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RESEARCH ARTICLE

Effects of Various Doses of Zinc on Yield and Quality of Flue-Cured Virginia Tobacco

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ABSTRACT

The yield and quality of tobacco crops are affected by the concentration of Zinc (Zn). The current study was designed to analyze the application of different doses of Zn on the quality and output of Flue-Cured Virginia (FCV) tobacco variety TM-2008. The Zn was applied during a) Root dipping (2% and 5%), b) Transplantation, c) Fertilisation (3% and 6% Zn), and d) Foliar spray (0.25% and 0.5% Zn), with a control without Zn application. Our results showed that the Soil-T2 treatment had the highest leaf potassium (K) concentration (34.43 gm/Kg), leaf Zn concentration (3.27 gm/Kg), nicotine content (2.81%), total sugars (15.51%), and chloride content (0.91%). The Soil-T1 treatment produced the highest green leaf yield (17190 Kg/ha) and leaf yield after curing (3228 Kg/ha), whereas Foliar-T2 produced the best leaf yield after curing (17120 Kg/ha). In conclusion, applying 3 Kg or 6 Kg of Zn to the soil is the ideal way to apply fertiliser and is suggested for improving tobacco leaf output and quality.

Key words: Nicotine content, sugar content, Root dipping, Transplantation, Fertilisation, Foliar spray, Zn

INTRODUCTION

The rapid expansion in industry and agricultural sectors have been resulted in a rise in the usage of heavy metals including Zn, which has consequently contaminated soils (Bolan et al., 2014). The heavy metal enrichment is caused by anthropogenic activities including mining, smelting and municipal sludge as well as excessive application of fertilizers, insecticides (Houben et al., 2013). Among the several heavy metals (HM), Zn is one of the most prevalent elements that might be detrimental to both people and animals (Smolková et al., 2019; Jahandari, 2020). Additionally, a high concentration of heavy metals has found to be harmful to plants by preventing root development (Qin et al., 2018), influencing the nutrients and water absorption (Zhang et al., 2017; Sánchez-Pardo et al., 2013; Hussain et al., 2023) as well as destroying chloroplast (Kalaji and Loboda 2007; Zhang et al., 2018; Zhang et al., 2020b) and restricting photosynthetic electron transfer to fix CO2 (Azhar et al., 2019; Zafar et al., 2024). The Zn plays a critical role in growth and development and is a vital nutrient for plant growth (King, 2018). The essential element of the Zn plant, acting as essential part in preserving Superoxide dismutase functionality. However, even now too much Zn can cause an imbalance of reactive oxygen species in plants. Zn exposure was noted by Madhava and Sresty (2000) might cause peroxidase to grow (POD, EC: 1.11.1.7) pigeon pea (*Cajanus cajan*) enzyme activity departs, but the Catalase is inhibited. Ascorbate peroxidase activity in *Phaseolus vulgaris* leaves was likewise seen to be inhibited by Zn stress (Cuypers et al., 2001), whereas Madhava and according to Sresty (2000), exposure to Zn increases enzyme activity of Ascorbate peroxidase activity in pigeon pea leaves.

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Numerous studies have been conducted in plants exposed to Cd and Zn to examine photosynthesis (Tang et al., 2016; Momchil et al., 2018; Szopinski et al., 2019; Hussain et al., 2023) and reactive oxygen species metabolism (Gomes-Junior et al., 2006; Wójcik et al., 2006; Nazar et al., 2012), but these studies have not yet been confirmed. There was no discernible increase in the yield or cost of flue-cured tobacco where Cu and Zn were added, according to Bacon et al. (1950). According to Bacon et al. (1950), flue-cured tobacco leaves had an average Zn level of 22 ppm with no Zn additions 5.6 Kg/ha of it was administered, bringing the concentration down to 74 ppm. They determined that Zn's minimum requirement was lower than in the leaf tissue, 10 pp. Tobacco *Nicotiana tabacum L.,* a commercial plant. In Ethiopia, tobacco is a fundamental agricultural commodity with significant social and economic impact. Native tobacco, also known as "Gaya," has long been used for pipe smoking, chewing, and snuffing. State-owned farms and farmers nearby these farms cultivate tobacco for commercial usage. Tobacco production and processing throughout the nation are to be organized by the National Tobacco Enterprise. Ethiopia produces three main commercial tobacco varieties: Virginia, Oriental, and Burley. A little over 74% of the overall production is produced in Virginia, followed by Oriental (22%), Burley (4%), and then (FAO, 1995 & 2003).

According to a UNODC report (Gebre and Gebre, 1996), Khat, tobacco, and alcohol are the most widely used drugs in Ethiopia, accounting for 48.2, 29.9, and 18.9% of total drug use, respectively. This demonstrates unequivocally how important a role tobacco had as a drug in Ethiopia. In Ethiopia, commercial tobacco varieties including Virginia, Oriental, and Burley are frequently used to make cigarettes. Cigarettes are made from tobacco leaves chewing, too. It naturally gathers and focuses. Leaves contain a significant number of heavy metals, including cadmium (Kaličanin and Velimirović, 2012; Ajab et al., 2014).

All heavy metals have a considerable negative impact on human health. Lead (Pb) and neurological illnesses are linked to cadmium, whereas cadmium is linked to bone and renal ailments (Sharma and Dubey, 2005; Nnorom et al., 2005). Overexposure to Cu and Zn is linked to metabolic problems that might be fatal (Stojanovic et al., 2004; Zhang et al., 2005). Tobacco is one of the principal sources of harmful metals in our environment. Cigarette smoking is a significant source of intake for these harmful substances, not only for the smoker but also for nonsmokers who are exposed to passive smoking. The amount of heavy metal buildup in tobacco plants is the consequence of intricate interactions between the soil and plant. The kind of soil, pH value, irrigation water quality, the chemical makeup of the metals, and type of tobacco plant all have an impact on how much metals from the soil accumulate (Grant et al., 1998; Golia et al., 2008). During the growing season, farmers apply copious amounts of insecticides and fertilizers growing of the tobacco plant. Fertilizers and pesticides frequently include high levels of metals, which significantly contribute to the contamination of agricultural soil and plants (Karaivazoglou et al., 2007; Lecours et al., 2012). The distribution and buildup of metals in tobacco leaves reflect the soil and environment where the plant is grown in terms of mineral content. As a result, tobacco's real metal content varies greatly depending on its geographic origin, use, and other factors. Various fertilizers with various chemical compositions and other distinguishing characteristics, including irrigation water (Peuarossa et al., 1990; Adeyeye, 2005; Lugon-Moulin et al., 2006). Heavy metal concentrations are significant in the phosphate fertilizers used in the growing of tobacco. The current project was designed to find the effect of Zinc on the tobacco plant, to find the effect of different doses of Zinc on the yield and quality of Flue Cured Virginia (FCV) tobacco and to explore the effect of Zn treatment at the time of Root dipping, Transplantation, Fertilization and Foliar spray.

By using inductively coupled plasma-mass spectrometry, the average amount of arsenic in tobacco samples from Africa, Asia, Europe, South, and North America was found to be 0.4 to 0.6 g/g (Lugon-Moulin et al., 2008). By using HPLC-ICP-MS, Taebunpakul et al., (2011) examined the total arsenic speciation in tobacco products, including cigarette smoke and tobacco leaves. The amount of arsenic in tobacco (0.02-2.04 g/g) and cigarettes (0.02-0.71 g/g) was measured by Lazarević et al., in 2012. Atomic absorption spectrometry was conducted electrothermally. Using HPLC-ICP-MS, Campbell et al. (2014) identified all inorganic arsenic species (144–3914 gm/Kg) in tobacco samples from various sources. According to Piadé et al. (2015), cigarettes and tobacco fillers both contain arsenic. The median tobacco level for arsenic in a vast number of samples collected worldwide was 237 ng/g, whereas the median mainstream smoke output for arsenic was 3.75 ng/cigarette. By using neutron activation analysis, Maruyama, and Komiya (1973) identified arsenic and mercury in tobacco leaves.

Mercury levels in tobacco and tobacco additives have been reported by Zhangyu et al. (2004) using microwave digestion and RP-HPLC via column enrichment online. Using a mercury analyzer, Kowalski and Wierciski (2009) observed mercury concentrations in cigarette tobacco (6.48-10.56 ng/g, 2.95-10.2 ng Hg per cigarette). The amounts of heavy metals in raw and processed tobacco leaves have also been determined in several studies using various methods in various regions of the world (Saldivar et al., 1991; Health Canada, 1999; Stojanovic et al., 2004; Kaličanin and Velimirović, 2012; Eneji et al., 2013; Ajab et al., 2014). Studies on the concentrations of essential and non-essential metals in cannabis leaves and psychoactive khat leaves have also been conducted in Ethiopia (Zerihun et al., 2015).

MATERIALS AND METHODS

Experimental Site

Tobacco research station is in the southwest of the district Mardan at 34°12'0N 72°16'0E, altitude of 283 meters (928 feet), and with an elevation of 314 meters above sea level.

Experimental Design

The experiment was laid out in RCB (Randomized Complete Block) design with split plot arrangement, having three tobacco varieties (Main plot) and treatment (sub plot), replicated thrice at the Tobacco Research Station, Khan Garhi, Mardan, during 2022-23. Spatial arrangement was done 3x2 feet row to row and plant to plant distances respectively.

Nursery Management

Nursery was raised on 20th December 2022. Seed rate of 4g/ha was used. Bed size was 10 m^2. Thinning was done to get optimum and healthy plant stand. Three tobacco hybrids of CSC series i.e., CSC 4302, CSC 447, CSC 4704 were sown.

Field Preparation

Before transplantation, land preparation was done using primary and secondary tillage implements. Good and viable seedlings were transplanted in the field and the field was irrigated to establish good root system.

Mode of Application

Transplantation

Transplantation was done during the last week of March 2022. Each plot and subplot having five rows, having 10 plants in each row. The row-to-row distance was 3, 3.5 and 4 feet, while plant to plant distance was 2, 1.8 and 1.8 feet respectively.

Field Management

After transplantation irrigation were applied 6-7 times. N:P: K fertilizers were applied with the rate 75:75:75 Kg ha^{-1}. After transplantation one dose was applied to the two sides of plants. Topping was done at 24 leaves stage. The parameters studied were plant height, leaf area plant-1, green leaves weight $plot^{-1}$ (Kg), number of green leaves kg^{-1}, cured leaves weight $plot^{-1}$(Kg), number of cured leaves Kg^{-1}, cured leaf yield ha^{-1}, nicotine and reducing sugar contents, using the following procedure.

Procedure of Spiking

Spiking tests using standard solutions of known volume and concentration were used to verify the effectiveness of established optimized techniques. For each metal, intermediate standard solutions (10 mg/L) were made from the stock solution (1000 mg/L). To 0.50 g of tobacco leaves obtained from Shewa Robit, 10 mg/L solutions of Cd, Cr, Ni, Pb, 50 g of Cu, and 70 g of Zn were added. The processed tobacco sample from Billate and Nyala received the identical additions of solutions, except for the volume of Cd added, which was raised to 30 L. (since the amount Cd was increased in samples). Following that, samples were digested and examined using the previously improved techniques.

Instrument and Apparatus

The raw and processed tobacco leaves were ground and homogenized in a ceramic pestle and mortar. The materials were weighed and dried using a digital analytical balance (Mettler Toledo, Model AT250, Switzerland) and an oven (Digitheat, J.P. Selecta, Spain). To digest the samples, 150 mL quick-fit round bottom flasks with reflux condensers were placed on a heated plate in a Kjeldahl apparatus. Heavy metals were identified using an air-C_2H_2 flame and deuterium ark background correctors-equipped Buck Scientific Model 210VGP atomic absorption spectrophotometer.

Digestion of Tobacco Samples

Using the improved method, 0.5 g of well-powdered tobacco was digested at 350 ℃ for 200 minutes with 3.0 mL HNO_3 (69-72%) and 3.0 mL $HClO_4$ (70%) in a micro Kjeldahl digestion equipment. The digest was filtered, and deionized water was used to dilute it to 25 mL after chilling. For each sample, digestions were performed in triplicate. The reagent combination was digested using the same digestion technique to create the blank solutions, which were then diluted to 25 mL with deionized water.

Determination of Metals in the Tobacco Samples

By using the standard solutions (10 mg/L) in flame AAS, four points calibration curves were created. The sample solutions were inhaled into the AAS apparatus right after calibration, and direct measurements of the metal concentrations were recorded. Each sample was subjected to three replication analyses. The components in each of the six digested blanks were determined using the same analytical technique.

Statistical Analysis and Data Collection

1. Plant Height (cm)

In each plot thirty plants were selected and measured from top to bottom and their mean was calculated.

2. Leaf Area (cm^2)

For leaf area, thirty plants randomly were taken then leaf length and breadth was measured. The average leaf size was computed from these plants by multiplying with a common factor of 0.644 derived by Suggs et al. (1960). Leaf area = Leaf length x leaf breadth x 0.644 2.

3. Green Leaves Weight $Plot^{-1}$ (Kg)

Green leaves weight $plot^{-1}$ was measured after each picking by using weight balance.

4. Number of Green Leaves Kg^{-1}

The number of green leaves was found by measuring the number of green leaves in each bundle

of plot. Number of green leaves Kg^{-1} = No of leaves in the determined weight x Kg/

/ Green weight determined

5. Cured Leaves Weight $Plot^{-1}$(Kg)

The green picking was cured and then weighted with weight balance.

6. Number of Cured Leaves Kg^{-1}

The number of cured leaves was found by measuring the number of cured leaves in each bundle plot. Number of cured leaves kg-1 = No of leaves in the determined weight x Kg/

/Cured weight determined

7. Cured Leaf Yield (Kg ha^{-1})

Data concerning leaf yield, the weight of cured leaf in each treatment was taken after each picking. The total cured leaf yield was calculated by the following formula:

Yield (Kg ha^{-1}) = Cured leaf weight $plot^{-1}$ x total no. of plants ha^{-1} /

/No. of leaves per plot

8. Nicotine Content (%)

Nicotine was determined by the method of Cundif and Markunas (1964). The nicotine contents were calculated by the following formula:

$$\text{Nicotine (\%)} = \frac{V1 \times N \times 32.45 \times 100}{\text{Weight of sample}}$$

Whereas

V1=Volume of titrant for non-acetylated aliquot.

N=Normality of perchloric acid.

9. Reducing Sugars (%)

Reducing sugars percentage was estimated as follow:

$$\text{Reducing sugars} = \frac{25 \times 100 \times 0.05}{\text{Titrate x wt. of sample}}$$

Data collected was analysed according to split plot design and means were compared using least significant difference (LSD) test (Steel and Torrie, 1981).

RESULTS

Plant Height

While analyzing the Plant height of tobacco, we observed that the Plant showed different variations with respect to applying different conditions. These conditions were mainly (10gm and 20gm Zn fertilization with irrigation plus NPK, seed priming of Zn with 2% and 5% consecutively for 12hr, Root dipping of 10g and 20g Zn for about 2 to 3hr over 90 plants at Transplantation, applying 1gm and 2gm of Zn through Soil plus NPK 1st dose and lastly Taking 10gm and 20gm of Zn per liter for 20 days of sowing over 90 plants consecutively). In all of the conditions merely two of the five Conditions showed decrease in plant Height and the rest showed almost no variation. The Control Height of Plant is 117cm. in above to condition plant height showed variation including

1. Seed Priming of Zn with 2% and 5% for 12hr

Here the plant Height reduced to 6.8% and 7.6% respectively in comparison to the Controlled Height.

Root Dipping of 10g and 20g Zn for about 2 to 3hr over 90 Plants at Transplantation

Here the Plant height showed significant decreased up to 13.6% and 22.8% respectively. For leaf area there was no cleared variation observed. Green leaf per Kg observed significant improvement in their treatment variation in comparison to the Controlled unit, which was 19.67%. The increased amount ranges from 14.1% to 56%. Following are the cases and their respective improvements.

1. 10gm and 20gm Zn Fertilization with Irrigation plus NPK

While applying this condition the scale improved up to 46.1% and 26.1% respectively in comparison to the Controlled unit of green leaves per Kg.

2. Seed Priming of Zn with 2% and 5% Consecutively for 12 hr.

In this case the scale improved up to 32% and 34.9% respectively in comparison to the Controlled unit of green leaves per Kg.

3. Root Dipping of 10g and 20g Zn for about 2 to 3hr over 90 Plants at Transplantation

This case also showed improvement in a scale of about 27.7% and 56% consecutively in comparison to the Controlled unit of green leaves per Kg.

4. Applying 1gm and 2gm of Zn through Soil plus NPK 1st Dose

This case is also similar in improvements as it showed 14.9% and 35.9% improvements with respect to the Controlled unit of green leaves per kg.

5. Taking 10gm and 20gm of Zn per Liter for 20 days of sowing over 90 Plants Consecutively

This last condition has also showed improvement in comparison to the Controlled unit of green leaves per kg in a scale of 44.7% and 18.1%.

While applying the above-mentioned conditions, we observed that all of the cases showed decrease in scale in comparison to the Controlled unit of Green wt/plot. Following are the cases and their respective percentage decrease scales.

1. 10gm and 20gm Zn Fertilization with Irrigation plus NPK

In this case the scale has decreased up to 48.8% and 22.3% in comparison to the control unit of green wt/ plot.

2. Seed Priming of Zn with 2% and 5% Consecutively for

12hr

This case is also similar to the previous one as it shown up to 66.1 and 43.7% decreased in comparison to the control unit of green wt/plot.

3. Root dipping of 10g and 20g Zn for about 2 to 3hr over 90 plants at Transplantation

This case also revealed significant amounts of decrease, as it has decreased from 53.3% and 90% in comparison to the control unit of green leaves per plot.

4. Applying 1gm and 2gm of Zn through Soil plus NPK 1st Dose

While observing this case it also shows significant amounts of decrease in comparison to the control unit of green wt per plot as it has decreased up to 33.2% and 45.6%.

5. Taking 10gm and 20gm of Zn per liter for 20 days of Sowing over 90 Plants Consecutively

Similarly, this case also shows significant amounts of decrease in scale as the scale has decreased up to 56.6% and 24.4% in comparison to the Control unit of green wt per plot.

Curved leaf per Kg also exhibited significance improvement in all the condition compared to control variant, while analyzing this parameter, we observed that all of the applied conditions resulted in lesser magnitude in comparison to the Controlled unit of curved wt per plot. Here the standard scale was 5.43 units. Following are the applied conditions and their respective variations.

1. 10gm and 20gm Zn Fertilization with Irrigation plus NPK

While applying the above-mentioned condition we observed that the first variant showed 25.5% decrement whereas the second variant showed a decrement of 8.2% as compared to the control unit of curved wt per plot.

2. Seed priming of Zn with 2% and 5% Consecutively for 12 hr.

Analyzing this condition, we observed that the first variant showed a decrement of a huge amount i.e. 51.2% whereas the second variant showed 40.1% decrement as compared to the control unit of curved wt per plot.

3. Root dipping of 10g and 20g Zn for about 2 to 3hr over 90 Plants at Transplantation

While analyzing this condition, we observed that the first variant showed 38.1% decrement whereas the second variant showed 80.9% decrement as compared to the control unit of curved wt per plot.

4. Applying 1gm and 2gm of Zn through Soil plus NPK 1st dose

While analyzing the current condition, the first variant showed 23.1% decrement while the second variant showed 26.2% decrement as compared to the control unit of curved wt per plot.

5. Taking 10gm and 20gm of Zn per liter for 20 days of sowing over 90 plants consecutively

While analyzing this condition, we observed that the first case shows 18.7% decrement while the later one showed 20.9% decrement as compared to the control unit of curved wt per plot.

Yield Kg per h

This parameter was observed under the above-mentioned conditions, we observed that all of the variants showed lesser outcomes as compared to the control unit of Yield Kg per h. The standard value of Yield Kg per h 32.58 unit. The highest decrement was observed in the third condition of magnitude 80.9%. This parameter is the most objective one among all of the parameters.

Nicotine

While observing this parameter under the above-mentioned condition, we observed that the variants showed random results. In some of the conditions, the variant showed decrement while in other cases the variant showed improvement as compared to the Controlled units of the above parameters. Here the standard scale was 2.81 units. The second condition improved well compared to other conditions.

Sugar

While observing this parameter under the above-mentioned condition we observed that the variant showed the random results. In some of the condition variant showed the decrease while in other cases the variant showed improvement as compared to the control unit of the above parameter. Here the standard scale was 13.33 unit. Like nicotine second condition improved well compared to other conditions, while in condition first reduction in sugar was noted.

DISCUSSION

Plant height of tobacco, we observed that the plant showed different variations with respect to applying different conditions. These conditions were mainly (10gm and 20gm Zn fertilization with irrigation plus NPK, seed priming of Zn with 2% and 5% consecutively for 12hr, Root dipping of 10g and 20g Zn for about 2 to 3hr over 90 plants at Transplantation, applying 1gm and 2gm of Zn through soil plus NPK 1st dose and lastly Taking 10gm and 20gm of Zn per liter for 20 days of sowing over 90 plants consecutively) (Zhang et al., 2017; Sánchez-Pardo et al., 2013; Hussain et al., 2023). In all of the conditions, merely two of the five Conditions showed a decrease in plant Height and the rest showed almost no variation. The control height of the plant is 117cm. We applied the above-mentioned conditions while observing the leaf area of our test plant, and we observed that no case shows any variation.

Table 1: Show Effect of different modes of Zinc application with different concentrations on the yield and quality of FCV tobacco for different parameter plant height, leaf area, green leaf per Kg, green wt per plot, curved leaves per Kg, curved wt per plot, yield Kg per h, nicotine, reducing sugar.

	Replication	Plant height	Leaf area (cm^2)	Green leaves/Kg	Green wt/plot	Cured leaves/Kg	Cured wt/plot	Yield Kg/H	Nicotine	Reducing sugar
To	1	117	849	16.00	40	97	6.00	3600	2.74	12.96
	2	121	862	19.00	34	118	5.60	3366	2.95	13.57
	3	112	828	24.00	28	146	4.68	2808	2.74	13.46
	Average	117	846	19.67	34.0	120.33	5.43	3258	2.81	13.33
T1	1	116	631	29.00	21.5	169.5	4.00	2400	2.71	12.28
	2	117	866	22.00	28	135	4.56	2736	2.53	11.26
	3	122	851	44.00	13	134.8	4.31	2586	2.41	11.62
	Average	118	783	31.67	20.8	146.43	4.29	2574	2.55	11.72
T2	1	115	650	28.00	24.5	151.1	4.50	2700	3.52	13.94
	2	122	853	21.00	34	125	5.50	3300	3.24	15.04
	3	117	829	28.00	23	128.9	5.00	3000	2.93	13.59
	Average	118	777	25.67	27.17	135	5.00	3000	3.23	14.19
T3	1	107	614	31.00	14.4	195	3.00	1800	3.36	16.17
	2	115.6	781	20.00	22	116	3.68	2208	3.48	15.24
	3	102	668	32.00	15	177	3.00	1800	3.69	17.16
	Average	108	687	27.67	17.13	162.66	3.23	1936	3.51	16.19
T4	1	104	629	27.00	18.8	134	3.60	2160	3.78	15.79
	2	120	881	18.00	33	113	5.;30	3180	3.55	16.74
	3	103	577	39.00	14	149	3.69	2214	3.59	16.1
	Average	109	695	28.00	21.9	132	3.65	2518	3.64	16.21
T5	1	103	543	29.00	20	151.8	3.89	2334	2.75	15.45
	2	112.6	606	21.00	24	122.5	4.00	2400	2.86	15.67
	3	90	665.4	28.00	15	134.5	3.18	1908	3.3	14.99
	Average	102	605	26.00	19.7	136.26	3.69	2214	2.97	15.37
T6	1	94	479	38.00	13.4	208	2.40	1440	3.26	14.52
	2	100	579	32.00	13	183.7	2.50	1500	3.13	13.93
	3	84	677	35.00	12	219	2.00	1200	3.03	14.84
	Average	93	578	35.00	12.8	203.56	2.30	1380	3.14	14.43
T7	1	115	743	23.00	22	156.4	3.47	2082	3.01	15.65
	2	117	829	23.00	22	143.2	3.50	2100	3.41	15.28
	3	118	770	22.00	29	112.6	6.00	3600	3.27	15.42
	Average	117	780	22.67	24.33	137.4	4.32	2594	3.23	15.45
T8	1	111	623	36.00	15	199.6	2.50	1500	2.94	14.49
	2	117	831	22.00	23	129.5	4.00	2400	2.98	14.67
	3	118	817	27.00	26	112.6	6.00	3600	3.02	15.18
	Average	115	757	28.33	21.3	147.23	4.17	2500	2.98	14.78
	1	115	647.04	30.00	17.1	133	3.90	2340	3.46	15.35
	2	118.4	828	39.00	14	121	4.46	2676	3.19	16.22
T9	3	118.2	819	24.00	26	114.9	5.4	3240	2.98	15.86
	Average	117	765	31.00	19.0	122.96	4.59	2752	3.21	15.81
	1	110.8	602.7	34.00	15.4	192.5	2.70	1620	3.31	13.86
T10	2	117.2	855.9	18.00	30	115.6	5	3000	2.95	13.71
	3	119.2	870.8	19.00	34	114	5.52	3312	2.8	13.29
	Average	116	776	23.67	26.5	140.7	4.41	2644	3.02	13.62
	1	117	849	16.00	40	97	6.00	3600	2.74	12.96

All of the case studies have almost the same leaf area. The controlled leaf Area is 846 cm^2. We observed that all of the cases under the applied conditions at different levels showed significant improvements in the scale in comparison to the Controlled unit, which was 19.67 units. The increased amount ranges from 14.1% to 56%. Following are the cases and their respective improvements. While applying the above-mentioned conditions, we observed that all of the cases showed a decrease in scale in comparison to the Controlled unit of Green wt/plot. In this case, the scale has decreased up to 48.8% and 22.3% in comparison to the Controlled unit of green wt/plot. This case is also similar to the previous one as it shows up to a 66.1 and 43.7% decrease in comparison to the control unit of green wt/plot. This case also shows significant amounts of decrease, as it has decreased from 53.3% and 90% in comparison to the Controlled unit of green leaves per plot. While observing this case it also shows significant amounts of decrease in comparison to the Controlled unit of green wt per plot as it has decreased up to 33.2% and 45.6%.

Similarly, this case also shows significant amounts of decrease in scale as the scale has decreased up to 56.6% and 24.4% in comparison to the Controlled unit of green wt per plot. We applied all of the mentioned

conditions to several variants and all of the variants shows significant improvements in comparison to the control unit of curved leaves per kg. Here the standard scale of curved leaves per Kg is 120.33. Following are the different cases and their respective percentage improvements. When we applied the above-mentioned condition the first variant showed 19.5% and the second variant showed 11.5% improvement as compared to the control unit of curved leaves per Kg. While analyzing this condition, it is observed that the first variant showed 29.9% improvements in comparison to the control unit of green leaves per kg whereas the second variant shows only 9.2% improvements as compared to the control unit of green leaves per kg. Analyzing this condition, we observed that the first case shows 12.3% improvements in comparison to the control unit of green leaves per kg while the second variant shows 51.3% improvements as compared to the Control unit of curved leaves per kg (Zerihun et al., 2015). Analyzing this condition, we observed that the first variant showed 13.2% improvements while the second variant showed 20.1% improvements as compared to the control unit of green leaves per kg. While analyzing this condition, the first variant showed only 2 1% improvements whereas the second variant showed 15.6% improvements as compared to the control unit of green leaves per kg. While analyzing this parameter, we observed that all of the applied conditions resulted in lesser magnitude in comparison to the control unit of curved wt per plot. Here the standard scale was 5.43 units. Following are the applied conditions and their respective variations. While applying the above-mentioned condition we observed that the first variant showed a 25.5% decrement whereas the second variant showed a decrement of 8.2% as compared to the control unit of curved wt per plot. Analyzing this condition, we observed that the first variant showed a decrement of a huge amount i.e. 51.2% whereas the second variant showed a 40.1 % decrease as compared to the control unit of curved wt per plot. While analyzing this condition, we observed that the first variant showed a 38.1% decrement whereas the second variant showed an 80.9% decrement as compared to the control unit of curved wt per plot. While analyzing the current condition, the first variant showed a 23.1% decrement while the second variant showed a 26.2% decrement as compared to the control unit of curved wt per plot. While analyzing this condition, we observed that the first case shows an 18.7% decrement while the later one showed a 20.9% decrement as compared to the Controlled unit of curved wt per plot (Lecours et al., 2012). This parameter was observed under the above-mentioned conditions, we observed that all of the variants showed lesser outcomes as compared to the Controlled unit of yield Kg/ha. The standard value of Yield Kg per h is 32.58 units. The highest decrease was observed in the third condition of magnitude 80.9%. This parameter is the most objective one among all of the parameters. In this condition, we observed that the first variant showed a decrement of 23.4% while the second variant showed a decrease of 8.2% as compared to the control unit of yield Kg/ha. While analyzing this condition, the first variant showed 50.9% of decrement while the second variant showed 25.6% as compared to the control unit of yield Kg ha^{-1}. This condition showed the highest value of decrement i.e. of 80.9% as compared to the control unit of yield Kg/ha. We observed that the first variant showed a decrease of 38.9% whereas the second variant showed an 80.9% decrement as compared to the Controlled unit of yield Kg/ha. While observing this condition, we observed that the first variant showed 22.6% of Decrement whereas the second variant showed 26.3% of decrement as compared to the control unit of yield Kg/ha.

Observing this condition, we get the results that the first variant showed a decrease of 16.8% whereas the second variant showed 20.8% of decrement as compared to the control unit of yield Kg/ha. While observing this parameter under the above-mentioned condition, we observed that the variants showed random results. In some of the conditions, the variant showed decrement while in other cases the variant showed improvement as compared to the Controlled units of the above parameters. Here the standard scale was 2.81 units. In the above condition, we observed that the first condition showed a decrease of 11.6% while the second variant showed an increase of 12.9% is compared to the control. We apply the above condition, and we note and observed that the first variant showed an increase of 21.8% and the second variant showed also an increase of 25.7% as compared to the control. The increase is highest in this parameter. This condition showed the highest value of increase is 5.53% as compared to the control unit of nicotine. We observed that both variants showed an increase as compared to control. While observing this condition, we observe that the first variant showed an increase of 13.9% whereas the second variant showed also an increase of 5.87% as compared to the control unit of yield kg/hr. Observing this condition, we get the result that the first variant showed an increase of 13.2% whereas the second variant showed 7.2 % increase as compared to the control unit. While observing this parameter under the above-mentioned condition we observed that the variant showed random results. In some of the condition variant showed a decrease while in other cases the variant showed improvement as compared to the control unit of the above parameter. Here the standard scale was 13.33 units. In the above condition, we observed that the first condition showed a decrease of 13% while the second variant showed an increase of 6.25% is compared to the control. We apply the above condition, and we note and observed that the first variant showed increase of 19.3% and second variant showed also increase of 19.4% as compared to control. Increase is highest in this parameter. This condition showed the highest value of increase is 13.7%

as compared to control unit of nicotine. We observed that both variants showed increase as compared to control. While observing this condition, we observe that the first variant showed increase of 14.7% whereas the second variant showed also increase of 10.3% as compared to control unit of yield Kg/ha**.** Observing this condition, we get the result that the first variant showed increase of 17% whereas the second variant showed 20.1% increase as compared to control unit.

Conclusion

Based on the results, it was determined that applying Zn to the soil at rates of 3 and 6 Kg per hectare, together with a baseline dosage of 50-60-80 Kg ha^{-1} NPK (12:15:20), enhanced the green and leaf yield after curing in comparison to other Zn treatment techniques. Furthermore, compared to other treatment techniques, soil application (6 Kg Zn ha^{-1}) substantially raised the concentration of Potassium (K) as well as quality metrics including Nicotine content and total Sugar contents.

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