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# Effects of straw management, tillage practices on soil fertility and grain yield of rice

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## ABSTRACT

*A long-term experiment to study on tillage practices and rice straw management by different ways such as burning, removal, left over, incorporation and mushroom cultivation, in intensive rice mono-culture has been conducted at the Cuu Long Delta Rice Research Institute (CLRRI), Omon, Vietnam. The data indicated that rice yield was not different among tillage practices during six consecutive rice seasons. Application of rice straw after mushroom cultivation or burning rice straw obtained the higher yield than removal all the rice straw. Nitrogen and phosphorus content of the soil became higher when rice straw was return to the soil anyway by burning, left over, incorporation or cultivation of mushroom. Other chemicals such as Ca, Mg, Na, Zn and Cu were found to be very little changed during three years with six rice seasons.*


## INTRODUCTION

In sustainable agricultural system, recycling of nutrients is the key to nutrient management (King 1990). Among the residues, rice straw is readily available in wetland rice fields and easily incorporated into the soil. Rice straw contains about 0.6%N, 0.1% each of P and S, 1.5% K, 5% Si and 40%C. Since rice straw is a good source of nutrients, yield increases due to straw incorporation over straw burning or removal is about 0.4 t/ha per season, and it increases with time as soil fertility builds up (Ponnamperuma 1984). Earlier reports indicated that straw incorporation improved soil fertility and to some extent increased yield (Marciano et al. 1983; Alberto et al. 1996). Despite the benefits obtained from rice straw incorporation, some farmers seem to adopt this practice. Some farmers remove or burn rice straw *in situ*, some other farmers collected rice straw for mushroom cultivation, resulting to significant losses in soil nutrients.

There is a need to assess the influence of different rice straw management practices on soil nutrient status, pest incidence and crop productivity. At present conditions, meanwhile farmyard has not been developed and the green manure cultivation occupies a large area, the management of rice straw in the field as crop residue for returning the organic matter to the soils is significant in rice production.

## MATERIALS AND METHODS

The experiment was conducted at the experimental field of the Cuu Long Delta Rice Research Institute, Omon district, Cantho province, latitude $10^{o}$ 07' 50"N, longitude $105^{o}$ 34' 80"E and altitude of 3 m above sea level, IR64 was used as a common variety. Soil was classified as *Fluvaquentic Humaquepts*. At the start point of experiment, the soil texture composition is heavy clay with 57% clay (including kaolinite 30-40%, and illite 30%), 42.5% silt and 0.5% sand. Soil texture does not change with depth. The soil was very slow infiltration rate, high water holding capacity and easy to puddle. Soil chemical property was presented in table 1.

The experiment was laid out in strip plot design with three replications including two main plots as no tillage and rotary tillage and four sub treatments with rice straw management. It started in 1998 wet season and ended by 2000 dry season.

Nitrogen applied at the rate of 80 kg N/ha in wet season and 100 kg N/ha in dry season. It was applied in 3 splits at 10, 25 and 45 days after sowing at a proportions of 20, 30, 30 kg N/ha and 30, 35, 35 kg N/ha in wet and dry season, respectively. Phosphorus was basal applied and incorporated into the soil at 50 kg$P_2O_5$/ha. Potassium applied at 50 kg $K_2O$/ha in two splits at 10 and 45 days after sowing. Seed rate of 170 kg/ha was applied.

## RESULTS AND DISCUSSIONS

### 1. Soil characteristics

a. Bulk density:

The data in table 2 showed that bulk density of initial soil was not significantly different among treatments and it was vary from 1.08 - 1.11 g/$cm^3$. Bulk density is lower than initial in plot with tillage application and not significantly different among rice straw

treatments (table 3). After three years without tillage, return rice straw then burning or rice straw left over showed bulk density lower than the plots with remove all of rice straw or application of rice straw after mushroom cultivation. No tillage gained higher bulk density than tillage application.

b. Soil fertility:

Soil organic matter has increased after three years of rice-rice continuous cropping system, even in the plots that remove all of the rice straw. Total nitrogen in soil has increased when return rice straw to the field. Removal of rice straw, total nitrogen has not decreased. Rice straw returned to the soil through incorporation, cultivation of mushroom or burning showed a little increase in phosphorus content of the soil as compared to removal of rice straw. Exchangeable K was also shown small increase when rice straw return to soil as compared to that removal. Other nutrients such as Ca, Mg, Na, Zn, and Cu showed very little change in different rice straw management (table 4).

Table 1: Soil characteristics at initial stage.

| | |
|---|---|
| Soil classification: *Fluvaquentic Humaquepts* | |
| Soil texture (%) | |
| Clay | 57 (Kaolinite 40-50; Illite 30) |
| Silt | 42.5 |
| Sand | 0.5 |
| Very slow infiltration | |
| High water holding capacity | |
| pH | 5.2 |
| Organic mater (%) | 4.24 |
| Total nitrogen (%N) | 0.27 |
| Total phosphorus (%$P_2O_5$) | 0.06 |
| Available phosphorus (ppm) | 0.51 |
| Total potassium (%$K_2O$) | 1.75 |
| K exchange (cmol/kg) | 0.386 |
| Na exchange (cmol/kg) | 0.409 |
| Ca exchange (cmol/kg) | 7.417 |
| Mg exchange (cmol/kg) | 3.020 |
| Zn (ppm) | 74.6 |
| Cu (ppm) | 17.3 |
| CEC (cmol/kg) | 17.5 |

Table 2: Buldensity of soil initial (g/cm$^3$)

| Treatment | Tillage regime | | Treat-means |
|---|---|---|---|
| | No tillage | With tillage | |
| Removal | 1.10 a | 1.09 a | 1.10 a |
| Burning | 1.11 a | 1.09 a | 1.10 a |
| Left over | 1.10 a | 1.11 a | 1.11 a |
| Mushroom | 1.08 a | 1.11 a | 1.10 a |
| Tillage-means | 1.10 | 1.10 | 1.10 |

CV (treat) = 1.6%; CV (treat x tillage) = 3.9%

*Means in a column followed by a common letter are not significantly different at the 5% level by DMRT.*

Table 3: Bulk density of the end of 5$^{th}$ crop (g/cm$^3$).

| Treatment | Tillage regime | | Treat- means |
|---|---|---|---|
| | No tillage | With tillage | |
| Removal | 1.04 a | 0.91 a | 0.98 ab |
| Burning | 0.88 b | 0.90 a | 0.89 b |
| Left over | 0.92 b | 0.91 a | 0.92 ab |
| Mushroom | 1.04 a | 0.93 a | 0.99 a |
| Tillage- means | 0.97 | 0.91 | 0.94 |

CV (treat) = 6.5%; CV (treat x tillage) = 5.3%

*Means in a column followed by a common letter are not significantly different at the 5% level by DMRT*

Table 4: Soil chemical properties at the end of the 5$^{th}$ crop.

| Treat | | OM | N (%) | $P_2O_5$ | $K^+$ | $Na^+$ | $Ca^{++}$ (cmol/kg) | $Mg^{++}$ | CEC | Zn (ppm) | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Initial | 4.24 | 0.27 | 0.064 | 0.12 | 0.12 | 13.9 | 6.3 | 17.5 | 74.6 | 17.3 |
| No | REM | 5.04 | 0.29 | 0.068 | 0.12 | 0.03 | 14.0 | 6.3 | 18.2 | 64.4 | 16.1 |
| tillage | BUR | 5.39 | 0.30 | 0.085 | 0.19 | 0.03 | 13.8 | 5.9 | 17.7 | 82.3 | 16.9 |
| | LEFT | 5.56 | 0.31 | 0.073 | 0.20 | 0.12 | 16.1 | 6.7 | 17.3 | 77.1 | 16.9 |
| | MUS | 5.39 | 0.30 | 0.083 | 0.13 | 0.11 | 14.6 | 6.5 | 17.7 | 80.2 | 16.1 |
| With | REM | 4.41 | 0.27 | 0.061 | 0.12 | 0.13 | 15.9 | 6.7 | 18.2 | 68.6 | 16.5 |
| tillage | BUR | 5.04 | 0.29 | 0.063 | 0.16 | 0.16 | 15.2 | 6.9 | 18.3 | 70.8 | 16.5 |
| | LEFT | 4.99 | 0.28 | 0.053 | 0.19 | 0.21 | 15.7 | 7.1 | 17.7 | 73.9 | 16.1 |
| | MUS | 5.10 | 0.28 | 0.061 | 0.21 | 0.09 | 15.0 | 6.9 | 18.3 | 69.6 | 16.3 |

**2. Rice yield**

In three wet seasons, the rice yields were not significantly different between tillage regimes (table 5). In 1998 wet season, no tillage and tillage did not significantly differ among the treatments. Oh (1979) also obtained that organic carbon contents in soil higher than 2.9% did not benefit for rice plant. In 1999 wet season, plots at no tillage regime and received rice straw burning produced grain yield little higher than that received only rice straw left over. With tillage, return rice straw to the soil produced more rice than removal rice straw. In 2000 wet season, plots in no tillage regime and received rice straw burning also obtained higher yield than that in plots only received rice straw left over on the field surface. In contrast, with tillage, plots received rice straw returning by burn, left over or mushroom cultivation obtained lower yield than removal of rice straw. It might be in the wet season with more toxic substance in the acid sulfate soil, addition of some more organic matter would create more harmful effects than benefit to the crop. Table 5 also shows that plots received rice straw burning without tillage produced higher yield than plots that received rice straw burning with tillage. It means that tillage did not help crop grow better when rice straw was burned in wet season.

Table 5: Effects of season, tillage regime and rice straw management on rice yields in wet seasons

| Treatment | Tillage practices | | Treat - means |
|---|---|---|---|
| | No tillage | With tillage | |
| WS1998 | | | |
| Removal | 3.03 a | 3.03 a | 3.03 a |
| Burning | 3.03 a | 2.98 a | 3.01 a |
| Left over | 2.63 a | 2.68 a | 2.66 b |
| Mushroom | 3.11 a | 2.56 a | 2.84 ab |
| WS1999 | | | |
| Removal | 2.97 ab | 2.66 b | 2.82 a |
| Burning | 3.22 a | 3.04 a | 3.13 a |
| Left over | 2.75b | 2.88 ab | 2.81 a |
| Mushroom | 3.19 ab | 2.86 ab | 3.03 a |
| WS 2000 | | | |
| Removal | 2.87 ab | 3.07 a | 2.97 a |
| Burning | 2.98 a | 2.50 b | 2.74 a |
| Left over | 2.40 b | 3.00 ab | 2.70 a |
| Mushroom | 2.79 ab | 2.71 ab | 2.75 a |
| Tillage - means | 2.91 | 2.83 | 2.87 |

CV (treat) = 7.2%; CV (treat x tillage) = 9.0%; CV (treat x tillage x season) = 9.4%

*Means in a column followed by a common letter are not significantly different at the 5% level by DMRT.*

In three wet seasons (1998,1999 and 2000), it was found that at no tillage, rice straw left over on the surface of the soil gave the lowest rice yield as compared to the other treatments (table 6). With tillage, the rice yields varied more or less similarly among rice straw managements. Application of rice straw after mushroom cultivation or rice straw burning in no tillage gave higher yield than that with tillage. Rice straw incorporated into the soil by tillage gave higher yield than rice straw leaf over without tillage.

In 1998 dry season, rice yields in both of tillage practices were not significantly different among rice straw treatments. In 1999 dry season, no tillage with rice straw burning treatment obtained higher yield than only left rice straw over on the field surface. In

contrast, rice straw burning with tillage gave lower yield than that rice straw after mushroom cultivation. The results of three-dry season average (table 8) showed that without tillage, there were not significantly different among treatments. While at tillage, application of rice straw after mushroom cultivation gained higher yield than rice straw burning. Without tillage, removal, burning or application of rice straw after mushroom cultivation were not different in grain yield, but they better obtained yield than rice straw just left over the soil surface without incorporation. Table 9 showed that average rice yields of six crops with tillage were not significantly different among treatments. While at no tillage, rice straw left over gave lower yield than all other treatments with rice straw incorporation into the soil.

Table 6: Effect of tillage regime and rice straw residue management on rice yield through 3 wet seasons

| Treatment | Tillage regime | | Treat - means |
|---|---|---|---|
| | No tillage | With tillage | |
| Removal | 2.96 a | 2.92 a | 2.94 |
| Burning | 3.08 a | 2.84 a | 2.96 |
| Left over | 2.59 b | 2.85 a | 2.72 |
| Mushroom | 3.03 a | 2.71 a | 2.87 |
| Tillage - means | 2.91 | 2.83 | 2.87 |

CV (treat) = 11.6%; CV (treat x tillage) = 8.1%; CV (treat x tillage x season) = 11.1%

*Means in a column followed by a common letter are not significantly different at the 5% level by DMRT.*

| COMPARISON | S.E.D. | LSD (5%) |
|---|---|---|
| *2 treatment means at each tillage regime* | *0. 13* | *0.29* |
| *2 tillage means at each treatment* | *0.12* | *0.24* |

Table 7: Effect of season, tillage regime and rice straw residue management on rice yield in 3 dry seasons.

| Treatment | Tillage regime | | Treat - means |
|---|---|---|---|
| | No tillage | With tillage | |
| DS 1998 - 1999 | | | |
| Removal | 6.69 a | 5.98 a | 6.33 |
| Burning | 6.40 a | 6.04 a | 6.22 |
| Left over | 6.43 a | 6.20 a | 6.32 |
| Mushroom | 6.37 a | 6.31 a | 6.34 |
| DS 1999 - 2000 | | | |
| Removal | 4.87 ab | 4.76 ab | 4.81 |
| Burning | 5.09 a | 4.67 b | 4.88 |
| Left over | 4.64 b | 4.86 ab | 4.75 |
| Mushroom | 4.80 ab | 5.54 a | 5.17 |
| DS 2000 - 2001 | | | |
| Removal | 5.02 c | 4.86 c | 4.94 |
| Burning | 5.68 b | 5.10 b | 5.39 |
| Left over | 5.74 ab | 5.71 ab | 5.72 |
| Mushroom | 5.71 ab | 5.24 ab | 5.48 |
| Tillage-means | 5.70 | 5.52 | 5.61 |

CV (treat) = 8.0%; CV (treat x tillage) =7.4%; CV(treat x tillage x season)=7.8%

*Means in a column followed by a common letter are not significantly different at the 5% level by DMRT.*

Table 8: Effect of tillage and rice straw management on rice yield in three dry seasons.

| Treatment | Tillage regime | | Treart-means |
|---|---|---|---|
| | No tillage | With tillage | |
| Removal | 5.86 a | 5.53 ab | 5.70 a |
| Burning | 5.72 a | 5.27 b | 5.50 a |
| Left over | 5.60 a | 5.59 ab | 5.59 a |
| Mushroom | 5.62 a | 5.70 a | 5.66 a |
| Tillage-means | 5.70 | 5.52 | 5.61 |

*CV (tillage x season) = 8.4; CV (treat x tillage x season)=6.5%*

*Means in a column followed by a common letter are not significantly different at the 5% level by DMRT.*

Table 9: Effect of tillage and rice straw management on rice yield (t/ha) after six consecutive rice seasons.

| Treatment | Tillage regime | Treat-means |
|---|---|---|

| | No tillage | With tillage | |
|---|---|---|---|
| Removal | 4.41 a | 4.23 a | 4.32 |
| Burning | 4.40 a | 4.06 a | 4.23 |
| Left over | 4.10 b | 4.22 a | 4.16 |
| Mushroom | 4.33 a | 4.20 a | 4.26 |
| Tillage-means | 4.31 | 4.18 | 4.24 |

CV (season) = 15.8%; CV (tillage x season) = 9.9%; CV (treat x tillage x season) = 7.4%
*Means in a column followed by a common letter are not significantly different at the 5% level by DMRT.*

| COMPARISON | S.E.D. | LSD (5%) |
|---|---|---|
| 2 tillage-means at each treatment | 0.11 | 0.24 |
| 2 treat-means at each tillage-regime | 0.10 | 0.21 |

## CONCLUSIONS

Management of rice straw is an important agronomic practice for rice cultivation, it is more important in the area with very highly intensive cultivation such as in the Mekong delta of Vietnam. Among four management practices of rice straw viz., removal, burning, left over and cultivation of mushroom, we found that removal of rice straw is reducing soil chemical property. Burning rice straw is not good as compared to incorporation into the soil. However, it is no time for soil fallow in the wet season, burning and no tillage gave better than rice straw left over without incorporation into the soil or removal. In long run, rice straw incorporation into the soil gave better yield and better physical & chemical property of the soil. Tillage 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. Otherwise, rice straw left over which gave negative effect on grain yield of rice.

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***SUMMARY IN VIETNAMESE***

## Ảnh hưởng của rơm rạ đến độ phì của đất và năng suất lúa

*Viện Lúa ĐBSCL thực hiện thí nghiệm dài hạn liên tục 6 vụ về ảnh hưởng của rơm rạ kết hợp với biện pháp canh tác: đốt đồng, phủ rơm, vùi rơm rạ xuống đất, bón rơm sau khi đã sản xuất nấm, đến năng suất lúa IR64 tại Ô Môn*

*Năng suất lúa không khác biệt giữa các nghiệm thức làm đất qua 6 vụ liên tục.*

*Bón rơm sau khi thu hoạch nấm hoặc đốt rơm sẽ cho năng suất cao hơn không bón rơm (lấy hết rơm sau khi thu hoạch lúa)*

*Hàm lượng N và P trong đất tăng khi rơm rạ được trả lại đất ruộng, cho dù bất cứ dạng nào như đốt rơm, phủ rơm, vùi rơm, hay bón rơm đã hoai sau khi thu hoạch nấm xong*

*Hàm lượng các nguyên tố khác như Ca, Mg, Na, Zn và Cu thay đổi rất ít thông qua ba năm thực hiện các nghiệm thức trong thí nghiệm*