Combined application of organic and inorganic fertilizer on Alfisol soil fertility and maize growth

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Abstract. Fertilizer is an important factor in crop production, but its effectiveness depends on climate and the balance of fertilizers applied. This research aimed to determine the potential use of organic fertilizers to reduce the use of inorganic fertilizers on the growth of maize and Alfisol soil fertility. This research was conducted in the Jumantono, Karanganyar, and used the Randomized Block Design with 9 treatments (A = Control, B = NPK standard, C = ¼ NPK + 1 PO, D = ½ NPK + 1 PO, E = ¾ NPK +1 PO, F = 1 NPK + 1 PO, G = ¾ NPK + ½ PO, H = ¾ NPK + ½ PO, I = ¾ NPK + ¾ PO). The results showed that organic fertilizers at doses ¼, ½ and ¾ accompanied by ¾ NPK standard gives N total, P total, K total, and the plant height, number of leaves and stem diameter which are not different with the dose of NPK standard. Organic fertilizers can reduce the use of NPK fertilizers.

1. Introduction
Plant growth is influenced by various factors including soil, temperature, sunlight and nutrients. The success of agricultural production through agricultural intensification activities cannot be separated from the contribution and role of production facilities, especially fertilizers. Fertilizer is an important factor in crop production, but its effectiveness depends on environmental conditions such as climate and the balance of fertilizers applied. Various studies have concluded that the continuous use of inorganic fertilizers will have a negative effect on soil conditions.

The use of inorganic fertilizers among farmers is still high, as are farmers in Jumantono. The continuous and excessive use of inorganic fertilizers causes a decrease in soil fertility. The type of soil in Jumantono belongs to the Alfisols order which has a characteristic high clay content (argillic horizon) so that it can cause high soil density, which makes it difficult for roots to penetrate. According to Wijanarko et al. [1] soil that has an argillic horizon causes high soil density so that plant roots are difficult to penetrate and low aeration pores. The intensification of agricultural activities with the addition of inorganic fertilizers in Jumantono can lead to land degradation. The provision of organic fertilizers as a substitute for inorganic fertilizers is an alternative solution to nutrient problems in the soil. Organic fertilizers can improve chemical and physical properties better, in addition to increasing plant growth. Based on the results of the study [2], the application of a combination of organic and inorganic fertilizers can significantly improve the physical and chemical properties of the soil in rice cultivation in Ultisol Nanning, China. Application of a combination of 10 tonnes ha$^{-1}$ of goat manure and 250 kg ha$^{-1}$ of NPK fertilizer has a significant effect on the growth and sweet corn yields [3].

The application of organic fertilizers combined with inorganic fertilizers is expected to increase plant growth and the availability of nutrients and reduce the use of excessive inorganic fertilizers.
among farmers. This research is expected not only to produce a recommended dosage of fertilization but also to be an alternative in reducing the use of inorganic fertilizers on Alfisols Jumantono.

2. Methods
The research was conducted in Jumantono, Karanganyar Regency. This research was conducted using the experimental method. The design used was a randomized block design (RBD), which consisted of 9 treatment combinations (Table 1). 7 organic fertilizer dosage treatments, 1 recommended fertilizer dosage treatment and 1 as a control as a comparison. Each treatment was repeated 3 times so that the total number of experimental plots was 27 plots.

The data obtained were then analyzed for variance to determine the effect of each treatment. Then the DMRT test was carried out. The parameters observed were plant growth data (plant height, stem diameter, and number of leaves) and nutrient content (N, P, and K). Implementation of research includes preparation of planting media, planting and fertilization, maintenance and harvest.

Table 1. Combination of organic fertilizer and inorganic fertilizer treatment on maize plants.

| Code | Treatment       | Organic Fertilizer (kg ha⁻¹) | Inorganic Fertilizer (kg ha⁻¹) |
|------|-----------------|-------------------------------|-------------------------------|
|      |                 |                               | Urea SP36 KCl                 |
| A    | Control         | 0                             | 0 0 0                         |
| B    | Standard NPK    | 0                             | 350 150 75                    |
| C    | ¼ NPK + 1 PO    | 5000                          | 87.5 37.5 18.75               |
| D    | ½ NPK + 1 PO    | 5000                          | 175 75 37.5                   |
| E    | ¾ NPK + 1 PO    | 5000                          | 262.5 112.5 56.25             |
| F    | 1 NPK + 1 PO    | 5000                          | 350 150 75                    |
| G    | ¾ NPK + ¾ PO    | 1250                          | 262.5 112.5 56.25             |
| H    | ¾ NPK + ½ PO    | 2500                          | 262.5 112.5 56.25             |
| I    | ¾ NPK + ¼ PO    | 3750                          | 262.5 112.5 56.25             |

Information:
a. Control is the treatment without organic fertilizers and inorganic fertilizers.
b. Standard NPK fertilizer is the recommended dosage of inorganic fertilizer treatment for maize plants (350 kg Urea, 150 kg SP-36, and 50 kg KCl per hectare)
c. The recommended dosage treatment for Organic Fertilizer is 5000 kg ha⁻¹.

3. Result
3.1. Plant growth of maize
3.1.1. Plant height
The results of the analysis of plant height at 14 and 28 days the maize plants showed significantly different effects between treatments (Table 2). This is presumably because the young plants absorb nutrients in the soil. For their growth, it appears that all treatments respond to plant height. At 42 days, there was a difference between treatments but not significantly different and 56 days showed a significantly different effect, it was seen that the plant height was significantly different between NPK fertilizer combined with organic fertilizer compared to the control treatment and standard NPK treatment.

Table 2 shows the growth dynamics between treatments. In general, the plants with the highest stand growth rate were shown by treatment I and the lowest was shown by treatment A. In the maximum growth period, the increase in the dose of organic fertilizers showed a significantly different effect on plant height with the control treatment. This is because organic fertilizers can provide nitrogen nutrient needs during their growth period.
Table 2. Plant height at 14, 28, 42 and 56 days after planting.

| Treatment | Plant Height (cm) |
|-----------|------------------|
|           | 14 days | 28 days | 42 days | 56 days |
| A         | 4.21 a  | 16.63 a | 44.00 a | 134.33 a |
| B         | 4.18 a  | 19.17 ab| 58.03 a | 156.20 ab|
| C         | 4.42 ab | 18.59 ab| 60.63 a | 159.73 ab|
| D         | 4.10 a  | 18.65 ab| 63.07 a | 165.47 b |
| E         | 4.41 ab | 20.21 ab| 51.23 a | 152.00 ab|
| F         | 4.47 ab | 17.32 a | 53.27 a | 159.27 ab|
| G         | 4.34 ab | 19.78 ab| 53.00 a | 169.53 b |
| H         | 4.52 ab | 18.75 ab| 55.43 a | 165.00 ab|
| I         | 5.21 b  | 22.79 b | 65.33 a | 175.00 b |

Information: The mean number followed by the same letter does not give a real difference based on Duncan's Multiple Range Test at the 5% level.

3.1.2. Number of leaves. The increase in the number of leaves is related to the absorption of nutrients by plant roots. In this case, the roots play an important role because the roots function as nutrient absorbers and translocation of nutrients from roots to stems, leaves, or fruits [4]. The calculation of the number of leaves of maize was carried out every 2 weeks, based on the observation data that the average number of leaves from each treatment was not significantly different (Table 3).

Table 3. Leaves number of maize at 14, 28, 42 and 56 days after planting.

| Treatment | Number of Leaves |
|-----------|------------------|
|           | 14 days | 28 days | 42 days | 56 days |
| A         | 4.47 ab | 7.40 ab | 11.07 ab| 14.40 a |
| B         | 4.60 ab | 7.53 ab | 11.33 ab| 15.20 a |
| C         | 4.67 ab | 7.13 a | 12.27 ab| 15.20 a |
| D         | 4.33 a  | 7.33 ab | 11.20 ab| 15.00 a |
| E         | 4.60 ab | 8.00 ab | 10.80 a | 14.93 a |
| F         | 4.53 ab | 7.60 ab | 11.07 ab| 14.87 a |
| G         | 4.47 ab | 8.27 ab | 11.33 ab| 15.30 a |
| H         | 4.40 ab | 7.60 ab | 11.53 ab| 15.13 a |
| I         | 5.00 b  | 8.27 ab | 12.00 ab| 15.40 a |

Information: The mean number followed by the same letter does not give a real difference based on Duncan's Multiple Range Test at the 5% level.

The combination of organic and inorganic fertilizers treatment at plant age at 14, 28 and 42 days showed significant differences in the number of leaves. In the maximum vegetative phase (56 days) the combination of organic fertilizers with inorganic fertilizers in all treatments was not different compared to control and NPK fertilizers. This occurs due to the ageing of the mature leaves so that the fresh leaves are relatively the same in all treatments.
3.1.3. Stem diameter. The effect of combination treatment of organic fertilizers and NPK fertilizers on stem diameter was observed at 14, 28, 42, and 56 days after planting (Table 4). From the results of the study, it can be seen that the effect of the combination of organic fertilizers and NPK fertilizers does not significantly affect the development of stem diameter at the age of 14, 28 and 56 DAS, while at the age of 42 DAS shows a significant difference. In all treatments combined with organic fertilizers, it gave a difference when compared to treatments that were only given NPK fertilizer.

Table 4. Maize stem diameter at 14, 28, 42 and 56 days after planting.

| Treatment | Stem Diameter (cm) | 14 Days | 28 Days | 42 Days | 56 Days |
|-----------|--------------------|---------|---------|---------|---------|
| A         | 0.35 a             | 0.89 a  | 1.61 a  | 1.99 a  |
| B         | 0.35 a             | 0.95 a  | 2.06 b  | 2.34 a  |
| C         | 0.37 a             | 0.93 a  | 1.95 ab | 2.39 a  |
| D         | 0.31 a             | 1.00 a  | 1.85 ab | 2.37 a  |
| E         | 0.33 a             | 1.08 a  | 1.85 ab | 2.30 a  |
| F         | 0.33 a             | 0.89 a  | 1.98 ab | 2.33 a  |
| G         | 0.33 a             | 0.93 a  | 1.99 ab | 2.43 a  |
| H         | 0.34 a             | 0.94 a  | 1.95 ab | 2.34 a  |
| I         | 0.36 a             | 1.26 a  | 2.00 ab | 2.44 a  |

Information: The mean number followed by the same letter does not give a real difference based on Duncan's Multiple Range Test at the 5% level.

3.2. The soil N total, P total and K total

Based on the results of the analysis, the combination treatment of Organic Fertilizer and N, P and K on the N-total, P-total and K-total soil showed a significant difference (Table 5).

Table 5. Soil N, P, K total with organic fertilizers and inorganic fertilizers.

| Treatment | Soil Fertility | N-total (%) | P-total (ppm) | K-total (me %) |
|-----------|----------------|-------------|---------------|----------------|
| A         |                | 0.19 a      | 211.33 a      | 100.67 a       |
| B         |                | 0.21 a      | 374.10 b      | 100.78 a       |
| C         |                | 0.21 a      | 363.00 b      | 103.6 bc       |
| D         |                | 0.2 abc     | 261.63 ab     | 103.23 b       |
| E         |                | 0.19 a      | 248.33 ab     | 105.67 c       |
| F         |                | 0.19 a      | 305.16 ab     | 102.77 ab      |
| G         |                | 0.21 a      | 201.93 a      | 100.37 a       |
| H         |                | 0.19 a      | 326.16 ab     | 102.18 ab      |
| I         |                | 0.2 abc     | 396.40 b      | 108.43 d       |

Information: The mean number followed by the same letter does not give a real difference based on Duncan's Multiple Range Test at the 5% level.

The effect of the combination of organic fertilizers with N, P, K fertilizers on soil fertility can be seen from the content of N-total, P-total and K-total. Overall treatments have an impact on soil chemical fertility. The highest treatment was treatment I (¾ NPK + ¾ PO). From Table 5 it is known that the application of organic fertilizers in treatment I was significantly different from the control, but not significantly different from treatment B (fertilizers N, P, K). The treatment I gave the largest P-total value of all treatments, namely 396.40 mg / 100g, greater than treatment B (NPK fertilizer), which was 374.10 mg/100g. This P content is a very high criterion. The effect of the combination of
organic fertilizers with NPK fertilizers on the N-total content had a significant effect. Treatments B, C and G gave the highest value for nitrogen content. Treatment I gave the highest effect on potassium content, which was 108.43 mg/100g. Potassium content is a high criterion, this is presumably because Alfisols has high potassium minerals.

4. Discussion
The combination of organic fertilizers with inorganic fertilizers (N, P, K) can increase the growth of maize plants (plant height, number of leaves and stem diameter). This is related to the role of each fertilizer on the growth of maize plants. Organic fertilizers can improve soil properties (chemical, physical and biological) properly, so that good soil conditions will create a suitable plant growth environment reflected in plant height, number of leaves and stem diameter. The results of statistical analysis were significantly different (14, 28 and 56 days) on plant height due to increasing plant age, the need for nutrients is getting bigger and this situation cannot be fulfilled by the soil where it is grown so that fertilizer application can increase the availability of nutrients, especially nitrogen (N) needed for vegetative growth of plants. As stated by Machfud et al. [5] that the N nutrient is needed by plants for vegetative growth, especially stems, branches and leaves.

Treatments that do not use Organic Fertilizers and N, P, K show a slower development of stem diameter compared to other treatments that use a combination of Organic Fertilizer with N, P, K. This is because fertilizers are needed for plant growth, especially in stimulating plant height growth and enlargement of the stem diameter. At the beginning of planting, nutrients will be focused on plant height growth, then nutrients will be absorbed for stem diameter growth [6]. The stem diameter will affect the sturdiness of the plant so that it doesn't collapse easily when it produces cobs. The large stem diameter of the maize usually produces large cobs and vice versa [7]. The stem diameter also affects the weight of the stover and the plant height, the bigger the stem diameter, the heavier the weight of the stover and the higher the plant. The highest value on plant height, number of leaves and stem diameter was indicated by treatment I, treatment I was a treatment with the right dose of organic fertilizer, so that it could affect the height of the maize plant. Research [8] the effect of the right dose of organic fertilizer can give the best plant height, number of leaves and stem diameter because these plants are able to produce well.

Organic fertilizers can reduce the use of inorganic fertilizers. The results showed that the reduction of various doses of NPK accompanied by the application of organic fertilizers showed that the growth of maize was not different from the use of 100% NPK fertilizer. The application of organic fertilizers can improve physical, chemical and biological properties [9]. These conditions will create an optimal environment for root growth. Roots are plant organs that are very important in nutrient absorption [10]. If the plant's root growth is good, the nutrient uptake is also high. On the other hand, organic fertilizers are a complete source of nutrient elements (macro and micronutrients) so that they can cover the deficiencies of microelements that are not present in NPK fertilizers. The results of this study are in line with several studies. [11] found that the combination of applying organic fertilizers and inorganic N fertilizers to maize plants can make efficient use of inorganic fertilizers as well as increase the availability of nitrogen in the soil and nitrogen uptake in plants, will be minimize nutrients lost because organic fertilizers are able to bind nutrients [12].

The application of organic fertilizers can increase the efficiency of P in the soil. This is because the organic acids in organic fertilizers are able to act as chelating Al compounds, so that P becomes more available [11]. According to Hanum [13] Applying P fertilizer to acidic soils without applying organic fertilizers causes inefficient and ineffective P fertilization. Potassium nutrients contained in organic fertilizers and NPK fertilizers play a role in increasing the activity of enzymes in photosynthesis reactions and respiration so that they have an impact on the growth of maize plants. The role of potassium in protein synthesis can stimulate the conversion of nitrate to protein thereby increasing the efficiency of nitrogen (urea) fertilization [14]. The higher the levels of N, P and K in the soil will increase the available nutrients for plants, so that plant growth will be more spurred. The use of organic fertilizers can reduce the use of inorganic fertilizers. Although it is not 100% suppressed,
the combination of organic and inorganic fertilizers can affect the growth of maize plants and soil fertility.

5. Conclusion
The combination of organic fertilizers and inorganic fertilizers affects the growth of maize plants and soil fertility Alfisol Jumantono. Organic fertilizers at doses ¼, ½ and ¾ accompanied by ¾ NPK standard give N total, P total, K total, and the plant height, number of leaves and stem diameter which are not different with dose of NPK standard. Organic fertilizers can reduce the use of NPK fertilizers. Climatic condition in the location also affect the effectiveness of organic fertilizers on maize plants.

Reference
[1] Wijanarko A, Sudaryono and Sutarno 2007 Karakteristik Sifat Kimia dan Fisika Tanah Alfisol di Jawa Timur dan Jawa Tengah Iptek Tanam Pangan 2 214–26
[2] Iqbal, Achmad M, Sapsal MT 2019 Organic Fertilizer Applicator Performance Test on Rice Field IOP Conference Series: Earth and Environmental Science 355 012112
[3] Wirayuda B and Koesriharti 2020 Pengaruh Pemberian Pupuk Organik Dan Pupuk Anorganik Terhadap Pertumbuhan Dan Hasil Tanaman Jagung Manis (Zea mays L. var. saccharata) J Produksi Tanam 8 201–9
[4] Akil M 2009 Aplikasi pupuk urea pada tanaman jagung Prosiding Seminar Nasional Serelia 2009 (Maros: Balai Penelitian Tanaman Serealia) pp 978–9
[5] Machfud Y, Sofyan E T, Saribun D S and Yuliana A 2017 Serapan P P K Tanaman Jagung (Zea mays, L.) pada Typic Eutrudepts akibat Pemberian Pupuk Organik Padat Curah (POPC) dan Pupuk Anorganik SoilREns. 15 14–9
[6] Makinde E A 2015 Effects of Fertilizer Source on Growth and Cumulative Yield of Amaranthus Int J Veg Sci 21 167-76
[7] Silaban E T, Purba E and Ginting J 2013 Pertumbuhan dan Produksi Jagung Manis (Zea mays sacarathia Sturt. L.) pada Berbagai Jarak Tanam dan Waktu Olah Tanah J Online Agroteknologi 1 806–18
[8] Biñas Jr. E and Cagasan U 2018 Growth and Yield of Sweetcorn (Zea mays L. var. Macho F1) as Influenced by Different Combination of Organic and Inorganic Fertilizers Science and Humanities Journal 12 79-9
[9] Weil R R and Brady N C 2017 Soil Phosphorus and Potassium The Nature and Properties of Soils (London: Pearson) chapter 14 pp 643–95.
[10] Marschner H 1995 Mineral Nutrition of Higher Plants (Cambrigde: Avademic Press)
[11] Irwan A W and Nurmala T 2018 Pengaruh Pupuk Hayati Majemuk dan Pupuk Fosfor Terhadap Pertumbuhan dan Hasil Kedelai di Inceptisol Jatinangor Kultivasi 17 750–9
[12] Zingore S 2011 Maize productivity and response to fertilizer use as affected by soil fertility variability, manure application, and cropping system Better Crops 95 4-6
[13] Hanum C 2014 Pertumbuhan, Hasil, dan Mutu Biji Kedelai dengan Pemberian Pupuk Organik dan Fosfor Indones J Agron 41 209–14
[14] Alfian D F, Nelvia and Yetti H 2015 Pengaruh Pemberian Pupuk Kalium dan Campuran Kompos Tandan Kosong Kelapa Sawit Dengan Abu Boiler Terhadap Pertumbuhan dan Hasil Tanaman Bawang Merah (Allium asacalonicum L.) J Agroteknologi5(2):1-6

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