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Effect of Organic and Inorganic Fertilizer Application on Soil Chemical Properties and Yield of Corn Crops (Zea mays L.)

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ABSTRACT

Decreased productivity of maize plants (Zea mays L.) is often related to decreased soil fertility due to unbalanced fertilization practices. This study aims to evaluate the effect of organic and inorganic fertilizer applications on changes in soil chemistry and corn crop yields in Inceptisol land. The research was carried out using a Complete Group Random Design (RAKL) with five treatments, namely: no fertilizer (control), organic fertilizer, inorganic fertilizer, organic + inorganic combination 100%, and organic + inorganic combination 50%. The observed parameters included soil pH, C-organic levels, total nitrogen, available phosphorus, and corn yield. The results showed that the combination of organic and inorganic fertilizers (full doses) gave the best results in improving soil chemistry and significantly increasing corn yields compared to other treatments. The increase in soil pH value, nutrient availability P, and C-organic content was recorded higher than the control. This treatment is also able to produce the highest corn productivity reaching 7.2 tons/ha. These findings suggest that integrated fertilizer applications can improve nutrient absorption efficiency and support sustainable agriculture. Therefore, integrated fertilization is recommended as the main strategy in soil management and increasing corn productivity on marginal land.

Keywords: Organic fertilizer, Inorganic fertilizer, Soil chemical properties

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INTRODUCTION

Agriculture is a strategic sector in national development, especially in ensuring food security and supporting the community's economy. One of the main food commodities that has an important role in Indonesia's agricultural system is corn (Zea mays L.) (Wahyudin et al., 2017). Corn is not only used as a source of human food, but also as animal feed and industrial raw materials. According to data from the Central Statistics Agency (2023), corn ranks second only to rice in terms of harvest area and production volume in Indonesia. Therefore, increasing the productivity of corn crops is an important agenda in the national agricultural intensification program.

However, increasing corn yields often faces obstacles, one of which is a decrease in soil fertility due to excessive land exploitation and the continuous use of inorganic fertilizers. Intensive application of inorganic fertilizers without being balanced with organic matter has led to degradation of the physical and chemical properties of the soil, such as decreased organic matter content, low cation exchange capacity (KTK), and increased risk of environmental pollution and loss of fertilization efficiency (Hartatik (2015)). This decline in soil quality has a direct impact on reducing crop productivity and the sustainability of agricultural systems.

To overcome these problems, one of the approaches that has been widely developed is balanced fertilization by combining organic and inorganic fertilizers. Organic fertilizers are derived from natural materials such as compost, manure, agricultural waste, and forage, which not only supply plant nutrients but also improve the physical, chemical, and biological properties of the soil (Haris & Putra 2022). The application of organic fertilizers can increase the content of soil organic matter, improve soil structure, increase porosity and water binding capacity, and stimulate the activity of soil microorganisms (Sufardi 2012). On the other hand, inorganic fertilizers have advantages in terms of speed of nutrient availability and ease of application. Therefore, the combination of organic and inorganic fertilizers is expected to create synergies that support fertilization efficiency, increase crop yields, and preserve soil function.

Some previous studies have shown that the use of organic fertilizers alone has a positive impact on improving soil fertility, but does not always provide optimal crop yields in the short term. In contrast, inorganic fertilizers often provide rapid yield improvements, but do not improve soil quality on an ongoing basis. Therefore, the concept of balanced and integrated plant nutrient management is an important solution in a sustainable agricultural system. Integrated fertilization aims to optimize fertilization efficiency and minimize negative impacts on the environment.

Corn plants are annuals that have high nutrient needs, especially nitrogen (N), phosphorus (P), and potassium (K). This lack of nutrients can lead to stunted growth, suboptimal cob formation, and low yields. Therefore, proper nutrient management is essential to support corn productivity. In addition, the quality of the soil where plants grow must also be considered. Soil chemical properties, such as pH, C-organic content, N-total, P-available, and K-available, are important indicators that affect nutrient availability for plants (Isir et al., 2022).

In this context, research on the influence of organic and inorganic fertilizer applications on soil chemistry and corn crop yields is particularly relevant. This study aims to find out how each treatment, whether organic, inorganic, or a combination of both, affects the parameters of soil fertility and productivity of corn plants. In addition, this research is also expected to make a scientific and practical contribution in developing effective, efficient, and sustainable fertilization strategies at the farmer level.

Different types of organic matter used as fertilizers, such as compost and manure, have varying nutrient content depending on the raw material and the decomposition process (Hanum 2013). Compost derived from agricultural waste contains macro and micronutrients, as well as humic and fulvic acids which play a role in increasing nutrient availability and improving soil structure. Meanwhile, inorganic fertilizers such as urea, SP-36, and KCl are the main sources of N, P, and K that are readily available to plants (Saptiningsih 2015). The combination of these two types of fertilizers in the right amount can overcome the limitations of each type of fertilizer, as well as increase fertilization efficiency.

In modern agricultural systems, fertilization is not only aimed at meeting the nutrient needs of plants, but also to maintain the balance of the soil ecosystem. Healthy and fertile soil will be able to provide nutrients in the amount and proportion that is appropriate to plant needs, as well as support the microbial activity of the soil that plays a role in the decomposition of organic matter and nutrient cycling (Febrianas & Susilastuti 2024. Therefore, fertilization

strategies that consider the preservation of soil function are essential in supporting long-term food security.

In general, success in increasing maize productivity is determined not only by varieties and agronomic management, but also by sustainable soil and nutrient management. Thus, this study focuses not only on short-term outcomes in the form of increased crop yields, but also on the long-term impact on soil quality. It is hoped that the results of this research can be a reference in the preparation of fertilization recommendations that are in accordance with the conditions of the local agroecosystem, and can be applied by farmers practically and economically.

Based on this background, the formulation of the problem in this study is: (1) How does the application of organic and inorganic fertilizers affect changes in soil chemical properties?, and (2) How does the impact of these treatments on corn crop yields?. To answer this question, field research was carried out with various fertilization treatments and observations of soil chemical properties and corn productivity parameters. The objectives of this study are:

1. Analyze the influence of organic and inorganic fertilizers on changes in soil chemical properties, such as pH, C-organic, N-total, and P-available.
2. Assess the effect of various combinations of fertilizers on corn crop yields.
3. Formulate a balanced fertilization strategy that can increase corn yields while improving and maintaining soil fertility.

With the preparation of this research, it is hoped that the results can contribute to the development of soil science, especially in the field of nutrient management and soil fertility, as well as provide agronomic solutions for farmers in increasing corn production efficiently and environmentally friendly. This research is also expected to be the basis for further research in the field of sustainable agriculture, especially related to the integration of the use of organic and inorganic materials in food crop cultivation systems.

METHODS

This research was carried out on farmland owned by farmers in Sukamaju Village, Jatirogo District, Tuban Regency, East Java. The location is located at an altitude of 45 meters above sea level, with an annual rainfall of about 1,500 mm and an average daily temperature of 27–32°C. The soil type is Inceptisol with a sour pH (5,3).

The research lasted for one planting season, namely February to June 2024. The experimental design used a one-factor Group Random Design (RAK), consisting of five fertilization treatments and three replicates, so that there were 15 experimental plots measuring 3 m x 4 m (12 m^2), with a distance of 0.5 m between plots and 1 m between replicates.

Fertilization treatment includes P0 (without fertilizer), P1 (compost 10 tons/ha), P2 (urea 250 kg/ha, SP-36 100 kg/ha, KCl 100 kg/ha), P3 (combination of compost of 5 tons/ha and inorganic 100% of the dose), and P4 (compost of 5 tons/ha and inorganic 50% of the dose). The organic fertilizer used comes from mature compost (C/N < 20), while inorganic fertilizer is according to the recommendation of the local BPTP. Corn of the Bisi-18 variety is planted in a row with a distance of 75 cm x 25 cm, organic fertilization is given one week before planting and inorganic in two stages (10 and 30 HST). Weeds are controlled manually every two weeks and pesticide spraying is not carried out because pests are minimal. The observed parameters included pH, C-organic, N-total, P-available soil, and dried corn yield per hectare. Soil analysis used the Walkley & Black method for C-organic, Kjeldahl for N-total, and Bray I for P-available. The data was analyzed using ANOVA and further tested by DMRT 5%. The results show that fertilization has a noticeable effect on all parameters.

The combination treatment (P3) yielded the best results, increasing pH to 6.1, C-organic to 2.1%, P-available to 17.5 ppm, and a yield of 7.2 tons/ha, higher than other treatments. In addition to improving the chemical properties of the soil, P3 treatment is able to create synergy between organic and inorganic fertilizers so that nutrient absorption is more efficient and plant growth is more optimal. These findings suggest that the sustainable application of integrated fertilization contributes to improved productivity and soil quality.

RESULT AND DISCUSSION

Soil pH Changes

The results of soil pH measurement at the end of the planting period show that fertilization treatment has a real effect on soil reaction. In the control treatment (P0), the pH value was recorded at 5.3 which was included in the sour category. This is common in land that does not receive input from ameliorant materials or nutrient sources, so it undergoes a continuous leaching process.

The application of organic fertilizer (P1) increases the pH of the soil to 5.9. This increase is due to the presence of alkaline cations in organic materials such as Ca^{2+}, Mg^{2+}, and K^{+} which play a role in neutralizing free H^{+} ions in soil solutions. In addition, the decomposition of organic matter produces organic acids that play a role in glazing aluminum (Al^{3+}), so that its toxicity is reduced and the pH of the soil increases.

In the treatment of inorganic fertilizer (P2), the pH value increased only slightly to 5.5. This shows that the use of inorganic fertilizers alone tends to be not effective enough in neutralizing soil acidity. Some types of inorganic fertilizers such as urea can even trigger an increase in soil acidity due to the nitrification process that produces H^{+} ions as a byproduct.

Combination organic and inorganic (P3) treatment showed the highest increase in soil pH, reaching 6.1. This value is close to neutral conditions, which is ideal for the availability of various nutrients. This combination allows for a synergistic role between the readily available elements of inorganic fertilizers and the ameliorative capabilities of organic matter. Partial combination (P4) also showed a positive effect with a pH value of 5.8.

A significant increase in soil pH in combination treatment indicates that an integrated fertilization strategy plays an important role in managing soil reactions, especially in acidic soils. Near-neutral pH conditions are essential in improving fertilization efficiency and soil microbial activity.

C-Organic Content of Soil

C-organic soil is a key indicator in assessing the long-term fertility status of soils. The control treatment (P0) showed the lowest C-organic value, which was 1.2%. This indicates the low content of organic matter in the soil prior to treatment, which can lead to low cation exchange capacity (KTK), resistance to erosion, as well as soil microbial activity.

The increase in C-organic content was recorded significantly in the treatment of organic fertilizer (P1) which reached 1.9%, and even higher in the combination of organic and inorganic (P3) by 2.1%. This improvement clearly illustrates the effectiveness of compost as a source of organic matter in improving soil quality. High C-organic content correlates with an increase in the soil's capacity to hold water and nutrients.

Inorganic fertilizer (P2) treatment only slightly increased the C-organic content to 1.4%. This suggests that without the contribution of organic matter, long-term soil fertility is difficult to achieve, although crop yields can increase in the short term.

Increased C-organic in combination treatments can also be attributed to increased plant biomass production which eventually returns to the soil in the form of residual roots and straw,

thus increasing the soil's carbon reserves. This strategy not only increases productivity in the short term, but also maintains the sustainability of the agricultural system.

Phosphorus Availability (P-available)

Phosphorus is an essential macronutrient that is often a barrier in acidic soils because Al^{3} and Fe^{3} easily absorb it^{+}. The results showed that phosphorus availability increased in all fertilization treatments. The highest available P-value was achieved at the combined P3 treatment (17.5 ppm), followed by P4 (15.3 ppm), P2 (13.8 ppm), P1 (11.6 ppm), and control.

Table 1 Effect of Fertilizer Treatment on Soil Chemical Properties and Corn Yield

Treatment	Soil pH	C-Organic (%)	P-Available (ppm)	Corn Yield (ton/ha)
P0 (Control)	5,3	1,2	8,4	3,5
P1 (Organic)	5,9	1,9	11,6	4,8
P2 (Inorganic)	5,5	1,4	13,8	5,9
P3 (Organic + Anorg)	6,1	2,1	17,5	7,2
P4 (Org + Anorg 50%)	5,8	1,8	15,3	6,5

Description:

- P0: No fertilization
- P1: Compost 10 tons/ha
- P2: Urea + SP-36 + KCl equivalent to 200 kg/ha
- P3: Compost 5 tons/ha + 100% inorganic fertilizer
- P4: Compost 5 tons/ha + 50% inorganic fertilizer

CONCLUSION

This study clearly shows that the application of organic and inorganic fertilizers, either alone or in combination, has a significant influence on improving soil chemical properties and increasing the yield of corn plants (Zea mays L.). From the results of the analysis carried out, it can be concluded that the combination of organic and inorganic fertilizer (P3) treatment is the best treatment compared to other treatments.

In terms of soil chemical properties, P3 treatment showed an increase in soil pH from acidic conditions (5.3) to somewhat neutral (6.1), which is ideal for corn growth. This increase in pH plays a role in increasing the availability of nutrients, especially phosphorus. In addition, the C-organic content also experienced a significant increase in this treatment, reaching 2.1%, compared to the control which was only 1.2%. The availability of phosphorus increased to 17.5 ppm, indicating that the combination of fertilizers accelerated the mineralization process and mobilized essential nutrients for the plant.

In terms of yield, combination treatment (P3) provided the highest production of 7.2 tons/ha, followed by half-dose combination treatment (P4) of 6.5 tons/ha, and inorganic fertilizer (P2) of 5.9 tons/ha. The application of organic fertilizer alone (P1) was still better than control, but much lower than combined. This shows a strong synergy between the short-term role of inorganic fertilizers in providing nutrients quickly, and the long-term role of organic fertilizers in improving soil quality.

Overall, the results of this study confirm that the integrated use of organic and inorganic fertilizers is able to increase soil fertility and corn productivity in a sustainable manner. This balanced fertilization approach is highly recommended in modern agricultural systems, as it not only increases crop yields but also maintains the sustainability of agroecosystems and long-

term soil health. Thus, integrated fertilization is an important strategy in the efficient and environmentally friendly cultivation of corn plants.

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