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Effects of NPK, Amino Acid Liquid Organic Fertilizer on Maize (*Zea mays* L.) Growth And Yield

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Abstract

Corn is one of the food crops cultivated in Indonesia. There has been a decline in corn production in Indonesia on a national scale and in Banten Province. Efforts are needed to increase sweet corn production, one of which is by using effective and efficient fertilizers. This research aims to determine the effect of applying amino acid Liquid Organic Fertilizer (POC) amino acids with different concentrations and different doses of single N,P,K on the growth and yield of sweet corn plants (*Zea mays subsp. mays* L.). This research was conducted with a Split Plot Design with amino acid POC concentration as the main plot with 4 levels: control (K0), 2mL/L/plot (K1), 4mL/L/plot (K2), and 6mL/L/plot (K3). Single dose of N,P,K as subplots with 3 levels: 100% dose (D1), 75% dose (D2), 50% dose (D3). The results showed that the concentration of amino acid POC 6mL/L/plot gave a significant effect on the parameters of cob weight, grain weight per cob, actual yield, and potential yield. The single N,P,K dose of 75% gave a real effect on the parameters of the weight of the cob, weight of the cob without the cob, weight of grains per cob, actual yield, and yield power.

Keywords: *NPK Fertilizer, Amino Acid Fertilizer, Sweet Corn*

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INTRODUCTION

Corn is one of the staple food crops cultivated in Indonesia. Sweet corn, in particular, is highly favored by many Indonesians due to its sweet taste and its role as a source of carbohydrates. However, Indonesia has experienced a decline in dry shelled corn production (at 28% moisture content). Badan Pusat Statistik (BPS) shows that production reached 19.99 million tons in 2023, with a monthly average of 1.67 million tons. This represents a decrease compared to 2022, when production was 22.36 million tons with a monthly average of 1.86 million tons. Similarly, Banten Province recorded a production of 40,043 tons in 2022, a reduction from 58,661.55 tons in 2021. This decline in corn production is attributed to several factors, primarily deteriorating soil health and insufficient nutrient availability for plants through fertilizers.

In crop cultivation, farmers commonly apply inorganic (chemical) fertilizers. According to Mansyur et al. (2021), inorganic fertilizers are products manufactured through chemical, physical, and/or biological engineering processes in industrial or fertilizer production plants. Examples include Urea, SP-36, NPK Phoska, and KCl. Based on their composition, inorganic fertilizers are categorized into single and compound types. Badan Penelitian dan Pengembangan Pertanian Kementrian Pertanian (2021) recommends single inorganic fertilizers for maize in Banten Province, Serang City, Curug District, with doses of 350 kg/ha for Urea, 125 kg/ha for SP-36, and 75 kg/ha for KCl. According to Anggraini et al. (2019), single fertilizers offer advantages over compound fertilizers, including rapid dissolution, which minimizes nutrient leaching due to rainfall, and their flexibility for application tailored to the specific nutrient requirements of different plant types. Single fertilizers are considered more efficient than compound fertilizers due to their rapid dissolution, which helps reduce nutrient leaching. They can also be applied to various plant types by adjusting to their specific nutrient requirements.

However, continuous use of chemical fertilizers without accompanying organic matter to improve soil's physical, chemical, and biological properties can lead to land degradation. Wahyunto and Dariah (2014) define agricultural land degradation as a decrease in productivity due to topsoil deterioration. Specifically, continuous chemical fertilizer application without maintaining adequate organic matter levels in the soil can cause land degradation. Syamsiah et al. (2023) further assert that periodic use of inorganic fertilizers can lead to land degradation, highlighting the necessity of organic fertilizer addition. This approach not only improves the soil's chemical, biological, and physical properties but also reduces the reliance on relatively expensive chemical fertilizers.

Amino acid fertilizer is one such organic fertilizer available in the market, officially listed in the Minister of Agriculture Regulation Number 70/Permentan/SR.140/10/2011. Al-Alaf (2017), cited by Alalaf et al. (2022), reported that amino acid fertilizers in grapefruit nurseries increase soil mineral content for plants and enhance vegetative growth and root development by improving the vegetative system. Radkowski et al. (2018) note that amino acids are essential organic compounds found in organisms, serving as crucial components of proteins, enzymes, nucleic acids, antioxidants, hormones, and other vital compounds. While plants can synthesize their own amino acids, this process is energy-intensive and time-consuming. Therefore, amino acid POC can serve as a biostimulator to expedite and conserve energy during plant development.

RESEARCH METHODOLOGY

This study employed an experimental design and was conducted from December 2024 to March 2025 at Sistem Pertanian Terpadu Banten Province, Curug District, Serang City, Banten. The tools used included a hoe, tractor, measuring tape, digital scale, documentation tools, measuring cups, scissors, hand sprayer, raffia rope, stakes, dibble stick, labels, and stationery. Materials comprised 'Bonanza F1' sweet corn seeds, urea fertilizer, KCl fertilizer, SP-36 fertilizer, "Ambition" brand amino acid liquid organic fertilizer, pesticides, furadan, and water. The study utilized a Split Plot Design with two factors: amino acid POC concentration as the main plot (4 levels: control (K0), 2 mL/L/plot (K1), 4 mL/L/plot (K2), and 6 mL/L/plot (K3)), and single NPK fertilizer doses as subplots (3 levels: 100% dose (D1), 75% dose (D2), and 50% dose (D3)). This resulted in 12 treatment combinations, with each treatment replicated 3 times, leading to 12 main plots and 36 subplots. Each subplot contained 5 plants, from which 3 sample plants were selected for observation, resulting in a total experimental population of 180 plants and 108 sampled plants.

A. Research Implementation

The land was cleared of crop residues, cultivated, and prepared by forming 12 main plots, each divided into 3 subplots measuring 3.4 m x 0.5 m, yielding a total of 36 subplots. Chicken manure was then applied as a basal fertilizer at a dose of 10,000 kg/ha (equivalent to 1.7 kg/plot). Bonanza F1 sweet corn seeds were selected and soaked in water for 12 hours before planting, with 2 seeds per hole, followed by furadan application. Inorganic fertilizers (urea, SP-36, KCl) were applied according to the respective treatment doses (100%, 75%, 50%) at 2, 6, and 8 weeks after planting (WAP). Amino acid POC was sprayed on the stems and leaves according to the specified concentrations (0, 2, 4, 6 mL/L) at 3, 6, and 8 WAP. Maintenance activities included watering, replanting, thinning, fertilizing, weeding, and mechanical and chemical pest and disease control. Observations were conducted on sample plants throughout their vegetative and generative phases. Harvesting was performed at 82-84 days after sowing (DAS) when the husk was tight, the cob was firm, and the silks had turned brown.

B. Data Analysis

After data collection, data were processed using analysis of variance. If the analysis of variance showed a significant to highly significant effect, further testing was conducted using Duncan's Multiple Range Test (DMRT) at the 5% level, utilizing DSAASTAT ver. 1.514.

RESULTS AND DISCUSSION

The research field was previously utilized for long bean cultivation, thus requiring the clearing of residual plants, stakes, and weeds before tillage. Sweet corn plants (cv. 'Bonanza F1') were planted in the fourth week of December 2024. Germination occurred between 5 days after sowing (DAS) and 1 week after sowing (WAS), with either 2 or 1 plant germinating per hole, necessitating replanting and thinning to leave a single plant per hole. During thinning, plants with uniform growth were selected as research samples, while newly grown and non-uniform plants were removed.

This research was conducted from December 2024 to March 2025 at Sistem Pertanian Terpadu Banten Province, Curug District, Serang City, Banten. Soil analysis of the experimental land revealed the following: nitrogen content of 0.19%, C-Organic 1.57%, P2O5 content 101.52 mg/Kg, K2O 22.19 mg/100g, a C/N ratio of 8, and a soil pH of 7.1. During the study period, the average daily temperature was 27.38°C, average daily humidity was 82.17%, and the average daily rainfall was 13.18 mm.

Plant Height

Plant height is a crucial growth parameter in corn plants used to determine the effect of applied amino acid POC concentrations and single NPK fertilizers. The average height of corn plants is presented in **Table 1**.

Gambar 1. Eksplan yang telah bertunas

Treatment	Plant Age			
	2 WAP	4 WAP	6 WAP	8 WAP
Amino Acid Concentration	Plant Height (cm)			
Control (K0)	32.21	74.83	158.19	198.43
2 mL/L/plot (K1)	32.60	79.25	170.00	195.96
4 mL/L/plot (K2)	32.07	77.99	161.06	199.99
6 mL/L/plot (K3)	32.55	74.73	157.01	195.56
Fertilizer Dosage N,P,K				
100% (D1)	31,95	75,60	159,89	197,68
75% (D2)	32,62	78,91	164,55	198,55
50% (D3)	32,49	75,59	160,26	196,22
KK K (%)	2,1	3,88	5,67	3,56
KK D (%)	2,04	4,47	6,47	3,73

Notes: Numbers followed by the same letter in the same column or row indicate that the results have no significant effect on the DMRT further test at the 5% level.
KK K: Coefficient of variation of amino acid POC concentration
KK D: Coefficient of variation of a single NPK dose

Based on Table 1, no significant effect was observed on the height of sweet corn plants from either the amino acid POC concentrations or single NPK doses at 2, 4, 6, and 8 weeks after planting (WAP). However, an interaction was noted at 2 WAP for corn plant height, even though the plants had not yet received any treatment at this age. According to Faesal et al. (2023), corn growth is influenced by both internal (e.g., genetic enzymes, hormones) and external factors (e.g., light, temperature, humidity, water availability, oxygen, and plant nutrients). Thus, the observed interaction at 2 WAP is presumed to be influenced by external conditions, specifically light and plant nutrition. In addition to amino acid POC and single NPK fertilizer treatments, basal fertilization was performed at the beginning of planting using chicken manure at a dose of 10,000 kg/ha. The application of basal chicken manure fertilizer significantly aids plant growth by providing essential nutrient input to the soil. This aligns with the findings of Saepuloh et al. (2020), who reported that chicken manure has higher nitrogen and phosphorus levels than other animal manure fertilizers and is more easily decomposed. This is because poultry, including chickens, have shorter digestive systems, leading to less nutrient absorption from their feed and higher nutrient retention in their manure.

At 4, 6, and 8 WAP, neither of the two treatments nor their interaction showed a significant effect on plant height. Observations on amino acid POC concentration treatment also revealed no significant effect on sweet corn plant height, as amino acid fertilizers contribute to homogenizing plant growth. This is consistent with Nag et al. (2001), cited by Alalaf et al. (2022), who stated that amino acids are nitrogenous organic fertilizers and natural compounds that can balance plant growth and enhance plant response to fertilizers. Similar results were reported by Brankov et al. (2020), whose research showed no significant effect on sweet corn plant height between amino acid POC treatment and control during the vegetative phase. This finding is in line with the current study, where no significant difference was observed between amino acid POC concentration treatment and the control.

The single NPK dose treatment also showed no significant effect on corn plant height. Beyond the effect of amino acid POC application, this outcome is also supported by favorable internal factors in the plants, specifically genetics. As noted by Oktaviani et al. (2020), variations in sweet corn plant height across different varieties can be attributed to the unique genetics and environmental adaptability of each variety. In addition to physiological factors, environmental factors also play a role in plant growth.

Number of Leaves

In this study, the number of leaves was observed at 2, 4, 6, and 8 WAP. Leaf count was manually recorded for data processing. The average leaf count measurements are presented in **Table 2**.

Table 2. Average Number of Sweet Corn Leaves (*Zea mays subsp mays* L.) in the Treatment of Amino Acid POC Concentration and Single NPK Dosage

Treatment	Plant Age			
	2 WAP	4 WAP	6 WAP	8 WAP
Amino Acid Concentration	Number of Leaves (blade)			
Control (K0)	4,70	8,41	10,30	11,67
2 mL/L/plot (K1)	4,96	9,15	10,78	11,89
4 mL/L/plot (K2)	4,59	8,44	10,41	11,70
6 mL/L/plot (K3)	4,85	8,37	10,15	11,70
Fertilizer Dosage N,P,K				
100% (D1)	4,72	8,56	10,61	11,86
75% (D2)	4,78	8,64	10,39	11,72
50% (D3)	4,83	8,58	10,22	11,64
KK K (%)	16,61	15,59	15,93	17,12
KK D (%)	14,17	7,94	10,15	12,22

Notes: Numbers followed by the same letter in the same column or row indicate that the results have no significant effect on the DMRT further test at the 5% level.
KK K: Coefficient of variation of amino acid POC concentration
KK D: Coefficient of variation of single NPK dose

Based on the analysis of variance results in Table 2, no significant effect was found on the number of sweet corn leaves at 2, 4, 6, and 8 WAP, from either the amino acid POC concentrations or single NPK doses. This is hypothesized to be due to external factors, specifically insufficient ideal rainfall for corn plants and the simultaneous growth of plants, which led to similar leaf numbers across various applied amino acid POC concentrations and single NPK doses.

The application of amino acid POC at different concentrations did not yield a significant effect in this study, likely due to low rainfall leading to suboptimal nutrient absorption from fertilizer applications. During the study period, rainfall was notably low, averaging 13,18 mm. Suherman et al. (2019) state that corn plants require at least 85-200 mm/month to meet their water needs during the vegetative period. While amino acids can act as biostimulants to enhance nutrient absorption in corn plants, inadequate water intake will also result in suboptimal nutrient absorption. According to Sagala et al. (2022), water acts as a solvent for soil nutrients, as plants absorb nutrients in solution. Therefore, water's role as a solvent is crucial for maximizing nutrient uptake.

The use of single NPK fertilizer at different doses also had no significant effect. This can be attributed to internal factors such as the genetic makeup of the plants. The rate of cell division varies depending on the genetic condition of each corn plant, and according to Khairiyah et al. (2017), differences in cell division, multiplication, and enlargement affect corn plant growth. Sweet corn plants possess influential genetics that can lead to variations in leaf number development. This condition, coupled with suboptimal weather and climate for corn, resulted in less than optimal growth despite varied NPK fertilizer applications.

An interaction between the two treatments was observed at 8 WAP, indicating a synergistic relationship influencing leaf number growth. This suggests that amino acid POC can stimulate NPK uptake for plant growth or potentially substitute for excessive inorganic fertilizer use. This finding is consistent with previous research by Abdo et al. (2022), which reported an interaction on the growth and yield of corn plants with the combined application of amino acid POC and single NPK. This is related to the ability of amino acid POC to enhance nutrient absorption in plants, especially in combination with single NPK. Amino acids can increase physiological processes such as photosynthesis and protein synthesis, which contribute to plant growth.

Sweet Corn Crop Yield

The yield components of sweet corn include the number of cobs per plant, fresh cob weight, de-husked cob weight, grain weight per cob, actual yield, and potential yield. Based on the research, the analysis of variance results for each variable are presented in **Table 3**.

Based on Table 3, the application of amino acid POC at different concentrations had a significant effect on fresh cob weight, de-husked cob weight, seed weight per cob, actual yield, and potential yield. The optimal result from amino acid POC application was observed at 6 mL/L/plot, yielding an average fresh cob weight of 417,09 grams, de-husked cob weight of 333,22 grams, grain weight per cob of 247,15 grams, actual yield of 2.81 kg, and potential yield of 13.221,96 kg/ha.

The significant effect of amino acid POC was specifically seen at the 6 mL/L/plot concentration. Amino acid POC was applied by spraying, aiming to maximize its absorption into the vegetative parts of the plant. According to Nag et al. (2001), cited by Alalaf et al. (2022), amino acids are nitrogenous organic fertilizers and natural compounds that can balance plant growth and enhance plant response to fertilizers. When applied as a foliar spray on vegetative parts (leaves, stems, roots), amino acids are rapidly translocated to all leaf cells, increasing chlorophyll concentration and energy required for protein synthesis. Increased chlorophyll levels in plants will enhance plant growth and yield through physiological and biochemical processes. Abdo et al. (2022) indicated that the involvement of amino acids in plant physiology and biochemistry leads to increased activation of metabolic pathways, thereby improving the growth and yield of sweet corn plants.

Table 3. Average Yield of Sweet Corn (*Zea mays subsp. mays* L.) in the Treatment of Amino Acid POC Concentration and Single NPK Dosage

Treatment	Corn Yield					
	Number of Cobs per Plant	Cob Weight	de-husked Cob Weight	grain weight per cob	Actual Yield	Potential Yield
Amino Acid Concentration	cob	g	G	g	kg	kg/ha
Control (K0)	1,59	335,78b	267,64	189,99b	2,39b	11.237,12b
2 mL/L/plot (K1)	1,63	325,11b	264,02	192,29b	2,46b	11.579,61b
4 mL/L/plot (K2)	1,59	345,430b	275,53	200,23b	2,46b	11.592,68b
6 mL/L/plot (K3)	1,56	417,09a	333,22	247,15a	2,81a	13.221,96a
Fertilizer Dosage N,P,K						
100% (D1)	1,67	334,21b	267,47b	192,22b	2,44b	11.481,57b
75% (D2)	1,56	378,69a	303,63a	220,96a	2,68a	12.596,47a
50% (D3)	1,56	354.65b	284,21ab	209,06ab	2,47b	11.645,49b
KK K (%)	16,61	15,59	15,93	17,12	9,43	9,43
KK D (%)	14,17	7,94	10,15	12,22	8,20	8,20

Notes: Numbers followed by the same letter in the same column or row indicate that the results have no significant effect on the DMRT further test at the 5% level.
KK K: Coefficient of variation of amino acid POC concentration
KK D: Coefficient of variation of single NPK dose

Amino acid POC can supplement or partially substitute nitrogen as a plant nutrient. This can stimulate plants to absorb available soil nutrients, including those provided through single NPK fertilization. Consequently, higher concentrations of applied amino acid POC tend to enhance the growth and yield of sweet corn plants. Futo and Bencze (2023) also reported that higher amino acid POC concentrations correlated with increased sweet corn kernel weight. This is because sweet corn seed formation requires phosphorus (P) nutrients for stalk development during the generative fruiting period. In this context, amino acids act as a stimulant for plants to absorb soil nutrients, including phosphorus.

The application of NPK fertilizer significantly affected corn yield, with the most effective dose being 75% of the recommended dose, which yielded the best results for fresh cob weight (378,69 g), de-husked cob weight (303,63 g), seed weight per cob (220,96 g), actual yield (2,68 kg), and potential yield (12.596,47 kg/ha). The 75% NPK fertilization dose demonstrated significant improvements across these yield parameters. This is attributed to optimal nutrient absorption by plants, which is linked to soil conditions that maintain C-organic content. Previous research by Wahyudi et al. (2018) supports this, showing that fertilization with 75% of the recommended single NPK dose resulted in superior 100-seed weight and dry shelled seed weight per plant compared to other treatments. This relates to the susceptibility of soil to organic matter depletion if single

NPK fertilizers are applied excessively. According to Sari et al. (2023), soil organic matter plays a crucial role in determining soil fertility. Low organic content can render soil particles vulnerable to breakdown by rainfall, leading to erosion. Additionally, carbon in the soil serves as a food source for soil microorganisms. The presence of C-organic stimulates microbial activity, thereby enhancing decomposition processes and organic matter reactions in the soil. Therefore, combining chemical fertilizers with organic fertilizers is necessary to partially substitute chemical fertilizers without compromising essential plant nutrient supply. Puspadewi (2016) also found that combining single NPK fertilizer with various types of POC yielded better effects than POC treatment alone. Single NPK fertilizers possess higher nutrient content, which is more readily absorbed by the soil as plant nutrients.

No interaction was observed on the yield of sweet corn plants, hypothesized to be due to several internal and external factors. Elfin et al. (2017) indicate that plant growth is influenced by multiple factors, and if any of these factors fall below optimal levels for plant requirements, it will negatively impact plant growth, resulting in suboptimal yields. In this study, suboptimal yield is hypothesized to be influenced by environmental conditions during the study, genetic factors, and soil conditions. Sulaiman et al. (2024) state that corn requires 200-300 mm of rainfall per growing season or 800-1200 mm annually distributed evenly. However, during the research period, rainfall was significantly lower, at only 13.18 mm over approximately 11 weeks of planting. Aside from environmental conditions, poor soil conditions can also reduce the effectiveness of nutrient absorption from NPK fertilizers and amino acid POC. Pre-planting soil analysis revealed poor conditions with low C-organic and nitrogen levels. Brankov et al. (2020) reported that unfavorable environmental conditions inhibit the maximum absorption of amino acids in plants. These suboptimal conditions for sweet corn plants resulted in less than optimal nutrient absorption.

Despite the lack of interaction in the yield component, the use of amino acid POC and single NPK at different doses can be a viable long-term combination for reducing chemical fertilizer use. Abdo et al. (2022) reported that the best sweet corn production results were achieved with the application of 75% of the recommended NPK dose combined with amino acid fertilizers. Beyond optimizing results, this treatment can also mitigate the environmental impact of excessive chemical fertilizer use.

CONCLUSION AND RECOMMENDATIONS

Based on the conducted research, the following conclusions can be drawn application of amino acid POC at a concentration of 6 mL/L/plot yielded the best effects on fresh cob weight 417,09 g, grain weight per cob (247,15 g), actual yield (2,81 kg), and potential yield 13.221,96 kg/ha. The use of a single NPK fertilizer at a 75% dose provided the best effects on fresh cob weight (378,69 g), de-husked cob weight (303,63 g), grain weight per cob (220,96 g), actual yield (2.68 kg), and potential yield (12596.47 kg/ha). An interaction exists between amino acid POC concentration and single NPK dose on plant growth, specifically on plant height at 2 WAP and leaf number at 8 WAP. After the research was conducted, significant effects were found for both treatments: amino acid POC concentration and single NPK dose. Based on these results, it is suggested that future research investigate different amino acid POC application treatments to determine their effect on the growth and yield of sweet corn plants.

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