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Response of second ratoon lowland rice (*Oryza sativa* L.) to NK fertilizers at different levels of K application

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Abstract

Granular fertilizers are effective nutrient materials for boosting crop yield in counteracting the possible low productivity problems caused by climate change. This study aimed to determine the response of second ratoon rice plants to nitrogen and potassium (NK) fertilizers at the different levels of potassium (K) application. Choose an NK fertilizer combination that provides a high ratoon yield, and evaluate the profitability of blending N and K fertilizers at different rates of K application. A Randomized Complete Block Design (RCBD) was adopted in establishing the experiment consisting of three replications and six treatments: T_0 = unfertilized control, T_1 = 120 - 60 - 60 kg ha^{-1} N, P_2O_5, K_2O, T_2 = 120 kg ha^{-1} N, T_3 = 120 kg ha^{-1} N + 20 kg ha^{-1} K_2O, T_4 = 120 kg ha^{-1} N + 40 kg ha^{-1} K_2O, and T_5 = 120 kg ha^{-1} N + 60 kg ha^{-1} K_2O. The ratooned plants applied with 120 kg ha^{-1} N + 60 kg ha^{-1} K_2O (T_5) significantly emanated the tallest plant height, more number of tiller hill^{-1}, greater leaf area index (LAI), higher fresh straw yield, longer panicle length, abundant production of spikelets per panicle and produced remarkable productivity compared to unfertilized control. This option obtained a higher gross margin (USD 848.30) similar to T_4 plants which achieved the highest gross margin of USD 866.28, due to lower variable cost incurred in applying K fertilizer. Therefore, T_4 is a feasible and cost-reducing fertilization strategy in providing higher profitability amidst climate change situations.

Keywords: Combined application, granular fertilizer, productivity, profitable investment, second ratooning

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Introduction

Lowland rice (*Oryza sativa* L.) is an essential cereal grain that is mostly cultivated for food production. It is utilized as food to more than fifty percent of the world's populace. This crop contributes remarkable importance to food security that is eventually considered as a primary staple food, the main source of energy and income (Fikriyah, 2018). This crop is grown mostly in Asia wherein this area is considered as the leading rice-producing continent in the world contributing almost ninety percent of the world's rice production (Medical News Today, 2020). In the Philippines, it is consumed by more than 100 million Filipinos, and every Filipino individual has an average consumption rate of milled rice equivalent to 126 kg per person per year (Philippine Statistics Authority [PSA], 2019). Besides, this crop is an important barometer for food sufficiency in the country (Tallada, 2019). However, regarding the rice sufficiency issues particularly on rice shortage, the country continues importing rice from neighboring rice-producing countries to fill the gaps and demands for food because of the country's increasing population. PSA (2015) projected that the population will grow to 128 million by 2030 and 142 million by 2040 and that increased demand for food is expected to increase abruptly.

To meet this challenge, it is imperative to increase the productivity of rice sustainably (Singh et al., 2021). This can be achieved through the adoption of an improved nutrient management option in rice production. The application of NPK fertilizers greatly increased rice yield at a recommended rate depending on the location. According to Bañoc and Asio (2019), rice plants are applied with inorganic fertilizer at the specific level of 90 kg ha^{-1} N, 60 kg ha^{-1} P_2O_5 and 60 kg ha^{-1} K_2O are adequate to produce higher rice yield that eventually achieved high net income. Another option to increase productivity is allowing rice crops to extend their growth as ratoon crops. Rice can be ratooned not only once but several times depending on the season, climatic conditions, and proper nutrition of the growing ratoon crops. With these promising strategies, it is important to study the influence and profitability of nutrient management to second ratoon lowland rice to save time, effort, and the utmost reason to ride on the privilege of a conducive environment in growing such crops.

The necessary macronutrients for the growth and development of crops are nitrogen, phosphorus, and potassium. For the aforesaid macronutrients, nitrogen is most limiting because of its high mobility that can be wasted easily through leaching, carried away by water through seepage and run-off. Another macronutrient that is also limiting and at the same time very important for the proper reproductive growth of ratoon crops is potassium. In this context, the application of both macronutrients is vital leading to higher productivity of second ratoon plants, thereby combining application is an utmost strategy to achieving higher ratoon yield.

The combined application of granular fertilizers is one of the fertilizer management strategies that can enhance the efficient utilization of nutrients. The applied nitrogen and potassium fertilizers at the correct rates and the proper combination provide an adequate supply of nutrients during the period of its growth. Excess application of potassium fertilizer reduces the utilization efficiency of potassium, and it triggers increasing potassium losses to the environment through evaporation, carried by irrigation water through seepage and run-off. Potassium contributes as a very essential nutrient for the growth and maturing of crops. It imbibes in the opening and closing of stomates, phloem transport, ionic balance, and resistance to stresses (Wang et al., 2013; Salami, and Saadat, 2013). It supports photosynthetic processes, distribution of carbohydrates, and synthesis of starch in storage organs that eventually results in achieving higher grain yield (Imas and Magen, 2007; White et al., 2010 and Philip et al., 2012). Insufficient application of potassium results in the reduced production of spikelets due to reduced spikelet fertility and thereby, decrease grain yield. However, to solve the above mentioned constraints, the most vital fertilizer management strategy is the application of inorganic fertilizers at the correct rates at the proper combination. This study aimed at determining the response of second ratoon rice plants to NK fertilizers at the different levels of K application, choosing an NK fertilizer combination that provides high ratoon yield, and evaluating the profitability of combining N and K fertilizers at different rates of K application.

Materials and Methods

The main purpose of this research undertaking was to determine the growth and productivity of lowland rice as ratoon crops. In this way, rice plants were manipulated as second ratooned crops by cutting all plant stubbles of the first ratoon crops uniformly to a height of 40.0cm. During this time, soil sampling was conducted to get soil samples from the entire experimental area. The samples were mixed completely, air drying for two weeks, pulverized, and then sieved in a mesh screen (2mm). The gathered soil specimen did for the purposeful analyses of pH, % organic matter, all nitrogen, available phosphorus, and exchangeable potassium.

A simple experimental design following an RCBD consisting of six treatments and three replications was adopted. A piece of land of ten square meters (5.0m × 2.0m) consisting of ten rows per treatment plot with a plant density of 250 hills per plot. An alleyway of 1.0m and 0.75m between replication and treatment plots, respectively, were arranged correctly for ease of in-field operation and gathering of agronomic and yield and yield component data. The designated treatments adopted in this study are as follows: T_0 = unfertilized (control), T_1 = 120 - 60 - 60 kg ha^{-1} N, P_2O_5, K_2O, T_2 = 120 kg ha^{-1} N only, T_3 = 120 kg ha^{-1} N + 20 kg ha^{-1} K2O, T_4 = 120 kg ha^{-1} N + 40 kg ha^{-1} K2O, and T_5 = 120 kg ha^{-1} N + 60 kg ha^{-1} K_2O.

The experiment tested NSIC Rc222, an inbred rice variety adaptable under lowland ecosystems. Inorganic fertilizer was not applied in the first ratoon plants; instead only spraying of seaweed-based organic fertilizers was adopted. For the fertilized second ratoon crops, however, application of complete fertilizer (14-14-14) was done ten days after harvesting of the first ratoon crops in T_1 plants, and urea (46-0-0) was also applied at a similar period for T_2, T_3, T_4, and T_5 treatment plots as reflected in Table 1. Urea fertilizer was then applied as topdressed at panicle initiation stage for T_1 and T_2 plants while potassium fertilizer was also top dressed in treatments; T_3, T_4, and T_5. The fertilizer applied as topdressed was manipulated during the panicle initiation stage of the second ratoon crop.

Hand weeding operation was manipulated three weeks after harvesting the first ratoon plants. On the other hand, weeding operations were done when there was still the presence of weeds that appeared before the closeout of its plant cover. Watering was done immediately following the harvesting of the first ratoon crop for 3 to 5cm depths. The succeeding irrigation was done intermittently at an interval of 14 days and constantly applied up to 14 days before harvesting the second ratoon crop. Insect pests and diseases were controlled by spraying pesticides while rodents were eliminated through baiting of Coumatetralyl rodenticide (0.75%), which was performed starting at the tillering stage of the second ratoon plants.

Harvesting of panicles was done by the use of a sickle when second ratoon plants attained 85% maturity. The process of harvesting, separating grains, winnowing, and solar drying in the first ratoon crops was done similarly to the second ratoon crops.

Plant parameters studied

The growth characteristics gathered were plant height (cm), the production of tillers hill^{-1}, the LAI in the measurement of leaves, and the straw yield (t ha^{-1}). Plant height (cm) was measured during the heading stage using ten samples of second ratoon plants. The productive tillers hill^{-1} were counted using ten sample plants in each treatment plot when growing panicles achieved 90% maturity. LAI is measured following the protocol of Gomez and Gomez, (1976). The measured leaf area of each leaf was amplified by the correction factor (0.75) developed by Yoshida (1981). The average number of tillers was used in multiplying into the total production of tillers per plant. Then, the entire leaf area of plants used as samples was divided by the total surface area of land grown by the sample plants with a similar formula adopted by Baňoc, (2020). The productivity of rice straws (t ha^{-1}) was set on through collecting all straws in the harvestable area and weighing. Then, the weight of straws per plot was transformed into a per hectare basis as followed by Baňoc, (2020).

The productivity and other yield component parameters gathered were the length of panicles (cm), the production of spikelets per panicle, and grain yield (t ha^{-1}). Panicle length was measured from the required sample panicles per plot at the harvesting period. The panicle length used during statistical analysis was a product of dividing the total length of all panicles by their corresponding number of sample panicles. The production of spikelets per panicle from ten sample panicles was obtained by counting all spikelets present on each panicle and the average production of spikelets per panicle was considered to get the final data. For the productivity of the ratoon (t/ha), all sample panicles in the harvestable area were reaped. The harvested panicles were threshed, grains were solar-dried until attaining 14% moisture, and weighed. Then, the grain load per plot was transformed into a per hectare basis (Baňoc, 2020).

The economic analysis, climatic data, the statistical analysis of variance (ANOVA), and the comparison of treatment means (Tukey's test) were based on the protocol adopted by Lutao and Baňoc, (2020).

Table 1 The application rates of different inorganic fertilizers for second ratoon crops

Treatment	Amount of inorganic fertilizer applied per plot (g)		
	Complete (14-14-14)	Urea (40-0-0)	Muriate of potash (0-0-60)
T_0 - unfertilized (control)	0	0	0
T_1 - 120 - 60 - 60 kg ha^{-1} N, P_2O_5, K_2O	428.57	130.43	0
T_2 - 120 kg ha^{-1} N only	0	260.87	0
T_3 - 120 kg ha^{-1} N + 20 kg ha^{-1} K_2O	0	260.87	33.33
T_4 - 120 kg ha^{-1} N + 40 kg ha^{-1} K_2O	0	260.87	66.66
T_5 - 120 kg ha^{-1} N + 60 kg ha^{-1} K_2O	0	260.87	99.99

Results and Discussion

Soil chemical properties

Results of soil analysis from the experimental site revealed that it contains chemical properties of 5.06 pH, 3.18 % organic matter (OM), 0.225 % nitrogen, 4.569 mg kg^{-1} available phosphorus, and 0.577 me 100 g^{-1} exchangeable potassium (Table 2). The results imply that the tested topsoil was categorized as strongly acrid, contains a low level of OM and available phosphorus, a medium level in total nitrogen, and the presence of a high amount of exchangeable potassium (Landon, 1991). The results of the soil analysis further revealed that the type of soil was appropriate for lowland rice production. However, a low amount of organic matter and available phosphorus are a good quantity of nutrients to adopt the fertilizer dosage of 120 kg ha^{-1} N for this undertaking.

Table 2 Chemical attributes of the soil before the start of the experiment of the second ratoon crops applied with NK fertilizers at different levels of K application

Treatment	Soil pH (H_2O)	Organic matter (%)	Total nitrogen (%)	Usable phosphorus (mg kg^{-1})	Exchangeable potassium (me $100g^{-1}$ soil)
Soil analysis	5.06	3.18	0.225	4.569	0.577

Agronomic characteristics

Statistical analysis revealed that second ratoon crops fertilized with 120 kg ha^{-1} N + 60 kg ha^{-1} K_2O (T_5) significantly ($P \leq 0.05$) obtained higher plant height (115.82cm) than that of unfertilized ratoon plants (73.16cm) but comparable to all other treatments evaluated (Table 3). It was closely followed by second ratoon crops fertilized with 120 kg ha^{-1} N + 40 kg ha^{-1} K_2O (T_4) with a plant height of 114.63cm. Then T_1, T_3, and T_2 with plant heights of 111.23cm, 110.0cm, and 106.22cm, respectively. The taller plant height of the second ratoon lowland rice was may be due to the application of inorganic fertilizers most especially the response of N & K nutrients applied in the soil which was utilized by ratoon plants and resulted to emanate taller plant height. The result of the study was not similar to the findings of Lupos (2015) stressed that the plant response could be attributed to an adequate amount of nutrients such as phosphorus and potassium added to the soil which was used by plants and resulted in promoting early heading and maturity but not on the effect of taller plant height. In this study, the effect of potassium is vital in the formation of carbohydrates and sugar which is the product of photosynthesis, thereby enhancing photosynthetic activity that results in the rapid growth of the rice plant.

For the production of tillers per hill, second ratoon rice crops fertilized with the highest rate of potassium at 60 kg ha^{-1} K_2O (T_5) produced remarkably a higher number of tillers per hill (16.77 tillers) when compared to unfertilized control with 6.63 tillers. All fertilized ratoon crops responded comparatively similarly relative to the productivity of tillers per hill (Table 3). The result of the study was in agreement with the findings of Mirza et al. (2010) claimed that the adoption of different fertilizer combinations to lowland rice would enhance the production of tillers per plant, and this was mainly attributed to the sufficient supply of available nutrients which provide a major role in cell division. Results implied that in attaining abundant productive tillers per hill, an adequate amount of N at 90 kg ha^{-1} is required regardless of methods of fertilizer application (Baňoc, 2020).

Relative to LAI, second ratoon crops fertilized with 120 kg ha^{-1} N + 60 kg ha^{-1} K_2O (T_5) emanated notably with greater LAI (6.74) when compared to unfertilized control plants (1.49) and also in those second ratoon plants applied with N fertilizer only with an LAI value of 5.11 (Table 3). Generally, fertilized ratoon plants regardless of K levels and fertilized with complete fertilizer responded similarly as indicated by comparable LAI values among the fertilizer treatments evaluated. The result constructed with the findings of Baňoc and Asio, 2019 stressed that when ratooned lowland rice was applied with nitrogen at 45 kg ha^{-1} eventually obtained a remarkable improvement in LAI. These findings, confirmed with the results of Gonzaga (2006), stressed that the remarkable increase in LAI in lowland rice was due to high application of inorganic fertilizer through the provision of sufficient available nutrients for enhancing their growth and development (Lasco, 2017). Hence, Hasanuzzaman et al. (2010) evaluated that when there is a sufficient amount of available nutrients to the plants, this results to cause maximum cell elongation or faster cell division that eventually developed better leaf sizes thereby resulting in higher LAI.

For the yield of fresh straws (t/ha), similarly, the second regrowth plants fertilized with 120 kg ha^{-1} N + 60 kg ha^{-1} K_2O (T_5) significantly produced the heaviest straws (6.91 t ha^{-1}) when compared to unfertilized control (1.02 t ha^{-1}), and in regrowth plants fertilized with a complete fertilizer (5.29 t ha^{-1}) and also in those ratoon plants fertilized solely with N fertilizer (T_2) with a straw yield of 5.25 t ha^{-1} (Table 3). However, the yield of fresh straws in T_5 plants was comparable to those plants fertilized with 120 kg ha^{-1} N + 20 kg ha^{-1} K_2O (T_3) and 120 kg ha^{-1} N + 40 kg ha^{-1} K_2O (T_4) with fresh straw yields of 6.58 t ha^{-1} and 6.88 t ha^{-1}, respectively. Results on agronomic characteristics of second ratoon crops showed that regrowth plants fertilized with the highest rate of potassium (60 kg ha^{-1}) combined with N fertilizer (T_5) remarkably elongated a taller plant height, produced an abundant number of tillers per hill, emanated greater LAI, and produced heavier fresh straw yield (t ha^{-1}) than those of unfertilized control plants. The result of the experiment proved that the applied fertilizer enhanced the development of leaf area due to the availability of nutrients resulting in more photo-assimilates, and consequently direct accumulation of dry matter, thereby, an increase in the fresh weight of rice plants (Sarwar et al., 2008). Thus, the improvement of growth characters as influenced by the application of fertilizers might be due to the enhanced metabolic activities which led to faster responses of various plant metabolites importantly responsible for cell division and elongation (Hartwar et al., 2003).

Table 3 Growth parameters of second ratoon lowland rice (*Oryza sativa* L.) applied with NK fertilizers at different rates of K application

Treatment	Plant height (cm)	No. of tillers per hill	LAI	Fresh straw yield (t/ha)
T_0 - unfertilized (control)	73.46 b	6.63 b	1.49 c	1.02 c
T_1 - 120-60-60 kg ha^{-1} N, P_2O_5, K_2O	111.23 a	15.47 a	6.15 ab	5.29 b
T_2 - 120 kg ha^{-1} N only	106.22 a	14.50 a	5.11 b	5.25 b
T_3 - 120 kg ha^{-1} N + 20 kg ha^{-1} K_20	110.00 a	16.37 a	5.64 ab	6.58 a
T_4 - 120 kg ha^{-1} N + 40 kg ha^{-1} K_20	114.63 a	16.67 a	6.44 a	6.88 a
T_5 - 120 kg ha^{-1} N + 60 kg ha^{-1} K_20	115.82 a	16.77 a	6.74 a	6.91 a
F value	48.74	32.26	53.43	234.49
P-value	0.0000**	0.0000**	0.000**	0.000**
CV %	3.76	8.26	8.72	4.75

Yield and yield component parameters

Statistical analysis showed that second regrowth crops fertilized with 120 kg ha^{-1} N + 60 kg ha^{-1} K_2O_5 (T_5) remarkably achieved the longest panicle length (30.80cm) when compared to those ratoon plants not applied with inorganic fertilizer (control) with a panicle length of 19.57cm (Table 4). It was followed by second regrowth fertilized with 120 kg ha^{-1} N combined with 40 kg ha^{-1} K_2O (30.64cm), then T_3, T_1, and T_2 ratoon plants with panicle lengths of 30.39cm, 30.14cm, and 29.52cm, respectively. The longer panicle length obtained in fertilized ratoon plants especially those fertilized with 120 kg ha^{-1} N + 60 kg ha^{-1} K_2O (T_5) was mainly attributed to a significant number of tillers hill^{-1} (16.77), the remarkable taller plant height (115.82cm), broader LAI (6.74), and the heavier fresh straws (6.91 t ha^{-1}). The result might be due to a higher translocation of photoassimilates through a more effective photosynthetic process during the reproductive growth phase as indicated by an excellent plant height, abundant production of tillers hill^{-1}, greater LAI, and heavier fresh straws. For the production of spikelets per panicle, T_5 plants remarkably ($p \leq 0.05$) produced the most abundant number of spikelets panicle^{-1} (164.47 spikelets) when compared to unfertilized ratoon plants (70.73 spikelets) but comparable to all other fertilizer treatments (Table 4). Results indicated that generally second ratoon lowland rice plants emanating longer panicles also equitably correspond with an abundant production of spikelets per panicle. The panicle length and the production of spikelets per panicle showed equitable trends with the production of tillers per hill as mainly attributed to the combined application of NK fertilizers at various levels of K application.

Relative to the grain productivity (t/ha), regrowth plants fertilized with 120 kg ha^{-1} N + 60 kg ha^{-1} K_2O (T_5) significantly achieved the highest grain yield (3.32 t ha^{-1}) when compared to all other treatments except those ratoon plants that adopted a combined application of nitrogen plus potassium at 20 kg ha^{-1} (T_3) and 40 kg ha^{-1} (T_4). The result was constructed with the findings of Baoy and Bañoc (2017) that the supply of N fertilizer contributes remarkably to increasing the productivity of lowland rice resulting in enhanced tiller production; longer length, and heavier weight of panicles; well-developed grains; and higher productivity. The result was confirmed with Sorita (1993), who stipulated that the applied nitrogen improves the development of panicles that eventually result in higher productivity of lowland rice.

The panicle length, the production of spikelets per panicle, and grain yield showed the same trends with the production of tillers hill^{-1} as affected by the combined application of NK fertilizers at the different levels of K application (Table 4). The result was constructed with the study of Stone (2021), who mentioned the role of potassium in supporting the growth of rice plants through the proper movement of water and nutrients between cells. They further revealed that potassium strengthens the stem of plants and helps them to protect from diseases. Thereby, it helps in the flowering process and eventually improves the quality of the fruits of crops.

Table 4 Panicle length (cm), number of spikelets panicle^{-1}, and grain yield (t ha^{-1}) of second ratoon lowland rice (*Oryza sativa* L.) fertilized with NK fertilizers at different rates of K application

Treatment	Panicle length (cm)	No. of spikelets per panicle	Grain yield (t ha^{-1})
T_0 - unfertilized control	19.57 b	70.73 b	0.53 c
T_1 - 120-60-60 kg ha^{-1} N, P_2O_5, K_2O	30.14 a	141.73 a	2.53 b
T_2 - 120 kg ha^{-1} N only	29.52 a	152.40 a	2.52 b
T_3 - 120 kgha^{-1}N + 20 kgha^{-1} K_20	30.39 a	160.33 a	3.00 ab
T_4 - 120 kgha^{-1} N + 40 kgha^{-1} K_20	30.64 a	163.47 a	3.31 a
T_5 - 120 kgha^{-1}N + 60 kgha^{-1}K_20	30.80 a	164.73 a	3.32 a
F value	87.16	11.06	68.94
P value	0.000*	0.0008**	0.0000**
CV %	2.86	13.20	8.60

Profitability analysis

The economic analysis of raising second regrowth rice plants revealed that ratooned plants fertilized with 120 kg ha^{-1} N + 40 kg ha^{-1} K_20 (T_4) gave a higher gross margin of USD 866.28 due to higher grain yield coupled with a lower cost of fertilizer material incurred than those of other treatments adopted (Table 5). Next was the second ratoon plant applied with 120 kg ha^{-1} N + 60 kg ha^{-1} K_20 (T_5) with a gross margin of USD 848.30 which was mainly due to higher productivity. In contrast, unfertilized ratooned plants (T_0) achieved lower gross income (USD212.00) and gross margin (USD 112.08) as mainly attributed to very low productivity (0.53 t ha^{-1}) for the second ratoon crops. Economic analysis implies that the N fertilizer applied at 120 kg ha^{-1} nitrogen + 40 kg ha^{-1} potassium (T_4) was a feasible strategy for growing second ratoon plants as indicated by attaining high profit for the aforesaid rice production. The other best alternative was the application of 120 kg ha^{-1} N fertilizer combined with 60 kg ha^{-1} potassium fertilizer (T_5).

Table 5 Profitability analysis of second ratoon lowland rice (*Oryza sativa* L.) applied with NK fertilizers at different rates of K fertilization

Treatment	Grain yield ($t\ ha^{-1}$)	Total income (USD) ($t\ ha^{-1}$)	Total variable cost (USD) ($t\ ha^{-1}$)	Total margin (USD) ($t\ ha^{-1}$)
T_0 - unfertilized control	0.53	212.00	99.92	112.08
T_1 - 120-60-60 kg ha^{-1} N, P_2O_5, K_2O	2.53	1,012.00	508.24	503.76
T_2 - 120 kg ha^{-1} N only	2.52	1,008.00	364.50	643.50
T_3 - 120 kg ha^{-1} N + 20 kg ha^{-1} K_20	3.00	1,200.00	416.55	783.45
T_4 - 120 kg ha^{-1} N + 40 kg ha^{-1} K_20	3.31	1,324.00	457.72	866.28
T_5 - 120 kg ha^{-1} N + 60 kg ha^{-1} K_20	3.32	1,328.00	479.70	848.30

Conclusion

The combined application of NK fertilizers to second ratoon lowland rice remarkably enhanced taller plant height, the productivity of tiller $hill^{-1}$, LAI, fresh straw yield, panicle length, the production of spikelets $panicle^{-1}$, and grain yield. The application of 120 kg ha^{-1} nitrogen + 40 kg ha^{-1} potassium (T_4) significantly produced higher productivity (3.31 t ha^{-1}) than those ratoon plants fertilized with a complete fertilizer (T_1), urea fertilizer only (T_2), and those unfertilized control plants (T_0). This strategy remarkably achieves the utmost gross margin (USD 866.28) due to a higher grain yield and this also incurs lower input cost in the application of potassium fertilizer compared to all other treatments evaluated. Therefore, an application of 120 kg ha^{-1} N + 40 kg ha^{-1} K_2O is a feasible strategy and a cost-reducing option that provides higher profit in times of unexpected malady relative to climate change scenarios.

Recommendation

The combined application of NK fertilizers amounting to 120 kg ha^{-1} nitrogen + 40 kg ha^{-1} potassium (T_4) is an adequate amount and correct combination highly feasible and economical option to second ratoon lowland rice in enhancing ratoon grain yield. This strategy is an excellent fertilizer management option in attaining higher productivity during the lean months to suffice the need of hungry rice consumers especially in areas that will experience problematic climatic conditions amidst climate change situations.

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