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RESEARCH ARTICLE

POTENTIAL OF CORN, SOYBEANS, CORN AND SOYBEAN MIXTURE RESIDUE AND BIOCHAR ON MINERALIZATION N AND C: INCUBATION STUDY

[1,*]Sjarifuddin Ende, [2]Indrianto Kadekoh, [2]Fathurrahman and [2]Saiful Darman

[1]Agrotechnology Study Program at the Tolitoli Mujahidin College of Agricultural Sciences, Indonesia
[2]Departmen of Agriculture, University of Tadulako, Palu, Indonesia

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ABSTRACT

Decomposition of cropresiduesand nutrient release patterns are important from the nutrient cycling in agricultural systems. An Incubation experiments were conducted to examine the effect of corn, soybean, mixed corn and soybean residue and biocharon N mineralization. The experiments were carried out in randomized completely design with tree aplications. The treatments consisted of corns, soybeans, a mixture of corn and soybeans residues, biocharand control. The results showed that C and N mineralization was significantly increased in soils that were applied with residues compared with no residues during the incubation periods of 20 and 40 days after incubations. Decomposition rates are influenced by the N content of the residue. Soybean residue can release Nhigher than other residues. At the end of incubation, the percentage of C organic was as follows; soybean residues (2.47%), biochar (1.90%), corn + soybeans (1.86%), corn (1.80%) and control (1.75%). The Ntotal were ocurred with soybean residues (0.47%), biochar and corn + soybeans (0.15%), maize (0.12% and control (0.09%). Therefore, it can be conclude that soybean residues can be potential source of C-organic and mineral N.

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INTRODUCTION

Plant residues are one source of organic materials that are used as soil enhancer material to improve the physical, chemical and biological conditions of the soil. Incorporated of residues on agricultural land can maintain soil organic carbon, increase soil biological activity, improve soil physical properties and increase nutrient availability (Esmaeilzadeh, and Ahangar, 2014). Crop residue decomposition and nutrient release from the crop residues is affected by the physical and chemical characteristic of crop residue (Choudhary, et al 2014; Rezieg, et al 2014). Or increase by increasing the quality of a plant residue (Abera *et al.,* 2012; Kamkar *et al.,* 2014). Generally, organic matter derived from cereal crops will be decomposed more slowly than legume. This is because the content of chemical compounds is low, especially N, compared to the plant of thelegum. It is a high-quality source of organic material because it contains, high N> 2.5%, low C: N low (<20) low lignin content (<15%) and low polyphenols (<4%) (Rahman *et al.,* 2006), so that it is easily decomposed by microorganisms in the soil.In contrast to crop residues as organic material that can supply soil nutrients through the process of decomposition and mineralization, biochar is a carbon compound that resists decomposition (Islami*et al.*, 2013; Sukartono, *et al.,* 2011). However, studies have shown that biocharcan improve soil quality (Chan *et al.,* 2007; Islamiet al., 2011; Liang *et al.,* 2008; Yamato *et al.,* 2006), can maintain N released from urea fertilizer in the form of N-NH_4^+ (Widowati, *et al.,* 2011), absorbs NO_3^- because of the functioning of alkaline compounds in biochar (Kameyama *et al.,* 2012). Nitrogen mineralization and immobilization are important processes in the N cycle (Cabrera, *et al.,* 2005). N availability of crop residues depends on the amount of N mineralized or immobilized during decomposition. Crop residues on the soil surface can reduce NO_3^- loss (Congreves, 2014), the concentrations of ammonium and nitrate in soil are higher and consistent than those released in residual soils (Kamkar, *et al.,* 2014). Knowledge about the dynamics of Nmineralization from residues is very important in order to determine the potential of crop residues and biochar for soil fertility through nutrient release. This study was conducted to test the hypothesis that 1) A mixture of residual corn and soybeans or those contain soybean residue are more efficient than the others, and 2) Biochar can reduce N loss than residue of corn, soybeans and mix of corn and soybeans. This study will answer the questions: 1) Whether the residues comefrom a mixtures of cereal and legume crops are more efficient in N release, 2) The organic matter in the form of biochar can reduce N loss from urea

***Corresponding author:* Sjarifuddin Ende,**
Agrotechnology Study Program at the Tolitoli Mujahidin College of Agricultural Sciences, Indonesia.

MATERIALS AND METHODS

The soil was taken at a depth of 0-15 cm in a composite manner. Soil characteristics were then analyzed according to Carter and Gregorich (2008), including; pH (method 1: 1 v v-1), organic material (loss on ignition), N (KCl extract method and colorimetric analysis), P (olesen method), CEC (estimated based on acetate ammonium extraction and pH), soil texture (hydrometer method.)

Soil incubation

The laboratory incubation was done at The Tadulako University Agro technology Laboratory. Before incubation the soil is cleaned from the remains of plant roots, then sieved using a 5 mm sieve. The water content of the soil was adjusted to 60% field capacity using deionized water for the preparation of the incubation study.

A. 500 g of soil was placed in a black plastic container (capacity of 1000 g). The soil in the container was treated with 200 kg of urea. Ha^{-1} (34.5 mg / 0.5 kg soil) as a control, and for the treatment of residues each was added 10 g / kg of soil (0.5 g / 500 kg soil). The treatments were laid out in completely randomized design (CRD) with four replications so that there were 20 treatment units. Corn residue, soybeans prepared from the rest of the farmer's harvest. Biochar was prepared by burning the remaining corn and soybeans in a pyrolysis furnace at 350^0C.

Analytical Procedures: N mineralization was determined by the method was described by procedure of Maynard (2008). Soil mineral N was measured in all treatments at 20, 40 and 60 days after incubation. Determination of N-NH4 +, and N-NO3- using colorimetric 2M KCl extract. Nitrogen mineralization is expressed as a value in mg N kg -1 soil by formula

$$\text{value,mg.L}^{-1}) \; x \frac{1000\,ug}{1\,mg} \; x \, \frac{0{,}02\,L}{soil\ dry\ weight\ (g)} \qquad (1)$$

The total nitrogen contents were determined by the Kjedahl method

Determination of C-organic using the wakley and black method. Weigh 0.5 g of fine soil (pass the 70 mesh sieve) dry air, enter the 500 ml Erlenmeyer, also provide for blank determination. then added 20 ml of concentrated H2SO4, shaken for 25 minutes, and let stand for 30 minutes, after which 200 ml of aquades was added, 10 ml of 80% H3PO4 and 1 ml (20 drops) of defenylamine, balances and samples titrated with ferosulfate solution 1 N until the green color is added again K2Cr2o7 1 N and then titrated with FeSO4 0.5 N from biuret until the green color reappears.

Determination of pH (H2O) using the volume ratio (V / V) method, weigh 10.0 g of soil sample, input into the bottle plus 50 ml of ion-free water, shake with a shaking machine for 30 minutes. Soil suspensions were measured with a pH meter calibrated using a pH 7.0 buffer solution and pH 4.0

Statistical analysis: All data were analyzed using analysis of variance (ANOVA) with SPSS version 17.0. To determine the difference of each treatment, Duncan distance test analysis was used ($p>0.05$). Pearson correlation was used to determine relationships between C and N parameters

RESULTS AND DISCUSSION

Results

The chemical composition of crop residues (corn, soybeans, mix corn and soybeans, biochar) are presented in Table 1. There are differences in the chemical composition of crop residues.

Table 1. Initial chemichal properties of maize, soybean, mixture and biochar

No	Treatments	C-organic (%)	N Total (%)	C/N	P (%)	K (%)
1	Corn	19.6	0,29	84.48	0.10	4.96
2	Soybean	14.37	0,57	39.82	0.12	2.22
3	Mix corn and soybean	18.16	1,66	13.67	0.09	3.20
4	Biochar	15.57	0,14	139,02	0.10	1.50

Sources: Agrotecnology laboratory of Tadulako University, 2016.

Ammonium Nitrogen ($N\text{-}NH_4^+$) (mg/kg soil): The average of$N\text{-}NH_4^+$ concentration during the incubation period is presented in Table 2. Table 2 showed that soybean residues and mixed residues of maize and soybeans be able to increase the concentration of N-NH4 $^+$ in 20 and 40 days after incubation. It is shows that theresidue has the potential to increase N levels in the form of $N\text{-}NH_4^+$ especially at the beginning of the decomposition process.

Concentration of Nitrogen Nitrate ($N\text{-}NO_3^-$) ($mg.kg^{-1}$soil)

The average ofNitrate ($N\text{-}NO_3^-$) concentration during the incubation period is presented in Table 3. The results showed that at the beginning of incubation (20 days after incubation) the nitrate released was highest in control and corn residue, this is showed that the process of changing ammonium to nitrate was higher in the control and corn residue, and then increased after incubation of 60 days.

Soil pH

The results of the analysis showed that the treatment of maize, soybean and biochar residues had no significant effect on soil pH after incubation 20, 40 and 60 days. The average of soil pH is shown in Figure 3. The results (Fig. 1), showed that the incubation time did not significantly in soil pH. The vakueof soilpH incubated for 20 days is lower than 40 days and gradually increased until up to 60 days after incubation. The soil pH moved to the neutral and the soybean residue were the best compared to the others (pH 6.31).

Total Nitrogen andSoil organic carbon: N release from soybean residue was higher than the control (60 days after incubation). Among the crop residues and biochar used as soil amendments, the release of N from soybean residues was higher and significantly compared to the other treatments. The average total N values (Table 3) released were respectively soybean residues (0.47% or 47 mg.kg-1), mix corn and soybean residues (0.15% or 15 mg.kg-1) biochar (0.15% or 15 mg.kg-1), corn residue (0.12% or 12 mg.kg-1) and control (0.09% or 9 mg.kg-1).

The Corn residue, soybean residue and biochar were significantly different ($p>0.05$) after the end of incubation (60 days after incubation).

Tabel 2. The ammonium ($N\text{-}NH_4^+$) concentration on 20, 40 dan 60 days after incubation

Treatments	The day after incubation		
	20	40	60
	……….Concentration of $N\text{-}NH_4^+$ ($mg.kg^{-1}$)……….		
Control	62,45[a]	51,97[a]	44,47[a]
Corn residue	103,96[b]	64,96[bc]	53,47[a]
Soybean residue	155,90[c]	69,94[bc]	55,71[a]
Mix corn and soybean residue	129,96[bc]	72,47[c]	64,97[a]
Biochar	106,22[b]	54,65[a]	64,83[a]

Means in the same column followed by the same letter are not significantly different (DMRT 0,05)

Tabel 3.Nitrate ($N\text{-}NO_3^-$) concentration on 20,40dan 60 days after incubation

Treatments	Time of incubation (days after incubationi)		
	20	40	60
	………..Consentrasiof $N\text{-}NO_3^-$ ($mg.kg^{-1}$)……….		
Control	90,93[b]	195,87[a]	233,85[a]
Corn residue	90,94[b]	231,87[ab]	298,8[a]
Soybean residue	64,86[a]	208,81[ab]	246,9[a]
Mix corn and soybean residue	64,98[a]	268,91[b]	296,9[a]
Biochar	51,89[a]	260,71[b]	286,89[a]

Means in the same column followed by the same letter are not significantly different (DMRT 0,05)

Table 3. Average N-total soil after 60 days of incubation

Treatments	N-Total (%) Kejdahl	C-Organic (%)
Control	0.09[a]	1.75[a]
Corn residue	0.12[b]	1.80[b]
Soybean residue	0.47[d]	2.47[d]
Mix corn and soybean residue	0.15[c]	1.86[bc]
Biochar	0.15[c]	1.90[c]

Means in the same column followed by the same letter are not significantly different (DMRT 0,05)

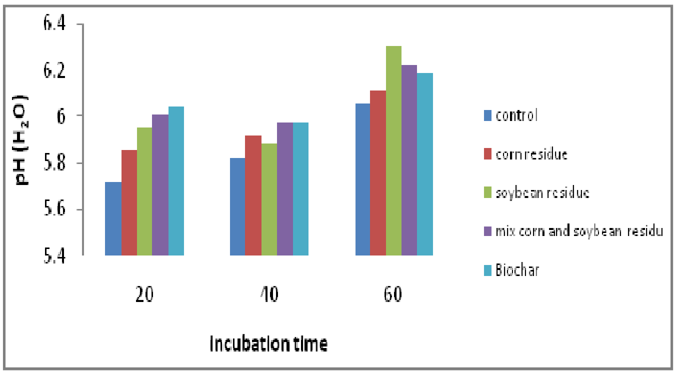


Fig. 1.Histogram pH of the soil that is given residue in 20, 40 dan 60 davs after incubation

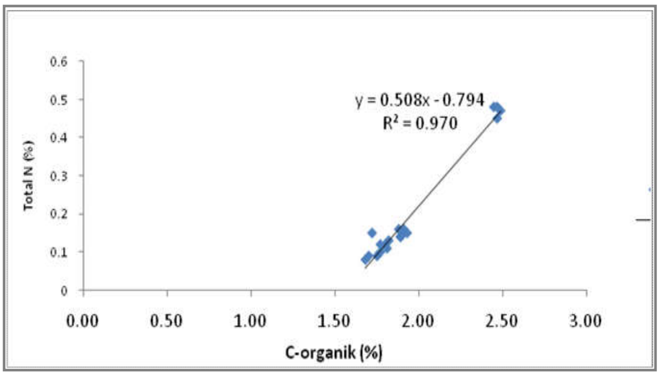


Fig 2. The relationship between c-Organic and Total N

The highest increase in organic C was found in soil amended with soybean residues (2.47%), and followed by corn + soybean residues 1.86%, corn biochar + soybeans 1.90%, 1.80% corn residues and 1.75% control, or an increase in C-organic 41-14% compared to control, or an increase of 71.53% compared to the initial soil before incubation (1.44%).

Correlation between C and N: The results of the regression analysis (fig. 4) show that there is a very strong relationship between the levels of C-organic with N total soil in 60 days after incubation

DISCUSSION

The results showed that the residue of maize, soybean, mix soybean and corn biocharincubated for 60 days affected the dynamics of soil N and C. The concentration of $N\text{-}NH_4^{\ +}$ decreases with increasing incubation time and NO_3^- concentration increases with increasing incubation time.

Urea as a nitrification substrate affects the availability of $N\text{-}NH_4^{\ +}$ which then undergoes nitrification to $N\text{-}NO_3^-$ and subsequently affects pH. Amide changes from urea to available N are highly dependent on various factors including organic matter which is incorporated with it is. The abilitiy Nfixation of soybean from the air be contributes to the N content of plant tissue. The results in line with (Adamu et al ;2015) that N content in peanuts was due to the N fixation ability of the plant. The high content of N in soybean residues will accelerate the decomposition process, so that it can release N. Decomposition and nutrient release of the corn residue are slower because of the high content of lignin and cellulose. The study showed that it can to increase of $N\text{-}NH_4^+$ on the 20 day after incubation and then decreased until 60thday and conversely tended to increase the concentration of N-NO3- and increase soil pH in 60thday.Mukhlis et al (2011); Rosmarkam and Yuwono (2002) state that on soils with a pH less than 6.3, urea will decompose as follows:

$$CO(NH_2)_2 + 2H^+ + 2H_2O \rightleftharpoons 2NH_4^+ + H_2CO_3.$$

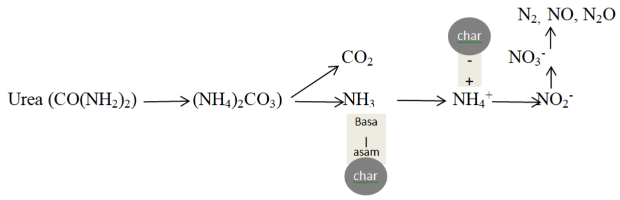
The changes of pH during the incubation process were not significantly influenced by corn and soybean residues and biochar. And this is also related to the concentration of nitrate and ammonium released during the incubation process, because the increase and decrease in acidity in the media follows the following chemical reactions;

$$3NO_3^- \longrightarrow 3NH_2 + 2\,OH^- \text{ (pH are high)}$$
$$3NH_4^+ \longrightarrow 3\,R-NH_2 + 4H^+ \text{(pH are down)}$$

This reaction it can explain the role of ammonium and nitrate associated with changes in pH in the soil, where NO_3^- has the potential to increase pH and NH_4^+ potentially reducing pH. And the results of the study show that there are a relationship between the increase of NO_3^- concentration and pH at 60 days after incubation. Becides from Urea, N-NH_4^+ and N-NO_3^- mineralization are also produced from ammonification and mineralization process. The process of changing organic matter into NH_4 + and NO_3^- are as follows;

$$\text{Organic matter} \longrightarrow \text{organic acid} + CO_2 \longrightarrow NH_4^+ \longrightarrow NO_3^-$$

In this diagram, it is explained that the N mineralization process involves a series of processes sequences of protein hydrolysis, aminization, ammonification and nitrification, and this process will be accelerated if the drainage and aerate condition are good and many basic cations. The acceleration of the N nutrient release process from organic matter are also determined by C / N ratio on soil or organic matter and significantly impacts to the rate of mineralization and immobilization. Therefore, C / N ratio information can be used to predict mineralization or immobilization will occur. Generally net mineralization occurs if the substrate C / N ratio is approximately 20-25: 1 or lower, where net immobilization occurs if this ratio is greater and microbial activity is stimulated by a high number of labile C. The results showed that soybean residues were better than corn residues. The effect of maize and soybean residue has been reported by many worker s (Hosseini, *et al.,* 2015 and Steward, *et al.,* 2015) that cereal residues such as maize results in direct clean immobilization while incorporation and the legume / soybean residue results clean mineralization. The high N content in soybean residues accelerates the decomposition process. As Li, et al (2011) states that residues with high N concentrations and low C / N ratios can accelerate mineralization compared to residues with low N concentrations and higher C / N ratios. However, the results of this study indicate soybean residues are better than others. This result are the same with Gezhahegen *et al.* (2016) who states that soybean residue has potential as source of mineral N than mix corn and soybean residue. The results of this study also showed that soybean residues could be potentially increase the C-Organic content and soil mineral N in 60 days after incubation. However, this result are different by Nguyen, et al (2016) who reported that the addition of residual mixtures increased CO2 evolution and N. mineralization. The relationship between C and N on the residue has also been explained by other researchers. (Roberts, *et al.,* 2015) stated that the addition of C due to plant residues would affect microbial activity and microbial N uptake. This shows that mineralization on soil without given organic material (plant residues) causes a decrease in microbial biomass due to the limited C and N. C mineralization is higher in soils which are amended with residues than those not amended (Moreno-Cornejo *et al.,* 2015; Diochon *et al.,* 2015). The results also found that biochar can increase the concentration of NH_4^+ in the soil after incubation of 60 days after incubation. Unlike plant residues, biochar is not susceptible to weathering, therefore the ability of biochar to increase the concentration of NH_4^+ in soil can be explained through a mechanism as below.



In this diagram explains that the presence of biochar can reduce N loss through volatilization and denitrification through adsorption of NH_3^+ reacting with acidic functional groups on the surface of biochar or directly forming cationic charge bonds with NH_4^+. Or in other words biochar is able to withstand N loss through acid-base bonds between negatively charged biochar and NH_4^+ which are positively charged, so that NH_4^+ concentrations in the soil rise.

Conclusion

The results showed that corn, soybean, mixture corn and soybean residue and bio char are decomposed and mineralized based on incubation time. The rate of decomposition and mineralization of N is not only influenced by the C / N ratio but also the N content on the tissue. Our results show that Soybean residue can increase the N and C content in the soil compared to the other and it has be potential as a source of N nutrients in low imput agriculture.

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