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Effects of Organic and Inorganic Fertilizers on the Growth and Yield of Rice (*Oryza sativa* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

To evaluate the effect of different levels of organic and inorganic fertilizers on the growth and yield of SinThuKha rice variety, the experiment was conducted with randomized complete block (RCB) design by three replications. The experiments were carried out in Water Utilization Research section, Department of Agricultural Research (DAR) at Yezin, Naypyitaw, Myanmar during dry and wet seasons, 2023.The organic sources used were poultry manure and cow dung manure. The treatments were T_1 (Control), T_2 (100% RFF) (Recommended Rate of Fertilizer), T_3 (6 t ha^{-1} Cow dung manure) (CM), T_4 (6 t ha^{-1} Poultry Manure) (PM), T_5 (25% RRF + 4.5 t ha^{-1} CM), T_6 (25% RRF + 4.5 t ha^{-1} PM), T_7 (50% RRF+ 3 t ha^{-1} CM), T_8 (50% RRF + 3 t ha^{-1} PM), T_9 (75% RRF+1.5 t ha^{-1} CM), T_{10} (75% RRF+1.5 t ha^{-1} PM). It was observed that the grain yields as well as the yield attributing parameters like number of tillers hill^{-1}, panicle length, number of panicles hill^{-1}, number of spikelets panicle^{-1}, filled grain percent were significantly different among different treatments except

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1000 grain weight. The maximum grain yield was resulted (796.10 g m^2) in dry season and (666.35 g m^2) in wet season at T_8 treatment (50% RRF + 3 t ha^{-1} PM). Among the treatments the higher yield of T_8 and T_{10} were observed in both seasons followed by T_2, T_7 and T_9.

Keywords: Cow dung manure; poultry manure; organic fertilizer.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is a widely consumed staple food and one of the most important sources of nutrition all over the world human population, especially in Asia and Africa [1]. Inorganic and organic are the main sources for replenishing plant nutrients in agricultural soils [2]. The improper application of synthetic fertilizers has polluted soil and water basins. Organic matter and important plant nutrients are no longer present in the soil. Continuous use of inorganic fertilizers leads to deterioration in soil chemical, physical, and biological properties, and soil health [3]. The negative impacts of chemical fertilizers, coupled with escalating prices, have led to growing interests in the use of organic fertilizers as a source of nutrients [4,3]. Inorganic fertilizers are also becoming very costly for farmers to apply the fully recommended rates. It is used in several negative health and environmental consequences [5]. In recent years, there has been serious concern about long-term adverse effects of continuous and indiscriminate use of inorganic fertilizers on deterioration of soil structure, soil health and environmental pollution [6,7,8,9].

Organic manure such as farmyard manure supplies a good amount of plant nutrients and contributes to crop yield. It increases the organic matter in the soil. Even the applications of recommended NPK fertilizers, devoid of organic manure have not sustained soil quality. Soil quality has declined even with the application of recommended NPK fertilizers without organic manure. Therefore, to make the soil well supplied with all the plant nutrients in the readily available form and to maintain good soil health, it is necessary to use organic fertilizer in combination with inorganic fertilizers to obtain optimum yields [10,11]. Use of organic matter to meet the nutrient requirement of crops would be an inevitable practice in years to come, particularly for resource poor farmers. Therefore, the objectives of this study were to evaluate the effects of different levels of organic and inorganic fertilizers and, their combination effects on the growth and yield of SinThuKha rice variety and to develop a suitable integrated level of organic and inorganic fertilizers.

2. MATERIALS AND METHODS

The experiment was carried out from January to June (dry season) and from July to November (wet season), 2023. Both experiments were conducted in Water Utilization Research section, Department of Agricultural Research (DAR) at Yezin, Naypyitaw. The experimental design was a Randomized Complete Block Design (RCBD) with ten treatments and three replications. There were 30 experimental units. The concrete tank with the size of (1.8m length × 0.9m breath × 0.5m height) was used as an individual unit. In the second season experiment, the same treatments were applied to the same plots as in the first season. The ten treatments were presented Table 1. The tested rice variety was SinThuKha rice variety with 135 days duration. Twenty-one days old seedlings were transplanted at the space of 20 cm × 15 cm. Before conducting the experiment, soil samples were collected for the analysis of some physiochemical properties. The results are shown in Table 2. The air-dried organic manures were applied in each treatment. According to the respective treatments, the Organic manures were well incorporated with the topsoil at the depth of 15 cm, with the date of 14 days before transplanting. Analytical results of two kinds of organic manures samples were described in Table 3. As a regular practice, the experimental units were irrigated whenever necessary. For cultural practices, irrigation, weed control, and pest and disease management practices were done when it was necessary.

2.1 Data Collection

Growth parameters such as plant height and number of tillers $hill^{-1}$ were recorded randomly selected 4 hills from each plot in 2 - weeks interval starting from 14 days after transplanting (DAT) until heading stages. For total dry matter, two plant samples were collected at 25 DAT, 55 DAT, 84 DAT and 110 DAT and dried in the shade and then put in an oven at 65℃ ± 5℃ for 48 hours. Dry weights were recorded. At harvest, the grain yields were computed from a central 0.72 m^2 size harvested area in each plot. Four hills were selected as samples to assess the yield component parameters.

Table 1. Treatments of the experiment for both seasons

Treatments	Fertilizers Rates
T_1	Control
T_2	100% RRF (N:P: K- 86:18.5:31 kg ha^{-1})
T_3	CM (6 t ha^{-1})
T_4	PM (6 t ha^{-1})
T_5	25% RRF + CM (4.5 t ha^{-1})
T_6	25% RRF + PM (4.5 t ha^{-1})
T_7	50% RRF + CM (3 t ha^{-1})
T_8	50% RRF + PM (3 t ha^{-1})
T_9	75% RRF + CM (1.5 t ha^{-1})
T_{10}	75% RRF + PM (1.5 t ha^{-1})

RRF=Recommended Rate of Fertilizer
CM=Cowdung Manure
PM=Poultry Manure

Table 2. Measurement of some physicochemical properties of experimental soil

Characteristics	Values	Rating	Analytical Methods
Soil Texture class		Loamy Sand	Pipette method
Soil pH	7.12	Neutral	4A1- 1:5 soil: water suspension
EC (dSm^{-1})	0.42	Non- saline	3A1- 1:5 soil: water suspension
Organic matter (%)	0.69 %	Low	Tyurin's method
Available N ($mg.Kg^{-1}$)	25.20	Very Low	Alkaline permanganate method
Available P ($mg.Kg^{-1}$)	12.87	Medium	9C-Olsen's P-Malachite green
Available K (mg kg^{-1})	75.21	Low	1N Ammonium acetate extraction

Table 3. Measurement of chemical composition in both manures of this experiment

Characteristics	Cow dung manure	Poultry manure
Organic Matter (%)	64.90	32.85
Total N (%)	1.47	2.02
Total P_2O_5 (%)	1.0	1.87
Total K_2O (%)	2.40	2.83
Total S (%)	0.56	0.84
Moisture (%)	2.06	8.37
Organic Carbon (%)	37.64	19.05
C:N ratio	25.60	9.43

Table 4. Amount of (N :P: K) contents in organic and inorganic fertilizers of this experiment

Treatments	Fertilizers Rates	Amount of Nutrients (N:P: K) (kg ha^{-1})
T_1	Control	-
T_2	100% RRF	(86:18.5:31)
T_3	CM (6 t ha^{-1})	(88:26:120)
T_4	PM (6 t ha^{-1})	(121:49:144)
T_5	25% RRF + CM (4.5 t ha^{-1})	(22:5:8) + (66:20:90)
T_6	25% RRF + PM (4.5 t ha^{-1})	(22:5:8) + (91:37:108)
T_7	50% RRF + CM (3 t ha^{-1})	(43:9:16) + (44:13:60)
T_8	50% RRF + PM (3 t ha^{-1})	(43:9:16) + (61:25:72)
T_9	75% RRF + CM (1.5 t ha^{-1})	(65:14:25) + (22:7:30)
T_{10}	75% RRF + PM (1.5 t ha^{-1})	(65:14:25) + (30:12:36)

2.2 Statistical Analysis

All experimental data were analyzed by using the Analysis of Variance (ANOVA) with Statistix (Version 8) software. The differences in treatment means were separated by Least Significant Difference (LSD) at 5% significant level.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height (cm)

Plant height significantly different both inorganic and organic fertilizers application. In both

seasons, plant height increased progressively in all treatments from 14 DAT to 98 DAT (Figs. 1 a and b). The results indicated that only the control treatment (T_1) i.e. (87.83 cm) in dry season and (95.25 cm) in west season) showed lowest plant heights at all growth stages. The treatment T_{10} (75% RRF + Poultry Manure 1.5 t ha $^{-1}$) i.e. (115.17 cm) in dry season and (122.07 cm) which combined with poultry manures and chemical fertilizers had a significantly higher plant height than the other treatments. A similar result was observed by Abdul- Rahman [12] and Moe et al. [13] in ascertaining the combined effect of organic manure and chemical fertilizer on rice. Major nutrient availability was thought to be the cause of the variance in plant height caused by different nutrient sources.

3.1.2 Number of tillers hill^{-1}

The number of tillers hill^{-1} counted at different growth stages between 14 and 98 days after planting, and the count was continuously raised illustrated in Figs. 2 (a and b). In the dry season, all treatments showed a significant change at the 1% level, except for 14 DAT. According to the results treatment T_8 (3 t ha^{-1} Poultry manure +50% NPK) (15.66) in dry season and (16.67) in wet season gave the maximum number of tillers hill^{-1} all different growth stages and the minimum tiller numbers were recorded from control (T_1) (8.73) in dry and (7.43) wet seasons. In the wet season, the maximum numbers of tillers hill^{-1} were found from T_8 (3 t ha^{-1} Poultry manure + 50% NPK) (16.67) which was followed by T_2 (100% NPK only) (15.83) and T_{10} (1.5 t ha^{-1} Poultry manure + 50% NPK) (15.83). Abdul-Rahman [12] and Krismawati et al. [14] reported that combined application of organic and mineral fertilizers produced a higher number of tillers hill^{-1} as compared to all other treatments.

3.1.3 Total dry matter

The total dry matter (TDM) in both seasons was recorded at active tillering, panicle initiation, heading, and harvesting stages. The progressive improvements of total dry matter from active tillering to harvesting stages were recorded Figs. 3 (a and b). The application of both organic and inorganic fertilizations was significantly different on all collecting growth stages. There were some significant differences on other growth stages due to combined application of organic and inorganic fertilizers. The maximum total dry matter was produced by (T_{10}) (75%RRF + Poultry Manure1.5 t ha $^{-1}$). Belay et al. [15] who demonstrated that treatment with poultry manure combined with inorganic fertilizers enhances nutrient availability and creates suitable conditions for growth by reducing nutrient loss and increasing plant dry weight. Organic manures are slow releasing N source found beneficial during subsequent stages of crop, which might have resulted in increasing the total dry matter. Similar results were reported by Moe et al. [13]

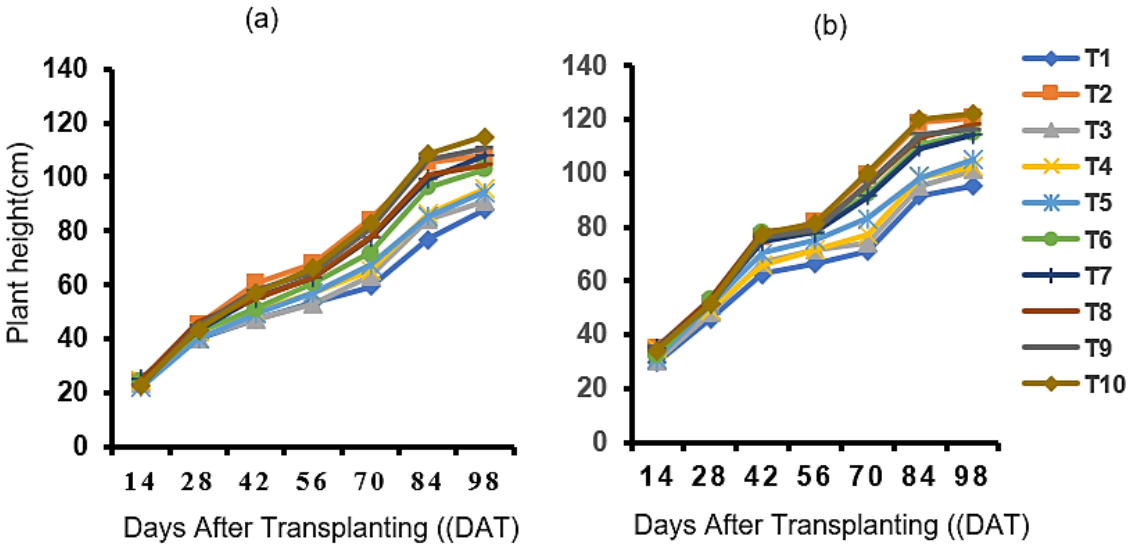


Fig. 1. Plant height (cm) as affected by organic and inorganic fertilizers in (a) dry season and (b)wet seasons, 2023

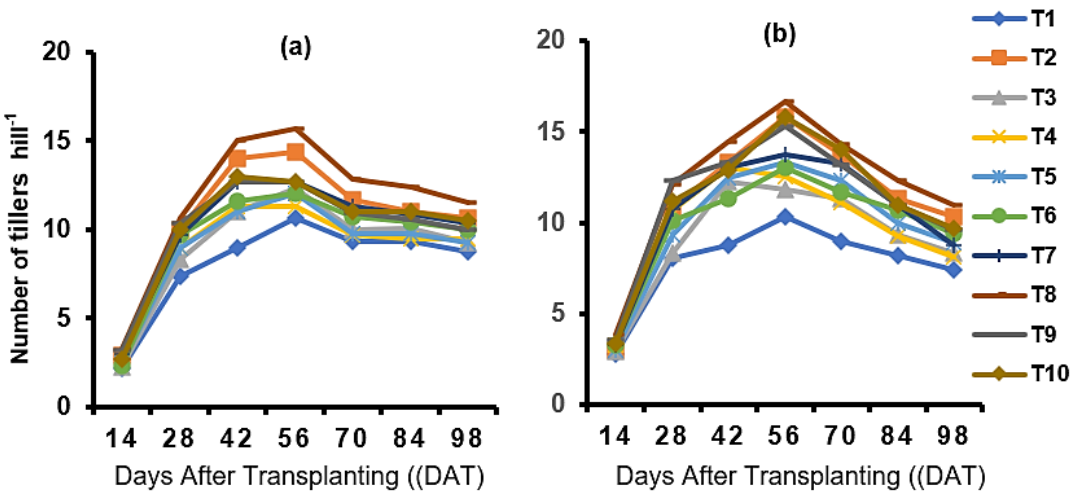
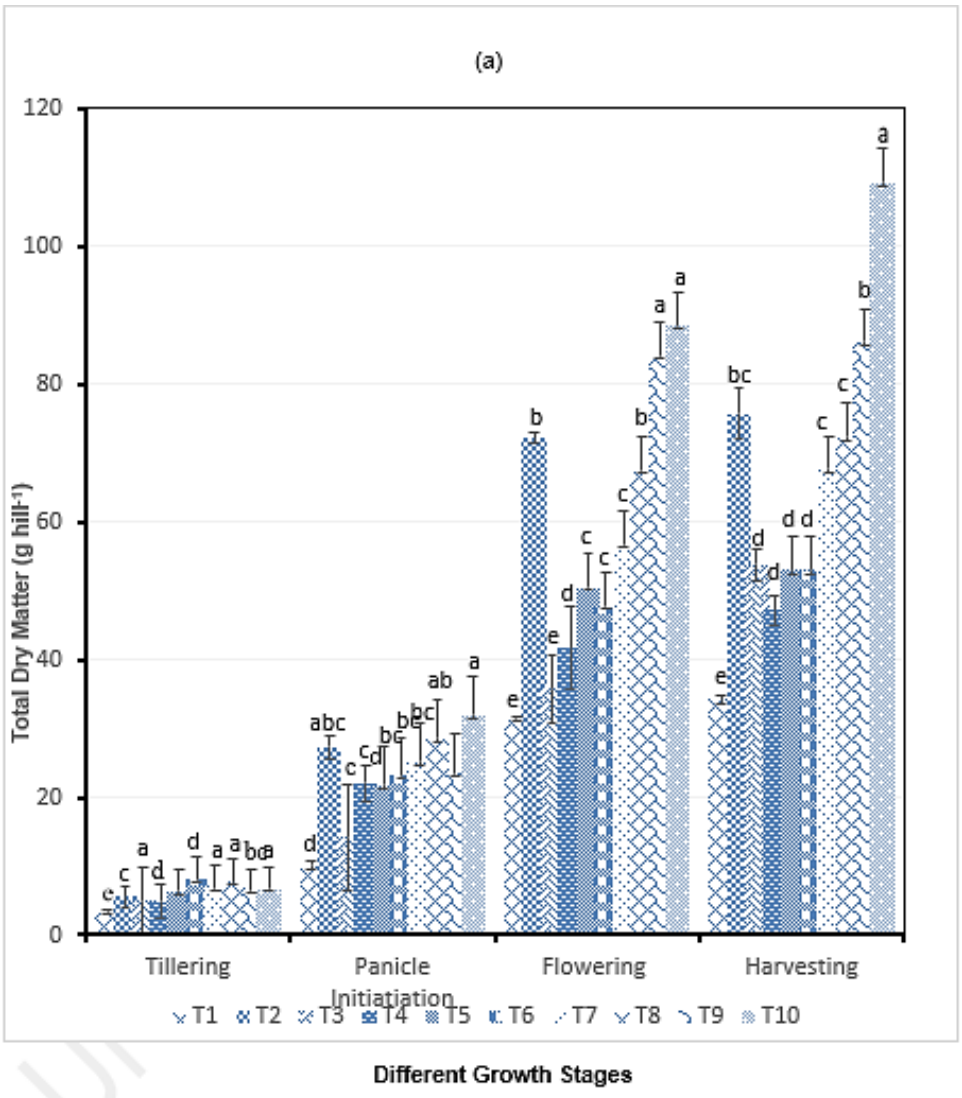


Fig. 2. Number of tillers hill^{-1} as affected by organic and inorganic fertilizers in (a) dry and (b) wet seasons, 2023



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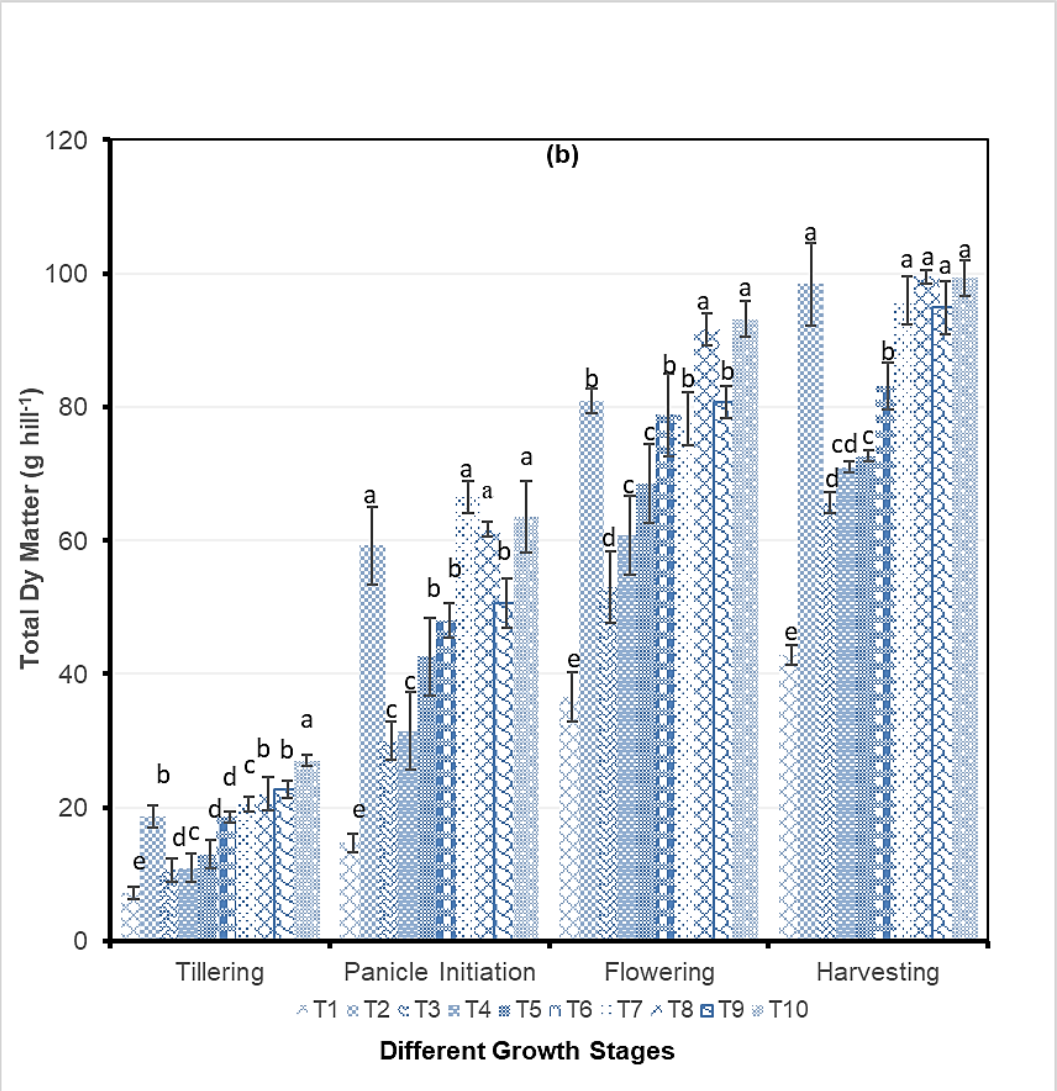

Fig. 3. Total dry matter (g hill^{-1}) at different growth stages as affected by organic and inorganic fertilizers applications in (a) dry and (b) wet seasons, 2023

3.2 Yield and Yield Component Characters

3.2.1 Number of panicles hill^{-1}

Number of panicles hill^{-1} were highly statistically significant difference among treatments at < 0.001(Tables 5 and 6). The maximum number of panicles hill^{-1} (14.00) in dry season and (10.43) in wet season respectively were found in combined application of poultry manure and NPK fertilizer treatment, T_8 (3 t ha^{-1} Poultry manure + 50% NPK). The state in which no fertilizer from T_1 (control) (8.46) in dry season and (7.50) in wet season resulted in the lowest number of panicles per hill. According to Moe et al. [13] combined application of organic and mineral fertilizers produced a higher number of panicles hill^{-1} as compared to all other treatments.

3.2.2 Number of spikelets panicle^{-1}

The effects of organic and inorganic fertilizers on the number of spikelets panicle^{-1} of rice showed highly significant differences among the treatments at 1% level (Tables 5 and 6). In dry seasons, the highest number of spikelets panicle^{-1} was produced by $T_{8,}$ T_{10} and T_2 treatments (175.67), (174.75) and (173.11) respectively. In wet season maximum number of spikelets panicle^{-1} gave T_8 (166.74). The minimum number of spikelets per panicle^{-1} was recorded from the control treatment T_1 (Control) which was significantly different from other treatments in both seasons. Number of spikelets panicle^{-1} is

the most important factor to maximize yield of rice which could be increased by combined application of organic manure and chemical fertilizer compared to the sole application or control treatment [16] and [17]. According to Mahmud [18], Hasan [19] and Sarker [20] organic fertilizers combined with inorganic fertilizer have been shown to improve soil structure, nutrient exchange and maintain soil health, thus providing higher grain yield by achieving a greater number of spikelets panicle^{-1}.

3.2.3 Percentage of filled grain (%)

A highly significant difference in the filled grain percentage was observed in both seasons when the SinThKha variety was treated with different rates of organic and inorganic fertilizers. There was a highly significant effect on filled grain (%) among different treatments. In dry season, the greatest percentage of filled grain resulted in T_8 (3 t ha-1 poultry manure + 50% NPK) (83.14) although T_{10} (1.5 t ha-1 poultry manure + 75% NPK) (82.79) and T_2 (NPK only) (82.43) did not differ significantly from one another. In wet season, (77.23) was produced by T_8 (3 t ha^{-1} poultry manure + 50% NPK) treatment. The lowest filled grain (%) was obtained from T1 (control) (62.66) and (51.57) In both seasons. Arief et al. [21] were observed that NPK fertilizers combined with poultry manure resulting in greater number of filled grain per panicle of rice.

3.2.4 1000 grain - weight (g)

Results showed that there was no significant difference in the effects of organic and inorganic fertilizers application on 1000-grain weight of Sin Thu Kha rice. In both seasons the highest 1000-grain weight was recorded from T_8 (3 t ha-^{1} Poultry Manure+ 50% NPK) (18.64g) in dry season and (19.76g) in wet season. The lowest 1000-grain weight was found in both seasons from (T_1) Control treatment (17.47g) in dry season and (19.10 g) in wet season as shows in Tables (5 and 6). This result was in conformity of the finding of Yang et al. [22] and Shrestha et al. [23] who recorded that 1000-grain weight was increased by the application of chemical fertilizer along with organic manure.

3.2.5 Panicle length (cm)

The combined application of organic and inorganic fertilizers gave significant panicle length of SinThuKha rice in both seasons shown in (Tables 5 and 6). The greatest panicle length was obtained from T_8 (3 t ha^{-1} Poultry Manure+ 50% NPK) (25.90 cm) in the dry season and (24.11 cm) in the wet season. The lowest panicle length was resulted in T_1 treatment (Control) (20.18 cm) in dry and (21.54 cm) in wet seasons. According to Kustera [24] panicle length increased with the application of organic and chemical fertilizers, and this could be due to the increase in the absorption of available nutrients. Alim [25] and Adhikari et al. [17] reported that the length of the panicle is one component that influences the outcome of the results of the rice plant, so the longer panicles potential results obtained tend to be larger than the shorter panicles.

3.2.6 Grain yield (g/m^2)

Grain yield of rice was affected by the application of organic and inorganic fertilizers in both seasons. There were highly significant differences among the treatments at 1% level. It was observed that the treatment T_8 (3 t ha^{-1} Poultry Manure + 50% NPK) gave the highest grain yield (796.10g) in dry and (666.4 g) in wet seasons. Similar yield was observed from treatment T_{10} (1.5 t ha^{-1} poultry manure + 75% NPK) in both seasons. In both seasons the lowest grain yield was given by the control treatment T_1 ranges from (324.83 g) to (317.2 g). Combined application of manure and chemical fertilizer at different levels on rice plants greatly influenced the grain yield due to the increased in plant height, tiller number, panicle length, grains panicle^{-1} and 1000 seed weight in a study by Alam [26]. This may have resulted from the presence of important nutrient sources for plant development and productivity. According to [17] by Mahmud, organic fertilizers supply nutrients through microbial activity, whereas chemical fertilizers make nutrients rapidly available by allowing them to be easily accessed in soil solution. Similarly, it was reported by [26, 27] Alam and Kumar et al. that applying nitrogenous fertilizer and organic manure combined application enhanced rice grain production.

3.3 Cost Analysis

Net return was found highest on T8 (50% RRF+3 t poultry manure ha^{-1}) in both seasons. The highest net return was obtained from T8 (50% RRF+3 t poultry manure ha^{-1}) 1308488 MMK in dry and 1057513 MMK in wet season while the lowest net return was found on T1 (Control) in both seasons Which was MMK 628560 in dry

and 613796 wet seasons. This shows that SinThuKha rice cultivation with T8 (50% RRF+3 t poultry manure ha^{-1}) has a relative economic advantage over T2 (100%RRF) and any other combination of the treatments shown in (Tables 7 and 8).

Table 5. Mean value of yield and yield components parameters of rice as affected by organic and inorganic fertilizers during dry season, 2023

Treatments	No. of Panicle $hill^{-1}$	No. of Spikelet $panicle^{1}$	Filled grain %	1000-grain weight (g)	Panicle Length(cm)	Yield (g/m^2)
T_1	8.46 d	104.49 e	62.66 d	17.47	20.18 f	324.83 g
T_2	13.16 ab	173.11 a	82.43 a	18.32	24.66 ab	720.13ab
T_3	10.42 d	127.10 d	67.98cd	18.27	22.69 de	429.90 ef
T_4	11.0 cd	129.63cd	68.86 bcd	17.92	22.50 e	453.34def
T_5	12.0 bc	133.37 c	69.93 bcd	17.96	23.09 cde	488.69 e
T_6	12.33 bc	133.85 c	78.32 abc	17.90	23.74 bcd	557.42 de
T_7	12.84 ab	154.02 b	78.96 ab	18.30	24.02 bc	621.91 bc
T_8	14.0 a	175.67 a	83.14 a	18.64	25.90 a	796.10 a
T_9	13.0 ab	163.52ab	79.47 ab	17.92	24.44 b	702.96 b
T_{10}	13.26 ab	174.75 a	82.79 a	18.32	24.66 ab	762.51 a
$LSD_{0.05}$	1.49	17.61	11.09	1.01	1.19	108.71
Pr>F	**	**	**	ns	**	**
CV%	7.21	6.95	8.57	3.28	2.94	10.78

*Means followed by different letters in the same column are not significantly different by LSD test at 5% level. * significant difference at 5% level, **significant difference at 1% level, ns non-significant difference*

Table 6. Mean value of yield and yield components parameters of rice as affected by organic and inorganic fertilizers during wet season, 2023

Treatments	No. of panicles $hill^{-1}$	No. of spikelets $panicle^{-1}$	Filled grain %	1000-grain weight (g)	Panicle length (cm)	Yield (g/m^{-2})
T_1	7.50 e	80.53 f	51.57 c	19.10	21.54 c	317.2 e
T_2	9.58 abc	142.72 b	68.91 ab	19.50	24.35 a	649.7ab
T_3	8.26 cde	111.85 de	62.02 bc	18.87	21.63 c	415.4 d
T_4	7.66 de	98.10 ef	64.227 b	19.44	21.71 c	433.5 d
T_5	9.08 abcd	118.10 cd	60.91 bc	19.14	22.31 bc	445.7 cd
T_6	9.2 abc	132.48 bc	66.87 ab	19.18	22.75 abc	545.9 bc
T_7	8.75 bcde	149.37 ab	68.37 ab	19.19	23.75 ab	583.1ab
T_8	10.43 a	166.74 a	77.23 a	19.76	24.11 a	666.4 a
T_9	9.58 abc	139.76 b	66.32 b	19.25	22.86 abc	596.7ab
T_{10}	10.00 ab	166.27 a	71.17 ab	19.42	23.65 ab	664.5 a
$LSD_{0.05}$	1.57	18.30	10.56	0.84	1.74	111.43
Pr>F	*	**	**	ns	*	**
CV%	10.19	8.17	9.37	2.54	4.45	12.17

*Means followed by different letters in the same column are not significantly different by LSD test at 5% level. * Significant difference at 5% level, **significant difference at 1% level, ns non-significant difference*

Table 7. Net returns incurred after application of different combinations of organic and inorganic fertilizer Dry season, 2023

Treatments	Cost of Fertilizers	Gross Return	Net Return
T_1	0	628560	628560
T_2	380000	1393483	1013483
T_3	60000	831875	771875
T_4	84000	877233	793233
T_5	140000	945636	805636
T_6	158000	1078632	920632
T_7	220000	1203423	983423
T_8	232000	1540488	1308488
T_9	300000	1360258	1060258
T_{10}	306000	1475490	1169490

Note: all the amount is in Myanmar Money Kyat MMK@ cost per ha

Table 8. Net returns incurred after application of different combinations of organic and inorganic fertilizer Wet season, 2023

Treatments	Cost of Fertilizers	Gross Return	Net Return
T_1	0	613796	613796
T_2	380000	1257198	877198
T_3	60000	803817	743817
T_4	84000	838841	754841
T_5	140000	862449	722449
T_6	158000	1056340	898340
T_7	220000	1128324	908324
T_8	232000	1289513	1057513
T_9	300000	1154640	854640
T_{10}	306000	1285836	979836

Note: all the amount is in Myanmar Money Kyat MMK@ cost per ha

4. CONCLUSION

From the results of the experiment, it may be concluded that combined application of (50% RRF and poultry manure 3 t ha^{-1}) were significantly influenced among different treatments that the grain yields as well as the yield attributing parameters such as number of tillers $hill^{-1}$, panicle length, number of panicles $hill^{-1}$, number of spikelets $panicle^{-1}$, filled grain percent except 1000 grain weight. The maximum grain yield was resulted (796.10 g m^2) in dry season and (666.35 g m^2) in wet season at T_8 treatment (50% RRF + 3 t ha^{-1} PM). The higher yield of T_8 and T_{10} were observed in both seasons followed by T_2, T_7 and T_9. Among the treatments shows that combined application treatment T_8 (50% RRF + 3 t poultry manure ha^{-1}) was the best combination as it was superior than other combinations treatments and T_2 (100% RRF) with a net return. From the economic point of view, farmers should use the combination of organic manures and reduced rate of inorganic fertilizers to boost the yield of rice as well as to maintain soil fertility and improve soil health. In summary, the combination of organic and inorganic fertilizers can reduce the use of inorganic fertilizers. Other combination of organic manures and chemicals fertilizer may be necessary to be tested for obtaining good agricultural practice for sustainable rice production in Myanmar.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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