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Soil chemistry characteristic in corn, peanut, and soybean after application of mulch corn and NPK fertilizer at Ultisol Aceh Besar (Indonesia)

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Abstract

NPK fertilizer on plant species (corn, peanuts, and soybeans). Corn mulch plus NPK fertilizers can be combined with plant species (corn, peanuts, and soybeans) to affect chemical properties (soil pH, N-total, P-available, and C-organic) on ultisol soil. This research aims to determine changes in soil chemical properties of corn, soybeans, groundnuts on ultisol soil by using mulch corn plus NPK fertilizer. The research was conducted in Jantho City, Aceh Besar District, and in Soil and Plant Laboratory, Faculty of Agriculture, Syiah Kuala University. August 2016 through December 2016. This research used a separate plot design with 3 x 4 pattern with 3 replications, the first factor as the main plot is the type of plant and the second factor of the subplot is mulch corn plus NPK fertilizer. The results showed that mulching of corn plus NPK fertilizer had significant effect on P-available soil analysis after treatment. However, the administration of corn mulch has no effect on other soil chemical properties (soil pH, C-organic, and N-total). Plant species (corn, peanuts, and soybeans) have an effect on P-available, but have no effect on soil chemical properties (soil pH, C-organic, and N-total).

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Introduction

Soil fertility has a major factor in improving agricultural productivity. Soils with good chemical conditions are essential for plant growth. Soil chemical conditions associated with easy soil cultivation, nutrient availability for plants, and neutral soil pH (Tambunan, 2008).

Ultisol soils include the largest part of the dry land in Indonesia that is 45.794.000 ha or about 25% of the total land area of Indonesia. Ultisol soil is one of the most potent mineral soils for expanding and increasing agricultural production in Indonesia, one of which is Aceh which has high rainfall and high topography (Sipayung *et al.*, 2014).

Land with ultisol soil type in Aceh especially research location in Teureubeh Village of Aceh Besar Regency. According to the ACIAR Research Team (2015) the research field is one type of ultisol soil with poor chemical properties and physical properties such as low organic matter content, low groundwater storage capacity, low cation exchange capacity, less macro nutrients, and high content Al are exchanged. Thus, it is not beneficial for the growth and development of the plant. The main factors such as C-organic content, soil acidity, and nutrient balance of N, P, K greatly affect the activity of microbes and enzymes in the soil, thus maintaining the quality of ultisol soil (Zheng *et al.*, 2015).

The process of improving soil properties on ultisol soil can be done by using mulch corn plus NPK fertilizer. The use of crop residues as mulch can improve soil chemistry such as improving soil structure, increasing water storage capacity, providing benefits and increasing activity of soil microorganisms (Sumarni *et al.*, 2009). Cahyanti (2015) giving mulch can increase the growth and yield of soybean crop. Thus, corn mulch is able to retain moisture, control pH, increase ion exchange capacity, and soil biological activity. Jannah *et al.*, (2012) stated that NPK fertilizer can increase growth at 30 HST, 40 HST, and increase of peanut crop yield. Furthermore, Pratikta *et al.*, (2013) the addition of NPK 400 kg/ha^{-1} fertilizer is able to provide optimal results for corn crops. the addition of N, P, and K fertilizers can give a good response to the soil including ultisol soil.

Material and methods

Place of study

The study was conducted in Teurebeh Village, Jantho City, Aceh Besar District, from August 2016 to December 2016.

Materials and tools

The material used in this study was organic material (corn mulch), NPK PHONSKA fertilizer, planting material used was corn variety Bonanza, Dena 1 variety soybean, and Bima variety peanut. The tools used are hoes, hand tractors, paper labels, analytical scales, stationery, shuffles, shaker machines, pH meters, and distilled water.

Data analysis

This research used a split plot design 3 x 4 with three replications. Thus, there were 12 treatment combinations with 36 experimental units. The first factor as the main plot is the type of plant consists of 3 levels, J1 = Corn, J2 = peanut, J3 = soybean. The second factor of subplot is mulch of corn plus NPK fertilizer consists of 4 levels, R0 = control (0 ton of corn mulch, 0 NPK), R1 = without mulch + 400 kg/ha^{-1} NPK, R2 = corn mulch 5 tons ha^{-1} + 400 kg/ha^{-1} NPK, and R3 = corn mulch 10 tons ha^{-1} + 400 kg/ha^{-1} NPK.

Soil sampling

Soil sampling was carried out by 3 samples of soil samples diagonally from the study area so that they could represent from that location, each soil sample was taken from the soil above 1–20 cm and sub soil 20–40 cm using a drill ground.

Seed Planting

Planting seeds of corn, peanuts and soybeans is carried out simultaneously in the ground holes which are made using a single tool with various corn plants (20 cm x 70 cm), peanuts (20 cm x 60 cm), and

soybeans (20 cm x 40 cm). Each planting hole is filled with 3 corn seeds, 4 peanut seeds, and 4 soybean seeds. The administration of mulch is done after planting corn, peanuts and soybeans according to the treatment.

Parameter

Analysis of the chemical properties performed was soil pH analysis, N-total, P-available, and C-organic.

Results and discussion

Soil pH

The results of the variance analysis showed that mulching of corn plus NPK fertilizer on plant species (corn, soybean, and peanut) in ultisol soil no effect. The average of soil pH changes due to mulching of corn plus NPK fertilizer on plant species (corn, soybean, and peanut) in ultisol soil can be seen in Table 1.

Based on the results of the research shown in Table 1, it is known that the soil pH is quite acidic with 5.5 – 6.5 based on the soil analysis criteria of Soil Research Institute (2009). Results of observation on corn crops have the highest pH value without corn mulch and without NPK fertilizer, in soybean crop has the highest pH value in corn mulching 10 ton ha^{-1} + 400 kg/ha^{-1} NPK, and in peanut plants have a tendency on without mulching corn + 400 kg/ha^{-1} NPK.

Table 1. The average soil pH due to mulching of corn plus NPK fertilizer on land planted by corn, peanuts and soybeans

Perlakuan	pH (H_2O)		
	Jagung	Kacang tanah	Kedelai
Kontrol (0 ton mulsa jagung, 0 NPK)	5.70	5.47	5.47
Tanpa mulsa + 400 kg ha^{-1} NPK	5.37	5.58	5.41
Mulsa jagung 5 ton ha^{-1} + 400 kg ha^{-1} NPK	5.56	5.48	5.20
Mulsa jagung 10 ton ha^{-1} + 400 kg ha^{-1} NPK	5.38	5.51	5.51

Table 2. The average N-total land due to mulching of corn plus NPK fertilizer on land planted by corn, peanuts and soybeans

Perlakuan	N-Total		
	Jagung	Kacang tanah	Kedelai
Kontrol (0 ton mulsa jagung, 0 NPK)	0.19	0.18	0.17
Tanpa mulsa + 400 kg ha^{-1} NPK	0.20	0.18	0.18
Mulsa jagung 5 ton ha^{-1} + 400 kg ha^{-1} NPK	0.18	0.18	0.18
Mulsa jagung 10 ton ha^{-1} + 400 kg ha^{-1} NPK	0.17	0.20	0.20

The decrease in soil pH value a due to high rainfall, when high rainfall in the area, then the soil there will be prone to erosion. When soil erosion occurs, nutrients needed by plants in the soil may be float off in the flow of water. The very low element in the soil can cause the acidity of the soil. Edward *et al*., (2017) the use of mulch plus NPK fertilizer is relatively small in affecting soil chemical properties one of the soil pH. Rheinheimer *et al.* (2018) changes in the chemical properties of one of the soil pH with the use of mulch and NPK fertilizer has not been able to centralize the condition of ultisol soil, because the corn mulch has not been decomposed optimally. Bahtiar *et al*., (2017) organic mulch (corn, straw) is an organic material that will decompose produce organic acids, so that the organic acids cause the acidity of the higher mulch (lower pH). Decreased soil pH due to mulch due to the decomposition process of organic matter occurs release of CO_2 with H_2O, H_2CO_3 (Raihana and Wiliam, 2006). Thus, the provision of

mulch corn plus NPK fertilizer has not been able to improve soil pH on ultisol soil.

N-Total

The result of variance analysis showed that mulching of corn plus NPK fertilizer on plant species (corn, soybean, and peanut) on ultisol soil no effect. The mean N-total changes due to corn mulch plus NPK fertilizer in plant species (corn, soybeans, and peanuts) in ultisol soil can be seen in Table 2.

Table 2 shows the N-total value in mulching of corn plus NPK fertilizer on corn, soybean, and peanut crops after general research was included in low criteria. This is due to several factors such as being absorbed by plants, evaporation or washing, as stated Nainggolan *et al.*, (2009) $NO3^-$ washing process, denitrification of $NO3^-$ to N_2, determined by clay mineral or utilized by soil microorganisms. Nariratih *et al.*, (2013) adds that the presence of N in the soil may be mutable or lost, this is due to denitrification, volatilization, hauling, and washing. Thus, the provision of mulch corn plus NPK fertilizer cannot be available in ultisol soil.

Table 3. The average P-available due to mulching of corn plus NPK fertilizers on land planted by corn, peanuts and soybeans

Perlakuan	P-tersedia (ppm)		
	Jagung	Kacang tanah	Kedelai
Kontrol (0 ton mulsa jagung, 0 NPK)	7.92a	9.77b	3.90a
Tanpa mulsa + 400 kg ha^{-1} NPK	30.03c	16.85c	15.68b
Mulsa jagung 5 ton ha^{-1} + 400 kg ha^{-1} NPK	13.45b	6.23a	5.83a
Mulsa jagung 10 ton ha^{-1} + 400 kg ha^{-1} NPK	14.33b	12.78b	7.62a

Table 4. The average C-organic soil due to mulching of corn plus NPK fertilizer on land planted by corn, peanuts and soybeans

Perlakuan	C-organik (%)		
	Jagung	Kacang tanah	Kedelai
Kontrol (0 ton mulsa jagung, 0 NPK)	1.14	1.12	1.19
Tanpa mulsa + 400 kg ha^{-1} NPK	0.19	1.34	1.15
Mulsa jagung 5 ton ha^{-1} + 400 kg ha^{-1} NPK	0.23	1.35	1.21
mulsa jagung 10 ton ha^{-1} + 400 kg ha^{-1} NPK	0.22	1.10	1.20

P-available

The result of variance analysis showed that mulching of corn plus NPK fertilizer on plant species (corn, soybean, and peanut) in ultisol field had significant effect. The average P-change available due to mulching of corn plus NPK fertilizer on plant species (corn, soybeans, and peanuts) in ultisol soils can be seen in Table 3.

Table 3 shows that the best available P-values for corn, soybeans, and peanuts with mulch treatment + 400 kg/ha^{-1} NPK were significantly different from other treatments. The value of P-available on corn mulch plus NPK fertilizer on corn, soybean, and peanuts after general research is included in very high criteria. P-available on corn plants with no mulch + 400 kg/ha^{-1} NPK administration has a positive effect on increasing the availability of phosphorus nutrients in the soil. Dharmayanti *et al.*, (2013) stated that the addition of NPK (inorganic) fertilizer can increase P-available in the soil, because the phosphorus level in the fertilizer is a slow solubility so that until harvest time the availability is still high. Sari (2015) states that if the nutrient content in the soil is fulfilled, then when vegetative growth and photosynthesis process in the plant will run actively.

C-Organic

The results of variance analysis showed that mulching of corn plus NPK fertilizer on plant species (corn, soybean, and peanut) in ultisol field had no effect. The average C-organic changes due to mulching of corn plus NPK fertilizer on plant species (corn, soybeans, and peanuts) on ultisol soil can be seen in Table 4.

Table 4 shows that the C-Organic value on mulching of corn plus NPK fertilizer on corn, soybean, and peanut crops after the research is included in the low criterion. It is assumed that mulching of corn plus NPK fertilizer takes a long time and a lot to improve the soil characteristics. Kitou and Yoshida (1994) stated that corn mulch plus NPK fertilizer cannot increase C-organic on the soil if the decomposition process is not optimal. Baiano dan Morra (2017) mulch to decompose takes 4–5 months, so that C-organic can be available and can maintain organic matter in the soil. The mulch process depends on the ratio of carbon and material nitrogen. Materials that have a small C:N ratio will experience a faster weathering process, compared to organic materials that have a greater C: N ratio (Hairiah *et al.*, 2000).

Conclusion

Administration of corn mulch plus NPK fertilizer significantly affected P-available after treatment. However, giving corn mulch plus NPK fertilizer does not affect other soil chemical properties (soil pH, organic C, and N-total). Plant species (corn, peanuts, and soybeans) have an effect on P-available but have no effect on soil chemical properties (soil pH, C-organic, and N-total).

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