Effect of Mo, B, Cu, Mn, Fe, Zn, growth and Productivity of *Hibiscus esculentus* under field conditions

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By

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APPROVAL

This is to certify that this thesis submitted by **Fayaz Hussain** is accepted in present form by the Department of Biological Sciences, Quaid-i-Azam University, Islamabad, as satisfying the dissertation requirements for the degree of **Master of Philosophy** in **Plant Physiology.**

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Dated: __________

DECLERATION

The whole of experimental work described in this thesis was carried out by me in Plant Physiology/ Tissue Culture Lab, Department of Biological Science, Quaid-i-Azam University, Islamabad. The conclusion is my own research after numerous discussions with my supervisor. I have not presented any part of this work for any other degree.

Fayaz Hussain

I certified that the above statement is correct.

Dr. M. Fayyaz Chaudhary
Supervisor

Dated: ________

DEDICATED

TO

MY LOVING PARENTS
AND
MY FAMILY

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I bestow my humblest praise for Almighty Allah, the most Benevolent and Merciful for His countless blessings enabling me to pursue all endeavors of life. I offer special praise to His last Messenger, Hazart Muhammad (peace be upon him) who will forever remain a touch of wisdom and leadership for mankind.

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Fayaz Hussain

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Abstract

A series of pot experiments were designated to study the effects of six micronutrients (Fe, B, Cu, Zn, Mn, & Mo) on the growth and yield of a malvaceous vegetable plant *Hibiscus esculentus (*Ladyfinger). Three different concentrations (C_1, C2, C3) of each micronutrient at three growth stages (t_1, t_2, t_3), through foliar, foliar plus soil and soil application (T_1, T_2, T_3) were tested. Results showed that foliar application of micronutrients positively affected the growth and yield of the plant as compared to soil and control treatments. It was observed that concentrations and timing of application also affected growth and yield significantly. Foliar application (T_1, t_1, FeC_1) and foliar plus soil treatment (T_2, t_1, FeC_1) of iron positively affected the yield of the fruit. Foliar application of boron (T_1, t_1, BC_1) produced negative effect on the lady fruit while foliar plus soil application of zinc produced maximum number of fruit. Similarly Copper foliar treatment (T_1, t_3, CuC_3) produced maximum number of fruit. Molybdenum application significantly affected the fruit yield as compared to the control, maximum numbers of fruits were obtained for foliar treatments. Manganese application also effected significantly the growth and yield of lady finger plant. Foliar treatment (T_1, t_3, MnC_3) effected significantly and produced maximum number of fruits per plant. Soil, foliar plus soil and control treatments of Mn produced minimum number of fruit.

Chapter No: 1

INTRODUCTION

Ladyfinger (*Hibiscus esculentus* L.) belonging to the family malvaceae, is cultivated annually and falls into the dicotyledons. It is amphidiploids (2n=130). The best environment for its growth is warm season but chilling and frost have harmful effect on its growth. Oil is produced from its harvested organs i-e edible capsules or immature seed pods. Its flowers resemble with other plants of hibiscus genus.

Historically it was used by Egyptians, later it was introduced to North America by African slaves. Optimum temperature ranges from 21to 39 ^{0}C. It can be cultivated on the soil having pH= 6.0 to 7.5. Its maturity duration is 60 to 90 days. Different cultivars are present which can be varying height, pod color, prominence of pod ridges and presence of species however, major commercial cultivars are spineless. Its F1 hybrid varieties are more uniform. Hand harvesting is done when pods reach their optimal edible size of about 7.10 cm. Those harvested pods are stored at 10 ^{0}C and high relative humidity (95%) in order to minimize the respiration and present desiccation. Texas, Georgia, Florida, California, Tennessee and Alabama are the major ladyfinger producing states in the U. S. A. Ladyfinger is also produced in four provinces of Pakistan. Major province producing ladyfinger is Punjab.

Okra or ladyfinger

Thai Name:	Krajaib Kaew
Scientific Name:	*Hibiscus esculentus Linn.*
Description- Size:	6 to 10 cm long.
Shape:	Five angles pod.
Color:	Green to dark green.
Nutritional Value:	33 kcal, 7.6g carbohydrate, 2.4 g protein, 70 mg calcium 31mg vitamin C, 0.32mg vitamin A, 0.17mg vitamin B1, 0.21 mg Vitamin B2, per 100 g serving.
Use:	Raw and cooked in salads soups with other vegetables.

Industrial Processing:	Canning and Deep freezing.
Season:	Throughout the year.
Storage:	3 to 10 days at 7 to 10 C, relative humidity 90- 95%.

1.1: Micronutrients

Micronutrients are elements which are essential for plant growth but are required in much smaller amounts than those of primary nutrients as nitrogen, phosphors and potassium. The micronutrients include boron, copper, iron, manganese, molybdenum, zinc, and chloride (Mauseth, 2003 and Nyle 1987).

In spite, the best efforts and intensive research, in Pakistan per crop yields are low with much gap to potential yield. Balance of fertilizer applications and other measures are needed to raise production of crops to fill the yield gap. The soil and climatic conditions of Pakistan appear to be quite conducive to micronutrient deficiencies in the plants (Chaudhry and sharif, 1975).

Widespread deficiency of micronutrients has been reported in various regions of country (Kausar *et al.*, 1976). The use of chemical fertilizers has mainly been confined to the application of macronutrients and little attention has been given to the micronutrients (Askari *et al.*, 1995). Micronutrients play a vital role in the growth and developments of plants. They are responsible for carrying out various metabolic processes by affecting enzyme activity, formation of hormones in the plant cells, electron transfer in oxidation – reduction reactions and in plant nutrition (Khattak *et al.*, 1983). Deficiencies of micronutrients have been increasing in some crops. Some reasons are higher crops yield which increase plant nutrient demand, use of high NPK fertilizers containing lower quantities of micronutrients contents and decreased use of farmyard manure on much agriculture soil (Mortvedt *et al.*, 1972).

1.2 Micronutrient Nutrition

A brief discussion of micronutrient functions and nutrient deficiency symptoms in plants and soil conditions affecting micronutrient availability is given below.

a. Iron

Iron is frequently taken in the ferric state (Fe^{+3}) but significant quantities of ferrous state (Fe^{+2}) may also be absorbed. Fe is incorporated directly in the cytochromes, into compounds necessary to the electric transport system in mitochondria and into ferrodoxin

(Devlin and Witham, 1986). Iron is essential for the synthesis of chloroplast proteins, possibly enzymes involved in chlorophyll synthesis (Gauch, 1957). The sufficient range of iron in plant tissue is normally between 25-50 ppm. In general when iron contents are 50 ppm or less in dry matter, deficiency is likely to occur (Mortvedt et al., 1972). Iron is immobile, deficiencies are found on calcareous soil, sandy soils low in organic matter. Poorly aerated or compacted soil, also reduce iron uptake (Samuel *et al.*, 1993 and Lindsay *et al.*, 1967). Important nutrient relation includes interaction of iron with zinc, copper, manganese, phosphate and nitrogen (Lindsay *et al.*, 1967).

b. Boron

Boron is the only non-metal among the micronutrients. The total concentration of B in the soil varies between 2-200ppm. Less than 5% of the total soil Boron is available to plants. (Muel *et al.*, 1993). Boron is important in the processes like pollen germination, cell division, nitrogen metabolism, water movement, carbohydrate transport, active salt absorptions , hormone metabolism and fat metabolism (Agarwala *et al.*, 1981; Nason and Mc Elroy, 1963; Rammah *et al.*, 1984). Boron deficiency is the most wide spread micronutrient deficiency. Boron deficiency is common in many countries during dry period. Sever symptoms include shortening of the stem internodes, resetting of terminal leaves and some times death of growing points.

Boron is not a very mobile element. Boron defiency is mainly found in acid sandy soil in regions of high rainfall and those with low organic matter. Borate ions are mobile in soil and can be leached from the root zone (Martvedt *et al.*, 1972).

c. Copper

Copper is absorbed by the plants as the cupric ions (Cu^{+2}) and may be absorbed as a component of either natural or synthetic organic complex. The normal range of Cu in many plants in fairly narrow, ranging from 5 to 20ppm. Wiklander (1958) estimated that the soil solution of ordinary soil contains 0.01 ppm copper and the actual water soluble amount does exceed 1%^ of the soil. Copper acts as component of phenolase, lactase, and ascorbic acid oxidase, and its role as a part of these enzymes probably represent an important function of copper in plants (Nason and Mc Eloroy, 1963). The chloroplast possesses copper containing protein called plastocyanin that is essential in electron photosynthesis (Loustalot *et al.*, 1945; Neish, 1939). Copper deficiencies are mainly reported in the organic soils and in sandy soils, which are low in organic matter. Copper uptake decrease as soil pH increases. Increased phosphors and iron availability in the soils decreases copper uptake by plant (Mortvedt and Cox, 1985).

d. Zinc

The normal range of Zn is most plants are between 20 to 100ppm. Roots absorb Zinc as Zn^{2+} and as component of synthetic or natural organic complex. Zn may be involved in biosynthesis of indole-3-acetic acid (Skoog, 1940). Zinc participates in the metabolism of plants as an activator of several enzymes such as dehydrogenases, and in maturation (Ikhtiar *et al.*, 2000). Soils of the Punjab are alkaline and calcareous, are matter content and receive heavy doses of nitrogen fertilizer for high yields. Nitrogen fertilizer has been reported to aggravate Zn deficiency in plants (Lucas, and Knezek; Mortvedt *et al.*, 1972). Zinc deficiencies are mainly found on sandy soils which are low in organic matter. Zn uptake by plants decreases with increased soil pH. High level of available phosphorus and iron in soil adversely affects the uptake of Zn by plants. (Mortvedt *et al,*, 1972).

e. Manganese

The Mn content of various soils has been found to vary between 200-260ppm with mean average of 432ppm (Ibrahim and Ahamad, 1973). Normal concentration of Mn in plants typically ranges from 20 to 500ppm. Manganese is an essential element in respiration and N2 metabolism; it also facilitates photosynthesis and oxidation of indole-3-acetate (Divilin and William, 1983). Mn can substitute for Mg++ in many photophosphorylating and group-transfer reaction. Mn is relatively immobile element and deficiency symptoms shown up in the younger parts. Mn deficiencies mainly occur on organic soils, high pH soils, and sandy soils low inorganic matter. Soils Mn may be less available in dry, well- aerated soils. High level of copper, iron or zinc can reduce Mn up take by plants (Mortvedt *et al.*, 1972).

f. Molybdenum

Normally Mo content of plant material is less than 1.0ppm and deficient plant usually contain less than 0.2ppm. Mo concentrations in plant are frequently low because of extremely small amount of MoO_4 -2 in the soil solution (Samuel *et al.*, 1973).

Mo is an essential component of nitrate reductase and nitrogen enzyme, both are involved in N2- fixation by root nodule bacteria of leguminous crops, by some algae, actinomycetes and by free living N2- fixing organisms such as Azotobacter (Katyal and Randhawa., 1983). Mo deficiencies lead to a drop in concentration of ascorbic acid in the plant (Agarwal and Hewitt, 1954) and disorganization of chloroplast (Hewitt, E.J. 1963). Mo deficiencies are found on and sandy soils in humid regions. Mo uptake by plants increases with increase of pH, which is opposite of the other micronutrients.

1.3 Foliar Application

In the last two decades, plant physiologists have developed the technique of foliar application i-e spraying solution of nutrients and chemical compound on the leaves of plants (Kochor and Krishnamoorty, 1988; Noggle and George, 2002). Foliar feeding has been used as means of supplying supplement doses of minor and major nutrients, plants hormones, stimulants, and other beneficial substances. Effects of foliar fertilizer application included yield increases, resistance to pathogen and insects, improved tolerance and enhanced crop quality. Since aerial plant organs absorb inorganic and organic substances from applied solutions (Buovac Witter, 1980) the application of foliar fertilizer during these periods of enhanced nutrient demand could allow for increased growth rate or yield (Garcia and Hanway, 1976). Due to the efficiency and rapidity of uptake, foliar-applied nutrients would be immediately available to the plant and would not be subjected to the time delay and fixation processes associated with soil application (Brady, 1984). For these reasons, the foliar application of mineral nutrients to aerial plant organs has tremendous potential. The application of certain micro and macronutrients available a routine practice in agriculture (Chamel, 1970).

The aims and objectives of this study to observe the effects of foliar and soil application of micronutrients (Fe, Mo, Mn, Cu, B and Zn) on the growth and yield of *Hibiscus esculentus*.

Major and minor nutrients require for plant growth.

Table1. Nutrients essential for plant growth.			
Nutrients from air and water	Nutrients from soil, lime and commercial fertilizers		
	Primary nutrients	Secondary nutrients	Micronutrients
Carbon (C)	Nitrogen (N)	Calcium (Ca)	Boron (B)
Hydrogen (H)	Phosphors (P)	Magnesium (Mg)	Chlorine (Cl)
Oxygen (O)	Potassium (K)	Sulfur (S)	Copper (Cu)
			Iron (Fe)
			Manganese (Mn)
			Molybdenum (Mo)
			Zinc (Zn)

Table: 2 Micronutrient deficiency symptoms, the probable cause and method of correction.

Element	General deficiency symptoms	Probable cause of deficiency	Method of correction
Manganese (Mn)	Interveinal chlorosis of leaves, stunted plants, yellow cast over deficient areas, reduced yield & quality	low soil Mn, high pH due to over liming	Low soil pH apply foliar spray or add Mn soil
Zinc (Zn)	Chlorotic leaves, slow growth, reduced vigor, white streaks parallel to leaf blade	Low zinc in soil, high soil Ph,	Lower soil pH, apply foliar spray or add Zn to soil
Copper (Cu)	Reduced growth, leaf-tip dies back, leaf tip breaks down, leaves ragged	Low soil Cu, high organic matter	Apply foliar spray or add Cu to soil
Boron (B)	Terminal bud dies, multiple lateral branches (rosette with short internodes, older leaves thick and leathery, petioles short, twisted, and ruptured), small deformed fruit (in grapes), cork spot (in apples)	Low soil B, esp. on sandy soils	Apply foliar spray or add B to soil
Molybdenum (Mo)	Reduced growth; pale green color; necrotic areas adjacent to midrib, between along leaf edges; twisted stems	Low soil pH,low Mo content in soil	Inoculate seed with Mo, apply foliar spray, or add Mo to soil
Chlorine (Cl)	Reduced growth; stubby roots; interveinal chlorosis; non succulent tissue (in leafy vegetables	Low soil Cl, esp. in soils subject to leaching	Apply Cl- containing fertilizer

Chapter No: 2

REVIEW OF LITERATURE

A series of experiments was conducted at Quaid-e-Azam University during 1999-2000 to evaluate foliar, soil and combined effects of foliar and soil application of NPK on different growth parameters and nodulation in *lens culinaris* Medic. The parameters studied were shoot length, fresh shoot weight, dry shoot weight, fresh root weight, dry plants treated with NPK both through soil and foliage. Use of detergent in foliar application of NPK enhanced different growth parameters. Optimal concentration of NPK for the various growth parameters were found to be 0.35% Nitrogen, 0.32% Phosphors and 0.50% Potassium at pH 7.0, both for foliar and soil application. Timing of fertilizer application also affected growth and nodulation. Multiple application of both soil and foliar application gave better results as compared to single application of NPK. Soil application produced better results compared to foliar application when applied alone. The foliar application of NPK enhanced the number of nodules per plant. However, foliar spray of nitrogen alone caused a decrease in nodules per plant but the size of nodules showed a significant increase.

Majority of the farmers used N (87kg/ha) fertilizer very close to the recommended dose (85kg/ha), which was often supplemented with farm yard manure. However phosphate use on sunflower crop was limited. There were so many factors which were responsible for explaining the variation in the quantity of total fertilizer applied by farmers. But two factors, number of irrigations and crop rotations, were the most important. With one extra irrigation about 26kg/ha more fertilizer were applied. This implied that water availability increased the use of chemical fertilizer. Farmers facing water shortage did not take risk of high dose of fertilizer. If previous crop was sugarcane then farmers applied less fertilizer (55kg/ha) than for other rotations.

The farmers who used more than the recommended dose of P, had the highest yield (1.9t/ha) as compared to the other fertilizer user groups. Similarly the farmers who used more than the recommended dose of N had the highest yield (1.8t/ha) as compared to the other nitrogen user groups. The gap between production and consumption of edible oil is growing at the rate of about 50,000 metric tons per year. To over come the growing

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gap between production and consumption, during the last decade Pakistan had to increase the import of edible vegetable oil almost two- fold in 1886. Foreign exchange costs increased from $ 31million in 1973 to an estimated $ 383 million in 1986. During the past decade, Pakistan imported edible oils that costed about $ 1.5 billion (USAID, 1987).

Traditional and non traditional oil seed crops grown in Pakistan meet 35 percent of the total edible oil requirement. Cotton seed and rape / mustard seed are the two main sources of edible oil accounting for about 85 percent of the local availability (Aslam and Akhtar, 1986). However, sunflower cultivation seems to be having potential in Pakistan and its production is increasing year by year, mainly due to increase in area under this crop. Increase in area is very slow, due to lack of adequate production technology. Moreover, the potential of sunflower has not been fully re realized by the farmer at large. There are so many factors which are responsible for low yield, one of which is proper management of fertilizer application (Beg *et al.*, 1984).

Chaudhary (1985) reported that fertilizer experiment was conducted with a local open pollinated variety Suncom-110 and hybrid variety IS-894 during the spring 1983 and spring 1984 respectively. The results indicated that fertilizer dose of 86:63kg N: P/ hectare were the optimum for harvesting the maximum yield of open- pollinated 1686 kg/ha and hybrid varieties (2000kg/ha).

Qureshi and Ahmed (1986) conducted an experiment to examine the effect of fertilizer on sunflower yield and other characteristics under irrigated conditions. They concluded that fertilizer combination of 150 kg N and 60kg P205/ha resulted in highest economical yields. Fertilizer dose below and above these level results in minimizations of net return. The application of this combination of fertilizer increase the seed yield from 1333 kg to 2d116kg/hectare (783kg). This quantity of fertilizer cost Rs. 1129 in contrast to the out put of Rs. 3328 for value of increased out put. This shows a cost benefit ratio of 1:3, which is very attractive and paying.

Aslam and Akhtar (1986) conducted a darm level survey of 72 farmers in rice producing area of tehsil Daska, District Sialkot. They reported that high yielding fields (>1975kg/ hectare) received N and P, 39 and 21 kg/ hectare respectively, which were 3 and 10 times more than the corresponding quantities noted at low yielding fields (>.975kg/hectare).

The effects of Ca and B fertilizers on the productivity of tomato cv. Deborah Max were investigated by Cardozo *et al.*, (2001). Amino or at 300 ml/100 liters gave the highest value for fruit weight, while Ca at 60g/ 100 litres and B at 150 g / 100 litres recorded the highest number of fruit.

The effects of intensive use of mineral and organic fertilizers were studied for the contents of more significant biogenic macro- (N, P, K, Ca, Mg) and micro elements (Fe, B, Zn, Mn, and Cu) in soil and leaves with objective of planning measures for rational application of fertilizers optimizing nutrition and environmental protection. The research was conducted in Yugoslavia and included 3 soils (alluvial, brown shallow and brown very shallow soils) and three vegetable crops (Tomato, Pepper and Watermelon). The soils were alkaline, carbonic and humus and they were well supplied with available phosphors, potassium, calcium and manganese. Application of Fe, Zn, Mn, and Cu was favorable, with small amounts of B. The status of P, K, Mg, Zn and Mn was not completely examined by foliar diagnostics. Adequate or high contents of nitrogen, especially nitrates, were established in vegetable leaves, indicating the possibility of reducing the application of nitrogen fertilizers. (Radulovic, 1996).

Cauliflower (*Brassica oleracea* L. Var. Botrytis) was grown in refined sand in complete nutrient solution and in solutions deficient each of Fe (0.56 ppm), Mn (0.0055 ppm) Fe, Mn, Fe- Mg, Mn-Mg and Fe- Mn – Mg. The magnitude of depression owing to Fe deficiency in dry matter, leaf iron, chlorophyll, starch, protein, RNA and the specific activities of catalase and per oxidase was mitigated, to variable extent, by the combined deficiencies of Fe-Mg, Fe-Mn and Fe-Mn- Mg. The depression in aldolase activity in iron deficiency became more pronounced by the combined deficiency of Fe- Mn and Fe-Mn-Mg. Hill activity per mg chlorophyll was least in Mn deficiency, its activity and those of Mg – ATPase and RNAase which were enhanced by Fe deficiency alone, were depressed by the combined deficiencies of Fe, Mn, Fe- Mg and Fe- Mn- Mg. In the latter two treatments and in Mg deficiency, the pyruate kinase activity was also depressed. (Agarwala, *et al.*, 1988).

Raj *et al.*, (1955) conducted an experiment with *Phalaris* aquatical under hydroponic conditions in the glasshouse at constant temperature of 250C and natural sun light. Plants were grown in double pot system with four sulfur and three molybdenum levels along with all major and micro nutrient elements. There was increase in growth, nitrate- reductase activity and contents of most of the nutrient elements at all levels of sulfur and 1.68ug/L molybdenum. Molybdenum at 3.36-ug/L level inhabited growth and nitrate-reductase activity and decreased concentration of nutrient elements in plant. The inhibitory effect of higher level of molybdenum is perhaps mediated through its role in the nitrate- reductase.

Pyrus communis L. trees were sprayed with different iron (Fe) compounds in an attempt to reduce a severe Fe chlorosis condition without causing unacceptable spray phytotoxicity to the fruit. All Fe material increased the Fe concentration in the leaves and fruit pell, and reduced Fe chlorosis by increasing the green color of the leaves and fruit. For both years, the Fe ligosulfonate spray resulted in greater fruit firmness than the controls and in the least amount of phytotoxicity to the fruit (acceptable). The residual effect of the sprays also resulted in greater shoot growth and fruit set than on the sprayed controls indicating a slight carry – over effect of the Fe sprays to the following year (Thomas and Donald, 1988).

The effect of zinc application and commercially available solution sample 3- a multi micronutrient product examined by Masud *et al.*, (1999) on the growth and yield of spring potato crop. On overall basis the micronutrients effect was good on yield and increase in yield variant 8.66 to 25%. A field experiment was conducted by Muhammad *et al.*, (2002) to study of the effect boron and zinc application on cotton (*Gossypium herbaceum* L.). Cultivars CIM-482 at central Cotton Research Institute, Multan. Application of zinc and boron improved the ratio of vegetative growth and increased Zn and B concentration in leaf tissues at flowering stage. Further more, the addition of 10.0kg Zn and 2.0kg B per hectare caused significant increases in seed cotton yield number of bolls per plant and boll weight fiber quality parameters did not differ significantly with the application of Zn and B. The higher concentration of B and Zn were observed in treatments receiving 2.0 kg B and 10.0kg Zn per hectare.

Porter (1993) reported that application of B results in 6.5% increase in the mean seed yield in Canola. At the onset of flowering plants sprayed with B had a 50% higher B concentration than plants receiving no. B. Seed yield increased and peaked at 135 kg N, decreased it higher N rates.

In a field experiment in (1999) irrigated sunflower were given 0-120kg N/ha with or without dusting or spraying with B (0.4%). Seed yield increased with up to 80 kg N. Seeds yield from the B treatment were d1.23,1.36 t/ha with no of boron dusting or spraying respectively. Seed oil content was decreased by N application and was not affected by B application (Rani and Reddy, 1993).

The application of NPK to lentil increased seed yield by 58% and yield was further increased when the trace elements were added. The highest seed yield of 5.11 ardab/feddon was obtained from the application of NPK+Zn + Fe +Mn+ Cu (Khalid and Khalifa)

Field experiments were conducted to assess the effect of different micronutrient on the growth trait of sugarcane variety Cp-65/357 (Ratoon crop) on silt loam soils at Sugarcane Crop Research Institute Mardan, Pakistan. It was observed that application of micro nutrients significantly affected all the growth traits of sugarcane variety CP-65/357, where as plant height, tops weight, cane length, internodes and length of internodes were significantly increased by the application of all the micronutrients over the control. The average plant height, tops weight, cane length, number of internodes and length of internodes of ratoon crop were maximized by the lowest rates of Zn and Cu. Furthermore data revealed of B and Mn increased all the growth traits in comparison to their lowest rates. (Jamaro, *et al.*, 2002).

The effect of essential trace elements on the growth of leaves, flowers and fruits yield components of *Solanum melongena* L. (egg plant) and *Capsicum annum* L. (Chili pepper) by foliar application was studied. In the treated plants the flowering and fruiting took place twenty days as compared to controls. The treated plants bore more fruits and their sizes were also bigger than those of the control series. The analysis of variance means reveals that in treated sets the growth factors was scientifically difference as compared with the control. (Askari *et al.*, 1995).

Saeed *et al.*, (2001) studied chlorophyll and carotenoids content of bean (*Phaseolus vulgaris* L.), and cucumber (*Cumis sativus* L.). Seedlings are influenced by different levels of boron (boric acid). Plants were grown hydroponicaly in nutrient solutions with and without boron. When seedlings were one month old, they were sampled for growth measurements and chloroplast pigments analysis. Shoot and leaf grown of both the species was significantly increased over control by boron supply. Chlorophyll a, b and total cartenoid contents were also enhanced in the presence of boron; however, the higher levels were not much better than the lower concentrations of boron. It appears that boron interaction at cell wall, plasma membrane inter face affect the uptake and transport of nutrients and thus play a role in improving the growth and pigment contents of crop plants.

Yang *et al.*,(1995) reported that the soil application of B to rape was shown to be superior to foliar application. Zn concentration in leaf blade and petiole increased youngest open leaves than youngest mature leaves during vegetative stage up to stem elongation YOL+2 leaf blades which are also YML are suitable for the diagnostic of Zn deficiency in Canola plant with critical Zn concentration being 7-8 mg Zn/kg DM.

In a green house experiment, Fe dust that has been collected for air pollution abatement by steel industry was evaluated to alleviate Fe chlorosis of *Sorghum* grown in Fe deficient calcareous soil. This by – product dust contained 43% Fe, 5% Zn and 2% Mn. Two sorghum cultivars, Fe- efficient and Fe- inefficient, were grown as test crops. The Fe by- product was mixed with the soil at 3 rates before planting as dust and as pelleted form. Similar treatments also were amended with H2SO4. As comparison treatments, H2SO4 alone also applied directly to the soil. The Fe concentration increased in plant tissue reflecting both the rate of applied Fe and the acid amendment. Pelleting the Fe dust reduced its effectiveness, likely due to reduced surface area of the Fe. The less response to be applied by the Fe – inefficient cultivar indicates the greater capability of the Fe- efficient cultivar to obtain sparingly soluble Fe from the soil. The Mn concentration in plants was depressed sharply by increased Fe rates and acid amendment, indicating Fe antagonism of Mn. The Zn concentration in plants increased significantly with added Fe by product material which incidentally supplied 5%Zn. (Anderson and Parkpian 1988).

Iron – containing fertilizers such as FeSo4, EDTA+ urea, Fe EDTA + super phosphate and a '' commercial product" (SD-807) containing N, Fe, Zn and Mn were applied to iron – chlorotic soybean leaves and the effects on regreening and reorganization of iron – chlorotic chloroplasts were studied. Fe- EDTA+ urea seemed most effective, but was in higher concentrations most likely to cause foliar injury. SD 807 had caused a lighter green than the other fertilizers. The recovered chloroplasts resembled chloroplast control plants, although they contained fewer thylakoids per granum than control chloroplasts, comparable with control chloroplasts. In more pronounced iron deficiency, when leaf color appeared to be yellow- white, chloroplasts displayed severe disintegration. In such cases it was not possible to achieve regreening by foliar fertilization (Hetch *et al.,* 1986).

Micronutrient levels in corn indicated no deficiency of Zn, Cu, Fe and Mn in the various soils despite the matter having found responsive to the micronutrient fertilization in wheat, expected to be deficient in the different micronutrients. Corn was grown with 10 ppm of Zn and Cu in pots containing 4.5kg each of the 23 soils taken from those areas to know their response and suitability of some extractions for measuring available Zn and Cu in soils. Dry weight result showed that corn was not that much responsive to Cu as to Zn. Concentration of Zn in plants, grown without Zn, ranged from 13-15 ppm which increased to 2-3 times with Zn application while that of Cu, with or without Cu application varied from 8-14 ppm falling within the adequate range (4-20ppm) of Cu. Both showed a depressive effect on the uptake of each other. Correlation between soil Zn extracted by various extractants and plants Zn uptake was highly significant. Soil available Zn and plants dry weights had no significant negative correlation (Tahir *et al.,* 1982).

Pot experiments were conducted to study the response of tomato (*Lycopersicon esculentum* Mill) seedlings, grown on both alluvial and calcareous soils, to Fe/ Zn combinations applied with different rates of P. Dry matter yields and total Fe and Zn uptake increased with P applications. Iron concentrations of plants increased only slightly while Zn concentration decreased when the same P treatments were applied (Ismil *et al.*).

Chaudhary F.M (1978) investigated that the response of rice and wheat to the application of CuSo4 on several alkaline calcareous soils. It was observed that the amounts of Cu extracted from the soils by four chemical methods were correlated with that taken up by the plants. None of the four methods used could predict Cu availability for rice plants. The amount of Cu extracted by DTPA (diethylenetriamine pentacetic acid) and NH4OAc had little positive correlation coefficient either with concentration or total contents of Cu in plants. The Hcl and EDTA methods significantly correlated soil – extractable Cu with plant Cu but the correlation coefficient was small and, therefore, not useful as a soil test for Cu. None of these methods could distinguish Cu deficiency from non deficient soils. The DTPA and NH4O Ac procedures adequately predicted Cu availability to wheat plants. The revalue of both the methods with total Cu contents in plants was 0.70. The value improved to 0.84 when Cu concentration in plants was considered. The critical concentration of available soil Cu by the two methods of about 0.8 and 0.4 ppm respectively. The chemical changes associated with flooding of rice soils which strongly effect Cu absorption by plants seem to be responsible for poor relationship between Cu extracted by various methods from dry soils and that taken up by submerged rice plants.

A soil incubation study with two alkaline calcareous soils of varying texture was conducted by Hussain and Rashid (1977) to find out the influence of salinity an Zn application on the extractability of Zn, Cu, Fe and Mn by DTPA(diethylenetriamine pentacetic acid) soil test method. There was not very much effect of salinity on the extractable metals expects that Mn in light textured soil showed marked increase at the highest salinity level, while Fe in heavy textured soil showed a steady decrease with increasing salinity. The strong inhibition of saline salts on micronutrient absorption by plant roots, however, indicate that under both soil situations, the net effect of salinity will lead towards metals studied expect that Fe showed a minor decrease in soil.

Surface soil samples collected from Swat, Dir and Malakand Agency of N.W.F.P analyzed by Mahmood *et al.*, (1986) for total and available (DTPA extractable) contents of Zn, Fe, Mn, Cu,. The micronutrient content was correlated with the soil parameters of pH. Organic matter and calcium carbonate contents. The available amounts of Fe, Mn and Cu were well above sufficiency levels for optimum crop production where as the available Zn varied from deficient to sufficient, 12% of the samples were deficient while another 33% were marginal in Zn. A highly significant positive correlation existed between the Zn and organic matter contents calcium carbonate appeared to have a dominant negative influence on Fe, but a positive influence on Mn. Expect for Zn, the total content of micro- nutrients did not correlate significantly with their available content.

The absorption of 99- Mo by excised tobacco, *Nicotina tobacum*- L. c.v.KY-D14 roots was examined by Jablonski *et al.*, (1985). The results showed that lower temperature, anaerobic conditions and various inhibitors of oxidative phosphorylation decreased the absorption of Mo, suggesting that the absorption of Mo was metabolism dependent. Similar results were obtained with the absorption of 86-Rb. The absorption of 99-Mo decreased exponentially with an increase in pH. The apparent Km for the sub absorption of ht Mo was 15Um, although at high concentrations of Mo, the absorption of Mo occurs primarily by passive process.

Foliar application of boron as boric acid at different concentrations in soybean (*Glycine max* L.) grown in sandy loam soil revealed an increased of leaves, number of branches, leaf area per plant, a and b (mg g-1 fresh weight) at different growth stages. A sharp decline in flowers drop was recorded through foliar application of boron @ 50.0mg L1. Reductions in total leaf area plant-1 and content (fresh weight) were noted at higher concentration (100mg L-1) of boron. Yield attributes are; total dry matter production, flower drop percent, pod set plant-1, length of pod, number of seed plant-1 and test weight of 100 seeds were fond to be maximum in case of plants applied with boron @ 50 mg L- (Garg, *et al.*, 1999).

Growth and yield responses of chill pepper (*Capsicum annum* L.) to four Fe levels were studied under sand culture by Anchondo *et al.*, (2002). A balanced nutrient solution was recirculated continuously to plants potted in acid- washed sand from the seedling stage to red fruit harvest. Plants received 1, 3, 10 and 30 uM Fe as ferric ethylenediamine di (0-hydroxyphenyl- acetate). Low Fe (1 or 3 uM Fe) in the nutrient solution was associated with lower relative growth rates (RGR), increased, specific leaf area, and higher root to shoot ratio (3 uM Fe plants only) at final harvest. High Fe levels (10 or 30 Fe) in the nutrient solution were associated with an increased yield of red fruit and total plant dry matter, RGR of low- Fe young chill plants was reduced before any chlorotic symptoms appeared.

The effect of two foliar sea weed – spray, micronutrient application (21 1b/ha F503 or no micronutrients), and two N and K on Agriest 761 tomato yields investigated by Csizinszky (1994). In the first harvest, marketable fruit yield was higher with the water sprayed control than with seaweed sprays, and extra large fruit yield was higher with residual than with added micronutrients. Seasonal total yields of extra large and marketable were greater with 261 1b N and 434 1b K/ha than with 171 1b N and 289 1b K/ha. Plants treated with 112ft sea weed concentrate/ acre at the higher N+K rate had a higher marketable yield for the season than plants sprayed with seaweed concentrates or water at the lower N=K rate. Seaweed sprays had no significant effect on nutrient uptake. Elemental concentrations in fruits were not affected by sea weed spray, or by micronutrient, N or K rates. Residual concentration of K in soil was higher at the higher than the lower rate.

Irrigation dynamics and the response of tomatoes cv. Caruso to different irrigation management treatments that is nutrient solution EC and irrigation matric potential set points were examined in plants grown in peat- based sub rate. Yield measurements indicated no significant effects due to different SMP set points, but the total yield average marketable fruit weight were higher for spring- grown plants under low – EC solution treatments. Foliar mineral concentration analysis of spring – plants indicated increases in nitrogen, potassium, zinc and manganese, and decrease in calcium in plants receiving high – EC solution. The study indicates that increasing nutrient solution EC from 1.5 to 3.0 dS m-1 can negatively affect the production and nutritional status of tomato plants more than changing irrigation set points from 4.5 to 6.5 Pa. (Norrie *et al.*, 1995).

The effects of foliar application of micronutrients (Zn, Mn, Fe and /B), applied 30 days after transplanting, on growth, yield and quality of tomatoes cv. *Pusa Ruby* was investigated by Bose and Tripathi (1996). The best growth (plant height of 81.56cm, highest number of branches / plant (19), highest number of fruits per plant (31.9) and highest yield/ plant (1.407kg) was observed after combined applications of micronutrients. This treatment reduced fruit cracking from 16.5 %(control) to 4.76%, low fruit cracking (5.3%) was also observed in plants sprayed with B alone.

In experiments 1992-93, plants of tomato cv. Marutham (Co-3) were potted in an inceptisol (calcareous mixed black soil, sandy clay loam, deficient in Fe and Zn) or alfisol (non – calcareous mixed black soil, clay loam, deficient in Zn and Cu) and supplied with NPK alone, NPK+micronutrients(soil or foliar application of straight micronutrients or Starnes micro food), NPK+ micronutrients+ compsted coir pith (CCP), or NPK+micronutrients +CCP+ biofertilizer (Azospirillum). In all, 14 treatments including a control (no fertilizers) were tested. Foliar (inceptisol) or soil (alisol) application of micronutrients, with or without CCp and biofertilizer, increased the quality of tomato fruits, with respect to total sugars, reducing sugars, non- reducing sugars, ascorbic acid content, total soluble solids, acidity and lycopene content. The failure of soil micro food applications to increase the quality of tomato fruits in the inceptisol was attributed to fixation of most of the applied Zn and Fe in the presence of a large amount of available P. (Selvi *et al.*, 1997).

Salinity either of soil or of irrigation water causes disturbance in plant growth and nutrient balance. Previous work indicates that applying nutrients as foliar application increases tolerance to salinity in cereals and leguminous plants. A pot experiment was carried out to study the effect of micronutrient foliar application on salt tolerance of tomato. Seedling were sprayed with micro nutrient mixture (Wuxal 1.5 ml l-1) containing Fe, Mn and Zn were irrigated with saline water containing different Nacl concentrations. Salinity adversely affected growth as (dry weight) and nutrient uptake. Spraying micronutrients could restore the negative effect of salinity on dry weight. Effect of salinity on nutrient uptake could also be partially counteracted by spraying micronutrients (El- Fouly *et al., 2002*).

The level of DTPA- extractable Cu determined by Kaplan (1999) in 210 soils (0-20 and 20-40 cm depth) and 105 leaf samples obtained from 105 tomato green houses.

The DTPA- extractable Cu contents of the soils taken from the 0-20 depth ranged between 0.76 and 88.3 mg / kg (mean 7.79 mg/kg). The percentage of soils containing DTPA- extractable Cu greater than the critical toxicity level (20 mg/kg was 8.1). The Cu content of tomato leaf samples ranged between 2.4 and 1490 mg/ kg mean 166.5 mg/ kg). The Cu concentration in leaf samples was very high due to the intensive use of foliar applied Cu- containing chemicals. As a consequence, 24.8% of the leaf tomato samples analysed contained over 200 mg Cu/kg, the maximum accepted tolerance level. It was concluded that it might be necessary to reduce the use of Cu – containing pesticides and fertilizers, or at least reduce the amount of Cu- containing fertilizers being used in those greenhouse where Cu – containing pesticides have been or being used.

Yadav *et al.,* (2001) conducted experiments to evaluate the effects of different concentrations of zinc and boron on the vegetative growth, flowering and fruiting of tomato. The treatments comprised five levels of zinc (0,2.5, 5.0, 7.50 and 10.0 ppm) and four levels of boron (0, 0.50, 0.75 and 1.00 ppm) as soil application, as well as 0.5% zinc and 0.3% boron as foliar application. The highest values for secondary branches, leaf area, total chlorophyll content, fresh weight, fruit length, fruit breath and fruit number were obtained with the application of 7.5 ppm zinc and 1.0 ppm.

Rodriguez *et al.,* (2000) studied the effects of foliar chemical treatments on the productivity recovery of green house- grown sweet pepper (*C. annum*) at low temperature. The treatments evaluated were: control (without treatment); SN (nutrient solution of N, P, K, Zn, Co, Mn, B, Mo and NAA); SNS (SN+sucrose); and SNSL (SNS+ commercial beer yeast). SNSL exhibited the highest productivity recovery of sweet pepper, which allowed a relative increase of 19% in fresh fruit weight an 45% in the total fruit number.

The efficiency of foliar sprays with compost water extracts (compost extracts) in reducing the severity of tomato bacterial spot caused by *Xanthomonos vesicatoria* was investigated by Dahmani *et al.,* (2003). Foliar sprays with a mixture of chlorothalonil and copper hydroxide or with acibenzolar – S- methyl reduced the severity of bacterial spot and the incidence of spot on the fruit.

Davis *et al.,* (2003) reported that boron deficiency in fresh- market tomatoes (*Lycopersicum esculentum*) is wide spread problem that reduces yield and quality but is often not recognized by growers. Regardless of the application method, boron was associated increased tomato growth and concentration of K, Ca and B in plants tissues. Boron application was associated with increased N uptake by tomato in field culture, but not under hydroponic culture. In field culture, foliar- and /or soil- applied B similarly increased fresh- market tomato plant root dry weight, uptake, and tissue concentration of N, Ca, K and B improved fruit set, total yields, marketable yields, fruit shelf life and fruit firmness. The similar growth and yield responses of tomato to foliar an root B application suggests that B is translocated in the phloem in tomatoes. Fruits from plants receiving foliar- or root – applied B contained more B, and K than fruits from plants not receiving B, indicating that B was translocated from leaves to fruits and is an important factor in management of K nutrition in tomato.

Macias *et al.,* (1996) conducted an experiment on control of bacterial speck (*Pseudomonos syringae* cv. Tomato). Seed treatment with BZM (an experimental mixture of several inorganic compounds). Germination of seed and their emergence were not affected. Champion 50WP (copper hydroxide), Miedzian 50 WG (copper oxychloride) and Agrovital DNO (foliar fertilzer) were highly effective in controlling bacterial speck of tomato. The activity of others chemicals (mancozeb and chlorothalonil) were not effective.

Jaiswal *et al.,* (1997) conducted a pre production verification trial on spring season tomatoes at 3 sites in Nepal to compare the performance of cultivars Monoprecos and CH-154 growing with or without 5 ml of Multiplex (micronutrients) / litre of water. Irrespective of the use of Multiplex, CH-154 was 13 and 7 days earlier at producing marketable fruits than Monoprecos at Daubes Kukule, respectively. Cultivar effect on marketable yield was significant at 2 sites where, irrespective of Multiplex use, CH-154 out yielded Monprecos by 30% at Dhanubase, and Monoprecos yielded 5.5- times more fruits than CH-154 at Kudule. The effect of Multiplex on marketable fruit yield was significant only at Kholakhet, where irrespective of cultivar, Multiplex use increased marketable fruit yield by 25% compared with control.

Tomato cultivars Naveen and Co. 3 were planted in planted in pots with boron – deficient calcareous soil. Boron was applied Borax at 10, 20 and 30kg/ ha, 0.1, 0.2 and 0.3% foliar sprays or boranated super phosphate. Soil treatment with 30 kg Borax / ha resulted in highest N contents in roots and shoots. The 0.3% foliar spray resulted in the highest P, Mg and K contents. Ca content increased with increasing boron levels (Prabha *et al.*, 1996).

Patnaik *et al.*, (2002) conducted field experiments to determine the effect of Zn and Fe on yield and quality of tomato cv. Marutham. The treatments comprised a control, soil application of 12.5 and 25 kg $ZnSo_4$ / ha, soil application 12.5 kg ZnSO4 / ha+ foliar spray of 0.2% ZnSO4 (thrice at weekly interval), soil application 12.5 kg ZnSO4/ha+ 0.5%FeSo4 spray (thrice at weekly interval), and soil application of 12.5kg ZnSO4 /ha along with sprays of 0.2% ZnSO4+ 0.5% FeSO4. Among the treatments, soil application of 12.5kg ZnSO4/ ha, followed by foliar sprays of 0.2% ZnSO4 and 0.5% FeSO4 thrice at weekly interval resulted in the highest fruit yield of 39.88t/ha with a maximum yield response of 39%. The Zn and Fe contents in index leaves of tomato were in range of 1d 8.5 – 273 mg/ kg and 116-110kg, respectively. The nutrients in index leaves were higher in the treatment where Zn and Fe were applied either through soil or through foliar spray. A similar trend was observed in fruits when Zn and Fe were sprayed along with soil application. In general, Zn and Fe contents were less in fruits (14.1- 17.6 mg/ kg) compared to leaves (37.2 – 72.7 mg/kg). The highest uptake of Zn and Fe was recorded with 12.5 kg ZnSO4 soil application along with 0.2% ZnSo4 and 0.5% Fe So4 sprays.

Irrigation and N fertilization are important aspects of bell pepper. Bell peppers were grown on bare ground in Alabama, USA, at N rates of 11 or 19 kgN/ week and irrigated according to irrigation scheduling model based on weather data and crop age. Yield response and the foliar content of all essential elements determined (N, P, K, Ca, Mg, B, Cu, Fe, Mo, Mn and Zn) responded linearly or quadratically to irrigations rates and most foliar nutrients contents remained within or above the sufficiency range. Foliar mineral content tended to be lower at 84 DAT. Current fertilization recommendations for bell pepper and 100% of the model irrigation rate resulted in highest yield (Simonne *et al.*, 1998).

Chapter No: 3

Materials and Methods

A series of experiments were designed and conducted at plant physiology Lab. Department of Biological Sciences, Quaid-i-Azam University, Islamabad to observe and evaluate the effects of different micronutrients through soil and foliar application on the growth and yield and production of *Hibiscus esculentus.*

3.1 Research materials and growing conditions:-

Certified seeds of *Hibiscus esculentus* variety of sabaz pari were brought from the National Agriculture Research Centre Islamabad (NARC). The seeds were grown in the plot in the university.

The chemicals used in this study were of the highest grade of purity, purchased from Sigma Chemical Co. U.S.A. and E. Merck of Germany.

The experimental work was carried out in the plot at university during the month of July 2005 Novemember 2005 in the open field.

All the material and glassware (beakers, flasks, Petri dishes, graduated cylinder and pipettes) used in the experimental work was washed with detergents and dried in oven for further use.

Soil Selection & Preparation

Soil was collected from the University Campus. All pebbles and stones were removed from the soils. It was thourghly mixed to achieve physical and chemical uniformity . Representative random samples were taken out for physical and chemical analysis of soil.

3.2 Soil Analysis

Soil was analyzed at Department of Soils Sciences, National Agriculture and Research Centre (NARC), Islamabad. Physical and chemical nature of the soil was analyzed. Chemical analysis of soil samples was conducted at Land Resources Research Institute, NARC.

(1) Physical Analysis

Texture method was used for the physical analysis of soil. Soil texture was determined by Bouycous hydrometer method (Bouycous, 1962).

(2) Chemical Analysis

The nitrogen was analyzed by Kjeldahl method. Ammonium bicarbonate – Diethylen triamin penta acetic acid (AB-DTPA) method was used to analyze both phosphorous and potassium (Soltanpour , 1985). Concentration of micronutrients was determined on Atomic Absorption , employing DTPA extraction method .

Seed sowing & Transplantation

Healthy seeds of *Hibiscus esculentus* (Lady Finger) with uniform size were randomly selected for experimental work. These seeds were sown in the field during the Month of July 2005.

3.3 Micronutrient Used

Six micronutrients that is Boron (B) Copper (Cu), Iron (Fe), Manganese (Mn), Molybdenum (Mo), and Zinc (Zn) were used during the present study. The micronutrients were used in the form as below.

1. Boron (B) H_3BO_3 (15%), (17%), (19%) respectively as three sprays.

2. Copper (Cu) $CuSO_4 .5H_2O$ (23%), (25%), (27%) respectively.

3. Iron (Fe) $FeSO_4$ (18%), (20%), (22%) respectively.

4. Manganese (Mn) $MnSO_4.4H_2O$ (22%), (24%), (26%) respectively.

5. Molybdenum (Mo) $Na_2MoO_4.2H_2O$ (37%), (39%), (41%) respectively.

6. Zinc (Zn) $ZnSo_4.H_2O$ (34%), (36%), (38%) respectively.

3.4 Micronutrients Concentrations Used

The following micronutrients concentration of Fe, Zn, Cu, B, Mn and Mo were prepared and used singly for soil, soil plus foliar and for foliar application to observe the growth and yield in *Hibiscus esculentus*.

The three times spray of each micronutrient at three different concentrations.

1. Iron (Fe) 1st concentration 500 ppm, 2nd concentration 1000 ppm, 3rd concentration 1500 ppm.
2. Boron (B) 1ST concentration 50 ppm, 2nd concentration 100 ppm, 3rd concentration 150 ppm.
3. Copper (Cu) 1st concentration 10 ppm, 2nd concentration 20 ppm, 3rd concentration 40 ppm.
4. Manganese (Mn) 1st concentration 50 ppm, 2nd concentration 100ppm, 3rd concentration 150 ppm.
5. Molybdenum (Mo) 1st concentration 20 ppm, 2nd concentration 40 ppm, 3rd concentration 60 ppm.
6. Zinc (Zn) 1st concentration 50 ppm, 2nd concentration 100ppm, 3rd concentration 150 ppm.

The micronutrients were used in three times spray at different percentages.

Table 4. Micronutrients used for soil, foliar and foliar soil application.

Sr	Micronutrients used	Source	%age			C_1 ppm	C_2 ppm	C_3 ppm
1	Iron (Fe)	$FeSO_4.7H_2O$	16	18	20	500	1000	1500
2	Copper (Cu)	$CuSO_45H_2O$	21	23	25	10	20	30
3	Zinc (Zn)	$ZnSO_4.H_2O$	32	34	36	50	100	150
4	Boron (B)	HBO_3	15	17	19	50	100	150
5	Molybdenum (Mo)	$Na2MO_4.2H_2O$	20	25	30	20	40	60
6	Manganese (Mn)	$MnSO_4.4H_2O$	20	22	24	50	100	150

3.5 Strategy For Micronutrients Application

Vegetative stage (t_1):-

C_1 of each micronutrient was applied after 20 days of transplantation date followed by applications of after 15 days of interval.

Flowering stage (t_2):-

C_2 of each micronutrient was applied after 40 days of transplantation date, followed by 3 applications after 15 days of interval.

Flowering plus fruit stage (t_3):-

C_3 of each micronutrient was applied after 60 days of transplantation date followed by 3 applications after 5 days interval.

Preparation of the Stock solution

Different concentrations of (C_1, C_2 and C_3) of micronutrients (Fe, Cu, Zn, B, Mn and Mo) were prepared by calculating the weight of each micronutrient. Calculated weight of each micronutrient was dissolved in distilled water and stirred it on magnetic stirrer and final volume made up to volume required .

pH: Spray – solution pH maintained at 7. If the pH adjustment was required , vinegar was used to acidity and backing soda to decrease it .

3.6 Treatment Applied

Micronutrient applied singly on the *Hibiscus esculentus*. The plant received following treatments:

I. Foliar Treatment (T_1):-

C_1, C_2, C_3, of each micronutrient were sprayed singly on the foliage of plants after the interval of 15 days. Ladyfinger plants received the following foliar treatments.

$T_1t_1\ FeC_1$, $T_1t_2Fe\ C_2$, $T_1t_3\ FeC_3$, $T_1t_1CuC_1$, $T_1t_2CuC_2$, $T_1t_3\ CuC_3$, $T_1t_1ZnC_1$ $T_1t_2ZnC_2$, $T_1t_3ZnC_3$, $T_1t_1BC_1$, $T_1t_2BC_2$, $T_1t_3BC_3$, $T_1t_1MnC_1$, $T_1t_1MnC_2$, $T_1t_3MnC_3$, $T_1t_1MoC_1$, $T_1t_2MoC_2$, $T_1t_3MoC_3$.

II. Foliar + Soil treatments (T_2):-

C_1 of each micronutrient were applied in the soil one time during the experiment and then micronutrients were sprayed on the foliage of plants after the interval of 15 days. The lady finger plant received the following soil plus foliar treatments .

$T_1t_1FeC_1$, $T_2t_1BC_1$, $T_2t_1ZnC_1$, $T_2t_1CuC_1$, $T_2t_1MnC_2$, $T_2t_2MoC_1$.

III. Soil Treatment (T_3):-

C_1 of each micronutrient were applied in the soil only one time during the experiment. The following soil treatments were received by the lady finger during the experiment .

$T_3t_1FeC_1$, $T_3t_1BC_1$, $T_3t_1ZnC_1$, $T_3t_1CuC_1$, $T_3t_1MnC_1$, $T_3t_1MoC_1$.

IV. Control Treatment (T_0):-

One set of plants was kept as control and sprayed with equivalent quantity of distilled water $T_0t_0C_0$.

Amount of micronutrient solution applied on plot.

For foliar application 2 litres of solution of micronutrient was sprayed on the plot during one spray. The spray on the ladyfinger was used thrice. Manual sprayer was used for this purpose.

Irrigation

The plot was irrigated three times a week after 10 days of sowing the seeds in the plot. Weeding was done regularly to keep the plants free from weeds. But some plants weeding not had done to see effect on the yield.

Harvesting

The lady finger was harvested on 10 November 2005. Data for yield and productivity was collected and recorded. This data includes shoot length , fresh shoot weight , dry shoot weight , number of branches per plant, number of leaf per plant , number of flower per plant , number of fruit per plant , size of fruit per plant .

3.7 Observation and Data Collections:-

The aim and objective of the study was to observe the effects of micronutrient application on the growth and yield of Ladyfinger by Foliar, Soil and Soil plus Foliar treatments. Observation and data was collected at the end of experiments on 10 November 2005.Three plants from each replicate per treatment per experiment were tested for each analysis and their mean was taken. The data and the parameters used were:

3.8 Parameters studied

Following parameters were studied /measured during the research project.

1- Shoot length
2- Fresh shoot weight
3- Dry shoot weight
4- Number of branches per plant
5- Number of leaf per plant
6- Leaf size
7- Number of flower per plant
8- Number of fruit per plant
9- Size of fruit per plant

Shoot length

Shoot length was measured with graduated meter rod in centimeters. Data for shoot length was collected from three individual plants within a plot and their mean was taken, this was mean single replicate. Then mean for each treatment was taken by taking mean of three replicates.

Number of branches

Number of branches per plant was counted and recorded. Data for number of branches was collected from three individual plants with in plot and their mean was taken, this was mean of a single replicate. Then mean for each treatment was taken by taking mean of three replicates.

Number of Floral Branches

Number of floral Branches per plant were counted and recorded. Data for number of floral braches was collected from three individual plants with a pot and their mean was taken, this was mean of a single. Then mean for each treatment was taken by taking mean three replicates.

Number of Leaves

Number of leaves per plant were counted and recorded. Data for number of leaves was collected from three individual plants withen a pot and their mean was taken, this was mean of a single replicate. Then mean for each treatment was taken by taking mean of three replicates.

Fresh Weight

Fresh weight was calculated by taken plants from the plot, washed the plants and weights it on electrical weight balance in grams. Fresh weight was taken from whole plant including flowers Data for fresh weight was taken from three individuals plants from the plot, this was mean of a single replicate .Then mean for each treatment was taken by taking mean of three replicate.

Dry weight

After recording fresh weight, the plants were kept in room for 12 days to get dry weight. Dry weight was taken from whole plant including dried flowers. Data for dry weight was taken from three individual plants. Then the mean for each treatment was taken by taking mean of three replicate.

Number of Fruits

Fruits per plant were counted and recorded. Data for number of flowers was collected from three individual plants from plot and their mean was taken, this was mean of a single replicate. Then the mean for each treatment was taken by taking mean of three replicates.

Fruits Length

Fruits length was measured with scale in centimeters. Data for fruits length was collected from three individual plants from plot and their mean was taken, this was mean of single replicate. Mean for each treatment was taken, this was mean of a single replicate. Then the mean for each treatment was taken by taking of three replicates.

3.9 Statistical Analysis

Experiment was conducted in plot at campus to design with three replication per treatment. The data for all parameters were taken and mean values at average were taken. The values taken from all treatments to each parameters and the data feeded to Microsoft Excel and get Chart for each parameter.

Chapter No: 4

RESULTS

4.1 Soil Analysis

Soil used in the present research work was analyzed physically and chemically. Bouycous hydrometer method was used to analyze the texture of soil. The results of physical soil analysis showed that the soil used in present experiment was sandy loamy in texture. Soil samples were analyzed for major and micronutrients by ammonium bicarbonate diethylene triamine penta acetic acid. Results showed that the Nitrogen and Phosphorous were deficient while Potassium was medium. Among the micronutrient copper was deficient, zinc & iron medium while manganese was high. The present values were compared to the standard values (Soltanpour, 1985) for different soil nutrients. Soil pH value, concentration of $CaCo_3$, soil organic matter and Electrical conductivity (EC) was also recorded. The results showed that soil used during the present studies was alkaline, Calcareous in nature and sandy loam in texture.

Table 4.1a: Physical and chemical characteristics of soil

Determination	Value	unit
Sand	53	%
Silt	38	%
Clay	09	%
Textural class	Sandy loam	-
pH	8.05	-
Saturation percentage	25	-
Ece	0.21	Dsm^{-1}
Organic matter	0.45	%
$CaCo_3$	6.30	$mgKg^{-1}$
N	8.04	$mgKg^{-1}$
P	6.3o	$mgKg^{-1}$
Zn	1.5	$mgKg^{-1}$
Cu	1.30	$mgKg^{-1}$
Mn	19	$mgKg^{-1}$
Fe	4.48	$mgKg^{-1}$

Table 4.1b Standard Values of Nutrients in the Soil Sample (Soltanpour, 1985)

Sr #	Elements	Low	Medium	High
1	N	<10.00	11-20	21-30
2	P	< 03.00	04-07	08
3	K	< 60.00	61-120	121-80
4	Zn	< 00.90	1.0-1.5	> 1.5
5	Fe	< 03.30	3.1-5.0	> 5.0
6	Cu	< 00.20	03-05	> 0.5
7	Mn	< 00.50	0.6-1.0	> 1.0

4.2 Iron

The data showing effects of iron on various study parameters of ladyfinger are represented in table 4.2 a.

Shoot length

The data in table (4.2a) shows that all the treatments differs significantly from the control (T_0 t_0 C_0), the maximum shoot length (35.40cm) was obtained in case of $T_1t_1FeC_1$while minimum shoot length was obtained in case of control .There is no significant difference between treatments ($T_1t_1FeC_1$ and $T_2t_1FeC_1$) and ($T_1t_1FeC_1$ and $T_1t_3FeC_3$). However, $T_1t_1FeC_1$ and $T_2t_1FeC_1$ differ significantly from $T_3t_1FeC_1$. Similarly there is no significant difference between $T_1t_1FeC_1$ and $T_1t_3FeC_3$.

Shoot Fresh Weight

The data 4.2a shows that, maximum shoot fresh weight (40.65g) was obtained when $T_3T_1FeC_1$ was applied while minimum shoot fresh weight (20.43gms) obtained in case of T_0 t_0 C_0. There is no significant difference between ($T_1t_1FeC_1$ and $T_2t_1FeC_1$). There is significant difference between treatment ($T_1t_1FeC_1$ and $T_3t_1C_1$) and ($T_3T_1FeC_1$and $T_1t_2FeC_2$,).

Shoot Dry Weight

The data 4.2a showed that maximum shoot dry weight was obtained (9.122 g) in case of $T_3T_1FeC_1$, while minimum shoot dry weight obtained in case of $T_1t_3FeC_3$.There is no significant difference between $T_1t_1FeC_1$, $T_2t_1FeC_1$ and $T_3T_1FeC_1$. Similarly the treatment $T_1t_2FeC_2$, $T_1t_3FeC_3$ and did not attain the level of significance.

Number of Secondary Branches per Plant

Table 4.2a showed that there was significant difference between the treatments. All the treatments gave approximately similar results.

Number of leaf per Plant

The table 4.2a showed that the foliar treatment $T_1t_2FeC_2$, yielded maximum number of leaves (19.33), (23.20) and (30.05) respectively per plant. The comparison between the treatments revealed that there was significant difference between treatments

($T_1t_1FeC_1$ and $T_2t_1FeC_1$) and ($T_1t_1FeC_1$, $T_1t_2FeC_2$ and $T_1t_3FeC_3$), however, differed significantly from $T_3T_1FeC_1$ and $T_0t_0FeC_0$.

Leaf area Index

This is clear from the table 4.2b that maximum leaf area (105.10mm) was obtained in case of treatment $T_2t_1FeC_1$, while minimium leaf area 48.40mm) was recorded when treatment $T_3T_1FeC_1$ was applied. There is no significant difference among $T_1t_1FeC_1$, $T_1t_2C_2$, and $T_3T_1FeC_1$ and $T_0t_0FeC_0$. Similarly treatment $T_2t_1FeC_1$ and $T_1t_3FeC_3$ did not differ significantly.

Number of Floral Branches

Results showed in table 4.2a that maximum number of floral branches (10.00 per plant) was recorded for $T_2t_1FeC_1$ and $T_1t_3FeC_3$ and differed significantly from $T_0t_0FeC_0$ which gave minimum (5 per plant). The treatment $T_1t_1FeC_1$, $T_3T_1FeC_1$, $T_1t_2FeC_2$, and $T_1t_3FeC_3$ did not show any significant difference when compared with each other.

Number of Fruits per Plant

Table 4.2a shows that treatment $T_1t_1FeC_1$ & $T_2t_1FeC_1$ gave maximum number of fruits (8.33) while $T_3T_1FeC_1$ and $T_0t_0FeC_0$ gave minimum number (3.00) of fruit per plant. The treatments $T_1t_1FeC_1$ & $T_2t_1FeC_1$ differ significantly from rest of the treatment. There is no significant difference between $T_3T_1FeC_1$, $T_1t_2FeC_2$ and $T_1t_3FeC_3$ and $T_0t_0FeC_0$.

Fruit length

The maximum fruit length (6 inches) was obtained during the spray of iron on the lady finger. 3 to 5 inches fruit length was obtained in second spray.

4.3 Boron

The data showing effect of boron application on various studied parameters of ladyfinger are represented in table 4.3a.

Shoot Length

Table 4.3a showed that the maximum shoot length (40.16cm) obtained in case of $T_1t_2BC_2$ while minimum shoot length (20.50cm) was obtained in case of control

($T_0t_0BC_0$). The comparison between treatments showed that $T_1t_2BC_2$is highly significant. There is no significant difference between $T_1t_1BC_1$, $T_2t_1BC_1$ & $T_3t_1BC_1$. $T_1t_2BC_2$ highly significantly differ from $T_1t_1BC_1$& $T_1t_3BC_3$.

Shoot Fresh Weight

Table 4.3a for showed that maximum shoot fresh weight (33.00g) was obtained in case of $T_1t_2BC_2$, while minimum shoot fresh weight (15 g).was obtained in case of $T_1t_1BC_1$. There is no significant between $T_1t_1BC_1$, $T_2t_1BC_1$, and $T_3t_1BC_1$& $T_0t_0BC_0$ only treatment $T_1t_2BC_2$ & $T_1t_3BC_3$ differ significantly from rest of the treatments.

Shoot Dry Weight

Table (4.3a) showed that maximum shoot dry weight (5.3grams) was obtained in case of $T_1t_2BC_2$while minimum shoot dry weight (4.3g) was obtained in case of $T_0t_0BC_0$.The comparison among treatment indicated that there is no significant except $T_1t_2BC_2$.

Number of Secondary Branches

Table 4.3a showed that all the treatment similar results so did not differ significantly. The number of secondary branch is high during the treatment of boron .Maximum number of secondary branches (5.00 g) per plant and differ significantly from ($T_3t_1BC_1$, $T_1t_2BC_2$, $T_1t_3BC_3$ & $T_0t_0BC_0$) treatments. The treatment $T_3t_1BC_1$& $T_0t_0BC_0$ produced the minimum number of secondary branches (2.00 per plant).

Number of Leaf per plant

The maximum number of leaves (15.00 per plant) was obtained in case of control while minimum number of leaves (6.00 per plant) was recorded in case of $T_1t_3BC_3$. A comparison between the treatments showed that there is no significant difference between ($T_1t_1BC_1$, $T_2t_1BC_1$, & $T_3t_1BC_1$) and ($T_1t_1BC_1$& $T_0t_0BC_0$) Table (4.3a).

Number of Floral Branches per Plant

The maximum number of floral braches (3.667 per plant) was recorded in treatment $T_1t_2BC_2$, while minimum number of floral branches (2.00 per plant) recoded in $T_3t_1BC_1$. there is significant difference between treatments $T_1t_1BC_1$& $T_3t_1BC_1$ and between treatments ($T_1t_1BC_1$ and $T_1t_2BC_2$). There is no significance between ($T_1t_1BC_1$and $T_2t_1BC_1$) and ($T_1t_2BC_2$ and $T_1t_3BC_3$).

Number of Fruits per Plant

In Ladyfinger (table 4.3a) maximum number of fruits (6.33 per plant) was recorded in case of $T_1t_3BC_3$ while minimum number of fruits (3.15 per plant) was recorded in case of. There is no significant difference among the treatments except $T_1t_1BC_1$.

Fruit Length

The treatment $T_1t_1BC_1$gave maximum fruit length (7.33 cm) while treatment $T_1t_3BC_3$ & $T_0t_0BC_0$ gave minimum fruit length (4.667 cm).Treatment $T_1t_1BC_1$ and $T_2t_1BC_1$ differ significantly, similarly treatments $T_1t_1BC_1$significantly differ from $T_2t_1BC_1$, $T_3t_1BC_1$, $T_1t_2BC_2$ and $T_1t_3BC_3$ (Table 4.3a).

4.4 Zinc

The data showing effect of zinc application on various study parameters of ladyfinger are represented in table 4.4 a.

Shoot Length

Table 4.4 a showed that the maximum shoot length (31.0 cm) obtained in case of $T_1t_1ZnC_1$ .while minimum shoot length (18.67 cm) was obtained in case of $T_3t_1ZnC_1$. The comparison among the treatments showed that $T_1t_1ZnC_1$ significantly differ from $T_3t_1ZnC_1$ & $T_0t_0ZnC_0$. There is no significant difference among treatments ($T_1t_1ZnC_1$, $T_2t_1ZnC_1$, $T_1t_2ZnC_2$, and $T_1t_3ZnC_3$ and $T_0t_0ZnC_0$).

Shoot Fresh Weight

Table 4.4 a reveal that maximum shoot fresh weight (30.00g) was obtained in case of $T_2t_1ZnC_1$, while minimum shoot fresh weight (13.87 grams) was obtained in case of $T_3t_1ZnC_1$.There is no significant difference between $T_1t_1ZnC_1$ and $T_2t_1ZnC_1$. Similarly there is no significant difference among ($T_1t_1ZnC_1$, $T_1t_2ZnC_2$, $T_1t_3ZnC_3$, and $T_0t_0ZnC_0$.

Shoot Dry Weight

The data 4.4 b showed that maximum shoot dry weight (7.00g) obtained in case of treatment $T_2t_1ZnC_1$, minimum dry weight (3.00g) in case of $T_1t_3ZnC_3$. There is significant difference between ($T_2t_1ZnC_1$, and $T_3t_1ZnC_1$). There is no significant difference between ($T_1t_1ZnC_1$ and $T_3t_1ZnC_1$), ($T_1t_1ZnC_1$, $T_1t_2ZnC_2$, $T_1t_3ZnC_3$ and $T_0t_0ZnC_0$).

Number of Secondary Branches

Table 4.4 a showed that the maximum number of secondary branches was obtained in case of $T_2t_1ZnC_1$ while the minimum number of branches obtained in case of $T_3t_1ZnC_1$. There is no significant difference between $T_1t_1ZnC_1$, $T_1t_2ZnC_2$ and T1t3ZnC3.

Number of leaf per Plant

The maximum number of leaves was obtained during the third spray was 12 in case of $T_2t_1ZnC_1$ while minimum number of leaves was 8 in case of $T_3t_1ZnC_1$. The comparison between the treatments showed that $T_1t_1ZnC_1$ and $T_2t_1ZnC_1$ differ significantly from rest of the treatments.

Number of floral Branches per Plant

The maximum number of floral braches (15.5) per plant was recorded. These recorded for treatment $T_1t_1ZnC_1$ and $T_2t_1ZnC_1$. There is significant difference between treatments ($T_1t_1ZnC_1$ and $T_3t_1ZnC_1$). There is no significant difference ($T_1t_1ZnC_1$ and $T_1t_2ZnC_2$) and ($T_1t_2ZnC_2$ and $T_1t_3ZnC_3$).

Number of Fruits per Plant

The maximum number of fruits (12.00 per plant) was recorded in case of $T_2t_1ZnC_1$ while minimum fruit was (5.00 per plant) was recorded in case of $T_0t_0ZnC_0$. The treatments $T_2t_1ZnC_1$ differ significantly from T_3t_1ZnC .There is no significant difference among treatments ($T_1t_1ZnC_1$ and $T_1t_2ZnC_2$) and ($T_1t_2ZnC_2$ and $T_1t_3ZnC_3$). Table 4.3a.

Fruit Length

The maximum fruit length of (7.00 cm) while control produces the minimum fruit length (3.00 cm). A comparison between treatments reveals that treatment $T_1t_3ZnC_3$ differ significantly, while the other treatments did not achieve the level of significance. (Table 4.4a).

4.5 Copper

The data showing effect of copper application on various study parameters of ladyfinger are represented in Table 4.5a.

Shoot length

The maximum shoot length (30.33g) was recorded in case $T_2t_1CuC_1$ while minimum (23.67gms) in case of T0t0CuC0, all the treatment except control ($T_0t_0CuC_o$).Treatments ($T_1t_1CuC_1$, $T_2t_1CuC_1$, $T_3t_1CuC_1$,T_1t2CuC_2 & $T_1t_3CuC_3$) did not show any significant difference when compare with each other. (Table 4.5a).

Shoot fresh weight

The maximum shoot fresh weight (25.00g) was obtained in case of $T_1t_2CuC_2$ and $T_1t_3CuC_3$, while minimum shoot fresh weight (14.00g) obtained in case of $T_3t_1CuC_1$. However, comparison showed that there is no significant difference among the treatments (Table 4.5a).

Shoot Dry weight

The maximum shoot dry weight of lady finger (6.00gms) was obtained in case of treatment $T_2t_1CuC_1$, minimum shoot dry weight (2.220gms) in case of $T_3t_1CuC_1$. There is no significant difference between $T_1t_1CuC_1$, $T_2t_1CuC_1$, and $T_1t_2CuC_2$ and $T_1t_3CuC_3$. However $T_1t_1CuC_1$, $T_1t_2CuC_2$, and $T_1t_3CuC_3$ differ significantly from $T_3t_1CuC_1$.

Number of Secondary Branches

In ladyfinger table 4.5a showed that maximum branches (4.000g) was obtained in case of $T_0t_0CuC_0$ while the minimum number of branches (2.000g) was obtained in case of $T_3t_1CuC_1$. There is no significant difference between $T_1t_1CuC_1$, $T_2t_1CuC_1$, and $T_1t_2CuC_2$ and $T_1t_3CuC_3$.

Number of Leaves per plant

The maximum number of leaf is (20.30g) was obtained in case of $T_1t_2CuC_2$ while minimum number of leaves (8.13g) was recorded in case of $T_3t_1CuC_1$.

There is significant difference between treatments. The treatments $T_1t_2CuC_2$ yields highly significant results (Table 4.5a).

Number of Floral Branches per plant

The maximum number of foliar branches (5.00) was recorded for treatment $T_2t_1CuC_1$ and $T_1t_3CuC_3$. Minimum foliar braches (3.00) were recorded in case of $T_3t_1CuC_1$ and $T_1t_3CuC_3$. The comparison between the treatments revealed that there is no significant difference between ($T_1t_1CuC_1$ and $T_2t_1CuC_1$), ($T_1t_1CuC_1$and $T_3t_1CuC_1$), ($T_1t_1CuC_1$, T1t2CuC2, and $T_1t_3CuC_3$). It showed in (Table 4.5a).

Number of Fruits per plant

The maximum number of fruit (7.234) was recorded in case of $T_1t_3CuC_3$ while minimum number of fruits (4.235) was recorded in case of control $T_0t_0CuC_0$. There is significant difference between $T_1t_3CuC_3$ and $T_0t_0CuC_0$. There is no significant difference among the treatments ($T_1t_1CuC_1$, $T_2t_2CuC_1$ and $T_3t_1CuC_1$) and ($T_1t_2CuC_2$ and T1t3CuC3) (Table 4.5a).

Fruit Length

The maximum fruit length (7 inch) observed in $T_1t_3CuC_3$, while the control yielded minimum fruit length (2 inch). A comparison between treatments revealed that there is no significant difference between treatment ($T_1t_1CuC_1$ & $T_2t_1CuC_1$) and between ($T_2t_1CuC_1$ and $T_3t_1CuC_1$). There is no significant difference between treatments $T_1t_1CuC_1$, $T_1t_2CuC_2$ and $T_1t_3CuC_3$ (Table 4.5a).

4.6 Molybdenum

The data showing effect of molybdenum application on various study parameters of tomatoes are represented in Table 4.6a.

Shoot Length

In ladyfinger (Table 4.6a) treatments $T_3t_1MoC_1$ produced highest shoot length (40.20cm) while the minimum shoot length (18.67cm) was produced in case of control ($T_0t_0MoC_0$). A comparison showed that treatment $T_3t_1MoC_1$ differ significantly while other treatment did not attain the level of significance.

Shoot fresh weight

The maximum shoot fresh weight (40.16gms) obtained in case of $T_3t_1MoC_1$, while minimum shoot fresh weight (19.20g) obtained in case of $T_0T_0MoC_0$. A comparison showed that $T_3t_1MoC_1$ differ significantly from rest of the treatments. The treatments $T_1t_1MoC_1$, $T_2t_1MoC_1$, $T_3t_1MoC_1$ and $T_1t_3MoC_3$ did not show any significant difference (Table 4.6a).

Shoot Dry weight

The maximum shoot dry weight (11.80gms) was obtained in case of treatment $T_3t_1MoC_1$, while minimum shoot dry weight (5.20gms) in case of $T_0t_0MoC_0$.Treatment $T_3t_1MoC_1$ showed highly significant effects when compare with rest of the treatments. Treatment $T_1t_1MoC_1$ however did not show significant difference when compared with $T_3t_1MoC_1$ and $T_1t_3MoC_3$ (Table 4.6a).

Number of Secondary Branches

All the treatments produced approximately similar number of secondary branches. A comparison between all treatments showed that the treatment did not achieve the level of significance (Table 4.6a).

Number of Leaf per plant

It is observed that maximum number of leaf (20.00gms) was obtained in case of $T_3t_1MoC_1$ while minimum number of leaf (8.00gms) was recorded in case of $T_1t_3MoC_3$. There is significant difference between $T_1t_1MoC_1$. Similarly there is significant difference between $T_1t_1MoC_1$ and $T_0t_0MoC_o$.

Number of Floral Branches per plant

There is no significant difference between the treatments. All the treatments produced approximately same results (Table 4.6a).

Number of Fruits per Plant

The maximum number of fruit (10.00) was recorded in case of $T_3t_1MoC_1$ and $T_3t_1MoC_1$ while minimum number of fruit (4.00) was recorded in case of $T_0t_0MoC_0$. There is no significant difference between $T_1t_1MoC_1$, $T_3t_1MoC_1$, $T_3t_1MoC_1$ and $T_1t_3MoC_3$. All the treatments differ significantly when compared with control (Table 4.6a).

Fruit Length

The maximum fruit length of ladyfinger was shown in (table 4.6a). Treatment $T_3t_1MoC_1$ gave maximum fruit length is (5.00 cm). A comparison between treatments revealed that there is no significant difference among treatments ($T_1t_1MoC_1$, $T_2t_1MoC_1$ and $T_3t_1MoC_1$). There is significant difference between $T_1t_1MoC_1$ and $T_3t_1MoC_1$.

4.7 Manganese

The data showing effects of manganese application on various parameters of ladyfinger are represented in table 4.7a.

Shoot Length

Treatments $T_3t_1MnC_1$ produced highest shoot length (35.30cm) while the minimum shoot length (23.67cm) was produced in case of control ($T_0t_0MnC_0$). There is no significance differ between the treatments. The treatments $T_1t_1MnC_1$ differs significantly from control ($T_0t_0MnC_0$) Table 4.7a.

Shoot Fresh Weight

Table 4.7a showed that maximum shoot fresh weight (33.65gms) obtained in case of $T_1t_2MnC_2$, while minimum shoot fresh weight (15.50gms) obtained in case of $T_3t_1MnC_1$. There is no significance difference among ($T_1t_1MnC_1$, $T_2t_1MnC_1$, and $T_1t_2MnC_2$ and $T_1t_3MnC_3$).

Shoot Dry weight

The data 4.7a showed that in case of ladyfinger the maximum shoot dry weight (10.12g) was obtained in case of treatment $T_1t_2MnC_2$, while minimum shoot dry weight (4.00g) in case of $T_3t_1MnC_1$. There is no significance difference between $T_1t_1MnC_1$ and $T_2t_1MnC_1$. $T_1t_2MnC_2$ treatment significantly differ from $T_1t_3MnC_3$ and $T_1t_1MnC_1$.

Number of Secondary Branches

Table 4.7a reveal that all the treatment produced approximately similar number of secondary branches except $T_1t_1MnC_1$. There is no significant difference between $T_2t_1MnC_1$, $T_3t_1MnC_1$, $T_1t_2MnC_2$, $T_1t_3MnC_3$ and $T_0t_0MnC_0$.

Number of Leaf per plant

It is observed that maximum number of leaf (25.00g) was obtained in case of $T_1t_2MnC_2$, while minimum number of leaf (13.00g) was recorded in case of $T_3t_1MnC_1$. Treatment $T_1t_2MnC_2$ differ significantly while there is no significant difference between ($T_1t_1MnC_1$ and $T_2t_1MnC_1$) and ($T_1t_1MnC_1$, $T_3t_1MnC_1$ and $T_1t_2MnC_2$) and ($T_1t_2MnC_2$ and $T_0t_0MnC_0$)(Table 4.7a).

Number of Floral Branches per plant

Maximum number of floral branches (5.16 per plant) was recorded in case of $T_1t_2MnC_2$ while minimum number of floral branches (2.15 per plant) in case of $T_3t_1MnC_1$. There is no significant difference between $T_1t_1MnC_1$; $T_2t_1MnC_1$, and $T_3t_1MnC_1$. Treatment $T_1t_1MnC_1$ significantly differ from $T_1t_2MnC_2$ (Table 4.7a).

Number of Fruits per Plant

The maximum number of fruit (4.00) was recorded in case of $T_1t_1MnC_1$ while minimum number of fruit (2.16) was recorded in case of $T_2t_1MnC_1$. There is no significant difference among the treatments (Table 4.7a).

Fruit Length

Treatment $T_1t_3MnC_3$ produced maximum fruit length (7.00 inch) and minimum (3.00 inch) in case of control. Treatment $T_1t_1MnC_1$ significantly differs from $T_2t_1MnC_1$, $T_3t_1MnC_1$ and $T_0t_0MnC_0$. There is no significance difference between $T_1t_1MnC_1$ and $T_1t_3MnC_3$ (Table 4.7a).

Table-4.2a

MEAN TABLE SHOWING THE EFFECT OF IRON APPLICATION ON VARIOUS STUDY PARAMETERS OF LADYFINGER

Treatments	Shoot Length (cm)	Shoot Fresh weight (g)	Shoot Dry weight (g)	No. of Sec. Branches/Plant	No. of Leaf per plant	No. of floral braches per plant	No of Fruits per plant
$T_0t_0C_0$	22.60 D	20.43 C	4.640 B	4.000 A	13.00 C	5.00 BC	3.00 B
$T_1t_1FeC_1$	35.40 A	31.57 B	5.267 AB	4.545 A	18.67AB	3.620 AB	8.333 A
$T_2t_1FeC_1$	26.540 AB	31.57 B	7.670 A	4.420 A	16.60 B	10.00 A	8.333 A
T_3t1FeC_1	29.000 C	40.65 A	9.122 A	4.000 A	13.67 C	2.667 AB	3.330 B
$T_1t_2FeC_2$	29.00 AB	21.20 C	4.640B	4.545 A	19.33 A	3.620 AB	5.000 B
$T_1t_3FeC_3$	28.00 BC	22.20 C	4.233 D	4.540 A	17.620 B	7.000 A	4.000 B
Average	170.5400/6 = 28.4 cm	167.6200/6 = 27.93 g	35.5720/6 = 5.92 g	26.0500/6 = 4.34	98.8900/6 = 16.48	31.9070/6 = 5.31	31.9960/6 =5.33

Mean in a column followed by similar alphabets are not significantly different from each other.

Table-4.3a

MEAN TABLE SHOWING EFFECT OF BORON APPLICATION ON VARIOUS STUDY PARAMETERS OF LADYFINGE

Treatments	Shoot Length (cm)	Shoot Fresh weight (g)	Shoot Dry weight (g)	No. of Sec. Branches/Plant	No. of Leaf per plant	No. of floral braches per plant	No of Fruits per plant
$T_0t_0C_0$	20.50 D	15.00 C	4.3B	2.00 C	13.00 A	2.00 BC	3.15 A
$T_1t_1BC_1$	21.67 CD	14.30 C	4.00 B	2.00 C	12.00 B	2.667 C	2.000 B
$T_2t_1BC_1$	28.33 BC	21.63 C	4.00 B	2.52 C	11.00 AB	3.000 BC	3.333 A
$T_3t_1BC_1$	25.20 CD	19.05 C	4.600B	3.00 B	6.667 CD	2.000 BC	4.00 A
$T_1t_2BC_2$	40.16A	33.00 A	5.3A	5.00 A	6.67 CD	3.667 A	3.33 A
$T_1t_3BC_3$	32.25 AB	26.82 B	6.000B	3.335 B	6.000 D	3.333 AB	6.33 A
Average	168.1100/6 = 28.01 cm	129.8000/6 = 21.63 g	28.2000/6 = 4.70 g	18.8550/6 = 3.14	55.3370/6 = 9.22	16.6670/6 = 2.77	22.1430/6 = 3.69

Mean in a column followed by similar alphabets are not significantly different from each other.

Table-4.4a

MEAN TABLE SHOWING EFFECT OF ZINC APPLICATION ON VARIOUS STUDY PARAMETERS OF LADYFINGER

Treatments	Shoot Length (cm)	Shoot Fresh weight (g)	Shoot Dry weight (g)	No. of Sec. Branches/Plant	No. of Leaf per plant	No. of floral braches per plant	No of Fruits per plant
$T_0t_0C_0$	18.67 BC	13.00 AB	3.00 B	3.000 B	8.00 B	3.000 AB	5.00 C
$T_1t_1ZnC_1$	31.00 A	20.00 A	6.240AB	2.662 BC	16.33 A	15.5 A	6.00AB
$T_2t_1ZnC_1$	30.33 AB	30.00 A	7.00 A	4.000 A	12.00 A	3.667 A	7.00 A
$T_3t_1ZnC_1$	18.67 C	13.70 B	3.00 B	2.000 C	6.00 D	2.333 C	5.00 C
$T_1t_2ZnC_2$	28.00 AB	16.16 AB	3.100 B	3.320 AB	8.668 C	3.333 AB	5.320 BC
$T_1t_3ZnC_3$	24.67 ABC	16.45 AB	3.520 B	3.000 B	8.000 C	2.667 BC	6.320 B
Average	151.3400/6 = 25.22 cm	109.3100/6 = 18.21 g	25.8600/6 = 4.31 g	17.9460/6 = 2.99	58.9980/6 = 9.83	30.5000/6 = 5.08	34.6400/6 = 5.77

Mean in a column followed by similar alphabets are not significantly different from each other.

Table-Mo 4.5a

MEAN TABLE SHOWING EFFECT OF COPPER APPLICTION ON VARIOUS STUDY PARAMETERS OF LADYFINGER

Treatments	Shoot Length (cm)	Shoot Fresh weight (g)	Shoot Dry weight (g)	No. of Sec. Branches/Plant	No. of Leaf per plant	No. of floral braches per plant	No of Fruits per plant
$T_0t_0C_0$	23.67 B	19.43 A	4.667 BC	4.000 AB	13.00 C	3.333 B	4.235 B
$T_1t_1CuC_1$	26.33 A	18.40 A	5.600 AB	2.667 AB	11.00 D	5.000 AB	5.000 AB
$T_2t_1CuC_1$	30.33 A	20.45 A	6.00 A	4.000 A	14.33 BC	5.000 AB	4.325 AB
$T_3t_1CuC_1$	24.35 A	14.00 A	2.22 C	2.220 B	8.13 E	3.000 B	5.000 AB
$T_1t_2CuC_2$	26.33 A	25.00 A	6.600 AB	3.330 A	20.30 A	5.000 AB	5.667 A
$T_1t_3CuC_3$	27.00 A	25.00 A	6.530AB	2.567 AB	12.65 B	2.00 B	7.234 A
Average	158.0100/6 = 26.33 cm	122.2800/6 = 20.38 g	31.3870/6 = 5.23 g	18.7840/6 = 3.13	79.4100/6 = 13.23	23.3330/6 = 3.88	31.4610/6 = 5.24

Mean in a column followed by similar alphabets are not significantly different from each other.

Table 4.6a

MEAN TABLE SHOWING THE EFFECT OF MOLYBDENUM OF THE ARIOUS STUDY PARAMETERS OF LADYFINGER

Treatments	Shoot Length (cm)	Shoot Fresh weight (g)	Shoot Dry weight (g)	No. of Sec. Branches/Plant	No. of Leaf per plant	No. of floral braches per plant	No of Fruits per plant
$T_0t_0C_0$	18.67 B	19.20 C	5.20 D	4.235 A	14.00 B	5.000 A	4.00 C
$T_1t_1MoC_1$	22.67 B	26.27 B	7.600BC	4.240 A	14.00 B	5.200 A	8.340 AB
$T_2t_1MoC_1$	28.30 B	31.20 B	7.600BC	4.000 A	18.65 A	3.000 B	6.000 B
$T_3t_1MoC_1$	40.20 A	40.16 A	11.80 A	4.000 A	20.00 A	5.00 A	10.00 A
$T_1t_2MoC_2$	22.30 B	23.20 BC	5.700CD	4.425 A	9.340 C	5.000 A	10.00 A
$T_1t_3MoC_3$	30.32 B	31.80 B	9.130 B	4.425 A	8.00 C	3.345 B	9.330 A
Average	162.4600/6 = 27.07 cm	171.8300/6 = 28.63 g	47.0300/6 = 7.83 g	25.3250/6 = 4.22	83.9900/6 = 13.99	26.5450/6 = 4.42	47.6700/6 = 7.94

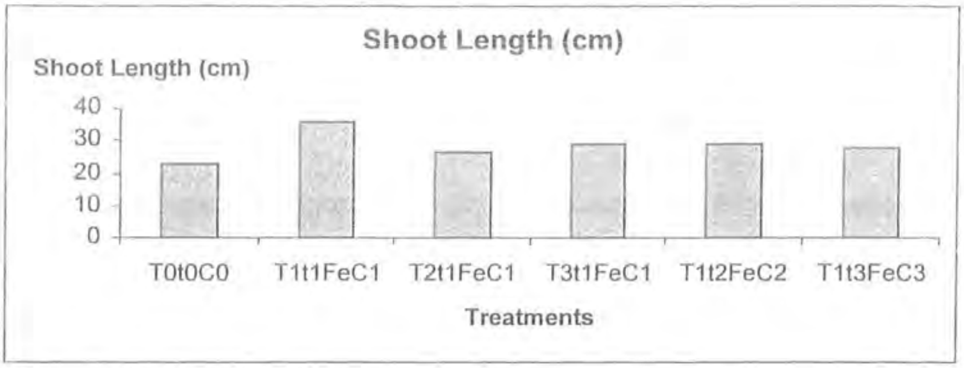
Mean in a column followed by similar alphabets are not significantly different from each other

Table-Mn 4.7a

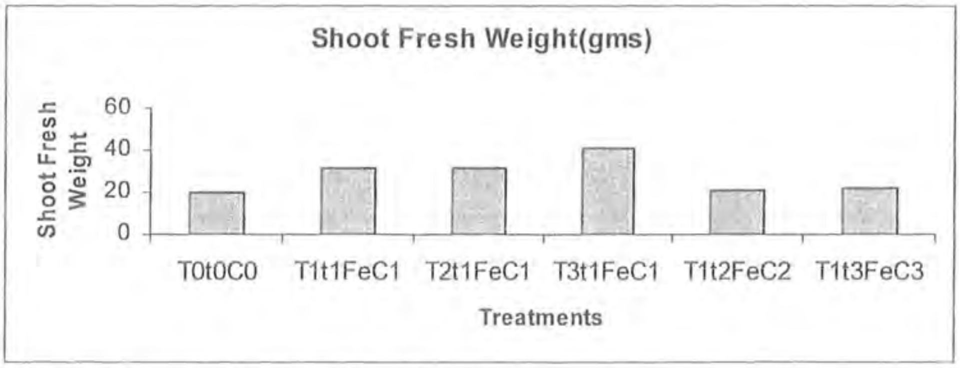
MEAN TABLE SHOWING EFFECT OF MANGANESE APPLICATION ON VARIOUS STUDY PARAMETERS OF LADYFINGER

Treatments	Shoot Length (cm)	Shoot Fresh weight (g)	Shoot Dry weight (g)	No. of Sec. Branches/Plant	No. of Leaf per plant	No. of floral braches per plant	No of Fruits per plant
$T_0t_0C_0$	23.67 B	22.60 B	4.550 CD	4.000 A	12.00B	3.000 BC	4.00 A
$T_1t_1MnC_1$	29.33 AB	29.25 A	7.820BC	3.000 B	10.54 C	2.570 BC	4.00 A
$T_2t_1MnC_1$	23.00AB	26.20 A	9.820AB	3.295 A	11.00 C	3.285 BC	2.16 B
$T_3t_1MnC_1$	35.30 A	15.50 B	4.00 D	4.258 A	13.00 B	2.15 C	3.251 A
$T_1t_2MnC_2$	31.60 AB	33.65 A	10.12 A	3.285 A	25.00 A	5.16 A	4.250 A
$T_1t_3MnC_3$	33.00 A	30.00 A	8.00 BC	4.258 A	12.65 BC	3.766 AB	3.825 A
Average	175.9000/6 = 29.31 cm	157.2000/6 = 26.20 g	44.3100/6 = 7.38 g	22.0960/6 = 3.68	84.1900/6 = 14.03	19.9310/6 = 0.55	21.4860/6 3.58

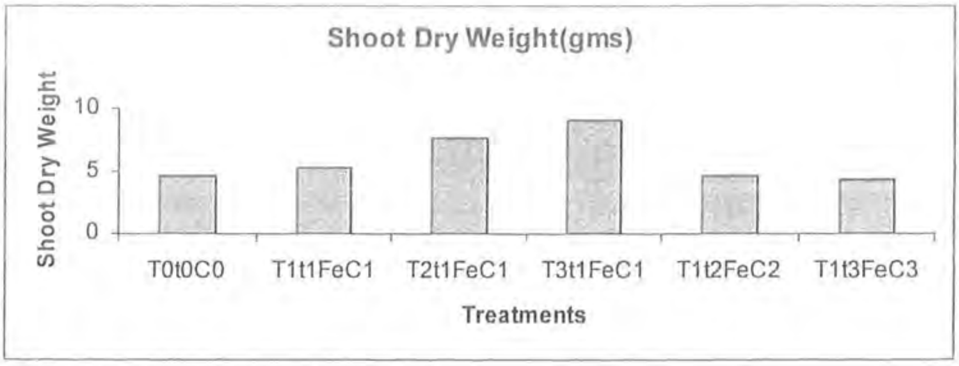
Mean in a column followed by similar alphabets are not significantly different from each other.



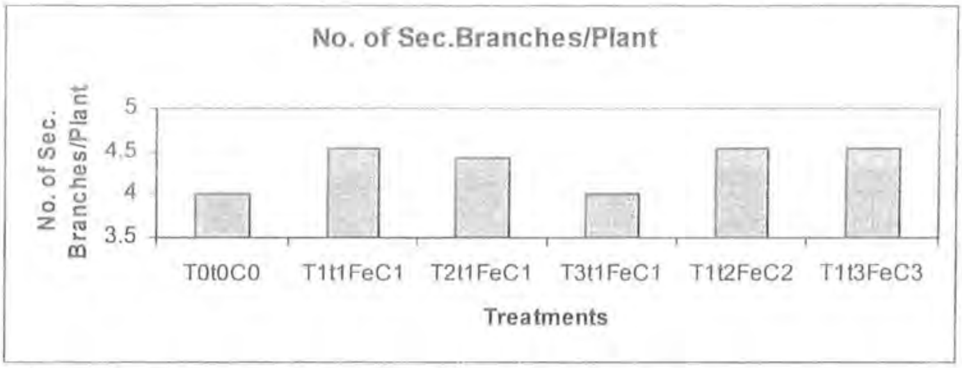
Effect of iron on shoot length.



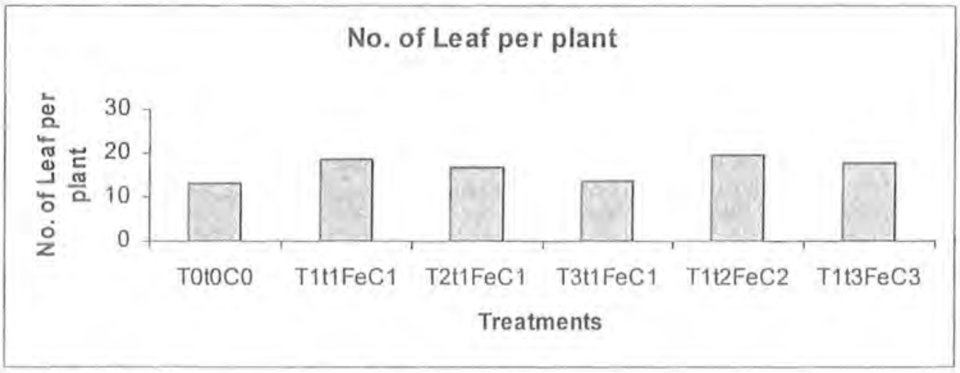
Effect of iron on fresh weight of shoot.



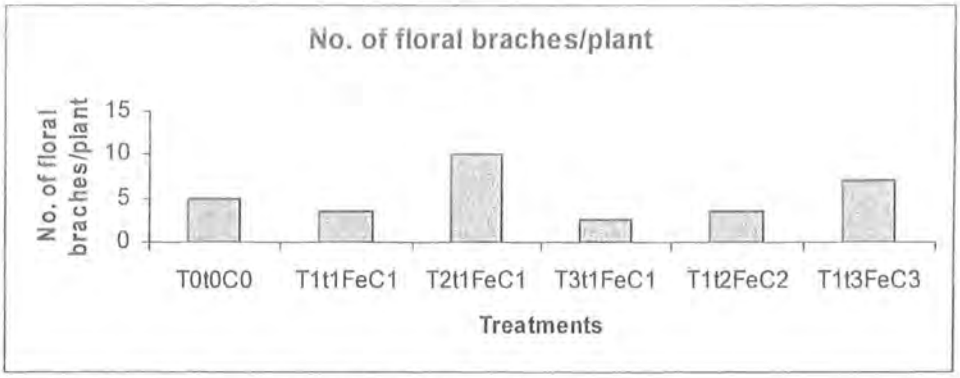
Effect of iron on shoot dry weight.



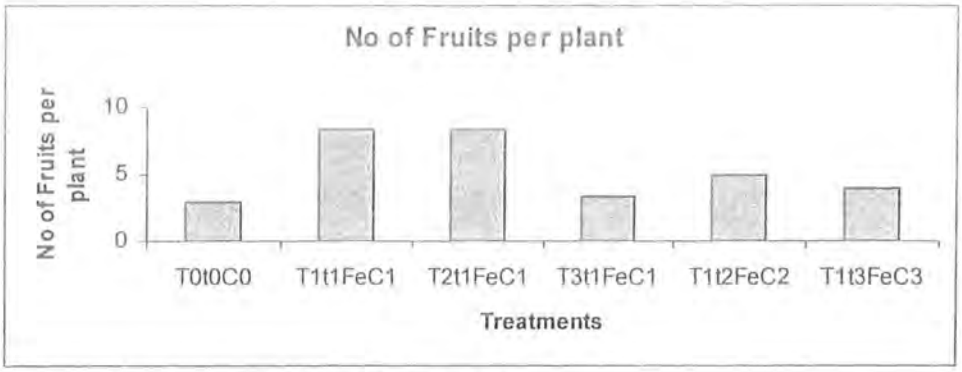
Effect of iron on number of secondary branches per plant.



Effect of iron on number of leaf per plant.

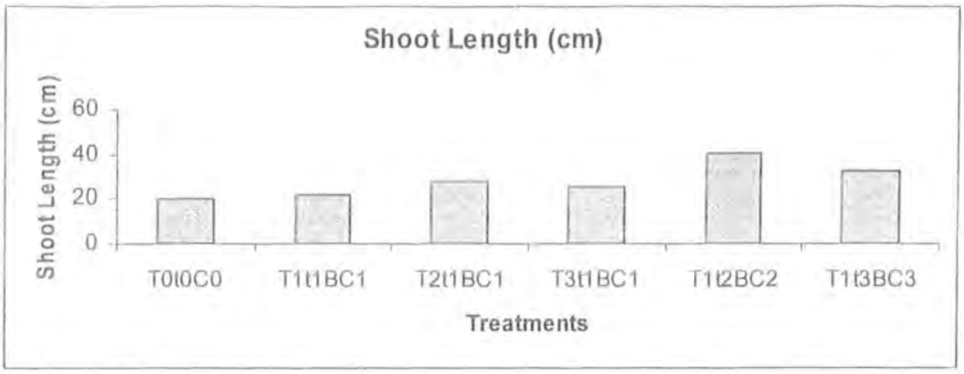


Effect on iron on number of floral branches per plant.

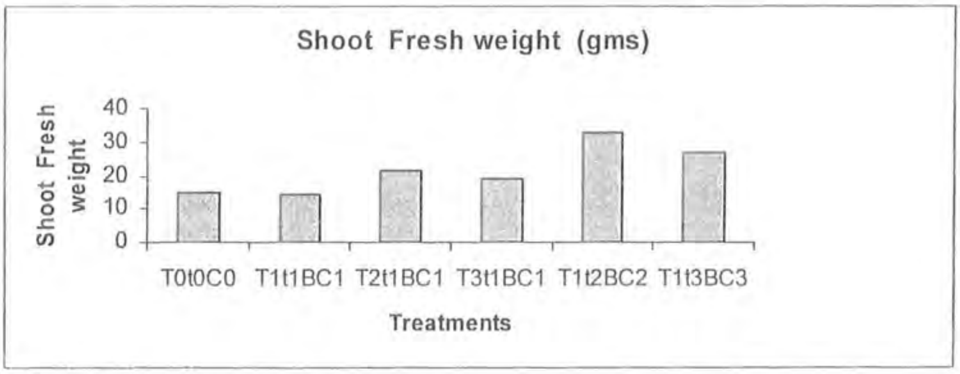


Effect of iron on number of fruit per plant.

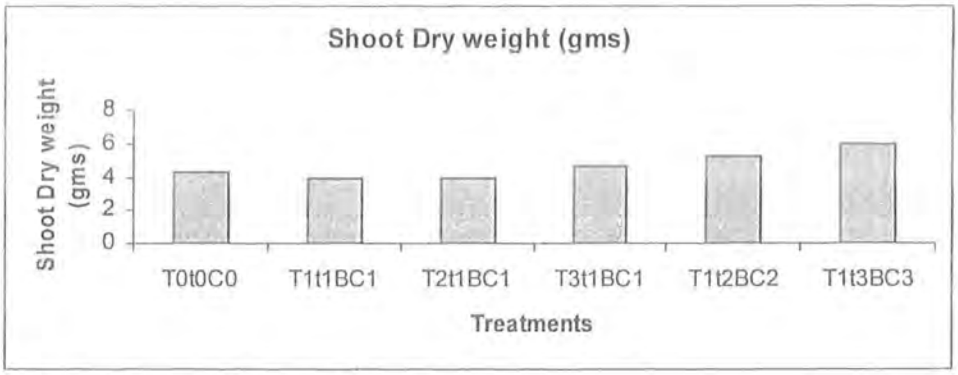
Figure 1: Effects of Iron applications on various study parameters of Ladyfinger



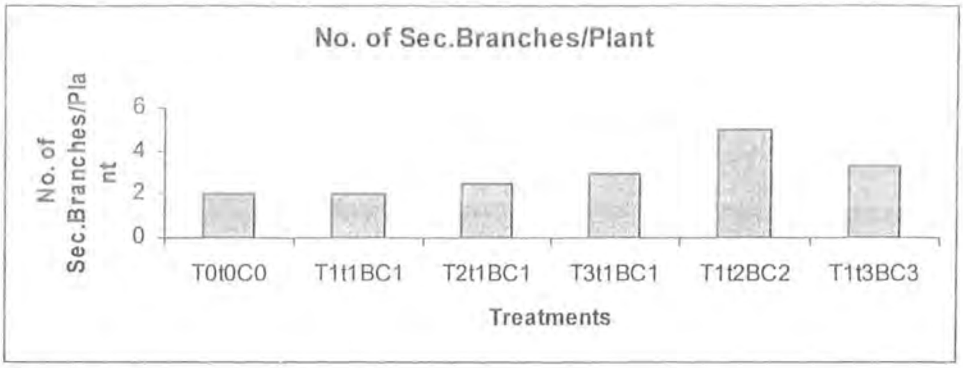
Effect of boron on shoot length.



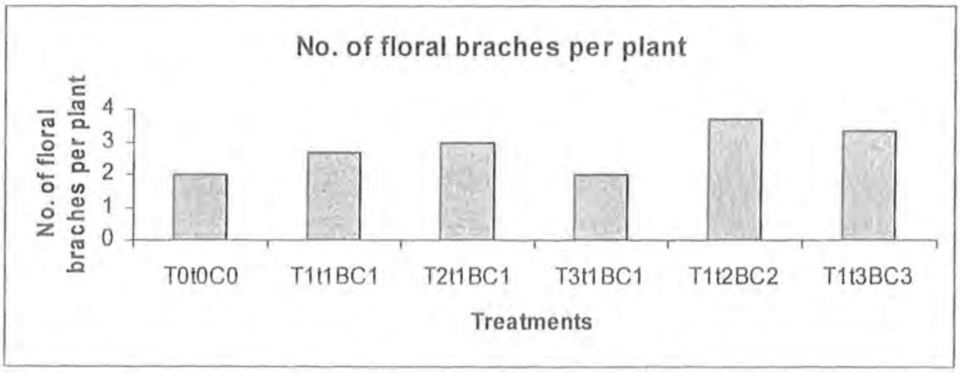
Effect of boron on shoot fresh weight.



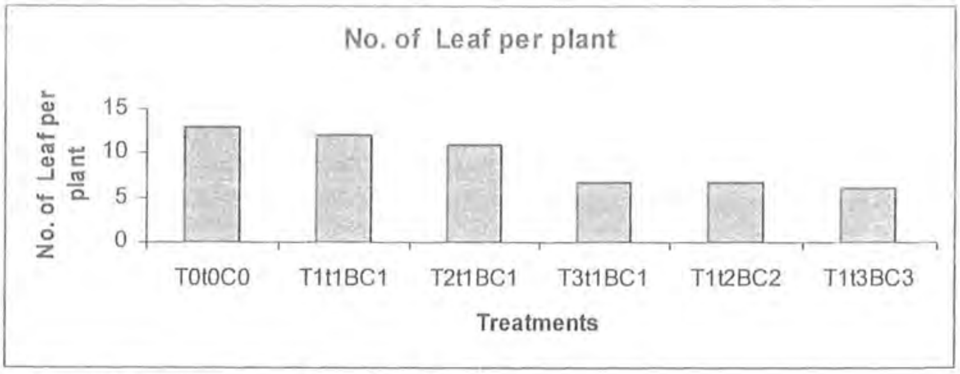
Effect of boron on shoot dry weight.



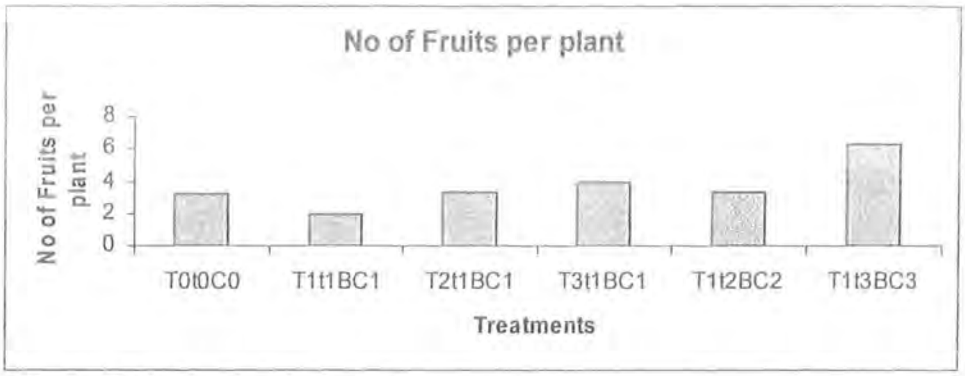
Effect of boron on number of secondary branches per plant.



Effect of boron on number of floral branches per plant.

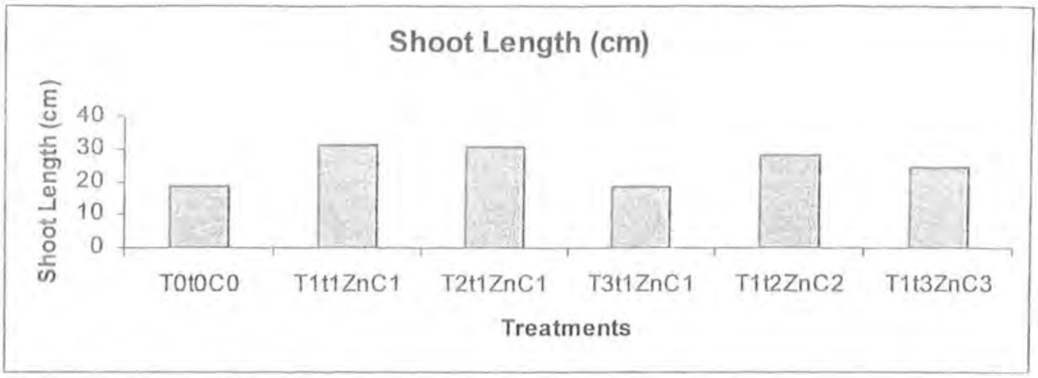


Effect of boron on number of leaf per plant.

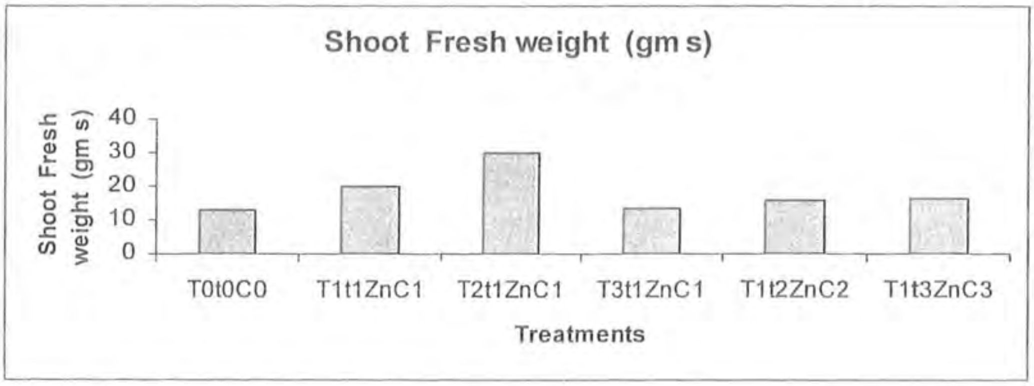


Effect of boron on number of fruit per plant.

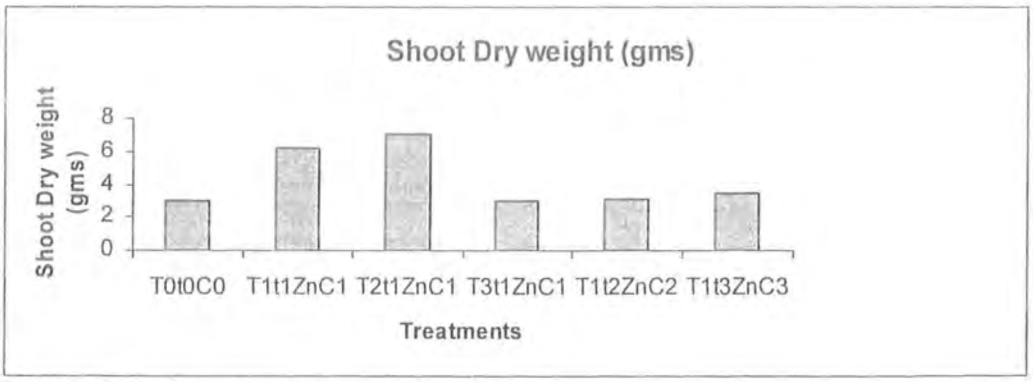
Figure: 2 Effects of Boron applications on various study parameters of Ladyfinger



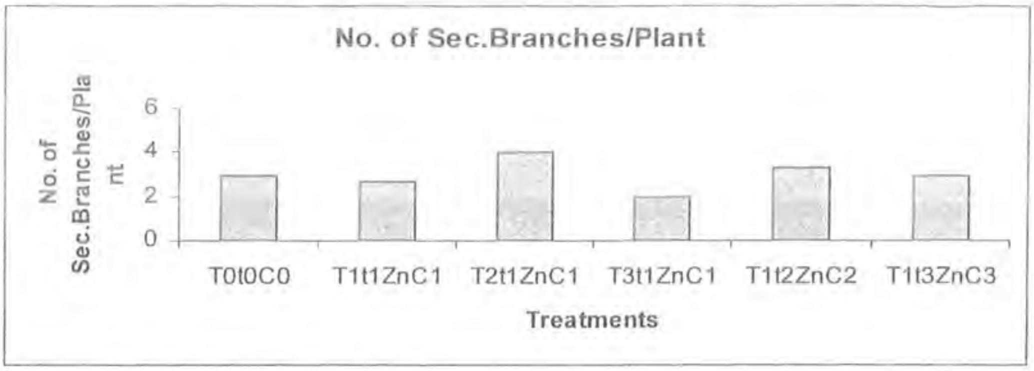
Effect of zinc on shoot length.



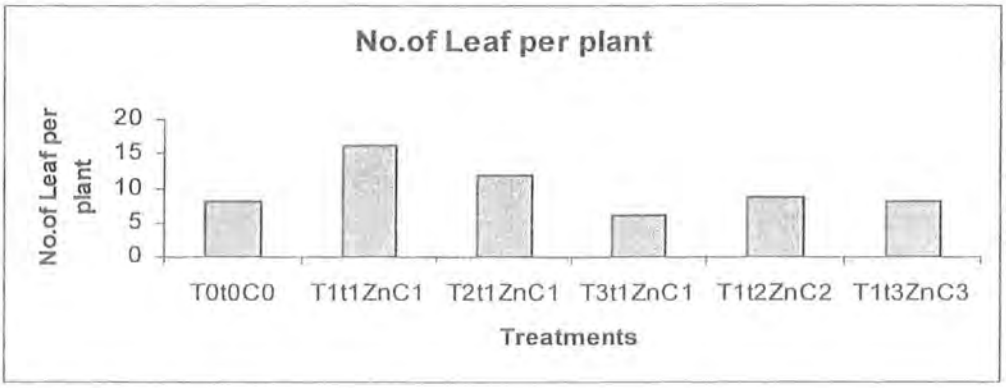
Effect of zinc on fresh shoot weight.



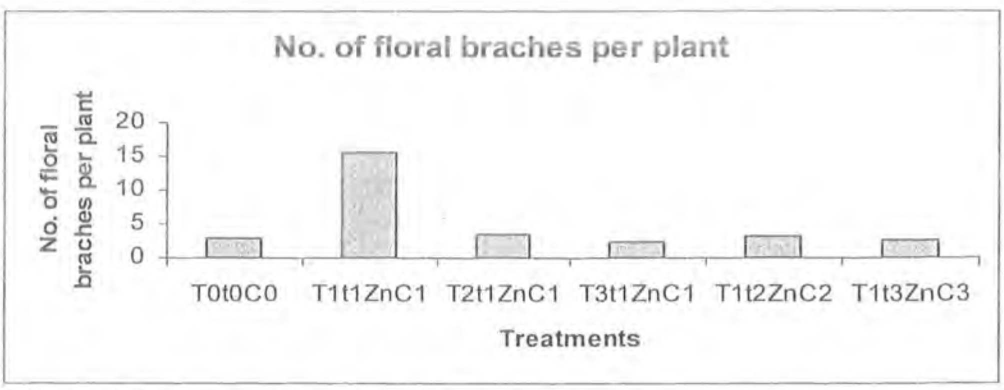
Effect of zinc on shoot dry weight.



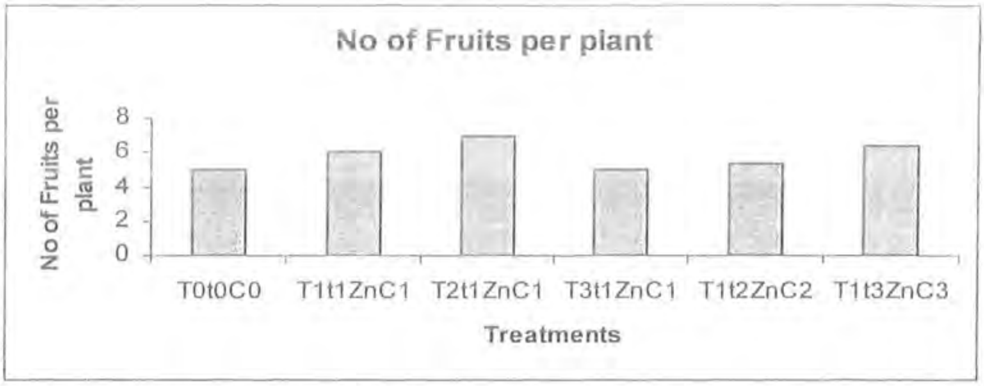
Effect of zinc on number of secondary branches per plant.



Effect of zinc on number of leaf per plant.

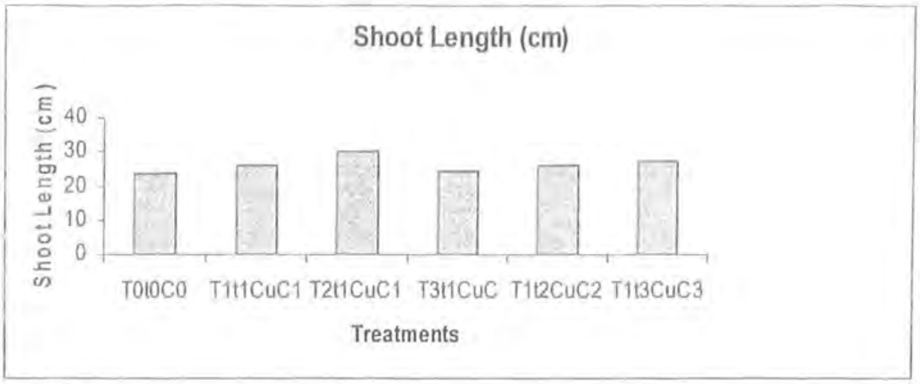


Effect of zinc on number of floral branches per plant.

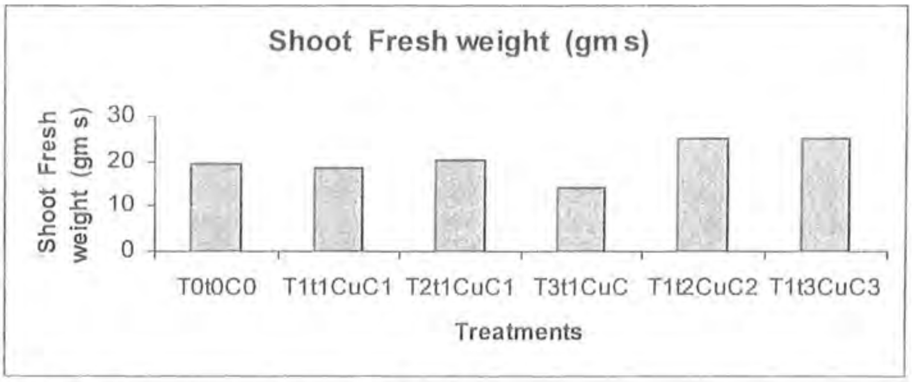


Effect of zinc on number of fruit per plant.

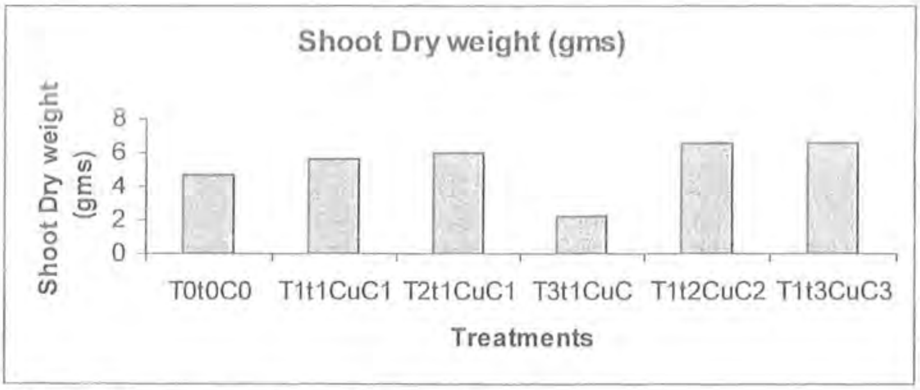
Figure: 3 Effects of Zinc applications on various study parameters of Ladyfinger



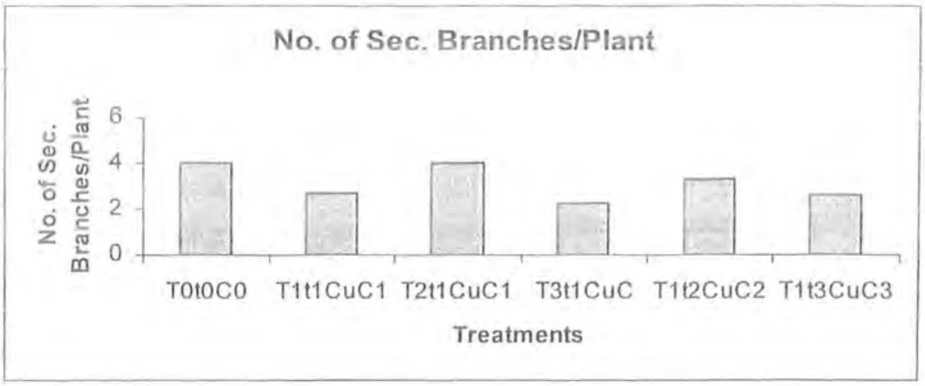
Effect of copper on shoot length.



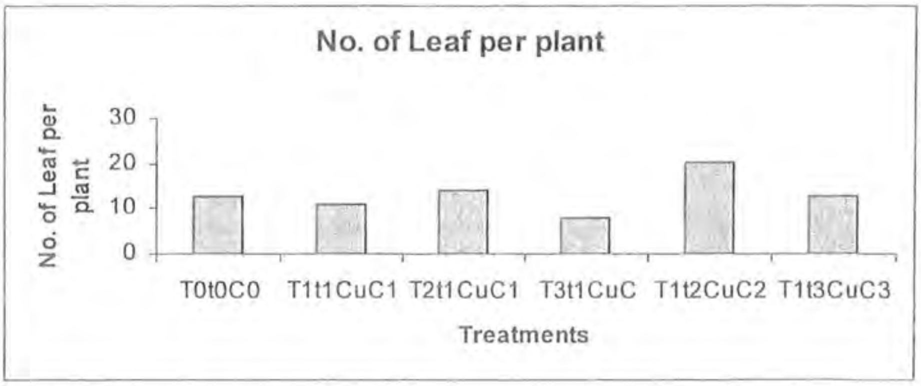
Effect of copper on shoot fresh weight.



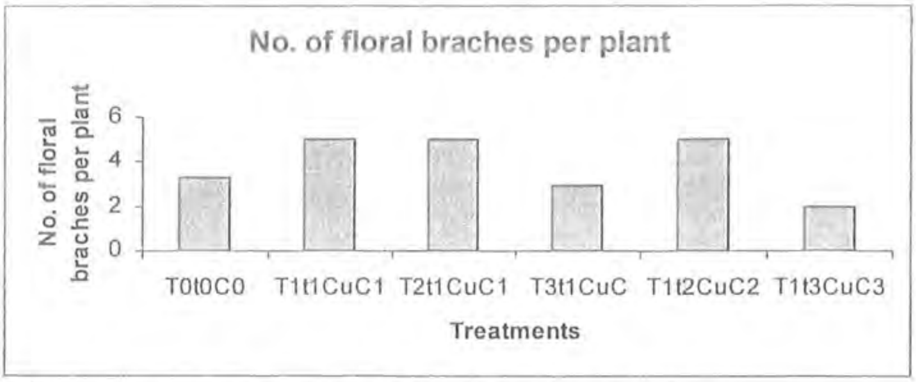
Effect of copper on shoot dry weight.



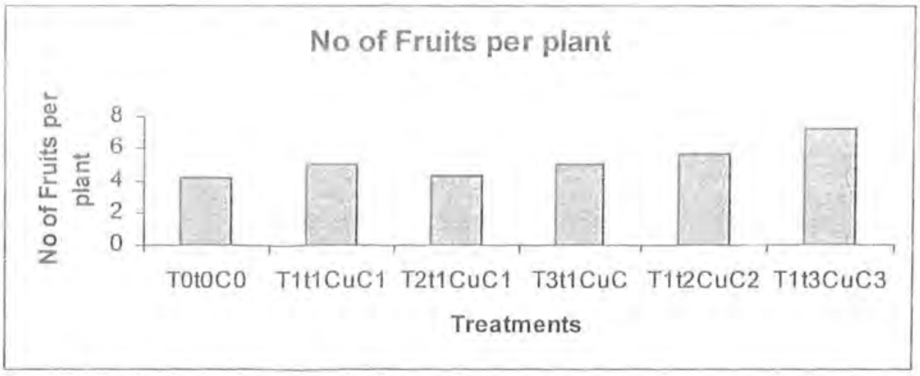
Effect of copper on number of secondary branches per plant.



Effect of copper on number of leaf per plant.

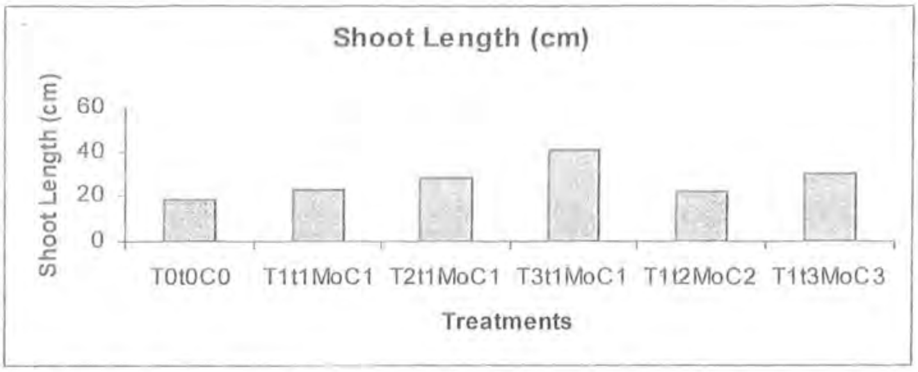


Effect of copper on number of floral branches per plant.

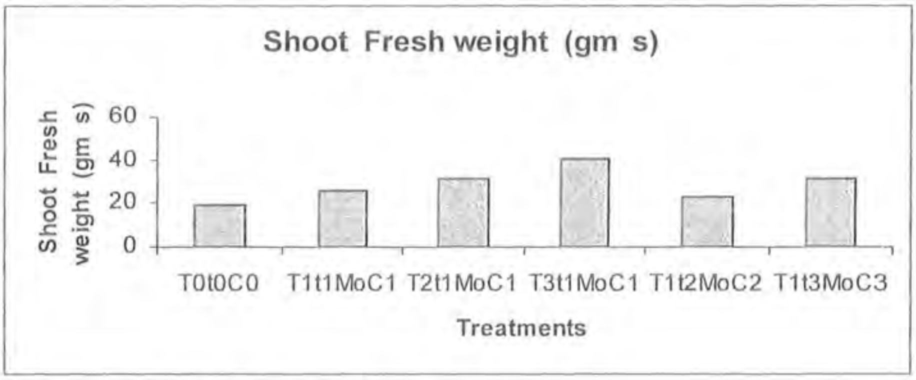


Effect of copper on number of fruits per plant.

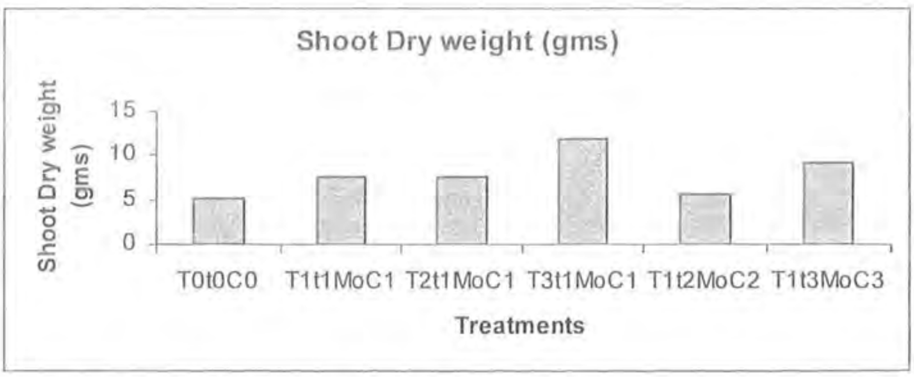
Figure: 4 Effects of Copper application on various study parameters of Ladyfinger



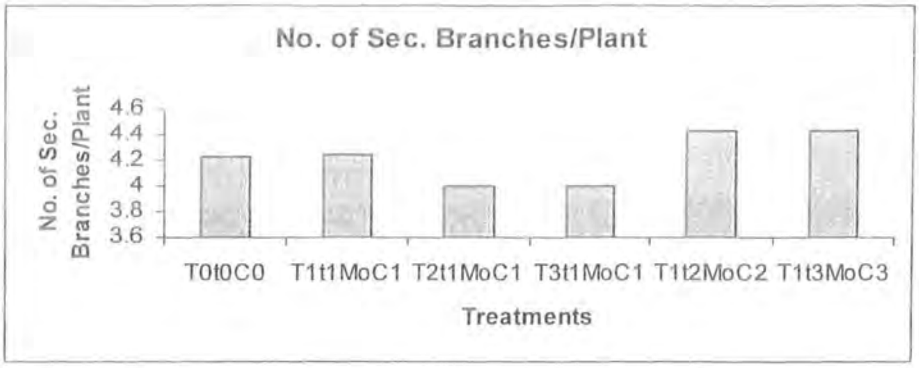
Effect of molybdenum on shoot length.



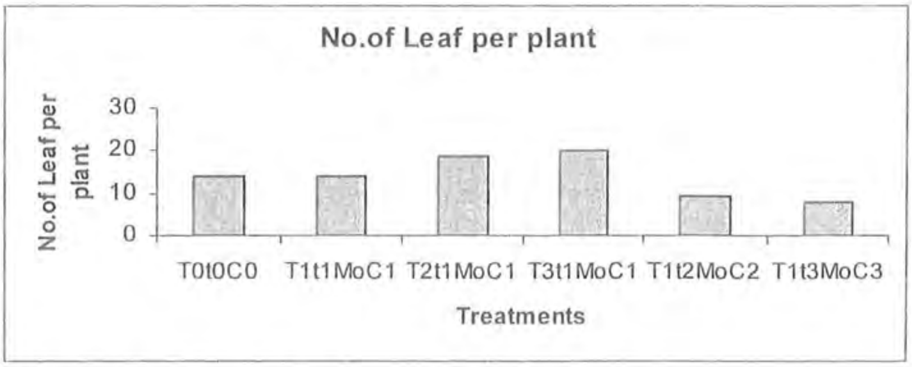
Effect of molybdenum on shoot fresh weight.



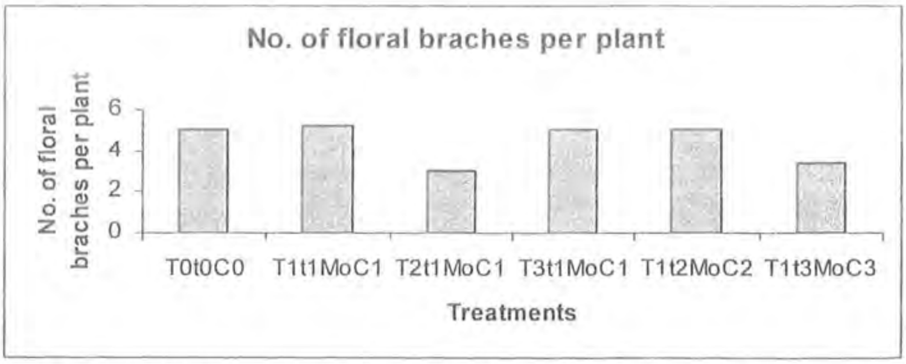
Effect of molybdenum on shoot dry weight.



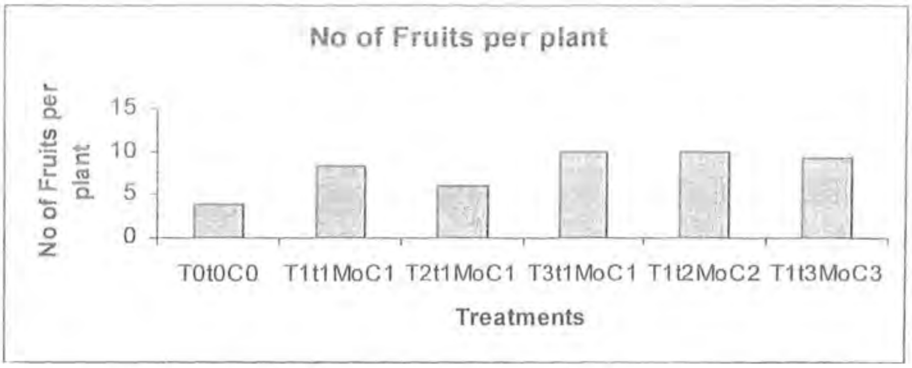
Effect of molybdenum on number of secondary branches per plant.



Effect of molybdenum on number of leaf per plant.

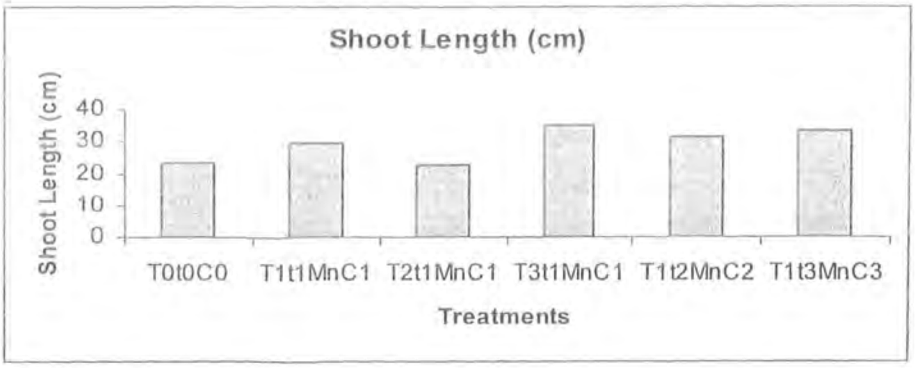


Effect of molybdenum on number of floral branches per plant.

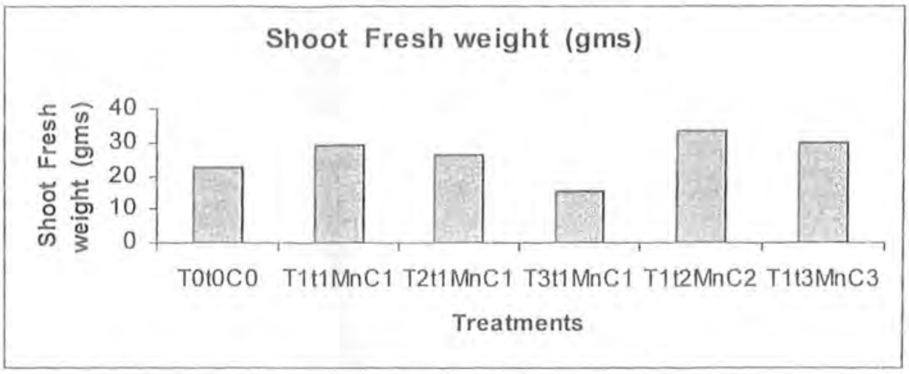


Effect of molybdenum on fruit per plant.

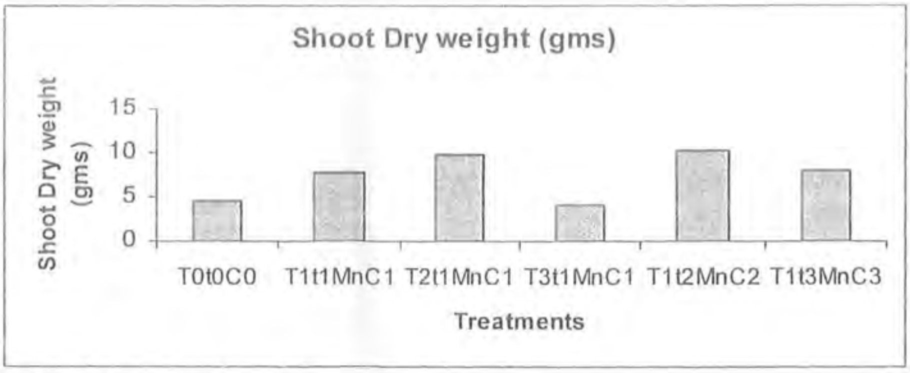
Figure: 5 Effects of Molybdenum application on various study parameters of Ladyfinger



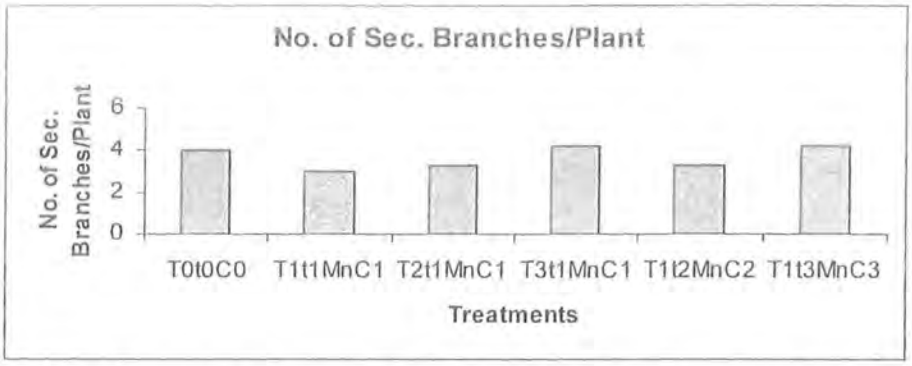
Effect of manganese on shoot length.



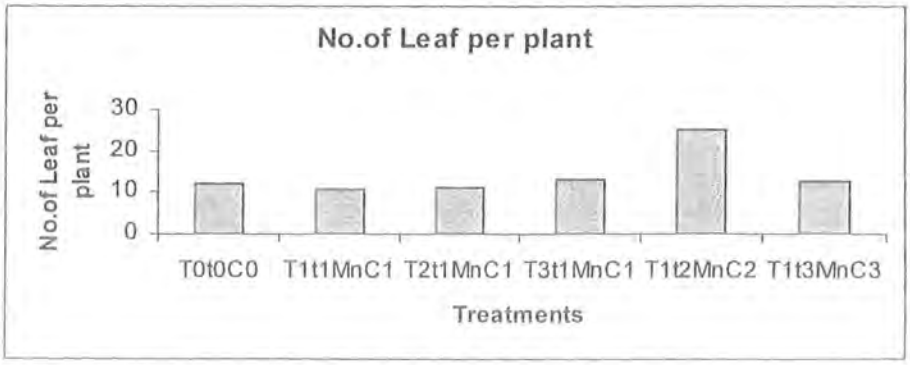
Effect of manganese on shoot fresh weight.



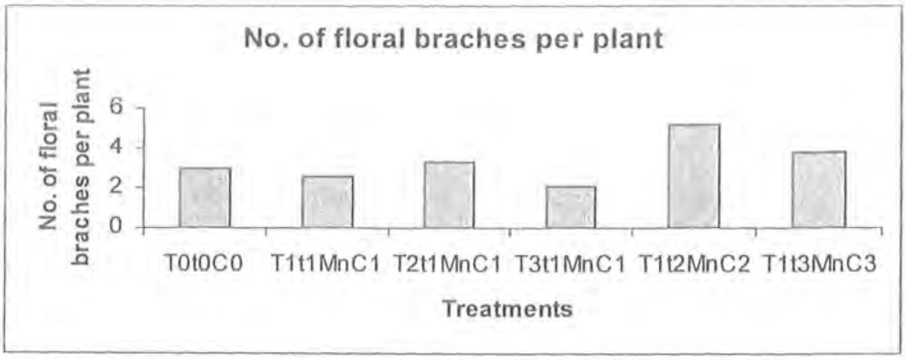
Effect of manganese on shoot dry weight.



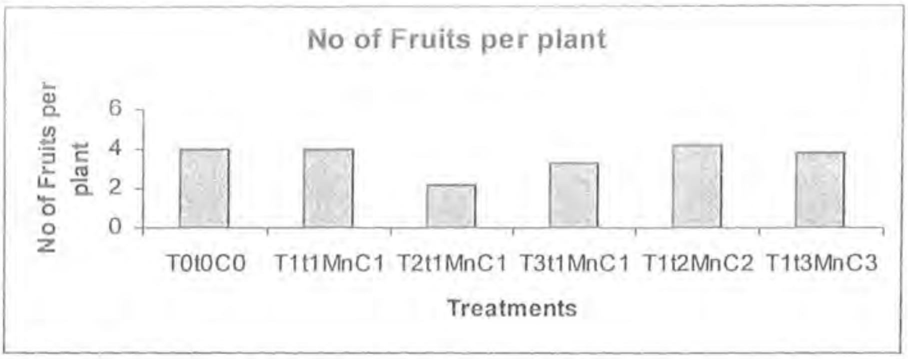
Effect of manganese on number of secondary branches per plant.



Effect of manganese on number of leaf per plant.



Effect on manganese on number of floral branches per plant.



Effect of manganese on number of fruit per plant.

Figure: 6 Effects of Manganese application on various study parameters of Ladyfinger

Chapter No. 5

DISCUSSION

A set of experiments was conducted to assess the effects of different micronutrients on the growth and yield of (*Hibiscus esculentus*), a vegetable belonging to Malvaceae Family. During the present studies six micronutrients (Iron, copper, zinc, boron, manganese and molybdenum) were applied through soil, soil plus foliar and foliar applications. Most of the micronutrients application significantly affected the growth and yield of the plant.

Iron

Data given in table 4.2a for *Hibiscus esculentus* revealed that all treatments of iron nutrition significantly increased the mean shoot length as compared to control. Nevertheless, foliar application of Fe at 500ppm ($T_1t_1FeC_1$) proved superiority in stimulating shoot length (35.40cm) over the other treatments. During the present study the maximum significant shoot fresh weight (40.65gms) was observed when Fe micronutrient was applied in the soil ($T_3t_1FeC_1$).

In *Hibiscus esculentus* maximum shoot dry weight (9.122g) was obtained when soil treatment $T_3t_1FeC_1$ was applied while minimum dry weight was obtained in case of $T_1t_3FeC_3$.

No exact report is available for comparison, however, Ismail *et al.*, (1986) conducted that tomato seedling dry matter yield is significantly affected by iron, zinc and phosphors application. A specific ratio of Fe/Zn/P was needed for plant growth in the soil and to adjust the balance among three elements to produce the highest dry matter yield. It was observed from the results that average number of secondary branches per plant was not affected by iron application.

Number of floral branches under the effect of iron application was also investigated in *Hibiscus esculentus*. The results showed that control gave minimum number of floral branches (5 per plant) while foliar plus soil and foliar application of iron (1500ppm) produced the maximum floral branches (10.00 per plant). The present iron micronutrient treatment was applied on tomato and gave maximum floral branches, 4.00 per plant and minimum floral branches were 3.00 per plant.

During this study, the maximum mean number of fruit (8.33) per plant in *Hibiscus esculentus* plant was obtained for $T_1t_1FeC_1$ and $T_2t_1FeC_1$, in which the iron micronutrient was applied both through foliar and foliar plus soil application. According to the Hatwar *et al.* (2003), single application of foliar iron was the most effective in case of fruits. Thomas and Donald (1988) observed that in case of *Pyrus communsis,* iron spray resulted greater fruit set and more firm fruits then unsprayed control. Patnaik *et al.* (1993) also found that soil application of iron ($FeSo_4$) followed by foliar spray thrice at weekly interval resulted in the highest fruit yield of *Hibiscus esculentus*.

Boron

During the present study, in *Hibiscus esculentus* best results for the mean shoot length (40.16cm) were observed when boron micronutrient was applied in the form of foliar spray ($T_1t_2BC_2$). Soil application ($T_3t_1BC_1$) or low concentration foliar spray ($T_1t_1BC_1$) produced non-significant effects.

Yadav *et al.*, (2001) evaluated the effects of different concentrations of boron on the vegetative growth of *Hibiscus esculentus* . They concluded that 1.0ppm boron in soil and foliar spray increased the fresh weight of the plants. During the present study different treatments of boron (as soil, soil plus foliar and foliar applications) produced significant effects on shoot and other parameters. In *Hibiscus esculentus* the maximum shoot fresh weight was 33.00g.

In *Hibiscus esculentus* the maximum shoot dry weight (5.3g) was obtained in case of $T_1t_2BC_2$. Rammah *et al.*, (1998) reported that on calcareous soil, the boron foliar spray and soil application increased the dry matter yield of alfalafa. Mawadi *et al.*, (1977) using a sand culture found that low concentration of B did increase the dry yield of alfalfa and its boron concentration. Bussler and Doring (1979) reported that the occurrence of significant concentration of boron in chloroplasts and they suggested a role of boron in photosynthesis which might have increased dry matter production.

In *Hibiscus esculentus* boron application did not produce any significant effects on number of secondary branches. The maximum weight of secondary branches was 5.00g. The treatment $T_3t_1BC_1$ & $T_0t_0BC_0$ produced the minimum weight of secondary branches 2.00 per plant.

Number of leaf per plant was also recorded. The maximum number of leaf per plant 15.00 was obtained in case of control, while minimum number of leaf was recorded in case of foliar treatment $T_1t_3BC_3$.

The findings related to number of secondary branches, number of leaf per plant is similar to the finding of Garg *et al.*, (1999), in case of soybean.

Number of floral branches was also recorded for *Hibiscus esculentus* plant. The maximum number of floral branches (3.667 per plant) was recorded for $T_1t_2BC_2$, while the minimum number of floral branches (2.00 per plant) recorded for soil application of boron ($T_3t_1BC_3$). The same results were obtained when these treatments were applied on tomato plant.

The maximum number of fruit per plant was recorded (6.33 per plant) in case of $T_1t_3BC_3$, while minimum number of fruits (3.15 per plant) was recorded in case of control. It has also good effects on the fruit length. The maximum fruit length (7.33 inches) was in case of $T_1t_1BC_1$ and the minimum fruit length was (4.667 inches) in case of control.

The results obtained with boron application may be correlated with the fact that Boron content through foliar application can be readily made available in requisite amount. However, the basal application may delay the availability of boron from the soil to the plant because it depends upon various soil and plant factors, such as soil, pH, temperature, water availability, differentiation of conducting tissue (Garg *et al.*, 1999). Boron application increased the crude protein %age, acid detergent fibers and hemicelluloses %age, hence caused increase in dry matter yield (Rammah *et al.*, 1984). Boron application improve maintenance of iron inactive form, improve nitrogen accumulates which can take part in chlorophyll, protein and enzyme synthesis and over all growth and sink development of plants. Boron as boric acid forms a polyhydroxy complex with sugar is more readily translocated through cellular membrane then the non borated sugar molecules (Dugger, 1983). Boron might affect the membrane transport properties, since it increases uptake of Nutrients (Muzafar, 1989). Boron deficiency reduced the chlorophyll content and photosynthetic activity of mustard plants. Higher chlorophyll and carotenoid contents in sunflower (Sharma and Rehmchandra., 1970; Stoyanov *et al.*, 1991) and sugar beet (Stratieva *et al.*, 1991) leaves have been observed by foliar spray of boron.

Zinc

Zinc shows certain positive effects on various study parameters of *Hibiscus esculentus* plant. ata presented in Table 4.4a showed the effects of zinc ($ZnSo_4$) on various study parameters of *Hibiscus esculentus* plant. Application of zinc showed

During the present studies in *Hibiscus esculentus*, the mean maximum shoot length (31.00cm) was recorded for foliar treatment $T_1t_1ZnC_1$, while the minimum shoot length was (18.67cm) obtained in case of T3t1ZnC1. According to Hatwar *et al.*, (2003) 0.1% Zinc sulfated was most effective, yielding the plant Height. Masud *et al.*, (1991) studied the effects of Zinc application on the growth and yield of Potato. They found that foliar spray of $ZnSo_4$ produced highest yield value.

From the present studies, it was observed that zinc application also increased the shoot dry weight. Maximum shoot dry weight (7.00g) in *Hibiscus esculentus* plant was obtained in case of $T_2t_1ZnC_1$. Kausar and Sharif reported that in case of maize plant dry matter increased remarkably due to applied Zn by all methods.

The number of secondary branches per plant in *Hibiscus esculentus* indicated that soil application of zinc followed by foliar spray ($T_1t_2ZnC_1$) produced significant effects and yielded maximum number of secondary braches (5.00 per plant). The soil treatment ($T_3t_1ZnC_1$) produced positive effects on number of secondary branches per plants. No exact previous report is available on the effects of Zn on the number of branches per plant

During the present studies number of leaf was also recorded for *Hibiscus esculentus*. Foliar treatment ($T_1t_1ZnC_1$) and soil plus foliar treatment ($T_2t_1ZnC_1$) produced the significant results. The treatment $T_1t_1ZnC_1$ produced maximum number of leaf (12.00 per plant) while minimum number of leaf (8.00 per plant) was recorded in case of $T_3t_1ZnC_1$.The comparison between the treatments showed that $T_1t_1ZnC_1$ and $T_2t_1ZnC_1$ differ significantly from rest of the treatments.

From the present study in *Hibiscus esculentus* plant, it is indicated that foliar treatment ($T_1t_1ZnC_1$) and soil plus foliar ($T_2t_1ZnC_1$) treatment produced significant number of floral branches (15.5 per plant). Minimum number of foliar branches (5.00 per plant) was recorded for soil treatment ($T_3t_1ZnC_1$). No previous report about the effects of zinc on number of floral branches for comparison is available

In *Hibiscus esculentus* present observation showed that soil plus foliar spray ($T_2t_1ZnC_1$) produced significant results 12.00 per plant while the soil treatment produced minimum number fruits (5.00 per plant) in case of $T_0t_0ZnC_0$.

The application of foliar fertilizer (zinc) during the periods of enhanced nutrients demand could allow for increased growth rate and yield (Garcia and Han-Way, 1976). Due to the efficiency and rapidity of uptake, foliar applied nutrients would be immediately available to the plant and would not be subject to the time delay or fixation processes associated with soil application. (Brady, 1994; Bukovac *et al.*, 1957). Zinc may be involved in the biosynthesis of plant auxin indole -3-acetic acid (Skoog, 1940). The synthesis of auxin might cause the significant response on growth and yield. Zinc participates in the metabolism of plants as an activator of several, enzymes, e.g carbonic acid anhydrase and alcohol dehydrogenase (Nason *et al.*, 1953; Hewitt *et al.*, 1950). Zinc may also act as an activator for some phosphate transferring enzyme, such as hexose kinase or triose phosphate dehydrogenase. Zinc also plays an important role in protein synthesis (Possingham, 1956).

Copper

Data presented in table 4a showed effect of copper on the growth and yield of *Hibiscus esculentus*. In *Hibiscus esculentus* plant all the treatments except control significantly affected the plant height. Maximum plant height was recorded when foliar plus soil treatment of Cu was applied. These results showed that Cu foliar application and Cu foliar plus soil application affects significantly the plant height. However Askari *et al.*, (1995) tested some commercial micronutrient preparation and found that plant height is significantly affected by foliar application of micronutrient preparations containing 50ppm and 10 ppm of copper.

During the present investigation the maximum shoot length (30.33g) was recorded in case of $T_2t_1CuC_1$ while the minimum shoot length (23.67g) was recorded in case of $T_0t_0CuC_0$.

During the present investigation shoot fresh and dry weight was also recorded for *Hibiscus esculentus*. The maximum shoot fresh weight (25.00g) was obtained in case of $T_1t_2CuC_2$ & $T_1t_3CuC_3$, while the minimum shoot fresh weight (14.00g) obtained in case of $T_3t_1CuC_1$. The maximum shoot dry weight was (6.00g) in case of $T_2t_1CuC_1$, while the minimum shoot dry weight (2.220g) in case of $T_3t_1CuC_1$. According to Yeong *et al.*, (2002) noted that fresh and dry weight of one cultivars of *Capsicum* is similar to that of control, while in other cultivars of capsicum fresh and dry weight signification higher in the treatment than in control as the seedling age increased.

The maximum number of secondary branches (4.000g) was obtained in case of $T_0t_0CuC_0$ while the minimum number of branches was (2.000g) obtained in case $T_3t_1CuC_1$. None of the treatment produced any significant effects. The maximum number of foliar branches (5.00) was recorded in case of $T_2t_1CuC_1$ and $T_1t_3CuC_3$. Minimum number of foliar branches (3.00) was recorded in case of $T_3t_1CuC_1$ and $T_1t_3CuC_3$.

In the present studies number of leaves per plant was also recorded. Foliar treatment $T_1t_2CuC_2$ produced maximum number of leaves (20.30g), while the minimum number of leaves (8.13g) was recorded in case of $T_3t_1CuC_1$. Yeong, *et al.*, (2002) noted that in early stage, number of leaves showed no significant difference but in later stage, number of leaves increased significantly, in two cultivars of capsicum.

Number of floral branches for *Hibiscus esculentus* was also recorded. Maximum number of floral branches (5.00) was recorded for treatment $T_2t_1CuC_1$ and $T_1t_3CuC_3$. Minimum foliar branches (3.00) were recorded in case of $T_3t_1CuC_1$ and $T_1t_3CuC_3$.

In *Hibiscus esculentus* mean values for number of fruits per plant, showed that foliar treatment $T_1t_3CuC_3$ affected positively as compare to control. Maximum number of fruits (7.234) was recorded in case of $T_1t_3CuC_3$ while minimum number of fruits (4.235) was recorded in case of control $T_0t_0CuC_0$.

Fruit length of *Hibiscus esculentus* plant was also significantly affected by copper application. Maximum fruit length was recorded for $T_1t_3CuC_3$ (7inches) while the control yielded minimum fruit length (2inches). The soil used during the present study was alkaline, calcareous, sandy and low in organic matter. In such soil, availability of copper is expected to be low for root absorption (Mortvedt *et al.* 1972). Copper is necessary for carbohydrate and nitrogen metabolism. Copper is also required for lignin synthesis (Mortvedt *et al.*, 1972). Copper is essential part of copper containing protein called plastocyanin that plays a significant role in electron transport chain during the process of photosynthesis. (Devlin and Witham, 1986). Copper also plays a significant role in chlorophyll synthesis, respiration and in protein metabolism (Ikhtiar *et al.*, 2002).

Molybdenum

During the present studies effects of Molybdenum on various study parameters of *Hibiscus esculentus* were recorded and showed in Table 4.6a effects of Mo on growth and yield of *Hibiscus esculentus*.

Results represented in Table 4.6a for tomato showed that soil application of molybdenum significantly affected the shoot length. Maximum shoot length (40.20cm) was recorded for soil treatment. This shoot length was recorded in case of $T_3t_1MoC_1$, while the minimum shoot length (18.67cm) was recorded in case of control.

During the present studies it was investigated that soil application of Mo also produced significant effects on shoot fresh weight (40.16g) which was maximum in case of $T_3t_1MoC_1$, while minimum shoot fresh weight (19.20g) was obtained in case of $T_0t_0MoC_0$. The maximum shoot dry weight (11.80g) was obtained in case of treatment $T_3t_1MoC_1$ and minimum shoot dry weight (5.20g) in case of control.

Table 4.6a showed that the application of Molybdenum did not produce any best effects on number of secondary branches.

The maximum number of leaf per plant (20.00g) was obtained in case of $T_3t_1MoC_1$ while the minimum number of leaf (8.00g) was recorded in case of $T_1t_3MoC_3$. It shows that the Mo application has good effects on the leaf in *Hibiscus esculentus* plant.

Table 4.6a showed that Mo application produced non-significant effect on number of floral branches. These results cannot be compared, as no previous record is available.

During the present studies all treatment produced positive effects on number of fruits per plant for *Hibiscus esculentus* except control. Maximum number of fruits (10.00) was recorded in case of $T_3t_1MoC_1$ & $T_3t_1MoC_1$ while minimum number (4.00) was recorded in case of $T_0t_0MoC_0$. Maximum significant fruit length was5.00 inch),while minimum fruit length .Askari *et al.*, (1995) noted that foliar application of micronutrients preparation containing 40ppm Mo, significantly increased the number of fruits per plant in chili and egg plant.

Jablonski *et al.*, (1985) reported that low temperature, anaerobic condition and various inhibitors of oxidative phosphorylation decreased the absorption of Mo, suggesting that the absorption of Mo was metabolism-dependent. Molybdenum depressed the yield and nitrogen uptake of Berseem, might be due to its higher contents in the soils used. Phosphors, potassium and molybdenum have some antagonistic effected, which may be due to nutrition imbalance (Ranjha, 1989). Cabbage head weight increased with gradual increase of Mo above 1.5Kg/ha up to 2.0Kg/ha. There was no increase of head weight after 2.0Kg/ha (NARC annual report 1999/2000).

Results obtained with Mo application on the growth and yield could be due to its beneficial effect on nitrate-reductase. Mo is metabolic co-factor for nitrate-reductase enzyme protein and helps in transfer of electron from NADH to nitrate for its reduction to nitrite (Devlin and Witham, 1986). It has been reported that increasing levels of sulfur depresses Mo uptake by the plants (Stout *et al.*, 1950; Pasricha *et al.*, 1977; Guyette *et al.*, 1989). Soil used during the present studies might be deficient of Mo and high in sulfur. When Mo applied in the soils or sprayed on leaves it produced positive effect on growth and yield.

Manganese

The table 4.7a showed that the effects of Manganese on the growth and yield of *Hibiscus esculentus* plant.

During the present studies best results for mean shoot length (35.30cm) of *Hibiscus esculentus* were observed for foliar treatment $T_3t_1MnC_1$, while the minimum shoot length (23.67cm) was observed in case of control. However, Jamaro *et al.*, (2002) observed that foliar application of Mn (1.00, 2.00 and 3.00kg/ha) significantly effected stem height, in case of sugarcane.

In *Hibiscus esculentus* the maximum shoot fresh weight (33.65g) was recorded for foliar treatment $T_1t_2MnC_2$, while minimum shoot fresh weight (23.67cm) was produced in case of control ($T_0t_0MnC_0$). However, Jamro *et al.*, (2002) observed that foliar Mn application significantly effected sugarcane top fresh weight.

Foliar treatment $T_1t_2MnC_2$ yielded maximum significant shoot dry weight (10.12g) for *Hibiscus esculentus* plant, while soil treatment produced the minimum shoot dry weight (4.00g) in case of $T_3t_1MnC_1$. In lady finger all foliar treatments produced significant effects on shoot dry weight, while control, soil and foliar plus soil treatments showed similar results approximately.

This study reveals that all the treatments produced approximately similar number of secondary branches except $T_1t_1MnC_1$. There is no significant difference among all the treatments. No previous record is available to compare the observations.

Number of leaf per plant for *Hibiscus esculentus* was also recorded. Table 4.7a showed that Manganese foliar treatment $T_1t_2MnC_2$ produced maximum number of leaf (25.00g) while minimum number of leaf was (13.00g) was recorded in case of $T_3t_1MnC_1$.

In *Hibiscus esculentus* maximum number of floral branches (5.16 per plant) was recorded in case of $T_1t_2MnC_2$ while minimum number of floral branches (2.15 per plant) in case of $T_3t_1MnC_1$.

While taking mean values for number of fruits, the maximum number of fruit (4.00) was recorded in case of $T_1t_1MnC_1$ while minimum number of fruit (2.16) was recorded in case of $T_2t_1MnC_1$. However Askari *et al.*, (1995) noted that foliar micronutrient preparation containing Mn (500ppm) significantly increased the fruit of chili and egg plant. During the present studies, fruit length was also recorded.The maximum fruit length (7.00 inches) was obtained in case of treatment $T_1t_3MnC_3$, while the minimum fruit length obtained (3.00inches) during the control.

The results obtained with Mn application may be co-related with the fact that physio-chemical nature of the soil used during the present study seems to be main reason for positive response of Mn on the growth and yield of *Hibiscus esculentus* plants. The sandy calcareous soil and low organic matter reduce Mn uptake of plant. Mn unavailability seemed to be corrected by foliar application (Mortvedt *et al.*, 1972). To yield maximum response, for a nutrient element, its critical level, its physiological equilibrium with other element, and binary ratios of leaf levels are accepted to be important (Guzamn and Romero, 1986). The combine role of Mn and Fe are much more important then their individual roles. Fe/Mn ratios of 1.5-2.5 is required for the normal growth of plants. Similarly, the application of Fe and Mn along with different levels of Phosphorous has variable effects on yield, plant height and number of tillers of wheat (Alam, 1982).

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