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Growth and Production of Sweet Corn (Zea *mays* var. *Saccharata* Sturt.) at Various Doses of Micro Inorganic Fertilizers (3.14% Zn – 2.54% Cu)

Pertumbuhan dan Produksi Tanaman Jagung Manis (Zea mays var. Saccharata Sturt.) pada Berbagai Dosis Pupuk Anorganik Mikro (3.14% Zn – 2.54% Cu)

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ABSTRAK

Jagung manis adalah komoditas hortikultura yang banyak dibudidayakan di Indonesia. Tujuan dari penelitian ini adalah untuk mengetahui respon perkembangan dan pertumbuhan dari tanaman jagung manis terhadap pemberian dosis pupuk anorganik mikro (3.14% Zn – 2.54% Cu) yang berbeda. Penelitian dilakukan di Kebun Percobaan Sindangbarang, Bogor, Jawa Barat. Percobaan ini menggunakan rancangan acak kelompok (RAK) dengan faktor tunggal yaitu dosis pemberian pupuk. Perlakuan disusun dalam 4 taraf aplikasi yaitu: (1) kontrol, (2) NPK standar, (3) NPK + 1 dosis mikro, (4) ¾ NPK + 1 dosis mikro. Hasil pengujian ini menunjukkan bahwa taraf aplikasi pupuk anorganik mikro pada taraf aplikasi pupuk NPK Standar + 1 dosis mikro dan perlakuan pupuk ¾ NPK Standar + 1 dosis mikro secara umum dapat memberikan tinggi tanaman, diameter batang, jumlah daun, panjang tongkol, diameter tongkol, bobot brangkasan, bobot tongkol berkelobot, bobot tongkol tanpa kelobot, produksi per petak, dan produktivitas yang secara statistik lebih tinggi terhadap perlakuan kontrol. Aplikasi NPK Standar + 1 dosis mikro dan perlakuan pupuk ¾ NPK Standar + 1 dosis mikro memiliki nilai Relative Agronomic Effectiveness (RAE) yang memenuhi persyaratan lulus uji efektivitas pupuk, dengan nilai RAE tertinggi didapatkan pada pengaplikasian pupuk ¾ NPK Standar + 1 dosis mikro sebesar 118%.

Kata kunci: copper, efektifitas pupuk, tanaman hortikultura, zinc

ABSTRACT

Sweet corn is a horticultural commodity that is widely cultivated in Indonesia. This study aimed to determine the development and growth response of sweet corn plants to the application of different doses of micro inorganic fertilizer (3.14% Zn – 2.54% Cu). The research was conducted at Sindangbarang Experimental Field, Bogor, West Java. This experiment used a Randomized Complete Block Design (RCBD) with a single factor, namely the dose of fertilizer application. Treatments were arranged in 4 levels of application, namely: (1) control, (2) standard NPK, (3) NPK + 1 micro dose, (4) ¾ NPK + 1 micro dose. The results of this test indicate that the application level of micro inorganic fertilizers at the application level of NPK fertilizer + 1 micro dose and ¾ NPK + 1 micro dose fertilizer treatment can generally provide plant height, stem diameter, number of leaves, cob length, cob diameter, stover weight, cob weight with husk, cob weight without husk, production per plot, and productivity which were statistically higher than the control treatment. The application of NPK + 1 micro dose and fertilizer treatment of ¾ NPK + 1 micro dose have Relative Agronomic Effectiveness (RAE) values that meet the requirements to pass the fertilizer effectiveness test, with the highest RAE value obtained in the application of ¾ NPK + 1 micro dose fertilizer at 118%.

Keywords: copper, effectivity of fertilizer, horticulture plants, zinc

INTRODUCTION

Sweet corn is a widely cultivated horticultural commodity due to its high consumption in Indonesia. High and sustainable production of sweet corn is needed to meet the consumption needs of the Indonesian people every year. The growth and yield of corn plants are strongly influenced by the availability of adequate and balanced nutrients in soil (Shedley et al., 2008). The growth and development of corn plants is strongly supported by the availability of nutrients from the soil in providing nutrients for plants. Plants need the amount of nutrients that are in the optimum amount and concentration and are in balance in the soil. Fertiliziation has avery essential role, especially in replacing nutrient losses in the soil and to meet the needs of nutrients in increasing plant productivity. Fertilizers contain nutrients for plants to support optimum growth dan production. The optimal dose of fertilizer can increase crop production. The need for nutrients in plants can be done by applying inorganic fertilizers. Inorganic fertilizers can be used as a means of achieving high plant productivity (Siwanto et al., 2015).

The process of intensification of agricultural land without proper fertilizer management can result in depletion of nutrients in the soil and a decrease in the productivity agricultural products. Currently, the intensification of agricultural land productivity is focused mainly on providing essential macro-nutrients such as N, P, and K. On the other hand, cereal foods crops such as rice and corn also absorb zinc (Zn) nutrients, where the response of corn to Zn deficiency is quite high (Fageria, 2002). Zn fertilization as an effort to increase its availability is rarely done so that it damages plant growth and development in the long run.

Zinc (Zn) nutrient is an essential nutrient required in small (micro) amounts. Zn is needed as a regulator of N and carbohydrate metabolism, a constituent of several enzymes, cell proliferation, photosynthesis, pollen formation, and seed production, phytohormone synthesis (Alloway, 2008; Hafeez et al., 2013; Maqbool and Beshir, 2019). Visual symptoms of Zn deficiency cause short internodes, leaf area narrowing, and auxin metabolism inhibition (Kirkby and Römheld, 2004). The dynamics of Zn in soil are similar to Cu and Fe, at pH less than 5 its availability will be higher, but it can be lost due to leaching as solubility increases. The availability of Zn to plants decreases due to high pH in calcareous soils and liming, Zn fixation by phosphorus from both soil and fertilizers, and Zn losses in sandy soils with low cation exchange capacity (CEC) (Hafeez et al., 2013; Montalvo et al*.,* 2016; Akhtar et al., 2019). In previous studies, Zn Fertilization was shown to increase the growth and production of corn plants (Suganya et al., 2020; Capo et al., 2024). Copper (Cu) is an essential nutrient plants require in small (micro) amounts. Cu is required as an enzyme cofactor in photosynthesis, respiration, protein and carbohydrate metabolism, lignification, and pollen formation (Alloway, 2008; Yruela, 2009; Sayyad et al., 2010; Printz et al., 2016). Cu deficiency reduces growth, infertility, seed filling, and translocation of other elements in the plant (Brown, 1981; Ishka and Vatamaniuk, 2020; Chen et al., 2022). Cu deficiency mainly occurs in alkaline soils or those developed from lime parent material and highly clayey soils (Haque et al., 1993; Sayyad et al., 2010). Cu fertilization as an effort to restore micro nutrient is rarely done so it is feared that it will have a negative impact on plant growth and development in the long run. The purpose of study was to determine the development and growth response of wet corn plants to the application of different doses of micro inorganic fertilizer (3.14% Zn and 2.54% Cu).

MATERIALS AND METHODS

The research was conducted from February to April 2025 at the IPB Sindangbarang Experimental Field, Bogor Regency, West Java. The materials used were sweet corn seeds (*Zea mays* var. *Saccharata* Sturt.) Exotic variety, micro inorganic fertilizers (3.14% Zn and 2.54% Cu), urea, SP-36, and KCl. The tools used in this study included general cultivation tools such as hoes, vernier caliper, measuring tools such as rulers, scales, meters, cameras, and stationery. This study was arranged using a Randomized Complete Block Design (RCBD) with six replications. The treatment consisted of 1 factor with 4 levels of fertilization namely, (1) No. fertilizer tested (control), (2) standard NPK fertilizer as a comparison (NPK standard), (3) NPK fertilizer + 1 micro dose, (4) ¾ NPK fertilizer + 1 micro dose, there were 24 experimental units. The size of experimental plots used as experimental units was 5 m x 5 m.

The standard NPK fertilizer doses for N, P, and K requirements of sweet corn were 135 kg N ha^{-1}, 72 kg P_2O_5 ha^{-1}, and 120 kg K_2O ha^{-1} equivalent to 300 kg ha^{-1} urea, 200 kg ha^{-1} SP-36, and 200 kg ha^{-1} KCl. The nutrient content of standard NPK fertilizer (NPK- std) used were urea (45% N), SP-36 (36% P_2O_5), and KCl (60% K_2O) which are selling on the market and have been tested for their effectiveness. Details of the treatments tried in this study are shown in Table 1.

Table 1. Details of micro-inorganic fertilizer treatment (3.14% Zn and 2.54% Cu)

Treatment	Fertilizer (kg ha^{-1})	Urea (kg ha^{-1})	SP-36 (kg ha^{-1})	KCl (kg ha^{-1})
P0 (Control)	0	0	0	0
P1 (NPK standard)	0	300	200	200
P2 (NPK + 1 micro dose)	12	300	200	200
P3 (¾ NPK + 1 micro dose)	12	225	150	150

Micro inorganic fertilizers were applied through foliar spraying. Application was made at 14, 24, 34, and 44 DAP (Days After Planting). The foliar application (1 dose) for each application is 7.5 g plot $^{-1}$ or can be made 7.5 g 5 L $^{-1}$ for one plot of 25 m^2 (Table 2). The application was done at 8 – 9 AM.

Land preparation is done 7 days before planting, then 20 tons ha^{-1} of manure was added. Sweet corn was planted at a spacing of 75 cm x 25 cm. Each hole was planted with two sweet corn seeds and insecticide with the active ingredient carbofuran. At 4 weeks after planting, the plant was thinned and left with 1 plant per hole. SP-36 fertilizer was applied entirely at planting time, while KCl fertilizer in the standard NPK treatment and calcium nitrate compound fertilizer was applied twice, at planting time and 4 weeks after planting (WAP) at ½ dose each.

This study involved observations of plant growth and production components. Observations of plant growth components including plant height, number of leaves, and stem diameter were conducted at 4, 6, and 8 WAP on 10 sample plants per experimental plot. Corn plants were harvested at around 10 weeks after planting. Parameters related to production components measured from 10 sample plants per plot were fresh weight of the upper stalk of the plant, cob length, cob diameter, cob weight with cob, and cob weight without husk. Besides the sample plants, all filled cobs from each plot, including those from peripheral plants, were harvested and weighed for productivity calculations. The total weight of filled cobs per plot was recorded and converted to estimate productivity.

The next observation is to calculate the Relative Agronomic effectiveness (RAE) value, micro inorganic fertilizer is considered effective if the inorganic fertilizer treatment tested is statistically equal or higher than the standar fertilizer treatment or better than the control treatment at a real level of 5%, and the RAE value of the test fertilizer is more than or equal to 95%. The agronomic effectiveness of inorganic fertilizers is determined by the Relative Agronomic Effectiveness (RAE) (Machay et al., 1984) with the following formula:

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

The measurement data obtained from this study were analyzed by analysis of variance (ANOVA) using SAS (Statistical Analysis System) software. If the results of the variance analysis showed a significant difference, followed by the Duncan Multiple Range Test (DMRT) at the α = 5% level.

RESULTS AND DISCUSSION

General Conditions of Trial

The results of the analysis of variance showed that the micro inorganic fertilizer treatments levels (3.14% Zn and 2.54% Cu) tested gave a diverse effect on the variables of growth component and yield components of corn plants. The coefficient of variation obtained in the growth component ranged from 4.35% -5.50% for the variable plant height, 5.59% -10.93% for the variable of stem diameter, 2.79-5.59% for the variable of number of leaves, and 10.13% for the variable of stover weight.

Table 2. Details of micro-inorganic fertilizer applications (3.14% Zn and 2.54% Cu) at 14, 24, 34, and 44 days after planting (DAP)

Treatment	Fertilizer micro (g per plot)	Spray volume (L per plot)
P0 (Control)	0	0
P1 (NPK standard)	0	300
P2 (NPK + 1 micro dose)	12	300
P3 (¾ NPK + 1 micro dose)	12	225

The coefficient of variation obtained in the yield component ranged from 3.83% -13.30%, with the lowest coefficient of variation obtained in the cob diameter variable, while the highest coefficient of variation was obtained in the weight of the cob (Table 3).

Plant condition in the field was responsive to each fertilizer treatment. In relation to the climatic conditions during the study, there were months with prolonged and heavy rainfall. Analysis of the content of micro inorganic fertilizers (3.14% Zn and 2.54% Cu) was carried out at the beginning of the study to see the nutrient content contained in this fertilizer. The results of the nutrient content analysis of micro inorganic fertilizer (3.14% Zn and 2.54% Cu) used can be seen in Table 4.

Based on the results of the initial fertilizer quality test, the Zn and Cu contents in each fertilization treatment could be determined. The purpose of the initial test was to assess the effectiveness of fertilizers containing Zn and Cu compared to no fertilizer and the standard fertilizer treatment.

Soil analysis was carried out before implementation of the experiment by taking soil samples from all treatment plots and then compositing them. The results of soil analysis are presented in Table 5.

Effect of micro inorganic fertilizer dosage (3.14% Zn and 2.54% Cu) on Sweet Corn Growth Components

The results of analysis of variance showed that the level of fertilizer treatment had a very significant effect on plant height from 4 WAP to 8 WAP (Table 6).

Table 3. Recapitulation of analysis variance of the effect of micro inorganic fertilizer doses (3.14% Zn and 2.54% Cu) on growth and production components of sweet corn

Variable	Treatment	P-value	Coefficient of variance (%)
Growth component:			
Plant height			
4 WAP	**	0.0002	5.50
6 WAP	**	<.0001	4.65
8 WAP	**	0.0003	4.35
Stem diameter			
4 WAP	**	0.0003	10.93
6 WAP	**	<.0001	5.59
8 WAP	**	<.0001	6.32
Number of leaves			
4 WAP	**	<.0001	3.71
6 WAP	**	<.0001	2.79
8 WAP	**	0.0046	5.58
Stover weight	**	<.0001	10.13
Yield component:			
Cob length	**	0.0008	4.95
Cob diameter	**	0.0001	3.83
Weight of weighed cob	**	0.0016	13.30
Weight of cob without cob	**	<.0001	10.53
Production per plot	**	<.0001	9.63
Productivity	**	<.0001	9.59

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

Table 4. Analysis results of micro inorganic fertilizer content (3.14% Zn and 2.54% Cu)

Testing parameters	Unit	Test results
Zn	%	3.14
Cu	%	2.54
Water content	%	1.90
As	%	0.01
Hg	%	0.03
Pb	ppm	5.20
CD	ppm	4.20

Table 5. Soil analysis results before the experiment

Parameter	Unit	Value	Category*
pH H_2O	-	5.43	Sour
C- organic	%	2.20	Medium
N-total	%	0.25	Medium
P- available (Bray I)	ppm P_2O_5	20.40	Very high
CEC	cmol kg^{-1}	18.20	Medium
K-dd	cmol K kg^{-1}	0.26	Low
P- Potential	mg P_2O_5 100 g^{-1}	103.00	Very high
K- Potential	mg K_2O 100 g^{-1}	28.30	Medium
Cu-Total	mg kg^{-1}	41.70	Moderate
Zn-Total	mg kg^{-1}	74.00	Moderate

*Source: *Balittanah* (2023)

Table 6. Plant height at different application rates of micro inorganic fertilizers (3.14% Zn and 2.54% Cu)

Treatment	Plant height (cm)		
	4 WAP	6 WAP	8 WAP
P0 (Control)	69.33^{c}	110.02^{b}	158.65^{b}
P1 (NPK standard)	88.35^{a}	141.82^{a}	190.63^{a}
P2 (NPK + 1 micro dose)	83.66^{ab}	134.87^{a}	186.05^{a}
P3 (¾ NPK + 1 micro dose)	82.40^{b}	136.17^{a}	186.70^{a}

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

The average plant height obtained from each treatment level at each observation time respectively ranged from 69.33-88.35 cm (4 WAP); 110.02-141.82 cm (6 WAP); and 158.65-190.63 cm (8 WAP).The level of micro inorganic fertilizer treatment (3.14% Zn–2.54% Cu) (code P2-P3) at plant height from 4 WAP to 8 WAP can give significantly higher plants than the control treatment. However, at the NPK fertilizer treatment level + 1 dose of micro (P2) did not result in significantly different plant height that is significantly different from the standard NPK comparison treatment (P1) at 4 WAP. Meanwhile, the fertilizer treatment of ¾ NPK + 1 micro dose (P3) has not been able to provide plant height that is significantly different from the standard NPK comparison treatment (P1) at 6 WAP and 8 WAP. Fertilizer treatment of ¾ NPK + 1 micro dose (P3) had a highly significant effect, producing taller plants than the control (P0) for plant height 4 WAP to 8 WAP.

Fertilization treatment P2 and P3 compared to the control treatment gave a very significant effect on the diameter of the plant stem at 4 WAP to 8 WAP (Table 7). The average stem diameter obtained from each treatment level at each observation time resepectively ranged from 7.54 – 12.22 mm (4 WAP); 13.94 – 18.12 mm (6 WAP); and 15.12 – 20.61 mm (8 WAP). The treatment of NPK fertilizer + 1 micro dose (P2) and ¾ NPK + 1 micro dose (P3) were able to provide a significantly wider diameter than the control treatment (P0) on the stem diameter variable from 4 WAP, 6 WAP, and 8 WAP. The results of the analysis in Table 8 show that the number of leaves at 4 WAP to 8 WAP was influenced very significantly by the fertilization treatment.

Table 7. Stem diameter at different application rates of micro inorganic fertilizers (3.14% Zn and 2.54% Cu)

Treatment	Stem Diameter (mm)		
	4 WAP	6 WAP	8 WAP
P0 (Control)	7.54^{c}	13.94^{c}	15.12^{c}
P1 (NPK standard)	12.22^{a}	19.10^{a}	20.60^{a}
P2 (NPK + 1 micro dose)	10.52^{b}	18.12^{ab}	19.74^{ab}
P3 (¾ NPK + 1 micro dose)	10.71^{b}	17.52^{b}	19.04^{b}

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

Table 8. Number of leaves at different application rates of micro inorganic fertilizers (3.14% Zn and 2.54%Cu)

Treatment	Number of leaves (blade)		
	4 WAP	6 WAP	8 WAP
P0 (Control)	5.97[c]	8.20[c]	9.98[b]
P1 (NPK standard)	6.85[a]	9.97[a]	11.53[a]
P2 (NPK + 1 micro dose)	6.83[a]	9.48[b]	11.52[a]
P3 (¾ NPK + 1 micro dose)	6.52[b]	9.80[ab]	11.57[a]

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

The average number of leaves obtained from each treatment level at each observation time respectively ranged from 5.97 – 6.85 (4 WAP); 8.20 – 9.97 (6 WAP); and 9.98 – 11.57 (8 WAP). The treatment levels of NPK fertilizer + 1 micro dose (P2) and ¾ NPK + 1 micro dose (P3) were able to provide a significantly high number of leaves compared to the control treatment (P0) at all observation times. Only the P3 treatment gave a high number of leaves against the standard NPK treatment (P1) at 8 WAP.

Effect of micro inorganic fertilizers Dosage on Sweet Corn Yield Components

The results of the analysis of variance showed that the level of fertilizer treatment had a very significant effect on cob length and cob diameter (Table 9). The average cob length obtained in this experiment ranged from 16.64 to 19.52 cm. Meanwhile, the average cob diameter in this experiment ranged from 41.22 to 48.51 mm. The fertilizer treatment of ¾ NPK + 1 micro dose (P3) had a very significant effect higher than the control (P0).

Fertilization treatment gave a very significant effect on the variable of stover weight (Table 10). The average stover weight obtained in this experiment ranged from 0.17 to 0.27 kg. Weight of cob with husk and weight cob without husk were significantly affected by the fertilization treatment (Table 10). The average weight of the cob with and without husk obtained in this experiment ranged from 0.18 to 0.31 kg and 0.14 to 0.24 kg, respectively. NPK fertilizer treatment + 1 micro dose (P2) and ¾ NPK treatment + 1 micro dose (P3) were able to provide higher stover weight than the control treatment (P0). NPK fertilizer treatment + micro (P2 and P3) increases the weight of the cob more than the control teratment (P0).

Table 9. Observations result of cob length and cob diameter at various levels of micro inorganic fertilizer treatment (3.14% Zn and 2.54% Cu)

Treatment	Cob length (cm)	Cob diameter (mm)
P0 (Control)	16.64[b]	41.22[b]
P1 (NPK standard)	19.47[a]	47.94[a]
P2 (NPK + 1 micro dose)	19.78[a]	48.02[a]
P3 (¾ NPK + 1 micro dose)	19.52[a]	48.51[a]

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

Table 10. Observations results of yield components and wet weight of stover at various levels of micro inorganic fertilizer treatment (3.14% Zn and 2.54% Cu)

Treatment	Stover Weight (kg)	Weight of Weighted Husk (kg)	Weight of Cob Without Husk (kg)
P0 (Control)	0.17[b]	0.18[b]	0.14[b]
P1 (NPK standard)	0.27[a]	0.29[a]	0.23[a]
P2 (NPK + 1 micro dose)	0.28[a]	0.28[a]	0.23[a]
P3 (¾ NPK + 1 micro dose)	0.27[a]	0.31[a]	0.24[a]

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

Fertilizer treatment of ¾ NPK + 1 micro dose (P3) increased the weight cob without husk which was higher than the control treatment (P0) and the NPK standard fertilizer comparator (P1). The results of the analysis of production per plot and productivity showed a very significant effect of the fertilizer treatment given (Table 11). The averages obtained for production per plot and productivity ranged from 8.13 – 16.46 kg and 5.16 – 10.24 tons ha $^{-1}$, respectively. NPK fertilizer + 1 micro dose (P2) and ¾ NPK + 1 micro dose (P3) gave significantly higher results when compared to the control treatment (P0), but there was no significant difference with comparison treatment (P1), both in production per plot and productivity.

Relative Agronomic Effectiveness (RAE) is a measure of the effectiveness of a fertilizer; fertilizer is declared effective if it has an RAE value of ≥ 95%. This value indicates that the fertilizer can increase the yield greater when compared with the increase in yield of fertilizer comparison to the control. The results of the RAE value of micro inorganic fertilizer were presented in Table 12. The results of the RAE calculation show that the fertilizer treatment is effective when given NPK fertilizer + 1 micro dose (P2) and ¾ NPK + 1 micro dose (P3). The highest effectiveness value was obtained in the ¾ NPK + 1 micro dose (P3), which was 118%. This means that the use of micro inorganic fertilizer at ¾ NPK + 1 micro dose (P3) can increase yields by 1.18 times higher than the increase in yield from comparator fertilizers to the control treatment (P0).

The result showed that application of NPK fertilizer + 1 micro dose (P2) and ¾ NPK fertilizer + 1 micro dose (P3) significantly affected the vegetative growth and yield components of corn which were statistically higher than the control treatment (P0). The fertilizer application treatment of ¾ NPK + 1 micro dose (P3) (12 kg ha $^{-1}$ micro fertilizer (3.14%Zn – 2.54%Cu) + 225 kg ha^{-1} Urea + 150 kg ha^{-1} SP-36 + 150 kg ha^{-1} KCl) generally produce cob length, cob diameter, stover weight, cob weight, cob weight without husk, production per plot and productivity were statistically higher than the control tretament (P0) and the NPK standard comparison treatment (P1). NPK+Mg compound fertilizer provides plant height, number of leaves, stem diameter, cob weight, production and productivity (Nindita et al., 2024).

Nitrogen, potassium, and phosphorus in compound fertilizers, besides being elements needed by plants, have different roles for plants. The application of nitrogen, potassium, and phosphorus to plants is required in large quantities, but amount available in the soil cannot meet the needs of these plant, so other sources outside the soil system are needed. Nitrogen is one of the constituent components of organic compounds such as amino acids, proteins, and nucleic acid (Daroga et al., 2017; Fathi, 2022). N fertilizer plays an important role in increasing corn production. N is the main nutrient that makes up chlorophyll, which plays an important role in the photosynthesis process in plants. Plants that are deficient in N nutrients will have yellowing leaves, resulting in the photosynthesis process not being maximized. In addition, N nutrients also play a role in the constituents of amino acids, proteins and cell nucleus components.

Table 11. Production per plot and productivity at different treatment micro inorganic fertilizer (3.14% Zn and 2.54% Cu)

Treatment	Production per Plot (kg)	Productivity (ton ha^{-1})
P0 (Control)	8.13^{c}	5.16^{b}
P1 (NPK standard)	14.92^{ab}	9.48^{a}
P2 (NPK + 1 micro dose)	14.65^{b}	9.30^{a}
P3 (¾ NPK + 1 micro dose)	16.46^{a}	10.24^{a}

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

Table 12. Relative Agronomic Effectiveness (RAE) valued at different application rates of micro inorganic fertilizer (3.14% Zn and 2.54% Cu)

Treatment	RAE (%)
P0 (Control)	-
P1 (Standard NPK)	-
P2 (Standard NPK + 1 micro dose)	96
P3 (¾ Standard NPK + 1 micro dose)	118

Excessive application of N fertilizer to corn plants can increase damage from pests and diseases, especially in the rainy season, prolong life, and plants are more prone to collapse duet o stems from leaves that are excessive from normal size, while the roots are unable to withstand. Excessive fertilizer use, in addition to increasing production costs, will also damage the environment due to the emission of N_2O gas in the process of ammonification, nitrification and dinitrification (Wahid, 2003). Nitrogen deficiency can inhibit growth and leaves can be light green in color. Conversely, with excess nitrogen, plants appear overly fertile, leaf size becomes larger, and the stems become succulent (Novizan, 2002). While deficiency in phosphorus, plants show symptoms of slow and growth, inhibited root development, and inhibited fruit ripening. The role of potassium (K) in plants is closely related to biophysics and biochemistry processes (Beringer, 1980). K has an important role in regulating osmosis and and turgor pressure, which will then affect cell growth and development as well as the opening and closing of stomata. Potassium deficiency can result in the rate of retranslocation from the nutrient absorption site.

Zinc (Zn) an essential nutrient that is required in small (micro) amounts. Zn is required as a regulator of N and carbohydrate metabolism, a constituent of several enzymes, cell proliferation, photosynthesis, pollen formation and seed production, phytohormones synthesis, flowering gene expression, and pathogen response (Alloway, 2008; Hafeez et al., 2013; Maqbool and Beshir, 2019). Visual symptoms of Zn deficiency include short internodes, narrowing of leaf area, and inhibition of auxin metabolism (Kirkby and Römheld, 2004). Zn fertilization in previous studies was proven to be able to increase the growth and production of corn plants (Suganya et al., 2020; Capo et al., 2024). Cu is essential nutrient required by plants in small (micro). Cu is needed as an enzyme cofactor in the process of photosynthesis, respiration, protein and carbohydrate metabolism, lignification, and pollen formation (Alloway, 2008; Printz et al., 2016; Sayyad et al., 2010; Yruela, 2009). Cu deficiency leads to decreased growth, infertility, seed filling, and translocation to other elements in the plant (Brown, 1981; Ishka and Vatamaniuk, 2020; Chen et al., 2022). Cu fertilization as an effort to restore micronutrients is rarely done so it is feared that it will have a negative impact on plant growth and development in the long run.

Increases in growth and yield components were also observed in this experiment along with the doses of test fertilizers applied. Optimum growth occured when ¾ NPK fertilizer + 1 dose of micro fertilizer (P3) (12 kg ha^{-1} micro fertilizer (3.14% Zn – 2.54% Cu) + 225 kg ha^{-1} Urea + 150 kg ha^{-1} SP-36 + 150 kg ha^{-1} KCl). This treatment can provide significantly higher growth components and yield components to the control treatment (P0) and comparable to the standard NPK treatment (P1) in several results observation. The results of the RAE analysis in this test showed that the application of NPK fertilizer + 1 micro dose (P2) and ¾ NPK fertilizer + 1 micro dose (P3) were effectively used in sweet corn (*Zea mays*), with the highest RAE value of 118% obtained in the ¾ NPK fertilizer + 1 micro dose (P3). RAE values equal to or higher than 95% indicate that the tested fertilizer were able to provide an increase in yield against the same control, or even higher than the increase in yield obtained from the use of standard NPK fertilizer. These results also indicate that NPK fertilizers with the addition of the right amount of Zn and Cu can be used in sweet corn cultivation by taking into account the fertilizer needs of the crop and the correct content of N, P_2O_5, and K_2O.

CONCLUSIONS

The results of this test indicate that the application level of micro inorganic fertilizer (3.14% Zn – 2.54% Cu) at the application level of NPK fertilizer + 1 micro dose (P2) and ¾ NPK fertilizer + 1 micro dose (P3) can generally provide plant height, stem diameter, number of leaves, cob length, cob diameter, stover weight, weight of weighted husk, weight of cob without husk, production per plot, and productivity which were statistically higher than the control treatment (P0). The highest RAE reached 118% or 1.18 times the increase in yield from the comparison treatment, which was obtained in the ¾ NPK fertilizer + 1 micro dose (P3). Based on results, the ¾ NPK fertilizer + 1 micro dose (P3) fertilizer treatment is more recommended for sweet corn application because the results are also significantly different from the standard NPK fertilizer. Reducing fertilizer application can save the cost of fertilizer use, overcome the scarcity of fertilizer availability and fertilizer application will be more effective.

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