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Field performance of adlai *(Coix lacryma-jobi* l*.)* under organic planting system in acidic marginal upland in the Philippines

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Abstract Adlai (*Coix lachryma-jobi* L.) is a resilient crop that can be grown even in acidic marginal uplands and is considered a climate-resilient crop. The effects of goat manure as an organic fertilizer on the growth and yield of Adlai on acidic marginal land were investigated. The results revealed that the application of 5 tons per hectare (T3) of goat manure obtained the highest effects on the growth, the number of tillers, and the yield of Adlai, with 2.23 t ha^{-1} with a net income of Php 32,700.42, and obtained a 96.04 percent return of investment (P=<0.01). However, because of the treatment's higher cost of production, the application of 2.5 tons/ha of goat manure (T2) generated a maximum net income of PhP 31. 329.57 with a 107.36 percent ROI. The application of goat manure at 2.5–5 tons per hectare is best for Adlai production when planted in acidic marginal upland since its effects are comparable to inorganic fertilizer. Further studies may be conducted on the residual effects of fertilizer materials on the ratooned Adlai plants.

Keywords: Adlai, Acidic marginal upland, Organic fertilizers, Planting system

Introduction

One of the key issues confronting the country is the insufficient supply of rice, which is the staple food of the Filipinos. Although corn is considered a secondary staple food for about 20% of Filipinos, it is primarily utilized as an essential ingredient in animal feed rations, so it cannot be adequately relied on as an alternative source of food to feed the growing population of the country. One of the options was to search for an alternative staple crop that might substitute for rice and corn (Gaitan, 2013).

Adlai, also spelled as “adlay” (*Coix lacryma-jobi* L.), is an indigenous crop recently considered a staple food. It is also called Job's tears and belongs to the Poaceae family or grasses. Unlike most grasses, its stem could grow up to 3 meters. The grains are white or brown, spherical, and have a grove at one end. It is the staple food of indigenous people in the highlands, particularly the

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Subanens in the Zamboanga Peninsula. It is abundantly grown in regions 9, 10, and the Cordillera Administrative Region (Gaitan, 2013).

Adlai is as versatile as rice. It can be cooked and processed in varied recipes like rice-based "*kakanin"* or delicacies. Adlai's nutritional analysis proved to be higher than rice and corn. (Eleazar, 2011). The sugar content of Adlai is less than three parts of an Irish potato (Cabahug, 2018). Thus, it is an ideal food for people who have diabetes. Its origin is unknown, but it has now been introduced in southern and eastern Asia, including the Philippines. Adlai is eaten as a substitute for rice and corn. It can also be processed into flour for bread making and wine and beer production, as practiced by the Subanen tribe in the Zamboanga Peninsula (Andalahao *et al.,* 2016).

Tumanod Pusaka Subanen Midsalip Organization (TUPUSUMI), Midsalip, Zamboanga del Sur considered dalai or adlai a family treasure. The crop is handed down like a precious gift from their ancestors. They have glutinous and non-glutinous types of Adlai. TUPUSUMI distributed Adlai seeds for research and seed production nationwide. (Basagan and Wee, 2011)

Adlai can be grown in broad soil types and climatic conditions. It can tolerate low pH, poor soil quality, and waterlogging where other cereals cannot normally grow. It can also potentially tolerate extreme weather conditions (Gaitan, 2013). Adaptability trials of Adlai varieties conducted in different parts of the country showed variations in yield (Gloria *et al.,* 2015).

One factor that affects Adlai's performance is the availability of plant nutrients for growth. This can be achieved through fertilizer application to supply the essential nutrient elements lacking in the soil for normal plant growth and development. Fertilizer materials are either inorganic or organic in form. Moreover, continuous and excessive application of inorganic fertilizer can cause detrimental effects on the soil (Bernal, 2013).

An organic production system is a farming method that works in harmony with nature rather than against it. Organic fertilizer application can maintain a healthy and biologically active soil with large plant nutrients reservoirs that provide crop needs (Sideman, 2007). The application of organic fertilizer increases the soil's organic matter content, thus improving and stabilizing soil structure. Organic materials contain the major elements needed by plants like N, P, and K and many trace elements, although in relatively lower quantities than inorganic fertilizers (Reoma, 1986).

One source of organic fertilizer is goat manure. Goat raising is an essential component of a farm family. Hence goat manure could be a good source of organic fertilizer. In a trial conducted at the J. H. Cerilles State College – Dumingag Campus, School of Agriculture, goat manure is proven to be very effective in providing the necessary nutrients of corn (Dela Cruz and

Elemento, 2016). Cabahug (2018) found that application of goat manure in marginal upland at 5 tons per hectare gave comparable effects with inorganic fertilizer at 90-60-60 kg/ha in terms of plant height, LAI, the number of grains per tiller, percent fertility, and weight of 1,000 grains. This is attributed to the nutrient content of composted goat manure which had 2.80% total N, 0.518% total P, 2.85% total K, and a pH of 9.12.

At present, there is still limited study concerning this crop. Hence, conducting a nutrient management study of Adlai in marginal uplands may eventually utilize marginal upland lands for Adlai production.

The study was to investigate how's the effects of goat manure as organic fertilizer on the growth and yield of Adlai (Guinampay variety) and to assess the profitability of growing Adlai using goat manure as organic fertilizer under acidic marginal upland.

Materials and methods

The study was conducted in the farmer's field in Sitio Panamin, Dulop, Dumingag, Zamboanga del Sur has a GPS coordinate of 8°12'17.24"N 123°14'42.47"E. The study site is a mountainous area situated approximately 15 kilometers from the town proper of Dumingag. The soil in the area is considered acidic marginal upland because of reddish soil and poor growth of vegetation due to erosion. The area remained uncultivated for several years, and cogon grass dominated the vegetation. An area of 483 m^2 (23 m x 21 m) was cleared by mowing the grasses and other tall vegetations and was plowed thoroughly using an animal-drawn implement. Plowing and harrowing were done two times to pulverize the soil, at one-week intervals, to allow the weed seeds to germinate and eventually control them. Right after the last harrowing, furrows were made 75 cm apart.

Four treatments were used in the experiment and replicated four (4) times arranged in Randomized Complete Block Design (RCBD). Each plot measured 4.5 m x 5 meters with 6 rows per plot and 10 hills in each row. To facilitate farm operations, management, and data gathering, plots were separated by a 0.5-meter alleyway between plots and replications. The treatments used in this study were the rates of fertilizer materials. They were designated as follows: T_1-Control (no fertilizer), T_2-Goat manure at 2.5 t/ha, T_3-Goat manure at 5 t/ha, and T_4-Inorganic fertilizer at the rate of 60-60-60 kg/ha N-P_2O_5-K_2O.

One week before planting, the decomposed goat manure was applied in specified treatment plots (T2 and T3). The inorganic fertilizer (T4) was applied basally using complete fertilizer (14-14-14).

Table 1. The actual number of fertilizers applied per plot (kg/plot)

Treatments	Amount of fertilizers (kg/plot)	
	1 Week Before Planting	At Planting
T_1- (No fertilizer)		
T_2- 2.5 t ha^{-1} of goat manure	5.625 kg	
T_3- 5 t ha^{-1} of goat manure	11.25 kg	
T_4- 60-60-60 kg ha^{-1} N, P_2O_5, K_2O		964g (14-14-14)

Adlai seeds were planted in the furrows at a distance of 0.75 m between rows and 0.50 m between hills at 3-4 seeds per hill. However, after germination, only 2 plants per hill were maintained. After planting, the seeds were covered with soil.

First, the weeding operation was done 20 days after planting. Succeeding weeding operations were done until the reproductive phase. It is at this phase that Adlai plants efficiently compete with the weeds. There were no severe vertebrate, insect pests or disease infestation noted on Adlai plants during the entire duration of the study.

Harvesting was done when all of the grains in the panicles were ripened. The grains are considered ready to harvest when the grains change their color (from greenish to whitish) and firm. All sample plants in the harvestable area, excluding two border rows on each side and end hills of each row, were harvested. Unlike rice, Adlai grains do not shatter easily unless it is partially dried. The panicles were cut at the panicle base by a sharp bolo, sundried before threshing, dried, and winnowed before all the necessary data were gathered.

Average weekly data of temperature (^{0}C), and relative humidity (%), were taken and recorded. Analysis of variance (ANOVA) was used to compute data in Randomized Complete Block Design (RCBD). The data were analyzed using the Statistical Tool for Agricultural Research (STAR Computer Software). Mean comparisons were done using Least Significance Difference (LSD).

Results

The average weekly relative humidity and temperature are shown in figure 1. It was taken and recorded using a portable gadget. The temperature reading was relatively high in the third and fourth weeks of the study. The lower temperature and relative humidity were due to dry solid winds that blew in December 2020 and January 2021.

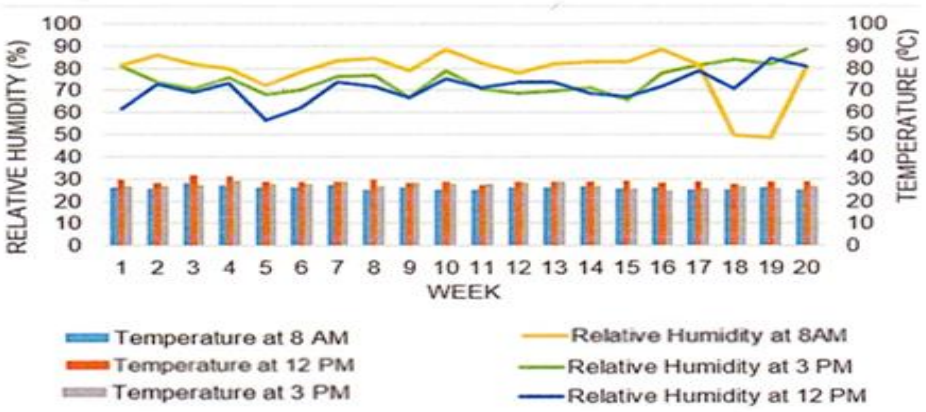

Figure 1. Agro-meteorological (temperature and relative humidity) data during the conduct of the study

The laboratory analysis of soil samples and goat manure is shown in Table 2. The soil in the research area is strongly acidic and low in organic matter, nitrogen, and available phosphorus. However, there is high exchangeable potassium. The goat manure is strongly alkaline (pH 8.75), and contained 1.9% nitrogen, 2.81% available phosphorus, and 3.61% potassium. The laboratory analysis of goat manure revealed that it contains a higher amount of plant nutrients when compared to other organic fertilizers. Besides, it does not acidify the soil when applied.

Table 2. Chemical properties of the soil before planting and goat manure nutrient analysis used as fertilizer

Treatments	pH	Organic Matter (%)	Nitrogen (%)	Available P (ppm)	Exchange-able K (ppm)	CEC	Ca (meq/100g)
Soil Analysis:	4.61	2.99	0.1495	2.48	562	14.98	0.51
Interpretation:	Strongly acidic	Very low	Very low	Very low	High		
Goat Manure Analysis	8.75		1.97%	2.81%	3.61%		

The agronomic characteristics of Adlai in terms of its average number of days from planting to flowering and number of days from planting to maturity, as influenced by the rates of fertilizer materials in acidic marginal upland, are shown in Table 3. The plants applied with inorganic fertilizers were the earliest

to produce flowers and mature with a mean of 72 days and 135.50 days, respectively, while the plants with zero fertilizer were the latest to produce flowers (86.25 days) and matured (148.50 days). On the other hand, when Adlai was applied with goat manure, Treatment 2 (2.5 tons/ha) and 3 (5 tons/ha) were comparable in the number of days from planting to flowering with 74.25 days and 76.25 days, respectively. It was observed that from planting to maturity, Treatment 2 and 3 were the earliest to mature when compared to treatment 1 (control) but when compared to treatment 4, only treatment 2 was comparable. The results suggested that fertilizer application enhanced the development of Adlai planted under an organic planting system in acidic marginal upland.

Table 3. Agronomic characteristics of Adlai in terms of the average number of days from planting to flowering, and number of days from planting to maturity

Treatments	Agronomic Characteristics	
	Number of days from planting to flowering	**Number of days from planting to maturity**
T_1 - Control	86.25^{a}	148.50^{a}
T_2 – 2.5t GM	74.25^{bc}	136.75^{c}
T_3 - 5 t GM	76.25^{b}	139.50^{b}
T_4 – 60-60-60 N, P_2O_5, K_2O	72.00^{c}	135.50^{c}
F-tests	**	**
C.V. %	1.91	1.16

Notes: Means having the same letter are not significantly different from each other. ** - significant at a 1% level of significance

The average plant height of Adlai in centimeters from 15 to 105 days after planting (DAP) as influenced by rates of fertilizer materials in acidic marginal upland is presented in Table 4. The plants applied with fertilizers (either goat manure or inorganic fertilizer) significantly affected the growth of Adlai, wherein the plants in the control treatments consistently had the lowest height. The plants applied with 5 tons of goat manure per hectare had the highest plant height at 105 DAP of 204.13 centimeters. However, the data differences among treatments applied with fertilizers were not significantly different. It had been noted that at 60 DAP, the plant began its reproductive phase, and the growth increment began to decline. The increase in plant height beyond 60 DAP was due to the internode elongation of the plant in preparation for its flowering stage, and the slight height increment between 90 DAP and 105 DAP as observed was due to the exerted panicles of Adlai, which finally produced grains.

Table 4. Average plant height (cm) of Adlai at 15, 30, 45, 60, 75, 90, and 105 DAP as influenced by rates of fertilizer materials in acidic marginal land

Treatments	Number of days from planting						
	15 DAP	**30 DAP**	**45 DAP**	**60 DAP**	**75 DAP**	**90 DAP**	**105 DAP**
T1 - Control	12.70[b]	39.84[b]	56.84[b]	93.03[b]	112.53[b]	141.55[b]	157.10[b]
T2 – 2.5tGM	19.05[a]	53.03[a]	72.25[a]	134.48[a]	166.33[a]	197.72[a]	199.87[a]
T3 - 5 t GM	19.19[a]	52.18[a]	72.35[a]	146.88[a]	171.05[a]	200.59[a]	204.13[a]
T4 – 60-60-60	17.61[a]	53.89[a]	72.20[a]	146.71[a]	162.44[a]	191.15[a]	192.98[a]
F-tests	*	**	**	*	*	*	*
C.V. %	8.04	5.40	6.13	12.20	10.77	7.47	7.04

Notes: Means having the same letter are not significantly different from each other. * - significant at a 5% level of significance ** - significant at a 1% level of significance

The average number of tillers produced of Adlai per hill as influenced by the rates of fertilizer materials in acidic marginal upland is shown in Table 5. The plants applied with 5 tons of goat manure per hectare consistently produced the highest number of tillers per hill from 15 DAP up to 60 DAP, wherein it had the final average of 18.23 tillers at 60 DAP. Although the statistical analysis revealed a non-significant difference among the treatments applied with fertilizer, the treatments with zero fertilizer application were significantly the lowest. The results suggested that applying fertilizer to Adlai plants planted in acidic marginal upland improved the plant's production of tillers. It was also observed that the Adlai plant continued to produce tillers until at the 60 DAP because without additional tillers were recorded.

Table 5. The average number of tillers of Adlai per hill at 15, 30, 45, and 60 DAP as influenced by the rates of fertilizer materials in acidic marginal upland

Treatments	Number of days from planting			
	15 DAP	**30 DAP**	**45 DAP**	**60 DAP**
T1 - Control	1.30[b]	6.03[b]	9.35[b]	11.20[b]
T2 – 2.5t GM	2.33[a]	11.45[a]	16.23[a]	17.10[a]
T3 - 5 t GM	2.77[a]	12.15[a]	15.88[a]	18.23[a]
T4 – 60-60-60	2.65[a]	11.85[a]	16.70[a]	17.93[a]
F-tests	*	*	*	*
C.V. %	15.68	21.31	15.00	16.11

Notes: Means having the same letter are not significantly different from each other. * - significant at a 5% level of significance.

The yield and yield components of Adlai as influenced by the rates of fertilizer materials in acidic marginal upland are reflected in Table 6. The application of fertilizer significantly affected the yield components and the grain yield of Adlai. The application of 5 tons of goat manure per hectare of Adlai production resulted in the highest number of grains per tiller (126.05), percent filled grains (96.23%), heaviest weight of 1,000 grains (84.06 grams), actual grain yield (2.67 kg/12 m^2 harvestable area), and highest projected grain yield (2.23 t/ha). The data gathered from plants with 5 tons of goat manure per hectare surpassed the data taken from plants with 60-60-60 kg N, P_2O_5, K_2O/ha inorganic fertilizers, although they were not significantly different. The results suggested that the fertilizer application (either organic or inorganic) improved Adlai's yield and yield components.

Table 6. Yield and yield components of Adlai as influenced by the rates of fertilizer materials in acidic marginal upland

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	78.17[c]	86.53[b]	73.56[b]	1.25[b]	1.04[b]
T2 – 2.5t GM	104.83[b]	94.33[a]	82.66[a]	2.42[a]	2.02[a]
T3 - 5 t GM	126.05[a]	96.23[a]	84.06[a]	2.67[a]	2.23[a]
T4 – 60-60-60	125.53[a]	93.95[a]	82.08[a]	2.49[a]	2.07[a]
F-test	**	*	*	**	**
C.V. %	4.10	2.46	2.86	10.47	10.47

Notes: Means having the same letter are not significantly different from each other. * - significant at a 5% level of significance. ** - significant at a 1% level of significance.

The cost and return analysis of Adlai production as influenced by the rates of fertilizer materials in acidic marginal upland is shown in Table 7. The application of 2.5 tons of goat manure per hectare of Adlai production had the highest net income of PhP 31,329.57. Its returned-on investment of 107.36%, although the plants applied with 5 tons of goat manure per hectare had the highest grain yield of 2, 225 kilograms compared to 2,017 kilograms to plants applied with 2.5 tons of goat manure. The higher expense incurred in Treatment

3 (5 tons/ha goat manure) was due to the higher fertilizer and labor cost of fertilizer application, thus, reducing the net income.

Table 7. Cost and return analysis of Adlai production as influenced by the rates of fertilizer materials in acidic marginal upland

Treatments	Grain yield (kg/ha)	Gross Income (PhP/ha)	Production Cost (PhP/ha)	Net Income (PhP/ha)	Return on Investment (%)
T_1 - Control	1,042	31,260.00	22,195.74	9,064.26	40.84
T_2– 2.5 t GM	2,017	60,510.00	29,180.43	31,329.57	107.36
T_3 - 5 t GM	2,225	66,750.00	34,049.58	32,700.42	96.04
T_4 – 60-60-60 N, P_2O_5, K_2O	2,075	62,250.00	36,420.21	25,829.79	70.92

Price of Adlai grains (unmilled): PhP 30.00/kg

Discussion

The research's purpose was to figure out how goat manure as an organic fertilizer affected the growth and yield of Adlai. (Guinampay variety) and to assess the profitability of growing Adlai using goat manure as organic fertilizer under acidic marginal upland (Batubara *et al*., 2021; Kurniawati *et al*., 2021). Adlai (*Coix lacryma-jobi* L.) is a staple food that can be considered an alternative to rice and corn and has been planted and utilized by the Subanen tribes of Zamboanga del Sur Philippines. Subanen farmers preferred to grow Adlai because it can tolerate a wide range of soil types and even waterlogged areas. It is pest and disease resistant and yields more in the highlands. (Dela Cruz, 2011).

The plants applied with 60-60-60 kg N, P_2O_5, and K_2O/ha produced flowers first with a mean of 72 days and the earliest to mature with a mean of 135.50 days. The unfertilized plants were the last to flower and mature. The Adlai plants responded to the application of fertilizers, wherein the plants applied with 5 tons/ha of goat manure consistently obtained the highest average plant height from 15 DAP to 105 DAP. The final plant height was 204.13 centimeters (Mowa *et al.*, 2017), while the unfertilized plants had the lowest plant height of 157.10 centimeters.

Adlai produced more tillers when applied with fertilizers. The mean number of tillers produced at 60 DAP in plants with 5 tons/ha of goat manure was 18.23. The Adlai plant stopped producing tillers beyond 60 DAP since no more increase in the number of tillers was taken after 60 DAP.

Yield and yield components of Adlai showed that the plants applied with 5 tons/ha of goat manure had the highest number of grains per tiller (126.05), the highest percentage of filled grains (96.23 %), heaviest weight of 1,000 grains (84.06 grams) and the highest yield (2.23 t/ha) (Talip and Sison, 2017). Its effects surpassed the effects on plants applied with inorganic fertilizers (60-60-60 kg N, P_2O_5, K_2O/ha) and on plants with 2.5 tons/ha of goat manure. There was no considerable difference in the parameters taken from plants applied with fertilizers. However, when compared to the control plants, the results are significant. The fertilizer application improved the growth and yield of Adlai grown in acidic marginal upland (Caruana and Cagasan, 2020).

The highest return on investment (107. 36%) was noted in treatment with 2.5 tons/ha of goat manure. However, its yield and components were lower with the treatments applied with 5 tons/ha of goat manure than Treatment 2 due to the lower cost of production. Additionally, Treatment 3 (5 tons/ha goat manure) obtained the highest net income of Php 32, 700.42 with 96.04 ROI.

Based on the results, it is hereby concluded that the application of 5 tons per hectare of goat manure obtained the highest effects on the growth and yield of Adlai (Guinampay variety). However, because of its higher cost of production, the application of 2.5 tons/ha of goat manure gave the highest return on investment. Goat manure, applied at 2.5-5 tons per hectare, proved to be an excellent alternative to inorganic fertilizer in Adlai. The lingering effects of fertilizer components on ratooned Adlai plants could be investigated further.

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