INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 14, No. 1, p. 484-494, 2019

RESEARCH PAPER OPEN ACCESS

Yield response of upland Rice + Peanut intercropping schemes to Rhizobial (Bio-N) inoculation

MSA Jona Longat Asuncion*

College of Agriculture, Cagayan State University, Philippines

Key words: Intercropping, Rhizobial Inoculation, yield response.

http://dx.doi.org/10.12692/ijb/14.1.484-494 Article published on January 31, 2019

Abstract

This research was conducted during the dry season to evaluate the intercropping schemes in peanut and Rhizobial inoculation. The study aimed to compare the growth and yield performance of Rhizobium inoculated upland rice and peanut, to determine the land productivity through Land Equivalent Ratios, determine the nitrogen level of the soil per treatment before and after the conduct of the study and do a simple analysis on the cost and returns using the different intercropping schemes and inoculation. Two- Factorial in RCBD was used in evaluating the effects of Factor A (inoculation) and Factor B (intercropping pattern). Rice yield parameters like plant height, herbage yield, and yield per plot in rice are not significantly affected by cropping pattern and Rhizobial inoculation. There was a significant effect in number of tillers. In peanut, cropping pattern and inoculation affected pod yield per plot and hay yield. The combined yield of peanut and upland rice was significantly in T_1: inoculated 1R: 3P over the monoculture. Using LER as index of productivity, 2R:2P without inoculation produce the highest LER at 1.92. There was an appreciable improvement in the Nitrogen content of the experimental plots after the conduct of the study. Considering higher ROI, it is recommended to follow 1R:3P with inoculation and monocrop peanut with inoculation. The use of multiple cropping is obviously beneficial as when one crop fails, there is still another crop from which the farmer could derive income as in the case of rice.

* **Corresponding Author:** Jona Longat Asuncion ✉ gilbertmagulod_rdecsulasam28@yahoo.com

Introduction

Upland rice is grown in rainfed, naturally well-drained soils with bunded or unbunded fields without surface water accumulation. The general perception about the upland environment is that it is drought-prone, usually sloping land with erosion problems, soil degradation, physical and chemical properties, and low fertility. Farmers in these environments are among the poorest and usually cannot afford to apply external inputs such as fertilizer. Upland rice varieties are mostly grown as a low-yielding subsistence crop to give stable yields even under the adverse environmental conditions of the uplands.

Intercropping, the growth of two or more crop species simultaneously (cogrowth) in the same field area, has been widely practiced worldwide (Vandermeer 1992, Francis 1986). Furthermore, intercropping also provides an important pathway to reduce soil erosion, fix atmospheric N2, lower the risk of crop failure or disease and increase land use efficiency (Li *et al.*, 2013). There are very close relationships between yield advantage and nutrient acquisition in intercropping systems (Norris & garritti, 1993). Intercropping is an efficient cropping system in terms of resource utilization (Vandermeer, 1992).

Intercropping which is the growing of two or more crops in the same field at the same time is one of the methods of crop intensification commonly practiced by traditional farmers in small farms in the Philippines. The benefits derived from intercropping are: maximized land utilization, increased farm profits, better income distribution, better labour use, production of more food crops, reduction of weed growth, and cost of weed control and improvement of soil physical characteristics and fertility.

Bacterial nitrogen fertilization is being exploited in integrated soil fertility management strategy as it had shown a significant element in the processes to reverse the degradation of cultivated land. This particular strategy is believed to help farmers who cannot afford the expensive inorganic fertilizers for staple crops. The introduction of bacterial nitrogen fertilization in upland rice production system is geared towards the improvement of yield, thereby contributing to the attainment of the food security program of the government. Thus, there is need to determine the most appropriate row ratio of upland rice and peanut that will consequently improve the yield of upland rice and peanut.

In the previous studies, Zhi-Ghang Wang *et al.* (2014) how intercropping Enhances Productivity and Maintains the Most Soil Fertility Properties Relative to Sole Cropping. They found out intercropping enhanced productivity and maintained the majority of soil fertility properties for at least three to four years, especially at suitable P application rates. In like manner, Liang *et al.* (2016) studied the effects of intercropping rice and water spinach on net yields and pest control, their finding suggests that rice and water spinach intercropping is a viable alternative for sustainable rice production with a small farming scale in southern China. Further, Chu *et al.* (2004) proved that the new intercropping system is very promising for the development of sustainable food production within the limited natural resources of China.

Highlands of Cagayan and Mountain Provinces are proudly cultivating upland varieties connected with their identity as a clan or a tribe. These upland rice farmers follow traditions in cultivating upland rice which generally patterns the organic methods and therefore the products are considered to be safe and environment friendly. The intensification of land use could be achieved by multiple cropping. The growing of two or more crops on the same piece of land at a given time maintains soil fertility especially when leguminous crops are grown in association with the main crop. For optimum yield, crop plants require a supply of mineral nutrients, the most important of which is nitrogen. Exhausted soils are often low in nitrogen, meaning that farmers are normally applying inorganic fertilizers. However, as fertilizer cost increase, farmer struggle to obtain good yields. This problem can be addressed by incorporating legumes to the cropping system like upland rice. Peanut is an important economic crop, and is often used as a component crop intercropped with maize or with spring wheat in China (Zuo *et al.*, 2000).

As rice can be cultivated in aerobic soil and intercropped with legumes, we asked what happens when the novel intercropping system is practiced? Is the intercropping system facilitated to both component crops, especially in N nutrition.

This study is intended to provide the farmer with a useful harvest while at the same time improving the fertility of the soil in order to benefit fully from cereal-legume with rhizobial inoculation to maximize the productivity of the legume crop in addition to the cereal. Generally, the study aimed to determine the yield response of upland rice and peanut to intercropping row ratio and inoculation with Rhizobium. Specifically, it aimed to: (1) determine the growth and yield performance of Rhizobium inoculated upland rice and peanut; (2) determine the land productivity through Land Equivalent Ratios (LER); (3) to determine the nitrogen level of the soil per treatment before and after the conduct of the study; (4) to determine the return on investment using the different intercropping schemes and inoculation.

Materials and Methods

Procurement and Description of Rice and Peanut Seeds

Upland Rice (Aringay Variety)

The upland rice variety used is the popular Aringay grown in Lasam is a special and sturdy landrace of upland rice variety, has brown and dense grains and native to the place. It is being planted and nurtured by the original settlers tilling the upland areas in the town of Lasam. The Aringay is characterized by a unique aroma and its ability to withstand the adversities of nature

Peanut (Pn9 Variety)

Pn 9 is a peanut variety that has a pinkish seed coat, is medium seeded, moderately susceptible to leaf rust, slightly tolerant to excessive soil moisture, resistant to sclerotium disease, moderately resistant to cercospora leaf spot and leaf hoppers and defoliators and contain two (2) seeds/pod. Maturity occurs in 90-110 days after planting. A hectare field can give a yield of 1.50-2.0 tons unshelled pods.

Location of the Experimental Area

The location of the experimental area is at the Research and Development of Isabela State University Cabagan Campus near the Tropical Gene bank.

Soil Sampling and Analysis

The soil analysis was done prior to the conduct of the study in order to determine the right amount of fertilizer to be applied.

Land Preparation

The usual land preparation for upland rice and peanut was followed, i.e. two plowings with alternate harrowing. Final harrowing was done a day before planting. Furrowing was done prior to planting and spaced at a uniform distance of .50 m for peanut and the upland rice is .20 m. The intercropped treatment combinations was set in furrows. Furrows were oriented on an east-west direction to have greater and uniform light distribution for the crops.

The Treatments

The experiment was aimed at determining the effects of 2 factors; (a) the use and non-use of Bio- N inoculant and (b)intercropping patterns for rice and peanut. The treatments are shown in the table below:

Factor A (inoculation)	*Factor B (cropping pattern)*
a_1= inoculated (Bio-N)	b_1= 1 row of rice: 3 rows of peanut
a_2= not inoculated	b_2=2 rows of rice: 2 rows of peanut
	b_3= 3 rows rice: 1 row peanut
	b_4= Monoculture (upland rice)
	b_5= Monoculture of peanut

Treatments No.	Description	Cropping Pattern
T_1	a_1b_1= (inoculated 1 row of rice to 3 rows of peanut)	1:3
T_2	a_1b_2= (inoculated 2 rows of rice to 2 rows of peanut)	2:2
T_3	a_1b_3= (inoculated 3 rows of rice to 1 row of peanut)	3:1
T_4	a_1b_4= (inoculated monoculture of upland rice)	inoculated monoculture of rice

Treatments No.	Description	Cropping Pattern
T_5	$a_1b_{5=}$ (inoculated monoculture of peanut)	inoculated monoculture of peanut
T_6	$a_2b_{1=}$ (not inoculated 1 row of rice to 3 rows of peanut)	1:3
T_7	$a_2b_{2=}$ (not inoculated 2 rows of rice to 2 rows of peanut)	2:2
T_8	$a_2b_{3=}$ (not inoculated 3 rows of rice to 1 row of peanut)	3:1
T_9	$a_2b_{4=}$ (not inoculated monoculture of upland rice)	not inoculated monoculture of rice
T_{10}	$a_2b_{5=}$ (not inoculated monoculture of peanut)	not inoculated monoculture of peanut

Fertilizer Application and Nutrient Management

Fertilizer applications were based on a recommended scheme (Table 2). The rate of fertilizer being applied on the plants were based on the soil analysis (Appendix A). The recommended rate of fertilizer was applied as top dress 20 days after sowing and 40 days after sowing. The second top dress, third top dress were applied during the booting stage.

Table 2. Fertilizer recommendation (Soils Lab., Ilagan Isabela).

Rice	80-30-60
Basal application	3.0 bags/ha. 16-20.0 & 1.0 bag/ha. 0-0-60 10 bags/ha. Organic fertilizer
1st Topdress	2.0 bags/ha.21-0-0, 7-10 days after transplanting
2nd Topdress	1.5 bags/ha. 46-0-0, 20-25 days after transplanting
3rd Topdress	0.5 bag/ha. 46-0-0 or based on the leaf chart, 35-40 days after transplanting 1.0 bag/ha. 0-0-60 at booting stage
Peanut	20-40-30
	2.9 bags/ha
	14-14-14, 2.2 bags/ha.
	0-18-0 & 0.3 bag/ha.0-0-60

Planting

Planting of upland rice and peanut was done by dropping seeds on previously prepared furrows after covering the basally applied fertilizer with a thin sheet of soil. The rate of seeding for rice is 100kgs/ha. while for peanut is 90kgs/ha based. The upland rice seeds were hill planted in the furrows called for by the different treatments. Seeds of peanuts were seeded at the rate of 2 to 3 seeds per hill. As a standard production technology, peanut and upland rice seeds were inoculated with Rhizobium (Bio-N) by slurry method before planting based on the treatments.

Weeding and Cultivation

Weeding started at two weeks after emergence of the seeds. The operation was repeated at biweekly interval and weeding was done depending on the prevalence of the weeds. Hand weeding by uprooting or cutting was employed. Cultivation (off-barring) was done two weeks after the emergence of the seeds. Hilling- up was done a week after off-barring.

Insect Pest and Disease Prevention and Control

Monitoring of insect pest and disease occurrence in the experimental area was done on a daily basis to avoid possible serious damage occurrence. Bio pesticides was applied based on need.

Harvesting

Harvesting of rice crop was done when the panicles became golden brown and the spikelets at the base portion became brown. Peanut were harvested 100 days after planting season.

Data gathered

The following data were gathered:

Growth Parameters

A. Rice

a. Plant height. This was taken every week to measure the distance from the base of the plant at the soil level up to the uppermost part of the plant. Ten (10) plants were randomly chosen as samples measured in centimeters.

b. Number of Tillers. The number of tillers of every sample plant in every plot was counted and recorded at six (6) week after emergence (WAE) and biweekly thereafter.

c. Herbage yield. This data was taken from the vegetation extracted from yield after removing the grains and left on the plots to dry for few days.

d. Yield per plot (kg/ha). This data was taken by weighing yield (kg) per plot.

e. Cost and Return Analysis. The cost and return analysis was determined by computing the total cost of producing the upland rice per treatment and the return (based on prevailing market prices) computed. Seed yield (kg/ha) was projected from yield to of harvested area.

B. Peanut

a. Pod yield per plot. This was taken from the harvest area. Pods were sundried for 5 days or until they have attained a moisture content of 14% then the weight recorded for yield determination.

b. Peanut hay yield. All plants from the harvest area was sundried for ten days or until the moisture content of 14% was reached then the weight was recorded.

C. Land Equivalent Ratio was determined using the formula:

LER= $Y_A/S_A + Y_B/S_B$

Where $/S_A$ and S_B are yields of the crops grown alone while Y_A and Y_B are yields of the component crops in the mixture.

D. *Soil*

a. Nitrogen content of the soil before and after the conduct of the experiment.

Rainfall data. This was taken at the Agro meteorological Station at Department of Science and Technology- Philippines Atmospheric, Geophysical, Astronomical Service Administration (DOST-PAGASA) in Regional Center at Carig, Cagayan.

Results and discussion

A. Rice

a. Plant Height

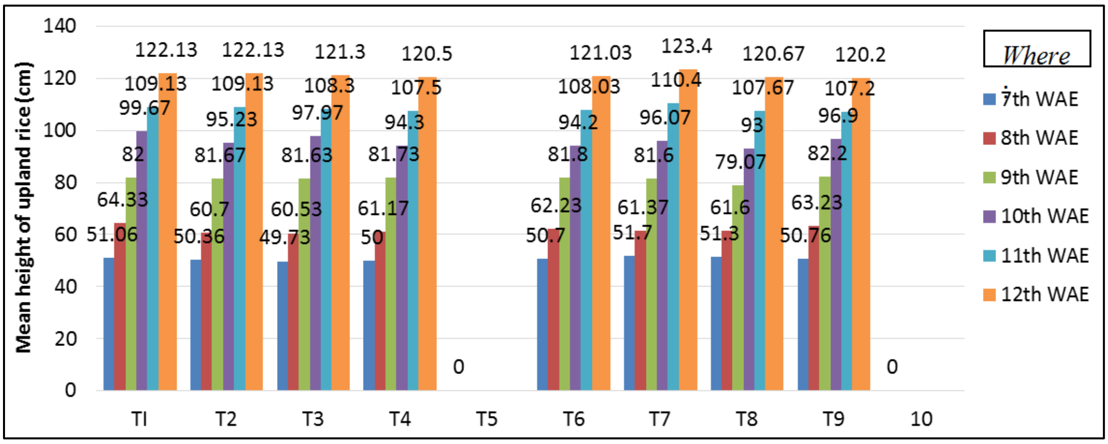

Fig. 2. Mean Height of upland rice taken at 7th WAE to 12th WAE.

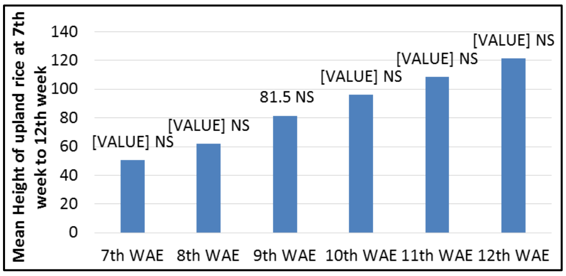

Fig. 2a. Results of height in ANOVA 7th WAE to 12th WAE.

On the 7^{th} week after emergence, T_7 – not inoculated 2R:2P rice plant exhibited tallest at 51.7 followed by T_8, T_1 T_6 T_9 T_2 T_4, T_3 in descending order of small differences (51.3, 51.06, 50.7, 50.36, 50, 49.77, respectively. Results show that the different cropping pattern applying inoculated and not inoculated no significant effect on the 7^{th} week of plant height.

There was no interaction effect of the two factors on this parameter. On the 8^{th} week after emergence, T_1, inoculated (1R:3P) rice plant exhibited tallest at 64.33 followed by T_9, T_6, T_8, T_7, T_4, T_2, T_3 in descending order of small differences (63.23, 62.23, 61.60, 61.37, 61.17, 60.70 and 60.50, respectively. Results show that the different cropping pattern applying inoculated and not inoculated no significant effect the 8^{th} week of plant height. There was no interaction effect of the two factors on this parameter (See appendix Table 2c).

In 9th week after emergence T_9, not inoculated monoculture of rice plant exhibited tallest at 82.20 followed by T_1, T_6, T_4, T_2, T_3, T_7, T_8 in descending order of small differences (82, 81.80, 81.73, 81.67, 81.63, 81.60 and 79.07 respectively. Results show that the different cropping pattern applying inoculated and not inoculated no significant effect the 9th week of plant height.

There was no interaction effect of the two factors on this parameter. In 10th week after emergence T_1, inoculated 1R:3P plant exhibited tallest at 99.67 followed by T_3, T_9, T_7, T_4, T_6, T_8, T_8 in descending order of small differences (99.97, 96.90, 95.23, 94.30, 94.20 and 93, respectively. Analysis of variance results showed insignificantly effect of the treatments. The positive source of variation was recorded on the Replication (possibly the effect of blocking).

In 11th week after emergence T_7, not inoculated 2R:2P plant exhibited tallest at 110.40 followed by T_1, T_2, T_3, T_6, T_8, T_4, T_9 in descending order of small differences (110.40, 109.13, 108.30, 108.03, 107.67, 107.50 and 107.20 respectively. In 12th week after emergence T_7, not inoculated 2R:2P plant exhibited tallest at 123.40 followed by T_1, T_2, T_3, T_6, T_8, T_4, T_9 in descending order of small differences (122.13, 121.30, 121.03, 120.67, 120.50 and 120.20 respectively.

Table 3 presents the average height (cm) of different cropping pattern as affected by inoculation and not inoculation in 7th week to 12th week, Analysis of variance results show that despite numerical variations, there was no significant difference in terms of plant height at 7th week to 12th week which ranged from 50.7 to 81.5 (See Appendix Table 4b). Contrary to this result, Sinahon, 1993 reported that the different population applied to upland rice and peanut intercrops significantly affected some of growth characteristics and yield parameters of both crops. This effect, according to Geijersstam and Martensson 2006 *et al*, could be due to the ability of transfer fixed Nitrogen legumes can transfer fixed nitrogen to intercropped cereals during their joint growing periods and this Nitrogen is an important resource for the cereals.

Number of Tillers

The number of tillers observed in cropping pattern as affected by the inoculation and not inoculation is reflected in Table 4. Evaluation showed that the inoculation significantly affected the number of tillers. See Appendix Table, 1.b

In 6th week T_9= not inoculated monoculture of rice gave the highest number of tillers of 29.33, followed by row ratios of not inoculated, T_6= 1R:3P, T_7= not inoculated 2R: 2P, T_8= not inoculated 3R:1P, T_3= inoculated 3R:1P, T_4= inoculated monoculture of rice, T_2= inoculated 2R:2P and T_2= inoculated 1R: 3P which had means of 29.13, 27.67 while the T_2 26.17, T_3 26.40, T_4 26.30, T_8 26.70 were almost the same result and the lowest is 25.93 in T_1.

The 7th week T_9= not inoculated monoculture of rice gave the highest treatment of 32.77 followed by T_6 not inoculated = 1R:3P 32.50, T_7 with a mean of 31.33, In T_2=inoculated 2R:2P, T_3= inoculated 3R: 1P, T_8= inoculated 3R:1P, and T_4 inoculated monoculture of upland rice with a mean of 30.83, 30.73, 30.73 and 30.47 are almost the same mean while the lowest is T_1= inoculated 1R:3P.

Last in 8th week T_9= not inoculated monoculture of rice again was the highest with a mean 34.57 followed by the T_6 not inoculated = 1R:3P 33.57, T_7 with a mean of 32.57. In T_2=inoculated 2R:2P, T_8= inoculated 3R:1P, T_3= inoculated 3R: 1P, T_4 inoculated monoculture of upland rice with a mean of 32.27, 31.93, and 31.87 are almost the same mean while the T_1 inoculated 1R:3P are the lowest with a mean of 31.10 respectively.

Analysis of variance reveals significantly difference in 6th weeks to 8th weeks with significantly more tillers in (A2) without inoculation compared to (A1) with inoculation.

According to Af Geijersstam and Martensson 2006 *et al*, legumes can transfer fixed nitrogen to intercropped cereals during their joint growing periods and this nitrogen is an important resource for the cereals but in this study, there was no effect of inoculation also, International Atomic Energy Agency 1998 reported that increased nitrogen fixation improved the grain yields and observed the possible benefits on the nitrogen balance of selected legumes like chickpea, groundnut, cereals, soybean and lentil showed significant yield and nitrogen fixation responses after rhizobial inoculation in most field trials.

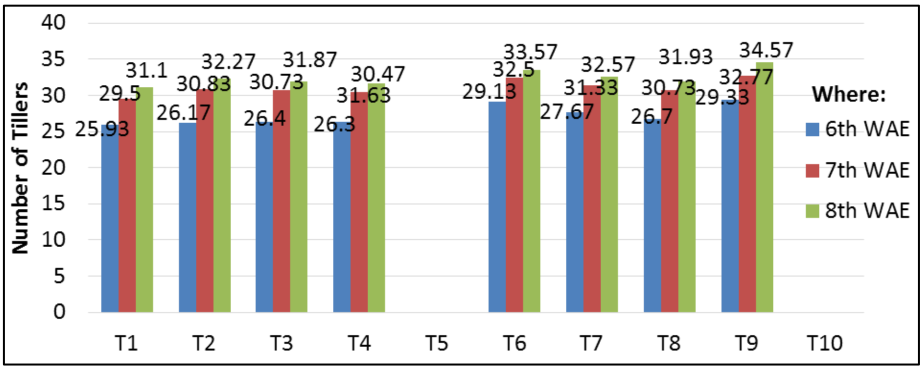

Fig. 3. Number of tillers of upland rice taken at 6TH WAE to 8th WAE.

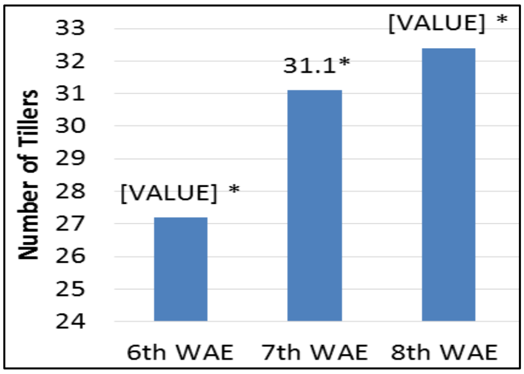

Fig. 3a. ANOVA of number of tillers in 6th WAE 8th WAE.

Herbage yield of Rice (kgs/plot)

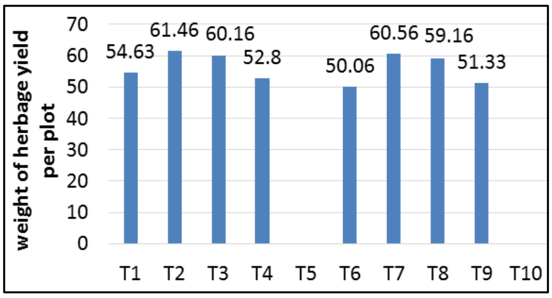

Fig. 4. Mean weight of herbage yield in rice (kgs/plot).

Rice herbage yield in Fig. 4 shows that, T_2 inoculated 2R:2P got the highest at 61.46 kilograms followed by T_7, T_3, T_8, T_1, T_4, T_9, and T_6 in descending order of small differences (60.56, 60.16, 59.16, 54.63, 52.8 and 51.33), respectively. Analysis of variance reveals insignificant difference, however T_2- inoculated 2R:2P are highest herbage yield among the treatments, according to Vessey 2004, rhizobial inoculation showed a positive effect on dry matter and grain yield of different crop. A clear significant response to inoculation was also found in "virgin" soils, meaning soils that had never been inoculated with rhizobia.

Yield per plot

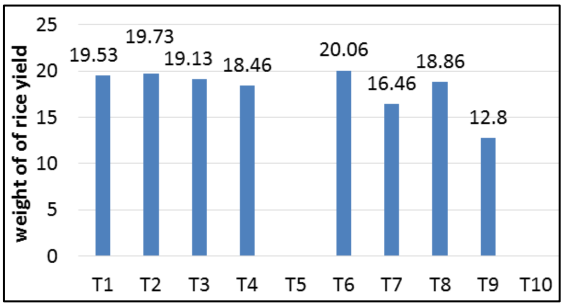

Fig. 5. Rice yield per plot in rice (gms).

The highest mean in different treatment is T_6 (not inoculated 1R:3P), followed by the T_2- (inoculated 2R:2P), T_1- (inoculated 1R:3P), T_3- (inoculated 3R:1P) with a mean of 19.73, 19.53, 19.13 followed by the T_8- (not inoculated 3R:1P) and T_4- (inoculated monoculture of peanut) 18.86 and 18.46. And the lowest is T_7 and T_9 is 16.46 and 12.8 respectively. Analysis of variance reveals that treatments are not significantly different as to yield of rice per plot. According to our interview with Aringay growers in Lasam (source of seeds) they grow this upland rice in the month of June. This study was conducted at the start of November which coincided with drought as show in the PAG-ASA data (see appendix table) Drought could have severely affected Aringay which is not a drought tolerant variety.

Peanut

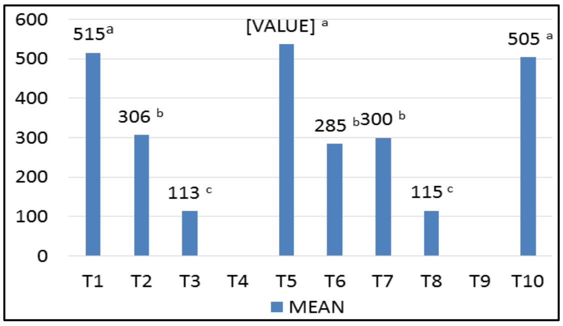

Fig. 6. Peanut yield per plot in rice (gms).

The monoculture of peanut (T_5) obtained the highest pod yield per plot is T_5 at 536, second rank is T_1- inoculated (1R:3P) 515, in the third rank T_{10}- (not inoculated monoculture of peanut) 505. In T_2 the mean is 306, followed by the T_7- not inoculated (2R:2P) 300, while the T_6 the mean is 285. The lowest was observed at T_8- not inoculated (3R:1P) and T_3 inoculated (3R:1P) with a mean of 115 and 113 respectively. As shown in Appendix Table 12b and Appendix Table 12c, inoculated peanut have higher yield compared to non-inoculated. However, on cropping pattern, inoculated monoculture of peanut had higher yield compared to the intercrops in peanut which showed that the B_3 (3R:1P) is lowest. According to the study of Macaballug, 1993., rice which is tall statured crop, depressed the pod yield of peanut due to progressive shading imposed on peanut and similar observation was noted by Fernandez, *et al* (1998) on the yield of peanut grown in partial shade where, pod was significantly reduced under partial shade as compared to those in open condition. Analysis of variance reveals highly significantly differences caused by inoculation, cropping scheme.

Peanut Hay Yield (grams)

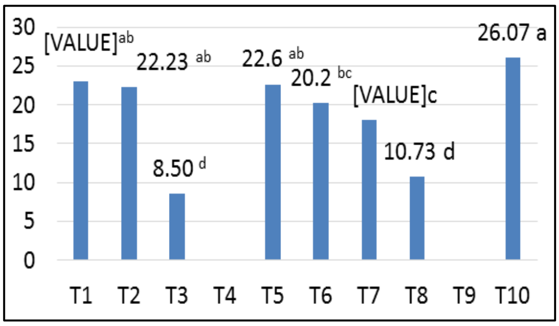

Fig. 7. Hay yield as affected by intercropping pattern in inoculation and not inoculation.

Data on peanut hay yield recorded at 14% moisture content showed notable differences among the different cropping pattern as affected by the inoculation and non-inoculation (Table 6). The highest hay yield of peanut was observed in the T_9- not inoculated monoculture of peanut, the mean weight of peanut hay yield was 26.07. This was followed by row ratio T_1= inoculated 1R: 3P with a mean of 22.97, Next in T_5= inoculated monoculture of peanut with a mean of 22.60, The T_2= inoculated 2R:2P and T_6= not inoculated 1R:3P with a mean of 22.23 and 20.20 and the lowest is T_8= not inoculated 3R:1P and T_3= inoculated 3R:1P with a mean of 10.73 and 8.50 respectively. Analysis of variance reveals that highly significant differences on the peanut hay yield, as shown in Table 12b and Table 12c inoculated peanut have higher yield compared to non-inoculated. However, on cropping pattern, inoculated monoculture of peanut had higher yield compared to the intercrops in peanut which showed the B_3 (3R:1P).

Land Equivalent Ratio

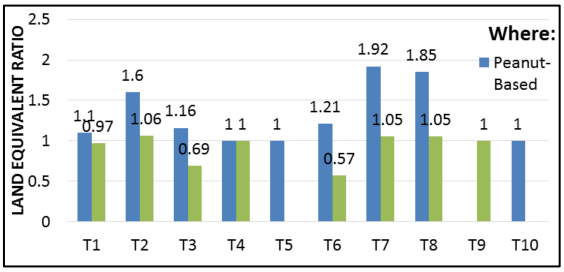

Fig. 8. Land Equivalent Ratio (LER) of rice and peanut as affected by intercropping pattern and inoculation.

The land equivalent ratio (LER) peanut-based the highest at row ratio T_7- not inoculated (2R:2P) 1.92. Next in rank were T_8- not inoculated (1R:3P) 1.85 and T_2 inoculated (2R:2P) 1.60, followed by the T_6 not inoculated (1R:3P) 1.21 and T_1 at 1.1, LER values are the same 1.0, T_4 – inoculated monoculture of rice, T_5- inoculated monoculture of peanut, T_9- not inoculated monoculture of rice and T_{10}- not inoculated monoculture of peanut.

The land equivalent ratio (LER) if rice-based is the highest at T_2 (1.06) followed by row ratio T_7- not inoculated (2R:2P) at 1.05 and T_8 (1.05), T_4, T_5, T_9, T_{10} had 1.0 LER, T_1, T_3, T_6 in .97, .69 and 57 respectively.

The study on legume as a component crops are always expected to have as LER lesser than one (1.0) which demonstrates the inhibitory polyculture interaction described by Hart, 1975. Plants do not compete with each other on water, nutrient material, heat and light if the supply of such is in excess of the needs of both. However, when the immediate supply of one growth factor (i.e. water) Fall below the combined demands of the plants, competition begins. In this case, water had become limiting to rice was at a disadvantages position with indicators of less than 1.0 LER (as cited by May, 1980). Rice is inherently hydrophilic (water loving), so it easily respond negatively to droughty conditions.

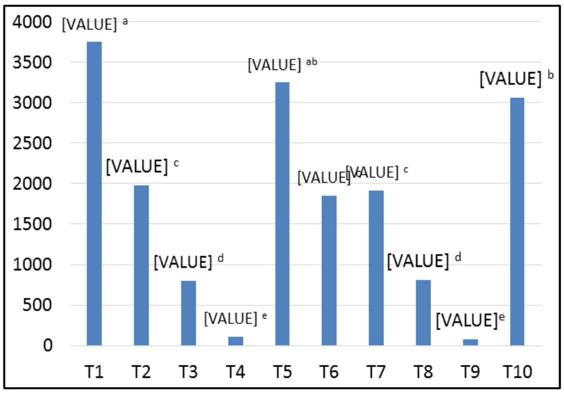

Fig. 9. Combined Yield per Hectare (Peanut and Rice) kgs/ha.

Combined yield of rice and peanut in Fig. 9 when analyzed revealed significant effect of inoculation and cropping scheme on yield. Highest combined yield was noted in T_1 and T_5 which were not significantly different from each other from DMRT but different to other group of treatments (T_2, T_7, T_8) which ranked next in yield and with all the rest (T_3, T_8) and with the lowest in T_9.

Higher combined yield was favorable for 1 row rice and 3 rows peanut which were inoculed with Bio- N, and monoculture of peanut with inoculation. Monoculture of rice, inoculated or not was lowest. Group of treatments where there is peanut whether inoculated or not were observed to have higher yields and lowest yields were observed in monoculture rice.

The 2- way table in Appendix shows that inoculated treatments is significantly different in yield with those inoculated with Bio- N having the higher yield. The effect of cropping scheme is highest on (b) 1 row of rice and 3 rows of peanut and the monoculture of peanut (b_5) which were significantly different with (b_2) 2R:2P, (b_3) 3R:1P and (b_4) monoculture rice. This results amplifies the benefit of using legume (peanut) as intercrop with inoculation by improving the nutritional status and structure of the soil. Percentage yield advantage is conspicuous in groups of treatments with intercrops over the monoculture (Frederick, 1978). The factorial treatments showed T_1 and T_5 to be highest over the rest in ranked order where T_{10} ranked 2nd followed by T_2, T_7, T_6, T_8, T_3 with least yield seen in T_4 and T_9.

Soil.

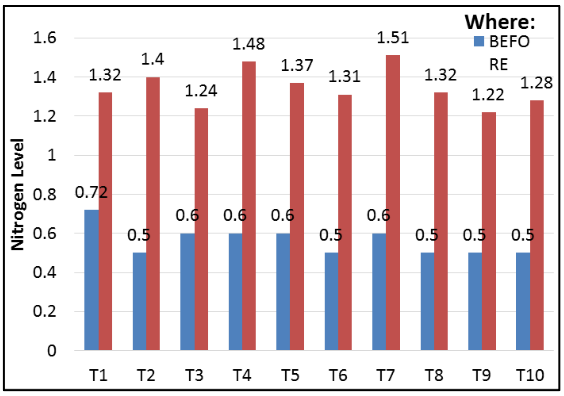

Fig. 10. Nitrogen level before and after.

As shows in the Fig. 10 before the conduct of the study the T_1- inoculated 1R:3P are highest nitrogen level followed by T_3 the same to the T_4, T_5 while the lowest is T_2, the same to T_6, T_8, T_9, and T_{10} in descending order of small differences (0.6, 0.5). As shows in the Fig. 10 after the conduct of the study is T_7- not inoculated 2R:2P are highest nitrogen level with a 1.51 followed by T_4, T_2, T_5, T_1, T_8, T_6, T_{10}, T_3 and T_9, in descending order of small differences (1.48, 1.48, 1.37, 1.32, 1.32, 1.31, 1.28, 1.24 and 1.22). According to Jabbar *et al.* 2005 discussed that the use of effective legumes crops, may increase nitrogen fixing bacteria inputs which can minimize soil N losses as well as improve soil N inputs, explaining that that governing of endemic soil N and N2 fixation through leguminous plant has the potential to improve soil N nutrition, Also observed Thuy *et al.*, 1987 reported that considering both environmental and economic perspectives, maintenance of available soil N resource and improvement of N output from plant sources is one of the desirable options to reduce use of chemical fertilizer in rice cropping system. Introducing legume with upland rice based intercropping systems can improve soil physical properties and enhance residual soil N content.

Cost and Return Analysis

As to ROI, T_1 (1R:3P) with rhizobium got the highest at 399.25% followed by T_3 (monoculture of peanut with rhizobium) @ 314.21. Rank in the order of 3rd, 4th, 5th, 6th ,7th and 8th are T_2, T_6, T_{10}, T_7, T_8 in descending of 176.37%, 147.80%, 131.13% 28.97%, 19.82% and17.80%. T_9 and T_3 got negative returns.

Where there are more of peanut plants than rice plants (1R:3P) and inoculated with Rhizobium, peso investment is the highest at 399.25% on R+P is recommended. Monoculture of peanut with Rhizobium was similarly profitable @ 314.21%. Any of the intercropping schemes produced returns except for monoculture rice. Thus the advantage of intercropping over mono-cropping especially of rice which is highly sensitive to environmental changes. Legumes like peanut even as monocrop would always yield good in terms of product and improvement of the soil. Much more, with the use of Rhizobium which enhance the N fixation in the soil.

The different cropping pattern arrangements of plant height, herbage yield, rice yield, are not significantly different for both intercrops of upland- rice and peanut to rhizobial inoculation The highest number of tiller was obtained from not inoculated monoculture of rice at 6th week to 8th week produced 29.33, 32.77 and 34.57 while row ratio not inoculated 1R:3P produced to 6th week to 8th week 29.13, 32.50 and 33.57, next row ratio of not inoculated 2R:2P produced 27.67, 31.33 and 32.57 were significantly different due to cropping pattern. On peanut, the effect of cropping pattern and inoculation on pod yield per plot and hay yield was significantly different. Hay yield is higher in inoculated peanut than to non-inoculated, however on cropping pattern, inoculated monoculture of peanut had higher yield compared to the intercrops in peanut which showed in the B_3(3R:1P). The land equivalent ratio (LER) is used in determining the productivity of intercropping upland rice and peanut. In the peanut-based the highest is T_7- not inoculated (2R:2P) gave 1.92 (92 percent) yield increase over rice in monoculture of rice both inoculated and not inoculated. While in the rice-based the highest again is T_2- inoculated (2R:2P) gave higher LER in rice. In combined yield showed significantly different in yield with those inoculated with Bio-N having the higher yield. The effect of cropping scheme is highest on (b) 1 row of rice and 3 rows of peanut and the monoculture of peanut (b_5) which were significantly different with (b_2) 2R:2P), (b_3) 3R:1P and (b_4) monoculture rice Results revealed that intercropping 1R:3P with inoculation and monocrops of peanut with inoculation produced the higher ROI@ 399.25% and 314.21% respectively.

Conclusions

Based from the result of the study, the following conclusions were drawn: Results indicate no significant effect of the treatments on height, herbage yield and yield/ plot in kilograms in rice. Significant results were seen on the treatment effect on number of tillers in rice. Peanut pod yield per plot (kgs) is revealed significant differences due inoculation, cropping scheme and their interaction. LER values were highest in 2R: 2P @ 92% productive advantage over monoculture. Combined yield was significantly affected where 1R:3P and mono peanut is better that 2R:2P, 3R:1P and monoculture of rice. Considering higher ROI, it is recommended to follow 1R:3P with inoculation and monocrop peanut with inoculation The use of multiple cropping is obviously beneficial as when one crop fails, there is still another crop from which the farmer could derive income as in the case of rice. In this study, Aringay, an upland rice variety was planted at a wrong time as it is recommended to be planted in June instead of January in this experiment.

Recommendations

Based on the results, the following are recommended:

(1) The application of inoculation and cropping pattern is recommended since there was significant increase the number in tillers of rice.

(1) Inoculation and cropping arrangement is also recommended for peanut as it affected herbage yield and pod yield; (2) Rice plus peanut is recommended over monoculture.; (3) 1R:3P and monoculture peanut is recommended; (4) Intercropping is recommended for 1R:3P with inoculation. Monocropping of peanut is a good companion for a sensitive crop species (Aringay) in adverse conditions (drought and marginal lands as in this experiment).

References

Chu GX, Shen QR, Cao JL. 2004. Nitrogen fixation and N transfer from peanut to rice cultivated in aerobic soil in an intercropping system and its effect on soil N fertility. Plant and Soil **263,** 17–27, 2004. © 2004 Kluwer Academic Publishers. Printed in the Netherlands.

Francis CA. 1986. Multiple cropping systems. Macmillan Publishing Company.

Kaiming Liang, Tao Yang, Shaobin Zhang, Jia-en Zhang, Mingzhu Luo, Ling Fu & Benliang Zhao. 2016. Effects of intercropping rice and water spinach on net yields and pest control: an experiment in southern China, International Journal of Agricultural Sustainability **14(4),** 448-465.

Li L, Zhang LZ, Zhang FS. 2013. Crop Mixtures and the mechanisms of overyielding. In:, Levin SA, editors., Encyclopedia of biodiversity, second edition, Waltham, MA: Academic Press. Volume **2,** pp. 382–395.

Magulod GC. 2018. Climate change awareness and environmental attitude of College students in one campus of a State University in the Philippines. J. Bio. Env. Sci **12(2),** 211-220, February 2018.

Morris R, Garrity D. 1993. Resource capture and utilization in intercropping; non-nitrogen nutrients. Field Crops Research **34,** 319–334.

Morris R, Garrity DP. 1993. Resource capture and utilization in intercropping: Water. Field Crops Research **34,** 303–317. 13.

Vandermeer JH. 1992. The ecology of intercropping. Cambridge University Press.

Wang ZG, Jin X, Bao XG, Li XF, Zhao JH. 2014. Intercropping Enhances Productivity and Maintains the Most Soil Fertility Properties Relative to Sole Cropping. PLoS ONE **9(12),** e113984. doi:10.1371/ journal.pone. 0113984