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Effects of granular organic and inorganic fertilizer combinations on N, P, K uptake and sweet corn yield

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Abstract

Sweet corn is a high-value crop with rich nutritional content. Optimizing crop yield requires proper nutrient management, particularly in the absorption of nitrogen (N), phosphorus (P), and potassium (K). This study evaluates the effects of a combination of granular organic fertilizer (GOF) and inorganic NPK fertilizer on nutrient absorption and sweet corn yield grown on Inceptisol soil. The research was conducted from February to May 2024 at the Experimental Field of Universitas Padjadjaran, using a randomized block design with six treatments, including different combinations of GOF and NPK at varying doses (Control, 1 NPK, ¾ NPK + ½ GOF, ¾ NPK + 1 GOF, ¾ NPK + 1 ½ GOF, 1 NPK + 1 GOF). The results indicated that the combination of GOF and NPK enhanced the absorption of N, P, and K compared to the application of NPK alone. The best treatment was ¾ NPK + 1 ½ GOF, which showed a significant increase in nutrient absorption (52.31 mg plant^{-1} N, 6.30 mg plant^{-1} P, and 55.63 mg plant^{-1} K) as well as the highest yield (23,040 kg ha^{-1} fresh cob weight).

Keywords: Crop Productivity; Fertilizer Combination; Granular fertilizer; Nutrient Uptake; Soil fertility

1. Introduction

Sweet corn (*Zea mays saccharata* sturt) is a valuable crop known for its high nutritional content and economic significance. Achieving optimal yields requires effective nutrient management, particularly concerning the uptake of essential macronutrients such as nitrogen (N), phosphorus (P), and potassium (K).

Integrating organic and inorganic fertilizers has been recognized as a sustainable approach to enhance nutrient availability and improve crop performance. Organic fertilizers, such as compost or manure, contribute to soil health by improving structure, increasing microbial activity, and providing a slow-release source of nutrients. In contrast, inorganic fertilizers supply readily available nutrients that can be immediately utilized by plants. Combining these two fertilizer types aims to leverage their complementary benefits, potentially leading to improved nutrient uptake and increased crop yields.

Granular organic fertilizer (GOF) has emerged as a superior alternative to traditional organic fertilizers due to its enhanced efficiency, ease of application, and improved nutrient availability. Unlike conventional organic fertilizers such as compost, manure, or liquid biofertilizers, granular organic fertilizers undergo a controlled processing method that ensures uniform nutrient distribution, longer shelf life, and better soil integration. These advantages make granular organic fertilizers a preferred choice for sustainable agricultural practices.

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One of the key benefits of granular organic fertilizers is their slow-release nature, which allows for a more consistent supply of nutrients over an extended period. Traditional organic fertilizers, such as raw manure or compost, decompose irregularly, leading to fluctuating nutrient availability. In contrast, granular formulations release nutrients gradually, reducing the risk of leaching and volatilization losses, thus improving nutrient use efficiency (Azeem et al., 2019). This slow-release characteristic ensures that crops receive a steady supply of essential nutrients, enhancing plant growth and yield.

Research has demonstrated the positive effects of combining organic and inorganic fertilizers on nutrient uptake and crop yield. For instance, a study by Sofyan et al. (2018) evaluated the effect of organic fertilizer (i.e., cow manure) and inorganic fertilizer application on nutrient uptake and yield of sweet corn. The study found that the combined application of organic and inorganic fertilizers resulted in higher N, P, and K uptake, as well as increased sweet corn yield, compared to the application of inorganic fertilizers alone.

Similarly, research published in the Journal of Tropical Soils indicated that the integration of organic and inorganic fertilizers positively influenced nutrient uptake and yield in sweet corn cultivation. The study concluded that the combined application of these fertilizers enhanced the availability of N, P, and K, leading to improved plant growth and productivity.

Further studies have supported these findings. For example, a study by Canatoy (2018) examined the effects of fertilization on the growth and yield of sweet corn under no-tillage conditions in Bukidnon, Philippines. The results indicated that the application of inorganic fertilizer in combination with organic fertilizer significantly increased dry matter yield in stover and grains, as well as the nitrogen, phosphorus, and potassium uptake of sweet corn plants.

2. Materials and methods

This research was conducted from February to May 2024 at the Experimental Land, Universitas Padjadjaran, which is located at an altitude of 794 m above sea level. Materials in this study include Inceptisols soil, sweetcorn seeds, granular organic fertilizer at a dose of 600 kg ha^{-1} (Intansari & Subiksa 2022) 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 granular organic fertilizer and NPK combination. Each treatment was repeated four times. Soil media samples were taken during the maximum vegetative phase at 56 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 study was carried out in several phases: soil preparation, fertilization and planting, maintenance, observation, soil and plant sampling, and harvesting.

3. Results and discussion

N, P, K Uptake Plants require adequate nutrients during their growth phase, particularly in the vegetative stage, to achieve optimal growth. The levels of N, P, and K changed after applying granular organic fertilizer and NPK. The influence of NPK fertilizer and granular organic fertilizer on N, P, and K uptake is presented in Table 1.

Table 1 N, P, and K uptake response due to application of granular organic fertilizer (GOF) and NPK on Inceptisol soil

Code	Treatment	N Uptake (mg $plant^{-1}$)	P Uptake (mg $plant^{-1}$)	K Uptake (mg $plant^{-1}$)
A	Control	12.26 a	2.86 a	20.31 a
B	1 NPK	37.75 e	4.47 c	42.42 e
C	¾ NPK + ½ GOF	18.88 ab	3.01 ab	24.44 a
D	¾ NPK + 1 GOF	34.07 d	4.52 c	32.85 c
E	¾ NPK + 1 ½ GOF	52.31 e	6.30 d	55.63 d
F	1 NPK + 1 GOF	24.34 c	5.32 c	27.24 b

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 presented in Table 1 demonstrate the effects of granular organic fertilizer (GOF) and NPK combinations on nitrogen (N), phosphorus (P), and potassium (K) uptake in sweet corn grown on Inceptisol soil. The results reveal significant differences among treatments, highlighting the importance of balanced nutrient management in optimizing plant uptake efficiency.

3.1. Nitrogen Uptake

Nitrogen uptake varies significantly among treatments, with the lowest value recorded in the control (12.26 mg plant^{-1}). This is expected, as the control treatment lacks external nutrient input, relying solely on the soil's native fertility. The highest nitrogen uptake was observed in treatment E (¾ NPK + 1 ½ GOF) at 52.31 mg plant^{-1}, indicating that the combination of granular organic fertilizer and a reduced dose of inorganic fertilizer enhances nitrogen availability and absorption. Studies suggest that organic fertilizers improve soil microbial activity, which facilitates nitrogen mineralization and uptake efficiency (Zhang et al., 2022). The significant increase in nitrogen uptake in treatment E compared to full NPK treatment (B) (37.75 mg plant^{-1}) suggests that incorporating organic amendments can enhance nitrogen use efficiency, reducing dependence on chemical fertilizers (Toda et al., 2023).

3.2. Phosphorus Uptake

Phosphorus uptake also shows a clear response to fertilizer treatments. The lowest uptake is recorded in the control (2.86 mg plant^{-1}), while the highest uptake is found in treatment E (6.30 mg plant^{-1}). The combination of ¾ NPK with increased GOF application enhances phosphorus availability, likely that the application of a mixture of biochar, compost, and inorganic fertilizer can enhance phosphorus uptake in corn more effectively than using inorganic fertilizer (Osei-Agyeman et al., 2021). Treatment B (full NPK) recorded a phosphorus uptake of 4.47 mg plant^{-1}, similar to treatment D (¾ NPK + 1 GOF). This suggests that a balanced combination of organic and inorganic fertilizers can maintain phosphorus uptake at levels comparable to full NPK application while improving soil health.

3.3. Potassium Uptake

Potassium uptake follows a similar trend, with the control showing the lowest value (20.31 mg plant^{-1}) and treatment E recording the highest (55.63 mg plant^{-1}). The increased uptake in treatment E indicates that organic fertilizers contribute to improved potassium availability by enhancing cation exchange capacity (CEC) and reducing potassium leaching (Bader et al., 2021). Treatment B (full NPK) recorded a potassium uptake of 42.42 mg plant^{-1}, lower than treatment E but higher than treatments with reduced NPK and GOF combinations. The increased uptake in treatments E and F suggests that incorporating organic amendments improves potassium retention and availability, benefiting plant growth and productivity.

The findings demonstrate that a combination of granular organic fertilizer and inorganic fertilizers enhances nutrient uptake compared to sole NPK application or control treatments. Treatment E (¾ NPK + 1 ½ GOF) consistently achieved the highest uptake values for N, P, and K, highlighting the effectiveness of integrating organic fertilizers to improve nutrient use efficiency. Additionally, reducing NPK input while maintaining high nutrient uptake levels suggests that a sustainable approach to fertilization can minimize environmental impacts without compromising crop productivity.

3.4. Sweet Corn Yield Response

The components of sweet corn yield consist of cob weight per plant (kg), cob weight per plot (kg), and fresh cob weight per hectare (kg). The statistical analysis results for these yield parameters are shown in Table 2.

Table 2 Yield response of sweet corn with granular organic fertilizer and NPK on Inceptisol

Code	Treatment	Cob Weight (kg plant^{-1})	Cob Weight (plot plant^{-1})	Fresh Cob Weight (kg ha^{-1})
A	Control	0.33	7.92	14,080 a
B	1 NPK	0.44	10.56	18,773 b
C	¾ NPK + ½ GOF	0.46	11.04	19,627 b
D	¾ NPK + 1 GOF	0.47	11.28	20,053 bc
E	¾ NPK + 1 ½ GOF	0.54	12.96	23,040 d
F	1 NPK + 1 GOF	0.51	12.24	21,760 c

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

The table presents the yield response of sweet corn to the application GOF and NPK on Inceptisol soil. The results indicate that fertilizer application significantly influenced cob weight per plant, cob weight per plot, and fresh cob weight per hectare. The control treatment (A) recorded the lowest values across all parameters, with a fresh cob weight of 14,080 kg ha^{-1}, demonstrating the necessity of nutrient supplementation for optimal corn growth. The application of 1 NPK (B) resulted in a substantial increase in cob weight (0.44 kg $plant^{-1}$) and fresh cob weight (18,773 kg ha^{-1}), confirming the role of NPK in enhancing yield.

Further improvements were observed when combining NPK with granular organic fertilizer. The ¾ NPK + ½ GOF (C) and ¾ NPK + 1 GOF (D) treatments showed progressive increases in fresh cob weight to 19,627 kg ha^{-1} and 20,053 kg ha^{-1}, respectively. The highest yield was recorded in the ¾ NPK + 1 ½ GOF (E) treatment, with 23,040 kg ha^{-1}, followed by 1 NPK + 1 GOF (F) at 21,760 kg ha^{-1}. This suggests that integrating organic fertilizers with NPK optimizes nutrient availability and uptake, leading to enhanced corn yield.

These findings align with previous research indicating that a combination of organic and inorganic fertilizers enhances nutrient absorption and soil fertility, thereby improving crop productivity (Berhe et al., 2021; Xiao et al., 2022). Organic fertilizers contribute to soil organic matter and microbial activity, which play a crucial role in nutrient cycling and plant growth (Bhattacharyya et al., 2021). Moreover, NPK provides readily available macronutrients essential for plant metabolism (Prasad et al., 2023).

The significant increase in cob weight and fresh cob yield with ¾ NPK + 1 ½ GOF suggests that partially replacing synthetic fertilizers with organic amendments can enhance productivity while potentially reducing environmental risks associated with excessive chemical fertilizer use. This supports sustainable agricultural practices and aligns with efforts to maintain soil health in intensive cropping systems (Zhang et al., 2023).

4. Conclusion

- The integration of granular organic fertilizer with NPK enhances N, P, K uptake and improves the yield of sweet corn.
- The application of ¾ NPK + 1 ½ GOF is the most effective combination for maximizing N, P, K uptake and increasing sweet corn yield.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed

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