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# The Effectiveness of Mn-EDTA (12%) Micronutrient Fertilizer on Agronomic Performance of Sweet Corn (*Zea mays saccharata Sturt.)*

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**Abstract.** Sweet corn *(Zea mays saccharata Sturt.*) is an increasingly popular horticultural commodity in Indonesia, attracting both farmers and consumer. This study aims to evaluate the effectiveness of single-micronutrient fertilizer Mn-EDTA (12%) in enhancing the growth and yield of sweet corn (*Zea mays saccharata Sturt.)*. The treatments consisted of control, standard NPK, 0.25 NPK, 0.50 NPK, 0.75 NPK, and 1.00 NPK. The experimental findings demonstrated that the application of single-micronutrient Mn-EDTA (12%) fertilizer had a highly significant effect on vegetative growth and yield components of sweet corn, with statistically higher values compared with the control treatment. In general, fertilizer dosages equivalent to 0.25–1.00 NPK produced greater plant height, stem diameter, leaf number, ear length, ear diameter, biomass weight, ear weight with husk, ear weight without husk, plot yield, and productivity than the control. The RAE calculation indicated that the fertilizer was effective when applied at dosages equivalent to 0.75 and 1.00 NPK. The highest effectiveness was observed at the 1.00 NPK dosage, with an RAE value of 101%. Notably, the application of Mn-EDTA (12%) fertilizer at the 1.00 NPK dosage provided significant field effectiveness, as reflected by the RAE value of 101%. This result implies that the use of single-micronutrient Mn-EDTA (12%) fertilizer at the 1.00 NPK dosage increased yield by 1.01 times compared with the yield improvement obtained from the reference fertilizer relative to the control treatment.

**Keywords:** Horticulture; Manganese; Nutrient Management; Productivity; Sustainable Agriculture.

## 1. INTRODUCTION

Sweet corn *(Zea mays saccharata Sturt.*) is an increasingly popular horticultural commodity in Indonesia, attracting both farmers and consumers. Demand continues to rise in line with shifting dietary patterns toward healthier and more nutritious foods. According to the Ministry of Agriculture (2021), sweet corn production in Indonesia has shown a positive trend over the past decade, particularly in horticultural centers such as West Java, Central Java, and North Sumatra. Sweet corn holds high economic value as it can be marketed fresh, processed, or frozen. Research by Sari et al. (2020) demonstrated that sweet corn has considerable yield potential when cultivated with appropriate agronomic practices, including efficient and balanced fertilization. Moreover, sweet corn has a relatively short growth cycle, making it well suited for intensive farming systems and intercropping (Rahman et al., 2022).

Plant growth and development are strongly influenced by the availability of nutrients in the soil. Crops require essential elements in optimal amounts and concentrations, maintained in balanced proportions within the soil. Fertilization plays a critical role in replenishing nutrient losses and meeting plant requirements to enhance productivity. Fertilizers provide essential nutrients that support optimal growth and yield, with appropriate application rates significantly improving crop performance. Nutrient requirements can be met through the use of inorganic fertilizers, which serve as an effective means of achieving high productivity (Siwanto et al.,

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2015). Inorganic fertilizers may be classified as single-nutrient or compound fertilizers. Compound fertilizers contain more than one nutrient, including both macro- and micronutrients. Micronutrient fertilizers are particularly important in agriculture because, although required in small quantities, they play crucial roles in plant physiological processes and contribute substantially to yield improvement (Havlin et al., 2017).

Manganese (Mn) is an essential micronutrient that plays a pivotal role in photosynthesis, chlorophyll synthesis, and the activation of enzymes involved in carbohydrate and nitrogen metabolism. Adequate Mn availability in the soil enhances photosynthetic efficiency and accelerates vegetative growth. Conversely, Mn deficiency can lead to interveinal chlorosis, stunted growth, and reduced yield. Previous studies have demonstrated that Mn fertilization significantly increases leaf number, ear length, and grain weight in sweet corn (*Zea mays saccharata Sturt.)* (Wati et al., 2012; Nindita et al., 2024). Furthermore, interactions between Mn and other nutrients such as nitrogen and magnesium also influence the quality of crop yield (Marschner, 2012)**.** This study aims to evaluate the effectiveness of single-micronutrient fertilizer Mn-EDTA (12%) in enhancing the growth and yield of sweet corn (*Zea mays saccharata Sturt.).*

## 2. THEORITICAL REVIEW

Sweet corn (*Zea mays saccharata*) requires balanced nutrient management to achieve optimal growth and productivity. Among the essential macronutrients, nitrogen (N), phosphorus (P), and potassium (K) play distinct but complementary roles in plant physiology. Nitrogen is a fundamental component of amino acids, proteins, nucleic acids, and chlorophyll, directly influencing photosynthetic capacity and vegetative vigor (Daroga et al., 2017; Fathi, 2022). Phosphorus contributes to energy transfer through ATP, root development, and reproductive processes, thereby enhancing kernel formation and crop maturation (Zhao et al., 2016). Potassium regulates osmotic balance, stomatal function, and enzyme activation, improving stress tolerance and carbohydrate translocation, which are critical for ear development (Beringer, 1980).

The experimental findings demonstrated that the application of single-micronutrient Mn-EDTA (12%) fertilizer had a highly significant effect on vegetative growth and yield components of sweet corn (*Zea mays saccharata* Sturt.). Compared with the control treatment, Mn fertilization consistently produced superior agronomic performance, underscoring the importance of micronutrient supplementation in crop management (Montgomery, 2022; Salomé, 2018).

Across the tested dosage range of 0.25–1.00 NPK equivalents, Mn-EDTA application significantly enhanced plant height, stem diameter, and leaf number. These vegetative parameters are critical indicators of crop vigor and photosynthetic efficiency. The observed improvements align with the role of Mn as a cofactor in photosynthesis and nitrogen metabolism, supporting chlorophyll synthesis and enzyme activation (Daroga et al., 2017; Fathi, 2022). Such physiological functions explain the robust vegetative development observed in Mn-treated plants.

Yield components also responded positively to Mn-EDTA application. Ear length, ear diameter, biomass weight, ear weight with husk, and ear weight without husk all showed statistically significant increases compared with the control. These improvements translated into higher plot yield and overall productivity, confirming that Mn fertilization contributes not only to vegetative growth but also to reproductive success. Similar findings have been reported in studies combining Mn with NPK, which increased fresh ear weight by 10–20% and improved grain quality, including sugar content (Nindita, et al., 2024; Syahputra et al., 2024).

The Relative Agronomic Effectiveness (RAE) analysis further substantiated the efficiency of Mn-EDTA fertilizer. Treatments at 0.75 and 1.00 NPK dosages were classified as effective, with the highest RAE value of 101% recorded at the 1.00 NPK dosage. This implies that Mn-EDTA fertilizer at optimal dosage can increase yield by 1.01 times compared with the yield improvement achieved by the reference fertilizer relative to the control. Comparable studies on maize have also demonstrated high RAE values for micronutrient fertilizers when applied at appropriate dosages (Nurdin, et al., 2020).

Overall, the results indicate that Mn-EDTA (12%) fertilizer, when applied at appropriate dosages, can be integrated into sweet corn production systems to enhance growth and yield performance. Its effectiveness depends on balancing micronutrient supplementation with macronutrient requirements, particularly N, $P_2O_5$, and $K_2O$. Proper dosage calibration ensures maximum agronomic benefit while avoiding risks of nutrient imbalance or toxicity, making Mn-EDTA a valuable component of sustainable fertilization practices (Wati, 2012; Syafrullah et al., 2020).

## 3. RESEARCH METHODS

The field experiment to evaluate the effectiveness of single-micronutrient fertilizer Mn-EDTA (12%) was conducted from October 2025 to January 2026 at the Sindang Barang Experimental Field. Soil analysis was carried out at the Testing Laboratory, Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University, Bogor.

The materials used in this experiment included hybrid F1 sweet corn seeds of the Exotic Pertiwi variety and fertilizers consisting of single-micronutrient Mn-EDTA (12%), urea, SP-36, and KCl, as well as pesticides. The equipment employed comprised cultivation tools (hoes, hand weeders, sprayers), a camera for documentation, and bamboo stakes for sample plants. Data processing was carried out using a computer equipped with the SAS statistical analysis program.

The evaluation of single-micronutrient Mn-EDTA (12%) fertilizer on sweet corn *(Zea mays saccharata*) was conducted using a Randomized Complete Block Design (RCBD). For inorganic fertilizers with established recommended dosages, the treatments consisted of: (P0) control, (P1) standard NPK, (P2) 0.25 NPK, (P3) 0.50 NPK, (P4) 0.75 NPK, and (P5) 1.00 NPK. To meet the requirement of degrees of freedom (d.f.) $\geq 15$, each treatment was replicated four times, with replications arranged as blocks based on slope gradient. In total, 24 experimental plots were evaluated.

Land preparation was carried out by tilling the soil to a depth of 25 cm, followed by the application of basal fertilizers consisting of goat manure at 10 tons $ha^{-1}$ and dolomite at 2 tons $ha^{-1}$. Sweet corn seeds were planted by making holes using a dibble stick, with a spacing of 75 cm × 25 cm. Each hole was sown with two sweet corn seeds along with Furadan. At four weeks after planting, thinning was performed to maintain one plant per hole.

The standard inorganic fertilizer dosage for maize was determined based on the recommended nutrient requirements of N, P, and K, namely 135 kg N $ha^{-1}$, 72 kg $P_2O_5$ $ha^{-1}$, and 120 kg $K_2O$ $ha^{-1}$ (equivalent to ~300 kg urea, 200 kg SP-36, and 200 kg KCl per hectare). The nutrient composition of the standard NPK fertilizer (NPK-std) used consisted of urea (45% N), SP-36 (36% $P_2O_5$), and KCl (60% $K_2O$), which are commercially available and have been tested for effectiveness. SP-36 was applied entirely at planting, while urea and KCl were applied in two split doses: half at planting and half at four weeks after planting (WAP). The specific fertilizer dosages for each treatment are presented in Table 1. Urea, SP-36, and KCl were applied in furrows to the right or left along the plant rows.

**Table 1.** The detailed dosage of single-micronutrient fertilizer Mn-EDTA (12%).

| Treatment | Mn (12%) (kg/ha) | Urea (kg/ha) | SP-36 (kg/ha) | KCL (kg/ha) |
|---|---|---|---|---|
| P0: Control | 0 | 0 | 0 | 0 |
| P1: NPK Standard | 0 | 300 | 200 | 200 |
| P2: 0,5 NPK | 0,045 | 75 | 50 | 50 |
| P3: 0,75 NPK | 0,045 | 150 | 100 | 100 |
| P4: 1,0 NPK | 0,045 | 225 | 150 | 150 |
| P5: 1,5 NPK | 0,045 | 300 | 200 | 200 |

The single-micronutrient fertilizer Mn-EDTA (12%) was applied as a foliar spray at a concentration of 0.05 g $L^{-1}$ (equivalent to 1 g per 20 L). Applications were carried out three times at 4, 6, and 8 weeks after planting (WAP), with each spray volume amounting to 300 L $ha^{-1}$. Thus, the foliar application per treatment corresponded to 0.1125 g $plot^{-1}$, or 0.1125 g in 2,250 mL for a plot size of 25 $m^2$ (Table 2). Spraying was conducted between 08:00 and 09:00 a.m.

**Table 2.** The detailed fertilization schedule for each application of single-micronutrient Mn-EDTA (12%) at 4, 6, and 8 weeks after planting (WAP).

| Treatment | Mn (12%) (g/plot) | Spray volume (ml/plot) |
|---|---|---|
| P0: Control | 0 | 0 |
| P1: NPK Standard | 0 | 0 |
| P2: 0,5 NPK | 0,1125 | 2.250 |
| P3: 0,75 NPK | 0,1125 | 2.250 |
| P4: 1,0 NPK | 0,1125 | 2.250 |
| P5: 1,5 NPK | 0,1125 | 2.250 |

Vegetative observations included plant height, leaf number, and stem diameter, recorded at 4, 6, and 8 weeks after planting (WAP) on 10 sample plants per plot. Sweet corn was harvested at approximately 10–11 WAP. The production parameters measured from 10 sample plants per plot were: (1) ear weight with husk, (2) ear weight without husk, (3) ear length without husk, and (4) ear diameter without husk. In addition to the sample plants, ears with husk and filled kernels from each plot (excluding border plants) were harvested to calculate productivity. The ear weight with husk and filled kernels per plot was then recorded.

The fertilizer was considered technically effective if the inorganic fertilizer treatment tested was statistically equal to or higher than the standard fertilizer treatment (reference) or superior to the control at the 5% significance level, and if the Relative Agronomic Effectiveness (RAE) value of the tested fertilizer was greater than or equal to 95%. Agronomic effectiveness of inorganic fertilizers was determined using the Relative Agronomic Effectiveness (RAE) method (Mackay et al., 1984; Nurdin et al., 2020), calculated using the following formula:

$$\text{RAE} = \frac{\text{corn productivity from tested fertilizers} - \text{control}}{\text{corn productivity from comparison fertilizer} - \text{control}} \times 100\%$$

Data obtained from the measurements were statistically analyzed using analysis of variance (ANOVA), followed by Duncan's Multiple Range Test (DMRT) at the 5% significance level.

## 4. RESULTS AND DISCUSSION

### General Conditions of Experiment

The quality test results of the single-micronutrient fertilizer Mn-EDTA (12%) are presented in Table 3, with the official test certificate provided in Appendix 1. The analysis showed that the fertilizer contained 12.04% Mn-EDTA, with a moisture content of 0.11%. Heavy metal contamination levels were found to be very low, namely As < 0.002 mg $kg^{-1}$, Hg < 0.001 mg $kg^{-1}$, Cd < 0.002 mg $kg^{-1}$, and Pb < 0.002 mg $kg^{-1}$ (Table 3).

**Tabel 3.** The quality test results of Mn-EDTA (12%).

| Testing Parameters | Unit | Test Results |
|---|---|---|
| Mn EDTA | % | 12,04 |
| Water Content | % | 0,11 |
| As | mg/kg | <0,002 |
| Hg | mg/kg | <0,001 |
| Cd | mg/kg | <0,002 |
| Pb | mg/kg | <0,002 |

Soil analysis was conducted prior to the experiment by collecting soil samples from all treatment plots, which were then composited. The purpose of the soil analysis was to determine the fertility status of the soil to be used before the trial. The results of the soil analysis are presented in Table 4.

**Table 4.** Soil analysis results before the experiment.

| Parameter | Unit | Value | Category* |
|---|---|---|---|
| pH $H_2O$ | - | 5,02 | Acid |
| C-organic | % | 1,97 | Low |
| N-total | % | 0,25 | Medium |
| P-available (Bray I) | ppm $P_2O_5$ | 33,3 | Very high |
| CEC | cmol $kg^{-1}$ | 15,9 | Low |
| K-dd | cmol K $kg^{-1}$ | 0,22 | Low |
| P-Potential | mg $P_2O_5$ 100 $g^{-1}$ | 127 | Very high |
| K-Potential | mg $K_2O$ 100 $g^{-1}$ | 24,5 | Medium |
| Mn-Total | Mg $kg^{-1}$ | 2,58 x $10^3$ | Very high |

Source: Balai Penelitian Tanah (2023).

The analysis of variance indicated that the treatment with single-micronutrient Mn-EDTA (12%) had a highly significant effect on both growth components and yield components of maize. The coefficients of variation (CV) for growth components ranged from

1.69%–8.96% for plant height, 1.44%–4.89% for stem diameter, 1.32%–8.77% for leaf number, and 12.56% for biomass weight. The CV values for yield components ranged from 3.30%–15.66%, with the lowest CV observed in ear diameter and the highest CV in plot yield (Table 5).

**Table 5.** Recapitulation of analysis variance.

| Variabel | Treatment | Coefficient of Variance (%) |
|---|---|---|
| Growth Component: | | |
| Plant height | | |
| 4 WAP | ** | 8,96 |
| 6 WAP | ** | 6,41 |
| 8 WAP | ** | 1,69 |
| Stem diameter | | |
| 4 WAP | ** | 4,89 |
| 6 WAP | ** | 1,85 |
| 8 WAP | ** | 1,44 |
| Leaf number | | |
| 4 WAP | ** | 8,77 |
| 6 WAP | ** | 2,09 |
| 8 WAP | ** | 1,32 |
| Biomass Weight | ** | 12,56 |
| Yield Component: | | |
| Ear length without husk | ** | 5,82 |
| Ear diameter without husk | ** | 3,30 |
| Ear weight with husk | ** | 13,19 |
| Ear weight without husk | ** | 11,60 |
| Plot Yield | ** | 15,66 |
| Productivity | ** | 15,65 |

Note: *Significant at α=5% level, ** Significant at α=1% level.

**The effect of Mn-EDTA (12%) fertilizer on the vegetative growth components of sweet corn**

The analysis of variance showed that the treatment with single-micronutrient Mn-EDTA (12%) had a highly significant effect on plant height from 4 to 8 weeks after planting (WAP) (Table 6). The mean plant height obtained from each treatment at each observation time ranged from 74.95–104.64 cm (4 WAP), 101.02–157.67 cm (6 WAP), and 136.18–211.03 cm (8 WAP).

The application of Mn-EDTA (12%) fertilizer significantly increased plant height compared with the control treatment across all observation periods. Fertilizer dosages equivalent to 0.25–1.00 NPK produced higher plant height values than the control for the 4–8 WAP growth period.

**Table 6.** Plant height at different application rates of Mn-EDTA (12%) fertilizer.

| Treatment | Plant height (cm) | | |
|---|---|---|---|
| | 4 WAP | 6 WAP | 8 WAP |
| Control | 74,95[c] | 101,02[d] | 136,18[e] |
| NPK Standard | 111,94[a] | 151,46[ab] | 208,09[ab] |
| 0,50 NPK | 103,29[ab] | 133,59[c] | 189,26[d] |
| 0,75 NPK | 93,11[b] | 157,67[a] | 211,03[a] |
| 1,00 NPK | 116,02[a] | 140,79[bc] | 203,58[b] |
| 1,50 NPK | 104,64[ab] | 137,04[c] | 195,64[c] |

Note: number followed by different letters in the same column indicate significant differences based on the results of DMRT α 5% test.

The treatment with single-micronutrient Mn-EDTA (12%) had a highly significant effect on stem diameter of sweet corn plants from 4 to 8 weeks after planting (WAP) (Table 7). The mean stem diameter obtained from each treatment at each observation time ranged from 7.45–15.80 mm (4 WAP), 13.68–18.47 mm (6 WAP), and 16.82–21.42 mm (8 WAP). Fertilizer dosages equivalent to 0.25–1.00 NPK significantly increased stem diameter compared with the control treatment during the 4–8 WAP growth period.

**Table 7.** Stem Diameter at different application rates of Mn-EDTA (12%) fertilizer.

| **Treatment** | **Stem diameter (mm)** | | |
|---|---|---|---|
| | 4 WAP | 6 WAP | 8 WAP |
| Control | 7,45[d] | 13,68[d] | 16,82[e] |
| NPK Standard | 15,70[a] | 18,47[a] | 21,42[a] |
| 0,50 NPK | 13,78[b] | 17,65[bc] | 20,12[bc] |
| 0,75 NPK | 14,45[b] | 18,05[ab] | 20,32[b] |
| 1,00 NPK | 15,80[a] | 18,45[a] | 19,75[cd] |
| 1,50 NPK | 11,80[c] | 17,27[c] | 19,52[d] |

Note: number followed by different letters in the same column indicate significant differences based on the results of DMRT α 5% test.

The analysis presented in Table 8 showed that the application of single-micronutrient Mn-EDTA (12%) had a highly significant effect on leaf number from 4 to 8 weeks after planting (WAP). The mean leaf number obtained from each treatment at each observation time ranged from 6.47–8.90 leaves (4 WAP), 8.20–10.52 leaves (6 WAP), and 11.05–12.45 leaves (8 WAP). Fertilizer dosages equivalent to 0.25–1.00 NPK significantly increased leaf number compared with the control treatment during the 4–8 WAP growth period.

**Table 8.** Leaf number at different application rates of Mn-EDTA (12%) fertilizer.

| **Treatment** | **Leaf number** | | |
|---|---|---|---|
| | 4 WAP | 6 WAP | 8 WAP |
| Control | 6,47[c] | 8,20[c] | 11,05[c] |
| NPK Standard | 8,45[ab] | 9,67[b] | 12,45[a] |
| 0,50 NPK | 8,37[ab] | 10,45[a] | 12,40[a] |
| 0,75 NPK | 7,35[bc] | 9,45[b] | 12,40[a] |
| 1,00 NPK | 8,05[ab] | 9,62[b] | 11,97[b] |
| 1,50 NPK | 8,90[a] | 10,52[a] | 12,37[a] |

Note: number followed by different letters in the same column indicate significant differences based on the results of DMRT α 5% test.

**The effect of Mn-EDTA (12%) fertilizer on the Yield Components of Sweet Corn**

The analysis of variance (Table 9) showed that the application of single-micronutrient Mn-EDTA (12%) had a highly significant effect on ear length and ear diameter of sweet corn. The mean ear length obtained in this experiment ranged from 14.39–20.63 cm, while the mean ear diameter ranged from 38.15–49.10 mm. Fertilizer dosages equivalent to 0.25–1.00 NPK significantly increased ear length and diameter compared with the control treatment.

**Table 9.** Ear length and ear diameter at different application rates of Mn-EDTA (12%) fertilizer.

| Treatment | Ear Length (cm) | Ear Diameter (mm) |
|---|---|---|
| Control | 14,39$^{c}$ | 38,15$^{c}$ |
| NPK Standard | 20,63$^{a}$ | 49,10$^{a}$ |
| 0,50 NPK | 18,58$^{b}$ | 46,12$^{b}$ |
| 0,75 NPK | 19,41$^{ab}$ | 47,67$^{ab}$ |
| 1,00 NPK | 20,11$^{ab}$ | 48,84$^{a}$ |
| 1,50 NPK | 19,31$^{ab}$ | 48,14$^{ab}$ |

Note: number followed by different letters in the same column indicate significant differences based on the results of DMRT α 5% test.

The treatment with single-micronutrient Mn-EDTA (12%) had a highly significant effect on biomass weight, ear weight with husk, and ear weight without husk of sweet corn (Table 10). The mean biomass weight obtained in this experiment ranged from 0.18–0.33 kg. The mean ear weight with husk ranged from 0.13–0.35 kg, while the mean ear weight without husk ranged from 0.10–0.26 kg. Fertilizer dosages equivalent to 0.25–1.00 NPK significantly increased biomass weight, ear weight with husk, and ear weight without husk compared with the control treatment.

The treatment with single-micronutrient Mn-EDTA (12%) had a highly significant effect on plot yield and productivity of sweet corn (Table 11). The mean values obtained for plot yield and productivity ranged from 7.05–18.98 kg and 4.48–12.05 t ha$^{-1}$, respectively. Fertilizer dosages equivalent to 0.25–1.00 NPK significantly increased plot yield and productivity compared with the control treatment.

**Table10.** Yield component and biomass weight at different application rates of Mn-EDTA (12%) fertilizer.

| Treatment | Biomass Weight (kg) | Ear Weight With Husk (kg) | Ear Weight Without Husk (kg) |
|---|---|---|---|
| Control | 0,18$^{c}$ | 0,13$^{c}$ | 0,10$^{c}$ |
| NPK Standard | 0,33$^{a}$ | 0,35$^{a}$ | 0,26$^{a}$ |
| 0,50 NPK | 0,26$^{b}$ | 0,26$^{b}$ | 0,20$^{b}$ |
| 0,75 NPK | 0,27$^{ab}$ | 0,31$^{ab}$ | 0,23$^{ab}$ |
| 1,00 NPK | 0,32$^{a}$ | 0,35$^{a}$ | 0,26$^{a}$ |
| 1,50 NPK | 0,29$^{ab}$ | 0,32$^{ab}$ | 0,24$^{a}$ |

Note: number followed by different letters in the same column indicate significant differences based on the results of DMRT α 5% test.

**Table 11.** Plot Yield and productivity at different application rates of Mn-EDTA (12%) fertilizer.

| Treatment | Plot Yield (kg) | Productivity (ton/ha) |
|---|---|---|
| Control | 7,05[c] | 4,48[c] |
| NPK Standard | 18,89[a] | 11,99[a] |
| 0,50 NPK | 13,99[b] | 8,88[b] |
| 0,75 NPK | 17,49[ab] | 11,10[ab] |
| 1,00 NPK | 18,61[a] | 11,81[a] |
| 1,50 NPK | 18,98[a] | 12,05[a] |

Note: number followed by different letters in the same column indicate significant differences based on the results of DMRT α 5% test.

Relative Agronomic Effectiveness (RAE) is a measure of fertilizer effectiveness. A fertilizer is considered effective if it achieves an RAE value of ≥ 95%. This threshold indicates that the fertilizer can provide a greater yield increase compared with the yield improvement obtained from the reference fertilizer relative to the control.

The Relative Agronomic Effectiveness (RAE) values of the single-micronutrient Mn-EDTA (12%) fertilizer are presented in Table 12. The RAE calculation indicated that the fertilizer was effective when applied at dosages equivalent to 0.75 and 1.00 NPK. The highest effectiveness was observed at the 1.00 NPK dosage, with an RAE value of 101%. This result implies that the application of Mn-EDTA (12%) fertilizer at the 1.00 NPK dosage increased yield by 1.01 times compared with the yield improvement obtained from the standard fertilizer relative to the control treatment.

**Table 12.** Relative Agronomic Effectiveness (RAE) value at different application rates of Mn-EDTA (12%) fertilizer.

| Treatment | RAE (%) |
|---|---|
| Control | - |
| NPK Standard | - |
| 0,50 NPK | 59 |
| 0,75 NPK | 88 |
| 1,00 NPK | 98 |
| 1,50 NPK | 101 |

The experimental results demonstrated that the application of single-micronutrient Mn-EDTA (12%) fertilizer had a highly significant effect on vegetative growth and yield components of sweet corn, with statistically higher values compared with the control treatment. In general, fertilizer dosages equivalent to 0.25–1.00 NPK produced greater plant height, stem diameter, leaf number, ear length, ear diameter, biomass weight, ear weight with husk, ear weight without husk, plot yield, and productivity than the control. These findings are consistent with those reported by Pepó and Karancsi (2017), who stated that increasing NPK fertilizer dosage is directly proportional to increases in plant height, stem diameter, and leaf number.

Nitrogen, potassium, and phosphorus in compound fertilizers, besides being essential nutrients required by plants, play distinct physiological roles. Although these macronutrients are needed in large amounts, their availability in soil is often insufficient to meet crop demands, thus requiring external supplementation. Nitrogen is a fundamental component of organic compounds such as amino acids, proteins, and nucleic acids (Daroga et al., 2017; Fathi, 2022). N fertilizer is crucial for increasing maize production, as nitrogen is the primary constituent of chlorophyll, which plays a central role in photosynthesis. Nitrogen deficiency causes leaf yellowing and reduces photosynthetic efficiency. Moreover, nitrogen contributes to the synthesis of amino acids, proteins, and cellular structural components. However, excessive N application in maize can increase susceptibility to pests and diseases, particularly during the rainy season, prolong crop maturity, and cause lodging due to excessive leaf and stem growth unsupported by the root system. Overuse of N fertilizers not only raises production costs but also harms the environment through $N_2O$ emissions during ammonification, nitrification, and denitrification processes (Wahid, 2003). Phosphorus (P) is vital for energy formation (ATP), root development, and crop maturation, and strongly influences the productivity of food crops such as sweet corn (Zhao et al., 2016). Potassium (K) is closely related to biophysical and biochemical processes in plants. It plays an important role in regulating osmotic pressure and turgor, which in turn affect cell growth and development as well as stomatal opening and closure (Beringer, 1980).

Manganese (Mn) plays an essential role in supporting the growth and yield of sweet corn, functioning as a cofactor for enzymes involved in photosynthesis, nitrogen metabolism, and chlorophyll formation. Application of Mn fertilizer has been shown to enhance leaf greenness, expand the photosynthetic area, and improve plant vigor, resulting in larger and more uniform ears. Studies have demonstrated that Mn supplementation in combination with macronutrient fertilizers such as NPK can increase fresh ear weight by 10–20% and improve grain quality, including higher sugar content (Nindita et al., 2024). In addition, Mn contributes to plant tolerance against oxidative stress, enabling sweet corn to withstand suboptimal environmental conditions (Syafrullah et al., 2020). However, excessive Mn application may cause toxicity symptoms such as brown leaf spots, highlighting the need for dosage adjustment according to soil conditions and crop requirements (Wati et al., 2012). The combined use of NPK and Mn produces a synergistic effect, with NPK supplying the fundamental energy for growth while Mn ensures optimal photosynthesis and metabolism. Syahputra et al. (2024) reported that integrating organic fertilizers with NPK improved ear weight and grain quality in sweet corn. The addition of Mn to NPK fertilizers has the potential to further enhance yield both quantitatively and qualitatively, particularly in low-fertility or acidic soils where micronutrient deficiencies are common.

Enhancements in both vegetative growth components and yield components were observed in this experiment with increasing application dosages of the tested fertilizer. The treatment with single-micronutrient Mn-EDTA (12%) applied at dosages equivalent to 0.25–1.00 NPK, significantly improved growth and yield parameters compared with the control. The Relative Agronomic Effectiveness (RAE) calculation indicated that the fertilizer was effective at 0.75 and 1.00 NPK dosages, with the highest effectiveness recorded at 1.00 NPK (101%). This result implies that Mn-EDTA (12%) fertilizer at the 1.00 NPK dosage increased yield by 1.01 times compared with the yield improvement obtained from the reference fertilizer relative to the control. These findings further suggest that the appropriate application of Mn-EDTA (12%) fertilizer can be integrated into sweet corn cultivation, provided that nutrient requirements and the balance of N, $P_2O_5$, and $K_2O$ are carefully considered.

## 5. CONCLUSION AND RECOMMENDATION

The experimental findings demonstrated that the application of single-micronutrient Mn-EDTA (12%) fertilizer had a highly significant effect on vegetative growth and yield components of sweet corn, with statistically higher values compared with the control treatment. In general, fertilizer dosages equivalent to 0.25–1.00 NPK produced greater plant height, stem diameter, leaf number, ear length, ear diameter, biomass weight, ear weight with husk, ear weight without husk, plot yield, and productivity than the control.

The RAE calculation indicated that the fertilizer was effective when applied at dosages equivalent to 0.75 and 1.00 NPK. The highest effectiveness was observed at the 1.00 NPK dosage, with an RAE value of 101%. Notably, the application of Mn-EDTA (12%) fertilizer at the 1.00 NPK dosage provided significant field effectiveness, as reflected by the RAE value of 101%. This result implies that the use of single-micronutrient Mn-EDTA (12%) fertilizer at the 1.00 NPK dosage increased yield by 1.01 times compared with the yield improvement obtained from the reference fertilizer relative to the control treatment.

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