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Impact of foliar spray of micronutrients on mulberry (Var. Goshoerami) growth parameters

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Abstract
Investigation on "Effect of foliar spray of micro-nutrients on the growth of mulberry and its impact on the silkworm, *Bombyx mori* L. rearing" was carried at the experimental farm of College of Temperate Sericulture, Mirgund SKUAST-Kashmir, which is located at 340.17N latitude and 74^0.17E longitude at an altitude of 1585 meters above mean sea level. Goshoerami variety was taken as mulberry variety. The present investigation was carried with two experiments, "Influence of foliar spray on mulberry qualitative and quantitative parameters with Randomized Block Design (RBD)" and "Influence of foliar spray on silkworm rearing and cocoon parameters with Complete Randomized Design (CRD)", during 2017 and 2018 with 17 different treatments including one control, where no micronutrient spray was used. Foliar spray of liquid formulations was done twice, first on 30th day after sprouting/pruning of mulberry and second 15 days after first spray at the rate of 600 litres of formulation/hectare/spray. Rearing was conducted as usual up to 3rd stage. From day 1st of 4th age up to Seri-position the worms were reared on treated leaves as per the experiment details. Iron sulphate, zinc sulphate, manganese sulphate and copper sulphate were used as foliar sprays for supplementing Fe, Zn, Mn and Cu respectively. Iron, zinc, manganese and copper was sprayed at 4 different concentrations each *viz*., 0.1%, 0.2%, 0.3% and 0.4%. Maximum values for length of longest branch, average branch length, number of leaves per plant, fresh weight of 100 leaves, leaf yield, moisture content and crude protein content (120.118 cm), (102.890 cm), (1022.160), (439.117 g), (4.957 kg), (78.653%) and (17.719%) during spring and (123.333 cm),(105.333 cm), (785.452), (596.550 g), (5.216 kg), (76.060%) and (16.072%) during autumn, were recorded in T_{12}(Mn@04%) respectively. Higher content of iron (254.140 ppm), zinc (32.950ppm), manganese (104.825 ppm) and copper (16.245ppm) in mulberry leaves were recorded in treatments with higher levels of foliar spray *viz*., T_4=Fe@0.4%, T_8=Zn@0.4%, T_{12}=Mn@0.4% and T_{16}=Cu@0.4% respectively. Silkworm larvae were fed on treated leaf and all biological and economic parameters were recorded. Results obtained indicated that foliar spray of Fe, Zn, Mn and Cu had a significant effect on many rearing parameters. Supplementing leaf with Fe, Zn, Mn and Cu through foliar spray had a significant effect on many mulberry and rearing parameters. Foliar spray of T_{12}=Mn@04% had resulted in increased leaf yield and improvement in rearing parameters, suggesting the need for use of manganese @ 0.4% in conjunction could pave way for increased cocoon crop.

Keywords: Foliar spray, nutrients, rearing, yield, *Bombyx mori*

Introduction
Sericulture is an art of rearing silkworms for production of Silk cocoons which serves as the basic raw material for the production of silk- the natural fiber (Kamili and Masoodi, 2000) [12]. The silk cocoon production is the most important source for sericulture farmers and industries income. The global raw silk production accounts for 91,221 MT (International sericulture commission, 2022) [1-2]. China is the largest producer of raw silk with a production of 50,000 MT followed by India with raw silk production of 34,903 MT, the Second largest producer of silk in the World (International sericulture commission, 2022) [1-2]. Mulberry silk accounts for 95% of the total world silk production and about 87% of Indian silk production (Misra, 2000) [16]. Being an agro-based industry, Sericulture suits to rural-based farmers, entrepreneurs, and artisans and requires low investment.

Under tropical conditions of India, sericulture is practiced throughout the year by harvesting as many as five to six crops; whereas, in temperate areas only one rearing is practiced under natural conditions in a year. Jammu and Kashmir (UT)is the only traditional bivoltine/univoltine belt in the country, which because of salubrious climatic conditions for silkworm rearing is in a position to produce quality bivoltine silk (Tazima, 1958) [32]. Over 80% of the population of J & K depends, directly or indirectly on agriculture.

Mulberry (*Morus* spp.) is a perennial and high biomass producing plant and continuous production of mulberry for a long-time results in gradual reduction in leaf yield and quality (Rashmi *et al*., 2009) [22] which needs to be restored through supplementation of nutrient. Supply of all essential nutrients to mulberry plantation in adequate quantities depends on the soil fertility status (Bongale *et al*., 2003) [3]. Therefore, all the essential nutrients, primary (NPK), secondary (S, Ca, and Mg) or micronutrients (Zn, Mn, Cu, Fe, B, Mo) must be available to the crop in adequate quantities (Singhvi *et al*., 2006) [29]. Micronutrients plays an important role in ROS detoxification because they activate the enzymes which act as ROS scavengers like Ascorbate peroxidase (APX), Superoxide dismutase (SOD), Catalase (CAT) and Peroxidase (POD) (Kumar *et al*., 2008) [12]. Micronutrients play a significant role in Plant growth, Photosynthesis, Chlorophyll formation, cell wall development, resistance to plant diseases and nitrogen fixation (Vitti *et al*. 2014) [33]. They also play an important role in enzymatic reactions and important for activities of soil microorganisms (Noor-Ul-Din 2012) [20].

Micronutrients are important like macronutrients as each micronutrient plays a significant specific role in physiological and biochemical processes of mulberry (Gowda *et al*., 2000) [9]. Fortification of mulberry leaves with supplementary nutrient (Muniandy *et al.*, 2001) [17] and feeding silkworms is a useful modern technique to increase economic value of cocoon. Foliar sprays minimize wastage and the quantity to be sprayed is fairly a fraction of what be required for soil application. Foliar application of micronutrients reportedly improves the yield, quality and micronutrient status of mulberry leaf (Dhiraj and Kumar, 2011) [6] as well as the quantitative traits of silkworm (Bose and Majumder, 1996) [5].

During the last two decades studies on foliar nutrition has received considerable attention especially in agriculture, horticulture and other foliage crops and beneficial effects from foliar sprays of nutrients were well established (Narahari Rao *et al.*, 2001) [18]. Effects of foliar fertilization include yield increases, resistance to disorder and insect pests, improved drought tolerance and plant growth (Sebastian and Christopher, 2007) [25].

Micronutrients in general, zinc and iron in particular stimulate the metabolic activity in silkworm leading to improved rearing performance, silk content and higher fecundity rate (Bose *et al*., 1995) [4]. Among micronutrients feeding of zinc and iron enriched mulberry leaves to silkworms increases the fecundity of silk moths significantly (Shankar *et al*., 1996) [27]. Because of co-factor functions, iron (Nichol *et al*., 2002) [19] and zinc are considered as having almost universal importance to insects in general. Mn is necessary for metabolic activities, among the micronutrients, Mn and Zn are important for normal growth of the plants. Manganese serves as an activator for enzymes in growth processes. Manganese (Mn) is essential for the synthesis of chlorophyll. It is not mobile and its principal function is to activate some of the enzyme systems in plant physiology and to some extent regulation of Fe metabolism, in addition, it has a close relation with N metabolism (protein), assimilation of carbohydrates and formation of vitamin C. It is involved in oxidation reduction processes and electron transport system (Shankar 1997) [26]. Cu may interfere with many physiological processes such as photosynthesis, pigment synthesis, oxidative stress response, nitrogen and protein metabolism and mineral uptake.

Although considerable work has been done in India on the supplementation of micro nutrients through foliar application under tropical conditions and under Kashmir climatic conditions some work has also been done on foliar spray of N, P, Ca and Mg (Saquib, 2015 and Sheetal *et al*., 2016) [24, 28], which has resulted in improvement of most mulberry and cocoon parameters. Keeping in view the importance and impact of foliar spray of micronutrients on leaf quality and economic traits of *Bombyx mori* L. the present study was taken to generate information about leaf quality improvement through foliar leaf supplementation for successful cocoon production in Kashmir valley.

Materials and Methods

The present investigation "Effect of foliar spray of micro-nutrients on the growth of mulberry and its impact on the silkworm, *Bombyx mori* L. rearing" was carried out at the experimental farm of College of Temperate Sericulture, SKUAST-Kashmir, Mirgund (located at 34°.17N latitude, 74°.17E longitude and at an altitude of 1585 meters above mean sea level) during the year 2017 and 2018. Chemo-assay of the mulberry genotype was carried out at the Division of Soil Science FoA, Wadura, SKUAST-K Shalimar. The material and methods used for the study are presented under the following heads.

a) Mulberry variety

Established 20 year old mulberry plantation of Goshoerami (the most popular variety of mulberry used for commercial rearing in the region) with uniform growth and vigour was used for the study. The plantation was maintained as dwarf at 6´x 6´ spacing. FYM was applied @20MT ha^{-1} in winter on 1st of January. Cultural operations were followed as per the package of practices recommended by the College of Temperate Sericulture, Mirgund.

b) Climate

The climate is Temperate-cum-Mediterranean and of continental type characterized with marked seasonality. The region falls into mid to high altitude temperate zones which are characterized by a sub-microthermic regime where winter is severe extending from 15th December up to mid of March. During winter the valley remains almost covered with snow and temperature often goes below the freezing point.

c) Foliar spray

Foliar spray of liquid formulations was done on 30th day after pruning/sprouting of mulberry at the rate of 600 litres of formulation/ hectare/spray. Iron sulphate, zinc sulphate, manganese sulphate and copper sulphate was used as foliar sprays for supplementing Fe, Zn, Mn and Cu respectively.

d) Pruning

Pruning of the mulberry plants was done only once in a year, in the first week of June, corresponding with the end of spring rearing by resorting to basal pruning.

Treatment details
T_1 = Fe @ 0.1%
T_2 = Fe @ 0.2%
T_3 = Fe @ 0.3%
T_4 = Fe @ 0.4%
T_5 = Zn @ 0.1%
T_6 = Zn @ 0.2%
T_7 = Zn @ 0.3%
T_8 = Zn @ 0.4%
T_9 = Mn @ 0.1%
T_{10} = Mn @ 0.2%
T_{11} = Mn @ 0.3%
T_{12} = Mn @ 0.4%
T_{13} = Cu @ 0.1%
T_{14} = Cu @ 0.2%
T_{15} = Cu @ 0.3%
T_{16} = Cu @ 0.4%
T_{17} = No spray (CONTROL)

e) Foliar spray
Preparation of spray formulation
Stock solution for Fe, Zn, Mn and Cu were prepared separately as:

Iron
24.8, 49.6, 74.4 and 99.20 g of $FeSo_4$ were dissolved in 5 litres of distilled water to get 0.1%, 0.2%, 0.3% and 0.4% solution of Fe respectively.

Zinc
22.10, 44.20, 66.30 and 88.40 g of $ZnSo_4$ were dissolved in 5 litres of distilled water to get 0.1%, 0.2%, 0.3% and 0.4% solution of Zn respectively.

Manganese
15.36, 30.70, 46.05 and 61.40g of $MnSo_4$ were dissolved in 5 litres of distilled water to get 0.1%, 0.2%, 0.3% and 0.4% solution of Mn respectively.

Copper
19.64, 39.25, 58.90 and 78.55g of $CuSo_4$ were dissolved in 5 litres of distilled water to get 0.1%, 0.2%, 0.3% and 0.4% solution of Cu respectively.

Spraying of formulations
Foliar spray of liquid formulations was done twice. First spray was done on 30th day after pruning of mulberry (June pruned) and second after 15 days of first spray at the rate of 600 litres of formulation/hectare/spray. The formulations were sprayed during the morning hours of the day.

d) Silkworm rearing
Rearing was conducted during 2017 and 2018 as per the package of practices recommended by the College of Temperate Sericulture, Mirgund. Rearing was conducted as usual up to 3rd stage. From day 1st of 4th age up to seriposition the worms were reared on treated leaves as per the experiment details.

Experimental details
Influence of foliar spray on mulberry qualitative and quantitative parameters of mulberry leaf
Design of experiment: Randomized Block Design (RBD)
Mulberry variety: Goshoerami
Number of treatment: 17
Number of replication: 03
No. of plants/treatment/replication: 05

Mulberry growth parameters
1. **Length of the longest branch (cm)**
   Length of the longest branch from three plants was recorded by taking the length of longest branch after measuring all the branches by means of a measuring tape.
2. **Average branch length (cm)**
   Average branch length was calculated by measuring all the branches of three plants using a measuring tape and mean were calculated and taken as average branch length.
3. **Total shoot length (cm)**
   Total shoot length was calculated by measuring all the branches of three plants in each replication using a measuring tape and subsequent mean were taken as total shoot length.
4. **Number of branches per plant**
   The numbers of branches per plant in three plants was counted and mean per plant were calculated by using the formula.

$$\text{Number of branches per plant} = \frac{\text{Total branches in three plants}}{\text{Total no of plants taken (3)}}$$

Statistical analysis
The statistical analysis of the data was done by developing ANOVA for comparison of different treatment means by least significant difference (Gomez and Gomez, 1984) [8]. The correlation among different parameters was worked out by using Karl Pearson's Co-efficient of Correlation (Draper and Smith, 1981) [7]. The statistical software, OP STAT and SPSS, were used for the purpose.

Results
Length of longest branch
Data pertaining to the length of longest branch during spring season is presented in Table-1 and illustrated in Fig. 1 and 2.

A) As influenced by season
Highest length of longest branch of 120.118cm was recorded in T_{12} which was significantly different from rest of treatments. T_{11} with length of longest branch of 117.421cm ranked 2nd was in turn at par with T_4 with value of 117.330cm. T_3 with length of longest branch of 115.195cm ranked 3rd and was at par with T_{10} and T_6 with values of 115.021 and 113.312cm respectively. T_5 with length of longest branch of 112.632cm ranked 4th which was significantly different from rest of treatments. T_7 with length of longest branch of 110.242cm ranked 5th and was at par with T_9, T_2 and T_8 with values of 109.631, 109.120 and 109.023cm respectively.
T_{13} with length of longest branch of 105.244cm ranked 6th and was at par with T_1 with value of 103.990cm. T_{14} with length of longest branch of 102.930cm ranked 7th and was at par with T_{15} with value of 101.200cm. Least length of longest branch of 99.233cm was recorded in control.

B) As influenced by concentration
1. **Influence of Iron**
   Length of longest branch recorded increase with increase in concentration from 0.1% to 0.4% and highest branch length of 117.330cm was recorded concentration of 0.4%.

2. **Influence of Zinc**
   Highest Length of 113.312cm was recorded with 0.2% concentration and further increase in concentration resulted in decrease in length of longest branch.
3. **Influence of Manganese**
   Increase in concentration of manganese as foliar spray resulted in increase in Length of longest branch and highest Length of longest branch of 120.118cm was recorded with 0.4% concentration.
4. **Influence of Copper**
   Higher Length of longest branch of 105.244cmwas recorded with 0.1% concentration and further increase in concentration resulted in decrease in Length of longest branch.

Improvement in Length of longest branch over control

Perusal of data (Table-1) reveal that T_{12}, T_{11}, and T_4 with length of longest branch of 120.118, 117.421 and 117.330cm revealed an increase of 21.05%, 18.33% and 18.24% respectively over control.

Average branch length

Data pertaining to the average branch length during spring season is presented in Table-1 and illustrated in Fig. 3 and 4.

A) As influenced by season

Highest average branch length of 102.890cm was recorded in T_{12} which was at par with T_4, T_6 and T_{11} recording, average branch length of 102.410, 102.123 and 100.921cm respectively. T_{10} with average branch length of 100.395cm ranked 2ndand was in turn at par with T_7, T_3 and T_8 with values of 100.100, 98.220 and 98.150cm. T_9 with average branch length of 98.000cm ranked 3rdand was at par with T_2, T_1 and T_5 with values of 97.800, 96.821 and 96.000cm respectively. T_{13} with average branch length of 94.102cm ranked 4th was in turn at par with T_{14}, T_{15}, T_{16} and T_{17} with values of 94.000, 93.921, 93.410 and 93.200cm respectively

B) As influenced by concentration

1. **Influence of Iron:** Average branch length recorded increase with increase in concentration from 0.1% to 0.4% and highest average branch length of 102.410cm was recorded concentration of 0.4%.
2. **Influence of Zinc:** Highest average branch length of 102.123cm was recorded with 0.2% concentration and further increase in concentration resulted in decrease in average branch length.
3. **Influence of Manganese:** Increase in concentration of manganese as foliar spray resulted in increase in average branch length and highest average branch length of 102.890cm was recorded with 0.4% concentration.
4. **Influence of Copper:** Higher average branch length of 94.102cm was recorded with 0.1% concentration and further increase in concentration resulted in decrease in Average branch length.

Improvement in Average branch length over control

Perusal of data (Table-1) reveal that T_{12}, T_4, and T_6 with average branch length of 102.890, 102.410 and 102.123cm revealed an increase of 10.39%, 9.88% and 9.75% respectively over control.

Table 1: Influence of foliar spray of micro nutrients on growth parameters of mulberry variety Goshoerami during spring season

Treatments	Length of longest branch(cm)	Percent increase in length of longest branch over control	Average branch length(cm)	Percent increase in Av. branch length over control
T_1 =Fe@ 0.1%	103.990	4.79	96.821	3.88
T_2 =Fe@ 0.2%	109.120	9.96	97.800	4.93
T_3 =Fe@ 0.3%	115.195	16.09	98.220	5.38
T_4=Fe@ 0.4%	117.330	18.24	102.410	9.88
T_5 =Zn@ 0.1%	112.632	13.50	96.000	3.00
T_6 =Zn@ 0.2%	113.312	14.19	102.123	9.75
T_7 =Zn@ 0.3%	110.242	11.09	100.100	7.40
T_8=Zn@ 0.4%	109.023	9.87	98.150	5.31
T_9 =Mn@ 0.1%	109.631	10.48	98.000	5.15
T_{10} =Mn @ 0.2%	115.021	15.91	100.395	7.72
T_{11} =Mn @ 0.3%	117.421	18.33	100.921	8.28
T_{12}=Mn @ 0.4%	120.118	21.05	102.890	10.39
T_{13} =Cu@ 0.1%	105.244	6.06	94.102	0.97
T_{14} =Cu @ 0.2%	102.930	3.73	94.000	0.86
T_{15} =Cu @ 0.3%	101.200	1.98	93.921	0.77
T_{16}=Cu @ 0.4%	99.422	0.19	93.410	0.22
T_{17}= Control	99.233		93.200	
CD ($p \leq 0.05$))	1.984		2.339	

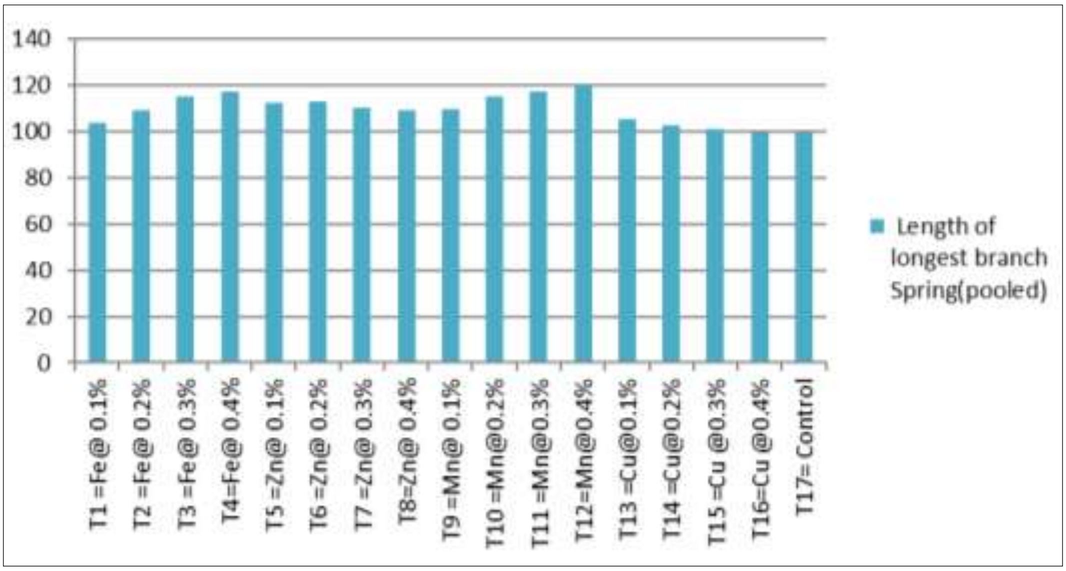

Fig 1: Influence of micronutrients on length of longest branch (cm)

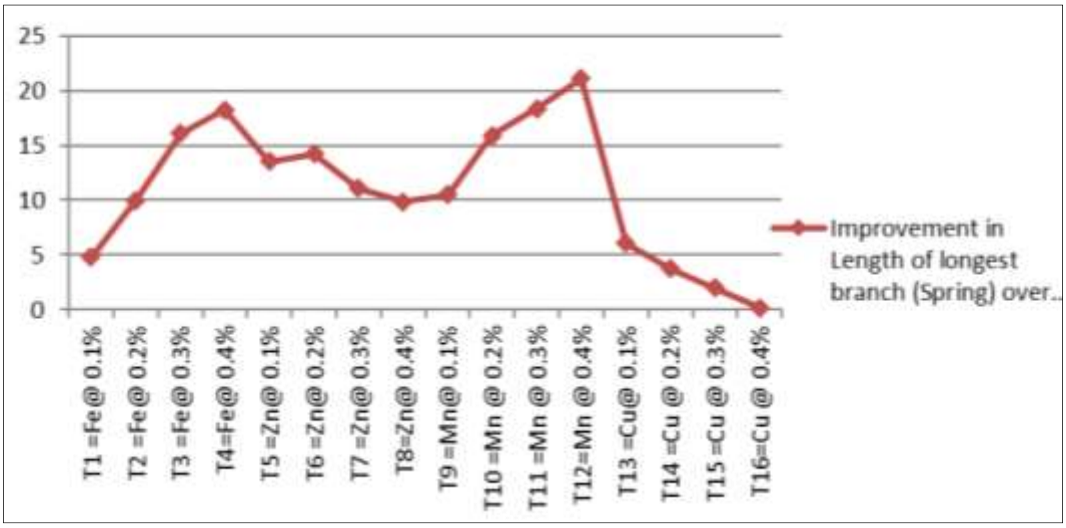

Fig 2: Improvement in length of longest branch over control (%)

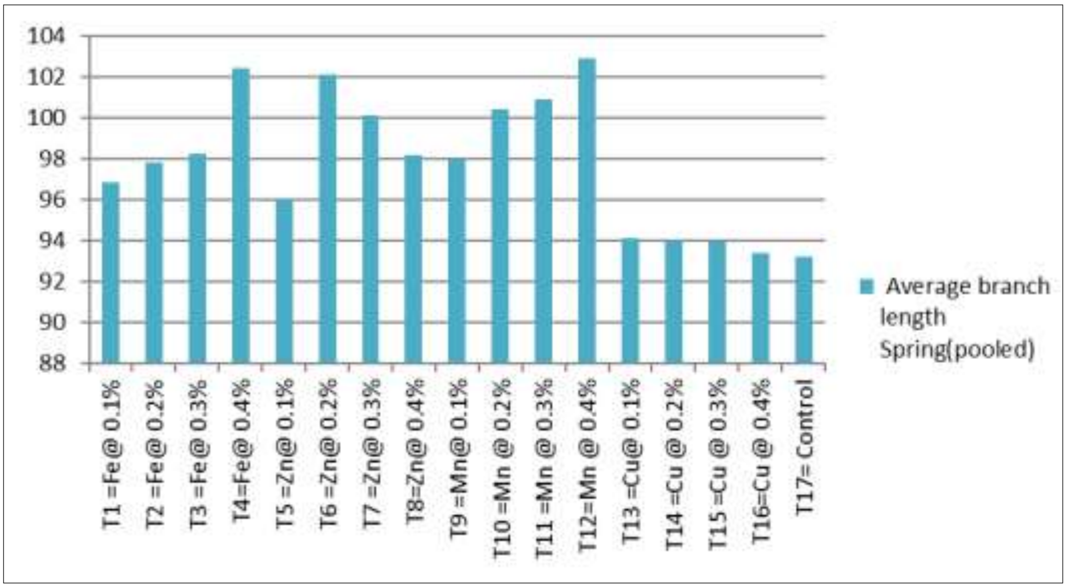

Fig 3: Influence of micronutrients on average branch length (cm)

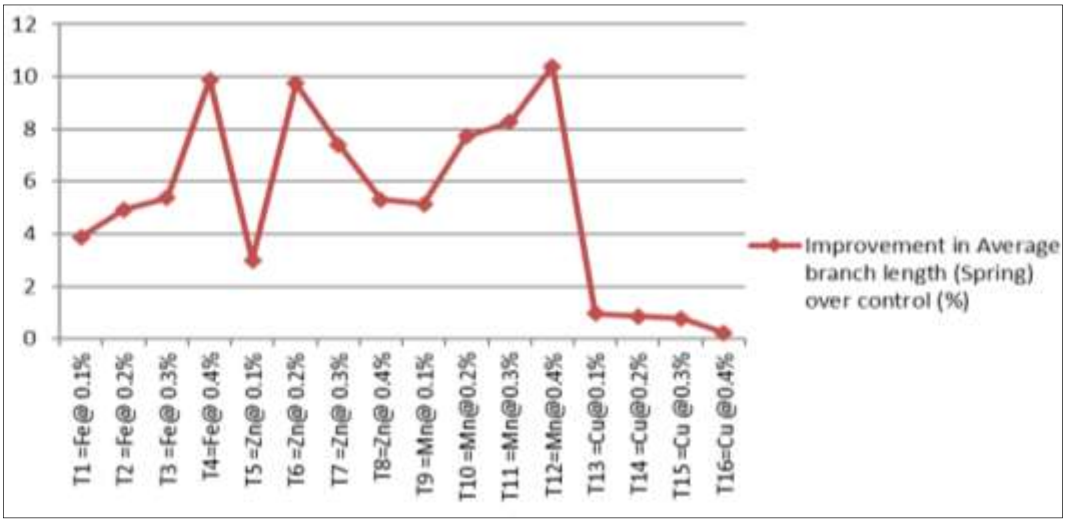

Fig 4: Improvement in average branch length over control

Length of longest branch

Data pertaining to the length of longest branch during autumn season is presented in Table-2 and illustrated in Fig. 5 and 6.

A) As influenced by season

Highest length of longest branch of 123.333cm was recorded in T_{12} which was significantly different from rest of treatments.$T_{11}$with length of longest branch of 120.833cm ranked 2nd which was significantly different from rest of treatments. T_4 with length of longest branch of 119.000cm ranked 3rd and was at par with T_3 with value of 118.000cm.T_{10} with length of longest branch of 116.667cm ranked 4th which was at par with T_6 with value of 115.667cm. T_5 with length of longest branch of 113.500cm ranked 5th and was at par with T_7 with value of 112.167cm. $T_9$with length of longest branch of 111.667cm ranked 6th and was at par with T_2 and T_8 with values of 111.333 and 111.167cm respectively. T_{13} with length of longest branch of 107.667cm ranked 7th and was at par with T_1 with value of 106.167cm. T_{14} with length of longest branch of 105.333cm ranked 8th and was at par with T_{15} with value of 103.500cm. Least length of longest branch of 101.000cm was recorded in control.

B) As influenced by concentration

1. **Influence of Iron:** Length of longest branch recorded increase in length of longest branch with increase in concentration and highest length of longest branch of 119.000cm was recorded at 0.4% concentration.
2. **Influence of Zinc:** Higher length of longest branch of 115.667cm was recorded with 0.2% concentration and further increase in concentration resulted in decrease in length of longest branch.
3. **Influence of Manganese:** Increase in concentration resulted in increase in length of longest branch and highest length of longest branch of 123.333cm was recorded with concentration of 0.4%.
4. **Influence of Copper:** Highest length of longest branch of 107.667cm was recorded with 0.1% concentration and further increase in concentration resulted in decrease in length of longest branch.

Improvement in Length of longest branch over control

Perusal of data (Table-2) reveal that T_{12}, T_{11}, and T_4 with length of longest branch 123.333, 120.833 and 119.000cm recorded an increase of 22.11%, 19.64% and 17.82% respectively over control.

Average branch length

Data pertaining to the average branch length during autumn season is presented in Table-2 and illustrated in Fig. 7 and 8.

A) As influenced by season

Highest length of longest branch of 105.333cm was recorded in T_{12} which was in turn at par with T_6, T_4, T_{11} and T_5 with values of 104.267, 104.033, 103.997 and 103.133cm respectively. T_{10} with average branch length of 102.700cm ranked 2ndand was in turn at par with T_7, T_3 and T_8 with values of 102.234, 101.667 and 101.134cm respectively. T_9 with average branch length of 99.300cm ranked 3rd and was in turn at par with T_2, T_1, $T_{13,}$ T_{14}, $T_{15,}$ T_{16} and T_{17} with values of 99.233, 98.900, 97.500, 97.313, 97.200, 97.110 and 97.000cm respectively.

B) As influenced by concentration

1. **Influence of Iron:** Average branch length recorded increase with increase in concentration and highest average branch length of 104.033cm was recorded at 0.4% concentration.
2. **Influence of Zinc:** Higher average branch length of 104.267cm was recorded with 0.2% concentration and further increase in concentration resulted in decrease in average branch length.
3. **Influence of Manganese:** Increase in concentration resulted in increase in average branch length and highest average branch length of 105.333cm was recorded with concentration of 0.4%.
4. **Influence of Copper:** Highest average branch length of 97.500cm was recorded with 0.1% concentration and further increase in concentration resulted in decrease in average branch length.

Improvement in Average branch length over control

Perusal of data (Table-2) reveal that T_{12}, T_6, and T_4 with average branch length of 105.333, 104.267 and 104.033cm recorded an increase of 8.59%, 7.49% and 7.25% respectively.

Table 2: Influence of foliar spray of micro nutrients on growth parameters of mulberry variety Goshoerami during autumn season

Treatments	Length of longest branch(cm)	Percent increase in length of longest branch over control	Average branch length(cm)	Percent increase in Av. branch length over control
T_1 =Fe@ 0.1%	106.167	5.12	98.900	1.96
T_2 =Fe@ 0.2%	111.333	10.23	99.233	2.30
T_3 =Fe@ 0.3%	118.000	16.83	101.667	4.81
T_4=Fe@ 0.4%	119.000	17.82	104.033	7.25
T_5 =Zn@ 0.1%	113.500	12.38	103.133	6.32
T_6 =Zn@ 0.2%	115.667	14.52	104.267	7.49
T_7 =Zn@ 0.3%	112.167	11.06	102.234	5.40
T_8=Zn@ 0.4%	111.167	10.07	101.134	4.26
T_9 =Mn@ 0.1%	111.667	10.56	99.300	2.37
T_{10} =Mn @ 0.2%	116.667	15.51	102.700	5.88
T_{11} =Mn @ 0.3%	120.833	19.64	103.997	7.21
T_{12}=Mn @ 0.4%	123.333	22.11	105.333	8.59
T_{13} =Cu@ 0.1%	107.667	6.60	97.500	0.52
T_{14} =Cu @ 0.2%	105.333	4.29	97.313	0.32
T_{15} =Cu @ 0.3%	103.500	2.48	97.200	0.21
T_{16}=Cu @ 0.4%	101.670	0.66	97.110	0.11
T_{17}= Control	101.000		97.000	
CD($p \leq 0.05$))			2.317	

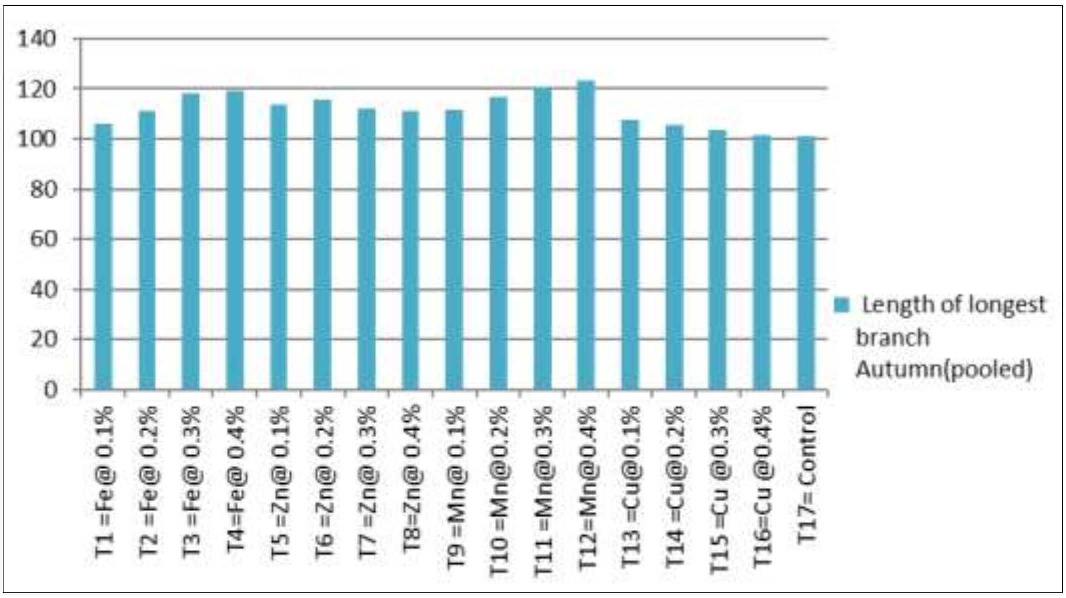

Fig 5: Influence of micronutrients on length of longest branch (cm)

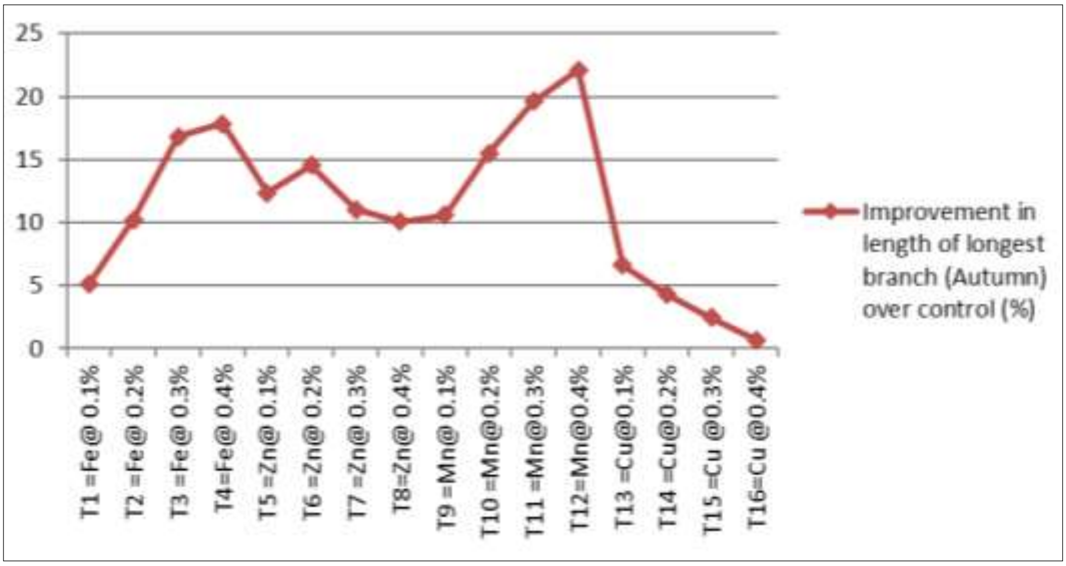

Fig 6: Improvement in length of longest branch over control

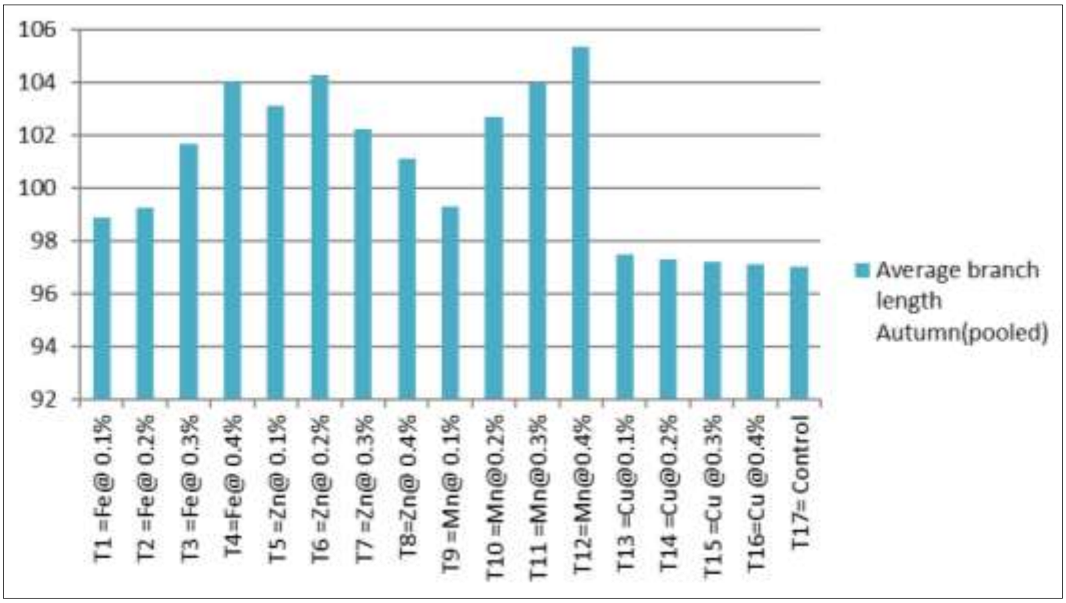

Fig 7: Influence of micronutrients on average branch length (cm)

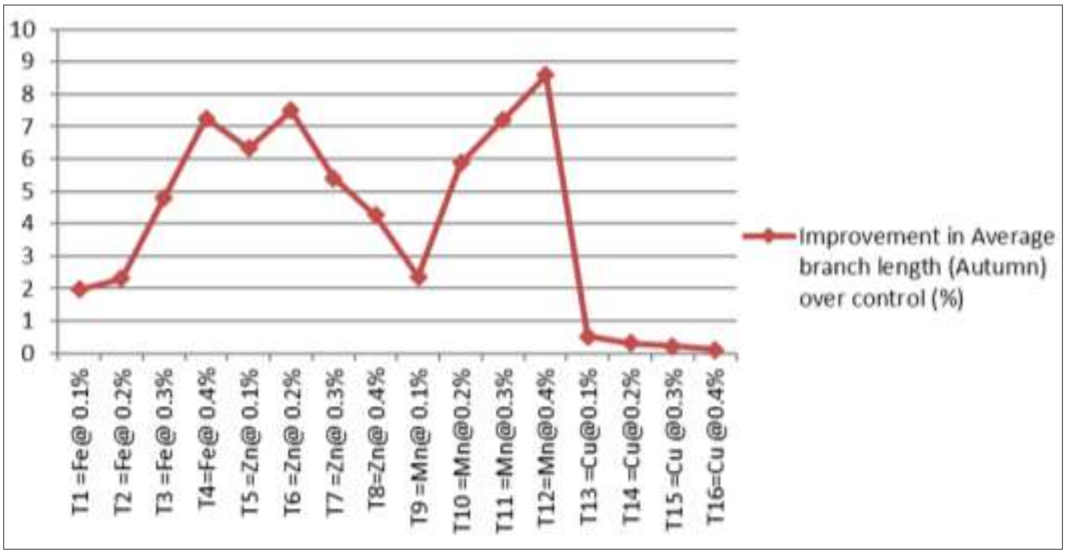

Fig 8: Improvement in average branch length over control (%)

No of branches/plant

Data pertaining to the number of branches per plant during spring season is presented in Table-3 and illustrated in Fig. 9.

Observations recorded revealed that treatments had no significant effect on the no of branches/plant. However, maximum no of branches/plant was recorded in T_9(30.833) and minimum no of branches/plant was recorded in T_5(28.833).

Total shoot length

Data pertaining to total shoot length during spring season is presented in Table-3 and illustrated in Fig. 10.

Observations recorded revealed that treatments had no significant effect on the total shoot length. However, maximum total shoot length was recorded in T_{12} (52.59m) and minimum total shoot length was recorded in T_{17} (47.11m).

Table 3: Influence of foliar spray of micro nutrients on growth parameters of mulberry variety Goshoerami during spring season

Treatments	No of branches/plant	Total shoot length(m)
T_1 =Fe@ 0.1%	29.000	47.88
T_2 =Fe@ 0.2%	28.999	47.99
T_3 =Fe@ 0.3%	29.000	49.88
T_4=Fe@ 0.4%	29.999	52.28
T_5 =Zn@ 0.1%	28.833	48.02
T_6 =Zn@ 0.2%	29.333	51.58
T_7 =Zn@ 0.3%	29.833	50.88
T_8=Zn@ 0.4%	28.999	48.52
T_9 =Mn@ 0.1%	30.833	48.61
T_{10} =Mn @ 0.2%	30.333	50.36
T_{11} =Mn @ 0.3%	29.999	51.59
T_{12}=Mn @ 0.4%	30.000	52.59

T_{13} =Cu@ 0.1%	30.666	50.79
T_{14} =Cu @ 0.2%	30.166	49.76
T_{15} =Cu @ 0.3%	29.333	47.74
T_{16}=Cu @ 0.4%	29.166	47.42
T_{17}= Control	29.166	47.11
CD($p \leq 0.05$))	NS	NS

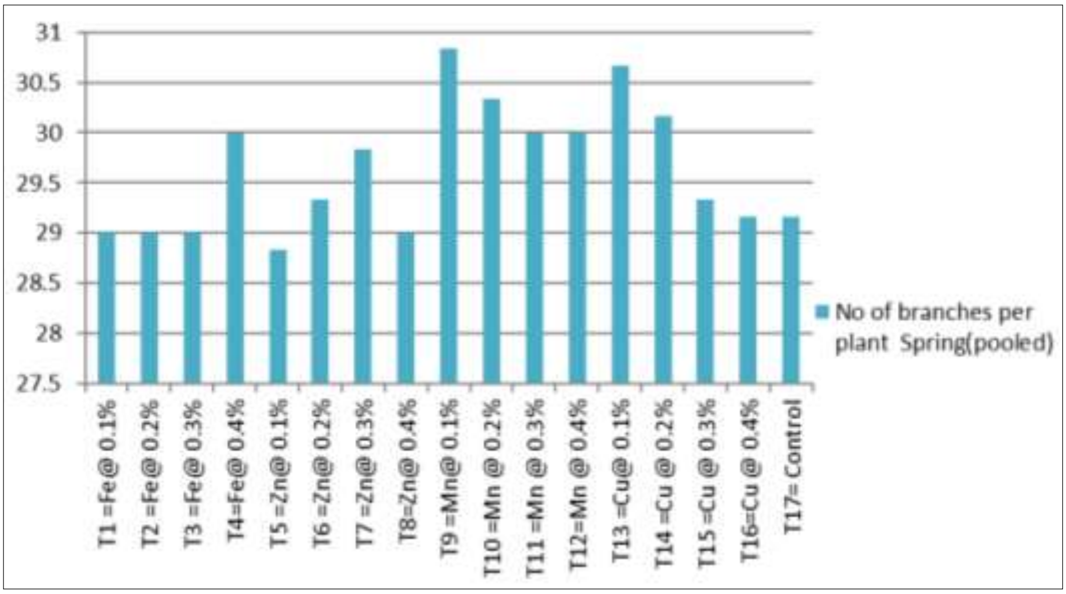

Fig 9: Influence of micronutrients on no of branches/plant

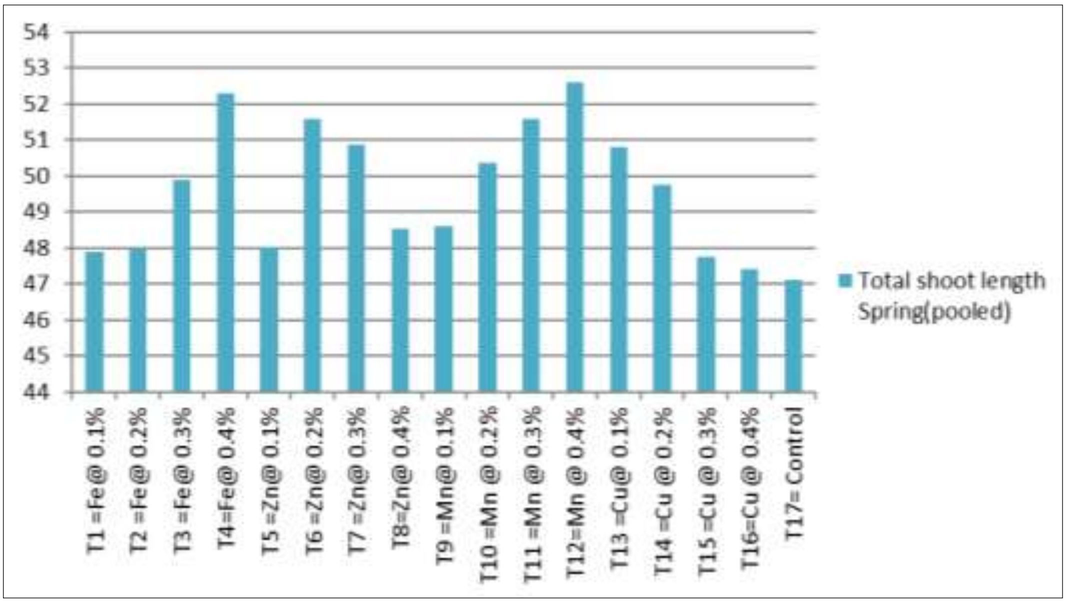

Fig 10: Influence of micronutrients on total shoot length (m)

No of branches/plant

Data pertaining to the number of branches per plant during autumn season is presented in Table-4 and illustrated in Fig. 11.

Observations recorded revealed that treatments had no significant effect on the no of branches/plant. However, maximum no of branches/plant was recorded in T_9 (30.833) and minimum no of branches/plant was recorded in T_5 (28.833).

Total shoot length

Data pertaining to the total shoot length per plant during autumn season is presented in Table-4 and illustrated in Fig. 12.

Observations recorded revealed that treatments had no significant effect on the total shoot length. However, maximum total shoot length was recorded in T_{12} (31.59m) and minimum total shoot length was recorded in T_{17} (28.29m).

Table 4: Influence of foliar spray of micro nutrients on growth parameters of mulberry variety Goshoerami during autumn season

Treatments	No of branches/plant	Total shoot length(m)
T_1 =Fe@ 0.1%	29.000	28.68
T_2 =Fe@ 0.2%	28.999	28.77
T_3 =Fe@ 0.3%	29.000	29.48
T_4=Fe@ 0.4%	29.999	31.20
T_5 =Zn@ 0.1%	28.833	30.02
T_6 =Zn@ 0.2%	29.333	30.58
T_7 =Zn@ 0.3%	29.833	30.49
T_8=Zn@ 0.4%	28.999	29.32
T_9 =Mn@ 0.1%	30.833	30.61
T_{10} =Mn @ 0.2%	30.333	31.15
T_{11} =Mn @ 0.3%	29.999	31.19
T_{12}=Mn @ 0.4%	30.000	31.59
T_{13} =Cu@ 0.1%	30.666	29.74
T_{14} =Cu @ 0.2%	30.166	29.35
T_{15} =Cu @ 0.3%	29.333	28.51
T_{16}=Cu @ 0.4%	29.166	28.32
T_{17}= Control	29.166	28.29
CD(p≤0.05))	NS	NS

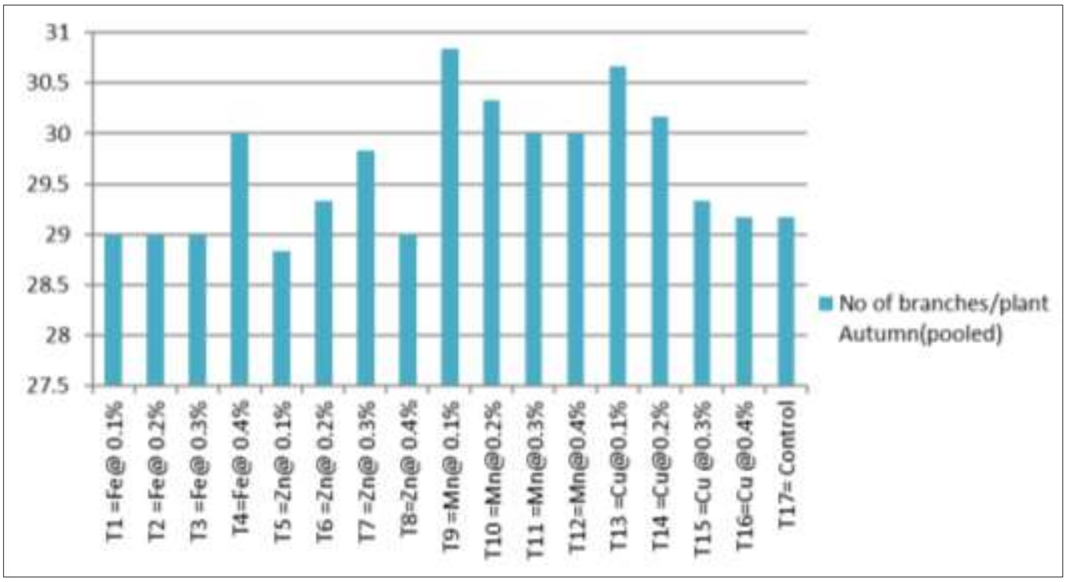

Fig 11: Influence of micronutrients on no of branches/plant

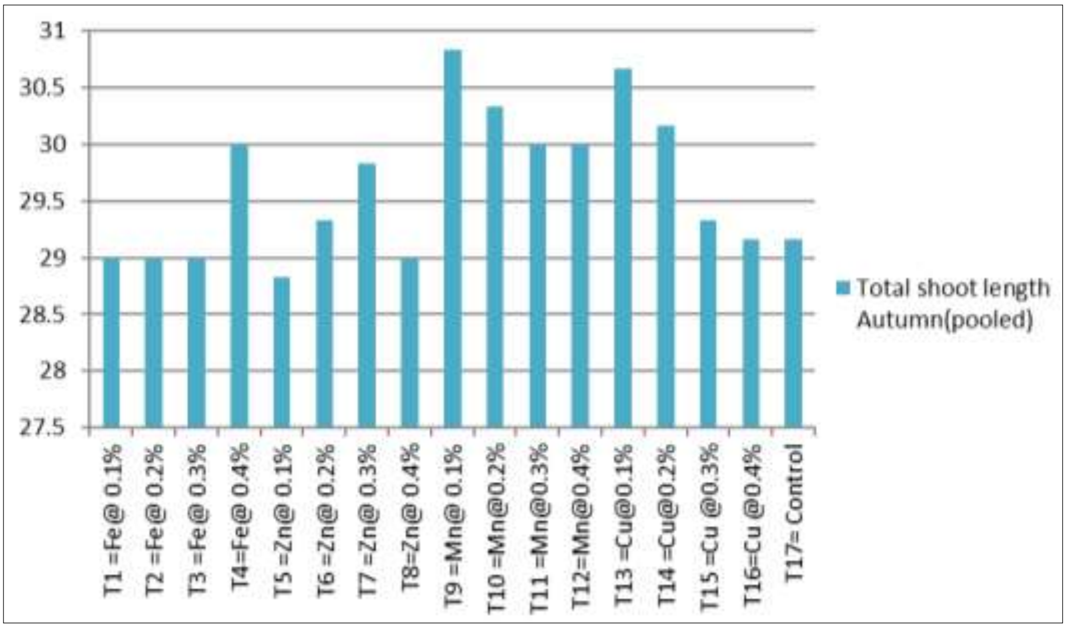

Fig 12: Influence of micronutrients on total shoot length (m)

Discussions

The data presented in (table-1) revealed that during spring season, longest branch length (cm) was recorded in treatment (T_{12}) having Mn@ 0.4% with value of 120.118cm which was statistically different from rest of treatments. The data presented in (table-2) revealed that during autumn season, longest branch length (cm) was recorded in treatment (T_{12}) having Mn@ 0.4% with value of 123.333cm which was statistically different from rest of treatments. Further it was found that application of Mn has more pronounced effect on the length of longest branch of goshoerami during both the seasons. This might be due to Physiological mechanism by which Mn increases the plant height and plant growth may be due to stimulation of photosynthetic apparatus, cellular elongation and cell division development (Salomon and Keren, 2011) [23]. Similar observations have been reported by Ibrahim *et al.*, (2007) [11] in bean and Yadav *et al.*, (2009) [34] in *Sesamum*, who reported that foliar spray of micronutrients improve metabolic function of plant causing more vegetative growth which manifested increase in height. These observation are in line with those of Loknath and shivashankar, (1986) [14] who reported that plant nutrient like magnesium, manganese, iron, zinc and boron are also provided to mulberry as foliar nutrients for enhancing its growth, as well as quality of leaf. The present finding are supported by the finding of Swietlik, (1999) [31] who reported that the higher plant height obtained may be due to zinc, zinc is involved actively in synthesis of tryptophan which is precursor of indole acetic acid synthesis consequently, it increased tissue growth and development.

The data presented in (table-1) revealed that during spring season, highest average branch length (cm) was recorded in treatment (T_{12}) having Mn@ 0.4% with value of 102.890cm which was statistically at par with application of Fe@ 0.4% (T_4), Zn@ 0.2% (T_6) and Mn@ 0.3% (T_{11}) with values of 102.410, 102.123 and 100.921cm respectively. The data presented in (table-2) revealed that during autumn season, highest average branch length (cm) was recorded in treatment (T_{12}) having Mn@ 0.4% with value of 105.333cm which was statistically at par with application of application of Zn@ 0.2% (T_6), Fe@ 0.4% (T_4), Mn@ 0.3% (T_{11}) and Zn@ 0.1%(T_5)with values of 104.267, 104.033, 103.997 and 103.133cm respectively. Further it was found that application of Mn has more pronounced effect on the average branch length of goshoerami during both the seasons. This might be due to the involvement of micronutrients in chlorophyll formation, which might have helped to influence physiological activity of plants *viz.*, cell division, meristematic activity in apical tissue, expansion of cell and formation of cell wall which in turn enhanced the growth and yield parameters as reported by Prasanna Kumar *et al.* (2001) [21] and Misra *et al.* (1995) [15]. These results were in conformity with Sinha *et al.* (2006) [30] who reported that, application of micronutrients had positive effects on growth and yield attributes of *Terminalia arjuna.*

The data presented in (table-3) revealed that during spring season, treatments had no significant effect on the total shoot length. However, maximum total shoot length was recorded in (T_{12}) Mn@ 0.4% with value of 52.59mand minimum total shoot length was recorded in (T_{17}) control with value of 47.11m. The data presented in (table-4) revealed that during autumn season, treatments had no significant effect on the total shoot length. However, maximum total shoot length was recorded in (T_{12}) Mn@ 0.4% with value of 31.59m and minimum total shoot length was recorded in (T_{17}) control with value of 28.29m.The data presented in (table-3) revealed that during spring season, treatments had no significant effect on the number of branches/plant. However, maximum number of branches/plant was recorded in T_9 (Mn@ 0.1%) with value of 30.833 and minimum no of branches/plant was recorded in T_5 (Zn@ 0.1%) with value of 28.833. The data presented in (table-4) revealed that during autumn season, treatments had no significant effect on the no of branches/plant. However, maximum no of branches/plant was recorded in T_9 (Mn@ 0.1%) with value of 30.833 and minimum no of branches/plant was recorded in T_5 (Zn@ 0.1%) with value of 28.833. Similar results have been reported by Hasani *et al.*, (2012) [10].

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