Caraka Tani
Journal of Sustainable Agriculture
ISSN 2613-9456 (Print) 2599-2570 (Online)

Caraka Tani: Journal of Sustainable Agriculture, 38(1), 99-112, 2023
URL: https://jurnal.uns.ac.id/carakatani/article/view/65014
DOI: http://dx.doi.org/10.20961/carakatani.v38i1.65014

Physical Properties of Alfisols, Growth and Products of Hybrid Corn Affected by Organic and Inorganic Fertilizer

Jauhari Syamsiyah*, Slamet Minardi, Ganjar Herdiansyah, Ongko Cahyono and Fegi Cahya Mentari

Department of Soil Science, Faculty of Agriculture, Universitas Sebelas Maret, Surakarta, Indonesia

**Corresponding author:* ninukts@staff.uns.ac.id

Abstract

The nutrients of plants and the physical condition of the soil must both be considered to increase corn productivity. The continuous use of inorganic fertilizer without manures will cause a decrease in the physical properties of the soil. Therefore, this study aims to obtain doses of organic fertilizer from cow manure and inorganic fertilizers namely urea, KCl and SP-36 that will give the best effect on the physical properties of Alfisols, growth and yield of hybrid corn. The experiment was carried out using the randomized complete block design (RCBD) with two factors namely organic and inorganic fertilizers. Each factor was given at four dosages: 1, ¾, ½ and ¼ of the standard dose each with three replications. Observation parameters include bulk and particle density, soil porosity, aggregate stability, root volume and fresh weight, plant height, as well as the weight of corn with and without husks. The results showed that organic and inorganic fertilizers significantly affected bulk density, soil porosity, aggregate stability, root fresh weight, root volume, as well as the weight of corn with and without husks. Additionally, treatment with 7.5 to 10 tons of organic fertilizer as well as ¼, ¾ and 1 dose of inorganic fertilizers produced the best effect on soil physical properties of Alfisols, growth and yield of hybrid corn, while the lowest results were obtained in the control treatment. This indicates that organic treatment can reduce the use of inorganic fertilizers between ¼ to ¾ of the standard dose.

Keywords: aggregate stability; bulk density; particle density; soil physical properties; soil porosity

Cite this as: Syamsiyah, J., Minardi, S., Herdiansyah, G., Cahyono, O., & Mentari, F. C. (2023). Physical Properties of Alfisols, Growth and Products of Hybrid Corn Affected by Organic and Inorganic Fertilizer. *Caraka Tani: Journal of Sustainable Agriculture*, *38*(1), 99-112. doi: http://dx.doi.org/10.20961/carakatani.v38i1.65014

INTRODUCTION

Corn (*Zea mays* L.) is the second-most important carbohydrate-producing annual crop after rice and is used in Indonesia for food, feed and industrial needs. In 2019 and 2020, Indonesia imported 293.21 thousand and 724.21 thousand tons respectively (Ministry of Agriculture, 2020), while in 2021, the amount reached 995.99 thousand (Statistic Indonesia, 2021). This shows that the availability of corn to supply domestic needs is still in deficit. Corn production can be increased using agricultural intensification, which is the application of fertilizers. The Indonesian government has made efforts to intensify agriculture specifically during the green revolution in 1961 to 1967 which made the country achieve self-sufficiency in rice production. According to Hudoyo and Nurmayasari (2019), at the beginning of the green revolution, the average productivity of corn was 0.97 tons ha^{-1} and the next period was 1.12 tons ha^{-1}, with an average productivity increase of 0.01% tons ha^{-1} $year^{-1}$. During this period, farmers were introduced to inorganic fertilizers because one of the green revolution pillars is the optimal use of inorganic fertilizers.

The faster response on plant growth and yields compared to manure causes farmers to become dependent on inorganic fertilizers and use them

* *Received for publication September 6, 2022*
Accepted after corrections December 6, 2022

Copyright © 2023 Universitas Sebelas Maret

excessively. However, excessive usage can damage the soil's physical, chemical and biological properties, leading to land degradation. The chemicals left in plants which transported during harvest and the leaching of nutrients into the groundwater can also endanger human and animal health (Mahmood et al., 2017; Ramadhan and Sumarni, 2018). Pahalvi et al. (2021) stated that the application of inorganic fertilizers in excessive doses has negative consequences, such as decreased organic matter, hardens the soil, reduced fertility, pollutes the air, water and soil, as well as reduces essential nutrients of the soil and minerals, thereby bringing harm to the environment. This occurs probably due to the low external supply of organic matter to the soil or failure to return the plant biomass after harvest. When this condition continues over time, it can cause degradation, preventing agricultural land from being used sustainably. Moreover, the lower organic matter content of the soil is in line with the decrease in the physical properties. According to Al-Maliki et al. (2018), organic matter has humic which plays an important role in physical properties because the interaction between soil minerals and humic will form stable aggregates.

One of the efforts to reduce the excessive use of inorganic fertilizers and improve soil physical properties is by applying manures. The application can reduce soil density as indicated by the value of particle and bulk densities. The higher value of both properties will cause the soil to become compact. This further makes plant roots difficult to penetrate, and root growth will be hampered in absorbing water and nutrients more widely. According to Safitri et al. (2018), the treatment with compost of 10 tons ha^{-1} caused a decrease in particle density and combination with corn stalk biochar of 40 tons ha^{-1} reduced the bulk density and increased the porosity of Alfisols. Furthermore, Limbong et al. (2017) reported that goat manure treatment is more effective in reducing soil bulk density than petrogenic fertilizer, straw mulch and rice straw. Based on a study by Widodo and Kusuma (2018), the highest dose of compost fertilizer namely P5 at 25.5 kg $plot^{-1}$ with a plot size of 1.5 m^2 produced higher soil pore, aggregate stability and lower bulk density than the control without fertilizer.

The release of nutrients in organic fertilizer is slower than inorganic fertilizer because they must pass through a decomposition process first (Guajardo-Ríos et al., 2018). Therefore, combining the two is needed to create good soil physical, chemical and biological properties that will produce maximum plant growth and yields. Based on a study by Prasetyo et al. (2014), the combination of manure and urea can increase cassava yield and porosity, while also reducing the bulk density of Alfisols compared to inorganic fertilizer treatment. Moreover, Iqbal et al. (2020) reported that the combination of manure and inorganic fertilizers significantly improved the physical and chemical properties of the soil in rice cultivation in Ultisol Nanning, China. The combination of goat manure and N, P, K fertilizer culminated in higher plant height and sweet corn yields than the control treatment, the higher the goat manure, the higher the value (Uwah and Eyo, 2014).

Investigations related to the effect of organic and inorganic fertilizers on corn and the physical properties of Alfisol Jumantono are rare. Previous studies only examined the effect of fertilizer on soil chemical properties including the effect of organic fertilizer based on Azolla, natural phosphate and rice husk ash on peanut plants (Sambodo et al., 2014). Another study investigated the application of superorganic fertilizer and its effect on spinach cultivation (Suntoro et al., 2017), while Minardi et al. (2020) examined the effect of manure and zeolite on the chemical properties of soil and peanut yields. Some other studies also focused on improving the soil chemistry of Alfisols but information on the ability of manures to reduce the use of inorganic fertilizers is needed to create sustainable agricultural land. According to Rayne and Aula (2020), manure has provided many benefits as evidenced by several studies which have been reviewed such as improving various soil properties and yields of crops to make manure a viable option to restore the degraded land and become sustainable possibly. Therefore, this study aims to obtain doses of organic fertilizer from cow manure and inorganic fertilizers namely urea, KCl and SP-36 that will give the best effect on the physical properties of Alfisols, growth and yield of hybrid corn.

MATERIALS AND METHOD

Time and site location

This study was conducted from December 2020 to October 2021 in the experimental land of Sukosari Village, Jumantono Sub-district, Karanganyar Regency on land with an altitude of 171 m above sea level, located at -7.631° S and 110.949° E.

Copyright © 2023 Universitas Sebelas Maret

Table 1. Code and description of organic and inorganic fertilizer treatment

Code	Treatments
A	Control (without fertilizer)
B	N, P, K standard (350 kg ha^{-1} urea, 100 kg ha^{-1} KCl, 125 kg ha^{-1} SP-36)
C	¼ NPK + 1 OF (87.5 kg ha^{-1} urea, 25 kg ha^{-1} KCl, 31.25 kg ha^{-1} SP-36 + 10 ton ha^{-1} OF)
D	½ NPK + 1 OF (175 kg ha^{-1} urea, 50 kg ha^{-1} KCl, 62.5 kg ha^{-1} SP-36 + 10 ton ha^{-1} OF)
E	¾ NPK + 1 OF (262.5 kg ha^{-1} urea, 75 kg ha^{-1} KCl, 93.75 kg ha^{-1} SP-36 + 10 ton ha^{-1} OF)
F	1 NPK + 1 OF (350 kg ha^{-1} urea, 100 kg ha^{-1} KCl, 125 kg ha^{-1} SP-36 + 10 ton ha^{-1} OF)
G	¾ NPK + ¼ OF (262.5 kg ha^{-1} urea, 75 kg ha^{-1} KCl, 93.75 kg ha^{-1} SP-36 + 2.5 ton ha^{-1} OF)
H	¾ NPK + ½ OF (262.5 kg ha^{-1} urea, 75 kg ha^{-1} KCl, 93.75 kg ha^{-1} SP-36 + 5 ton ha^{-1} OF)
I	¾ NPK + ¾ OF (262.5 kg ha^{-1} urea, 75 kg ha^{-1} KCl, 93.75 kg ha^{-1} SP-36 + 7.5 ton ha^{-1} OF)

Notes: The dosage is based on the recommendations of the Ministry of Agriculture for the Jumantono area, Karanganyar Regency, namely organic fertilizer (OF) 10 ton ha^{-1}, urea 350 kg ha^{-1}, KCl fertilizer 100 kg ha^{-1} and SP-36 fertilizer 125 kg ha^{-1} (Husnain et al., 2020). The dose in 1 plot (20 m^2) is 20 kg of manure, 700 g of urea, 200 g of KCl fertilizer and 250 g of SP-36 fertilizer

Experimental treatments and design

The experiment was conducted using a randomized complete block design (RCBD) with two factors namely organic and inorganic fertilizer. Each factor was given at four dosages levels with three replications, totaling 27 experimental plots. Table 1 shows the code and descriptions of treatments.

Steps taken during the study included tillage by plowing and making 27 planting plots with a size of 20 m^2 and spacing of 75 x 25 cm. Furthermore, organic fertilizer was applied for two weeks before planting, urea was used three times, namely 14 days after planting (DAP) and 28 DAP, while SP-36 and KCl were applied at the time of planting. There was no watering because the planting was conducted during the rainy season. Weed eradication, pest and disease control were then carried out, while harvesting was performed at 130 DAP.

Characteristics of cow manure

The organic fertilizer used in this experiment is cow manure which has been decomposed and applied two weeks before planting. The characteristics of cow manure are presented in Table 2.

Table 2. Characteristic of manure

Variable	Value
C-organic (%)	15.01
C/N ratio	19.12
Water content (%)	11.77
Macro nutrients	
N (%)	0.78
P_2O_5 (%)	0.68
K_2O (%)	1.85
pH	7.98

Determination of soil and plant analysis

The plant variables observed include height, fresh root weight, root volume, as well as the weight of corn with and without husks. A total of five samples were taken in each plot randomly. Root samples were taken by removing all plant roots from the soil and then cleaning from the attached soil. The weight was calculated using an analytical balance, while plant volume was assessed with a measuring cylinder. Variables of soil physical properties used include soil moisture content (gravimetric method), organic matter (walkey and black method), bulk density (clod method), particle density (pycnometer method), soil porosity and aggregate stability (double sieve method).

Data analysis

Data analysis was performed using the two-way ANOVA test with SPSS to examine the effect of treatment on variables, followed by Duncan's Multiple Range Test (DMRT) with a 5% confidence level to determine differences between treatments and a correlation test to assess the relationship between observed variables.

RESULTS AND DISCUSSION

Initial soil characteristics before treatment

Based on Table 3, the experimental land is a dry Alfisols type with a very low organic matter content of 0.95%. These results are in line with previous studies which stated that the organic matter content of Alfisols in Sukosari Village, Jumantono Sub-district was 0.97% (Minardi et al., 2015). The initial soil's bulk and particle densities values were 1.23 and 2.24 g cm^{-3} while the porosity was 44.99% with good grades. The value of the bulk density and soil porosity

Copyright © 2023 Universitas Sebelas Maret

were included in good rates because the land had been previously processed often and used for experimental planting hence, there was no compaction on the surface. Furthermore, the initial soil aggregate was included in the unstable category with a value of 36.44%, while the texture was categorized in the silty clay class. Alfisols are generally formed from limestone parent material (Sudaryono, 2002) and have a brown to red color, loam to clay texture, blocky structure, pH 6.0 to 7.5, low organic matter content, as well as high nutrient availability (Setyawati et al., 2021). This soil has a color of more than 10 YR and an argillic horizon with a high clay content that does not decrease significantly, has a blocky structure and a glossy surface (Kumari et al., 2018; Ndzana et al., 2018).

Soil characteristics after treatment

Bulk density

The application of organic and inorganic fertilizers showed a significant difference in the bulk density value with p = 0.002. Data analysis results regarding the effect of treatment on bulk density are shown in Figure 1. Based on the results, Treatment C produced the lowest bulk density of 0.94 g cm^{-3}, significantly different from the control and standard NPK. This proves that the treatment with ¼ of NPK recommended dose produced the best effect. According to a previous study, the addition of materials with a low density such as organic matter can reduce bulk density (Haynes and Naidu, 1998). Chaudhari et al. (2013) also found a negative correlation between organic matter and bulk density, wherein the higher the organic matter, the lower the bulk density.

The standard NPK treatment had the highest bulk density value of 1.21 g cm^{-3}, indicating that this fertilizer did not reduce the bulk density. This is in line with Gautam et al. (2022) which showed that the treatment with high manure of 80.477 kg ha^{-1} produced the lowest bulk density compared to medium at 40.126 kg ha^{-1}, low at 15.916 kg ha^{-1}, as well as inorganic fertilizer and control.

Treatment F yielded a higher bulk density than Treatment I, and this is presumably due to the application of chemical fertilizers in a higher amount, which also leaves a higher residue. Mustamu (2020) stated that inorganic fertilizer residues that are not absorbed by plants are difficult to decompose, causing the soil to become harder. The experimental area is marked with high rainfall. The presence of rainwater causes the fertilizer residue to become sticky and bound to the soil, causing hardening after drying (Soekamto and Fahrizal, 2019).

Particle density

The ANOVA test results showed no significant difference in the value of particle density with p = 0.962. Figure 2 shows that the addition of manures can reduce the value of particle density from the control and standard NPK treatments, although there was no significant difference between the treatments. These results are similar to those of Rühlmann et al. (2006); Istiqomah et al. (2015); Arifin et al. (2017). Meanwhile, the value of particle density is not only influenced by organic matter, but also the composition of soil solids, minerals and texture. The treatments that showed the greatest decrease in specific gravity compared to the control were Treatment E and I, with values of 0.037 g cm^{-3}.

Table 3. Initial characteristics of Alfisols Jumantono

Variable	Unit	Result	Class
Organic matter	%	0.95	Very low*
Bulk density	g cm^{-3}	1.23	Good***
Particle density	g cm^{-3}	2.24	-
Soil porosity	%	44.99	Good***
Aggregate stability	-	36.44	Not stable**
Texture			
Sand	%	7.13	
Silt	%	49.32	Silty clay*
Clay	%	43.56	

Notes: * = Based on Sulaeman et al. (2005); ** = Based on Indonesian Center for Agricultural Land Resources Research and Development (2006); *** = Based on Lal (1994)

Copyright © 2023 Universitas Sebelas Maret

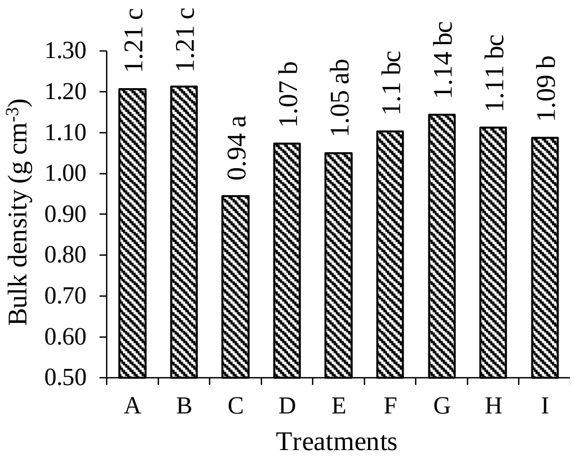

Figure 1. Effect of treatments on bulk density

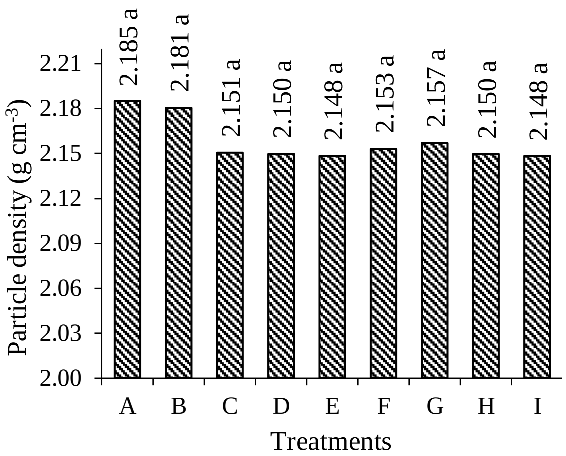

Figure 2. Effect of treatments on particle density

Notes: A = without fertilizer; B = N, P, K standard; C = ¼ NPK + 1 OF; D = ½ NPK + 1 OF; E = ¾ NPK + 1 OF; F = 1 NPK + 1 OF; G = ¾ NPK + ¼ OF; H = ¾ NPK + ½ OF; I = ¾ NPK + ¾ OF. OF = organic fertilizer. The values followed by the same letter do not show significant differences according to the DMRT test at 5% level

The treatment of 2.5 tons ha^{-1} of manure produced the highest specific gravity value compared to the application of manure with doses of 5, 7 and 10 tons ha^{-1}. This shows that the organic matter reduced the mass of soil solids, while also decreasing the specific gravity. However, all combinations of organic and inorganic fertilizers were not significantly different from the control (A) and standard NPK treatments. An increase in soil Azolla matter will reduce the value of particle density (Brogowski et al., 2014).

Soil porosity

The application of organic and inorganic fertilizers at different doses produced a significant difference in soil porosity with p = 0.004 as presented in Figure 3. Based on the results of the DMRT test, Treatment C produced the highest porosity value and was significantly different from other treatments with a yield of 56.07%. This shows that only ¼ of the NPK fertilizer recommended dose can give the best effect on soil porosity. The decomposition of manure by microbes will produce polysaccharides and bacterial gums which function as binding agents for soil particles, hence, the application of manure increases soil pores (Rasool et al., 2008). The treatment with a low porosity value was standard NPK (B) at 44.41% and was not significantly different from the control. This result is in line with Singh et al. (2021) and Wan et al. (2021) reporting that the application of organic and inorganic fertilizers culminated in higher porosity than the control and inorganic.

Based on the results obtained, the porosity value increased with higher doses of the manure. This is in line with Ramli et al. (2016) stating that the value of soil porosity boosted along with the higher dose of manure given. Furthermore, Arsyad et al. (2011) reported that a rise in soil organic matter was observed with higher doses of green manure applied which significantly uplifted the total pore space of the soil. Particles of organic matter fill the coarse pore fraction to form the number of fine pores between them, thereby increasing the total porosity of the soil (Zhang et al., 2005).

Aggregate stability

The application of various doses of organic and inorganic fertilizers showed a significant difference in the value of Alfisols aggregate stability with p = 0.009. Based on the results in Figure 4, the treatment that produced the highest aggregate stability was F at 73.66 with a stable grade. In contrast, the lowest value was produced by the control treatment (A) with a less stable value. Treatment F showed an increase in aggregate stability of 22.73 from the control. Mustoyo et al. (2013) found that the application of 5 tons ha^{-1} manure significantly increased the stability of soil aggregates compared to the treatment of 0 tons ha^{-1}. The decomposition of soil organic matter into organic particles causes the aggregation of sand, silt and clay (Finn et al., 2017). This is evidenced in a study by Xiao et al. (2020); Yavitt et al. (2021) where the larger the aggregate contained, the more the soil organic matter and the greater the stability.

Copyright © 2023 Universitas Sebelas Maret

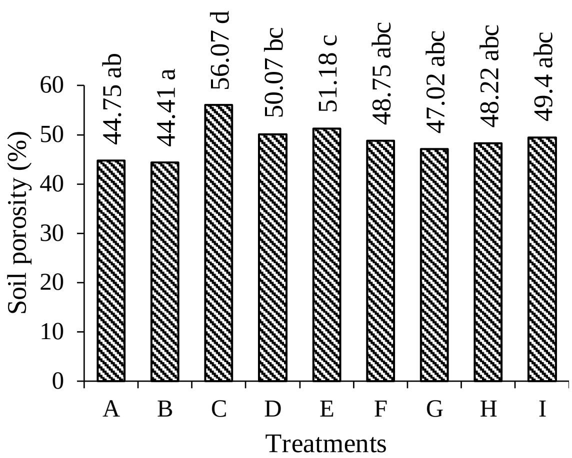

Figure 3. Effect of treatments on soil porosity

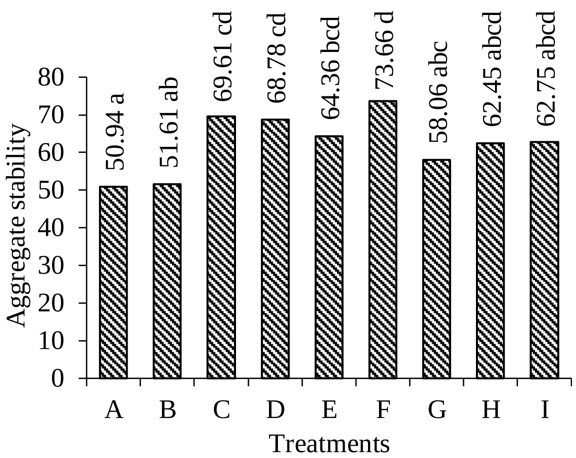

Figure 4. Effect of treatments on aggregate stability

Notes: A = without fertilizer; B = N, P, K standard; C = ¼ NPK + 1 OF; D = ½ NPK + 1 OF; E = ¾ NPK + 1 OF; F = 1 NPK + 1 OF; G = ¾ NPK + ¼ OF; H = ¾ NPK + ½ OF; I = ¾ NPK + ¾ OF. OF = organic fertilizer. The values followed by the same letter do not show significant differences according to the DMRT test at 5% level

The manure dose given successively produced aggregate stability ranging from high to low with the treatment of 10, 7.5, 5, and 2.5 tons ha^{-1}. These results indicate that the higher the dose of the manure, the greater the stability value of soil aggregates. According to Jumarni et al. (2021), the value of soil aggregate stability increased with higher doses of goat manure. Besides, aggregate stability is influenced by two factors, namely intrinsic or soil characteristics such as organic matter, texture, minerals, microbes, climate and application of organic amendments, as well as temporal factors including the impact of land management (Annabi et al., 2011).

Plant characteristics after treatment

Root fresh weight

The ANOVA test results showed that the combination of organic and inorganic fertilizer doses significantly affected the fresh root weight of corn plants with p = 0.24. Based on Figure 5, the highest average root fresh weight was produced by Treatment I of 53.67 g, while the lowest was 19.67 g from the control. This shows that manure can reduce the effect of NPK fertilizer on the fresh root weight of corn plants by ¼ of its dose. Furthermore, the growth of plant roots is influenced by the physical state of the soil. When the soil is in a solid state, it will inhibit the penetration of roots in absorbing water and nutrients (Purba et al., 2021) but when the soil is in a liquid state, this will cause the roots to rot.

In Treatment C with NPK fertilizer, only ¼ of the recommended dose produced results that were not significantly different from the control. Wisdom et al. (2012) showed that the NPK treatment produced the greatest root biomass of corn plants compared to cow dung manure and the control. This is presumably because the low input dose of NPK causes reduces the availability of P nutrients in the soil. This statement is reinforced by Novizan (2005), stating that element P is useful for stimulating root growth, especially in young plants.

Root volume

The ANOVA test showed that the combination of organic and inorganic fertilizer doses significantly affected root volume with p = 0.020. Based on the 5% DMRT test in Figure 6, the highest root volume was produced by Treatment F with a value of 75 ml and the lowest was found in the control with a value of 21.67 ml. The standard NPK treatment culminated in a lower volume of corn roots than the NPK + 7.5 tons ha^{-1} manure treatment. This shows that manure can reduce the effect of NPK fertilizer on the root volume by ¼ of its dose. Iqbal et al. (2019) found that the application of cattle manure with inorganic fertilizers produced a higher root volume of rice plants compared to the control but not significantly different from the inorganic fertilizer treatment. Moreover, Lin et al. (2019) suggested that the presence of organic matter around plants can increase soil friability and the total of soil pores to create good conditions for the development and growth of roots.

Copyright © 2023 Universitas Sebelas Maret

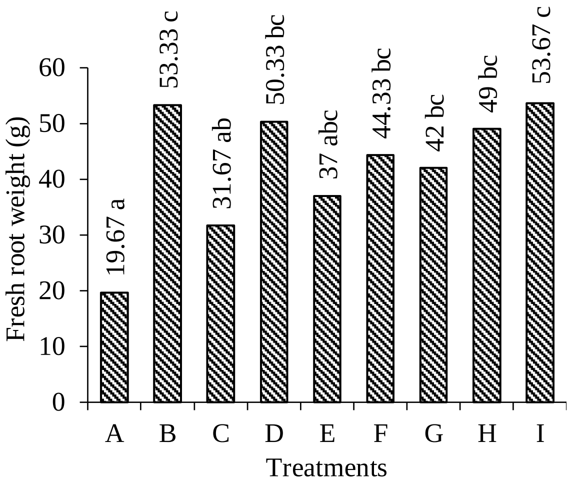

Figure 5. Effect of treatments on fresh root weight

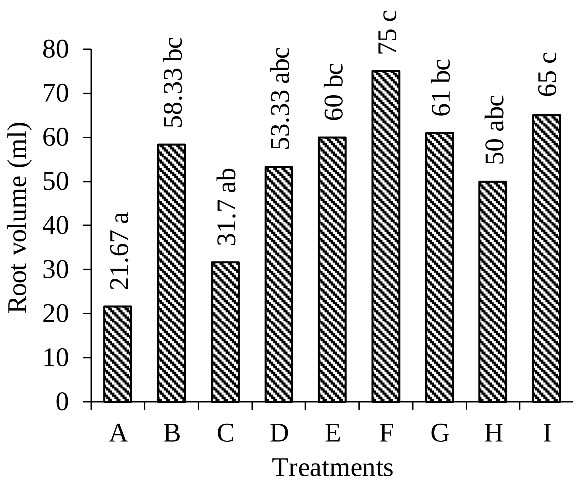

Figure 6. Effect of treatments on root volume

Notes: A = without fertilizer; B = N, P, K standard; C = ¼ NPK + 1 OF; D = ½ NPK + 1 OF; E = ¾ NPK + 1 OF; F = 1 NPK + 1 OF; G = ¾ NPK + ¼ OF; H = ¾ NPK + ½ OF; I = ¾ NPK + ¾ OF. OF = organic fertilizer. The values followed by the same letter do not show significant differences according to the DMRT test at 5% level

Plant height

The combination of organic and inorganic fertilizers produced no significant effect on plant height based on the ANOVA test results with p = 0.153. Figure 7 shows that the application of organic and inorganic fertilizers can increase the height of corn plants even though there were no significant differences between treatments. These results are in line with Suprianto et al. (2016), stating that the application of a combination of chicken manure with NPK did not have a significant effect on the height of sweet corn plants. This is presumably because the corn plants have reached maximum growth, hence, the further addition of fertilizer doses can not significantly increase their height.

The treatment that produced the best plant height was Treatment I with a value of 175 cm, while the lowest was the control with a height of 134.33 cm. The combination of organic and inorganic fertilizers namely treatments C, D, G, and I culminated in a more optimal plant height than standard NPK and F Treatments. This indicates that manures were able to reduce the use of inorganic fertilizers in their effect on plant height. Dailami et al. (2015) showed that the plant height produced by NPK fertilizer of 300 kg ha^{-1} and vermicompost of 4 tons ha^{-1} was lower than the dose of 250 kg ha^{-1} and 4 tons ha^{-1} respectively. This is presumably due to the presence of excess nutrients which might be an inhibiting factor of plant growth.

The weight of corn with and without husks

The ANOVA test results showed that the doses of organic and inorganic fertilizers significantly affected the weight of corn with and without husks with p-values of 0.26 and 0.17 respectively. Based on Figure 8, the control treatment had the lowest weight of corn with and without husks compared to the organic and inorganic fertilizers. The highest average was in Treatment F and the lowest was in A (control). Treatment F produced corn with husks of 29.23 kg plot^{-1} when converted to a one-hectare land area of 14.6 tons ha^{-1} and without husks of 25.3 kg plot^{-1}.

The higher dose of NPK fertilizer produced larger corn weights in the manure treatment of 10 tons ha^{-1}. This is consistent with a study by Ejigu et al. (2021) where the best treatment was the maximum dose of compost 10 tons ha^{-1} + urea/NPSB 100/100 kg ha^{-1}, compared to urea/NSPB of 100/100 kg ha^{-1}. Furthermore, Faloye et al. (2017) found a strong synergy between biochar and NPK fertilizers when applied together, culminating in increased grain yields and biomass of corn. According to Avila-Segura et al. (2011), corn cobs and grains contain higher N, P and K than other nutrients, hence, the application of NPK fertilizer can significantly increase corn yields.

Copyright © 2023 Universitas Sebelas Maret

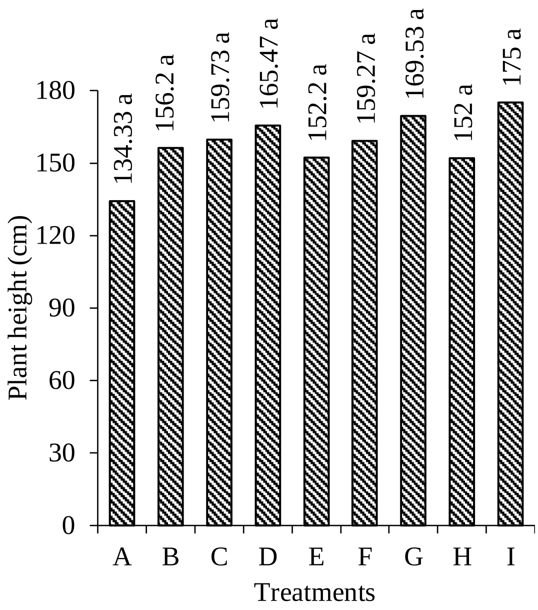

Figure 7. Effect of treatments on plant height

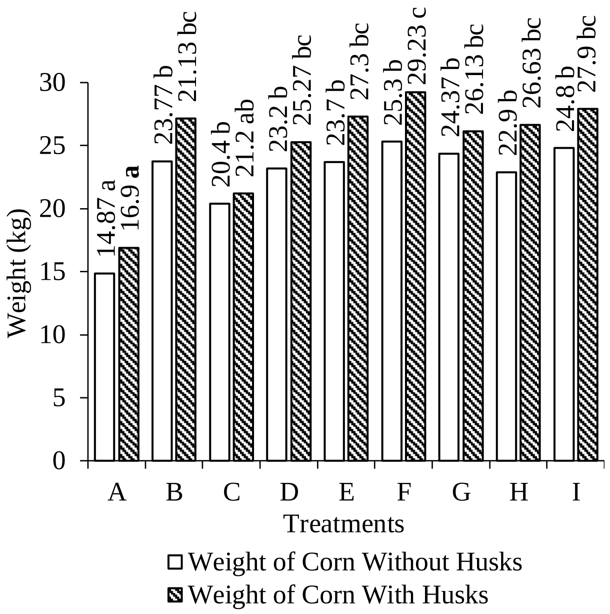

Figure 8. Effect of treatments on the weight of corn with and without husks

Notes: A = without fertilizer; B = N, P, K standard; C = ¼ NPK + 1 OF; D = ½ NPK + 1 OF; E = ¾ NPK + 1 OF; F = 1 NPK + 1 OF; G = ¾ NPK + ¼ OF; H = ¾ NPK + ½ OF; I = ¾ NPK + ¾ OF. OF = organic fertilizer. The values followed by the same letter do not show significant differences according to the DMRT test at 5% level

Treatments E and I had higher corn weights with husks than standard NPK treatments. Meanwhile, Treatments G and I showed a higher weight of corn without husks than the standard NPK. This shows that manures can reduce the use of inorganic fertilizers in their effect on corn crop yields. Verdiana et al. (2016) found significant differences in the combination of biochar and NPK fertilizer doses on crop yields with the best treatment being a dose of biochar 2 tons ha^{-1} and NPK 180 kg ha^{-1}. This treatment reduced the use of inorganic fertilizers by 45% of the standard NPK treatment at 300 kg ha^{-1}.

Correlation of observation variables

Table 4 shows a negative correlation between soil porosity and bulk density, in other words, the lower the bulk density value, the higher the porosity. Fang et al. (2021) reported that the combination treatment of green and swine manure with inorganic fertilizers had the lowest bulk density and the highest porosity compared to the control and inorganic fertilizers. Furthermore, aggregate stability was negatively correlated with bulk density and positively correlated with porosity. Organic matter has a low weight, hence, it can reduce the density of soil contents and form aggregate stability. This is because it functions as a particle adhesive that makes the soil not easily destroyed, thereby positively affecting porosity (Duaja, 2012; Rayne and Aula, 2020; Amanah and Taufiq, 2021). Additionally, stable aggregates are reported to maintain good soil porosity compared to unstable (Indonesian Agency for Agricultural Research and Development, 2006).

The plant height parameter correlated positively with the weight of the corn with and without husks, hence, the taller the plants, the heavier the weight of the corn. Furthermore, root fresh weight and root volume were positively correlated, and both also correlated positively with the weight of corn with and without husks. The weight of corn with the husk was positively correlated with those without husks. A previous study by Krismawati et al. (2021) found a strong positive correlation between plant height, number of seeds per cob, seed weight and dry weight of corn due to the application of biochar and inorganic fertilizers. This is supported by Bojtor et al. (2022), reporting that the formation of corn is influenced by elements of N, P and K because nitrogen plays a role in photosynthesis, K functions in stem tissue to strengthen stems and leaf formation, while phosphorus contributes to the formation of corn grains, leaves, stems and cobs.

Copyright © 2023 Universitas Sebelas Maret

Table 4. Correlation between soil physical parameters, growth and yield of hybrid corn

Parameters	A	B	C	D	E	F	G	H	I
A	1								
B	0.312	1							
C	-0.978**	-0.109	1						
D	-0.433*	-0214	0.402*	1					
E	-0.087	-0.112	0.069	0.194	1				
F	0.152	-0.316	-0.227	0.015	0.381	1			
G	0.87	-0.269	-0.151	0.237	0.301	0.721**	1		
H	0.090	0.054	-0.082	0.264	0.418*	0.503**	0.459*	1	
I	0.171	-0.012	-0.182	0.325	0.387*	0.540**	0.546**	0.929**	1

Notes: A = bulk density; B = particle density; C = soil porosity; D = aggregate stability; E = plant height; F = root fresh weight; G = root volume, H = the weight of corn with husks; I = the weight of corn without husks. * = Correlation is significant at the 0.05 level; ** = correlation is significant at the 0.01 level

The results did not show a correlation between soil and plant parameters, this is presumably because soil parameters, such as physical properties, are more influenced by organic matter, while plant parameters are more affected by the dose of inorganic fertilizer given. According to Kalev and Toor (2018); Harvey et al. (2020), increased soil physical quality is associated with high organic matter content because it can stimulate biological activity and the formation of aggregations to create stable aggregates and good porosity. The results also demonstrated that higher doses of N, P and K fertilizers produced relatively greater corn growth and yields. Similarly, Rambe (2014) reported that the growth and production parameters of corn were affected by 50% NPK fertilizer treatment, while the other 50% was influenced by factors such as technical culture, climate, genetics, planting media and phytochemicals present in the plant.

CONCLUSIONS

The application of organic and inorganic fertilizers significantly affected bulk density, porosity, aggregate stability, root fresh weight, root volume, and weight of corn with and without husks. Treatments with 7.5 to 10 tons of organic fertilizer as well as ¼, ¾, and 1 dose of inorganic fertilizers produced the best effect on soil physical properties of Alfisols, growth, and yield of hybrid corn, while the lowest results were shown in the control. This indicates that organic fertilizer treatment can reduce the use of inorganic fertilizers between ¼ to ¾ of the standard dose. Therefore, it is recommended that organic fertilizers be applied to increase soil physical properties and crop yield, as well as to reduce the use of inorganic fertilizers.

ACKNOWLEDGEMENT

The authors are grateful to Universitas Sebelas Maret and related parties who have facilitated and assisted in carrying out this study.

REFERENCES

Al-Maliki, S., AL-Mammory, H., & Scullion, J. (2018). Interactions between humic substances and organic amendments affecting soil biological properties and growth of *Zea mays* L. in the arid land region. *Arid Land Research and Management*, *32*(4), 455–470. https://doi.org/10.1080/15324982.2018.1495670

Amanah, A., & Taufiq, A. (2021). Respon sifat fisika Inceptisol terhadap pemberian blotong dan pupuk. *Ilmiah Media Agrosains*, *7*(1), 23–32. Retrieved from https://jurnal.polibara.ac.id/index.php/agrosains/article/view/219

Annabi, M., Le Bissonnais, Y., Le Villio-Poitrenaud, M., & Houot, S. (2011). Improvement of soil aggregate stability by repeated applications of organic amendments to a cultivated silty loam soil. *Agriculture, Ecosystems & Environment*, *144*(1), 382–389. https://doi.org/10.1016/j.agee.2011.07.005

Arifin, Z., Susilowati, L. E., & Kusuma, B. H. (2017). Soil quality index changes in dry land as a result of input of anorganic-organic fertilizer. *Jurnal Agroteksos*, *26*(2), 1–17. Retrieved from https://agroteksos.unram.ac.id/index.php/Agroteksos/article/view/81

Arsyad, A., Farni, Y., & Ermadani. (2011). Application of green manure (*Calopogonium mucunoides* and *Pueraria javanica*) on the available soil water and soybean yield. *Jurnal Hidrolitan*, *2*(1), 31–39. Retrieved from

Copyright © 2023 Universitas Sebelas Maret

https://online-journal.unja.ac.id/hidrolitan/article/view/458

Avila-Segura, M., Barak, P., Hedtcke, J. L., & Posner, J. L. (2011). Nutrient and alkalinity removal by corn grain, stover and cob harvest in upper midwest USA. *Biomass and Bioenergy*, *35*(3), 1190–1195. https://doi.org/10.1016/j.biombioe.2010.12.010

Bojtor, C., Mousavi, S. M. N., Illés, Á., Golzardi, F., Széles, A., Szabó, A., Nagy, J., & Marton, C. L. (2022). Nutrient composition analysis of maize hybrids affected by different nitrogen fertilisation systems. *Plants*, *11*(12), 1593. https://doi.org/10.3390/plants11121593

Brogowski, Z., Kwasowski, W., & Madiniak, R. (2014). Calculating particle density, bulk density, and total porosity of soil based on its texture. *Soil Science Annual*, *65*(4), 139–149. https://doi.org/10.1515/ssa-2015-0007

Chaudhari, P. R., Ahire, D. V, Ahire, V. D., Chkravarty, M., & Maity, S. (2013). Soil bulk density as related to soil texture, organic matter content and available total nutrients of coimbatore soil. *International Journal of Scientific and Research Publications*, *3*(1), 2250–3153. Retrieved from https://www.ijsrp.org/research-paper-0213/ijsrp-p1439.pdf

Dailami, A., Yetti, H., & Yoseva, S. (2015). Pengaruh pemberian pupuk kascing dan NPK terhadap pertumbuhan dan produksi tanaman jagung manis (*Zea mays* Var *saccharata* Sturt). *JOM Faperta*, *2*(2), 9–19. Retrieved from https://jom.unri.ac.id/index.php/JOMFAPERTA/article/view/8359

Duaja, W. (2012). Pengaruh pupuk urea, pupuk organik padat dan cair kotoran ayam terhadap sifat tanah, pertumbuhan dan hasil selada keriting di tanah Inceptisol. *Bioplantae*, *1*(4), 236–246. Retrieved from https://online-journal.unja.ac.id/bioplante/article/view/1724

Ejigu, W., G.Selassie, Y., Elias, E., & Damte, M. (2021). Integrated fertilizer application improves soil properties and maize (*Zea mays* L.) yield on Nitisols in Northwestern Ethiopia. *Heliyon*, *7*(2), e06074. https://doi.org/10.1016/j.heliyon.2021.e06074

Faloye, O. T., Alatise, M. O., Ajayi, A. E., & Ewulo, B. S. (2017). Synergistic effects of biochar and inorganic fertiliser on maize (*Zea mays*) yield in an Alfisol under drip irrigation. *Soil and Tillage Research*, *174*, 214–220. https://doi.org/10.1016/j.still.2017.07.013

Fang, H., Liu, K., Li, D., Peng, X., Zhang, W., & Zhou, H. (2021). Long-term effects of inorganic fertilizers and organic manures on the structure of a paddy soil. *Soil and Tillage Research*, *213*, 105137. https://doi.org/10.1016/j.still.2021.105137

Finn, D., Kopittke, P. M., Dennis, P. G., & Dalal, R. C. (2017). Microbial energy and matter transformation in agricultural soils. *Soil Biology and Biochemistry*, *111*, 176–192. https://doi.org/10.1016/j.soilbio.2017.04.010

Gautam, A., Guzman, J., Kovacs, P., & Kumar, S. (2022). Manure and inorganic fertilization impacts on soil nutrients, aggregate stability, and organic carbon and nitrogen in different aggregate fractions. *Archives of Agronomy and Soil Science*, *68*(9), 1261–1273. https://doi.org/10.1080/03650340.2021.1887480

Guajardo-Ríos, O., Lozano-Cavazos, C. J., Valdez-Aguilar, L. A., Benavides-Mendoza, A., Ibarra-Jiménez, L., Ascacio-Valdés, J. A., & Aguilar-González, C. N. (2018). Animal-based organic nutrition can substitute inorganic fertigation in soilless-grown grape tomato. *Acta Agriculturae Scandinavica, Section B — Soil & Plant Science*, *68*(1), 77–85. https://doi.org/10.1080/09064710.2017.1367030

Harvey, H. J., Wildman, R. D., Mooney, S. J., & Avery, S. V. (2020). Soil aggregates by design: Manufactured aggregates with defined microbial composition for interrogating microbial activities in soil microhabitats. *Soil Biology and Biochemistry*, *148*, 107870. https://doi.org/10.1016/j.soilbio.2020.107870

Haynes, R. J., & Naidu, R. (1998). Influence of lime, fertilizer and manure applications on soil organic matter. *Nutrient Cycling in Agroecosystems*, *51*(123), 123–137. https://doi.org/https://doi.org/10.1023/A:1009738307837

Hudoyo, A., & Nurmayasari, I. (2019). Peningkatan produktivitas jagung di Indonesia. *Indonesian Journal of Socio*

Copyright © 2023 Universitas Sebelas Maret

Economics, *1*(2), 102–108. Retrieved from https://jurnal.fp.unila.ac.id/index.php/IJSE/article/view/3627

Husnain, Widowati, L. R., Las, I., Sarwani, M., Rochayati, S., Setyorini, D., … & Susilawati. (2020). *Rekomendasi pupuk N, P, dan K spesifik lokasi untuk tanaman padi, jagung dan kedelai pada lahan sawah (per kecamatan)*. Jakarta: Badan Penelitian dan Pengembangan Pertanian. Retrieved from http://repository.pertanian.go.id/bitstream/handle/123456789/12423/Rekomendasi%20Pupuk%20N%2C%20P%2C%20dan%20K%20Spesifik%20Lokasi%20untuk%20Tanaman%20Padi%2C%20Jagung%20dan%20Kedelai%20pada%20Lahan%20Sawah%20%28Per%20Kecamatan%29.%20Buku%20I%20Padi.pdf?sequence=1&isAllowed=y

Indonesian Center for Agricultural Land Resources Research and Development. (2006). *Sifat fisik tanah dan metode analisisnya*. Retrieved from http://repository.pertanian.go.id/bitstream/handle/123456789/14955/BUKU%20SIFAT%20FISIK%20TANAH.pdf?sequence=1

Iqbal, A., He, L., Ali, I., Ullah, S., Khan, A., Khan, A., Akhtar, K., Wei, S., Zhao, Q., Zhang, J., & Jiang, L. (2020). Manure combined with chemical fertilizer increases rice productivity by improving soil health, post-anthesis biomass yield, and nitrogen metabolism. *PLoS ONE*, *15*(10), e0238934. https://doi.org/10.1371/journal.pone.0238934

Iqbal, A., He, L., Khan, A., Wei, S., Akhtar, K., Ali, I., Ullah, S., Munsif, F., Zhao, Q., & Jiang, L. (2019). Organic manure coupled with inorganic fertilizer: An approach for the sustainable production of rice by improving soil properties and nitrogen use efficiency. *Agronomy*, *9*(10), 651. https://doi.org/10.3390/agronomy9100651

Istiqomah, D. N., Gustomo, D., & Prijono, S. (2015). Uji efektivitas kombinasi jenis pupuk organik dan biourin kelinci terhadap kemantapan agregat dan pertumbuhan tebu pada fase pertunasan. *Jurnal Tanah dan Sumberdaya Lahan*, *2*(1), 129–137. Retrieved from https://jtsl.ub.ac.id/index.php/jtsl/article/view/122

Jumarni, Widjajanto, D., & Hasanah, U. (2021). Perubahan kemantapan agregat dan natrium dapat tertukar sebagai akibat pemberian pupuk kandang kambing pada tanah sodik sidondo lembah Palu. *Agrotekbis*, *9*(1), 233–239. Retrieved from http://103.245.72.23/index.php/agrotekbis/article/view/798

Kalev, S. D., & Toor, G. S. (2018). The composition of soils and sediments. In *Green Chemistry* (pp. 339–357). Elsevier. https://doi.org/10.1016/B978-0-12-809270-5.00014-5

Krismawati, A., Arifin, Z., Hermanto, C., & Tafakresnanto, C. (2021). Application of biochar to improve maize performance on volcanic and sediment soil based parent materials in dry land. *IOP Conference Series: Earth and Environmental Science*, *648*, 012177. https://doi.org/10.1088/1755-1315/648/1/012177

Kumari, P., Sharma, B., & Kumari, R. (2018). Micropedological features of Alfisols. *Indian Farmer*, *5*(9), 1072–1076. Retrieved from https://indianfarmer.net/assets/archieves/2018/SEPTEMBER%202018.pdf#page=121

Lal, R. (1994). *Methods and guidelines for assessing sustainable use of soil and water resource in the tropics*. Soil Conservation Service, and U.S. Agency for International Development. Retrieved from https://pdf.usaid.gov/pdf_docs/pnabs982.pdf

Limbong, W. M. M., Sabrina, T., & Lubis, A. (2017). Alteration of paddy soil physical properties planting with watermelon through the application of organic materials. *Jurnal Agroekoteknologi Universitas Sumatera Utara*, *5*(1), 152–158. https://doi.org/10.32734/jaet.v5i1.14922

Lin, W., Lin, M., Zhou, H., Wu, H., Li, Z., & Lin, W. (2019). The effects of chemical and organic fertilizer usage on rhizosphere soil in tea orchards. *PLoS ONE*, *14*(5), e0217018. https://doi.org/10.1371/journal.pone.0217018

Mahmood, F., Khan, I., Ashraf, U., Shahzad, T., Hussain, S., Shahid, M., Abid, M., & Ullah, S. (2017). Effects of organic and inorganic manures on maize and their residual impact on soil physico-chemical properties. *Journal of Soil Science and Plant Nutrition*, *17*(1), 22–32. https://doi.org/10.4067/S0718-95162017005000002

Minardi, S., Hartati, S., & Pardono, P. (2015). Imbangan pupuk organik dan anorganik

Copyright © 2023 Universitas Sebelas Maret

pengaruhnya terhadap hara pembatas dan kesuburan tanah lahan sawah bekas galian C pada hasil jagung (*Zea mays* L). *SAINS TANAH-Journal of Soil Science and Agroclimatology*, *11*(2), 122–129. https://doi.org/10.15608/stjssa.v11i2.228

Ministry of Agriculture. (2020). *Outlook jagung 2020: Komoditas pertanian subsektor tanaman pangan*. Pusat Data dan Sistem Informasi Pertanian Kementrian Pertanian. Retrieved from https://satudata.pertanian.go.id/assets/docs/publikasi/Outlook_Komoditas_Tanaman_Pangan_Jagung_Tahun_2020.pdf

Mustamu, N. E. (2020). *Sludge biogas sebagai alternatif pengganti pupuk kimia*. Malang: CV Literasi Nusantara Abadi. Retrieved from https://books.google.co.id/books?hl=id&lr=&id=N-s-EAAAQBAJ&oi=fnd&pg=PR1&dq=Sludge+Biogas+mustamu&ots=mGeYCy2EYj&sig=DRO6KOZ9PfdrQTDgnPDQfU-u-vQ&redir_esc=y#v=onepage&q=Sludge%20Biogas%20mustamu&f=false

Mustoyo, Simanjuntak, B, H., & Suprihati. (2013). Pengaruh dosis pupuk kandang terhadap stabilitas agregat tanah pada sistem pertanian organik. *AGRIC*, *25*(1), 51–57. https://doi.org/10.24246/agric.2013.v25.i1.p51-57

Ndzana, G. M., Huang, L., Wang, J. B., & Zhang, Z. Y. (2018). Characteristics of clay minerals in soil particles from an argillic horizon of Alfisol in central China. *Applied Clay Science*, *151*(3), 148–156. http://dx.doi.org/10.4067/S0718-95162013005000055

Novizan. (2005). *Petunjuk pemupukan yang efektif*. Jakarta: AgroMedia Pustaka. Retrieved from https://scholar.google.com/scholar?hl=id&as_sdt=0%2C5&q=Petunjuk+Pemupukan+yang+Efektif+novizan&btnG=

Pahalvi, H. N., Rafiya, L., Rashid, S., Nisar, B., & Kamili, A. N. (2021). Chemical fertilizers and their impact on soil health. In *Microbiota and Biofertilizers, Vol 2* (pp. 1–20). Springer International Publishing. https://doi.org/10.1007/978-3-030-61010-4_1

Prasetyo, A., Listyorini, E., & Utomo, W. H. (2014). Hubungan sifat fisik tanah, perakaran dan hasil ubi kayu tahun kedua pada Alfisol Jatikerto akibat pemberian pupuk organik dan anorganik. *Jurnal Tanah dan Sumberdaya Lahan*, *1*(1), 27–37. Retrieved from https://jtsl.ub.ac.id/index.php/jtsl/article/view/97

Purba, T., Ningsih, H., Junaedi, P. A. S., Junairah, B. G., Firgiyanto, R., & Arsi. (2021). *Tanah dan nutrisi tanaman*. Medan: Yayasan Kita Menulis. Retrieved from https://books.google.co.id/books?hl=id&lr=&id=4B85EAAAQBAJ&oi=fnd&pg=PA35&dq=Tanah+dan+Nutrisi+Tanaman+purba&ots=vyfwbbxKLP&sig=J33t8XWJE48BCDZuWbgemTvVUgA&redir_esc=y#v=onepage&q=Tanah%20dan%20Nutrisi%20Tanaman%20purba&f=false

Ramadhan, A. F. N., & Sumarni, T. (2018). Response of shallot (*Allium ascalonicum* L.) to manure and inorganic fertilizer (NPK). *Jurnal Produksi Tanaman*, *6*(5), 815–822. Retrieved from http://protan.studentjournal.ub.ac.id/index.php/protan/article/view/713

Rambe, R. D. H. (2014). Pengaruh pemberian pupuk organik dan pupuk anorganik terhadap pertumbuhan dan produksi jagung manis (*Zea mays saccharata* L.). *Wahana Inovasi*, *3*(2), 436–443. Retrieved from http://penelitian.uisu.ac.id/wp-content/uploads/2017/05/Rahmi-Dwi-Handayani-Wahana.pdf

Ramli, Paloloang, A. K., & Rajamuddin, U. A. (2016). Perubahan sifat fisik tanah akibat pemberian pupuk kandang dan mulsa pada pertanaman terung ungu (*Solanum Melongena* L), Entisol, Tondo, Palu. *J. Agrotekbis*, *4*(2), 160–167. Retrieved from https://scholar.google.com/scholar?hl=id&as_sdt=0%2C5&q=The+changed+physical+of+land+Entisol+Tondo+caused+by+giving+cage+manure+and+mulsato+the+grown+of+purple+eggplant+%28Solanum+Melongena+L%29&btnG=

Rasool, R., Kukal, S., & Hira, G. (2008). Soil organic carbon and physical properties as affected by long-term application of FYM and inorganic fertilizers in maize–wheat system. *Soil and Tillage Research*, *101*(1–2), 31–36. https://doi.org/10.1016/j.still.2008.05.015

Rayne, N., & Aula, L. (2020). Livestock manure and the impacts on soil health: A review. *Soil Systems*, *4*(4), 64. https://doi.org/10.3390/soilsystems4040064

Rühlmann, J., Körschens, M., & Graefe, J. (2006). A new approach to calculate the particle density of soils considering properties of the soil organic matter and the mineral matrix. *Geoderma*, *130*(3–4), 272–283.

Copyright © 2023 Universitas Sebelas Maret

https://doi.org/10.1016/j.geoderma.2005.01.024

Safitri, I. N., Setiawati, T. C., & Bowo, C. (2018). Biochar dan kompos untuk peningkatan sifat fisika tanah dan efisiensi penggunaan air. *Techno: Jurnal Penelitian*, *7*(01), 116–127. https://doi.org/10.33387/tk.v7i01.611

Sambodo, A. S., Sudadi, S., & Sumarno, S. (2014). The effect of azolla- based organic fertilizer, rock phosphate and rice husk ash to peanut in Alfisols. *Caraka Tani: Journal of Sustainable Agriculture*, *29*(2), 73–80. https://doi.org/10.20961/carakatani.v29i2.13324

Setyawati, A., Komariah, Pujiasmanto, B., Fatawi, A., & Batubara, I. (2021). Secondary metabolites of turmeric and ginger on various altitudes and soil characteristics. *IOP Conference Series: Earth and Environmental Science*, *724*, 012020. https://doi.org/10.1088/1755-1315/724/1/012020

Singh, N., Kumar, S., Udawatta, R. P., Anderson, S. H., de Jonge, L. W., & Katuwal, S. (2021). X-ray micro-computed tomography characterized soil pore network as influenced by long-term application of manure and fertilizer. *Geoderma*, *385*, 114872. https://doi.org/10.1016/j.geoderma.2020.114872

Soekamto, M. H., & Fahrizal, A. (2019). Upaya peningkatan kesuburan tanah pada lahan kering di kelurahan aimas distrik aimas kabupaten sorong. *Abdimas: Papua Journal of Community Service*, *1*(2), 14–23. https://doi.org/10.33506/pjcs.v1i2.670

Statistic Indonesia. (2021). *Buletin statistik perdagangan luar negeri impor desember 2021*. Retrieved from https://www.bps.go.id/publication/2022/03/01/b3a21519f1598b4b439b00c3/buletin-statistik-perdagangan-luar-negeri-impor-desember-2021.html#:~:text=Pada%20Desember%202021%20nilai%20impor,menjadi%2017.367%2C2%20ribu%20ton.

Sudaryono. (2002). Pemberdayaan Alfisol untuk pengembangan sentra area tanam dan agribisnis kacang tanah di Indonesia. *Buletin Palawija*, *4*, 84–99. Retrieved from http://ejurnal.litbang.pertanian.go.id/index.php/bulpa/article/view/8624

Sulaeman, Suparto, & Eviati. (2005). *Chemical analysis of soil, plants, water and fertilizers*. Indonesian Soil Research Institute. Retrieved from http://repository.pertanian.go.id/bitstream/handle/123456789/14959/juknis_kimia.pdf?sequence=1

Suntoro, S., Minardi, S., & Sutopo, S. (2017). Engineering super organic fertilizer formula in vegetable cultivation on spinach (*Amarantus* Sp). *Caraka Tani: Journal of Sustainable Agriculture*, *26*(1), 1–6. https://doi.org/10.20961/carakatani.v26i1.14082

Suprianto, A., Armaini, & Yoseva, S. (2016). Pengaruh pemberian kombinasi pupuk kandang ayam dengan pupuk NPK terhadap pertumbuhan dan produksi tanaman jagung manis (*Zea Mays* L Var *Saccharata* Sturt). *JOM Faperta*, *3*(2), 1–14. Retrieved from https://media.neliti.com/media/publications/201606-none.pdf

Uwah, D. F., & Eyo, V. E. (2014). Effects of number and rate of goat manure application on soil properties, growth and yield of sweet maize (*Zea mays* L. *saccharata* Strut). *Sustainable Agriculture Research*, *3*(4), 75–83. https://doi.org/10.5539/sar.v3n4p75

Verdiana, M. A., Sebayang, H. T., & Sumarni, T. (2016). The efffect of various doses biochar rice huskand npk fertilizer on the growth and yield of maize (*Zea mays* L.). *Jurnal Produksi Tanaman*, *4*(8), 611–616. Retrieved from http://protan.studentjournal.ub.ac.id/index.php/protan/article/view/335

Wan, L.-J., Tian, Y., He, M., Zheng, Y.-Q., Lyu, Q., Xie, R.-J., Ma, Y.-Y., Deng, L., & Yi, S.-L. (2021). Effects of chemical fertilizer combined with organic fertilizer application on soil properties, citrus growth physiology, and yield. *Agriculture*, *11*(12), 1207. https://doi.org/10.3390/agriculture11121207

Widodo, K. H., & Kusuma, Z. (2018). Pengaruh kompos terhadap sifat fisik tanah dan pertumbuhan tanaman jagung di Inceptisol. *Jurnal Tanah Dan Sumberdaya Lahan*, *5*(2), 959–967. Retrieved from https://jtsl.ub.ac.id/index.php/jtsl/article/view/221

Wisdom, S. G. O., Ndana, R. W., & Abdulrahim, Y. (2012). The comparative study of the effect of organic manure cow dung and inorganic fertilizer n.p.k on the growth rate of

Copyright © 2023 Universitas Sebelas Maret

maize (*Zea Mays* L). *International Research Journal of Agricultural Science and Soil Science*, *2*(12), 516–519. Retrieved from https://www.interesjournals.org/articles/the-comparative-study-of-the-effect-of-organic-manure-cow-dung-and-inorganic-fertilizer-npk-on-the-growth-rate-of-maize-.pdf

Xiao, L., Yao, K., Li, P., Liu, Y., Chang, E., Zhang, Y., & Zhu, T. (2020). Increased soil aggregate stability is strongly correlated with root and soil properties along a gradient of secondary succession on the Loess Plateau. *Ecological Engineering*, *143,* 105671. https://doi.org/10.1016/j.ecoleng.2019.105671

Yavitt, J. B., Pipes, G. T., Olmos, E. C., Zhang, J., & Shapleigh, J. P. (2021). Soil organic matter, soil structure, and bacterial community structure in a post-agricultural landscape. *Frontiers in Earth Science, 9,* 590103. https://doi.org/10.3389/feart.2021.590103

Zhang, B., Horn, R., & Hallett, P. D. (2005). Mechanical resilience of degraded soil amended with organic matter. *Soil Science Society of America Journal*, *69*(3), 864–871. https://doi.org/10.2136/sssaj2003.0256

Copyright © 2023 Universitas Sebelas Maret