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Ratooning Response of Lowland Rice NSIC Rc216 to the Residual Effect of Goat Manure Application

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Abstract

This study investigated the response of NSIC Rc216 lowland rice ratoon crop to the residual effect of applied goat manure supplemented with various inorganic fertilizer rates. It also evaluated the profitability of rice ratooning as influenced by the abovementioned treatments. The experiment was laid out in a randomized complete block design (RCBD) with three replications and six treatments. The residual effect of goat manure supplemented with inorganic fertilizer during ratoon cropping affected the yields of fresh straws and grains of lowland rice. Ratoon plants with residual effect from the application of 5 t ha^{-1} goat manure in the main crop and supplemented with 30-30-30 kg inorganic NPK ha^{-1} achieved remarkably higher grain yield (1.57 t ha^{-1}) than the residual effect of goat manure alone and unfertilized control plants. This higher yield is mainly attributed to a remarkable yield of fresh straws and abundant tiller production. This treatment also obtained the highest gross margin (Php16,585) during ratooning. This option is an alternative measure in adapting to climate change due to the lower cost of production and shorter period of growing ratoon crops.

Introduction

Rice (*Oryza sativa* L.) is the most crucial food crop in the world (Food and Agriculture Organization Corporate Statistical Database [FAOSTAT], 2012). It is the primary staple food for the majority of the world population (Global Rice Science Partnership [GRiSP], 2013; Ghimiray et al., 2008) and is eaten regularly as the main source of energy and income (Fikriyah, 2018). In the Philippines, Filipinos consume rice abundantly, but one of the problems most Filipino farmers face is the decreasing rice productivity.

Ratooning is one of the potential practices for increasing rice production. It is the ability of the plant to regenerate new tillers from the stubbles of the main crop (Dawn, 2007). This practice saves seed material, efficiently uses the growing season, facilitates crop intensification, and improves agricultural productivity (Sandara, 2011). Rice ratooning offers an opportunity to increase cropping intensity per unit cultivated area because a ratoon crop has a shorter growth duration than the main crop. Moreover, ratoon rice cropping is a cultivation technology that has the potential to increase annual rice production per unit of land area (Mengel & Wilson, 1981). Compared with traditional double-cropping rice systems, ratoon rice cropping can save labor, time, seed, and water and requires neither nursery supplies nor land preparation (Munda et al., 2009). The labor and seed inputs for ratoon rice cropping were reduced by 29% and 52%, respectively, compared with double cropping systems (Liang et al., 2016; Sen & Bond, 2017). The leading rice crop's growth duration ranges from 85-175 days in most varieties, while the ratoon crop's time only ranges from 40-90 days.

The yield of a ratoon crop may reach up to 50% of the main crop yield if crop management practices are adopted. This option can be practiced in the lowland rice ecosystem, wherein it provides higher resource use efficiency per unit of land area. Better production from ratoon crops is possible by adopting appropriate management practices, particularly the maximum utilization of residues from the preceding crop or main crop. This result can be realized by applying animal wastes that might excrete organic matter that cannot be utilized during the present cropping; instead can be used for the succeeding crop. In ratooning, those animal wastes, particularly goat manure applied during the main crop, might be beneficial to the ratooned crop as residue.

Goat manure is one of the good sources of organic fertilizer, and it is also cheap, accessible, and locally available (Usman, 2015). This manure contains 4.9% total nitrogen, 4.1% phosphorus, 1.9% potassium, 1.0% calcium and 0.9% magnesium (Awoduni & Olafusi, 2007). The application of goat manure increases nutrient efficiency and reduces the leaching of nutrients by ensuring nutrient availability to the crop. According to Payne and Lawrence (2019), manure returns organic matter and other nutrients such as calcium, magnesium, and sulfur to enhance soil fertility and quality. Goat manure applied in the soil was found to increase the dry matter of crops, improve soil fertility, and enhance soil microbial growth and water holding capacity (AgriFarming, 2022). According to Odedina et al. (2011), animal droppings especially goat manure are considered an important source of Ca, Mg, and S, and contain little micronutrients and sufficient amounts of N, P, and K that might provide on boosting the physical conditions of the soil. Their research team proved that the application of 10 t ha^{-1} goat manure and NPK fertilizer treatments increased N components deposited in the stem when compared to nonapplied control, and these were remarkably different from other types of animal manures. Awoduni and Olafusi (2007) reported that applying goat manure at the rate of 8 t ha^{-1} enhanced soil organic matter, nitrogen, pH, and phosphorus compared with the pure application of urea, and the former option achieved high pod count and weight. Sanista et al. (2019) in their study confirmed that when high-quality goat manure was applied as fertilizer to cactus resulted to increase in height, diameter, number of rackets $plant^{-1}$, and the number of primary rackets $plant^{-1}$. In another development, Imthiyas and Seran (2017) concluded that the residual effect of goat manure attributed to excellent growth and productivity responses of cowpea (*Vigna unguiculata* L.) when compared to control plants. However, the residual effect of the applied goat manure on the next cropping particularly on ratoon lowland rice is not known. The application of goat manure alone on the main crop would not be practical and economical for lowland rice production since it might require a voluminous quantity of goat manure in the said option. The cost and timing of application need further investigation relative to its nutrient uptake and utilization under lowland rice culture specifically in ratoon crops.

Hence, this study was conducted to determine the growth and yield performance of ratoon lowland rice as affected by the residual effect of goat manure supplemented with inorganic fertilizer during ratoon cropping. It also evaluated the profitability of rice ratooning as influenced by the residual effect of goat manure supplemented with inorganic fertilizer on the ratoon crop.

Materials and Methods

This study was conducted in the experimental field of the Department of Agronomy, Visayas State University (VSU), Visca, Baybay City, Leyte, Philippines, from April 27 to June 14, 2018. The main focus of this study was on the residual effect of goat manure on ratoon lowland rice (*Oryza sativa* L) NSIC Rc216 supplemented with different levels of inorganic fertilizer during ratoon cropping.

During the harvest of the main crop, plant stubbles were cut uniformly to a height of 30cm in all treatment plots. Five soil samples were collected randomly in each treatment plot from the experimental field using a soil auger. The samples were composited, air-dried, pulverized, and sieved in a 2mm wire mesh and submitted to the

Central Analytical Services Laboratory (CASL), PhilRootcrops, VSU, Visca, Baybay, Leyte, Philippines. The samples were analyzed for soil pH by adopting the Potentiometric Method at a 1:1 soil-water ratio (Philippine Council for Agriculture and Resources Research [PCARR], 1980), total N by Kjeldahl Method (International Soil Reference and Information Center [ISRIC], 1995), organic matter by Walkley-Black Method (Nelson & Sommers, 1982), available P by modified Olsen method (Olsen, et al., 1954), and exchangeable K by ammonium acetate extraction atomic absorption spectrophotometry (ISRIC, 1995). After harvesting the ratoon crop, five soil samples were collected from each treatment plot. These soil samples were composited separately, following a similar procedure as the initial soil sampling. These were processed and analyzed for the same soil parameters mentioned above.

The study adopted a Randomized Complete Design (RCBD) with three replications. Each replication was divided into six plots, each measuring 5m × 2m (10m²) with ten rows in each plot. Replication and treatment plots separated by 1.0m and 0.5m alleyways were maintained to facilitate farm operation, management, and data gathering. The original layout and the different treatments of the experiment during the establishment of the main crop were adopted. Only the inorganic fertilizer supplementation was added to the ratooning study: T_0=no fertilizer application (control); T_1=Residual effect (RE), 5 t ha^{-1} Goat Manure (GM); T_2=RE, 5 t ha^{-1} GM + 30-30-30 kg ha^{-1} N, P_2O_5, K_2O applied on the ratoon crop; T_3 = RE, 2.5 t ha^{-1} GM + 60-30-30 kg ha^{-1} N, P_2O_5, K_2O applied on the ratoon crop; T_4 = RE, 2.5 t ha^{-1} GM + 90-30-30 kg ha^{-1} N, P_2O_5, K_2O applied on the ratoon crop; and T_5 = 120-60-60 kg ha^{-1} N, P_2O_5, K_2O applied on the ratoon crop.

Cultural Management of the Ratoon Crop

After harvesting the main crop, the rice stubbles were cut at 30cm above the soil surface using a sickle. Cutting of rice stubbles was done right after the main crop was harvested. The ratoon crops were supplied with a complete fertilizer (14-14-14) and urea (46-0-0). Complete fertilizer was used to satisfy the 30-30-30 kg ha^{-1} N, P_2O_5, K_2O for treatments T_2, T_3, and T_4, and the rate of 60-60-60 kg ha^{-1} N, P_2O_5, K_2O for T_5. However, the remaining amount of N was supplied with urea at 65.22g, 130.43g, and 130.43g for treatments T_3, T_4, and T_5, respectively. Table 1 presents the amount (g) of fertilizer applied per 10m² plot. The ratoon crop was hand weeded two weeks after the emergence of regrowth to control weeds. The subsequent hand weeding operations were done as soon as weeds emerged until the plant canopies closed in.

After harvesting the main crop, the area was irrigated to a 2-3cm depth. Intermittent irrigation started 14 days after the emergence of regrowth and continued until two weeks before harvesting the ratoon crop. Spraying of Methomyl insecticide (Lannate) and Panyawan were done three weeks after harvesting the main crop to control insect pests.

Table 1

Type and Amount of Inorganic Fertilizer Applied per 10m² Plot, by Treatment

Treatment	Complete (14-14-14) 14 Days after harvesting (g)	Urea (46-0-0-) Panicle Initiation (g)
T_0- No fertilizer application (control)	-	-
T_1- RE (5 t ha^{-1}) goat manure (GM)	-	-
T_2- RE (5 t ha^{-1}) GM + 30-30-30 NPK (kg ha^{-1}) applied on the ratoon crop	214.29	-
T_3- RE (2.5 t ha^{-1}) GM + 60-30-30 NPK (kg ha^{-1}) applied on the ratoon crop	214.29	65.22
T_4- RE (2.5 t ha^{-1}) GM + 90-30-30 NPK (kg ha^{-1}) applied on the ratoon crop	214.29	130.43
T_5- 120-60-60 NPK (kg ha^{-1}) applied on the ratoon crop	428.57	130.43

Harvesting was done when the rice grains of each treatment plot reached 85% physiological maturity, as indicated by the yellow color and healthy grains. All sample plants within the harvestable area (5.04m^2), excluding two border rows on each side of each treatment plot and two end hills at both ends of the row, were cut at the crop base with a sharp sickle. These were threshed, and the grains were sundried for three days to attain 14% moisture before gathering the necessary data. The collected data were mainly the agronomic characteristics, yield and yield component parameters, harvest index, cost and return analysis, and meteorological data from harvesting the main crop until harvesting the ratoon crop. The agronomic characteristics gathered were the number of days from harvesting of the main crop to heading of the ratoon crop, the number of days from harvesting of the main crop to the harvesting of the ratoon crop, plant height (cm) at heading, leaf area index (LAI), flag leaf length (cm) at maturity and fresh straw yield (t ha^{-1}). The yield and yield component parameters gathered were the number of productive tillers per hill, number of filled spikelets per panicle, panicle length (cm), panicle weight (g), weight (g) of 1,000 grains, and grain yield (t ha^{-1}). Harvest index (HI), cost, and return analysis adopting gross margin analysis were gathered, including meteorological data such as total weekly rainfall (mm), minimum and maximum temperatures (°C), and relative humidity (%) throughout the conduct of this study. Analysis of variance (ANOVA) of all data gathered was done using Statistical Tool for Agricultural Research (STAR). Tukey's HSD test was used to compare treatment means.

Results and Discussion

Soil Analysis

The soil test results relative to the initial soil analysis showed that the soil had a pH of 4.89, organic matter (OM) of 5.85%, total N of 0.55%, obtainable phosphorus (P) of 1.34 (mg kg^{-1}), and convertible potassium (K) of 0.61 (me 100g^{-1}) as reflected in Table 2. The results indicated that the experimental area is very strongly acidic with a medium amount of organic matter, a high amount of total N, a meager amount of obtainable P, and a high amount of convertible K (Landon, 1991).

The final soil test result showed that soil pH, % OM, total N, and convertible K generally declined after harvesting the ratoon crop while obtainable P increased. The reduction of soil pH might be due to the application of inorganic fertilizer, especially in T1-T4 plots. The decrease in OM, total N, and

Table 2

Soil Test Results After Harvesting the Main and Ratoon Crops of Lowland Rice in the Experimental Area

Treatment	Soil pH (1:1)	Organic Matter (%)	Total N (%)	Available P (mg kg^{-1})	Exchangeable K (me 100g^{-1})
Initial Analysis	4.89	5.85	0.55	1.34	0.61
Final Analysis					
T0- No fertilizer application (control)	4.62	3.34	0.24	7.64	0.33
T1- RE (5 t ha^{-1}) goat manure (GM)	4.87	3.39	0.24	8.77	0.16
T2- RE (5 t ha^{-1}) GM + 30-30-30 NPK (kg ha^{-1}) applied on the ratoon crop	4.80	3.67	0.27	8.43	0.37
T3- RE (2.5 t ha^{-1}) GM + 60-30-30 NPK (kg ha^{-1}) applied on the ratoon crop	4.82	3.99	0.28	8.84	0.26
T4- RE (2.5 t ha^{-1}) GM + 90-30-30 NPK (kg ha^{-1}) applied on the ratoon crop	4.71	3.38	0.24	8.73	0.25
T5- 120-60-60 NPK (kg ha^{-1}) applied on the ratoon crop	4.89	4.19	0.28	7.17	0.22
Mean	4.79	3.66	0.26	8.26	0.26

convertible K could be attributed to crop utilization and losses due to leaching (Lutao & Baňoc, 2020). However, the increase of obtainable P might be due to organic fertilizer applied in T1, application of inorganic fertilizer in T5, and organic and inorganic fertilizers in T2, T3, and T4 plots. The result of soil analysis conformed with the findings of Chairoj et al. (1984) that applying organic fertilizer resulted in the enrichment of readily decomposable organic matter. Lupos (2015) stated that a slight increase in available P was observed upon applying different levels of organic fertilizer. The increase may be attributed further to the mineralization of nutrients from the applied organic materials, crop residues of the previous cropping, and the decomposed plant materials of the ratooned crop (Baňoc et al., 2022).

Agronomic Characteristics

Statistical analysis revealed that the residual effect of goat manure supplemented with different levels of inorganic fertilizer did not significantly affect the number of days from harvesting of the main crop to heading and maturity of the ratoon crop (Table 3). On the other hand, significant differences were observed in plant height, leaf area index, flag leaf length, and straw yield (t ha^{-1}).

Among the treatments tested, ratoon lowland rice applied with 120-60-60 kg ha^{-1} N, P_2O_5, and K_2O (T5) achieved the tallest plant significantly. This result implies that application of inorganic fertilizer alone at the recommended rate of application (T5) could significantly contribute to taller plant height due to the high availability and immediate release of nutrients available for crop uptake as compared to treatments applied with organic fertilizer, wherein it releases nutrients slowly due to the decomposition process.

A similar trend was obtained in the leaf area index (LAI). Islam et al. (2008) reported that the tallest plant of the main crop, as well as the ratoon crop, was produced by F3 plants applied with inorganic fertilizer at the rate of 120-65-70 kg ha^{-1}

Table 3

Agronomic Characteristics of Ratoon Lowland Rice (Oryza sativa L.) to the Residual Effect of Goat Manure Application Supplemented with Different Levels of Inorganic Fertilizer during Ratoon Cropping

Treatment	Number of days from harvesting of the main plant to		Plant Height (cm)	Leaf Area Index	Flag Leaf Length (cm)	Fresh Straw Yield (t ha^{-1})
	Heading	Maturity				
To- No fertilizer application (control)	10.67	83.00	86.73^{b}	1.10^{b}	11.14^{ab}	8.12^{b}
T1- RE (5 t ha^{-1}) goat manure (GM)	12.33	82.66	92.20^{b}	1.26^{b}	11.36^{ab}	7.50^{b}
T2- RE (5 t ha^{-1}) GM + 30-30-30 NPK (kg ha^{-1}) applied on the ratoon crop	12.66	81.33	96.96^{b}	1.30^{b}	10.24^{ab}	9.88^{ab}
T3- RE (2.5 t ha^{-1}) GM + 60-30-30 NPK (kg ha^{-1}) applied on the ratoon crop	14.00	84.00	93.05^{b}	1.52^{b}	9.49^{b}	11.47^{ab}
T4- RE (2.5 t ha^{-1}) GM + 90-30-30 NPK (kg ha^{-1}) applied on the ratoon crop	12.33	83.66	99.51^{b}	1.21^{b}	12.18^{ab}	13.47^{ab}
T5- 120-60-60 NPK (kg ha^{-1}) applied on the ratoon crop	13.00	82.33	114.16^{a}	2.57^{a}	17.40^{a}	16.12^{a}
C.V. (%)	12.82	2.14	5.81	21.10	22.78	24.73

Treatment means within the same column followed by a common letter, and those without a letter are not significantly different from each other at a 5% level using Tukey's HSD Test.

of N, P_2O_5 K_2O supplemented with 13 kg and 4 kg ha^{-1} of S and Zn, respectively. They stipulated that applying a higher nitrogen level might be related to the stimulating effect of nitrogen on various physiological processes like cell division and cell elongation, which constantly increased plant height. Moreover, a higher level of N application resulted in an increase in plant height due to adequate availability of N, which is essential for maximum growth (Maqsood et al., 2000).

In terms of flag leaf length (cm), T5 achieved the most extended flag leaf length of 17.40cm significantly but comparable to T4, T1, T0, and T2, with flag leaf lengths of 12.18cm, 11.36cm, 11.14cm, and 10.24cm, respectively. Haque et al. (2016) indicated that organic fertilizer could be better supplemented with inorganic fertilizer to increase flag leaf, better root development, and rice growth. Li et al. (1998) reported that an increase in flag leaf length could be explained in terms of a possible increase in nutrient absorption capacity of plants and associated with increased photosynthesis rates (Fabre et al., 2016). The significant increase in flag leaf length can remarkably support the translocation of nutrients, specifically potassium, to attain a higher percentage of filled grains during the ripening growth phase (Li et al., 1998). In as much as long flag leaf length help protect the filled spikelets from the damage of birds; Maya (*Lonchura malacca*) and Gorion (*Passer montanus*) (Singh & Agarwal, 2001).

For straw yield, rice plants exposed to the residual effect of goat manure (regardless of the level of application) significantly produced heavier straws when compared to rice plants exposed to the residual effect of 5 t ha^{-1} goat manure alone and in those unfertilized ratoon plants. The residual effect of 5 t ha^{-1} goat manure alone (T1) significantly produced a lower straw yield (7.5 t ha^{-1}) of ratoon crop compared to those ratoon plants that experienced residual activity and supplemented with inorganic fertilizer at different levels; 30-30-30 kg ha^{-1}, 60-30-30 kg ha^{-1}, and 90-30-30 kg ha^{-1} N, P_2O_5, K_2O. A high coefficient of variation (CV) of 24.73% in the fresh straw yield might be attributed to the uneven growth of ratoon plants within its treatment, especially control plants. Although it is acceptable similar to the results of Ratilla and Cagasan (2011) in lowland rice that a high CV of 33.31% and 44.63% on the number of filled and unfilled grains panicle^{-1}, respectively was probably due to a slight infection of tungro virus of some varieties tested. As mentioned by Zach (2021), there is no definite value on a CV that is treated as acceptable, and this all depends on the real situation. However, Zach further mentioned that lower CV values are considered superior since it reflects less variableness around their mean.

The result confirmed the findings of Satyanarayana et al. (2002) that the application of farmyard droppings at the rate of 10 t ha^{-1} remarkably enhanced the straw yield of rice plants by 12% when compared to control plants. They further specified that at the same level of the application provides 30-70 kg ha^{-1} N in rice as well as providing a significant residual effect on succeeding crops (Sharma, 1995).

Yield and Yield Components and Harvest Index

The yield and yield components revealed that the panicle length and harvest index were not significantly affected by the treatments (Table 4). On the other hand, the number of productive tillers, panicle weight, number of filled grains, 1,000 grains (g), and grain yield (t ha^{-1}) were significantly affected by the different treatments adopted. Ratoon plants fertilized with 120-60-60 kg ha^{-1} N, P_2O_5, K_2O (T5) significantly produced an abundant number of productive tillers among other treatments but comparable to ratoon plants exposed to the residual effect of goat manure and supplemented with 30-30-30 kg ha^{-1} N, P_2O_5, K_2O (T2), and 90-30-30 kg ha^{-1} N, P_2O_5, K_2O (T4). The yield components such as panicle weight and the number of filled grains per panicle exhibited the same trend with the number of productive tillers as influenced by the residual effect of goat manure supplemented with different levels of inorganic fertilizer. In terms of weight of 1,000 grains, ratoon crops under (T5) achieved significantly the heaviest weight of 28.20g but comparable to T4 (24.93g), T3 (23.76g), and T1 (23.16g).

Relative to the grain yield of the ratoon crop, the residual effect of goat manure, especially at 5 t ha^{-1} (T2), remarkably produced a higher grain yield (1.57 t ha^{-1}) of ratoon lowland rice than those of other treatments except T4 and T5 with comparable grain yields of 1.39 and 1.91 t ha^{-1} (Table 4). The result implies that the additional application of inorganic fertilizer into the residual effect of goat manure can increase the grain yield

Table 4

Yield and Yield Components and Harvest Index (HI) of Ratoon Lowland Rice (Oryza sativa L.) to the Residual Effect of Goat Manure Application Supplemented with Different Levels of Inorganic Fertilizer during Ratoon Cropping

Treatment	Number of productive tillers	Panicle Weight (g)	Panicle Length (cm)	Number of filled grains panicle^{-1}	Weight of 1,000 grains (g)	Grain Yield (t ha^{-1})	Harvest Index
T_0	11.67^{bc}	1.43^{b}	8.20	29.33^{b}	22.53^{b}	0.76^{c}	0.39
T_1	9.00^{c}	1.50^{b}	10.91	30.00^{b}	23.16^{ab}	0.73^{c}	0.41
T_2	15.00^{ab}	2.36^{b}	8.21	34.00^{b}	22.36^{b}	1.57^{ab}	0.34
T_3	11.33^{bc}	3.08^{b}	8.70	54.00^{a}	23.76^{ab}	1.06^{bc}	0.34
T_4	14.66^{ab}	3.08^{b}	6.36	61.00^{a}	24.93^{ab}	1.39^{ab}	0.41
T_5	17.00^{a}	4.38^{a}	9.76	63.00^{a}	28.20^{a}	1.91^{a}	0.31
C.V. (%)	10.20	24.73	19.84	12.86	8.97	15.81	15.09

Treatment means within the same column followed by a common letter, and those without a letter are not significantly different from each other at a 5% level using Tukey's HSD Test.

of the ratoon crop. The addition of 30 kg ha^{-1} NPK in T_2 can increase ratoon grain yield by 840kg or about 16.8 bags compared to those under T_1 (Table 3).

The result of the study conformed to the findings of Dotollo (2018), who reported that the application of nitrogen at panicle initiation was utilized by the rice crop for panicle and grain development as manifested by high grain yield. As the N application rate was increased, nitrate reductase activity, chlorophyll contents, and net photosynthetic rate in leaves of ratoon rice also increased (Jiang et al., 2005). Thus, it may increase the number of productive tillers and the weight of 1,000 grains due to the increased translocation of photosynthates. Ruales (2018) stated that the high grain yield of the ratooned crop could be generally attributed to higher LAI, more productive tillers, and the heavier weight of 1,000 grains. The significant increases in all yield components of ratoon lowland rice except panicle length were due to the residual effect of goat manure. The result was proven veracious because goat manure contains adequate amounts of nutrients that ratoon plants need for optimal growth, and the residual effect of goat manure was more clearly emphasized during ratooning.

In this study, the utilization of the goat manure as a residue at the same time as an additive to the ratoon crop was more effective. The effect of goat manure as an additive might be crucial as conform to the results of AgriFarming in 2022 that goat manure must be composted before using as an additive. The goat manure is more useful and effective after four to six months of composting before its application into the soil and more effective when applied 120 days before harvesting the main crop (AgriFarming, 2022). Thus, goat manure residues in this study were more beneficial for rice ratooning given utilization of nutrients was performed in the next cropping period or for the ratoon crop. It can be concluded that the residual effect of goat manure is attributed to excellent growth and productivity responses to ratoon crop compared to control plants. Thereby, this study construed with the findings of Imthiyas and Seran (2017) claimed that the residual effect of goat manure (1.5kg/m^2) increased the crop biomaterial and marketable yield of cowpea when compared to all other treatments tested. They further stipulated that the application of 1.5kg/m^2 of goat manure to the preceding radish crop was an excellent strategy concerning the residual effect on the marketable pod yield of succeeding cowpea. According to Satyanarayana et al. (2002) that the application of organic manure takes part in enhancing soil permeability to air and water, and water-stable aggregates thereby alleviating soil physical properties and nutrient uptake that would tantamount to promoting growth, yield, and yield components of applied crops (Singh et al., 1994; Pandey et al., 1999; Mondal & Chettri, 1998). Thereby, the application of farmyard manure hinges largely on enhancing the organic matter, both physical, chemical, and microbial attributes in the soil (Gaur et al., 1984).

Cost and Return Analysis

The cost and return analysis of ratoon lowland rice as affected by the residual effect of goat manure supplemented with different levels of inorganic fertilizer during ratooning revealed that ratoon crop under T2 achieved the highest gross margin of Php16,585.00 (Table 5). Treatments (T5) and (T4) closely follow with gross margins of Php13,331.42 and Php10,036.43, respectively. The higher gross margin of T2 was mainly attributed to high grain yield (1.57 t ha^{-1}) and lower total variable cost of production (Php14,815.00). In terms of the total variable cost, plants applied with inorganic fertilizer at the rate of 120-60-60 kg ha^{-1} N, P_2O_5, K_2O (T5) obtained the highest production cost of Php24,868.57 ha^{-1} due to the high amount of inorganic fertilizer applied in the said treatment.

However, in terms of rice ratooning in this study, this option would save time and resources for the farmers and increase farm productivity and income. Ratooning of rice saves labor incurred in land preparation, raising seedlings in the seedbed, and transplanting in the field. Thus, production costs are lower because land preparation, transplanting, etc. are no longer performed (Bond & Bollich, 2006).

Conclusions

The residual effect of goat manure supplemented with the application of different levels of inorganic fertilizer on the ratoon crop remarkably increases the fresh straw yield, the number of productive tillers, and grain yield compared to the residual effect of goat manure alone (T1) and unfertilized control plants (T0). Ratoon plants (T2) exposed to the residual effect of goat (5 t ha^{-1}) and supplemented with inorganic fertilizer at the rate of 30-30-30 kg ha^{-1} N, P_2O_5, K_2O achieved a higher gross margin of Php16,585.00 when compared to other treatments adopted.

Table 5

Cost and Return Analysis of Ratoon Lowland Rice (Oryza sativa L.) to the Residual Effect of Goat Manure Application Supplemented with Different Levels of Inorganic Fertilizer During Ratoon Cropping

Treatment	Grain Yield (t ha^{-1})	Gross Income (Php)	Total Variable Cost (Php)	Gross Margin (Php)
T0- No fertilizer application (control)	0.77	15,400.00	6,788.00	8,612.00
T1- RE (5 t ha^{-1}) goat manure (GM)	0.73	14,600.00	6,692.00	7,908.00
T2- RE (5 t ha^{-1}) GM + 30-30-30 NPK (kg ha^{-1}) applied on the ratoon crop	1.57	31,400.00	14,815.00	16,585.00
T3- RE (2.5 t ha^{-1}) GM + 60-30-30 NPK (kg ha^{-1}) applied on the ratoon crop	1.06	21,400.00	16,078.53	5,323.47
T4- RE (2.5 t ha^{-1}) GM + 90-30-30 NPK (kg ha^{-1}) applied on the ratoon crop	1.39	27,800.00	17,763.57	10,036.43
T5- 120-60-60 NPK (kg ha^{-1}) applied on the ratoon crop	1.91	38,200.00	24,868.57	13,331.42

**Calculation is based on the current price of dried palay @ Php 20/kg*

Recommendation

To achieve a more profitable investment in rice ratooning, it is recommended that the application of 5 t ha^{-1} goat manure during the main crop should be supplemented with 30-30-30 kg ha^{-1} N, P_2O_5, K_2O during the ratoon cropping for higher ratoon grain yield. This fertilization strategy is an alternative way to adapt to the recent problem of climate change to reduce the accumulation of methane gas into the atmosphere.

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