Research article

Comparison of Fertilizer Management to Increase Yield and Quality of Rice

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Abstract The purpose of this research was to improve the productivity and quality of rice. This research was to compare various types of fertilizers that are suitable for growing rice. Six experimental models were arranged in RCBD with 3 replications consisting of 18 field plots comprising a total of 5 Rai. Each model was designated as: T0 (no fertilizer: Control group), T1 (pellet compost), T2 (Compost mixed bio-liquid fertilizer), T3 (compost mixed mineral formula called formula-1), T4 (compost mixed higher mineral formula called formula-2), and T5 (compost mixed the highest mineral formula called formula-3). Each type of fertilizer was used at a rate of 50 kilograms per Rai. The rice seed used in the testing was Phitsanulok #2. The experiment was located at Moo 13, Ban Huaidang, Prompiram city, Phitsanulok Province, Thailand during April 2012 to September 2012. The soil data and fertilizers used in an experiment were collected for reference and analysis. Plant Environmental data, growth data, Yields, yield components and production costs were also collected. The data were statistically analyzed using ANOVA and DMRT at a 95% level of confidence. The analysis on the macro- nutrients from the fertilizer was designated: T5, T4, T3, T2 and T1, respectively. The plant growth data the maximum outputs are ranked from T3, T5, T4, T2, T1 and T0 models, respectively. According to the study results on yield and yield components the maximum outputs are ranked from T3, T5, T4, T2, T1 and T0 models (1,119.4, 990.3, 949.3, 872.2, 813.2 and 781.0 kilograms per Rai, respectively). In case of the T3 model compared with T0 (no fertilizer), it was found that the productivity increased 43.3% and the percentage of withered rice decreased 60%. In the study of total production costs, it was found that the maximum production costs per Rai was T5, T4, T3, T2, T1 and T0 models with 6,850, 6,800, 6,730, 6,540, 6,380 and 5,880 Baht per Rai, respectively. When compared with the yields, the least-costs rice production per 1 kilogram were ranked from T3,T5, T4, T2, T0 and T1 models with 6.01, 6.19, 7.16, 7.49, 7.52 and 7.84 Baht per kilogram, respectively. When selling rice at 11,500 Baht per ton, it was found that the highest profits of the models were as follows: T3, T5, T4, T2, T0 and T1 with 6,143.1, 4,538.4, 4,116.9, 4,390.3, 3,101.5 and 2,971.8 Baht per Rai, respectively.

Keywords fertilizer, fertilizer management, rice, quality of rice

INTRODUCTION

The farmers at Moo 13, Ban Huaidang, Prompiram Sub-district, Prompiram District, Phitsanulok Province, Thailand utilize water from Naresuan dam located in Phitsanulok Province to irrigate their rice farms twice a year. The majority of farmers use chemical fertilizer and pesticide to increase the productivity without any basic knowledge on types of fertilizers, proper use or rice production costs. This lack of knowledge leads to higher production cost, soil deterioration, and chemicals left on the product that is unsafe to the consumers (Intanon et al., 2011). As a result of the poor farming methods these farmers have a low income with higher debts.

OBJECTIVE

Therefore, this research aimed to improve productivity and the quality of rice by promoting the cultivation of high-yield rice using effective economical fertilizers.

METHODOLOGY

1. The Experimental Plan: The six experimental models were arranged in RCBD with 3 replications. There were 18 field plots covering a total of 5 Rai. Each model consists of T0 (no fertilizer: Control group), T1 (pellet compost), T2 (Compost mixed bio-liquid fertilizer), T3 (compost mixed mineral formula called formula-1), T4 (compost mixed higher mineral formula called formula-2), and T5 (compost mixed the highest mineral formula called formula-3). Each type of fertilizers was used at a rate of 50 kg per Rai 1) Rai = 1,600 M^2(, the rice seed used for the testing was Phitsanulok #2. The growing test area was located at Moo 13, Ban Huaidang, Prompiram Sub-district, Prompiram District, Phitsanulok Province, Thailand, the test period was between April 2012 to September 2012.

2. Data Collection: data collected consists of following information: 1) weather condition and plant environment at the field plots; 2) analysis of soil before and after the experiment by exploring the macro-nutrients (N, P, K) ,the secondary nutrients (Ca, Mg, S), the micro-nutrients (B, Fe, Cu, Zn, Mn), and the analysis of pH and OM; 3) analysis of the fertilizers by investigating the macro-nutrients (N, P, K), the secondary nutrients (Ca, Mg, S), the micro-nutrients (B, Fe, Cu, Zn, Mn), these tests were conducted at the Soil Science Lab, Faculty of Agriculture Natural Resources and Environment, Naresuan University, Phitsanulok; 4) data on the vegetative growth collected every ten days (e.g. the stem and leaf height, the number of leaves per plant, the number of stem per clump, root-system length and total weight per plant); 5) data on yields and yield components after harvesting and an investigation on the length of panicle of rice, number of rice seeds per panicle of rice, number of healthy seeds and withered seeds per panicle of rice, the number of panicle of rice per square meter, the number of panicle of rice per field plot, the weight of 1,000 seeds, the weight of seeds per field plot, and production per Rai; 6) data on the total production costs. The data were statistically analyzed using ANOVA and DMRT model at a 95% level of confidence used for comparison of treatments.

RESULTS AND DISCUSSION

The weather condition and plant environment at the field plots during the test period of April to September 2012 showed that temperature ranged between 23-36^{o}C, the average rainfall was 73.3 millimeters per month. However, the model area was also irrigated with water from the Naresuan dam. The analysis of soil before the experiment illustrated poor soil conditions, low to moderate level organic compounds of soil, acid soil with a low pH, a very low level of phosphorus and potassium and low acidic water (Japkaew and Intanon, 2010). After the experiment, it was found out that the acidity of the soils that were fertilized with the three types of compost mixed mineral formula was reduce. This could result from the minerals, calcium or dolomites contained in the formula adjusting the levels of the acid soil pH.

Fertilizer analysis data in Table 1 showed that the analysis of fertilizer nutrients used in the experiment and the models that contained maximum nutrients (the macro-nutrients, the secondary nutrients, the micro-nutrients) were T5, T4, T3, T2, and T1with 66.07%, 62.09%, 61.53%, 12.29%, and 9.66%, respectively.

Vegetative growth data showed that the models having the highest results on vegetative growth were as follows: T3, T5, T4, T2, T1, and T0, respectively. The height of the stem and leaves was in accordance with nutrient balance of the fertilizers which provided high level of nitrogen, secondary nutrients, and micro-nutrients. As a result, the compost mixed mineral formula (T3, T5, T4) provided a better growth than other fertilizers (Intanon, 2009). Besides having nitrogen which is necessary component in cell division in the fertilizers, the secondary nutrients,

and the micro-nutrients were also correlated to cell division, the construction of chlorophyll, photosynthesis in plants, growth of stems and leaves (Table 2).

Table 1 Analysis of fertilizers used in the experiment

Treatments	pH	OM %	Total N,P,K (%)	Total Ca, Mg, S (%)	Total B, Fe, Cu, Zn, Mg (%)	Total (%)
T0 No fertilizer (Control)	-	-	-	-	-	-
T1 Pellet compost	6.8	14.50	4.12	4.54	0.004221	8.66
T2 Compost mixed bio-liquid fertilizer	6.8	12.20	7.31	4.98	0.005323	12.29
T3 Compost mixed mineral formula, called formula-1	7.0	5.09	50.90	10.63	0.006268	61.53
T4 Compost mixed higher mineral formula, called formula-2	7.2	3.23	50.50	11.59	0.005687	62.09
T5 Compost mixed the highest mineral formula ,called formula-3	7.5	3.13	53.00	13.07	0.006165	66.07

Table 2 the analysis of vegetative growth

Treatments	stem height*	number of leaves per plant	number stem per tussock	root-system length	total weight per plant
T0 No fertilizer (Control)	80.2c	27.8c	7.6d	25.0c	4.8d
T1 Pellet compost	86.5b	29.8c	7.7d	26.4b	5.5c
T2 Compost mixed bio-liquid Fertilizer	86.5b	31.6b	8.2c	26.6b	5.5c
T3 Compost mixed mineral formula, called formula-1	94.7a	37.3a	9.8a	28.9a	7.0a
T4 Compost mixed higher mineral formula, called formula-2	88.5b	33.8b	8.8b	27.6a	6.2b
T5 Compost mixed the highest mineral formula, called formula-3	91.8a	36.2a	9.5a	28.6a	6.8a
F-Test	*	*	*	*	**
% cv	9.5	9.6	6.6	8.7	8.8

* *Significant at 95% confident interval in each column of the same period, the different in small letter indicated significant at 95% by DMRT*

** *Significant at 99 % confident interval in each column of the same period, the different in small letter indicated significant at 99 % by DMRT*

Yields and yield component data showed that the yields and yield components related to the length of panicle, number of rice seeds per panicle of rice, number of healthy seeds and withered seeds per panicle of rice, the number of panicle of rice per square meter, the number of panicle of rice per a field plot, the weight of 1,000 seeds, the weight of seeds per a field plot. The highest results were from methods as follows: T3, T5, T4, T2, T1 and T0 methods. In addition, it was found that the maximum outputs production per Rai were ranked from T3, T5, T4, T2, T1 and T0 methods (1,119.4, 990.3, 949.3, 872.2, 813.2 and 781.0 kilograms per Rai, respectively). In case of the T3 model compared with T0 (no fertilizer), it was found that the productivity increased 43.3% and the percentage of withered rice decreased 60% (Table 3).

As illustrated in Table 3, fertilizers had a continuous and relative influence on the plants and vegetative growth. Plants grew fast and well resulting from the balance of nutrients which consists of the macro-nutrients, the secondary nutrients, and the micro-nutrients. In the vegetative phase, there were more green area which could be seen from the higher shoots, more leaves, and more clump. Therefore, this created more areas for photosynthesis in plants. Nutrients (Nitrogen, Iron, Copper, Zinc, Sulphur, and Magnesium) were the main factors in synthesis which created organic compounds (carbohydrate and sugar) in plants. The greater number of nutrients, the more organic compound was produced (Chuinon and Intanon, 2011). As a result, there was the weight gain in terms of the weight of each ear of rice and the weight of 1,000 seeds due to the accumulation of

more carbohydrate. It was shown that the yield components improvement resulted in high productivity. It is clear that compost mixed higher mineral formula provided the maximum outputs production (T3, T5, and T4, respectively). In contrast, inadequate and unbalanced nutrient use could significantly result in an increase of withered rice grains per ear (T0 and T1 respectively).

Table 3 Yield and yield components

Treatments	ear length (cm)	number of seeds per ear (seed)	number of healthy seeds per ear (seed)	number of withered rice per ear (seed)	number of ear per square meter (ear)	number of ear per plot field (ear)	weight of ear (g)	weight of 1,000 seeds (g)	weight of ear per plot field (kg)	yield (kg/Rai)
T0 No fertilizer (Control)	19.5c	114.1c	81.7d	50.6c	197.0d	5,920d	2.24c	22.4c	13.26e	781.0d
T1 Pellet compost	22.1c	126.1b	88.4d	36.2b	219.7c	6,226d	2.43b	28.4b	15.12c	813.2c
T2 Compost mixed bio-liquid fertilizer	22.2c	126.7b	103.0c	35.4b	222.3c	6,590c	2.45b	28.6b	17.14b	872.2b
T3 Compost mixed mineral formula, called formula-1	26.8a	135.3a	120.5a	12.6a	236.3a	7,550a	2.93a	35.2 a	22.12a	1,119.4a
T4 Compost mixed higher mineral formula, called formula-2	23.6b	130.5a	113.1b	18.5a	229.3b	7,264b	2.66a	32.1a	19.32b	949.3b
T5 Compost mixed the highest mineral formula ,called formula-3	24.8b	132.6a	116.0a	15.5a	232.0a	7,332b	2.78a	32.5a	20.38a	990.3a
F-Test	*	**	*	**	**	*	*	**	*	**
%cv	6.5	8.8	6.6	9.6	12.2	9.5	12.7	8.8	9.6	12.2

* *Significant at 95 % confident interval in each column of the same period, the different in small letter indicated significant at 95 % by DMRT*

** *Significant at 99 % confident interval in each column of the same period, the different in small letter indicated significant at 99 % by DMRT*

In the study of total production costs, it was found out that T5 has the highest production cost of 6,850 Bahts follows by T4) 6,800 Bahts, T3) 6,730 Bahts, T2) 6,540 Bahts, T1) 6,380 Bahts, Baht per tons, it was found that the highest profits of the successive models were as follows: T3, T5, T4, T2, T0 and T1 (6,143.1, 4,538.4, 4,116.9, 4,390.3, 3,101.5 and 2,971.8 Baht per Rai, respectively).

Total production cost was indicated that the production cost of the three types of compost mixed higher mineral formula were higher, especially T3, however, it yielded the highest productivity per Rai which reduced the production cost per kilogram .Even though T3 had the higher production cost, it provided the highest profit (Intanon et al., 2010). While T0, T1, and T2 had the lower production cost, they received less productivity. It is clear that the production cost per kilogram of T0, T1, and T2 were higher when selling rice at 11.50 Baht per kilogram or at 11,500 Baht per ton and obtained less profit (Table 4).

Table 4 The total production costs

Description	T0 No fertilizer (Control)	T1 Pellet compost	T2 Compost mixed bio-liquid fertilizer	T3 compost mixed mineral formula, called formula-1	T4 Compost mixed higher mineral formula, called formula-2	T5 Compost mixed the highest mineral formula ,called formula-3
1. ploughing and levelling (2 times x 300 Baht/Rai)	600	600	600	600	600	600
2. seeds (35 kg/Rai x 20 Baht)	700	700	700	700	700	700
3. fertilizer/bag	-	400	560	750	820	870
4. plant growth hormones (250 Baht x 1 time) and plant hormones for ear of rice(300 Baht x 2 times) = 850 Baht per Rai	850	850	850	850	850	850
5. pesticide (220 Baht x 1 time)	220	220	220	220	220	220
6. insecticide (200 Baht x 2 times)	400	400	400	400	400	400
7. fuel for water pump and fuel for looking after rice plants	800	800	800	800	800	800
8. harvesting machine rent, included fuel	600	600	600	600	600	600
9. total expense	4,170	4,570	4,730	4,920	4,990	5,040
10. labour cost during the production period *	1,710	1,810	1,810	1,810	1,810	1,810
11. total cost	5,880	6,380	6,540	6,730	6,800	6,850
12. rice yield(kg/Rai)	781.00	813.20	872.20	1,119.40	949.30	990.30
13. cost of productivity (Baht/kg)	7.52	7.84	7.49	6.01	7.16	6.19
14. income when selling 11,500 Baht/ton or 11.50 Baht/kg	8,981.5	9,351.8	10,030.3	12,873.1	10,916.9	11,388.4
15. profit (Baht/kg)	3.98	3.66	4.01	5.49	4.34	5.31
Profit(Baht/Rai)	3,101.5	2,971.8	3,490.3	6,143.1	4,116.9	4,538.4

** a labour cost of production six-month-period excluded T0 which had no fertilizer and direct seeding labour cost.*

CONCLUSION

According to the research findings, it can be concluded that:

1. The fertilizers that contained the most N, P,K, Ca, Mg, S and micro nutrients were T5, T3, T4, T2, and T1, respectively.
2. Fertilizers that enhance rice growth to achieve maximum vegetative growths must have a balance of nutrients consisting of a high number of macro-nutrients and secondary nutrients. It can be little of micro-nutrients and complete with all types of nutrients.
3. Fertilizers or yield models used to maximize outputs were ranked from T3, T5, T4, T2, T1 and T0 (1,119.4, 990.3, 949.3, 872.2, 813.2 and 781.0 kilograms per Rai, respectively). In case of the T3 model compared with no fertilizer, it was found that the productivity increased 43.3% and the percentage of withered rice decreased 60%.
4. In the study of total production costs, it was found that the maximum production costs per Rai was T5, T4, T3, T2, T1 and T0 models (6,850, 6,800, 6,730, 6,540, 6,380 and 5,880 Baht per Rai, respectively). When compared with the yields, the least-costs rice production per 1 kilogram were ranked from T3,T5, T4, T2, T0 and T1 models (6.01, 6.19, 7.16, 7.49, 7.52 and 7.84 Baht per kilogram, respectively).

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