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Effect of Nano-multi Micronutrients on Agronomic Traits, Nutrient Uptake and Soil Fertility in Pot Trial of Maize (*Zea mays* L.)

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Abstract

A pot experiment of maize was carried during summer seasons of March–July, 2023 and 2024 at the experimental field of Rashtriya Chemicals and Fertilizers, Mumbai, India, to assess the impact of multi nano micronutrients formulation (NM) on maize growth. The experiment was structured using a Completely Randomized Block Design with 12 treatments, including control with only water, Recommended Dose of Fertilizer (RDF), and different concentrations of NM having zinc (Zn), copper (Cu), iron (Fe), manganese (Mn) and boron (B) ranging from 20 mg to 0.15 mg 15 kg^{-1} of soil, as well as commercial micronutrients and micronutrient salts. Results revealed that application of 100% RDF+0.312 mg (T_9) and 0.156 mg (T_{10}) of nano micronutrients with drenching recorded better results of nutrient uptake (NU), apparent recovery (ANR) and agronomic efficiency (ARE). The NU (kg ha^{-1}) of nitrogen (120.368), potassium (101.422), Cu (0.114), Fe (1.235), Mn (0.107) and Zn (6.069) was higher in T_9 when compared to 100% RDF. The ANR was 9154.19% higher in T_{10} and 158.28% higher for Nitrogen(N), Phosphorus (P), and Potassium compared to 100% RDF. The protein and chlorophyll content were better in T_9 and T_{10} of nano micronutrients respectively. The applications of T_9 and T_{10} was found to be most effective in NU, ARE, ANR, protein content and chlorophyll content. Higher nutrient content in soil was found in treatment with lower concentrations. Overall, lower concentration of nano micronutrients appeared to be more effective for all traits.

Keywords: Nano multi micronutrient, maize, nutrient uptake, soil fertility

1. Introduction

Maize (*Zea mays* L.) is widely cultivated cereal crop which significantly contributes to global food security and economic development along with rice and wheat (Shiferaw et al., 2011). The adaptability of maize from tropical to temperate regions has made it the world's most widely grown cereal producing over 1.2 billion t in 2022 (Anonymous, 2023 and Jat et al., 2025). The agricultural priority is to overcome the maize yield gap, as it has increasing demand from population growth, urbanization and in industries (Rosegrant et al., 2013). Conventional fertilizer has low nutrient use efficiency resulting in economic waste and environmental pollution (Zhang et al., 2015 Micronutrient application boost crop growth, yield and quality supporting sustainable agriculture (Khatun et al., 2024 and Yadav et al., 2025). Higher maize recovery depends on the optimal uptake of N, P, K and micronutrients like Zn and Fe for key physiological processes (Stewart et al., 2021). The foliar application of single or combined micronutrients like Cu, Zn, Mn, Fe, B and Mo increases the growth, yield and quality, but the combined micronutrients along with N, P and K show greater improvements, crucial for integrated nutrient management (Samiksha et al., 2024 and Jarecki et al., 2025). The use of zinc oxide nano particles rapidly increased the chlorophyll content (Rehman et al., 2021). The nano Zn and nano Mn increase the protein content when compared with the untreated control treatment and shows significant response to nano fertilizers (El-Khouly et al., 2023 and Sary et al., 2025). The application of nano Zn and nano silicon (Si) fertilizer improve improves physiological, agronomic, chemical traits, NU and yield under saline conditions (Shoukat et al., 2025). The application of nano Zn along with 100% NPK and 50% recommended dose of Zn enhances growth and yield in hybrid maize (Deblina et al., 2023). The application of B. *Subtilis* and nano Zn at 3 kg ha^{-1} promotes maize growth, yield and Zn recovery in maize maize with the improved Zn deficiency and recovery (Jalal et al., 2023). In deficient soils the individual application of nano Mn, nano Fe increases the NU and biomass (Sary et al., 2025). The application of the nano Cu boosts maize seed germination and mineral nutrient content (Chaudhary et al., 2021). Compared to conventional B fertilizer, nano B (25 ppm) increases the biomass and nutrient use efficiency than the conventional B fertilizer (Cristina et al., 2023). Latest research concludes that the use of the single nano micronutrients and the combined nano micronutrients along with nano N, P, and K are beneficial in crop growth and productivity, but the use of the combined nano micronutrients has synergetic improvements in the growth, productivity and quality when compared with the single nano micronutrient (Samiksha et al., 2024). In calcareous soil, nano Zn, nano Mn and nano Mo of 40 mg l^{-1} concentration boosts productivity, yield, NU and vegetative growth (Sary et al., 2025). Applying nano Zn, nano Mn and nano Mo with chelates improves the nutrient content and soil fertility (Sary et al., 2025). The parameters like NU, ARE and AE can be studied in both the pot and field trials to assess its efficiency (Dobermann, 2007). Crop growth, yield and quality can be assessed in pot and field trials but pot trial evaluates growth, NU and nutrient use efficiency precisely under controlled conditions (Gomez and Gomez, 1984).

Nutrient use efficiency (NUE) measures fertilizer e4ffectiveness in maize. ARE, NU and ANR impact yield and grain quality. Recent studies Showed that nano micronutrient fertilizers boosts NU, ARE and ANR (Subramanian et al., 2015 and Prasad et al., 2017). There is need to improve ARE for sustainable productivity as the nutrient recovery for N in maize is often below 50% (Zhang et al., 2015 and Upadhyay et al., 2025). In view of the above findings, this study aimed to assess and compare the total NU, ANR, ARE, soil fertility and chlorophyll content in the pot trial of maize by using nano multi micronutrient formulation containing Cu, Zn, Mn, Fe and B, along with commercial micronutrients and salts of micronutrients.

2. Materials And Methods

2.1. Environmental conditions

The pot trial experiment on maize was carried with red soil during two seasons in March–July of 2023 and 2024, in the Research and Development Centre at Rashtriya Chemicals and Fertilizers Limited Chembur in the state of Maharashtra in southern part of the Mumbai with latitude of 19.034434 and longitude of 72.890891 with a total of the 12 treatments in triplicates. Soil samples (15 cm depth) were analysed for available N, P, K, and micronutrients. The soil at the experimental site was having pH 5.51, conductivity 0.21 ms, available N, P and K contents were 178.2, 59.87 and 356.35 kg ha^{-1} respectively. During the cropping period of both the seasons the meteorological data for maximum and minimum recorded was 32°C and 21.7°C while the average relative humidity was 70% and 89% respectively. The average rainfall during experimental seasons was 20 mm in summer and 1900 mm in monsoon seasons.

2.2. Experiment and treatments

The nano micronutrients formulation containing Zn, Cu, Fe, Mn and B was synthesized in the laboratory by mechanical ball milling method. The nano particles were characterized for particle size, zeta potential, XRD, IR, FE SEM and EDX; the nano size of the formulation was confirmed. In the pot experiment, seeds were directly placed in pots filled with 15 kg of soil, and 100% of the RDF was applied along with various doses of the nano-micronutrient formulation delivered in 100 mL of water through drenching. The experiment was performed in randomised block design having the treatments: Absolute control only water (T_1), 100% (RDF) in the ratios of 120:60:40 NPK (T_2), 100% RDF+20 mg pot^{-1} nano micronutrient (NM) (T_3),) 100% RDF+10 mg pot^{-1} NM (T_4), 100% RDF+5 mg pot^{-1} NM (T_5), 100% RDF+2.5 mg pot^{-1} NM (T_6), 100% RDF+ 1.25 mg pot^{-1} NM (T_7), 100% RDF + 0.62 mg pot^{-1} NM (T_8), 100% RDF+ 0.31 mg pot^{-1} NM (T_9), 100% RDF+0.15 mg pot^{-1} NM (T_{10}), 100% RDF+commercial micronutrient (T_{11}), 100% RDF+ micronutrient salts (T_{12}). The commercial micronutrient was applied by spraying at the concentration of 0.25% while micronutrient salts were applied at the rate of 25 kg ha^{-1} by drenching. The nano multi micronutrient formulation was applied at 20 days from the date of sowing at the rate of 20, 10, 5, 2.5, 1.25, 0.625, 0.312 and 0.156 mg $(100\ ml)^{-1}$ water.

2.3. Cultural operations

The corn seeds of hybrid variety F_1 Sweet corn, sweet 16 was sown into the pot with 3 seeds in each pot at the depth of 3–4 cm. The seeds were sowed for the development of sprouts. The fertilizer application was carried out after 20 days from the time of sowing as per the treatment schedule, and weeding was performed simultaneously as and when required. At the physiological maturity the crop was harvested after 100 days. The earthing of the soil was done twice at 30 and 60 days.

2.4. Observation recorded

When the maize was harvested, the growth parameters like plant height, weight of 100 grains, length, diameter and radius of maize were measured from the plants according to the treatments, yield attributes like grain and stover yield were recorded after the harvesting the maize crop and threshing. The grain and stover samples of respective treatments were collected and dried into the sunlight, ground to analyse the nutrient concentration in the laboratory by digesting the samples with acid and then were analysed using an inductively coupled plasma membrane to calculate the NU, ANR, ARE. Nitrogen was estimated on Kjeldahl method using the standard Kjeldahl digestion and was further distilled and titrated on Kjeldahl apparatus. The protein content, protein yield was calculated from the nutrient concentration in grain and stover for N content while chlorophyll content was estimated by grinding the leaf sample in 80% acetone and further transferred into centrifuge instrument and the readings were recorded on spectrophotometer.

2.5. Analytical procedures

The soil samples were taken from various pots, well mixed to ensure uniformity, allowed to air dry, and then sieved through a 2 mm sieve. In the soil analysis, the Kjeldahl on Pelikan Kelplus-Classic DX instrument was used to estimate the N content; the Thermo Scientific Evolution 201 instrument was used to estimate the P; the Systronic brand flame photometer, pH meter, and conductivity meter were used to estimate the potassium, pH, and conductivity; and the Thermo Scientific iCAP 6000 series instrument was used to estimate the micronutrients using an inductively coupled plasma membrane. The Thermo Scientific Evolution 201 and Thermo Scientific ultracentrifuge and spectrophotometer were used to estimate the chlorophyll.

2.6. Statistical analysis

For all the parameters the data of each parameter were pooled from both the seasons and statistically analysed by using ANOVA. Data was statistically analysed using ANOVA in OPSTAT, with treatment differences assessed at a 5% significance level using the critical difference (C.D.) method. The standard error of the mean (SEm±) and the CD value were indicated in the tables to compare the difference between the mean values. Based on the statistically analysed data, the following equations were employed for the calculation of the different parameters.

1. Protein yield (kg ha^{-1})=(Protein content (%)× seed yield kg ha^{-1})/100
2. Grain protein content (%)=Grain nitrogen content (%)×6.25
3. ANR (%)=Nutrient uptake in fertilised plot (kg ha^{-1})-Nutrient uptake in control plot (kg ha^{-1})×100/ Nutrient applied (kg ha^{-1})
4. AE (kg ha^{-1}) = Yield in fertilised plot (q ha^{-1})-Yield in control (q ha^{-1})/ Nutrient applied (kg ha^{-1})
5. Total chlorophyll content mgg^{-1} FW=(20.2×A_{645}+ 8.02×A_{663})×V/1000×W

3. Results and Discussion

3.1. Nutrient uptake

The total NU was the sum of the nutrients present in grain and stover at the harvest. The data regarding NU in maize by application of nano multi micronutrient formulation was presented in Table 1 revealed that T_{10} consistently outperforms other treatments in nearly all measured nutrient categories. Specifically, T_9 demonstrated the highest N uptake at 120.36 kg ha^{-1}, while T1 has the lowest uptake at 15.67%. For P, T_6 Showed the highest uptake at 62.22%, whereas T_1 had the lowest at 8.88%. In terms of K, T_9 led with 101.42%, while T_1 again had the lowest at 24.21%. T_6 also exhibited the highest B uptake at 0.104 ppm, significantly surpassing T_1 low value of 0.018 ppm. Similarly, T_9 excels in Cu uptake (0.114 ppm), Fe uptake (1.235 ppm), Mn uptake (0.107 ppm), and Zn uptake (6.06 ppm), far surpassing T_1, which consistently showed the lowest values

Table 1: Effect of nutrient management practices on total nutrient uptake at harvesting

Treatment	N kg ha^{-1}	P kg ha^{-1}	K kg ha^{-1}	B kg ha^{-1}	Cu kg ha^{-1}	Fe kg ha^{-1}	Mn kg ha^{-1}	Zn kg ha^{-1}
T_1	15.679	8.882	24.218	0.018	0.02	0.161	0.029	0.139
T_2	41.543	16.518	47.469	0.04	0.045	0.425	0.056	0.951
T_3	51.279	25.994	63.512	0.062	0.072	0.509	0.056	1.329
T_4	74.263	21.683	53.524	0.056	0.071	0.799	0.073	2.587
T_5	79.644	42.479	65.884	0.063	0.069	0.998	0.088	2.783
T_6	95.932	62.224	93.011	0.104	0.096	0.703	0.08	5.424
T_7	62.355	35.522	62.177	0.059	0.078	0.612	0.062	2.464
T_8	77.406	35.423	75.358	0.042	0.073	0.59	0.057	2.572
T_9	120.368	52.660	101.422	0.063	0.114	1.235	0.107	6.069
T_{10}	93.464	44.121	71.033	0.083	0.111	0.693	0.086	3.483
T_{11}	60.506	34.930	44.648	0.038	0.064	0.426	0.071	1.224
T_{12}	32.755	17.804	30.265	0.023	0.042	0.217	0.039	0.651
SEm±	0.983	4.839	8.676	0.002	0.002	0.086	0.007	2.432
CD (p=0.05%)	2.163	10.651	19.095	0.005	0.005	0.189	0.015	5.353

T_1: Absolute control only water; T_2: 100% (RDF) in the ratios of 120:60:40 NPK; T_3: 100% RDF+20 mg pot^{-1} nano micronutrient (NM); T_4: 100% RDF+10 mg pot^{-1} NM; T_5: 100% RDF+5 mg pot^{-1} NM; T_6: 100% RDF+2.5 mg pot^{-1} NM; T_7: 100% RDF+1.25 mg pot^{-1} NM; T_8: 100% RDF+0.62 mg pot^{-1} NM; T_9: 100% RDF+0.31 mg pot^{-1} NM; T_{10}: 100% RDF+0.15 mg pot^{-1} NM; T_{11}: 100% RDF+commercial micronutrient; T_{12}: 100% RDF+micronutrient salts for these nutrients. The differences in NU across treatments were statistically significant, with the uptake differences well exceeding the Critical Difference (CD at *p*=0.05) threshold, particularly for N, P, K, B, Cu, Fe, Mn, and Zn. The NU was 189.74, 218.8,113.65, 160, 153.33,190.58, 91.07 and 538.17% higher in N, P, K, B, Cu, Fe, Mn and Zn as compared to 100% RDF. These results confirmed that T_9 provided significantly higher NU compared to all other treatments, making it the most nutrient-efficient treatment across the board. In the present study, the NU of N, K, Cu, Fe, Mn and Zn was higher in T_9 while the P and B was high in treatment T_6. These findings are similar to the results of maize crop with the 100% P, K and 50% N dose with the combined dose of nano Zn, nano N and nano Cu which gave the higher NU values and concentrations in grains and stover of maize (Khardia et al., 2023; Upadhyay et al., 2023). Slight reduction in growth and yield in T_7 and T_8, may be linked to nano particle toxicity, though values remained above control (Salama, 2012). These findings aligned to the findings to the research conducted on foliar application of Zn and Fe increases the nutrient uptake and also the application of 0.1% zinc sulphate along with RDF increases the nutrient uptake in maize crop (Hasan et al., 2021, Ramanjineyulu et al., 2016 and Shruthi et al., 2023). For the higher NU and yield, the biological potassium fertilizer had been used in maize crop which helps in solubilising the potassium and the nano B of 5 mg l^{-1} increases the nutrient concentration and yield in maize (Qureshi et al., 2014 and Raiwad et al., 2023).

3.2. Post harvest soil analysis

Post harvest soil analysis was performed to evaluate changes in soil physiochemical properties and nutrient status of the soil. The data regarding the post-harvest soil analysis as influenced by various treatments are presented in Table 2 which indicated that the available N was significant in all the treatments when compared to control. The available P exhibited high significance in treatment T_9 and T_{11} (87.037 and 87.062 respectively) in 100% RDF with commercial micronutrients and 0.312 mg NM. The available K recorded the higher values in T_7 (167.92 kg ha^{-1}) with 100% RDF with 1.25 mg nano micronutrients which demonstrated significant difference with the control. Copper showed high values in T_2 100% RDF (0.45 ppm) which is significant when compared to control. The available Zn registered high value in T_6 100% RDF with 2.5 mg NM (0.497 ppm) which confirmed the significant difference when compared to control. The available Mn attained high value in T_6 with 100% RDF with nano micronutrients (15.785 ppm) which reflected significant difference with the control. Available N reached high value in T_2 100% RDF (19.258 ppm) which is significant over control. Available B attained high value in treatment T_{11} 100% RDF with commercial micronutrients and is significant when compared to the control. The soil pH and electrical conductivity remained within the normal range of all treatments. The highest N content was recorded in treatment T_6, P in T_9, K in T_7, Cu, Mn and Fe in T_2 and B in T_8. These findings align with the research conducted by (Sary et al., 2025) showing increase in the nutrients in the soil which increases soil fertility through application of NMs. The application of the phyto biochars maintains the soil fertility due to increased soil extractable Zn, Fe, Mn, B and S (Rani, et al., 2023). These results were in agreement with those reported by Shreshtha et al., 2021, in which the application of the residual B and Zn into the soil increases the uptake and soil fertility in in dry seasons crops and combination of Zn and zinc sulphate along with inorganic fertilizers increases the soil

Table 2: Effect of nutrient management practices on soil fertility after harvest

Treatment	pH	Conductivity ms	N kg ha^{-1}	P kg ha^{-1}	K kg ha^{-1}	Cu ppm	Zn ppm	Mn ppm	Fe ppm	B ppm
T_1	6.359	0.177	42.592	39.84	127.323	0.362	0.46	8.752	9.609	1.025
T_2	6.108	0.16	57.293	47.06	132.983	0.45	1.03	14.639	19.258	1.863
T_3	6.163	0.211	29.357	62.642	136.717	0.336	0.472	13.033	11.325	1.734
T_4	6.414	0.158	57.71	61.813	131.908	0.288	1.04	7.498	9.864	1.33
T_5	6.337	0.155	56.125	58.075	133.23	0.326	0.485	10.097	10.987	1.846
T_6	6.307	0.196	120.57	64.538	140.362	0.32	0.497	15.785	13.134	1.991
T_7	6.245	0.226	93.598	52.938	167.927	0.141	0.321	9.111	7.102	2.22
T_8	6.246	0.234	81.797	66.105	141.158	0.173	0.363	7.224	6.127	3.722
T_9	6.283	0.211	44.523	87.037	147.162	0.141	0.182	8.829	6.116	2.546
T_{10}	6.161	0.216	82.44	55.345	140.935	0.185	0.385	9.019	7.004	2.745
T_{11}	6.012	0.18	80.163	87.062	127.108	0.076	0.273	5.996	3.705	3.647
T_{12}	6.072	0.216	43.215	66.507	129.463	0.058	0.19	4.427	3.342	3.383
SEm±	0.283	0.109	1.955	1.245	1.136	0.026	0.052	0.629	0.588	0.282
CD (*p*=0.05%)	0.623	0.24	4.302	2.741	2.5	0.058	0.114	1.384	1.294	0.62

fertility and uptake increasing the productivity and sustainable agriculture (Verma et al., 2024).

3.3. Apparent recovery

The ANR was the measure of how much fertilizer applied was taken by the crop. The ANR (%) of nano micronutrients (B, Cu, Fe, Mn, Zn) over the standard fertilizer treatment T_2 (100% RDF) for different treatments was graphically depicted in Figure 1. This showed how efficiently each treatment enhanced micronutrient uptake compared to RDF alone. T_{10} (0.156 mg NM) recorded the highest recovery across all micronutrients 4277.79%. T_9 (0.321 mg NM) also performed exceptionally well 3722.41%. These findings aligned with the research conducted by Bhanuprakash et al., 2025 and water soluble fertilizers improving efficiency by proper nutrient management and reducing the conventional fertilizers doses in maize. T_{11} (commercial micronutrient) and T_{12} (salts of micronutrients) showed reflected very poor to negative recoveries across almost all nutrients. As NM dosage decreased, ANR generally increased, peaking at T_9 and T_{10}. High doses of 100% RDF+20 mg NM (T_3) and 10 mg NM (T_4) respectively had low recoveries, even lower than RDF (T_2), suggesting inefficiency or toxicity at those levels. These findings were similar to the results when the ANR in Zn was higher in the lower concentration of 75 ppm Zn nano particles due to high consumption of the Zn nano particles by Tomato (Ahmed et al., 2023).

ANR (%) indicated how efficiently plants utilized the nutrients from each treatment, relative to T_2 (100% RDF). Agronomic efficiency (%) of NPK nutrients from different fertilizer treatments over the control T_2 (100% RDF) is graphically depicted in Figure 2. Treatment T_9 (0.321 mg NM) attained the highest ANR (675.77%), indicating the most efficient NU. T_6 (2.5 mg NM) and T_{10} (0.156 mg NM) also had high recoveries, suggesting that lower NM dosages may be more effective. T_3

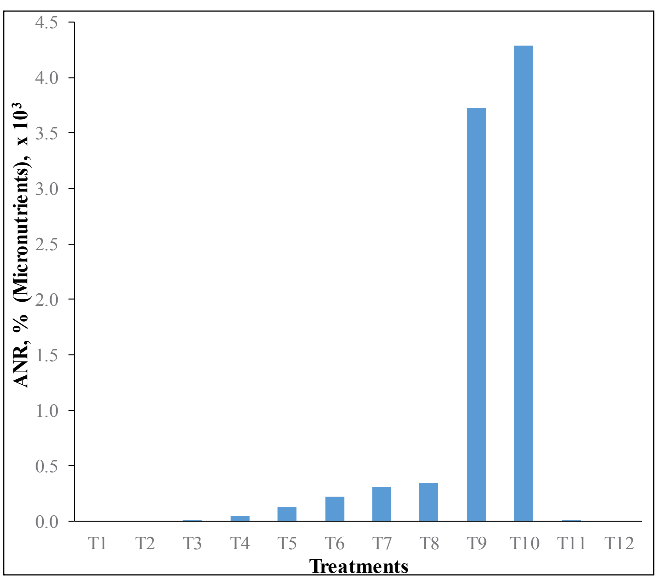

Figure 1: Effect of nutrient management practices on ANR of B, Cu, Fe, Mn and Zn

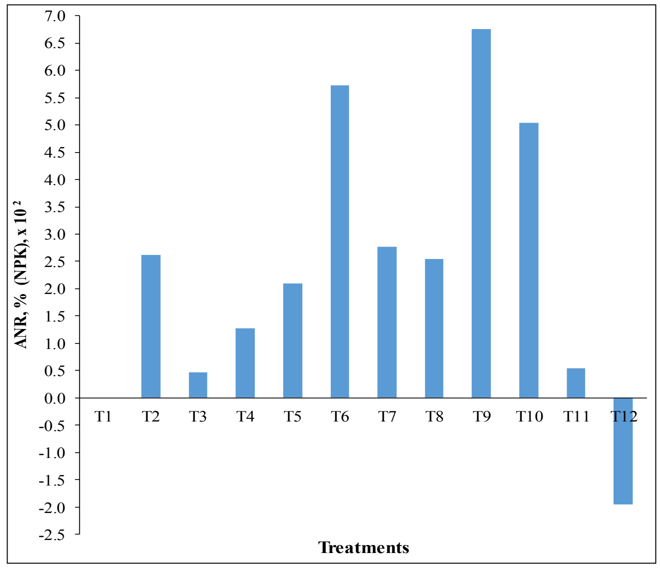

Figure 2: Effect of nutrient management practices on ANR of N, P and K

(20 mg NM) had very low recovery (47.10%), even lower than T_2, suggesting nutrient wastage or antagonistic effects at high NM dosage. T_{12} (salts of micronutrients) showed a negative recovery, implying a potential reduction in NU or loss. T_{11} (commercial micronutrients) also performed poorly compared to optimal NM doses. These findings were similar to the results observed with the application of the nano fertilizers like nano urea and nano diammonium phosphate which significantly increased the apparent recovery and nutrient uptake of N, P and K in the maize crop and Zn and Fe micronutrients (Asha Kiran et al., 2024 and Hasan et al., 2021).

3.4. Agronomic efficiency

Agronomic efficiency was how efficiently a crop converted the added fertilizer into harvestable yield. The ARE in which T_{10} (0.156 mg NM) showed the highest ARE, meaning it produced 69038.13 kg of yield kg^{-1} of nutrient applied as graphically depicted in Figure 3. T_9 (0.321 mg NM) and T8 (0.625 mg NM) also attained extremely high AE values. As NM dosage decreases, AE increases significantly, showing improved nutrient use efficiency at ultra-low nano doses. T_{11} (commercial micronutrient) and T_{12} (salt-based micronutrients) performed worse than optimized nano treatments, showing much lower AE. The ANR was 9154.19% and 158.28% higher in T_{10} for micronutrients and only RDF treatment.

These results were consistent with the findings of Wigar Ahmed et al., 2023, where ARE in zinc was higher in the lower doses of foliar-spray of zinc oxide nano particles at 50 mg kg^{-1}, seed-coating at 100 mg kg^{-1}, or soil-drench at 150 mg kg^{-1} in maize due to the better yield and optimum use of the doses of nano Zn.

3.5. Grain protein content, protein yield and chlorophyll content

The grain protein content expressed the percentage of protein

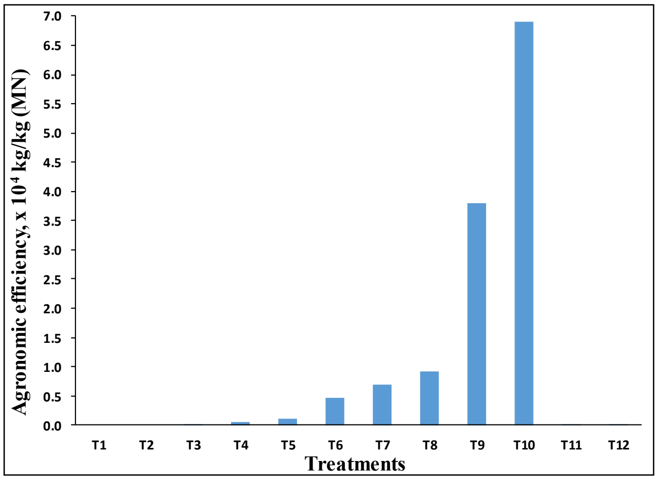

Figure 3: Effect of nutrient management practices on ARE of applied nano micronutrients in maize

in maize grain whereas grain protein yield estimated the total protein harvested (unit area)$^{-1}$ which was calculated by grain yield with protein content (Mosse, 1990). The treatment T_9 attained the highest protein content at 15.3%, followed by T_{10} 154.5% while T_{12} had the lowest at 9.2% as presented in Table 3. The grain protein yield was higher in treatment T_6 460.9 kg ha^{-1} followed by 415.6 kg ha^{-1} in T_9 and lower in treatment T_1. This significant difference indicated that T_6, T_9 and T_{10} resulted in higher protein content and yield. The results were in agreement with those reported by El-Khouly et al., 2023 where the treatment with the nano Zn and nano Mn which significantly increase the protein content when compared with the chelates of nano Zn and Mn. The protein showed a significant response to the nano fertilizers form of the applied nutrient compared to the untreated control (Sary et al., 2025).

The total chlorophyll content in the maize leaves was estimated by Arnon, 1949 method, in which the treatment T_9 had the highest chlorophyll content of 2.83 followed by T_{10} which showed 2.77 when compared with T_1 and T_2 of 1.28 and 1.92 respectively. These results were consistent with the findings of Anonymous, 2022 in which nano Zn and nano Fe with the RDF significantly increased the chlorophyll content in maize when compared with the RDF. The zinc oxide nano particles also increased the chlorophyll content when compared with the control without treatment (Rehman et al., 2021).

Table 3: Effect of nutrient management practices on grain protein content, protein yield and chlorophyll content

Treatment	Protein content (%)	Protein yield (kg ha^{-1})	Chlorophyll
T_1	10.27	59.28	1.28
T_2	12.65	163.81	1.92
T_3	10.76	259.09	1.88
T_4	14.25	204.05	2.37
T_5	13.78	297.29	2.63
T_6	12.85	464.97	1.77
T_7	12.03	320.79	1.97
T_8	12.73	343.86	2.23
T_9	15.33	416.59	2.83
T_{10}	14.64	368.53	2.77
T_{11}	11.94	399.95	2.46
T_{12}	9.2	261.61	1.38

4. Conclusion

An effective treatment for obtaining the NU, ANR, ARE, protein content, protein yield and chlorophyll content when compared with control, commercial and salts of micronutrients was observed with drenching application of 100% RDF with the lower doses of 2.5, 0.312 and 0.156 mg of the nano multi micronutrient. Therefore, lower nano multi micronutrient doses proved more efficient and economical for improving maize protein, chlorophyll and yield.

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