International Journal of Life Science and Agriculture Research
ISSN (Print): 2833-2091, ISSN (Online): 2833-2105
Volume 04 Issue 02 Febraury 2025
DOI: https://doi.org/10.55677/ijlsar/V04I02Y2025-04
Impact Factor: 7.88 , Page No : 81-84

The Application of Liquid Organic Fertilizer and Inorganic Fertilizer on Exchangable K, K-Uptake, and Sweet Corn (*Zea mays saccharata* Sturt) Yield in Inceptisols

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ABSTRACT: Inceptisols are widely distributed in Indonesia and are often characterized by low fertility, particularly in essential nutrients such as potassium (K), which is crucial for crop growth, including sweet corn. This study investigates the effects of liquid organic fertilizer (LOF) combined with NPK fertilizers on exchangeable potassium levels, potassium uptake, and the yield of sweet corn grown in Inceptisols. The experimental design used randomize block design with six treatments: 1 control treatment, 1 treatment with the recommended dose of NPK fertilizer, and four treatments of liquid organic fertilizer and NPK combination. Each treatment was repeated four times. The results showed that the combination of LOF and NPK improved both exchangeable K and K-uptake compared to NPK alone. Specifically, treatment E (¾ NPK + 1 ½ LOF) yielded the highest exchangeable K (0.76 cmol kg-1) and K uptake (1.64%), resulting in the highest cob weight per plant (0.52 kg) and per plot (12.48 kg). Additionally, treatment E achieved the highest fresh cob weight per hectare (22,187 kg ha^{-1}).

Published Online: February 07, 2025

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KEYWORDS: Crop Productivity, Fertilizer Combination, Soil Fertility

1. INTRODUCTION

Inceptisols are a widespread soil order in Indonesia, characterized by moderate weathering and limited horizon development. These soils often exhibit low fertility, particularly in essential nutrients such as potassium (K), which is crucial for plant growth and development. Improving soil fertility in Inceptisols is essential for enhancing crop yields, including sweet corn (Zea mays saccharata), a crop with significant economic value and high consumer demand.

Liquid organic fertilizers (LOF) have gained attention as sustainable alternatives to chemical fertilizers. LOF offer benefits such as improving soil structure, enhancing microbial activity, and providing essential nutrients. Research by Nursyamsi et al. (2002) demonstrated that combining LOF with NPK fertilizers improved the growth and yield of corn on Inceptisols.

Potassium in the soil exists in various forms, including exchangeable potassium (K-exchangeable), which is readily available for plant uptake. The availability of K-exchangeable is influenced by soil properties and fertilization practices. Research by Sofyan et al (2024) indicated that the application of LOF could improve the efficiency of inorganic fertilizer use (N, P, K) for the growth and yield of sweet corn in Inceptisols

Adequate potassium uptake is essential for sweet corn as it plays a vital role in processes such as photosynthesis, enzyme activation, and water regulation. However, the effectiveness of LOF in enhancing K-exchangeable levels, potassium uptake, and sweet corn yield in Inceptisols requires further investigation.

This study aims to evaluate the impact of liquid organic fertilizer application on soil K-exchangeable levels, potassium uptake, and the yield of sweet corn cultivated in Inceptisols. Understanding these effects will contribute to developing sustainable fertilization strategies that optimize nutrient availability and improve crop productivity on Inceptisols.

2. MATERIALS AND METHODS

This research was conducted from May to September 2024 at the Experimental Land, Universitas Padjadjaran, which is located at an altitude of 794 meters above sea level. Materials in this study include Inceptisols soil, sweetcorn seeds, liquid organic fertilizer at a dose of 20 L ha^{-1} Yafizham (2010) and compound NPK inorganic fertilizer (15-15-15) at a dose of 250 kg ha^{-1} (Kanso & Rostaman, 2013). The experimental design used randomize block design with six treatments: 1 control treatment, 1 treatment with the recommended dose of NPK fertilizer, and four treatments of liquid organic fertilizer and NPK combination. Each treatment was repeated four times. Soil media samples were taken during the maximum vegetative phase at 58 HST. Soil samples from the area around the root (rhizosphere) were taken about 500 grams per plant sample from each treatment to be analyzed in the laboratory adjusted to the parameters of analysis. The determination of soil K-exchangeable was carried out using the Atomic Absorption Spectrophotometer (AAS) method with 1M ammonium acetate extract at pH 7.0. The determination of plant K content was conducted using the wet ashing method with $HclO_4$ and HNO3.

3. RESULTS AND DISCUSSION

Exchangable K and K-uptake

Nutrients are needed in adequate amounts in the growth phase of plants, especially the vegetative growth phase of plants to get the best results. The percentage of K content changed after the application of liquid organic fertilizer and NPK. The effect of NPK fertilizer and liquid organic fertilizer on exchangable K and K-uptake is shown in Table 1.

Table 1. Exchangable K and K-uptake response due to application of liquid organic fertilizer and NPK on Inceptisol soil.

Code	Treatment	Exchangable K (cmol kg^{-1})	K-uptake (%)
A	Control	0.32 a	1.12 a
B	1 NPK	0.54 b	1.34 b
C	¾ NPK + ½ LOF	0.58 bc	1.46 bc
D	¾ NPK + 1 LOF	0.60 c	1.50 c
E	¾ NPK + 1 ½ LOF	0.76 e	1.64 d
F	1 NPK + 1 LOF	0.65 d	1.52 c

Note: Mean numbers followed by the same letter are not significantly different based on Duncan's Multiple Range Test at the 5% Level

Table 1 presents the effects of liquid organic fertilizer and NPK application on exchangeable K (cmol kg^{-1}) and K uptake (%) in Inceptisol soil. Treatment A (control) shows the lowest values for both exchangeable K (0.32 cmol kg^{-1}) and K uptake (1.12%). This is likely due to the absence of external nutrient input, making potassium availability rely solely on the soil's natural fertility. Berhe et al. (2021) emphasized that the application of fertilizers, whether organic or inorganic, significantly enhances soil nutrient availability, including potassium.

Treatment B (1 NPK) increased exchangeable K to 0.54 cmol kg^{-1} and K uptake to 1.34%, compared to the control. This improvement is attributed to the direct contribution of potassium from NPK fertilizers, which is readily available for plant absorption. Sultana et al. (2020) also reported that inorganic fertilizers like NPK are effective in increasing potassium ion concentration in the soil, leading to improved plant uptake.

The combined application of ¾ NPK and liquid organic fertilizer (treatments C, D, and E) showed better results in enhancing exchangeable K and K uptake compared to control and 1 NPK alone. Treatment C (¾ NPK + ½ liquid organic fertilizer) resulted in exchangeable K of 0.58 cmol kg^{-1} and K uptake of 1.46%, while treatment D (¾ NPK + 1 liquid organic fertilizer) further increased these values to 0.60 cmol kg-1 and 1.50%, respectively.

The highest results were observed in treatment E (¾ NPK + 1 ½ liquid organic fertilizer), with the highest exchangeable K value of 0.76 cmol kg^{-1} and K uptake of 1.64%. This suggests a synergistic effect between organic and inorganic fertilizers in providing nutrients and improving soil microbial activity, which plays a crucial role in nutrient cycling (Berhe et al., 2021).

Treatment F (1 NPK + 1 liquid organic fertilizer) also demonstrated significant improvement, with exchangeable K of 0.65 cmol kg^{-1} and K uptake of 1.52%. Although slightly lower than treatment E, this shows that combining organic and inorganic fertilizers enhances nutrient use efficiency compared to inorganic fertilizers alone. Bhattacharyya et al. (2021) also reported that combining organic and inorganic fertilizers contributes to sustainable soil fertility management.

Overall, the results highlight that the combination of liquid organic fertilizer and NPK is more effective in improving exchangeable K and K uptake than applying inorganic fertilizer alone. Organic fertilizers provide carbon and energy sources for soil microorganisms, supporting the release of nutrients (Bhattacharyya et al., 2021).

Sweet Corn Yield Response

Sweet corn yield components include cob weight per plant (kg), cob weight per plot (kg), and Fresh Cob Weight per Hectare (kg). The statistical test results of the yield parameters are presented in Table 2.

Table 2. Yield response of sweet corn with liquid organic fertilizer and NPK on Inceptisol soil

Code	Treatment	Cob Weight (kg plant^{-1})	Cob Weight (plot plant^{-1})	Fresh Cob Weight (kg ha^{-1})
A	Control	0.32	7.68	13,653 a
B	1 NPK	0.43	10.32	18,347 b
C	¾ NPK + ½ LOF	0.4	9.60	17,067 b
D	¾ NPK + 1 LOF	0.48	11.52	20,480 c
E	¾ NPK + 1 ½ LOF	0.52	12.48	22,187 d
F	1 NPK + 1 LOF	0.5	12.00	21,334 cd

Note: Mean numbers followed by the same letter are not significantly different based on Duncan's Multiple Range Test at the 5% Level.

The data show that the application of liquid organic fertilizers (LOF) combined with NPK increases cob weight per plant. The lowest cob weight per plant (0.32 kg) was recorded in the control (A), while the highest (0.52 kg) was observed in treatment E (¾ NPK + 1 ½ LOF). Previous studies suggest that organic fertilizers enhance soil microbial activity, which improves nutrient availability and absorption, resulting in better plant growth (Zhang et al., 2023). Additionally, the presence of LOF can increase nitrogen efficiency, reducing the need for full NPK application while maintaining productivity (Prasad et al., 2023).

Cob weight per plot followed a similar trend, with the control (7.68 kg) having the lowest value and treatment F (12.00 kg) achieving the highest. Interestingly, treatment E (12.48 kg) slightly outperformed treatment F, suggesting that optimized organic input with reduced NPK can be more effective. According to Rachman & Rani (2020), found that a balanced combination of organic and inorganic fertilizers enhances crop performance by providing a sustained release of nutrients.

The fresh cob weight per hectare ranged from 13,653 kg ha^{-1} (control) to 22,187 kg ha^{-1} (treatment E). The results indicate that increasing LOF can significantly enhance yield, even with reduced NPK input. This aligns with research by Hartatik et al. (2015), which found that organic fertilizers contribute to long-term soil fertility improvement, increasing crop yield stability. Furthermore, Xiao et al. (2022) reported that bio-organic fertilizers enhance enzyme activity and soil organic matter, promoting higher biomass production.

A ¾ NPK + LOF combination (C, D, and E) produces similar or better results compared to full NPK application (B, F), showing the potential for reducing synthetic fertilizer dependency (Rahman et al., 2022). Treatment E demonstrates the highest yield, confirming that integrating LOF can optimize crop productivity while promoting sustainable farming practices (El-Masry et al., 2016).

CONCLUSIONS

1. The combination of liquid organic fertilizer and NPK can increase the response of exchangable K, K-Uptake, and sweet corn yield in Inceptisols.
2. The application of a combination of ¾ NPK + 1 ½ LOF is the best combination in increasing exchangable K, K-Uptake, and sweet corn yield.

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