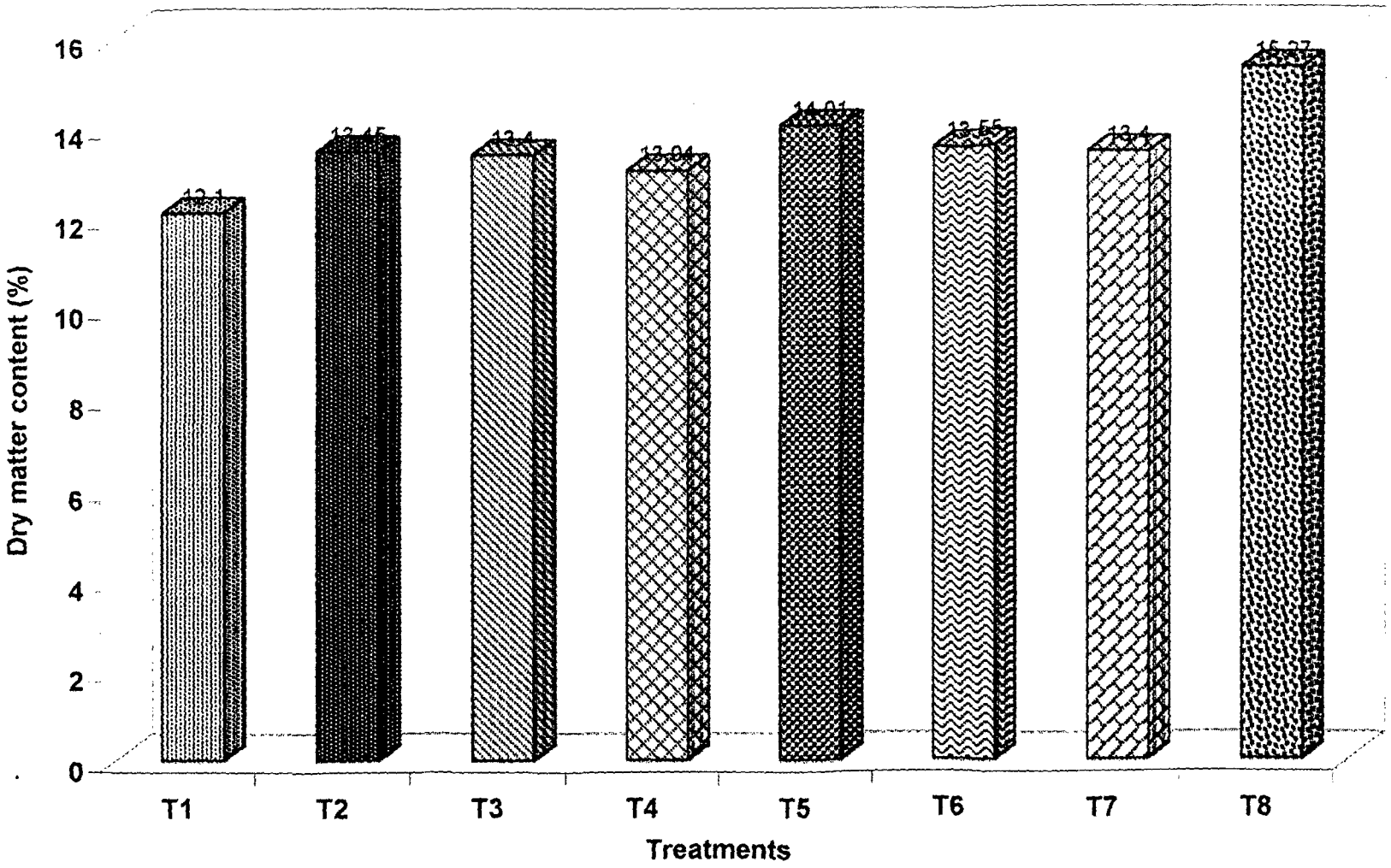


Fig. 4.8 : Effect of micronutrients (Zn, Fe and Mn) on dry matter content (%) of onion bulbs cv. 'Local White'

Table 4.9 : Effect of micronutrients (Zn, Fe and Mn) on sulphur content (%) of onion bulbs cv. 'Local White'

Symbol	Treatment	Sulphur content (%)
T_1	Control	0.2663
T_2	Zn	0.3798
T_3	Fe	0.3678
T_4	Mn	0.3593
T_5	Zn + Fe	0.3806
T_6	Zn + Mn	0.3675
T_7	Fe + Mn	0.3659
T_8	Zn + Fe + Mn	0.4662
	S.Em. ±	0.0305
	C.D. at 5%	0.0897
	C.V. %	16.52

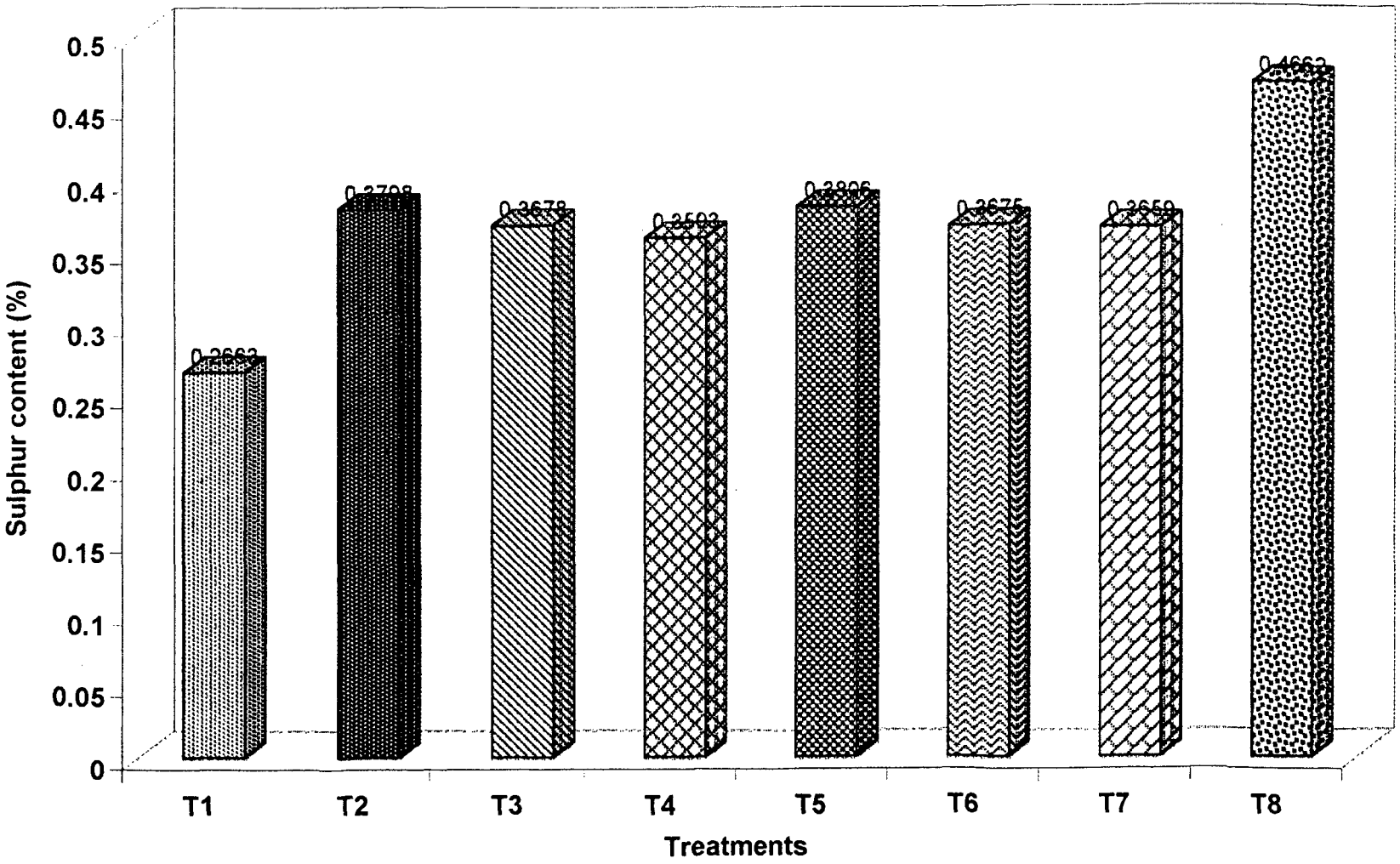


Fig. 4. 9 : Effect of micronutrients (Zn, Fe and Mn) on sulphur content (%) of onion bulbs cv. 'Local White'

4.5 ECONOMICS

The perusal of the data presented in Table 4.10 and Table 4.11 indicated that the highest bulb yield (54.112 t/ha) was obtained under the treatment T_8 [$ZnSO_4$ @ 10 kg/ha + $FeSO_4$ @ 10 kg/ha + $MnSO_4$ @ 10 kg/ha] and to obtain this level, expenditure was incurred to the extent of Rs. 38855/ha and the net income was Rs. 123481/ha which was the highest among all the treatments with 1:9.98 ICBR. The second best treatment was T_2 [$ZnSO_4$ @ 10 kg/ha) which produced 46.027 t/ha bulb yield and expenditure of Rs. 35995/ha with net income of Rs. 102126/ha and the ICBR was 1:15.38.

Due to the lower bulb yield there was less profit in control where micronutrients were not applied.

Table 4.10 : Economics of different treatments

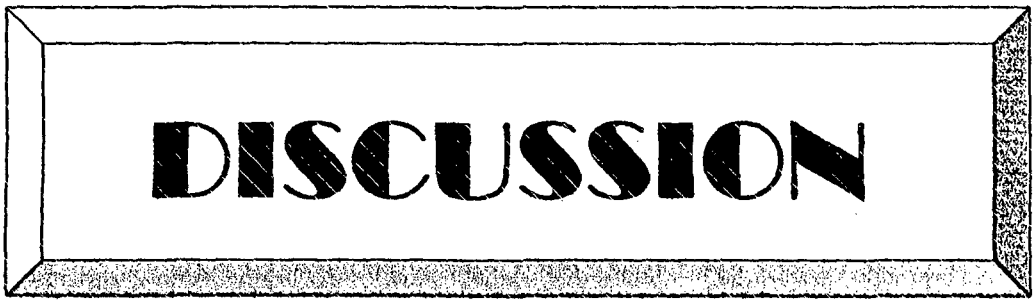
Treatments	Yield (t/ha)	Gross realization (Rs./ha)	Total expenditure (Rs./ha)	Net realization (Rs./ha)
T_1	38.379	115137	34555	80582
T_2	46.027	138081	35955	102126
T_3	41.040	123120	35455	87665
T_4	39.758	119274	36555	82719
T_5	42.617	127851	36855	90996
T_6	41.470	124410	37955	86455
T_7	40.521	121563	37455	84108
T_8	54.112	162336	38855	123481

1 kg onion	Rs. 3.00
100 onion seedlings	Rs. 5.00
5 kg $ZnSO_4$ (Zinc sulphate)	Rs. 700.00
5 kg $FeSO_4$ (Ferrous sulphate)	Rs. 450.00
5 kg $MnSO_4$ (Manganese sulphate)	Rs. 1000.00

Note : Rate as prevailing in market.

Table 4.11 : Incremental Cost Benefit Ratio (ICBR) for different treatments for the production of onion bulbs

Treatments	Yield (t/ha)	Additional yield over control (t/ha)	Incremental income (Rs./ha)	Incremental cost over control (Rs./ha)	Incremental benefit over control (Rs./ha)	Gross I.C.B.R.	Net I.C.B.R.
T_1	38.379	-	-	-	-	-	-
T_2	46.027	7.648	22944	1400	21544	1 : 16.39	1 : 15.38
T_3	41.040	2.661	7983	900	7083	1 : 8.87	1 : 7.87
T_4	39.758	1.379	4137	2000	2137	1 : 2.07	1 : 1.07
T_5	42.617	4.238	12714	2300	10414	1 : 5.53	1 : 4.53
T_6	41.470	3.091	9273	3400	5873	1 : 2.73	1 : 1.73
T_7	40.521	2.142	6426	2900	3526	1 : 2.22	1 : 1.22
T_8	54.112	15.733	47199	4300	42899	1 : 10.98	1 : 9.98


DISCUSSION

CHAPTER V

DISCUSSION

Among the several factors influencing vegetable crop production, macronutrients i.e. N, P and K alongwith micronutrients namely zinc, iron and manganese play an important role for better growth, higher yield and quality. The present work was therefore carried out to study the effect of micronutrients (Zn, Fe and Mn) on growth, yield and quality of onion during the *rabi* season of 2000-2001 at Horticultural Research Farm, Gujarat Agricultural University, Anand Campus, Anand. The results of the present research are reported in previous chapter are discussed here. For the sake of convenience, discussion has been made under the following headings.

Effect of micronutrients (Zn, Fe and Mn) application on

5.1 Growth characters.

5.2 Yield attributes and yield.

5.3 Quality attributes.

5.1 GROWTH CHARACTERS

5.1.1 Plant height

The effect of micronutrients (Zn, Fe and Mn) application on plant height was found to be non-significant at 45 DAT, while it was significant at 60 and 75 DAT (Table 4.1).

The results revealed that among all treatments T_5 (Zn + Fe) produced tall plants (63.65 cm) which was followed by the treatment T_8 (Zn + Fe + Mn) with plant height 61.21 cm. The increase in plant height may be attributed to improved root system of plants resulting in absorption of more water and nutrients from soil and consequently they improved different plant organs and also entire plant. The micronutrient like zinc has a vital role in growth of plant. It regulates oxidation-reduction in plants. This considerable increase in height may be due to the active synthesis of tryptophan in the presence of zinc, the precursor of IAA, which stimulates the growth of plant tissues. There is an enhancement in cell multiplication and cell elongation resulting in more plant height. Iron as an important catalyst in the enzymatic reactions of the metabolism would have helped in the larger biosynthesis of photoassimilates thereby exercised efficiently in bulb development so that

plant height was increased. These results are in agreement with the result of Lal and Maurya (1981), Baghel and Sarnaik (1988), Singh and Tiwari (1989) and Seema (2000) in onion. The height of plant in control T_1 (53.13 cm) was found to be minimum, may be due to the reason that there was no micronutrients application. This report is supported by the findings of Lal and Maurya (1981), who stated that the better absorption of nutrients which affect physiological activities of plants was governed by zinc and it was directly related to phosphate and calcium nutrition and availability of nitrogen.

5.1.2 Number of leaves per plant

The number of leaves per plant at 75 DAT differed significantly over the control (Table 4.2). Number of leaves were maximum (7.66) in the treatment T_8 (Zn + Fe + Mn) which was followed by T_2 (Zn) with number of leaves 6.8 and was at par with treatments T_5, T_6, T_7 and T_3 with the values being 6.64, 6.59, 6.50 and 6.42, respectively. Lowest number of leaves were found in control T_1 (5.94). It has been found that zinc is essential for vegetative growth because it affects apparently the photosynthesis, respiration and catalase activities of leaf. Iron being an important catalyst in the enzymatic reactions of metabolism would have enhanced biological

yield. Manganese is also known to function as auto-catalyst and is also important in nitrogen metabolism. Similar results in onion were also reported by Lal and Maurya (1981), Jawaharlal *et al.* (1986) and Seema (2000).

5.2 YIELD ATTRIBUTES AND YIELD

5.2.1 Equatorial bulb diameter

Among the different treatments, significantly maximum equatorial bulb diameter (6.65 cm) was found in T_8 (Zn + Fe + Mn) as compared to control (4.57 cm). This treatment was at par with T_2 (Zn), T_5 (Zn + Fe) and T_6 (Zn + Mn) with values being 6.25 cm, 6.24 cm and 6.19 cm, respectively. Rapidly increased photosynthetic activities and translocation of more photosynthates to growing bulb with the application of micronutrients (Zn, Fe and Mn) may be

the reason behind the increased size of bulb. The present findings are in agreement with the results of Baghel and Sarnaik (1988), Singh and Tiwari (1993) and Seema (2000).

5.2.2 Bulb weight

Significantly maximum bulb weight (160.86 g) was recorded due to the treatment T_8 (Zn + Fe + Mn) over the control T_1 with bulb weight 45.81 g. The next highest bulb weight (129.74 g) was observed in the treatment T_6 (Zn + Mn) which was at par with T_2 (Zn) and T_5 (Zn + Fe) with bulb weight (124.62 g) and (119.80 g), respectively. The increased weight of bulb could be due to the higher rate of photosynthesis, enhanced chlorophyll synthesis, translocation of more photosynthates to growing bulb and enzyme activity by application of micronutrients Zn, Fe and Mn. These findings are in agreement with those of Baghel and Sarnaik (1988), Singh and Tiwari (1993) and Seema (2000).

5.2.3 Neck thickness

The effect of micronutrients (Zn, Fe and Mn) application on neck thickness was found non-significant (Table 4.5). However, the maximum neck thickness (0.83 cm) was found in the treatment T_2 (Zn) and the minimum (0.60 cm) was found in T_3 (Fe).

5.2.4 Yield per hectare

It was observed that the effect of micronutrients (Zn, Fe and Mn) application on the yield of onion bulbs was significant (Table 4.6). Significantly maximum onion bulb yield (54.112 t/ha) was recorded under the treatment T_8 (Zn + Fe + Mn). The next highest yield (46.027 t/ha) was obtained in the treatment T_2 (Zn) while the minimum (38.379 t/ha) was recorded in the control T_1.The increase in yield of onion is directly related to increase in bulb weight and an increase in bulb weight under the influence of micronutrients (Zn, Fe and Mn) may be due to the higher rate of photosynthesis and sugar formation due to enhanced chlorophyll synthesis and enzyme activity which lead to translocation of more photosynthates to growing bulbs which ultimately leads to higher production of dry matter and consequently more yield. Also, the various reactions in plant metabolism are catalysed by micronutrients. Zinc as an essential catalyst in the synthesis of auxin from tryptophan would have encouraged the auxin biosynthesis in the active sinks which would have led to higher transport and accumulation of photosynthates in these sinks in bulbs and hence improving yield and hastening their maturity. The favourable effect of iron on yield may be attributed to higher rate of chlorophyll synthesis, cytochrome photo oxidase

activity which contributes to more photosynthetic activities and higher production of sugar. Iron is also an important catalyst in enzymatic reactions of the metabolism and would have helped in the larger biosynthesis of photoassimilates thereby enhancing both economic and biological yield. Manganese is also known to activate number of enzymes. It is essential for splitting the water molecule during photosynthesis. It is also important in nitrogen metabolism and carbondioxide assimilation. The above stated reasons may be the cause of appreciable increase in yield due to the application of micronutrients Zn, Fe and Mn singly and significant effect brought due to their combined application. These results are in conformity with those of Maurya and Lal (1975), Gupta *et al.* (1983), Baghel and Sarnaik (1988), Singh and Tiwari (1993) and Seema (2000).

5.3 QUALITY ATTRIBUTES

5.3.1 Total soluble solids (TSS)

The present study revealed that the effect of micronutrients application on TSS was significant (Table 4.7). Significantly higher per cent of TSS (16.73%) were observed in the treatment T_8 (Zn + Fe + Mn) over the control T_1 with TSS 11.61%. This treatment was at par with T_2 (Zn), T_5 (Zn

+ Fe), T_7 (Fe + Mn) and T_6 (Zn + Mn) with TSS values 15.74%, 15.00%, 14.56% and 14.27%, respectively. The constituents of TSS are organic and inorganic substances present in cell sap which contribute to osmo regulation of bulbs and help in the maintenance of turgidity. The increase in TSS of bulbs may be due to the increased carbohydrates production during photosynthesis and also due to some improved physiological and biochemical activities in plant system under the influence of micronutrients. Zinc plays very important role in photosynthetic activities. Iron being an essential component of many respiratory enzymes like catalase, cytochromes A, B and C which are involved in the respiratory process in the cell system would have naturally resulted in the conversion of reserve food materials to soluble simple sugars. These reasons might be the probable cause for the increase in TSS content in the bulbs due to the application of zinc, iron and manganese. These results are in conformity with the results obtained by Maurya and Lal (1975), Jawaharlal *et al.* (1988), Baghel and Sarnaik (1988), Singh and Tiwari (1993) and Seema (2000).

5.3.2 Dry matter content

The dry matter content of the bulb was significantly influenced by micronutrients application (Table 4.8). Significantly maximum dry matter content (15.27%) was registered in the treatment T_8 (Zn + Fe + Mn) than the control T_1 with dry matter content 12.10%. The next higher content of dry matter was found in the treatment T_5 (Zn + Fe) which was statistically at par with T_6 (Zn + Mn), T_2 (Zn), T_3 (Fe) and T_7 (Fe + Mn) with dry matter content 13.55%, 13.45%, 13.40% and 13.40%, respectively. The increase in dry matter production may be attributed to some improved physiological and biochemical activities in plant under the influence of zinc, iron and manganese. Zinc plays very important role in photosynthetic activities of plant and it would have led to higher transport and accumulation of photosynthates in bulb. This finding is supported by the results of Palanivel (1981), Jawaharlal and *et al.* (1986) and Seema (2000).

5.3.3 Sulphur content

The data presented on sulphur content in onion bulbs revealed significant effect of micronutrients application (Table 4.9). Significantly maximum sulphur content (0.4662%) was observed in the treatment T_8 (Zn + Fe + Mn) which was at par with T_5 (Zn + Fe) and T_2 (Zn) having sulphur

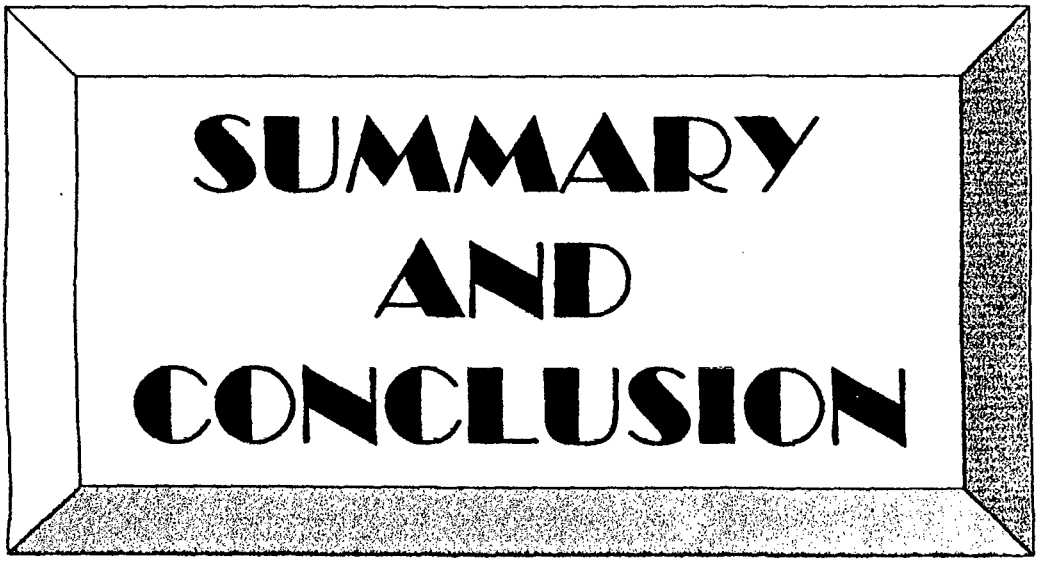
content 0.3806% and 0.3798%, respectively. Minimum sulphur content (0.2663%) was founding the control T_1. Sulphur is one of the constituents determining the quality of onion and it plays important role in protein production, it enters the composition of amino acids viz., cysteine, cystine, methionine, thiamine and biotin which are building blocks of protein. The pungency in onion is due to the presence of allylpropyl disulphide and the sulphur content in allylpropyl disulphide is around 43 to 44 per cent. The improvement in the sulphur content of onion bulbs may be due to cations under question because all the micronutrients viz., zinc, iron and manganese were applied as their sulphates. This finding is in consonance with those of Palanivel (1981), Jawaharlal *et al.* (1988), Singh and Tiwari (1993) and Seema (2000).

5.4 ECONOMICS

Onion cultivation with an application of micronutrients (Zn, Fe and Mn) was found economical in present study. Onion cultivation is economical for two groups of cultivators viz., those who can invest more and those who can afford less investment. The low input technology of growing onion will be beneficial for small and marginal farmers who are able to invest low level of inputs and will get comparatively less income.

High investment group of cultivators may apply $ZnSO_4$ @ 10 kg/ha + $FeSO_4$ @ 10 kg/ha + $MnSO_4$ @ 10 kg/ha whereas, low input group of cultivators may adopt low input technology with $ZnSO_4$ @ 10 kg/ha application for better growth, yield and quality of onion as compared to control.

Thus, for higher growth, yield and better quality of onion cv. 'Local White' the soil application of $ZnSO_4$ @ 10 kg/ha + $FeSO_4$ @ 10 kg/ha + $MnSO_4$ @ 10 kg/ha has been proved to be the best treatment. The next best treatment was $ZnSO_4$ @ 10 kg/ha application.


SUMMARY
AND
CONCLUSION

CHAPTER – VI

SUMMARY AND CONCLUSION

The present experiment entitled "Effect of micronutrients (Zn, Fe and Mn) on growth, yield and quality of onion (*Allium cepa* L.) cv. 'Local White' was conducted during *rabi* season of 2000-2001 at the Horticultural Research Farm, Department of Horticulture, B.A.College of Agriculture, Anand Campus, Anand.

The experiment was laid out in a Randomised Block Design with four replications. There were eight treatments comprised of basal application of micronutrients, $ZnSO_4$ @ 10 kg/ha (T_2), $FeSO_4$ @ 10 kg/ha (T_3), $MnSO_4$ @ 10 kg/ha (T_4), $ZnSO_4$ @ 10 kg/ha + $FeSO_4$ @ 10 kg/ha (T_5), $ZnSO_4$ @ 10 kg/ha + $MnSO_4$ @ 10 kg/ha (T_6), $FeSO_4$ @ 10 kg/ha + $MnSO_4$ @ 10 kg/ha (T_7), $ZnSO_4$ @ 10 kg/ha + $FeSO_4$ @ 10 kg/ha + $MnSO_4$ @ 10 kg/ha (T_8) and the control (T_1).

The salient features of the results are summarized below :

6.1 GROWTH CHARACTERS

6.1.1 Plant height (cm)

The effect of micronutrients application on plant height of onion was found to be significant. The maximum plant height (63.65 cm) was recorded

in the treatment T_5 [$ZnSO_4$ @ 10 kg/ha + $FeSO_4$ @ 10 kg/ha] while it was lowest (53.13 cm) in the untreated control (T_1) at 75 DAT.

6.1.2 Number of leaves per plant

The effect of micronutrients application on number of leaves per plant varied significantly. Maximum number of leaves per plant (7.66) were recorded in the treatment T_8 [$ZnSO_4$ @ 10 kg/ha + $FeSO_4$ @ 10 kg/ha + $MnSO_4$ @ 10 kg/ha] and lowest (5.94) in the control (T_1) at 75 DAT.

6.2 YIELD ATTRIBUTES

6.2.1 Equatorial diameter of onion bulb (cm)

The effect of micronutrients application on the equatorial bulb diameter of onion was found to be significant as compared to control. The maximum bulb diameter (6.65 cm) was recorded in the treatment T_8 [$ZnSO_4$ @ 10 kg/ha + $FeSO_4$ @ 10 kg/ha + $MnSO_4$ @ 10 kg/ha] while it was lowest (4.57 cm) in the untreated control (T_1).

6.2.2 Weight of onion bulb (g)

There was significant difference in the weight of onion bulb under the influence of micronutrients application. The treatment T_8 [$ZnSO_4$ @ 10 kg/ha + $FeSO_4$ @ 10 kg/ha + $MnSO_4$ @ 10 kg/ha] recorded maximum weight of onion bulb (160.86 g) and lowest (39.00 g) in the treatment T_4 [$MnSO_4$ @ 10 kg/ha] and the untreated control (T_1) was (45.81 g) which were at par with each other.

6.2.3 Neck thickness (cm)

The effect of micronutrients application was non-significant in respect of neck thickness of onion bulb at harvest though it was maximum (0.83 cm) in the treatment T_2 [$ZnSO_4$ @ 10 kg/ha].

6.3 YIELD OF ONION BULBS (t/ha)

There was a significant effect of micronutrients application on yield of onion bulbs per hectare. The maximum yield (54.112 t/ha) was obtained under the treatment T_8 [$ZnSO_4$ @ 10 kg/ha + $FeSO_4$ @ 10 kg/ha + $MnSO_4$ @ 10 kg/ha] while it was lowest (38.379 t/ha) in the control (T_1).

6.4 QUALITY ATTRIBUTES

6.4.1 Total soluble solids % (TSS)

The application of micronutrients had significant effect on TSS of onion bulbs. Significantly maximum TSS (16.73 %) were found in the treatment T_8 [$ZnSO_4$ @ 10 kg/ha + $FeSO_4$ @ 10 kg/ha + $MnSO_4$ @ 10 kg/ha] and minimum (11.66%) in the untreated control (T_1).

6.4.2 Dry matter content (%)

The application of micronutrients had significant effect in respect of dry matter content of onion bulbs. The maximum dry matter content (15.27%) was recorded in the treatment T_8 [$ZnSO_4$ @ 10 kg/ha + $FeSO_4$ @ 10 kg/ha + $MnSO_4$ @ 10 kg/ha] while it was lowest (12.10%) in the untreated control (T_1).

6.4.3 Sulphur content (%)

The results on sulphur content in onion bulbs revealed significant effect of micronutrients application. Maximum sulphur content (0.4662%) was observed due to the treatment T_8 [$ZnSO_4$ @ 10 kg/ha + $FeSO_4$ @ 10 kg/ha + $MnSO_4$ @ 10 kg/ha] and it was minimum (0.2663%) in the untreated control (T_1).

6.5 ECONOMICS

Among different treatments T_8 [$ZnSO_4$ @ 10 kg/ha + $FeSO_4$ @ 10 kg/ha + $MnSO_4$ @ 10 kg/ha] proved to be the best from economics point of view with highest yield (54.112 t/ha) and incurring a total expenditure of Rs. 38555/ha while giving net realization of Rs. 123481/ha with an ICBR of 1:9.98.

CONCLUSION

It can be concluded that soil application of micronutrients, $ZnSO_4$@ 10 kg/ha + $FeSO_4$ @ 10 kg/ha + $MnSO_4$ @ 10 kg/ha before transplanting alongwith a recommended dose of FYM and NPK to the onion crop is the most beneficial treatment for obtaining higher vegetative growth, yield and quality of onion bulbs. However, for low input technology soil application of $ZnSO_4$ @ 10 kg/ha can be followed for better growth, yield and quality of onion bulbs. Further, the treatment $ZnSO_4$ @ 10 kg/ha + $FeSO_4$ @ 10 kg/ha + $MnSO_4$ @ 10 kg/ha was found more beneficial in terms of net income and ICBR.

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* Original not seen.

APPENDICES

APPENDIX – I

METEOROLOGICAL PARAMETERS FOR THE CROPPING PERIOD FROM DECEMBER, 2000 TO APRIL, 2001

Meteorological standard week	Month	Temperature (°C)			Sun shine (hrs/day)	Relative humidity (%)	Rainfall (mm)
		Max.	Min	Mean			
51	Dec.	30.93	11.54	21.24	9.49	60.31	00
52	Dec.	29.88	11.23	20.55	8.48	55.75	4.3
1	Jan.	25.94	10.11	18.03	8.89	58.80	00
2	Jan.	27.27	10.17	18.72	9.54	48.33	00
3	Jan.	29.69	12.70	21.19	9.69	53.22	00
4	Jan.	27.97	7.24	17.61	9.94	49.34	00
5	Feb.	29.14	11.39	20.26	8.17	48.71	00
6	Feb.	30.33	7.69	19.01	10.20	53.78	00
7	Feb.	30.41	10.97	20.69	9.44	52.56	00
8	Feb.	33.20	13.39	23.29	10.07	57.35	00
9	Mar.	33.54	15.50	24.02	7.59	44.07	00
10	Mar.	35.03	13.46	22.24	9.84	44.47	00
11	Mar.	35.11	18.61	26.86	9.13	53.24	00
12	Mar.	36.37	19.80	28.09	8.86	52.12	00
13	Apr.	34.93	18.77	26.85	9.69	47.63	00
14	Apr.	39.50	18.13	28.81	9.61	33.93	00

APPENDIX – II

LIST OF ABBREVIATIONS

Abbreviation	Meaning
Anon.	Anonymous
@	At the rate of
B	Boron
°C	Degree Celcius
C.D.	Critical Difference
cm	Centimetre
Cu	Copper
cv.	Cultivar
C.V.	Co-efficient of variation
DAT	Days After Transplanting
et al.	Et alli, and others
Fe	Iron
Fig.	Figure
FYM	Farm Yard Manure
g	Gram
ha	Hectare
i.e.	That is
K	Potash
K.cal	Kilo calorie

(Contd...)

Abbreviation	Meaning
Kg.	Kilogram
m	Metre
max.	Maximum
mg	Miligram
min.	Minimum
N	Nitrogen
No.	Number
NS	Non-significant
P	Potassium
ppm	Parts per million
Rs.	Rupees
S.Em.	Standard error of mean
sq.m.	Square metre
TSS	Total Soluble Solids
Var.	Variety
viz.	Namely
Zn	Zinc
/	Per
%	Per cent