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Soil nutrient status as influenced by fallow, tillage and nitrogen management in rainfed lowland rice condition

Andrea F Dawan*, Ricardo B Casauay, Gerald L Seridon

College of Agriculture, Cagayan State University, Piat Campus, Piat, Cagayan, Philippines

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Key words: Carbon-nitrogen ratio, Fallow period, Soil organic matter

Abstract

This field experiment was conducted for two cropping seasons to evaluate the effects of fallow and tillage managements in rainfed lowland rice and on the soil chemical properties especially on soil organic matter (SOM). Fallow managements which are mowing and leaving rice stubbles during fallow period were assessed. Effects of conventional and zero-tillage and nitrogen fertilizer managements were also determined. Generally, fallow and tillage managements have no effect on soil C:N ratio, and on other soil chemical properties after two cropping seasons. However, notable increase in OM after two cropping seasons was observed due to the decomposed 30% threshed rice straw that were incorporated in the soil during fallow period. Increased SOM is also very evident since the soil has very low baseline OM content. In terms of grain yield, fallow- and tillage-managed plots did not vary significantly but for nitrogen fertilizer managed plots, significant effects were noted for two cropping seasons. Full-N applied plots have significantly higher yields compared with half-N and 0-N. The soil indigenous nitrogen supply (0-N plots) could not satisfy the need of the crop throughout its growing period. For tillage practice, rice under deep tillage produced significantly higher plants and grain yield during the second cropping season. This is due to higher OM content noted in these plots compared to zero-tilled plots, although the difference is not significant. Nevertheless, improvement of fallow and tillage management may lead to improved soil properties and increased yield of rice in the long term.

***Corresponding Author:** Andrea F. Dawan ✉ afdawan@csu.edu.ph

Introduction

Asia has about 46 million hectares of rainfed lowland rice comprising almost 30% of the global rice area. These areas were hindered by drought, submergence and problem soils which are associated with low productivity. Two of the major constraints contributing to low productivity are soil quality and crop practices (Haefele and Konboon 2009).

In continuous rice cultivation, fallow management is crucial. The indigenous supply of nutrients in the soil is not enough to support the cropping system. Consequently, the farmers require more fertilizer inputs. Pests and diseases will accumulate faster in rice mono-cropping causing farmers to use more pesticide. Thus, effective fallow management is recommended to break and minimize the cycle of pests and diseases. Mowing the standing biomass and hastening its decomposition during the fallow could reduce the habitat for pests and diseases and increase nutrient supply to rice (Dobermann and Fairhurst 2002). According to Tuyen and Tan (2001), among four management practices of rice straw such as removal, burning, left over and cultivation of mushroom, they found that removal of rice straw is deteriorating soil chemical property. In the long run, rice straw incorporation into the soil gave better yield and better physical and chemical property of the soil. Tillage, on the other hand, offered very small benefit in improving grain yield of rice in case of very intensive rice monoculture, but it is the main way to incorporate rice straw into the soil. Moreover, recent land preparation practices in rice cultivation have tended to reduce the depth of plowing. Some past research indicates that soil indigenous nutrient supply (INS) can be greater in deeper than shallow soil. Changes in tillage and fertilizer management practices required for no-till soils should reflect the increased potential for immobilization of surface applied N and the lower levels of plant available NO_3^- as compared with those under conventional tillage (Daryanto *et al.*, 2017).

The study, therefore, was conducted to evaluate the effects of two different fallow and tillage managements on the soil chemical properties especially on the soil organic matter (SOM) build-up and determine their effects on the yield of rainfed lowland rice. The specific objectives of the study include: 1) compare the two straw managements during fallow period, conventional (leaving the rice stubbles to ratoon until plowing) vs. improved (mowing the rice stubbles after harvest); 2) assess the effects of two tillage practices, conventional vs. zero till; and 3) evaluate the three N fertilizer managements, full N vs. half N vs. zero N.

Materials and methods

Time and place of the study

The experiment was undertaken for two cropping seasons (1) from September to December 2018 and (2) March to June 2019, under rainfed lowland condition at the Rice Field Experiment Area of Cagayan State University (CSU), Piat Campus, Baung, Piat, Cagayan which falls under the third type of climate where seasons are not very pronounced with a short dry season from one to three months, either during the period from December to February or from March to May, and wet during the rest of the year. The fallow periods fall on July to August 2018 and January to February 2019.

Soil characteristics and rice varieties used in the study

The soil is Bago sandy clay loam type (Dagdag *et al.*, 1967). Based on the results of soil chemical analysis conducted prior to establishment of experimental trial, the soil has a pH of 5.8 which is slightly acidic, and it has a very low SOM content of 0.96% and organic carbon (OC) content of 0.55%. The N, phosphorus (P), and potassium (K) are also relatively low with 0.03%, 3.3ppm (Bray) and 52.2ppm, respectively. Average mineralizable N content is 0.002%. The initial C:N ratio of the soil is 11 which is at medium range.

The test variety planted was NSIC Rc416 (Sahod Ulan 13) which matures at 116 days.

Experimental design, treatment and crop establishment

The experiment was laid out in a split-split plot design consisting of two mainplots, two subplots and three sub-subplots with 4 replications. The plot size was 4mx5m (20m^2) with a planting distance of 20cmx20cm. The two main plots represented two fallow management which was composed of (a) conventional (conv.) fallow management - a practice leaving the standing rice stubble after harvest, allowing it to ratoon and weeds to grow until the time the field is plowed (b) improved fallow management - mowing down the rice stubbles down to the ground level at harvest using a hand tractor-drawn mower. The threshed straws were spread back to the field in both conditions. It was ensured that the amount of rice straw in two mainplots was the same at the rate of 4 tons ha^{-1} (oven-dry weight). The straws incorporated contain 0.67% N, 0.07% P, 1.40% K and 0.31% S. Land preparation was done 2 weeks after spreading of rice straw, while transplanting was done 2 months after mowing and spreading of rice straw. Therefore the straw was allowed to decompose for a period of 2 months. The subplots were the two tillage practices which was composed of (a) conventional (conv.)- associated with deeper tillage, 30 to 50cm depth and land preparation is done by two plowings and one harrowing (b) zero tillage – associated with shallow tillage, 0 to 20cm depth and involves only one plowing to reduce ground surface litter.

The sub-subplots consists of N fertilizer application based on soil laboratory analysis recommendation (80-30-30): 1) no added N, full dose of PK, 2) full dose of NPK and 3) half dose of N, full dose of PK. This is to determine the amount of INS in the soil and evaluate if this INS could satisfy the need of the crop throughout its growth period.

Parameters measured

Soil chemical properties

Initial soil samples per replication were collected, processed and analyzed for OM content (Walkley and Black), pH [using water (1:1)], total N (Kjeldahl), available P (Bray), exchangeable K (Flame Photometer – NH_4OAC Extraction) and mineralizable N (Alkaline Permanganate). These soil chemical properties were the basis of determining whether soil nutrient supply could help sustain the growth of the rice plants. Before transplanting, composite soil samples from fallow management treatments were collected to determine the changes in C:N ratio as a result of fallow management. At harvest, soil samples were collected to assess the changes in C:N ratio and nutrient levels, as a result of different management treatments. All the chemical analyses were conducted at the Analytical Soils Laboratory, University of the Philippines Los Baños (UPLB), Laguna.

Grain yield and yield components

For yield, the sampling area per plot was the inner 3mx4m (12m^2). The hills were cut at the base or ground level, threshed and weighed. For computed grain yield, 1000g of sample was collected for oven-dry weight determination at 60°C for 72 hours. Yield components gathered (from the ten representative samples per plot) were plant height, tiller number hill^{-1}, panicle number hill^{-1}, and 1000 grain weight.

Statistical analysis

The data were analyzed using STAR (Statistical Tool for Agricultural Research) to determine the differences between treatment means at 5% level of significance by least significant difference (LSD).

Results and discussion

Soil chemical properties (2018)

The results of soil chemical analysis before transplanting including pH, OM content, OC, total N, available P, exchangeable K and mineralizable N are shown in Table 1. Based on the results, there were no significant differences among the treatments: conv. vs. improved fallow and conv. vs. zero till. Soil pH was slightly acidic ranging from 5.6 to 5.8. The OM content ranged 0.92 to 0.99%, which is very low and with the same level as of the initial SOM, 0.96%. The OC ranged from 0.51 to 0.55%. Total N content ranged 0.042 to 0.045%, which is almost the same low level as of the initial 0.03%. Available P ranged from 5 to 6ppm (Bray), which is higher compared with the initial value of 3.3ppm.

Exchangeable K (35 to 43ppm) was lower compared with the initial of 52.2ppm. The slight decrease in the nutrient status of the soil might be due to the immobilization of nutrients by microorganisms responsible for the decomposition of rice straw incorporated in the soil during the fallow period.

Table 1. Nutrient analysis of soil before transplanting* at CSU Piat, Cagayan (2018).

Parameter	Fallow Management		Tillage Management		N Fertilizer Management		
	Conv.	Improved	Conv.	Zero	0	Full	Half
pH	5.8 a	5.6 a	5.8 a	5.6 a	-	-	-
OM (%)	0.98 a	0.93 a	0.99 a	0.92 a	-	-	-
OC (%)	0.54 a	0.51 a	0.55 a	0.51 a	-	-	-
Total N (%)	0.04 a	0.04 a	0.04 a	0.04 a	-	-	-
Avail. P (ppm)	6.12 a	5.16 a	6.24 a	5.03 a	-	-	-
Exch. K (ppm)	43.75 a	34.58 a	39.58 a	38.75 a	-	-	-

*Two months after spreading the rice straw

In a row for each parameter measured, means followed by the same letter are not significantly different at 5% level of significance

Conv. – conventional, 0-no added N, full-full dose of N, half-half dose of N

Table 2 summarizes the results of soil chemical analysis at harvest. There were no significant differences observed among the treatments: conv. vs. improved fallow, conv. vs. zero till, and 0-N vs. Full-N vs. Half-N fertilizer. Soil pH was slightly acidic ranging from 5.9 to 6.0. This is a bit higher compared with the initial pH level (5.8). The OM content ranged from 1.2 to 1.3%, which is relatively higher compared with the initial SOM. The OC was 0.7% in all treated plots which is higher compared with the initial OC of the soil. Total N content was almost the same (0.06-0.07%). Available P ranged from 7 to 9ppm (Bray), which is higher compared with the initial value of 3.3ppm. Exchangeable K ranging from 22 to 26ppm decreased with reference to the initial K measurement of 52.2ppm. The amount of N in the soil which can readily be taken up by the plants is the mineralizable N percentage. Based on the results, mineralizable N of the soil at harvest (0.007%) generally increased from the initial mineralizable N content of 0.002%, although the increase (0.005%) is very minimal. The mineralizable N content based on the total N of the soil was 10% in all treated plots at harvest. This implies that some of the N is being immobilized by microorganisms and the other 50-80% of the total N were already assimilated by the crop (Bird *et al.*, 2002) since it is the most important source of plant-available N for rice.

Table 2. Nutrient analysis of soil after harvest at CSU Piat, Cagayan (2018).

Parameter	Fallow Management		Tillage Management		N Fertilizer Management		
	Conv.	Improved	Conv.	Zero	0	Full	Half
pH	5.9 a	5.9 a	6.0 a	5.9 a	5.9 a	6.0 a	5.9 a
OM (%)	1.2 a	1.2 a	1.3 a	1.2 a	1.2 a	1.2 a	1.2 a
OC (%)	0.7 a	0.7 a	0.7 a	0.7 a	0.7 a	0.7 a	0.7 a
Total N (%)	0.07 a	0.06 a	0.07 a	0.06 a	0.07 a	0.06 a	0.06 a
Avail. P (ppm)	7.6 a	9.1 a	7.3a	9.3 a	7.6 a	8.5 a	8.8 a
Exch. K (ppm)	24.8 a	22.9 a	22.3 a	25.4 a	26.3 a	23.1 a	23.4 a
Mineralizable N (%)	0.007 a	0.007 a	0.007 a	0.007 a	0.007 a	0.007 a	0.007 a
Mineralizable N (as % of total N)	10 a	10 a	10 a	10 a	10 a	10 a	10 a

In a row for each parameter measured, means followed by the same letter are not significantly different at 5% level of significance

Conv. – conventional fallow and tillage management, 0-zero N application

C:N ratio in fallow and tillage-managed plots (2018)

The relationship between C and N turnover in soil is determined primarily by the energy supply in the soil and the stability of the products formed by growing microbial community (Bird *et al.*, 2002). Rice straw is the only organic material available in significant quantities to most rice farmers. The average straw return rate is about 4g straw kg^{-1} soil (Gao *et al.*, 2004) and addition of 10t ha^{-1} rice straw at four to five weeks before transplanting rice is equivalent to the basal application of 40kg N ha^{-1} (Yadvinder-Singh *et al.*, 2009). About 70% of the rice straw incorporated was composed of stubbles left after harvest, and the other 30% from threshed rice straw. For organic materials such as rice straw with high C:N ratio (from 40 to 60:1), only about 10-20% of N is assimilated by the rice crop, 10-20% is lost through various pathways, and 60-80% is immobilized in the soil (Yadvinder-Singh *et al.*, 2009).

The C:N ratio of the soil in about two months after incorporation of rice straw, whether conventional or improved fallow did not vary significantly (Table 3). However, the C:N ratio of the soil increased slightly from 11 to 12. Such increase was due to the increased OC and decreased total N content in the soil. Incorporation of fresh straw resulted to the increase in OC while reduction in N could be due to denitrification process (Castillo *et al.*, 2012) wherein nitrate (NO_3^-) is being converted to nitrous oxide (N_2O) and dinitrogen (N_2) forms.

Table 3. Soil carbon:nitrogen (C:N) ratio at CSU Piat, Cagayan (2018).

Treatment	C:N ratio before start of the experiment			C:N ratio before transplanting*			C:N ratio at harvest		
	OC (%)	N (%)	C:N	OC (%)	N (%)	C:N	OC (%)	N (%)	C:N
Fallow Mngt									
Conventional	0.53	0.05	11	0.54 a	0.04 a	12 a	0.72 a	0.07 a	11 a
Improved	0.53	0.05	11	0.51 a	0.04 a	12 a	0.69 a	0.06 a	11 a
Tillage Mngt									
Conventional	0.53	0.05	11	0.55 a	0.04 a	12 a	0.73 a	0.07 a	11 a
Zero	0.53	0.05	11	0.51 a	0.04 a	12 a	0.69 a	0.06 a	11 a
N Fert. Mngt									
Zero N	0.53	0.05	11	-	-	-	0.73 a	0.07 a	11 a
Full N	0.53	0.05	11	-	-	-	0.71 a	0.06 a	11 a
Half N	0.53	0.05	11	-	-	-	0.69 a	0.06 a	11 a

*Two months after spreading of straw

In a column for each parameter measured, means followed by the same letter are not significantly different at 5% level of significance.

At harvest (157 days after straw incorporation), the levels of OC and total N both registered a slight increase with reference to the measurements gathered before transplanting regardless of fallow management and tillage practice. However, there were no significant differences obtained in their OC and total N levels even under N fertilizer managed-plots. Even so, the average C:N ratio of 11 for all the treatments implies that the straw incorporated has not been completely decomposed.

Grain yield and yield components of NSIC Rc416 as affected by the different treatments (2018)

In general, no significant differences were observed in the fallow- and tillage-managed plots in terms of rice yield component parameters tested (Table 4). However, significant differences were observed in plots treated with different amounts of nitrogen fertilizer. In conventional tillage, plant height (65.6cm) obtained was significantly higher compared with the zero-tilled plots of 59.8cm. This could be attributed to the increased rooting volume of rice thereby supporting its shoot growth and development. Other yield components measured such as tiller and panicle number hill^{-1} were not significantly affected by tillage managements. This conforms to the findings of Lal (1994) that no tillage method can cause a reduction of rice effective panicle. It is only of the nutrient that is added or not added that the effect can be shown. Thus nitrogen fertilizer application obtained significant results in terms of plant height, tiller number hill^{-1}, panicle number hill^{-1} and grain yield. Full N-applied plots obtained the tallest plant with 67.4cm, followed by half N- (63.5cm) and no N-applied plots with 57.1cm. Significantly higher tiller number and panicle number hill^{-1} were recorded in full N-applied, followed by half N and no N-applied with 11, 10 and 7, respectively, both for tiller and panicle number. It implies that applying full dose of N increases the tillers of rice plant. As the amount of nitrogen absorbed by the crop increases, there is an equivalent increase in the number of tillers per unit area (Yoshida *et al.,* 1972). The same was observed by Artacho *et al.* (2009) in terms of increase in number of panicles with increased in N fertilization.

Table 4. Grain yield and yield components of NSIC Rc416 as affected by the different treatments (2018).

Treatment	Growth and yield parameters				
	Plant Height (cm)	Tiller No. Hill^{-1}	Panicle No. Hill^{-1}	1000 Grain Weight (g)	Grain Yield (t ha^{-1})
Fallow Mngt					
Conventional	62.4 a	10 a	9 a	25 a	1.72 a
Improved	62.9 a	9 a	9 a	26 a	1.76 a
Tillage Mngt					
Conventional	65.5 a	10 a	10 a	25 a	1.69 a
Zero	59.8 b	9 a	9 a	26 a	1.79 a
N Fert. Mngt					
Zero N	57.1 c	7 c	7 c	25 a	1.27 b
Full N	67.4 a	11 a	11 a	25 a	2.08 a
Half N	63.5 b	10 b	10 b	26 a	1.87 a

In a column for each parameter measured, means followed by the same letter are not significantly different at 5% level of significance.

In terms of grain yield, no significant difference existed between conventional and zero tillage plots and even in two fallow managements (Table 4). However, higher grain yield was obtained under zero tillage (1.79t ha^{-1}) compared with conventional with 1.69t ha^{-1}. On the other hand, application of full N fertilizer resulted to highest yield of 2.08t ha^{-1}, followed by half N-applied with 1.87t ha^{-1}. The zero N applied plots obtained significantly lower yield of 1.27t ha^{-1} compared with full- and half- N applied. Grain yield response of full N applied plots is supported by the yield components such as plant height, which enhanced more leaf area resulting in higher photo assimilates and thereby resulted in more dry matter accumulation (Mandal *et al*., 1992). The production of tiller and panicle were also associated with increased N applied thereby producing significantly higher yield compared with no N fertilizer applied. The result also implies that the soil indigenous nitrogen supply could not satisfy the need of the crop throughout its growing period.

Soil chemical properties (2019)

Table 5 summarizes the chemical analysis of the soil before transplanting of NSIC Rc416 during the second cropping. In general, there were no significant differences in the soil chemical properties (soil pH, OM, OC, total N, available P and exchangeable K) as affected by the treatments.

Table 5. Nutrient analysis of soil before transplanting* at CSU Piat, Cagayan (2019).

Parameter	Fallow Management		Tillage Management		N Fertilizer Management		
	Conv.	Improved	Conv.	Zero	0	Full	Half
pH	5.9 a	5.8 a	5.9 a	5.8 a	5.8 a	5.9 a	5.9 a
OM (%)	1.27 a	1.20 a	1.23 a	1.24 a	1.28 a	1.21 a	1.22 a
OC (%)	0.74 a	0.70 a	0.72 a	0.73 a	0.75 a	0.71 a	0.71 a
Total N (%)	0.07 a	0.06 a	0.07 a	0.07 a	0.07 a	0.06 a	0.06 a
Avail. P (ppm)	9.2 a	11.1 a	8.7 a	11.6 a	9.2 a	10.7 a	10.5 a
Exch. K (ppm)	22.8 a	23.6 a	21.4 a	25.0 a	26.3 a	20.8 a	22.5 a

*Two months after spreading the straw

In a row for each parameter measured, means followed by the same letter are not significantly different at 5% level of significance

Conv. – conventional fallow and tillage management, 0-zero N application

The average soil pH was 5.9 for fallow, tillage and N fertilizer managements, slightly higher than the initial pH (5.8). An average of 1.24% OM content was obtained from the treated plots which is higher compared with the initial OM content of 0.96%. The average OC was 0.72% which was slightly higher than the initial OC of 0.55%. This implies that the rice straw initially incorporated to the soil increased soil C content. The total N of the soil was 0.06% on the average which was slightly higher than the initial N soil content (0.03%). Slight increase in total N of the soil might be due to the mineralization of immobilized N from the rice straw incorporated during the first cropping season (Bird *et al*., 2002).

Soil exchangeable K ranged from 20.8 to 26.3ppm. This is relatively lower than the initial 52.2ppm. Although the obtained values in each of the treatments are not significantly different from each other, the decrease in K content denotes that the straw incorporated even during the first cropping season is not yet mineralized and mineral K fertilizers were mostly taken up by the plant.

The results of the chemical analysis of the soil after harvest of NSIC Rc416 during the second cropping are shown in Table 6. There were no significant differences noted in the soil chemical properties as affected by the treatments.

Table 6. Nutrient analysis of soil after harvest at CSU Piat, Cagayan (2019).

Parameter	Fallow Management		Tillage Management		N Fertilizer Management		
	Conv.	Improved	Conv.	Zero	0	Full	Half
pH	5.9 a	5.9 a	5.9 a	5.9 a	5.9 a	5.9 a	5.9 a
OM (%)	1.2 a	1.4 a	1.3 a	1.3 a	1.3 a	1.3 a	1.3 a
OC (%)	0.69 a	0.84 a	0.79 a	0.74 a	0.77 a	0.76 a	0.76 a
Total N (%)	0.06 a	0.08 a	0.07 a	0.07 a	0.07 a	0.07 a	0.07 a
Avail. P (ppm)	3.4 a	4.5 a	3.1 a	3.9 a	3.5 a	3.3 a	3.6 a
Exch. K (ppm)	25.6 a	20.8 a	22.5 a	23.9 a	24.6 a	22.5 a	22.5 a
Mineralizable N (%)	0.005 a	0.006 a	0.006 a	0.005 a	0.005 a	0.005 a	0.005 a
Mineralizable N (as % of total N)	8 a	8 a	8 a	8 a	8 a	8 a	8 a

In a row for each parameter measured, means followed by the same letter are not significantly different at 5% level of significance

Conv – conventional fallow and tillage management, 0-zero N application

The soil pH was the same 5.9 for fallow, tillage and N fertilizer managements, slightly higher than the initial pH (5.8). An average of 1.3% OM content was obtained from the treated plots which is higher compared with the initial OM content of 0.96%. The average OC was 0.76% which was slightly higher than the initial OC of 0.55%. This implies that the rice straw initially incorporated to the soil increased soil C content. The total N of the soil was 0.07% on the average which was slightly higher than the initial N soil content (0.03%). Slight increase in total N of the soil might be due to the mineralization of immobilized N from the rice straw incorporated during the first cropping season (Bird *et al.*, 2002). Soil exchangeable K ranged from 20.8 to 25.6ppm. This is relatively lower than the initial 52.2ppm. Although the obtained values in each of the treatments were not significantly different from each other, the decrease in K content denotes that the straw incorporated even during the first cropping season is not yet mineralized and mineral K fertilizers were mostly used up by the plant.

Based from the results shown in Table 6, mineralizable N of the soil at harvest (0.005%) generally increased slightly from the initial mineralizable N content of 0.002%. However, no significant differences were noted as affected by the different treatments. The mineralizable N content based on the total N of the soil was 8% in all treated plots at harvest, which is lower than the value obtained during the first season (10%). This result may be supported by the findings of Castillo *et al.* (2012), where mineralizable N tends to be lower when SOM level is higher, although the difference in mineralizable N of the total soil N during the first and second cropping is very minimal. They explained that the recalcitrant nature of SOM is the reason behind the results. Recalcitrant OM includes humus of lignin-containing materials that a few organisms can decompose.

C: N ratio in fallow and tillage-managed plots (2019)

Crop residue management practices can affect N immobilization and stabilization processes important to efficient utilization of N from fertilizers, crop residues and soil organic matter (SOM). Immobilization of fertilizer and crop residue N in soil is one of the most critical aspects affecting long-term fertility in rice (Bird *et al.*, 2002).

The C:N ratios of the soil 52 days after incorporation of rice straw (before transplanting and at harvest), whether conventional or improved fallow are shown in Table 7. The comparable C:N ratios obtained (11) was attributed to the limited decomposition of rice straw, which could possibly improve the OC and total N of the soil, under rainfed lowland condition. Limited moisture also limits the condition of the straw for faster decomposition. No significant differences were observed in any treatments in terms of C:N ratio. The C:N ratio of 11 for all the management treatments also suggests that the straw incorporated has not been thoroughly decomposed.

Table 7. Soil carbon:nitrogen (C:N) ratio at CSU Piat, Cagayan (2019).

Treatment	C:N ratio before start of the experiment			C:N ratio before transplanting*			C:N ratio at harvest		
	OC (%)	N (%)	C:N	OC (%)	N (%)	C:N	OC (%)	N (%)	C:N
Fallow Mngt									
Conventional	0.72 a	0.07 a	11 a	0.74 a	0.07 a	11 a	0.69 a	0.06 a	11 a
Improved	0.69 a	0.06 a	11 a	0.70 a	0.06 a	11 a	0.84 a	0.08 a	11 a
Tillage Mngt									
Conventional	0.73 a	0.07 a	11 a	0.72 a	0.06 a	11 a	0.79 a	0.07 a	11 a
Zero	0.69 a	0.06 a	11 a	0.73 a	0.06 a	11 a	0.74 a	0.07 a	11 a
N Fert. Mngt									
Zero N	0.73 a	0.07 a	11 a	0.75 a	0.07 a	11 a	0.77 a	0.07 a	11 a
Full N	0.71 a	0.06 a	11 a	0.71 a	0.06 a	11 a	0.76 a	0.07 a	11 a
Half N	0.69 a	0.06 a	11 a	0.71 a	0.06 a	11 a	0.76 a	0.07 a	11 a

*Two months after spreading of straw

In a column for each parameter measured, means followed by the same letter are not significantly different at 5% level of significance.

Grain yield and yield components of NSIC Rc416 as affected by the different treatments (2019)

Table 8 summarizes the effects of the different treatments on the yield and yield components of NSIC Rc416 during the second cropping (2019). In general, significant differences were observed in plots treated with different amounts of nitrogen fertilizer. For fallow management, no significant effect was noted, however, tillage management showed positive effects on plant height and grain yield. Conventional tillage produced significantly higher plant and grain yield (65.6cm and 2.59t ha^{-1}, respectively) than the zero tillage. Conventional tillage showed significant effect on rice yield yet effect of zero tillage might not be noticeable in short term but may give positive yields in the long term.

Significantly higher yield was obtained in full N-applied plots with 2.75t ha^{-1}, followed by half N- with 2.42t ha^{-1} and zero N- with 1.34t ha^{-1}. N fertilizer applied was efficiently taken up by the rice crop, although half N- and full N-applied were not significantly different. This means that half application of N can meet the nutrient requirement of the crop, but its yield potential could not be maximized given the difference of 0.33t ha^{-1}. Other yield components were significantly affected by N fertilizer management except for 1000 grain weight.

Table 8. Grain yield and yield components of NSIC Rc416 as affected by the different treatments (2019).

Treatment	Growth and yield parameters				
	Plant Height (cm)	Tiller No. Hill^{-1}	Panicle No. Hill^{-1}	1000 Grain Weight (g)	Grain Yield (t ha^{-1})
Fallow Mngt					
Conventional	63.4 a	12 a	11 a	26 a	2.25 a
Improved	62.4 a	13 a	11 a	27 a	2.09 a
Tillage Mngt					
Conventional	65.6 a	13 a	11 a	26 a	2.59 a
Zero	60.2 b	12 a	11 a	27 a	1.79 b
N Fert. Mngt					
Zero N	53.1 b	10 b	9 b	26 a	1.34 b
Full N	69.2 a	15 a	14 a	26 a	2.75 a
Half N	66.4 a	13 a	13 a	27 a	2.42 a

In a column for each parameter measured, means followed by the same letter are not significantly different at 5% level of significance.

Significant effects on the yield components such as plant height, tiller and panicle number $hill^{-1}$, supported the grain yield differences in each treated plots.

Conclusion

In general, mowing of rice stubbles after harvest and tillage practices have no effect on soil chemical properties such as pH, OM, OC, total N, mineralizable N, available P and exchangeable K in both cropping seasons. However, during the second cropping, OM content of the soil was generally increased. Mineralizable N was noted to decline during the cropping season as OM increases, implying that OM is accumulated in the soil but is being immobilized by microorganisms. Mineralizable N is decreasing as SOM is increasing.

Incorporation of 4t ha^{-1} straw which is equivalent to one season straw biomass production per hectare was not enough to significantly change the level of SOM, as well as on the chemical properties of Bago sandy clay loam soil during the first cropping season. However, after the second cropping, increase in OM content of the soil was noted whether under improved or conventional fallow and tillage managements. Soil organic matter build-up can be obtained in a long-term practice of improved fallow and tillage management.

Grain yield was significantly affected by conventional tillage management; however, mowing of rice stubbles has no effect on the yield and yield components of rice in both cropping seasons. In general, full- and half-N fertilizer application significantly affected rice yield and yield components such as plant height, tiller and panicle number $hill^{-1}$. The soil indigenous nitrogen supply could not satisfy the rice crop for its normal growth and development, thereby producing significantly lower yield.

Over time, application or incorporation of organic materials such as rice straw could result to increased levels of soil organic matter, thus, continuous recycling and incorporation of rice straw in the soil during fallow period is recommended. With fallow management, the preservation and accumulation of soil organic matter can help improve soil properties, fertility level and productivity thus producing higher yield.

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