EFFECT OF RICE STRAW ORGANIC FERTILIZER ON RICE YIELD ON ALLUVIAL SOIL OF THE MEKONG DELTA

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ABSTRACT

The experiment was carried out at the Cuu Long Delta Rice Research Institute (CLRRI) in 4 seasons: Dry Season 2020-2021 (DS) and Wet season 2021 (WS) on rice variety (OM4900); DS2021-2022 and WS2022 crops on rice variety OM18; Rice straw organic fertilizer produced from rice straw treated with Trichoderma Sp inoculant (10^8 C.F.U./gram dry matter); sowing density of 100 kg/ha, completely randomized block layout, 7 treatments with 3 replications, experimental plot area of 30 m^2. The treatments included: NT1: Control (-F); NT2: 100% organic rice straw (6 tons ha^1); NT3: 40% NPK as recommended; NT4: 100% organic rice straw (6 tons ha^{-1}) + 40% NPK as recommended; NT5: 100% organic rice straw (6 tons ha^{-1}) + 60% NPK as recommended; NT6: 60% NPK recommended and NT7: 100% NPK recommended. Experimental results showed that, in the fertilizing treatments, NT5 (combined organic rice straw 6 tons ha^{-1} with 60% NPK as recommended) recorded the highest rice yield in all 4 crops (5.72 tons ha^{-1} in the DS2020-2021 and 4.27 tons ha^{-1} in the WS2021 on rice variety OM4900; 4.30 tons ha^{-1} in the DS2021-2022 and 5.04 tons ha^{-1} in the WS2022 on rice variety OM18). Thus, the treatment of 6 tons ha^{-1} of organic rice straw combined with 60% NPK as recommended is the best treatment recommended for organic rice production, helping to improve and maintain intensive rice production and sustainable farming.

Keywords: Long term experiment, organic rice straw, grain yield (GY).

INTRODUCTION

To meet the increasing food demand while land resources are limited, people have applied many necessary solutions to increase crop yield in general and rice yield in particular. In, it is necessary to mention the solutions to intensively cultivate two or three rice crops per year. Conditions of intensive farming increase crops on rice land, and farmers use too many chemical fertilizers which over time will lead to an imbalance of nutrients in the soil, affecting soil fertility and causing environmental pollution (Tran Thi Ngoc Son et al. 2009). In the report of Tran Ba Linh et al. (2002), in the area where rice is grown three times a year, soil fertility gradually decreases. Improving the soil fertility of improving, the application of organic fertilizers to the soil plays a decisive role in the yield and quality of the crop. In particular, the source of organic fertilizer from rice straw is important because the amount of straw left after the rice harvest is very large. According to Ponnamperuma (1984), rice straw contains about 0.6% N; 0.1% P as well as S; 1.5% K, 5% Si and 40% C, etc., they are considered an important source of nutrients to increase rice yield (0.4 ton ha^{-1}) when the rice straw is buried in the soil and used as a raw material that increases the fertility of the soil over time. Although rice straw contains a significant amount of nutrients, most farmers will burn it or bury it directly in the soil in time to prepare for

sowing for the next crop. Burning straw in the field causes pollution and only partially re-supply of inorganic nutrients to the soil. Plowing and burying rice straw directly in the soil during decomposition will cause organic toxicity to rice (Nguyen Thanh Hoi 2008). Therefore, the post-harvest treatment of rice straw is very urgent in intensive rice production areas because it is not only partially restores nutrient loss but also effectively reuses crop by-products.

MATERIALS AND METHODS

Materials

Varieties: OM4900 and OM18. These are high-yield rice varieties with a growth period of 90-100 days, and good resistance to pests and diseases.

Fertilizers: Urea (46% N), Super Phosphorus (16% P_2O_5), Potassium (60% K_2O), and straw after harvesting rice left in the field.

Fungal inoculant (*Trichoderma* sp.) in powder form that has been produced by CLRRI.

This experiment was conducted in an experimental field at the Cuu Long Delta Rice Research Institute (CLRRI), Thoi Lai district, Can Tho city, Vietnam (10°08'N, 105°35'E).

Methods

- Source of organic fertilizer from rice straw: Post-harvest straw is treated with *Trichoderma.* Sp inoculant (10^8 C.F.U./gram dry matter) in soluble powder and 28-30 days after treatment rice straw becomes a source of organic fertilizer. Rice straw organic fertilizer applied in the treatments using organic fertilizer was 6 tons ha^{-1}.

- Rice variety: The rice variety used in the experiment in the DS2020-21 and WS2021 crops are OM4900, in the DS2021-22 and WS2022 crops are OM18.

- The experiment was laid out in a completely randomized block design (RBD), with 3 replicates and 7 treatments. The treatments included: NT1: Control (-F), NT2: 100% organic rice straw (6 tons ha^{-1}), NT3: 40% NPK as recommended, NT4: 100% organic rice straw (6 tons ha^{-1}) + 40% NPK as recommended, NT5: 100% organic rice straw (6 tons ha^{-1}) + 60% NPK as recommended, NT6: 60% NPK as recommended and NT7: 100% NPK as recommended. Area of plot: 5 x 6 = 30 m^2.

- Recommended fertilizer formula for 100% NPK: DS: 100 N-30 P_2O_5-30 K_2O; WS: 80 N-30 P_2O_5-30 K_2O. Chemical fertilizers are applied as follows: P is completely applied before sowing, N is divided into 3 times of application: 10, 22 and 40 days after sowing (DAS). K is divided equally into 2 times of fertilizer 10 and 40 DAS.

Sowing method: Broadcast with 100 kg of seed ha^{-1} in both DS and WS seasons.

- Indicators of monitoring and data processing: Rice grain yield and yield components; All recorded data were analyzed by Mini-tab 16.0.

RESULTS AND DISCUSSION

Effects of organic rice straw and chemical fertilizers on rice yield components of OM4900 in DS2020-2021 and WS2021, OM18 in DS2021-2022 and WS2022

Number of Panicles/m^2: The number of panicles/m^2 of four crop seasons show in **Table 1**. The NT5 in the OM4900 variety was a significantly higher number of panicles/m^2 than the treatments NT1, NT2, NT4, NT6 and NT7 in DS2020-21 while in the OM18 variety, NT5 only gave a significantly higher number of panicles/m^2 than the treatment NT1 in DS2021-22. In WS2021 and WS2022 crops, the number of panicles/m^2 between treatments was not statistically significant, however, the number of panicles/m^2 of 6 tons ha^{-1} of organic rice straw with 60% NPK tended to be higher than that of the other treatments of the experiments. In general, in all 4 crops, the treatment of 6 tons ha^{-1} of organic rice straw + 60% NPK was effective in increasing the number of panicles/m^2 compared to other treatments. This

may be because the application of organic fertilizers helps the soil to be loose, so the rice roots develop well and absorb nutrients more easily (Nguyen Thanh Hoi 2008). In the report of B. R. A. Nagar (1985), the application of organic fertilizers, in addition to providing a number of nutrients to the soil, also improves the efficiency of chemical fertilizers.

Table 1. Effects of organic rice straw and chemical fertilizers on number of panicles/m^2 of OM4900 in DS2020-21 and WS2021, OM18 in DS2021-22 and WS2022**.**

Treatment	Rice variety OM4900		Rice variety OM18	
	DS2020-2021	WS2021	DS2021-2022	WS2022
NT1	370^{c}	291	291^{b}	265
NT2	381^{c}	326	345^{ab}	299
NT3	431^{ab}	315	349^{ab}	305
NT4	374^{c}	325	375^{ab}	313
NT5	474^{a}	351	380^{a}	339
NT6	393^{bc}	330	313^{ab}	316
NT7	406^{bc}	323	305^{ab}	325
F	**	ns	*	ns
CV (%)	9.86	8.19	12.17	10.11

In the same column numbers followed by no characters are not significantly different, followed by different characters are significantly different. * significant difference at 5% level; ** significant difference at 1% level.

Number of filled grains/panicle: Experimental results in 4 crops showed that the number of filled grains/panicle of the treatments of organic fertilizer application of rice straw with the addition of chemical fertilizers in the DS2021-2022 and WS2022, there was no statistically significant difference in 5% level. The number of filled grains/panicle in the DS2020-2021 crop was NT4 (6 tons ha^{-1} of The highest recorded organic rice straw + 40% NPK) and the difference was statistically significant compared with NT1 (-F). In the WS2021 crop, NT6 had the highest number of filled grains/panicles and the difference was statistically significant compared with NT2, NT3, and NT5. This result shows that the treatments of organic fertilizer application of rice straw in combination with chemical fertilizers have an effect on the number of filled grains/panicle, but the extent of the effect is not clear (**Figure 1**). In the DS2021-2022 crop, number of filled grains/panicle was lower than that of the WS2022 crop, possibly because the DS2021-2022 crop was affected by the rice stem gall midge *(Orseolia oryzae)*, which affected number of filled grains/panicle.

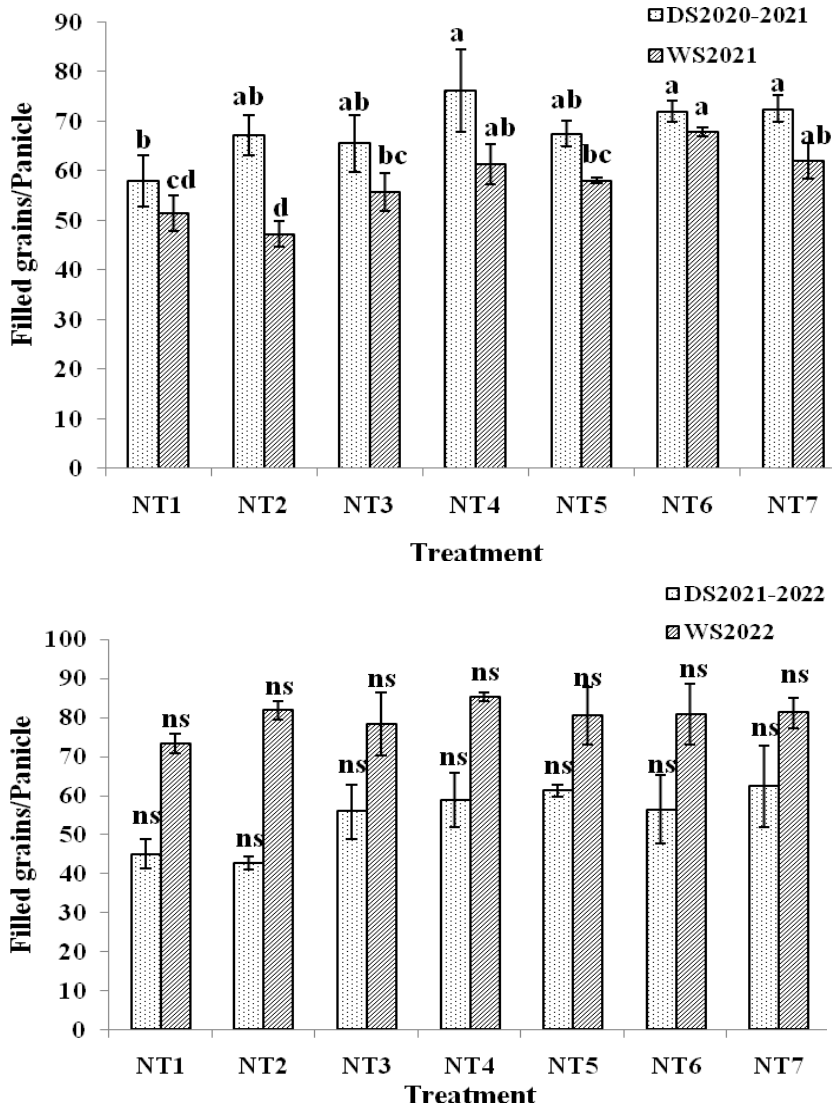

Figure 1. Effects of organic fertilizers of rice straw and chemical fertilizers on the number of filled grain/panicle in 4 seasons DS2020-2021, WS2021, DS2021-2022 and WS2022.

Percentage of unfilled grain (%): The percentage of unfilled grain is severely affected by climate and weather. The percentage of an unfilled grain of the treatments in 3 crops WS2021, DS2021-2022 and WS2022 were not different statistically at 5%. In the DS2020-2021 crop, the percentage of unfilled grain of NT5 was the lowest (21.1%) and was different significantly compared with that of NT4. From the experimental results, it was shown that the treatments of organic fertilizer application of rice straw in combination with chemical fertilizers did not affect the percentage of unfilled grain in the 4 experimental crops (**Figure 2**).

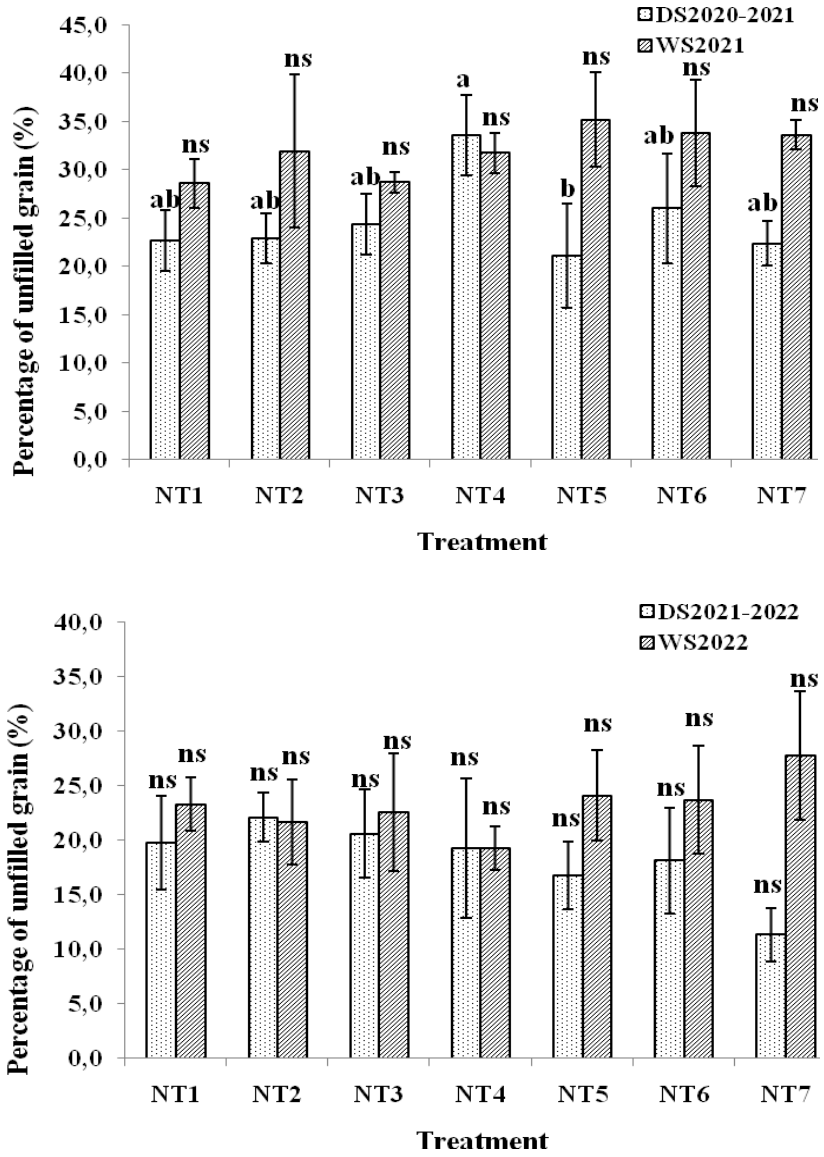

Figure 2. Effect of organic rice straw and chemical fertilizers on the percentage of unfilled grain (%) in 4 seasons DS2020-2021, WS2021, DS2021-2022 and WS2022.

Weight of 1.000 grains: There was no statistical difference between treatments for 1,000-grain weight in 4 crops DS2020-2021, DS2021-2022, WS 2021 and WS2022. The weight of 1,000 seeds of the treatments in 4 crops ranged from 24.4 g to 25.4 g (**Figure 3**).

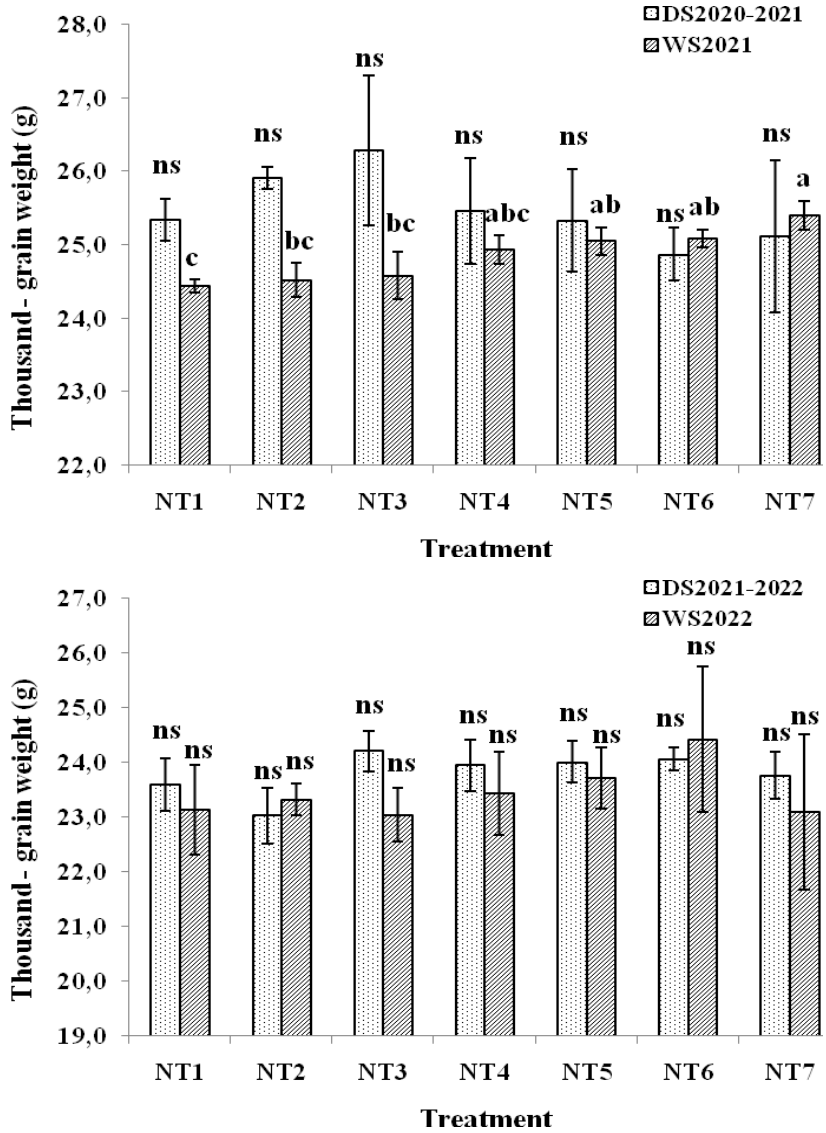

Figure 3. Effects of organic rice straw and chemical fertilizers on the weight of 1.000 grains (g) in 4 seasons DS2020-2021, WS2021, DS2021-2022 and WS2022.

Effects of organic rice straw and chemical fertilizers on rice yield OM4900 in DS2020-2021 and WS2021; OM18 in DS2021-2022 and WS2022

The yield in OM4900 variety of the two crops DS2020-2021 and WS2021 is shown in **Table 2** showing that in the DS2020-2021 crop, the rice grain yield in the treatments of organic straw fertilizer combined with chemical fertilizers was higher than that of in treatment (-F) and synthetic fertilizers treatment. The highest yield was recorded in the treatment of 6 tons ha^{-1} of organic rice straw combined with 60% NPK (5.72 tons ha^{-1}). Similar to the dry season, the rice yield of the treatment with 6 tons ha^{-1} of organic rice straw combined with 60% NPK had the highest yield (4.27 tons ha^{-1}) and the difference was statistically significant at the level of 5% compared with other treatments in WS2021.

The yield in OM18 variety in the two crops DS2021-2022 and WS2022 showed that in the DS2021-2022 crop, the highest rice yield was recorded in the treatment of 6 tons ha^{-1} of organic rice straw combined with 60% NPK (4.30 tons ha^{-1}) which was a statistically significant difference from the treatments NT1, NT2, NT3 and NT6. In the WS2022 crop, the rice yield of the treatment of 6 tons ha^{-1} of organic fertilizer with rice straw combined with 60% NPK had the highest value (5.04 tons ha^{-1}) and the difference was statistically significant at 5% compared with - F (**Table 2**). In the rice yield DS2021-2022 crop was lower than that of the WS2022 crop, possibly because the DS2021-2022 crop was affected by the rice stem gall midge *(Orseolia oryzae)*, which affected the rice yield.

Table 2. Effects of organic rice straw and chemical fertilizers on rice yield OM4900 in DS2020-2021 and WS2021; OM18 in DS2021-2022 and WS2022 (tons ha^{-1}).

Experiment	Rice variety OM4900		Rice variety OM18	
	DS2020-2021	WS2021	DS2021-2022	WS2022
NT1	3.94^{b}	2.80^{c}	2.55^{c}	3.44^{b}
NT2	4.42^{b}	3.65^{b}	2.64^{c}	4.57^{a}
NT3	5.17^{a}	3.70^{b}	3.32^{b}	4.29^{ab}
NT4	5.43^{a}	3.52^{b}	4.23^{a}	4.93^{a}
NT5	5.72^{a}	4.27^{a}	4.30^{a}	5.04^{a}
NT6	5.45^{a}	3.69^{b}	3.51^{b}	4.71^{a}
NT7	5.37^{a}	3.77^{b}	3.87^{ab}	4.79^{a}
F	**	**	**	**
CV (%)	12.74	12.11	20.56	13.53

In the same column numbers followed by no characters are not significantly different, followed by different characters are significantly different. * significant difference at 5% level; ** significant difference at 1% level.

The above results show that organic straw fertilizer plays a very important role in rice production. When fertilizing organic rice straw (6 tons/ha) in combination with 60% NPK fertilizer application gave the rice yield is equivalent to that of 100% chemical fertilizer. This result is consistent with the research results of Tran Thi Ngoc Son et al. (2009) when using organic straw decomposed by *Trichoderma* sp. and bio-fertilizers with chemical N at 25 kg N/ha showed increased rice yield, beneficial soil microorganisms, organic matter, N, P and K all increased significantly. Completely fertilizing rice straw organic fertilizer will increase rice yield by 16% compared to no fertilizer at all. Combining organic rice straw with chemical fertilizer will increase rice grain yield by 22% (Nguyen Ngoc Ha 2000).

CONCLUSIONS

Through 4 rice crops of DS2020-2021, WS2021, DS2021-2022 and WS2022, the results show that the continuous application of organic rice straw at 6 tons ha^{-1} combined with 60% of chemical fertilizers (NPK) as recommended, the number of panicles/ m^2 higher than applying 100% chemical fertilizers. Treatment NT5 (combining organic rice straw 6 tons ha^{-1} with 60% NPK as recommended) gave the highest rice yield in all 4 crops (5.72 tons ha^{-1} DS2021-2021 and 4.27 tons ha^{-1} in WS2021 on rice variety OM4900; 4.30 tons ha^{-1} in

DS2021-2022 and 5.04 tons ha^{-1} in WS2022 on rice variety OM18).

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ẢNH HƯỞNG BỔ SUNG PHÂN HỮU CƠ RƠM RẠ ĐẾN NĂNG SUẤT LÚA TRÊN ĐẤT PHÙ SA NGỌT Ở ĐỒNG BẰNG SÔNG CỬU LONG

Thí nghiệm được thực hiện tại Viện Lúa ĐBSCL trong 4 vụ: Đông Xuân 2020-2021 (ĐX) và Hè Thu 2021 (HT) trên giống lúa OM4900; vụ ĐX2021-2022 và HT2022 trên giống lúa OM18; phân hữu cơ rơm rạ được sản xuất từ rơm rạ được xử lý bằng chế phẩm Trichoderma Sp. (10^8 C.F.U./gram chất khô); mật độ gieo sạ 100 kg lúa giống/ha. Thí nghiệm được bố trí theo khối hoàn toàn ngẫu nhiên với 7 nghiệm thức 3 lần lặp lại, diện tích ô thí nghiệm 30m^2. Các nghiệm thức bao gồm: NT1: Đối chứng (-F); NT2: 100% rơm rạ hữu cơ (6 tấn ha^{-1}); NT3: 40% NPK theo khuyến cáo; NT4: 100% rơm rạ hữu cơ (6 tấn ha^{-1}) + 40% NPK theo khuyến cáo; NT5: 100% rơm rạ hữu cơ (6 tấn ha^{-1}) + 60% NPK theo khuyến cáo; NT6: Bón 60% NPK và NT7: bón 100% NPK. Kết quả thí nghiệm cho thấy, ở nghiệm thức NT5 (kết hợp rơm rạ hữu cơ 6 tấn ha^{-1} với 60% NPK theo khuyến cáo) cho năng suất lúa cao nhất trong cả 4 vụ (năng suất lúa đạt 5,72 tấn ha^{-1} vụ ĐX2021-2021 và 4,27 tấn ha^{-1} ở HT2021 trên giống lúa OM4900; 4,30 tấn ha^{-1} ở ĐX2021-2022 và 5,04 tấn ha^{-1} ở HT2022 trên giống lúa OM18). Như vậy, việc xử lý 6 tấn ha^{-1} rơm rạ hữu cơ kết hợp với 60% NPK theo khuyến cáo là cách xử lý tốt nhất khuyến cáo cho sản xuất lúa hữu cơ, giúp cải thiện và duy trì sản xuất lúa thâm canh bền vững.

Từ khóa: *Thí nghiệm dài hạn, rơm rạ hữu cơ, năng suất lúa.*