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Biofertilizer and system for upland rice production during off-season

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Key words: Upland rice, Bio-fertilizers, Fermented plant juice, Indigenous microorganism, Kuhol amino acid

Abstract

The research was conducted at Cagayan State University, Lal-lo, Cagayan, Philippines from June, 2017 to June, 2018 (dry season), to evaluate what bio-fertilizers is best for upland rice in terms of the following parameters: plant height, number of tillers, number of productive and non-productive tillers, length of panicles, number of filled and unfilled grains, weight of 1000 seeds, computed yield per hectare and gross margin analysis. The Randomized Complete Block Design was used in the study. The treatments used were Treatment 1- FPJ + KAA, Treatment 2- FPJ + IMO, Treatment 3- FPJ + $CaCO_3$, Treatment 4- FPJ, Treatment 5- Control. Based from the results of the study, FPJ + IMO produced the best productive tiller, panicle length, filled grains, weight of 1000 seeds, yield per hectare and Return of Investment. Therefore, this bio-fertilizer or natural farming inputs is recommended to the farmers in the locality to obtain higher income. It is further recommended that another trial using different level of FPJ + IMO must be conducted during wet season for the comparative results.

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Introduction

Upland rice is grown in rainfed fields prepared and seeded when dry, much like wheat or maize. The ecosystem is extremely diverse, including fields that are level, gently rolling or steep, at altitudes up to 2,000 meters and with rainfall ranging from 1,000 to 4,500mm annually. Soils range from highly fertile to highly weathered, infertile and acidic, but only 15 percent of total upland rice grows where soils are fertile and the growing season is long. Thus, new challenges are emerging in the world's upland rice farming areas, where already some of the world's poorest farmers try to wrest a living from fragile soils that are fast being degraded. The uplands have traditionally suffered from drought and infertile soils (https://en.wikipedia.org/wiki/Upland_rice).

On the other hand, Mendoza, Teodoro C. of the University of the Philippines, in his study "Natural Farming in the Philippines" stated that for almost three decades, farmers in the Philippines have been using chemical fertilizers, pesticides and growth regulators in their crop production strategies. Despite the high cost of these inputs, and the farmers' awareness that they can adversely affect soil fertility, food quality, human and animal health, and environmental quality; they are used extensively because there are few alternatives that would be considered practical and feasible. One reason for this is that, university-based research has strongly promoted the use of agricultural chemicals as the best means of achieving the highest possible crop yields. The predominant question then is how can the farmers shift from a chemical-intensive agriculture to one that is based on the utilization of natural systems, and still maintain their economic viability. It is encouraging that there are some efforts now underway by university researchers, the Philippine government, and the private sector to develop nature farming as an alternative to chemical-based agriculture. The government, in cooperation with non-government agencies, needs to set forth certain policy initiatives that would promote the necessary research for the development of productive, profitable, and sustainable natural farming systems, and to ensure that such knowledge is transferred effectively to the farmers. Furthermore, the oil crisis of 2008 created a big stir in the agriculture sector mainly due to the escalating prices of inorganic fertilizers.

With prices of fertilizers tripled, farmers were forced to look for alternative sources (as always) of nutrients in which the Department of Agriculture (DA), through the Bureau of Soils and Water Management (BSWM) responded with the Project on Rapid Composting as a part of the DA's National Organic Agriculture Program addressed mainly to rice farmers. The project involves training and provision of shredders to capacitate farmers to produce their own organic fertilizers. He further explained that one of the organic fertilizers or bio-fertilizers produce and used by the vegetable and rice growers are Indigenous Microorganisms (IMO) and fermented products such as Fermented Plant Juice, Kuhol Amino Acid and Calcium Carbonate ($CaCO_3$) as a part of Nutrient Management based on Korean Natural Farming (KNF) or Natural Farming Inputs (NFI) through the assistance of NGOs and SUCs in various training and extension programs. The FPJ contains plant growth hormones and micronutrients that stimulate the growth of beneficial microorganisms while KAA, IMO and $CaCO_3$ can also be used as soil amendments (Maghirang, 2011).

Hence, In support to the organic agriculture and integrated crop management and utilization of the program on Environment and Social Thrust of the Department of Agriculture, this research was conducted to improve the organic rice farming, integrated crop management and utilization of bio-fertilizers as natural farming inputs for upland rice production using "Aringay" variety. In this manner, the problem on upland rice production such as low yield, importation and heavy metals in soils (Felix E. Okieimen and Raymond A. Wuana, 2011) was reduced and consequently, food safety and security is achieved.

Materials and methods

a) Securing and Preparing the Seeds for Planting

The planting material (aringay) was purchased from the Department of Agriculture Southern Cagayan Experimental Station (DA-SCRC), Iguig, Cagayan.

b) Experimental Design and Treatments

The Randomized Complete Block Design (RCBD) was used in the study. A field with an area of 493 sq. meter (29 m x 17 m) including spaces between blocks and plots was divided into three (3) equal blocks with one (1) meter space between blocks to represent the three (3) replications. Each block was divided into five (5) equal plots with one (1) meter space between plots to represent the five (5) treatments. The blocks were labeled I, II and III while the treatments are; T1= (FPJ + KAA), T2= (FPJ + IMO), T3= (FPJ + $CACO_3$), T4= FPJ and T5- CONTROL

c) Preparing the land

The land was prepared thoroughly and properly. Plowing and harrowing were done three times to pulverize the soil ready for planting using a four wheel drive tractor and rotavator.

d) Preparing the Eco-friendly Farming Inputs

The natural farming inputs was prepared before the conduct of the study with the following materials and procedures:

a. Fermented Plant Juice (FPJ). The materials used were: Swamp cabbage, Manila paper (unprinted), molasses, container and rubber. The following pprocedures were as follows: The swamp cabbage (plant materials) was collected early in the morning while they are fresh and the microorganisms are still present. The plant materials were cut into small pieces so that the juice can be easily extracted. After which, two kilogram of molasses was added equal to the weight of the plant material, and mixed together in a bowl or large pan, then packed into a plastic container. Packed the container tightly with the mixed plant material and molasses until full. Cover the mouth of the container with a breathable material, like Manila paper to allow air exchange. The cover was secured (with string, rubber bands, etc.) to keep pests and other contaminants out. Store the covered container in a well-ventilated area away from artificial or natural light and extreme heat or cold. After seven days, drained to extract the liquid and squeeze hard to get the remaining extracts. Fermentation is complete when 1) the plant material floats and the liquid settles at the bottom (note: if too much brown sugar was used, this separation is not distinct); 2) there is a light alcohol smell due to breakdown of chlorophyll; and 3) the liquid tastes sweet, not bitter. Collect the fermented extracts and preserve in clean empty bottle. Wait until tiny bubbles disappear before sealing the cover and before storing. Always leave about ¾ of the empty bottle so that IMO can breathe. *b. Indigenous Microorganisms (IMO).* The materials were as follows: steam rice, molasses, wooden earthen or ceramic container, paper and rubber.The indigenous microorganism was made through: 1.) A one kilogram of rice was cook, after cooling, put the cook rice in a wooden, earthen or ceramic container. 2.) The mouth of the container was covered completely with cloth or paper, fixed in place with a rubber band, to prevent water or small insects from getting in. 3.) Put the covered container, protected from possible rain, under the trees, in a bamboo grove, a forest floor, or wherever a thick mat of leaves has formed. Leave it there for three days. 4.) After whitish moldy filaments have formed, transfer the entire contents of the container to a larger glass or earthen jar and add one kilo of molasses, and 5.) Cover the jar with clean cloth or paper, fixed with a rubber band. Keep the jar in a dark, cool place and let it ferment for seven days, until it appears muddy. *c. Kuhol Amino Acid (KAA).* The materials used in making Kuhol Amino Acid were as follows: Kuhol (golden apple snail) (1kg). Crude sugar or molasses (1kl), pail, manila paper and rubber band. The following pprocedures were used in making Kuhol Amino Acid: 1.) Two kilograms live golden apple snails were washed. Pestle or crushed materials 2.) Add the same amount of molasses and mixed thoroughly, and placed in a container. 3.) The container was covered with a manila paper and keep in dry and clean area. 4.) After 14 days, drained to extract liquid and transferred in a clean plastic bottle. Wait until tiny bubbles disappear before sealing the cover and before storing and always leave about ¾ of bottle empty so that IMO can breathe. *d. Calcium carbonate ($CaCO_3$) preparation from Eggshell.* The materials used were the following: 2 kgs. Eggshell, 2.5 gallon of sugarcane vinegar, manila paper, rubber band and pail. The procedures in making Calcium were the following: The eggshells were washed and crushed and take the inside filament or film. A 2 kilograms eggshell was fried until it was turned brown, set aside and cool. Placed in a plastic container and pour 2.5 gallons of pure coconut or sugarcane vinegar. Wait till the tiny bubbles disappear and stop. After 20 days, the fermented eggshells were screen and placed in an air tight container

e) Planting and thinning

The rows were set up 30 centimeters apart and the seeds were set five seeds per hole in 50cm furrow and were covered with fine soil for uniform growth. The plants were thinned 14 days after seedling emergence to maintain the desired population of 850 plants per plot.

f) Application of organic fertilizer

Twenty five (25) kilograms of vermicast were applied per treatment (10 tons per hectare) as based on the recommended rate of the analysis. This was incorporated to the different plots a day before planting.

g) Application of bio-fertilizers (natural farming inputs)

The Fermented Plant Juice (FPJ, IMO, KAA and Calcium Carbonate ($CaCO_3$) were sprayed started one month after planting, then followed every month until harvesting. The natural farming inputs were sprayed on plants early in the morning or late in the afternoon with the rate of 2 tablespoon per 5 liters of water as based on the recommended rate of the analysis

h) Cultivation and weeding

Cultivation was done 4 to 5 weeks after planting using a carabao drawn plow. Similarly, weeds were eliminated by using hoes twice at 20 and 40 days after the seeds germinated

i) Pest Management

Spraying was done early in the morning and late in the afternoon using metharhizium

j) Harvesting, Threshing and Drying the Seeds

The upland rice was harvested when the seeds are turning yellow/brown or 80% of the grains turn yellow. That is about 28-30 days after flowering or a month after flowering (seed maturity). Harvesting was done first for the ten sample plants separately for data gathering. Then the remaining plants follow. Cut the panicle (above flag leaf) and drying before threshing. The harvested rice was threshed and thoroughly cleaned. The grains were sun-dried until it reaches the desirable moisture content for sorting.

k) Data gathered

The following data were gathered from the study: Plant Height (cm) - the plants was measured from the base up to the tip of the plant using meter stick. This was gathered at 120 days after planting. Number of productive tillers (#) - this was taken by counting the total number of tillers that bear panicles. Number of non-productive tillers (#)- this was taken by counting the total number of tillers that did not bear panicles. Length of panicles (cm) - this was taken by measuring the panicle from the base to the tip of the ten samples plants. Number of filled grains (#)- after harvesting, the ten sample plants in each treatment were separated, after which the filled grains were counted. Number of unfilled grain (#) - this was taken by counting the unfilled grains from the 10 sample panicles. Weight of 1000 seeds (g) - this was taken by weighing 1,000 grains in each treatment using a digital weighing scale. Computed yield per hectare (tons) - yield of grains per plot was taken using crop-cut method or 100 hills per plot was computed to a hectare basis using this formula:

$$\text{Yield in Kg/ha.} = \frac{\text{yield/plot x Area/ha}}{\text{Area/treatment}}$$

Gross margin Analysis (ROI)- current prices of all inputs were considered in the computation. Labor inputs were computed in a person-day (PD) and the labor cost was based on the prevailing rates in the locality.

$$\text{ROI} = \frac{\text{Net Income}}{\text{Total Cost Production}} \times 100$$

l) Analysing the Data

The data gathered were analyzed using the Analysis of Variance (ANOVA) of Randomized Complete Block Design (RCBD).

Results and discussion

Plant height (cm) at maturity

Table 1 shows the result of plant height of upland rice at 120 days after planting (DAP) as utilized by bio-fertilizers. Plant height at 120 DAP revealed that the highest plant height was obtain by FPJ + KAA with a mean of 136.95cm followed by, FPJ + IMO with a. mean of 103.47cm, control with a mean of 100.12cm, FPJ with a mean of 99.30cm and FPJ + $CaCO_3$ with a mean of 97.97cm.

The utilization of bio-fertilizers and systems for upland rice showed no significant differences among treatments on the height of the upland rice at 120 days. The result revealed that whatever treatments used in upland rice production, can influence the growth performance of the plants.

Table 1. Plant height of upland rice (Aringay) at 120 days utilized by bio-fertilizers during off-season.

Treatment	Mean
T1-FPJ+KAA	136.95
T2-FPJ+IMO	103.47
T3-FPJ+CALCIUM	97.97
T4-FPJ	99.30
T5-CONTROL	100.12
Statistical Inference	ns

Number of Productive tillers

Table 2 shows the number of productive tillers of upland rice as utilized by bio-fertilizers. It showed that Fermented plant juice with Indigenous Microorganism had the most number of productive tillers with a mean of 8.03, followed by fermented plant juice with kuhol amino acid, fermented plant juice , fermented plant juice with $CaCO_3$, and control, with a mean of 7.23, 7.23, 6.57 and 5.73, respectively.

However, numerical differences among treatments on this parameter did not prove any significant result. The results revealed that the treatment used had comparable effects on the number of productive tillers.

Number of Unproductive tillers

Table 3 shows the number of unproductive tillers of upland rice (Aringay) as utilized by bio-fertilizers. It showed that Control (no application of bio-fertilizers) produced the highest number of unproductive tillers with a mean of 5.27 followed by fermented plant juice, fermented plant juice with $CaCO_3$, fermented plant juice with kuhol amino acid and fermented plant juice with indigenous microorganism, with a corresponding average number of unproductive tillers with a mean of 4.73, 4.27, 3.97 and 3.77, respectively.

However, numerical differences among treatments on this parameter did not prove any significant result. The result implied that whatever the treatments used in the study may cause of unproductive tillers of the plants.

Table 2. Number of Productive tillers of upland rice (Aringay) as utilized by organic-based farming inputs during off-season.

Treatment	Mean
T1-FPJ+KAA	7.23
T2-FPJ+IMO	8.03
T3-FPJ+CALCIUM	6.57
T4-FPJ	7.23
T5-CONTROL	5.73
Statistical inference	ns

Table 3. Number of Unproductive tillers of upland rice (Aringay) utilized by bio-fertilizers during off-season.

Treatment	Mean
T1-FPJ+KAA	3.97
T2-FPJ+IMO	3.77
T3-FPJ+CALCIUM	4.27
T4-FPJ	4.73
T5-CONTROL	5.27
Statistical inference	ns

Length of panicles

Table 4 shows the length of panicles of upland rice (Aringay) as utilized by bio-fertilizers. Results revealed that the longest panicle of upland rice plants (Aringay) were obtained by Fermented Plant juice with Indigenous microorganism followed by Fermented Plant Juice with Kuhol Amino Acid, Fermented Plant Juice with $CaCO_3$, Fermented Plant Juice, and Control with a means of 156.92, 150.43, 149.98, 143.18 and 126.20, respectively.

However, numerical differences among treatment on this parameter did not show any significant result. The results revealed that whatever the treatment used in upland rice, can influence the length of the panicles.

Table 4. Length of panicles of upland rice (Aringay) utilized by bio-fertilizers during off-season.

Treatment	Mean
T1-FPJ+KAA	150.43
T2-FPJ+IMO	156.92
T3-FPJ+CALCIUM	149.98
T4-FPJ	143.18
T5-CONTROL	126.20
Statistical inference	ns

Number of filled grains

Table 5 shows the number of filled grains of upland rice (Aringay) as utilized by bio-fertilizers. Results revealed that the most numbers of filled grains of upland rice (Aringay) were obtained by fermented plant juice with indigenous microorganism followed by fermented plant juice with kuhol amino acid, fermented plant juice with $CaCO_3$, fermented plant juice and control with a means of 650.57, 525.13, 497.43, 467.53 and 449.33, respectively.

However, numerical differences among treatment on this parameter did not prove any significant result. The results implied that all the treatments used in the study had comparable effects on the number of filled grains of upland rice.

Table 5. Number of filled grains of upland rice (Aringay) utilized by bio-fertilizers during off-season.

Treatment	Mean
T1-FPJ+KAA	525.13
T2-FPJ+IMO	650.57
T3-FPJ+CALCIUM	497.43
T4-FPJ	467.53
T5-CONTROL	449.33
Statistical inference	ns

Number of Unfilled grains

Table 6 shows the number of unfilled grains of upland rice (Aringay) utilized by bio-fertilizers. Results revealed that the most number of unfilled grains of upland rice (Aringay) were obtained by control followed by fermented plant juice, fermented plant juice with $CaCO_3$, fermented plant juice with kuhol amino acid and fermented plant juice with indigenous microorganism, with a means of 387.00, 380.90, 357.63, 338.97 and 326.60, respectively.

However, numerical differences among treatment on this parameter did not prove any significant. The result implied that whatever the treatment used in the crop may cause the number of unfilled grains of the plants.

Table 6. Number of unfilled grains of upland rice (Aringay) utilized by bio-fertilizers during off-season.

Treatment	Mean
T1-FPJ+KAA	338.97
T2-FPJ+IMO	326.60
T3-FPJ+CALCIUM	357.63
T4-FPJ	380.90
T5-CONTROL	387.00
Statistical inference	ns

Weight of 1000 seeds per plot

Table 7 shows the weight of 1000 seeds per plot of upland rice (Aringay. Results revealed that the heaviest weight of 1000 seed of upland rice (aringay) were obtained by fermented plant juice with indigenous microorganism followed by fermented plant juice with kuhol amino acid, fermented plant juice with $CaCO_3$, fermented plant juice, and control with a means of 25.00, 23.67, 22.67, 22.33, and 21.67, respectively.

However, numerical differences among treatment on this parameter did not prove any significant result. The results revealed that all the treatments used in the study can influenced the weight of 1000 seeds of the upland rice.

Table 7. Weight of 1000 seed of upland rice (Aringay) utilized by bio-fertilizers during off-season.

Treatment	Mean
T1-FPJ+KAA	23.67
T2-FPJ+IMO	25.00
T3-FPJ+Calcium	22.67
T4-FPJ	22.33
T5-CONTROL	21.67
Statistical inference	ns

Computed yield per ha (tons)

Table 8 shows the computed yield per plot of upland rice (Aringay) utilized by bio-fertilizers. Results revealed that the highest in computed yield per hectare (tons) of upland rice (Aringay) were obtained by fermented plant juice with indigenous microorganism followed by fermented plant juice with kuhol amino acid, fermented plant juice with $CaCO_3$, fermented plant juice, and control with means of 1.62, 1.14, 1.13, 1.11 and 1.00, respectively.

However, numerical differences among treatment on this parameter did not prove any significant result. This means that whatever treatment used in the study had comparable effects on the yield performance of upland rice.

Table 8. Computed yield per ha (tons) of upland rice production (Aringay) utilized by bio-fertilizers during off-season.

Treatment	Mean
T1-FPJ+KAA	1.14
T2-FPJ+IMO	1.62
T3-FPJ+Calcium	1.13
T4-FPJ	1.11
T5-CONTROL	1.00
Statistical inference	ns

Gross Margin Analysis (ROI)

The table 9 shows the gross margin analysis of upland rice as utilized by bio-fertilizers. The results of the study showed that Fermented Plant Juice with Indigenous Microorganism (FPJ + IMO) garnered the highest return on investment among the different treatment with a total of 65.58 %, followed by Control, 25.73%%, Fermented Plant juice with Kuhol Amino Acid (FPJ+ KAA) 15.82%, Fermented Plant Juice, 12.66% and Fermented Plant Juice with $CaCO_3$ (FPJ+ $CaCO_3$) with a total of 2.15%.

The result revealed that Fermented Plant Juice with Indigenous Microorganism (FPJ + IMO) was the best treatment in terms of return on investment (65.58%)).

This implies that in every peso invested in the study, there was a corresponding return of 0.6558 pesos.

Table 9. Gross Margin Analysis of Upland Rice as utilized by bio-fertilizers during off-season.

Treatment	Gross income/ha	Total cost of production/ha	Net income/ha	ROI %
T1-FPJ+KAA	28,442.00	20,556.27	7,885.73	38.36%
T2-FPJ+IMO	38,660.00	20,556.27	18,103.73	88.07%
T3-FPJ+$CaCO_3$	28, 192.50	20,556.27	7,636.23	37.15%
T4-FPJ	27,665.00	20,556.27	7,108.73	34.58%
T5-CONTROL	25,085.00	20,423.00	4,662.00	22.83%

Conclusion

Based from the results of the study, it was concluded that FPJ +IMO produced the best productive tiller, panicle length, filled grains, weight of 1000 seeds, yield per hectare and ROI, FPJ+KAA had the tallest plant height, and control had the most number of unfilled grains and unproductive tiller. Moreover, the results showed that utilization of bio-fertilizers (FPJ +IMO, FPJ+KAA, FPJ+$CaCO_3$) can contribute to the improvement of the growth and yield performance of upland rice when it compares to the performance of the controlled plants (no application of bio-fertilizer).

Recommendation

Based from the result of the study, fermented plant juice with Indigenous Microorganism (FPJ + IMO) produced the most number of productive tiller, longest panicle length, most number of filled grains, heaviest weight of 1000 seeds, highest yield per hectare and ROI. Therefore, this bio-fertilizer or natural farming inputs is recommended to the farmers in the locality to obtain higher income. It is further recommended that another trial using different level of FPJ + IMO must be conducted during wet season for the comparative results.

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