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Growth and Yield of Sweet Corn (*Zea mays* var. *Saccharata* Sturt.) in Response to the Application of Inorganic Calcium Nitrate Fertilizer

Respon Pertumbuhan dan Produksi Jagung Manis (Zea mays var. Saccharata Sturt.) terhadap Pemberian Aplikasi Pupuk Anorganik Kalsium Nitrat

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ABSTRACT

Jagung manis adalah komoditas hortikultura yang banyak dibudidayakan di Indonesia. Tujuan dari pengujian ini adalah untuk mengetahui efektivitas pupuk anorganik kalsium nitrat terhadap pertumbuhan dan hasil pada tanaman jagung manis (Zea mays var. Saccharata Sturt.) yang berbeda. Penelitian dilakukan di Kebun Percobaan Sindangbarang, Bogor, Jawa Barat. Percobaan ini menggunakan rancangan kelompok lengkap teracak (RKLT) dengan faktor tunggal yaitu dosis pemberian pupuk. Perlakuan terdiri dari 1 faktor dengan 6 taraf pemupukan yaitu (P1) kontrol, (P2) NPK standar (135 kg N ha^{-1}*, 72 kg* P_2O_5 *ha*$^{-1}$*, and 120 kg* K_2O *ha*$^{-1}$*), (P3) 0.5 dosis pupuk kalsium nitrat, (P4) 0.75 dosis pupuk kalsium nitrat, (P5) 1.0 dosis pupuk kalsium nitrat, (P6) 1.5 dosis pupuk kalsium nitrat. Hasil pengujian menunjukkan bahwa perlakuan aplikasi 0.5 – 1.5 dosis pupuk kalsium nitrat lebih tinggi meningkatkan bobot brangkasan, bobot tongkol berkelobot, bobot tongkol tanpa kelobot, produksi serta produktivitas yang secara statistik lebih tinggi terhadap perlakuan kontrol. Aplikasi pupuk kalsium nitrat 0.5 dosis memiliki nilai Relative Agronomic Effectiveness (RAE) tertinggi yang memenuhi persyaratan lulus uji efektivitas pupuk, dengan nilai RAE sebesar 95%.*

Kata kunci: efektifitas pupuk, hara, produktivitas, tanaman hortikultura

ABSTRACT

Sweet corn is a horticultural commodity that is widely cultivated in Indonesia. This experiment aimed to determine the effectiveness of inorganic calcium nitrate fertilizer on the growth and yield of different sweet corn plants (*Zea mays var. Saccharata Sturt*.). The study was conducted at the 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. The treatment consisted of one factor with six levels of fertilization, namely (P1) control, (P2) standard NPK (135 kg N ha^{-1}, 72 kg P_2O_5 ha^{-1}, and 120 kg K_2O ha^{-1}), (P3) 0.5 dose of calcium nitrate fertilizer, (P4) 0.75 dose of calcium nitrate fertilizer, (P5) 1.0 dose of calcium nitrate fertilizer, and (P6) 1.5 dose of calcium nitrate fertilizer. The test results showed that the treatment of applying 0.5 – 1.5 dose of calcium nitrate fertilizer is higher increased stover weight, cob weight with husked, cob weight without husked, production and productivity which were statistically higher than the control treatment. The application of 0.5 dose of calcium nitrate fertilizer has the highest Relative Agronomic Effectiveness (RAE) value that meets the requirements to pass the fertilizer effectiveness test, with an RAE value of 95%.

Keywords: fertilizer effectiveness, horticulture plants, nutrient, productivity

INTRODUCTION

Plant growth and development are strongly influenced by the availability of nutrients in the soil. Plants require nutrients in optimal amounts and balanced concentrations to support metabolism and maximize productivity. Fertilization plays a critical role in replenishing nutrient losses from the soil and meeting plant nutrient requirements to enhance crop yields (Siwanto et al., 2015; Marschner, 2012). The application of fertilizers at the proper dose has been shown to optimize plant growth and yield, particularly through the use of inorganic fertilizers as the main source of both macro- and micronutrients (DPPP, 2018; Bindraban et al., 2020).

Primary macronutrients such as nitrogen (N), phosphorus (P), and potassium (K) are essential components that have been extensively studied in plant metabolic systems. Nitrogen is crucial for chlorophyll formation, protein synthesis, and other organic compounds, and is indispensable for vegetative growth in corn (*Zea mays* L.). Nitrogen deficiency leads to stunted growth, leaf chlorosis, and reduced vigour (Haque et al., 2021). Phosphorus supports root development, respiration, and accelerates flowering and seed maturation. Its deficiency is characterized by purplish leaf discoloration and reduced growth. Potassium contributes to protein and carbohydrate synthesis, strengthens plant tissues, and enhances tolerance to biotic and abiotic stresses. Potassium deficiency results in necrosis of older leaves, small and poor-quality fruits, and overall yield reduction (DPPP, 2018; Xu et al., 2020). The research was resulted that the compound fertilizer contains NPK+Mg provides plant height, number of leaves, stem diameter, cob weight, production and productivity of sweet corn (Nindita et al., 2024). Beside that, the application micro inorganic fertilizer with using NPK+ Zn and Cu provide plant height, stem diameter, number of leaves, cob length, cob diameter, stover weight, Cob weigh with husk, Cob weight without husk, production per plot, and productivity of sweet corn (Mulyana et al., 2025). This indicates that the effect of N fertilizer is very beneficial for plants.

Secondary macronutrients such as calcium (Ca), magnesium (Mg), and sulphur (S) also play critical roles in plant growth. Calcium plays a vital role in strengthens cell walls, neutralizes toxic compounds, and supports root and seed formation. Calcium deficiency induces chlorosis in young leaves. Magnesium is a central component of chlorophyll and is involved in carbohydrate and lipid metabolism, as well as phosphate transport. Magnesium deficiency causes interveinal chlorosis in older leaves and reduced seed germination (DPPP, 2018). Micronutrients such as boron (B), manganese (Mn), copper (Cu), zinc (Zn), and chlorine (Cl), although required in small amounts, are equally important. For example, boron is essential for cell division, seed formation, and carbohydrate translocation, while its deficiency can result in barren maize cobs (Marschner, 2012; White and Brown, 2010).

One important inorganic fertilizer that supplies both macro- and micronutrients is calcium nitrate ($Ca(NO_3)_2$). This fertilizer provides readily available nitrate nitrogen (N), calcium (Ca) as a secondary macronutrient, and small amounts of boron (B). Calcium nitrate application has been reported to improve vegetative growth, crop quality, and stress tolerance in several crops, including sweet corn (*Zea mays* var. *saccharata*) (Chen et al., 2019; Yousaf et al., 2021). Therefore, this study aims to evaluate the effectiveness of calcium nitrate fertilizer on the growth and yield of sweet corn.

MATERIALS AND METHODS

The experiment was carried out at the IPB Sindangbarang Experimental Field, Bogor Regency, West Java, from July to October 2024. The plant material used was sweet corn (*Zea mays* var. *saccharata* Sturt.) of the Exotic variety, while the fertilizers applied included calcium nitrate (15.5% N, 26% CaO, 0.3% B), urea, SP-36, and KCl. The equipment used consisted of common cultivation tools, measuring instruments, as well as a camera and stationery. The study was arranged in a randomized complete block design (RCBD) with four replications. The treatment factor was the application of calcium nitrate fertilizer at six levels: (1) control (without any inorganic fertilizer), (2) standard NPK fertilization, (3) standard NPK without urea + 0.5 dose of calcium nitrate, (4) standard NPK without Urea + 0.75 dose of calcium nitrate, (5) standard NPK without Urea + 1.0 dose of calcium nitrate, and (6) standard NPK without Urea + 1.5 doses of calcium nitrate, resulting in 24 experimental units. Each experimental plot measured 5 × 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 urea ha^{-1}, 200 kg SP-36 ha^{-1}, and 200 kg KCl ha^{-1}. 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 have been previously validated for their effectiveness. The detailed treatment structure is presented in Table 1.

Table 1. Details of inorganic calcium nitrate fertilizer treatment

Treatment	Calcium nitrate (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 (PK standard + 0.5 dosage of calcium nitrat)	450	0	200	200
P3 (PK standard + 0.75 calcium nitrate)	675	0	200	200
P4 (PK standard + 1.0 calcium nitrate)	900	0	200	200
P5 (PK standard + 1.5 calcium nitrate)	1.350	0	200	200

Land preparation was carried out by hoeing the soil to a depth of approximately 25 cm, followed by exposure to direct sunlight. Sweet corn was planted by making holes with a dibble at a spacing of 75 cm × 25 cm. Two seeds were sown per hole together with an insecticide containing the active ingredient carbofuran. At two weeks after planting (WAP), seedlings were thinned to maintain one plant per hole. SP-36 fertilizer was applied entirely at planting, while KCl in the standard NPK treatment and calcium nitrate fertilizer were applied in two equal splits: at planting and at 4 WAP.

Observations were conducted on both vegetative growth and yield components. Growth parameters, including plant height, number of leaves, and stem diameter, were measured at 3, 5, 7, and 9 WAP using 10 sample plants per experimental plot. Harvesting was conducted at approximately 10 weeks after planting. Yield-related measurements included fresh weight of the aboveground biomass, cob length, cob diameter, cob weight with husk, and cob weight without husk, also using 10 sample plants per plot. In addition, all filled cobs from the net plot area (excluding border plants) were harvested, weighed, and converted to estimate crop productivity.

The Relative Agronomic Effectiveness (RAE) index was used to further evaluate agronomic performance. Inorganic fertilizer treatments were considered effective if their performance was statistically comparable or superior to the standard fertilizer treatment, or significantly better than the control at the 5% level. Fertilizers with RAE values ≥ 95% were regarded as agronomically effective (Machay et al.. 1984). The RAE was calculated using the formula:

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

All collected data were analysed using analysis of variance (ANOVA) with the F-test in SAS software. When significant differences were detected, mean separation was performed using Duncan's Multiple Range Test (DMRT) at a 5% significance level.

RESULTS AND DISCUSSION

General Conditions of Experiment

The analysis of variance indicated that the treatments applied had no significant effect on growth components (plant height, stem diameter, number of leaves) and fresh biomass weight, but significantly influenced yield components, including cob weight with husk, cob weight without husk, production per plot, and sweet corn productivity. The coefficients of variation (CV) for growth components ranged from 6.13–12.43% for plant height, 6.19–11.09% for stem diameter, 4.52–9.51% for the number of leaves, and 22.07% for fresh biomass weight. Meanwhile, the CV values for yield components ranged from 12.86–15.84%, with the lowest CV observed in cob weight without husk, and the highest in productivity (Table 2).

In addition, nutrient analysis of calcium nitrate fertilizer was conducted at the beginning of the study to determine its nutrient composition. The results of the nutrient analysis of the inorganic calcium nitrate fertilizer used in this experiment are presented in Table 3.

Based on the initial fertilizer quality test, the nutrient contents of N, CaO, Cl, and B in each fertilization treatment were determined. This preliminary analysis was carried out to evaluate the effectiveness of fertilizer containing N, CaO, Cl, and B in comparison with the control (no fertilizer) and the standard fertilization treatment.

Soil analysis was conducted prior to the experiment by collecting samples from all treatment plots and compositing them. The soil test aimed to determine the fertility status of the experimental field before treatment application. The results of the soil analysis are presented in Table 4.

Table 2. Recapitulation of analysis variance of the effect of inorganic calcium nitrate on growth and production components of sweet corn

Variable	Treatment	Coefficient of variance (%)
Growth components:		
Plant height		
3 WAP	tn	12.43
5 WAP	tn	11.97
7 WAP	tn	10.89
9 WAP	tn	6.13
Stem diameter		
3 WAP	tn	16.24
5 WAP	tn	10.97
7 WAP	tn	11.09
9 WAP	tn	6.19
Number of leaves		
3 WAP	tn	7.70
5 WAP	tn	6.96
7 WAP	tn	9.51
9 WAP	tn	4.52
Stover weight	tn	22.07
Result components:		
Cob weight with husk	**	15.82
Cob weight without husk	**	12.86
Production per plot	**	15.83
Productivity	**	15.84

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

Table 3. Analysis results of inorganic calcium nitrate fertilizer

Testing parameters	Unit	Test results
N	%	15.570
CaO	%	26.210
Cl	%	0.220
B	%	0.320
Water content	%	0.730
As	ppm	<0.002
Hg	ppm	<0.001
Cd	ppm	<0.002
Pb	ppm	<0.002

Table 4. Soil analysis results before the experiment

Parameter	Unit	Value	Category*
pH H_2O		4.86	Sour
C-organic	%	1.20	Low
N-total	%	0.18	Low
P-available (Bray I)	ppm P_2O_5	1.66	Very low
CEC	cmol kg^{-1}	16.93	Simply
Ca-dd	cmol Ca kg^{-1}	3.29	Low
K-dd	cmol K kg^{-1}	0.21	Low
P-Potential	mg P_2O_5 100 g^{-1}	82.96	Very high
K-Potential	mg K_2O 100 g^{-1}	11.16	Low
Ca-Total	%	0.01	Very low

*Source: *Balittanah* (2023)

The Effect of Inorganic Calcium Nitrate Fertilizer on Sweet Corn Growth Components

The results of the analysis showed that fertilizer treatments had no significant effect on plant height from 3 to 9 weeks after planting (WAP) (Table 5). The mean plant height ranged from 32.58–36.06 cm (3 WAP), 70.07–82.49 cm (5 WAP), 116.28–136.71 cm (7 WAP), and 154.70–166.14 cm (9 WAP). However, the application of inorganic calcium nitrate fertilizer (treatment P4) consistently produced taller plants compared to the control across all observation periods.

Similarly, treatment P4 resulted in a higher number of leaves than the control from 3 to 9 WAP (Table 6). The mean number of leaves ranged from 4.72–5.02 (3 WAP), 7.72–8.20 (5 WAP), 8.82–9.62 (7 WAP), and 11.35–12.25 (9 WAP), Nevertheless, statistical analysis indicated that fertilizer treatments had no significant effect on leaf number across these growth stages (Table 6).

The analysis presented in Table 7 shows that all doses of inorganic calcium nitrate fertilizer had no significant effect on stem diameter from 3 to 9 weeks after planting (WAP). The mean stem diameter ranged from 5.14–5.81 mm (3 WAP), 12.73–14.35 mm (5 WAP), 14.99–17.64 mm (7 WAP), and 16.26–18.20 mm (9 WAP) (Table 7).

Effect of Inorganic Calcium Nitrate Fertilizer on Sweet Corn Yield Components

The analysis showed that the application of inorganic calcium nitrate fertilizer had no significant effect on stover weight but significantly influenced cob weight with husk, cob weight without husk, yield per plot, and overall productivity ($p < 0.05$) (Table 8). The mean stover weight ranged from 1.30–1.67 kg, while the mean cob weight with husk and cob weight without husk ranged from 1.55–2.60 kg and 1.02–1.90 kg, respectively (Table 8).

Table 5. Plant height at different application rates of inorganic calcium nitrate fertilizer

Treatment	Plant height (cm)			
	3 WAP	5 WAP	7 WAP	9 WAP
P0 (Control)	34.74a	76.08a	127.47a	164.47a
P1 (NPK standard)	32.58a	70.07a	121.98a	154.70a
P2 (PK standard + 0.5 calcium nitrate)	34.29a	82.49a	134.07a	166.14a
P3 (PK standard + 0.75 calcium nitrate)	34.62a	71.12a	116.28a	148.21a
P4 (PK standard + 1.0 calcium nitrate)	36.06a	79.35a	136.71a	165.59a
P5 (PK standard + 1.5 calcium nitrate)	32.87a	75.00a	125.42a	157.72a

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

Table 6. Number of leaves at different application rates of inorganic calcium nitrate fertilizer

Treatment	Number of leaves			
	3 WAP	5 WAP	7 WAP	9 WAP
P0 (Control)	5.02a	7.92a	9.12a	12.10a
P1 (NPK standard)	4.85a	7.80a	8.82a	11.72a
P2 (PK standard + 0.5 calcium nitrate)	4.85a	8.02a	9.35a	12.25a
P3 (PK standard + 0.75 calcium nitrate)	4.72a	7.87a	8.82a	11.35a
P4 (PK standard + 1.0 calcium nitrate)	4.90a	8.20a	9.62a	12.10a
P5 (PK standard + 1.5 calcium nitrate)	4.72a	7.72a	8.97a	12.00a

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

Table 7. Stem diameter at different application rates of inorganic calcium nitrate fertilizer

Treatment	Stem diameter (mm)			
	3 WAP	5 WAP	7 WAP	9 WAP
P0 (Control)	5.63a	12.95a	16.62a	16.50a
P1 (NPK standard)	5.14a	12.78a	17.02a	17.13a
P2 (PK standard + 0.5 calcium nitrate)	5.56a	14.26a	17.04a	16.92a
P3 (PK standard + 0.75 calcium nitrate)	5.65a	12.73a	14.99a	16.26a
P4 (PK standard + 1.0 calcium nitrate)	5.81a	14.35a	17.64a	18.20a
P5 (PK standard + 1.5 calcium nitrate)	5.34a	13.19a	16.49a	17.48a

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

Table 8. Observations result of yield components and stover weight at various levels of inorganic calcium nitrate fertilizer

Treatment	Stover weight (kg)	Cob weight with husk (kg)	Cob weight without husk (kg)
P0 (Control)	1.50a	1.55b	1.02b
P1 (NPK standard)	1.60a	2.24a	1.65a
P2 (PK standard + 0.5 calcium nitrate)	1.65a	2.21a	1.70a
P3 (PK standard + 0.75 calcium nitrate)	1.30a	2.23a	1.74a
P4 (PK standard + 1.0 calcium nitrate)	1.67a	2.60a	1.90a
P5 (PK standard + 1.5 calcium nitrate)	1.55a	2.18a	1.73a

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

Further analysis of production per plot and productivity revealed highly significant effects of fertilizer treatments (Table 9). The mean production per plot ranged from 11.14–18.69 kg, while productivity ranged from 9.29–15.57 tons ha^{-1} (Table 9). Treatments with calcium nitrate fertilizer (P2–P5) produced significantly higher yields compared to the control (P0) but were not significantly different from the standard fertilizer treatment (P1) in terms of both production per plot and productivity.

Relative agronomic effectiveness (RAE) is an indicator used to measure the effectiveness of a fertilizer. A fertilizer is considered effective when it achieves an RAE value of ≥95%, indicating that its yield improvement surpasses the relative increase obtained from the reference fertilizer compared to the control. The RAE values of inorganic calcium nitrate fertilizer are presented in Table 10.

The results showed that inorganic calcium nitrate fertilizer was effective only when applied at 0.50 dose (P2), 0.75 dose (P3), and 1.0 dose (P4). The highest effectiveness was observed at the 1,0 doses. However, the treatment with 0.50 dose (P2) was sufficient for RAE value. This indicates that the application of inorganic calcium nitrate fertilizer at the 0.50 – 1.5 dose increased yield higher than the improvement achieved by the reference fertilizer over the control (P0).

The results of this study demonstrated that varying doses of inorganic calcium nitrate had no significant effect on vegetative growth or yield components of sweet corn. However, the application of a 0.5 – 1.5 dose showed the siginificant higher of stover weight, cob weight with husked, cob weight without husked, production per plot and overall productivity compared to the control.

Table 9. Production per plot and productivity at different treatment inorganic calcium nitrate fertilizer

Treatment	Production per plot (kg)	Productivity (ton ha^{-1})
P0 (Control)	11.14b	9.29b
P1 (NPK standard)	16.15a	13.46a
P2 (PK standard + 0.5 calcium nitrate)	15.89a	13.24a
P3 (PK standard + 0.75 calcium nitrate)	16.08a	13.40a
P4 (PK standard + 1.0 calcium nitrate)	18.69a	15.57a
P5 (PK standard + 1.5 calcium nitrate)	15.66a	13.05a

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

Table 10. Relative Agronomic Effectiveness (RAE) valued at different application rates of inorganic calcium nitrate fertilizer

Treatment	RAE (%)
P0 (Control)	-
P1 (NPK standard)	-
P2 (PK standard + 0.5 calcium nitrate)	95
P3 (PK standard + 0.75 calcium nitrate)	99
P4 (PK standard + 1.0 calcium nitrate)	151
P5 (PK standard + 1.5 calcium nitrate)	90

Similar findings were reported by Rosyad (2024), Calcium nitrate fertilizer treatment had a significant influence on all production characteristics except for fresh biomass weight and cob length without husk. Treatment of 0.5 Calcium Nitrate on sweet corn plants had the highest value for production characteristics per plot and productivity and a relatively high value for overall characteristics. Barker and Pilbeam (2006) explained that calcium itself serves multiple physiological roles in higher plants, including effects on membranes, enzymes, cell wall stability, and interactions with phytohormones. As a divalent ion, Ca^{2+} participates in both intra- and intermolecular complexes that are critical for cell division, elongation, and auxin signalling. This explains why root growth ceases rapidly upon calcium depletion in nutrient solutions. Furthermore, calcium contributes to postharvest fruit quality and shelf life, while the nitrate fraction of calcium nitrate provides a readily available source of N, stimulating root, stem, leaf, and kernel growth.

Relative Agronomic Effectiveness (RAE) analysis showed that the efficiency tretament of calcium nitrate at a dose of 450 kg ha^{-1}, with an RAE value of 95%. An RAE above 95% indicates that the tested fertilizer not only matches but surpasses the yield improvement achieved with the reference fertilizer. These findings suggest that calcium nitrate could serve as a potential substitute for urea in sweet corn cultivation, while simultaneously supplying essential CaO and B to optimize plant growth and productivity.

CONCLUSION

The results of this study indicated that the application of different doses of inorganic calcium nitrate fertilizer did not cause significant differences in the vegetative growth of sweet corn (plant height, stem diameter, and number of leaves) or in yield components (stover weight, cob weight with husk, cob weight without husk, production per plot, and productivity). However, application of the 0.5 dose of inorganic calcium nitrate fertilizer produced a sufficient Relative Agronomic Effectiveness (RAE) compared to the control and comparison treatment. Based on these findings, the recommended fertilizer dosage for sweet corn is 450 kg ha^{-1} of inorganic calcium nitrate, supplemented with 200 kg ha^{-1} of SP-36 and 200 kg ha^{-1} of KCl.

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