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Ratooned adlai production under different fertilizer schemes in acidic marginal upland condition

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Abstract Field tests were determined the effect of fertilizer applications on the production performance of ratooned Adlai (Guinampay variety) grown in marginal land. The results revealed that using goat manure at a rate of 5 t/ha-^{1} significantly increased the plant height (219.80 cm) and yield (2.02 t/ha^{-1}) of the ratooned Adlai ($P<0.01$) compared to the control treatment with a 0.78 t/ha^{-1} yield. The net income of 5 t/ha^{-1} of goat manure obtained to be amounted to 65,337 pesos per hectare and returned on investment of 183.21 percent. Inorganic fertilizer application at 60-60-60 NPK had comparable affected to a 5 t/ha^{-1} application in agronomic characteristics and yield performance. However, adding goat manure at a rate of 2.5 t/ha^{-1} was significantly increased in yield compared to the control treatment that obtained 1.58 t/ha^{-1} and a 199.20 returned on investment.

Keywords: Adlai, Acidic marginal upland, Goat manure, Ratooning

Introduction

For most Filipinos, rice remains the primary staple food (Sombilla *et al.*, 2013). However, the population's demand for rice outweighs the supply. The government is still trying to solve this problem, and one of the ways is by looking for new technologies and food sources (Tumapon *et al.*, 2012; Demafelis *et al*., 2013*).* Moreover, the Philippines' population has increased to 113 million (Worldometer, 2022), and crop production must increase proportionally to feed the larger population. In the nation and even worldwide, there is a shortage of arable land for crop cultivation (Chen and Han, 2015; Luan *et al*., 2014). So increasing crop yield per unit area is critical for resolving the food crisis. Along with it, food safety is another issue that drives the demand for organically grown food (Elif and Bulent, 2011; Hoffmann and Schlicht, 2013).

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Moreover, as an agricultural country, the effects of climate change are also variable in producing food. It is evident that prolonged drought and precipitation directly affect the farmer's food production system and livelihood (Redfern *et al*., 2012; Stuecker *et al*., 2018).

On the other hand, applying organic fertilizers is more profitable due to higher product prices than conventionally produced commodities, is environmentally friendly, and undeniably produces nutritious foods (Reganold and Wachter, 2016; Wang *et al*., 2018). In addition, applying organic matter improves the overall characteristics of the soil, such as its chemical, physical, and biological properties, and helps support soil productivity. Specifically, manure is a common source of organic materials derived from farm animals and used as fertilizer. The use of goat manure for Adlai production must be considered due to its relative advantages and high nutritional content (Tayyab *et al*., 2018).

Adlai (*Coix-lacryma-jobi* L.) is an alternative food source for Filipinos (Tumapon *et al*., 2012). This crop is higher in nutrients than rice and corn. In addition, it is pest- and disease-resistant, drought- and flood-resistant, and a single round of weeding is sufficient without using chemicals, with no irrigation required (Medina and Untalan, 2015). This crop helps mitigate climate change effects and can be used locally under the climate-smart agriculture of the Food and Agriculture Organization (2022) movement. The locally available cultivars of Adlai in the area are Gulian, Pulot, Guinampay, and Tapol. Mendoza *et al*. (2015) found that guinampay produced the highest yield per hectare among the studied cultivars. The yield per hectare of these cultivars ranges from 1.7 to 3.4 tons per hectare.

Adlai is like rice that can be ratooned 3–5 times. Ratooning is the practice of harvesting a second crop from a first crop's stubble (Nakano *et al*., 2020). It is a traditional and economically viable technology, much like rice and sugarcane production (Torres *et al*., 2020; Xu *et al*., 2021). However, no articles are available that show the economic/production performance of ratoon Adlai in a review of published reports on ratooning Adlai over the last decade.

Torres *et al*. (2020) claimed that ratooning is a low-input practice, needs minimal labor (Dong *et al*., 2017), and increases crop intensity per unit area (Negalur *et al*., 2017). With the benefits mentioned above of ratooning and the use of goat manure and the present pressure of food demand. The study was conducted to evaluate the production performance of ratooned adlai (Guinampay variety) using rates of goat manure on marginal land.

Materials and methods

The study was conducted at the farmer's field at Sitio Panamin, Dulop, Dumingag, Zamboanga del Sur, Philippines. The study was carried out between September 2021 and January 2022. The experiment was laid out with four treatments and replicated four (4) times arranged in a Randomized Complete Block Design (RCBD). Each plot measured 4.5 meters x 5 meters with six rows per plot and ten hills in each row—a 0.5-meter alleyway between plots. The treatments were as follows: T_1-Control (no fertilizer), T_2-Goat manure at 2.5 t/ha**,** T_3-Goat manure at 5 t/ha**,** T_4-Inorganic fertilizer at the rate of 60-60-60 kg/ha N-P_2O_5-K_2O.

Right after harvesting adlai plants, it was ratooned by cutting them 30 centimeters above the ground using a sharp bolo. Hand weeding was done five days after cutting. The fertilizer materials were side-dressed right after the first-hand weeding of the Adlai crops. The decomposed goat manure was air-dried before it was applied to the field in the amount specified in the treatments as treatment 1-(No fertilizer), treatment 2-5.625 kg of goat manure, treatment 3-11.25 kg of goat manure and treatment 4-964 g of 14-14-14 fertilizer.

Harvesting was done when all of the grains in the panicles were ripped. The grains were ready to harvest at 137 days after cutting Adlai stover; they changed their color (from greenish to whitish) and become firm. All sample plants in the experimental plot were harvested. The panicles were cut approximately 5-10 cm below the lowest panicle using a sharp bolo, sundried before threshing, dried, and winnowed before all the necessary data were gathered.

Observation variable

The observed variables were the number of days from ratooning to heading, and ratooning to maturity, final plant height before harvesting (cm), and the number of productive tillers. For the yield and yield components, number of grains/tillers, percentage filled grains/panicle, weight of 1,000 grains (g), actual grain yield (kg) per plot, projected Adlai grain yield (t/ha) and the cost and return analysis. The data were analyzed using the software Statistical Tool for Agricultural Research (STAR Computer Software). Mean comparisons were made using the Least Significance Difference (LSD).

Results

The addition of goat manure increased the growth and yield of ratooned Adlai. According to the study's findings, there was no significant statistical

difference between goat manure and inorganic fertilizer in terms of the number of days from ratooning to heading, the number of days from ratooning to maturity, and the number of productive tillers, as shown in Table 1. It was observed that the number of days from ratooning to heading ranges from 81.0-86.25 days and 137.0-148.5 days from ratooning to maturity. Moreover, the productive tillers were 12.55-15.63 productive tillers. The average final plant height of ratooned Adlai was a highly significant statistical difference ($P<0.01$). It was found that T4 had the maximum plant height of 222.53 cm but was not significantly different from T3 (219.80 cm). Furthermore, T2 was not significantly different from T1, with 200.68 cm and 194.22 cm, respectively.

Table 1. Agronomic characteristics of Adlai (Number of days from ratooning to heading, number of days from ratooning to maturity, number of productive tillers, and final plant height) as influenced by rates of fertilizer materials in acidic marginal upland

	Agronomic characteristics			
Treatment	Number of days from ratooning to heading	Number of days from Ratooning to Maturity	Number of productive tillers	Final plant height (cm)
T1-control	86.25	148.5	12.55	194.22b
T2-2.5t/ha GM	81.00	138.25	15.53	200.68b
T3-5T/ha GM	81.25	137.00	15.63	219.80a
T4-60-60-60	81.00	137.00	15.20	222.53a
F-test	ns	ns	ns	**
C.V=%	6.85	5.65	17.04	4.19

Means having the same letter is not significantly different from each other. ns - non significant. ** - significant at a 1% level of significance, GM= Goat Manure

No significant variations were observed in the number of grains per tiller, and percent filled grains. The same trend was observed in the weight of 1,000 grains between the application of goat manure at different rates and inorganic fertilizer (60-60-60), as reflected in Table 2. It was found that across the treatment, the number of grains per tiller ranged from 68.25- 83.50 grains, and the percent filled grains started from 92.86- 94.73 percent. The maximum weight of 1,000 grains was 72-75 grams. The actual grain yield (kg) and projected grain yield (t/ha) were recorded highly significant differences statistically ($P<0.01$). T3 obtained the highest actual grain yield and projected yield, with 4.56 kg and 2.02 tons per hectare but not significantly different from T4, with 4.54 kg and 2.02 tons per hectare, respectively. However, T3 and T4 were significantly different from T2 and T1, with 3.56 kg grain yield and 1.58 tons per hectare projected yield, while T1 obtained the lowest grain yield of 1.75 kg with 0.78 tons per hectare in projected grain yield.

Table 2. Yield and yield components of Adlai as influenced by the rates of fertilizer materials in marginal upland conditions

Treatments	Yield and Yield Components				
	Number of grains per tiller	Percent filled grains (%)	Weight of 1,000 grains (g)	Actual Grain Yield (kg)	Projected grain yield (t/ha)
T1 – Control	71.20	92.86	75.00	1.75c	0.78c
T2 – 2.5t/ha GM	68.25	93.06	72.00	3.56b	1.58b
T3 – 5 t/ha GM	83.50	94.70	72.00	4.56a	2.02a
T4 – 60-60-60	76.50	94.73	75.00	4.54a	2.02a
F-test	ns	ns	ns	**	**
C.V. %	10.21	4.29	8.15	8.08	8.41

Means having the same letter is not significantly different from each other. ns - non significant. ** - significant at a 1% level of significance, GM=Goat Manure

The cost and return analysis of ratooned Adlai production included the expenses, gross income, and return on investment (ROI), as in Table 3. In terms of expenses incurred, treatment 4 (60-60-60) obtained a total cost of ₱40,209.90, followed by treatment 3 (5t/ha goat manure) with ₱ 35,663.00, while treatment 2 (2.5t/ha goat manure) with ₱ 26,403.50 and treatment 1 (control) with ₱ 13,725.75. However, treatment 3 (5t/ha goat manure) and treatment 4 (60-60-60) obtained a gross sale of ₱ 101,000.00, followed by treatment 2 (2.5t/ha goat manure) with ₱ 79,000.00 and treatment 1 (control) with ₱ 39,000.00.

Table 3. Cost and return analysis of ratooned Adlai production as influenced by the rates of fertilizer materials in marginal upland conditions

Treatment	Grain yield (kg/ha)	Gross Income	Production cost	Net Income PHP/ha) (PHP/ha) (PHP/ha)	ROI (%)
T1-Control	780	39,000.00	13,725.75	25,274.25	184.41
T2-2.5t/ha GM	1,580	79,000.00	26,403.50	52,596.50	199.20
T3- 5t/ha GM	2,020	101,000.00	35,663.00	65,337.00	183.21
T4-60-60-60 N, P2O5, K2O	2,020	101,000.00	40,209.90	60,790.10	151.18

Price of Adlai grain (unmilled): PHP 50.00 /kg. GM: Goat Manure, PHP 200.00/50kg

The highest return of investment was obtained by treatment 2 (2.5t/ha goat manure) accounts for 199.20%, followed by treatment 1 (control) at 184.41% and treatment 3 (5 tons goat manure) at 183.21%, and treatment 4 (60-60-60) with 151.18%. The higher expense incurred in treatment 2, 3, and 4 was due to a higher fertilizer rate and the labor cost of fertilizer application, thus, reducing the net income and return on investment.

Discussion

The application of different fertilizer schemes of ratooned Adlai under the marginal upland condition in 4 treatments as follows: treatment 1 (no fertilizer application), treatment 2 (2.5 tons goat manure ha^{-1}), treatment 3 (5 tons goat manure ha^{-1}), treatment 4 (60-60-60 kg/ha^{-1}) of (N, P_2O5, K_2O). Adlai's growth and production parameter were significantly and favorably influenced by the addition of goat manure at an increasing rate and the use of inorganic fertilizer. Adlai's response was apparent because of the area's low fertility status. Goat manure applied in higher rates 5 tons ha^{-1} (treatment 3) and the application of inorganic fertilizer (treatment 4) promoted better growth and yield ($P<0.01$) than the other treatments probably due to the availability nutrients and more uptake. The result corresponds to the study of Maghfoer *et al*. (2015) that adding goat manure to horticultural crops increased the growth of the crop and its yield performance. Furthermore, Singh *et al*. (2020) emphasized that using organic inputs enhanced soil fertility and crop productivity and thus minimized the human health and environmental problems caused by synthetic inputs (Sharma, 2017). According to the study, the yield of ratooned Adlai is directly influenced by the addition of goat manure (treatment 2 and treatment 3) compared to the control treatment (no application) (Sanni and Okeowo, 2016). The results indicated that applying 5 tons per hectare of goat manure to ratooned Adlai was comparable and can be used as an alternative to inorganic fertilizers.

The cost and return analysis showed that under the recent buying price of Adlai grains, treatment 3 obtained the highest net income of 65 337.00 pesos with a 183.21 percent return on investment. Followed by treatment 4 with 60, 790.10 pesos and 151.18 return on investment. The data showed that Adlai ratooning on marginal land with goat manure as a nutrient source was a viable option that can help the poor farmers to increase yield and income. At the same time, by ratooning of this resilient crop maximized labor, alleviated labor shortages (Bollido, 2020; Zhang *et al.*, 2017), increasing total production per area (Shen *et al*., 2021) which compared to a single-season system was significantly contributed to the Philippines' stable food supply. Therefore,

applying goat manure of 5 tons per hectare in ratooned Adlai under marginal upland conditions improved the growth and yield performance.

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