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Effect of micronutrient on growth and yield parameter of Mint (*Mentha arvensis*)

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Abstract
The study was undertaken at the Floriculture Research Farm, College of Horticulture and Research Station, Sankara, Patan from February to June 2025, employing 10 treatments (T0 (Control), T_1 (Zn @ 300 ppm), T_2 (Zn @ 500 ppm), T_3 (Zn @ 700 ppm), T_4 (Cu @ 300 ppm), T_5 (Cu @ 500 ppm), T_6 (Cu @ 700 ppm), T_7 (Fe @ 300 ppm), T_8 (Fe @ 500 ppm), and T_9 (Fe @ 700 ppm). The aim was to assess the influence of different micronutrient applications and concentrations on mint growth and yield. Data collected from the experiment were statistically analyzed, and the results are discussed. Result indicated that the application of micronutrients had a significant impact on Plant spread, leaf plant ratio and on both fresh and dry herbage yield of mint. The maximum plant spread recorded in T_5 (Cu @ 500 ppm) 72.45cm, the maximum LPR recorded in T_5 (Cu @ 500 ppm) 91.17%, highest fresh herbage yield was obtained in T_8 (Fe @ 500 ppm) 302.62 g, For dry herbage yield, the maximum was recorded in T_5 (Cu @ 500 ppm) 73.11 g, These findings indicate that Fe @ 500 ppm and Cu @ 500 ppm were the most effective treatments for enhancing mint yield.

Keywords: Mint (*Mentha arvensis*), plant spread, leaf plant ratio**,** fresh herbage yield, dry herbage yield, foliar application, copper, iron, zinc

Introduction
Mint, commonly called as "pudina" is valued for its multipurpose uses in the field of pharmaceuticals, cosmetics etc. (Ohloff, 1994) [5]. Mint is found to be originated from Brazil and China. The four most species are Japanese Mint /Menthol mint (*M. arvensis*), Peppermint (*M. piperita*), Spearmint (*M. spicata*), Bergamot mint (*M. citrata*). *Mentha arvensis*, commonly known as Japanese mint, contains 80-85 % menthol (Ozguven and Kirici, 1999) [6]. Mint is mainly cultivated in the United States, India, and China. Among these, the United States and India are the leading producers of mint oil. India is the largest producer and an exporter for mint oil and its derivatives. Nation contributes around 80% to the total global mint oil production followed by China (9%), Brazil (7%) and USA (4%). India shares 33% of world export. (Directorate of Horticulture, 2021). India exports mint oil to more than 130 countries. (Yadav *et al*., 2023) [12]. Mint contains chemical substances namely menthone, isomenthone, neomenthol, limonene, methylacetate, piperitone, beta-caryophyllene, alpha-pinene, beta-pinene, tannins and flavonoids. Mint can be used as herb or as a flavouring agent. It also has its wide use in dental industry i.e. tooth paste and mouth freshners due to its physiological cooling effect (Dorman *et al*., 2003) [3].

Copper is an essential micronutrient for normal plant growth and metabolism. In plants, Cu plays a vital role in various metabolic processes, namely cell wall metabolism photosynthetic electron transport and mitochondrial respiration, biosynthesis of plant hormones, and as cofactor for a variety of enzymes (Bouazizi H *et al.*, 2010 and Xiong ZT *et al.*, 2007) [1, 4].

Foliar application of Fe during vegetative growth stages can maximize plant growth and development also significantly increases plant height, stem number, flag leaf area and leaf chlorophyll content (Rawashdeh and Sala 2014) [10].

Zinc has important roles in the plant growth and development, including production of biomass, chlorophyll production, pollen function, fertilization, metabolism of RNA, protein and the DNA formation (Pandey *et al.*, 2006 and Cakmak 2008) [7, 2].

Material and methods

The present study was conducted at the Floriculture Research Farm, College of Horticulture and Research Station, Sankara, Patan from February to June 2025, employing 10 treatments (T_0 (Control), T_1 (Zn @ 300 ppm), T_2 (Zn @ 500 ppm), T_3 (Zn @ 700 ppm), T_4 (Cu @ 300 ppm), T_5 (Cu @ 500 ppm), T_6 (Cu @ 700 ppm), T_7 (Fe @ 300 ppm), T_8 (Fe @ 500 ppm), and T_9 (Fe @ 700 ppm). The treatments were replicated thrice using a complete randomized block design. The transplanting was done on 25th February, 2025. Transplanting were done as per requirement, healthy seedlings were transplanted on grow bag size range from 11*12 inches in about 2.5 to 3 cm deep, and covered with thin layer of the soil. The grow bags were placed under shade net conditions (50% shading) to provide a moderated microclimate and reduce transplant stress. After transplanting irrigation was given in evening time for better established of the suckers in soil. The stolon of *Mentha arvensis* were selected from healthy, disease-free mother plants and cut into small segments measuring approximately 7-10 cm in length, each containing 2-3 nodes. A completely randomized design (CRD) with 10 treatments (T_0-T_9), three replicates, and 10 polybags per treatment was employed, resulting in a total of 300 experimental units.

Result and Discussion

Plant Spread (cm)

Plant spread refers to the canopy coverage of a plant, usually measured in East-West (E-W) and North-South (N-S) directions. It is a vital morphological trait because a wider spread generally indicates better vegetative growth, more photosynthetic surface area, and consequently, higher yield potential. In mint (*Mentha arvensis).* Plant spread was recorded at 60 DAP and at the time of harvest, with an average of 64.46 cm at 60 DAP and 134.32 cm at harvest Table 1 and Fig. no.1.

The maximum plant spread recorded in T_5 (Cu @ 500 ppm), 72.45cm followed by T_4 (Cu @ 300m ppm), 71.93 cm and T_8 (Fe @ 500 ppm) 71.71 cm at 60 DAP and time of harvest maximum plant spread recorded in T_5 (Cu @ 500 ppm), 155.81 cm followed by T_4 (Cu @ 300m ppm), 148.25 cm and T_8 (Fe @ 500 ppm) 144.10 cm. Singh *et al.* (2011) [8] reported that micronutrient fertilization significantly improved plant spread in *Mentha arvensis*, which led to higher herbage yield. Sahu *et al.* (2023) [9] observed that foliar application of micronutrients (Fe, Zn, Cu) substantially increased herbage yield in *Mentha arvensis*, which is consistent with improved plant spread and canopy development.

Table 1: Effect of micro nutrients on the Plant Spread (cm) of Mentha (*Mentha arvensis*)

	Treatments	60DAP	Harvesting
T_0	Control	43.14	81.24
T_1	Zn @ 300ppm	67.01	125.15
T_2	Zn @ 500ppm	67.62	135.89
T_3	Zn @ 700ppm	61.41	139.42
T_4	Cu @ 300ppm	71.93	148.25
T_5	Cu @ 500ppm	72.45	155.81
T_6	Cu @ 700ppm	65.24	142.68
T_7	Fe @ 300ppm	58.51	135.56
T_8	Fe @ 500ppm	71.71	144.1
T_9	Fe @ 700ppm	65.6	135.19
	SEM	1.62	2.65
	CD 5%	4.78	7.81
	CD 1%	6.52	10.65
	SED	2.29	3.74

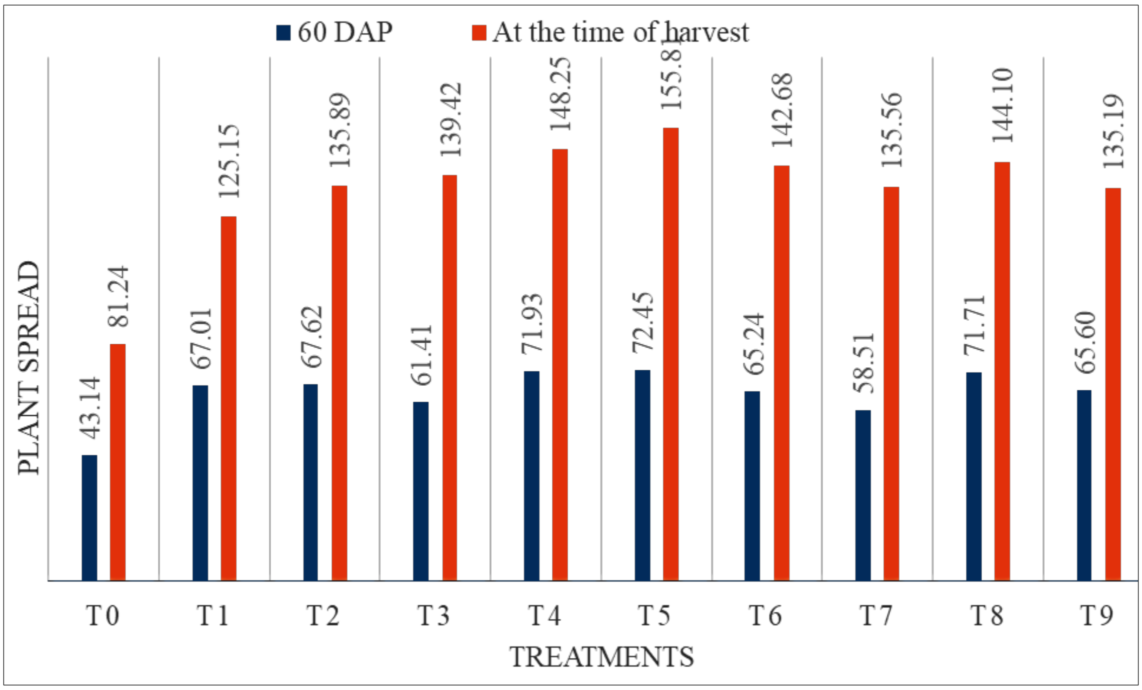

Fig 1: Effect of micro nutrients on the Plant Spread (cm) of Mentha (*Mentha arvensis*)

Leaf Plant Ratio: The Leaf Plant Ratio is the proportion of leaf biomass to the total above-ground biomass (leaves + stems + branches), usually expressed as a percentage. The maximum LPR recorded in T_5 (Cu @ 500 ppm), 91.17%, followed by T_8 (Fe @ 500 ppm) 89.26% and the minimum Leaf Plant Ratio was observed in the T_0 (control) 56.89% (Table 2 and Fig. no. 2). After treatment data revealed that all treatment was significantly differed to each other.

Table 2: Effect of micro nutrients on the leaf Plant ratio (%) of Mentha (*Mentha arvensis*)

Treatments		Leaf Plant ratio (%)
T_0	Control	56.89
T_1	Zn @ 300ppm	71.63
T_2	Zn @ 500ppm	83.07
T_3	Zn @ 700ppm	77.88
T_4	Cu @ 300ppm	82.26
T_5	Cu @ 500ppm	91.17
T_6	Cu @ 700ppm	80.83
T_7	Fe @ 300ppm	82.33
T_8	Fe @ 500ppm	89.26
T_9	Fe @ 700ppm	76.01
	SEM	1.48
	CD 5%	4.38
	CD 1%	5.97
	SED	2.10

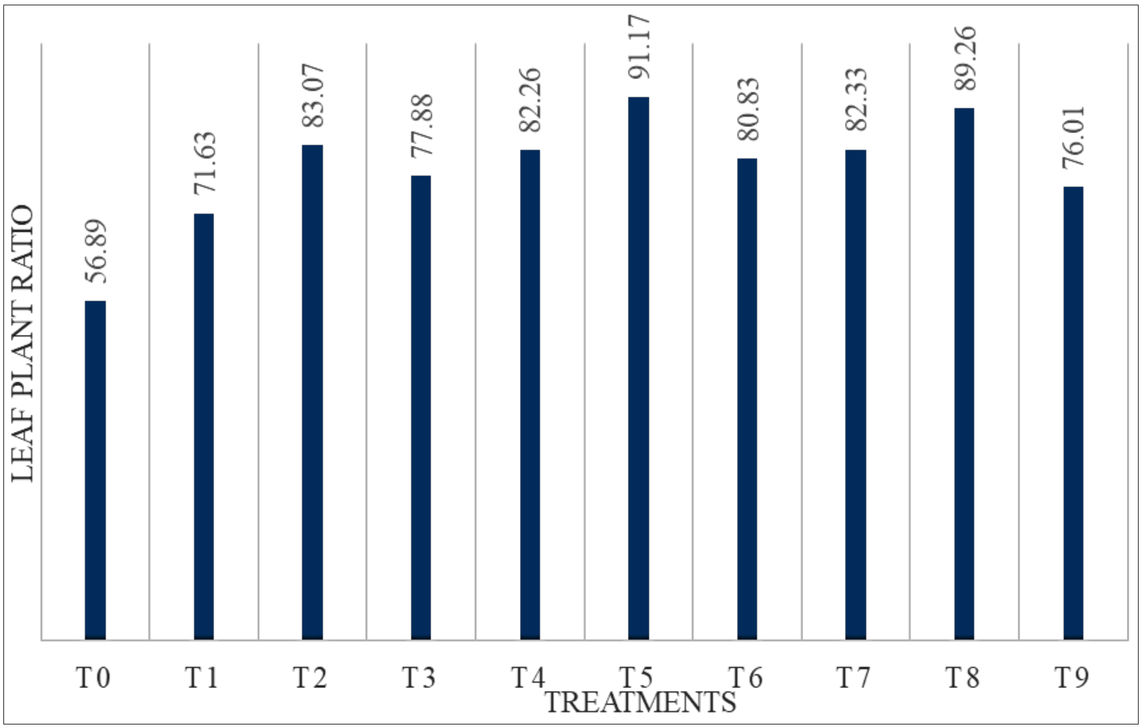

Fig 2: Effect of micro nutrients on the leaf Plant ratio (%) of Mentha (*Mentha arvensis*)

Fresh Herbage Yield per Plant (g)

Fresh herbage weight per plant (g) was recorded across all treatments. The lowest fresh weight was observed in the control (T_0) 131.99g, while the highest was obtained in treatment T_8 (Fe @ 500 ppm), 302.62 g, followed by T_5 (Cu @ 500 ppm), 307.14g, and T_2 (Zn @ 500 ppm), 288.66g. (Table 3 and Fig. no.3). In our experiments, fresh weight was recorded highest with 500 ppm Cu, Zn and Fe and reduced at 700 ppm for this might be due to toxic effects at higher concentration reported Similar results were obtained by Pandey *et al* 2007 and Sahu *et al* 2023 [13, 9].

Table 3: Effect of micro nutrients on the Fresh herbage yield per plant (g) of Mentha (*Mentha arvensis*)

Treatments		Fresh herbage weight (g)
T_0	Control	131.99
T_1	Zn @ 300ppm	154.10
T_2	Zn @ 500ppm	288.66
T_3	Zn @ 700ppm	157.60
T_4	Cu @ 300ppm	189.84
T_5	Cu @ 500ppm	307.14
T_6	Cu @ 700ppm	220.55
T_7	Fe @ 300ppm	236.09
T_8	Fe @ 500ppm	302.62
T_9	Fe @ 700ppm	254.31
	SEM	3.08
	CD 5%	9.08
	CD 1%	12.39
	SED	4.35

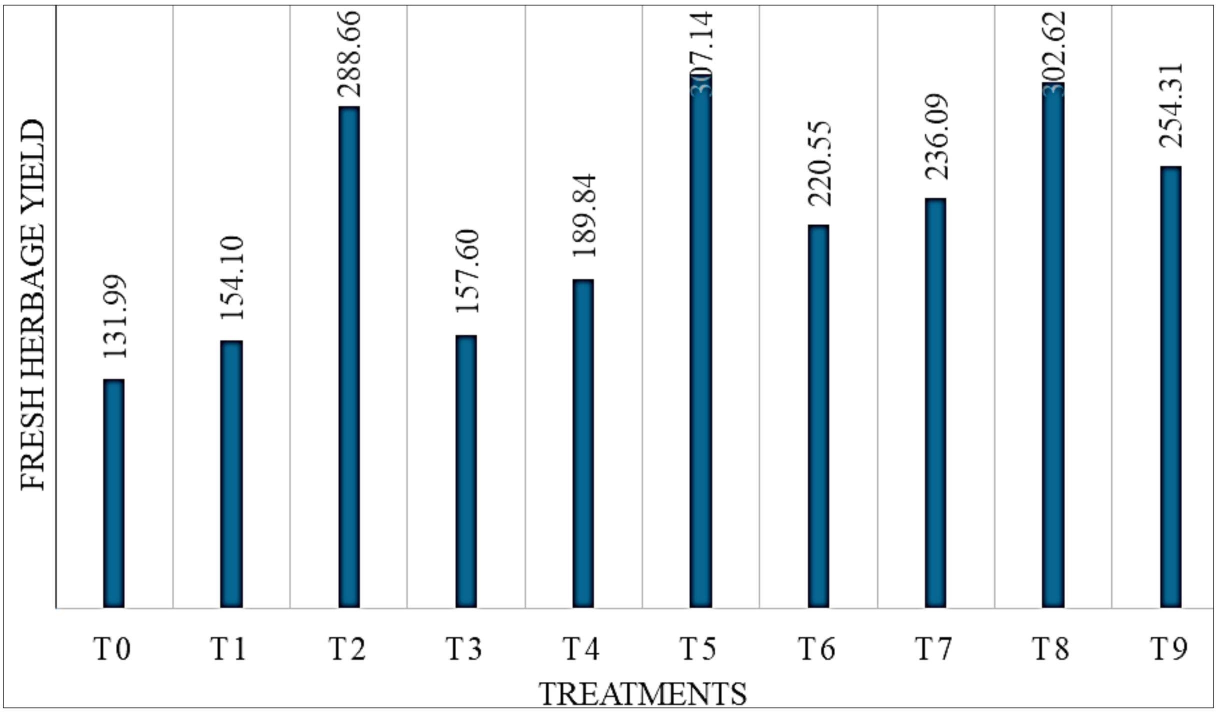

Fig 3: Effect of micro nutrients on the Fresh herbage yield per plant (g) of Mentha (*Mentha arvensis*).

Dry Herbage Yield per Plant (g)

The dry herbage yield per plant was influenced by micronutrient application, with significant variation observed among treatments. The lowest fresh weight was observed in the control (T_0) 40.02g, while the highest was obtained in treatment T_5 (Cu @ 500 ppm), 73.11 g T_8 (Fe @ 500 ppm), 71.86 g, followed by T_2 (Zn @ 500 ppm), 66.37g and similar results were obtained by Pandey P *et al* 2007 [13]. The maximum dry weight recorded in copper @ 500 ppm promoted higher dry biomass, reflecting its role as a cofactor in several enzyme systems related to lignin biosynthesis, respiration, and oxidative stress defense, ultimately facilitating sustained plant growth. Reported Saleem *et al* 2022 [11]. Fe @ 500 ppm may be attributed to iron's crucial role in chlorophyll biosynthesis, electron transport, and enzymatic activity, which collectively enhance photosynthetic efficiency and biomass accumulation. Similarly zinc @ 500 ppm also contributed substantially to dry matter production, likely due to its involvement in auxin metabolism, protein synthesis, and regulation of carbohydrate partitioning, all of which support vegetative growth. Similarly, the lower dry herbage weight in the control treatment (T_0) underscores the importance of micronutrient supplementation in improving physiological efficiency and yield attributes of mint. Sahu *et al.*, (2023) [9] observed that foliar application of Fe, Zn, and Cu significantly enhanced herbage yield in *Mentha arvensis*, indicating improved physiological efficiency and canopy development.

Table 4: Effect of micro nutrients on the Dry herbage yield per plant (g) of Mentha (Mentha arvensis)

Treatments		Dry herbage weight (gm)
T_0	Control	40.02
T_1	Zn @ 300ppm	40.68
T_2	Zn @ 500ppm	66.37
T_3	Zn @ 700ppm	46.02
T_4	Cu @ 300ppm	50.56
T_5	Cu @ 500ppm	73.11
T_6	Cu @ 700ppm	49.80
T_7	Fe @ 300ppm	49.56
T_8	Fe @ 500ppm	71.86
T_9	Fe @ 700ppm	62.80
	SEM	0.93
	CD 5%	2.74
	CD 1%	3.73
	SED	1.31

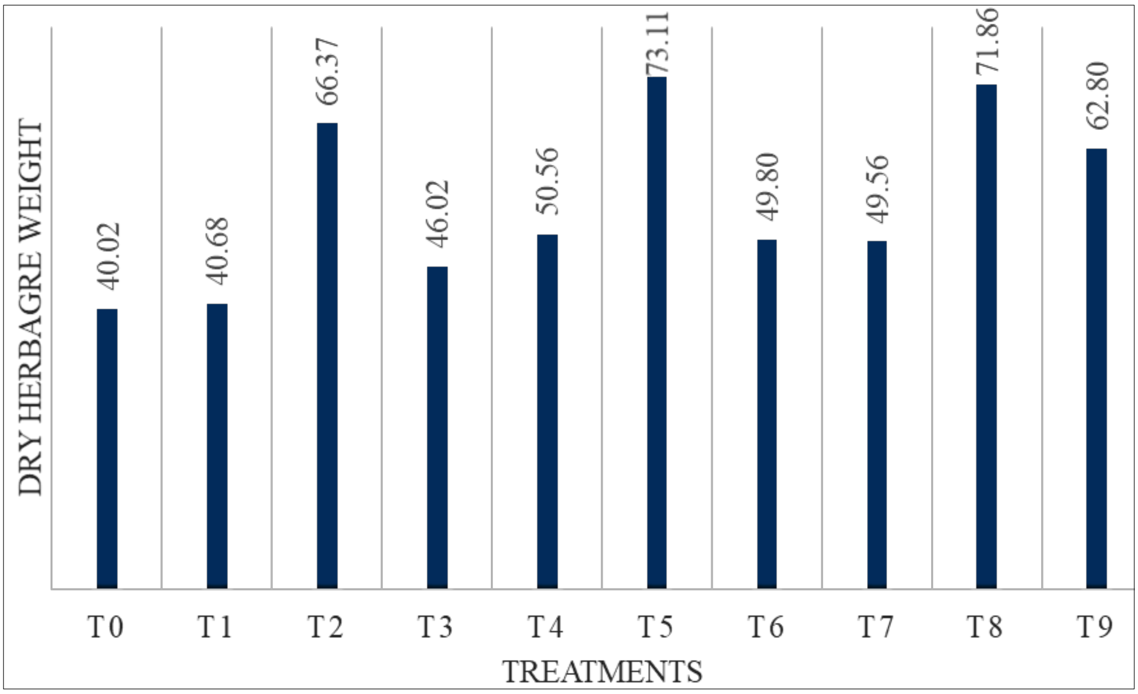

Fig 4: Effect of micro nutrients on the Dry herbage yield per plant (g) of Mentha (*Mentha arvensis)*

Conclusion

This study, conducted at the Floriculture Research Farm, College of Horticulture and Research Station, Sankara, Patan, from February to June 2025, investigated the impact of micronutrient applications on mint yield. Ten treatments were evaluated, involving varying concentrations of zinc (Zn), copper (Cu), and iron (Fe). Results showed that micronutrient application significantly influenced both fresh and dry herbage yields. Notably, Fe @ 500 ppm (T8) yielded the highest fresh herbage, while Cu @ 500 ppm (T5) produced the maximum dry herbage yield. These findings suggest that targeted micronutrient applications, specifically Fe @ 500 ppm and Cu @ 500 ppm, can enhance mint productivity**.**

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