Research article

The Effects of the Application of Compost and Chemical Fertilizer on the Growth and Yield of Rice (*Oryza sativa* L.)

THEINGI WIN*
Dept. of Soil and Water Science, Yezin Agricultural University, Myanmar
Email: theingiwin@yau.edu.mm

SWE SWE MAR
Dept. of Soil and Water Science, Yezin Agricultural University, Myanmar

KYI KYI SHWE
Dept. of Soil and Water Science, Yezin Agricultural University, Myanmar

WIN YU HLAING
Dept. of Soil and Water Science, Yezin Agricultural University, Myanmar

HSU MYAT THWIN
Dept. of Soil and Water Science, Yezin Agricultural University, Myanmar

KYAW NGWE
Dept. of Soil and Water Science, Yezin Agricultural University, Myanmar

TORU SAKAI
Japan International Research Center for Agricultural Sciences, Japan

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Abstract The addition of compost to the soil can increase the efficiency of chemical fertilizers, improve plant growth, and sustain the environment. This field experiment was conducted at Yezin Agricultural University Farm, Yezin, Nay Pyi Taw, during the 2020 wet season, from July to November, to investigate sustainable rice production along with optimum farm productivity. The experiment was arranged in a randomized complete block design (RCBD) with four replications. The treatments were as follows; T1 (control, no fertilizer), T2 (100-16-66-12 N, P, K, S) kgha^{-1}, T3 (4 ton ha^{-1} Compost), and T4 (4 ton ha^{-1}Compost and 50-8-33-6 N, P, K, S) kgha^{-1}. Urea, Triple superphosphate, Muriate of potash, and Gypsum were used as sources of N, P, K, and S and the rice variety tested was Sinthukha. The plant growth characteristics were collected at biweekly intervals and yield and yield components were recorded at harvest time. Results showed yield and yield components responded to the application of different treatments. The number of panicles hill^{-1}, the number of spikelets panicle^{-1}, filled grain percent, and harvest index were superior in T4 than for other treatments. The maximum grain yield (7.93 ton ha^{-1}) was observed in T4, followed by (7.03 ton ha^{-1}) T2 and (6.36 ton ha^{-1}) T3 treatments and the minimum grain yield (5.71 ton ha^{-1}) was produced under T1 conditions. According to the results of this study, the application of compost reduces the number of unfilled grain per panicle compared to the control. Therefore, it is necessary to apply organic materials such as compost, which is cheaper than chemical fertilizers and which promotes the recovery soil nutrients. Application of compost increases the yield of rice grain from 11 to 39% compared to the control.

Keywords rice, chemical fertilizer, compost, yield

INTRODUCTION

Rice (*Oryza sativa* L.) is a main staple food and is consumed by half the world's population **(**Chauhan et al., 2017). Production of rice globally was more than 759.6 Mt in 2017 (FAO, 2018). Approximately 90% of all rice is produced and consumed annually; in Asia. However, global mean yields are high compared to the mean yields in Asia. (Haider, 2018). Significantly, there are several ways to improve rice yields. For example, one important way of improving rice yields, is through the proper management of nitrogen (N) fertilizers (Stellacci et al., 2013).

In Myanmar, rice is critical for the economic livelihood and food security of the population (Okamoto, 2004). Throughout Myanmar, resource-poor rural farmers, and landless agricultural laborers combine to grow rice on small farms which average only 2.3 ha in size (Okamoto, 2004). Therefore, more efficient ways to produce rice, that are sustainable and have lower input costs are crucial to the farmers.

In recent times, farmers have mostly relied on costly chemical fertilizers to boost rice yields (Myint et al., 2011). Rice yields are increased initially, but application of chemical fertilizers often results in soil problems, declining crop yields, and contributes to worsening global environmental conditions. Therefore, we need to develop and adopt alternative ways that are environmentally sustainable and maintain soil health, by supplementing or replacing chemical fertilizers. Application of organic fertilizer can conserve the amount and quality of organic matter in the soil, and ensure supply of N, P, K, and essential micronutrients (Timsina and Connor, 2001; Gruhn et al., 2000). Although having many advantages, organic fertilizer application can deliver lower nutrient content compared to chemical fertilizers and may result in nutrient deficiencies and subsequently lower yield (Liu et al., 2009). However, combining the application of organic fertilizer and chemical fertilizer can ameliorate problems caused by the application of chemical fertilizer alone, by neutralizing soil pH, leading to higher levels of organic carbon and improving macro and micronutrient availability, physical properties, and microbial activity (Liu et al., 2009). The combined application also increases the crop yields (Kumar et al., 2014).

OBJECTIVE

The experiment was conducted to determine the effects of the application of compost and chemical fertilizer on the growth and yield of a rice crop and to determine which treatment best supports sustainable production along with optimum productivity.

METHODOLOGY

A field experiment was conducted at Yezin Agricultural University Farm, Yezin, Nay Pyi Taw during the 2020 wet season, from July to November. The Sinthukha rice variety was used for this experiment. Four treatments with four replications were set up with a Randomized Complete Block Design (RCBD). The treatments contained in this experiment were T1 (Control, no fertilizer application), T2 (100-16-66-12 N, P, K, S kg ha^{-1}), T3 (4 ton ha^{-1}, Compost) and T4 (4 ton ha^{-1}, Compost and 50-8-33-6 N, P, K, S kg ha^{-1}).

There were 16 plots and each plot size was $25m^2$ (5m x 5m). Double bunds were constructed 1 m apart between the plots and with 1.5 m between the blocks to prevent water and nutrients flowing from one plot to another. Twenty-five-day-old seedlings were immediately transplanted with two plants per hill at a spacing of 20 cm x 20 cm. Compost (4 ton ha^{-1}) was added one week before sowing to the T3 and T4 plots. Urea, Triple superphosphate, Muriate of potash, and Gypsum were used as N, P, K, and S sources. Triple superphosphate, Muriate of potash, and Gypsum fertilizers were applied basally by broadcast method. Urea was applied at three time splits in the basal, maximum tillering and panicle initiation stages. Regular weed control was undertaken, especially at the early stages of growth. The plots were irrigated whenever necessary. Soil physicochemical properties of the experimental site were as follow; sandy loam texture, moderately acid (pH 5.6) soil with low organic matter (1.28%) which had low level of available nitrogen (51 ppm), medium levels in both available phosphorus (11.4 ppm) and available potassium (178 ppm).

Growth parameters such as plant height and the number of tillers hill^{-1} were recorded from 5 randomly selected hills for each plot, starting 14 days after transplanting (DAT) and at two week intervals. The grain yield was determined from a central 1 m^2 harvested area in each plot and was adjusted for 14% moisture content. The yield component parameters were measured by harvesting 5 hills per plot on a random basis.

The harvest index was calculated by using the following formula; Grain harvest index = (Grain yield)/ (Grain + Straw yield) (Fageria 2011). All the collected data were analyzed using ANOVA with Statistix 8 software. The differences in treatment means were separated by the Least Significant Difference (LSD) at a 5 percent probability level.

RESULTS AND DISCUSSION

Plant height was recorded at 2-weeks intervals from 14 DAT to 98 DAT (Fig. 1). Plants exhibit a continuing increase in height over all treatments from 14 DAT to 84 DAT and the use of compost with chemical fertilizer (T4) significantly influenced the height of the Sinthukha rice variety at 1% level. The lowest height (103.25 cm) is observed in the T1. The highest plant height (109.88 cm) was, as mentioned, in T4, followed by (107.53 cm) in T2. Greatest increases in height were observed with the T4 treatment of compost with chemical fertilizer. The results are in agreement with the findings of Masarirambi et al. (2010). They also found that a half dose of chemical and organic fertilizers significantly increases plant height.

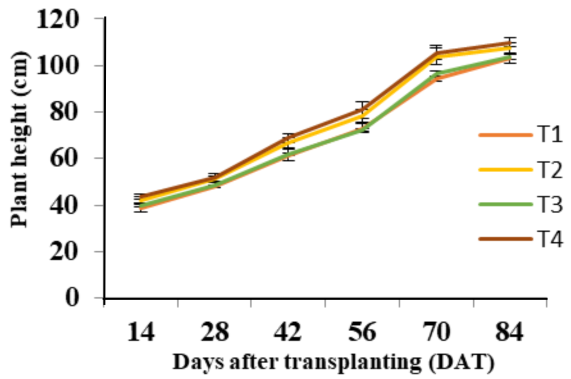

Fig. 1 Plant height (cm) as affected by compost and chemical fertilizer application

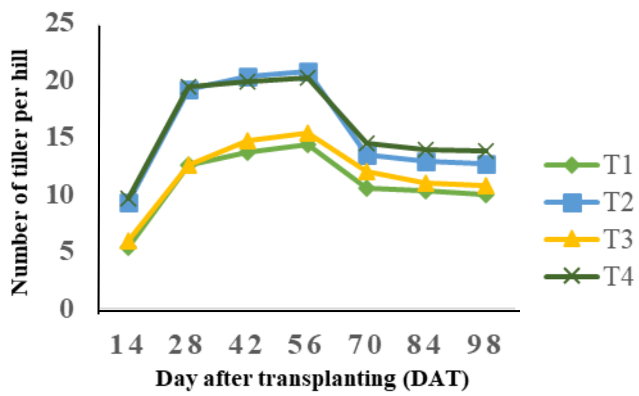

Fig. 2 Number of tillers hill^{-1} as affected by compost and chemical fertilizer application

Tillering, is an important trait for grain production with its correlation to rice yield. The number of tillers hill^{-1} counted at various growth stages are illustrated in (Fig. 2). A significant difference in the number of tillers hill^{-1} can be seen for all growth stages at the 1% level. The number of tillers hill^{-1} range from 10.05 to 13.85 and the maximum value was in T4 followed by T2, T3, with these recorded at the 98 DAT. The treatment T1 showed the lowest number of tillers hill^{-1}. Mirza et al.

(2010) reported that the increased number of tillers hill^{-1} in rice plants is due to the influence of different fertilizer combinations. The more balanced nutrition that the plants can get from organic sources, especially micronutrients, positively affect the number of tillers in plants (Miller, 2007).

The number of productive tillers influences rice productivity rather than the total number of tillers. There were significant differences at the 1% level in the number of panicles hill^{-1} among the treatments (Table 1). The highest number of panicles hill^{-1} (13.70) occurred in T4, followed by T2 (12.50), T3 (10.80), and the lowest value was in T1 (9.65). This result parallels Miller, (2007), who found that a single application of inorganic fertilizers with a high dose is not necessary to produce effective tillers if supplementation with compost as organic sources is provided, thus helping to supply essential micronutrients to the plants.

The panicle lengths range from (22.50 cm) to (23.31cm) and there is a significant difference at the 5% level among the treatments (Table 1). The longest panicle length (23.31cm) was found in T4 which is statically similar to T2 (23.19 cm), while the shortest panicle length (22.50 cm) was in T1. One of the most important factors that affect the rice yield is the number of spikelets per panicle (Yoshida, 1981). The mean value of the number of spikelets per panicle indicate no significant difference between treatments (Table. 1). The maximum number of spikelets panicle^{-1} were produced from T4 (165.55), whereas the second-highest number of spikelets panicle^{-1} (161.85) were from T2, followed by T3 (154.15) and the T1 (149.65) treatments. It was observed that the application of organic matter as a supplement can produce more effective tillering in comparison to sole application of inorganic fertilizers, which also help in providing essential micronutrients to the plants (Miller, 2007; Rakshit *et al*., 2008). Mirza *et al*. (2010) also reported similar results in rice. The filled grain % is not significantly different among the treatments (Table 1). The filled grain % range from 70.75 to 83. The highest filled grain % (83) was found in T4, followed by (76.75) the T2. The lowest filled grain % was in T1. According to the results of this study, the application of compost increases the number of filled grain % in comparison to the control.

The maximum number of 1000 grain weight of 22.01g was in T4 treatment, followed by treatment T2 (21.11 g). There was a significant difference among the treatments at the 5 % level. The treatments T1 and T3, which has the minimum 1000 grain weight, were statistically similar. These results are similar to the findings of Kuepper (2003) which showed that the organic fertilizer improved the 1000 grain weight. The application of inorganic fertilizers, with the addition of organic manures, shows a positive correlation with 1000 grain weight (Anas et al., 2016).

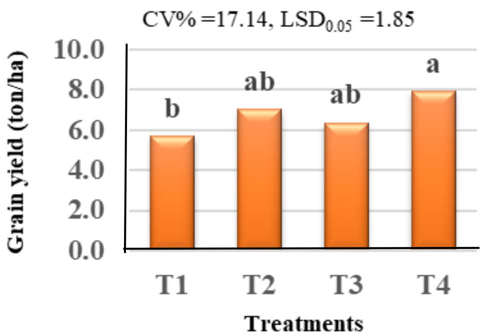

Fig. 3 Grain yields (ton ha^{-1}) with different compost and chemical fertilizer applications

In Fig. 3, T4 achieved the highest grain yield (7.93 ton ha^{-1}), whereas the lowest grain yield (5.71 ton ha^{-1}) was in T1. The maximum grain yield was followed by T2 (7.03 ton ha^{-1}) and T3 (6.36 ton ha^{-1}) treatments. The combined application of compost and chemical fertilizer increased grain yield compared to the control by up to 39% while the increase with the use of chemical fertilizer is 23% compared to the control. The application of compost increases yield by 11% compared to the control. An increase in paddy yield with the use of T4 treatment can be seen in this study and this is similar to that observed by Jagadeeswari and Kumaraswami (2000), and these increases are greater than for treatments with compost alone.

The harvest index of rice as affected by the application compost and chemical fertilizer is not significantly different among the treatments (Table 1). The harvest index ranges from 0.40 to 0.43.

The maximum harvest index (0.43) was recorded in T4 and the second highest (0.42) was observed for the T2 treatment. The minimum value (0.40) was found in T1. T4 produced the greatest number of panicles hill^{-1}, the number of spikelets panicle^{-1}, filled grain percent, and a harvest index superior to other treatments (Table 1). Muhammad (2008) observed that the plant height, number of tillers hill^{-1}, spikelet number panicle^{-1}, grain yield, and 1000 grain weight increased due to the application of organic and chemical fertilizers by enhancing the availability of nutrients.

Table 1 Effects of compost and chemical fertilizer applications on yield and yield components parameters of rice during wet season, 2020

Treatment	Number of panicle hill^{-1}	Number of spikelet panicle^{-1}	1000 grain weight (g)	Filled grain (%)	Panicle length (cm)	Harvest Index
T1	9.65 d	149.65	20.48 b	70.75	22.50 b	0.40
T2	12.50 b	161.85	21.11 ab	76.75	23.19 a	0.42
T3	10.80 c	154.15	20.47 b	76.50	22.96 ab	0.41
T4	13.70 a	165.55	22.01 a	83.00	23.31 a	0.43
$LSD_{0.05}$	0.93	14.19	1.18	18.46	0.58	0.09
pr≥F	**	ns	*	ns	*	ns
CV%	4.97	5.62	3.52	15.03	1.58	14.12

$^{**}p<0.01$; $^{*}p<0.05$; ns: no significant

CONCLUSION

The application of chemical fertilizers combined with composted organic matter increases the number of filled grain panicle^{-1}, 1000 grains weight, and rice yield. This combination of compost along with a half dose of chemical fertilizer provides a suitable integrated fertilizer application for the farmers in the study area. According to this study, the integrated application of compost and chemical fertilizer is a good way to achieve optimum growth and yields of rice and this also reduces cost of fertilizers for the farmers when compared to application of chemical fertilizer alone.

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