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Effect of Addition of New Crop Residues on Recovery of ^{15}n Previously Added Residues by Maize

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Abstract

A research was conducted to evaluate the effect of addition of new crop residues on recovery N at two crop cycle by maize. Two crops residue (rice straw=RS and soybean=SY) were grown in a glass-house under four ^{15}N concentration, i.e, 0 mM (N0), 0.625 0 mM (N1), 2.5 0 mM (N2), and 10 mM (N3) supplied as $CO(^{15}NH_2)_2$, in plastic pots containing 5 kg of quartz sand. The maize as plant pots containing 10 kg of soil and placed in the glasshouse, it was conducted to evaluate the microbial biomass N and recovery N by maize and to find of stimulation and retardation on mineralized nitrogen. ^{15}N-labelled crop residues added at the first crop cycle and unlabelled crop residues of the same species added at the second cycle. The result showed that the recovey of ^{15}N from crop residues during the first planting ranged from 71.36% (RSN1) to 80.64% (RSN3). During the second planting with no addition of new crop residues ranged from 4.54% (SYN3) to 28.29% (RSN3), while that with addition of new crop residues ranged from 8.12% (SYN3) to 18.55% (RSN3). Repeated addition of unlabelled SY and RS residues showed stimulation of N mineralization (2.50% to 3.63 in SY) but RS residues showed retardation of N mineralization (1.88% to 9.74%).

Keywords: ^{15}N recovery, rice straw, soybean, microbial biomass N

1. Introduction

In low external input agriculture systems of Indonesia, organic matters are applied to soils at least two times during one cropping year. New organic matters applied can affect decomposition rates of organic matters previously applied (Jenkinson, 1981). This effect can be positive or negative, and can influence recovery of organic matter N by crops. Ehaliotis et al. (1998) indicated that application of N rich legume residues to soil that was previously applied with ^{15}N labelled maize residues having high C: N ratio, significantly increased recovery of the maize residue N during five plantings. Release of N from organic matters depends on physical and chemical characteristics of the organic matters, environmental conditions, and community of decomposer organisms (Heal et al., 1997). Under similar environmental conditions, rate N mineralization from organic matters was determined by physical and chemical characteristics of the organic matters. N, lignin and polyphenol contents have been known to be the major factors determining the easy with which the organic matter to decompose and release N (Handayanto et al., 1994; Palm and Sanchez, 1991). A laboratory incubation study showed that during the period of 3-4 monts legume tree prunings released 70% N (Handayanto et al., 1995). Under field conditions, recovery of N from tropical legume tree prunings by crops commonly ranges from 10% to 30% (Giller and Cadisch, 1995). This low N use efficiency is due to lost of N through volatilization or lost of N through leaching, or due to retention of organic matter N by soil organic matter. There is only limited information on long term N mineralization and recovery of N from organic matters. This is probably due to low recovery of N from plant residues (5 % or less) (Sisworo et al., 1990). Understanding of long term N release is important, particularly for low quality organic matter that can only supply a small amount of N to crops.

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Low quality organic matters (low N, high pholyphenol contents) that decompose slowly contribute only small amount of N to crops. However, such low quality organic matter contribute to accumulation of soil organic matter and hence increasing potential N mineralizzation in the long term. This paper reported results of a study on the effects of repeated addition of crop residues on the residues N benefit to maize over two croping sequences using ^{15}N method.

2. Materials and Methods

This study was carried out the glasshouse of the Faculty of Agriculture, Malang Islamic University from March to September 2014, following a maize planting experiment reported by (Sholihah et al., 2012b). At the above reported experiment, recovery of six crop residues ^{15}N by maize grown in pots, each containing 10 kg of soil. The crops residues were RSN1, RSN2, RSN3, SYN1, SYN2, and SYN3. After harvest (8 weeks), the remaining soil in each pot was split into two-5 kg and air dried. Each of the 5 kg air diried soil was placed in a 20 cm diameter pot and used for growing maize (second planting). The first 5 kg of soil was used to evaluate the residual effects of the ^{15} N-labelled rice and soybean residues previously added to the soil on N uptake by maize. The second 5 kg of soil was used to examine the influence of addition of new rice and soybean residues (unlabelled, with no N supply for 3 months) on the residual effects of the ^{15} N-labelled rice and soybean previously added to the soil on N uptake by maize. Soil used for the experiment was collected from upland area in North Malang. The soil was classified as Inceptisol (Soil Survey Staff, 2010), having loamy texture, pH (H_20) 6.20, pH(KCl) 5.40; cation exchange capacity 28.95 cmol kg^{-1} soil (NH_4OAc pH7); and containing 1.91% organic C; 0.20% total N (Kjeldahl); 22,16 mg P kg^{-1} soil (Bray II); 0.053 mg N mineral kg^{-1} soil; 0.0035522 mg microbial biomass N kg^{-1} soil; and 0.28; 0.5; 1.53 cmol.kg^{-1} soil of respectively Na^+, K^+, Mg^2.

The twelve treatments were arranged in a randomized complete block design with four replicate. All pots received basal fertilizers similar to those applied in the first cropping. The moisture content of the soil in each pot was adjusted to its approximate water holding capacity. Five pre-germinated seeds of maize were planted in each pot and thinned to one plant after 1 week. The experiment was conducted for 8 weeks. At harvest (8 weeks after planting), maize shoots were harvested from all pots at a height of 1 cm above the soil surface. Roots were separated manually from the soil by sieving and rinsing with water. The shoots and roots were then oven-dried at 60^{o}C for 72 hours, weighed and ground to pass through a 1 mm sieve. The soil samples were then extracted with 2 M KCI and amounts of mineral-N in the KCl-soil extract were determined using the Kjeldahl distillation method. Amounts of mineral-N in the soil were determined by Kjeldahl method (Keeney and Nelson, 1982). Microbial biomass N at end of first and second cropping experiment were measured using chloroform fumigation and extraction method (Brookes et al., 1985). N biomass content was determined using Kjeldahl method with a constant value kEN = 0.45 (Jenkinson, 1988). N recovery in the microbial biomass was calculated using a method used by Ehaliotis et al. (1998). N concentration and ^{15}N enrichment of the harvested shoots and roots were determined using a Micromass 622 (UK) mass spectrometer at the National Nuclear Agency of Indonesia, Jakarta. Recovery of pruning N by maize was estimated using the direct ^{15}N recovery metods, as follows: % N recovery = $[(R_{maize} \times \text{total}_{maize}\ N)/(R_{crop\ residue} \times \text{crop residue N added})] \times 100$; where R = atom % ^{15}N excess. The difference between N recovery at treatments with addition of new unlabelled crop residues and N recovery at treatments with no addition of new unlabelled crop residues at the second cropping is considered as stimulation or retardation of mineralization and recovery of ^{15}N from previously added crop residues by maize, due to addition of new unlabelled crop residues.

3. Results and Discussion

3.1 Recovery of Crop Residue N by Maize

Recovery of ^{15}N from crop residues during the first planting as reported by Sholihah et al. (2012b) ranged from 71.36% (RSN1) to 80.64% (RSN3) (Figure 1). During the second planting, recovery of residual ^{15}N crop residues with no addition of new crop residues ranged from 4.54% (SYN3) to 28.29% (RSN3), while that with addition of new crop residues ranged from 8.12% (SYN3) to 18.55% (RSN3) (Figure 1). The overall two planting sequences, the overall recovery of rice straw (RS) N by maize were greater than that of soybean residues (SY). There was evidence that slow decomposable organic matter (RSN) improved mineralization potential of soil organic matter in the long run. Most crop residue N recovery occured at first planting. Another study also reported small amount of legume residue N recovery by crops for long terms (Sisworo et al., 1990). Interestingly, addition of new crop residues resulted in smaller N recovery compared to treatment with no addition of new crop residues. Crop residues that released substantial amount of N at first planting did not release substantial amount of N at second planting. However, at the end of second planting there was indication on changes of N release pattern; organic matter that decomposed slowly during the first planting released substantial amount of N at the second planting (Figure 1).

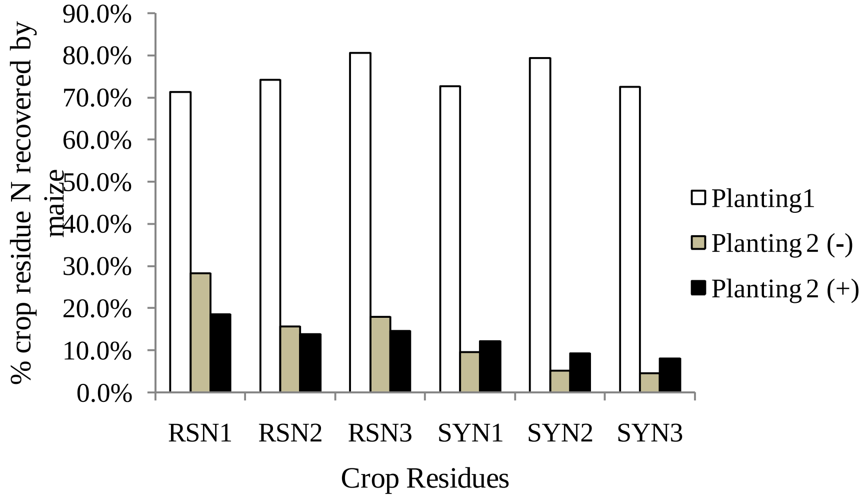

Figure 1: Crop residue N recovered by Maize over 8 Weeks

3.2. Stimulation and Retardation of N Mineralization

Addition of new unlabelled SY residues at the second planting increased 2.5% - 3.63% recovery by maize of SY ^{15}N previously added at the first planting. This positive interaction could be intrepreted as positive priming effect (stimulation), but addition of new unlabelled RS residues at the second planting increased as negative priming effect (retardation) 1.88% -9.74% (Figure 2). In general, priming effect is defined as stimulation or retardation of decomposition and recovery of N due to addition of new organic matters (Jenkinson, 1981). Vanlauwe et al. (1994) reported that a priming effect of 7 - 10% from maize residue fractions.

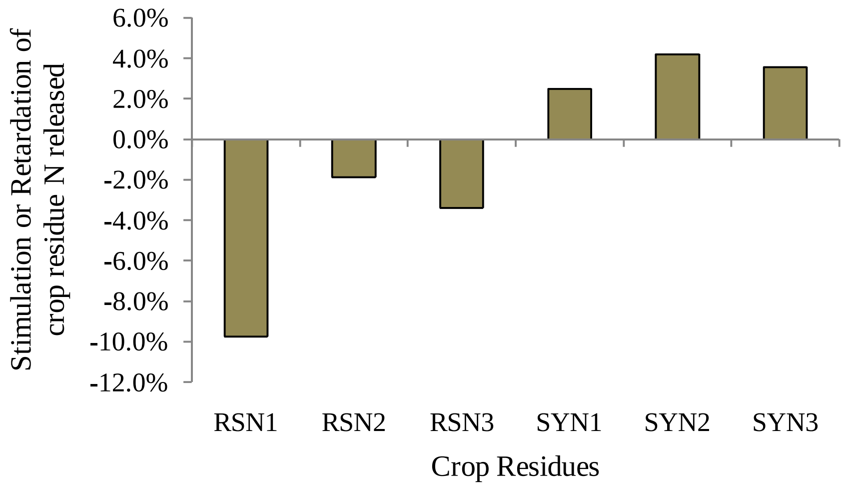

Figure 2: Stimulation and Retardation of Crop Residue during Two Planting Periods

Priming effect could be due to the increase of breakdown of recalcitrant organic matter due to the increase activity of catabolic enzymes from new added substrate. A direct evidence of the microbial data sufficiently supported this. % N microbial ranged from 28% (SYN1) to 46% (RSN3) during two planting periods (Figure 3).

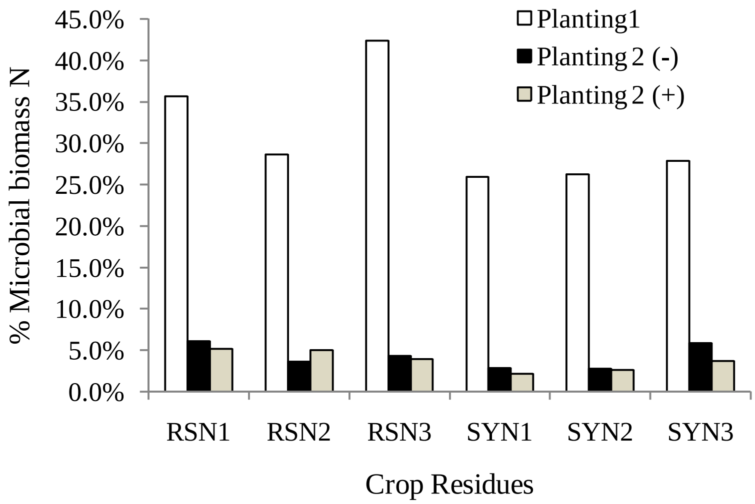

Figure 3: % Microbial Biomass N Amended With Crop Residue of SY Ang RS during Two Planting Periods

Addition of new organic matter did not significantly influence proportion of pruning N in microbial biomass. This was probably due to the occurrence of pool substitution effect (Ehaliotis et al., 1998) because newly added crop residues was preferred by microbial biomass and used for soil stabilization. In contrast with positive interaction of SY, recovery of SY ^{15}N decreased when treated with addition of new RS residues. This negative priming could be due to immobilization of ^{15}N microbial due to low N but high polyphenol contents in the new added unlabelled crop residues (Sholihah et al., 2012a), or the increase of stabilization of ^{15}N crop residues into soil organic matter. Because of no ^{15}N increase in microbial biomass at the end of second planting, effects of polyphenol content on crop residues decomposition or stabilization seemed to be processes responsible for the occurrence of negative effect of new crop residues addition. Previous experiments conducted by Sholihah et al. (2012ab) showed the important polyphenol: N ratio in governing crop residues N mineralization, and crop residues N uptake by maize. As application of new RS residue resulted in a negative priming effect, expecially that with low N content (RSN1), for the next planting sequence, addition of high quality crop residues, such as SY, to that was previoulle added with RS is recommended.

4. Conclusions

In this experiment,The overoll two planting sequences, the overall recovery of rice straw (RS) N by maize were greater than that of soybean residues (SY). The addition of SY crop residues into the soil providing priming effect positive (2.50% to 3.63%) but RS residues showed priming effect negative (1.88% to 9.74%) at two crop cycle by maize.

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References

Brookes, P.C., Landman, A., Pruden, G., & Jenkinson, D.S. (1985). Chloroform fumigation and the release of soil nitrogen: A rapid direct interaction method to measure microbial biomass nitrogen in soil. Soil Biology and Biochemistry, 17, 837-842.

Ehaliotis, C., Cadisch, G., & Giller, K.E. (1998). Substrate amendments can alter the microbial dynamics and N availability from maize to subsequent crops. Soil Biology and Biochemistry, 30, 1281-1292.

Giller, K.E., & Cadisch, G. (1995). Future benefits from biological nitrogen fixation in agriculture. An ecological approach.Plant and Soil, 174, 255-277

Handayanto, E., Cadisch, G., & Giller, K.E. (1994). Nitrogen release from prunings of legume hedgerow tree in relation to quality of the prunings and incubation method.Plant and Soil, 160, 238-247.

Handayanto, E., Cadisch, G., & Giller, K.E. (1995). Manipulation of quality and mineralization of tropical legume tree prunings by varying nitrogen supply.Plant and Soil, 176, 149-160.

Heal, O.W., Anderson, J.M., & Swift, M.J. (1997). Plant litter quality and decomposition: An historical overview. In K.E.Giller, & G. Cadisch (Eds), Driven by Nature: Plant Litter Quality and Decomposition. (pp 3-32),CAB International, Walingford, Oxon, UK.

Jenkinson, D.S. (1981). The fate of plant and animal residues in soil. In: D.J. Grrenland, & M.H.B. Hayes (Eds), The Chemistry of Soil Properties. (pp 505-561). John Wiley and Sons, Chichester.

Jenkinson, D.S. (1988). Determination of microbial biomass carbon and nitrogen in soil. In: J.R. Wilson (Ed),Advances in Nitrogen Cycling in Agricultural Ecosystems (pp 368-386). CAB International, Wallingford.

Keeney, D. R., & Nelson, D. W. (1982). Nitrogen - inorganic forms. In: A. L. Page, R.H. Miller, & D.R. Keeney (Eds), Methods of Soil Analysis, Part 2, Chemical and Microbiological Properties. (pp. 643-698), American Society of Agronomy Inc., and Soil Science Society of America Inc., Madison, Wisconsin, USA..

Palm, C. A., & Sanchez, P. A. (1991). Nitrogen release from the leaves of some tropical legumes as affected by their lignin and polyphenolic contents. Soil Biology and Biochemistry, 23, 83-88.

Sholihah, A., Prijono, S., Utami, S.R., &Handayanto, E. (2012a).N Mineralization from residues of crops grown with varying supply of ^{15}N concentrations. Journal of Agricultural Science.Vol. 4, No. 8, August 2012 (in press).

Sholihah, A., Prijono, S., Utami, S.R., & Handayanto, E. (2012b). Recovery of ^{15}N Labelled Rice and Soybean Residues by maize grown on an Alfisol of Malang, Indonesia. International Journal of Agricultural Sciences ISSN: 2167-0447 Vol. 2 (12), pp. 330- 336, December, 2012.

Sisworo, W. H., Mitrosuhardjo, M.M., Rasjid, H., & and Myers, R. J. K. (1990). The relative roles of N fixation, fertilizer, crop residues and soil in supplying N in multiple cropping systems in a humid, tropical upland cropping system. Plant and Soil, 121, 73-82.

Vanlauwe, B., Dendooven, I. and Merckx, R. (1994). Residue fractionation and decomposition: The significance of the active fraction. Plant and Soil 158: 263-274.