Annals of Tropical Research 39 (SUPPLEMENT A):20-30 (2017)

Evaluation of different cropping systems for marginal uplands in Barangay Caticugan, Sta. Rita, Samar

Ulysses A. Cagasan[1*], Ed Allan L. Alcober[2], Mark Gil B. Gerona[3] and Gretchen Mae M. Prado[4]

ABSTRACT

To help improve the lives of upland farmers in Barangay Caticugan, Sta. Rita, Samar, there is a need to find ways to increase crop yield and income. This study aimed to determine cropping systems that improve crop productivity, increase income and promote cropping systems technology to upland farmers in Barangay Caticugan, Sta Rita, Samar. The experimental units were arranged in Randomized Complete Block Design with three replications. The cropping systems tested were monocropping on corn, peanut and mungbean and intercropping corn + peanut and corn + mungbean. This paper considered only the data for one cropping planted during dry season.

The growth and yield characteristics of all crops under study were not significantly (*p*<0.05) affected by the cropping systems. Fresh herbage yield (t ha^{-1}) and total yield (t ha^{-1}) in all crops (corn, peanut & mungbean) and harvest index of peanut were significantly affected by the treatments. The significant variations on the said treatments were due to the difference in the plant population of monocultures and the intercrops. On the other hand, corn + mungbean gave a land equivalent ratio (LER) of 1.16, which means that such practice is more productive than growing corn or mungbean as monocrop. Likewise, corn + peanut have an LER value of 1.20 which means corn + peanut intercropping system is more advantageous over monocropping.

Economic analysis revealed that monoculture of peanut and mungbean is the most profitable cropping system as it provides a relatively higher yield and net income.

Keywords: Cropping systems, growth and yield, land equivalent ratio

[1,2,3,4] Department of Agronomy, Visayas State University, Baybay City, Leyte 6521-A, Philippines

* **Corresponding Author.** Address: Department of Agronomy, Visayas State University, Baybay City, Leyte 6521-A, Philippines; Email:uly_cagasan@yahoo.com
DOI: 10.32945/atr39sa2.2017

INTRODUCTION

Food scarcity is one of the major problems encountered in the country today due to increasing human population and reduction of arable lands. In the Philippines, almost 26% of the total upland areas are still to be developed and converted to become productive (Castillo 2010). These marginal areas needs to be studied to find effective production systems and strategies in attaining increased productivity and stability of marginal uplands in the country.

One way of increasing crop production is the adoption of different cropping systems such as crop rotation, relay cropping and intercropping. These include the yearly selection, sequence and spatial arrangement of crops that are adapted to the locality and provide an acceptable yield level (Escasinas 1990). This system promotes farm diversity and enhances farm stability and efficiency in the use of land and labor; thus, land productivity per unit area and time is maximized (Cantoneros 2008). Cropping system offers farmers the opportunity to engage nature's principle of diversity on their farms. Intercropping systems can be more productive than growing in monocropping. This practice aims to achieve maximum profit per unit land area per unit time because of the combined yields of the maincrop and the intercrop. This practice requires less labor, especially in weeding because of reduced space for weeds to grow. There is also a low risk in intercropping system since if one crop fails; there is another crop that the farmers can harvest.

However, farmers are still experiencing low production of most crops planted in their farms. This problem is attributed to many factors such as non-adoption of appropriate cultural management strategies, impact of climate change, capital constraints, pests and lack of information on improved varieties. Moreover, perhaps the present cropping system adopted by the farmers is not anymore feasible in the present situation of the farm. For instance, upland farmers in Sta. Rita, Samar can plant only once a year (June-October cropping), because water is so scarce in the other months. Also, they are using traditional varieties with no application of fertilizer, therefore, time and land utilization is not maximized and crop productivity and profitability are not attained. Therefore, identification of appropriate cropping systems and improved production practices are necessary to make marginal upland farming more productive.

However, systematic cropping patterns have to be considered for crop diversification to be productive and sustainable. Agronomic characteristics of the complementary crops, soil and climatic conditions and available farm resources need to be thoroughly evaluated. Thus, this study was conducted to determine cropping systems that would improve productivity and promote cropping systems technology to upland farmers in Sta. Rita, Samar.

MATERIALS AND METHODS

Site Description

The experimental area was situated in Barangay Caticugan, Sta. Rita, Samar, with 20-30% slope and the soil is very strongly acidic, low in organic matter but medium in nitrogen, available P and exchangeable K (Landon 1991).

The site was approximately five (5) kilometers away from the town of Sta. Rita, Samar. The vegetation was dominated by hagunoy (*Chromolaena odorota),* cogon grass (*Imperata cylindrica*) and makahiya (*Mimosa pudica*) growing on uncultivated areas. The most common crops grown by farmers were coconut, cassava, corn, mungbean and peanut. Low yield was experienced because farmers did not apply proper cultural management practices such as fertilizer application and variety and timing of planting the crops. The area was selected as the research site because the soil was characterized as acid upland, with low productivity due to soil erosion and infertility, weeds and drought.

The landform was predominantly medium gradient hill. The area was degraded and only small patches were cultivated for crop production. The area was dominated with *Melastoma malabathricum* (Hantutuknaw), *Imperata cylindrica* (Cogon), *Chromolaena odorota* (Hagunoy), *Mimosa pudica (Makahiya), Saccharum spontaneum* Linn. (Bugang), *Elephantopus tomentosus* (Malasambong) and *Psidium guajava* (Guava), which are indicators of soil degradation (Figure 1). The growth of perennial crops like coconuts, guavas, timbers and jackfruits were stunted and the leaves were yellowish green which suggest that the crops were deficient of essential nutrients.

Figure 1. The study site before the establishment of the experiment

Experimental Setup and Establishment

An area of 400m^2 was cleared to allow land cultivation. The area was plowed and harrowed five times alternately, using carabao drawn implement to break the hard pan, remove the weeds and pulverize the soil clods. Weed herbages and other plant debris were piled up and allowed to decompose.

Before planting, 10 core soil samples were randomly collected from the experimental area at a depth of 0-20cm. These samples were composited, air dried, sieved (2mm wire mesh) and analyzed for soil pH (potentiometric method at 1:2.5 soil water ratio), organic matter (modified Walkley- Black method), total N (modified Kjeldahl method), available phosphorous (modified Olsen's method) and exchangeable K (ammonium acetate method pH7.0 for extraction) and were quantified using Varian 220 FS Atomic Absorption Spectrometer at Central Analytical Services Laboratory (CASL), PhilRootcrops, Visayas State University (VSU), Baybay City, Leyte. For final analysis, five (5) soil samples from each treatment plot were gathered and analyzed for the same aforementioned soil parameters.

The experiment was laid out in randomized complete block design (RCBD), with three replications and five treatments. Except for the corn monoculture plot which measured 5mx4.5m, the other plots had a dimension of 5mx4m.

There were six (6) rows per plot. Alleyways of 1.0m between replication and between treatments plots were provided to facilitate farm operation and data gathering. The treatments were designated as follows: T_1=Corn alone; T_2=Peanut alone; T_3=Mungbean alone; T_4=Corn + Mungbean; T_5=Corn + Peanut.

Chicken manure was applied along the furrows in each treatment plot during planting, at the rate of 5t ha^{-1}. Half (45-30-30kg N, P_2O_5, K_2O ha^{-1}) of the required inorganic fertilizer (90-60-60kg N, P_2O_5, K_2O ha^{-1}) was applied using urea and complete before planting corn, by drilling along the furrows and then covered with soil. The other half of inorganic fertilizer (45-30-30kg N, P_2O_5, K_2O ha^{-1}) using urea and complete were side dressed, 30 days after transplanting. Full amount of inorganic fertilizer (complete) was applied in mungbean and peanut, based on the recommendation (30-30-30kg N, P_2O_5, K_2O ha^{-1}). Corn (IPB Var. 6) was sown at a distance of 0.75m between rows and 0.50m between hills.

Two seeds were planted per hill and thinned to 1 plant per hill one week after sowing to satisfy the desired plant population of 53,333 plants per hectare. Mungbean (Pagasa 19) seeds were drilled and thinned two weeks after planting, at 20 plants per linear meter. Peanut was planted at a distance of 0.50m between rows and 0.25m between hills, at 2 seeds per hill. Replanting of missing hills was done one week after planting to meet the desired plant population.

Hilling up was done manually in each treatment plot. Weeds were controlled by hand weeding and cultivation for better stability and anchorage of the plants. Harvesting was done when the corn plants had reached maturity as indicated by the change in color of the husk and leaves from green to brown, firm grains and clear and blackening of kernels' scutellum. Only plants from the four inner rows (excluding end hills) were harvested. Harvested corn ears were dehusked, sun-dried and shelled, after which the grains were sundried again before gathering the subsequent data.

For mungbean, two primings were done at seven days interval. The first priming was made when the pods had turned brown or black, leaves had begun to dry and defoliate and grains became firm. For peanut, harvesting was done 100 days after planting. The following agronomic characteristics were evaluated in corn (maincrop): number of days from seeding to emergence, tasseling, silking and maturity; plant height (cm); leaf area index (LAI) and fresh stover yield (t ha^{-1}). For the yield and yield components, the following parameters were measured: number of ears per plant; ear length (cm); weight of 1,000 seeds (g); grain yield (t ha^{-1}) and harvest index.

The following agronomic characteristics were evaluated for mungbean and peanut (intercrop): number of days from seeding to flowering and maturity; plant height (cm) at harvest; leaf area index (LAI) and herbage yield (t ha^{-1}). For the yield and yield components, the following parameters were measured: number of pods per plant; number of seeds per pod; weight of 1,000 seeds (g), grain yield (t ha^{-1}) and harvest index. Production cost and return analysis, land equivalent ratio (LER) and area time equivalent ratio (ATER) were also evaluated.

RESULTS AND DISCUSSION

General Observation

Establishing a farm after being left idle for a couple of years is work demanding, time consuming and expensive. The time spent and the number of laborers` required were doubled in order to clear the land and prepare the soil for planting. Water scarcity was the primary problem in the area; however, planting twice a year is possible, considering the choice of crop and the timing of planting. Planting upland crops during the 1st to the 3rd week of June is recommended because of the occurrence of occasional rain which can still support germination up to the early vegetative development of the crops.

Dominant pests and diseases in the area were corn borers, purple corn syndrome, pod sucking bugs, aphids, bean fly, leafhoppers and mites. However, these were minimized by spraying chemical Karate, following manufacturer`s recommendation at 10mL per 16L of water (1 tank load) and maintaining the surrounding area clean.

Soil Chemical Analysis

Initial soil analysis showed that the experimental area had a soil pH of 4.83, with 2.17% organic matter, 0.27% total N, 11.14mg kg^{-1} available P and 10.82mg kg^{-1} exchangeable K (Table 2). These indicate that the soil is very strongly acidic, low in organic matter but medium in nitrogen, available P and exchangeable K (Table 1, Landon 1991). For the final soil analysis, results show that soil pH did not change, except on the plot planted with peanut alone (T_2). This result suggests that peanut can reduce the acidity of the soil (Chong 1984).

In effect, the pH value of the soil planted with peanut was increased. Likewise, the organic content of the soil was increased in all treatment plots, except in the plots planted with corn alone. Moreover, plots planted with peanut and mungbean greatly improved the organic matter content of the soil. Total N and available P were reduced relative to the initial soil analysis in all treatment plots.

This result suggests that crops need high amount of macro nutrients, especially N and P. Moreover, the decrease in nutrients could be due to the nutrient uptake by plants and the effect of soil acidity. On the other hand, exchangeable K (mg kg^{-1}) increased after the plots were planted with the different crops.

Table 1. Summary of the soil chemical data interpretation (Landon JR 1991)

pH	Nitrogen (%)	Organic Matter (% OM)	Available P (mg kg^{-1})	Exchangeable K (me 100 g^{-1})
<4.5 extremely acidic	<0.1 very low	<2.0 very low	<5 very low	<0.15 very low
4.5-5.0 very strongly acidic	0.1-0.2 low	2-4 low	5-9 low	0.15-0.20 low
5.1-5.5 strongly acidic	0.2-0.5 medium	4-10 medium	10-50 high	0.20-0.50 medium
5.6-6.0 moderately acidic	0.5-1.0 high	10-20 high	>50 very high	>0.50 high
6.1-6.5 slightly acidic	>1.0 very high	>20 very high		
6.6-7.3 neutral				
7.4-7.8 mildly alkaline				
7.9-8.4 moderately alkaline				
8.5-9.0 strongly alkaline				
>9.0 very strongly alkaline				

Note: Values were obtained by the following method of analyses:
pH= 1. 2.5: water ratio;
Total N (%) = Kjeldahl Method;
OM (%) = Walkley- Black Method;
Available P (%) = Olsen's P;
Exchangeable K = NH_4 Ac Extraction Method

Table 2. Initial and final soil analyses of the experimental area as affected by different cropping systems

	Soil pH	OM (%)	Total N (%)	Available P (mg kg^{-1})	Exchangeable K (mg kg^{-1})
Initial Soil Analysis	4.83	2.17	0.27	12.06	10.82
Final Soil Analysis					
T_1-Corn alone	4.77	2.73	0.16	11.52	16.56
T_2-Peanut alone	5.60	3.12	0.19	11.14	16.90
T_3-Mungbean alone	4.66	3.35	0.16	11.54	37.07
T_4-Corn + Mungbean	4.75	3.20	0.17	10.58	19.05
T_5-Corn + Peanut	4.64	3.20	0.19	11.39	32.83

Agronomic Characteristics, Yield and Yield Components of the Main-crop (Corn)

Tables 3-4 present the data on agronomic characteristics, yield and yield components of the corn plants. The growth and yield of the monocultures and intercropped corn did not vary significantly (p<0.05) except on fresh herbage yield (t ha^{-1}) and grain yield (t ha^{-1}).

Table 3. Agronomic Characteristics of corn under monocropping and intercropping systems

Treatments	Days from seeding to tasseling	Days from seeding to maturity	Plant Height (cm)	Leaf Area Index	Fresh Herbage Yield (t ha^{-1})
Corn alone	56.00	101.00	192.60	4.47	13.26^{a}
Corn + Mungbean	57.33	101.00	177.95	4.35	6.74^{b}
Corn + Peanut	58.00	101.00	176.25	4.39	7.86^{ab}
CV (%)	1.37	0.00	5.36	10.75	21.67

Means with the same letter in columns are not significantly different at 5% level, HSD

Table 4. Yield and yield components of corn under monocropping and intercropping system

Treatments	Number of ears per plant	Ear length (cm)	Ear diameter (cm)	Weight of 1,000 seeds (g)	Grain yield (t ha^{-1})	Harvest Index
Corn alone	1.00	15.84	4.51	275.19	3.31^{a}	0.49
Corn + Mungbean	1.13	16.78	4.47	299.31	1.31^{b}	0.48
Corn + Peanut	1.47	17.56	4.43	319.16	2.89^{a}	0.47
CV (%)	13.61	9.29	7.49	14.46	4.77	22.4

Means with the same letter in columns are not significantly different at 5% level, HSD

Results revealed that corn alone significantly (p<0.05) gave the highest fresh herbage yield (t ha^{-1}) as well as grain yield (t ha^{-1}), but was more comparable to corn + peanut than to corn + mungbean.

This result implies that corn can be grown in an intercropping scheme with peanut or it can be grown in monocropping system in the marginal upland of Sta. Rita, Samar. Moreover, monocropping corn (IPB var. 6) yielded 3.31t ha^{-1} comparable to corn + peanut intercropping (2.89t ha^{-1}), while only 1.31t ha^{-1} on corn + mungbean, (Table 4). This implies that the practice of doing intercropping is recommended for corn + peanut than corn + mungbean under this study. This result further correlates the findings of Armachuelo (1987) that intercropping corn with peanut did not significantly reduce the grain yield, yield components and harvest index of corn, suggesting high corn tolerance to interspecific competition for soil nutrients and compatibility of the crops in an intercropping scheme.

Agronomic Characteristics, Yield and Yield Components of Intercrops (Peanut & Mungbean)

The agronomic characteristics of the intercrops mungbean and peanut are presented in Tables 5-8. Results showed that most of the agronomic and yield components of the intercrops were not significantly (p<0.05) affected by the cropping systems, except on fresh herbage yield (t ha^{-1}), pod yield (t ha^{-1}) and harvest index (HI). Results revealed that peanut and mungbean planted in monocropping system produced heavier weights in fresh herbage yield (t ha^{-1}) due to more number of plants planted in the area under monocropping system as compared to plots under intercropping system. These results suggest that mungbean and peanut monocultures grew bigger stem, leaves and more branches under monocropping system and had experienced less competition for growth factors such as nutrient, light, space and water thus, resulted to having higher value in total weight than planted under intercropping systems with corn. However, this result did not cause any significant (p<0.05) differences in the total grain yield of mungbean, except on peanut pod yield (t ha^{-1}). Moreover, high harvest index was noted on peanut planted as monocrop, compared to peanut planted with corn (peanut + corn intercropping). This result revealed that more photosynthates produced by the plants had been translocated to the reproductive parts of the plant for the production of more pods relative to vegetative parts, which resulted to higher pod yield (t ha^{-1}) when peanut was planted under monocropping system.

Table 5. Agronomic characteristics of mungbean under monocropping and intercropping system

Treatments	Days from seeding to flowering	Days from seeding to maturity	Plant Height (cm)	Leaf Area Index	Fresh Herbage Yield (t ha^{-1})
Mungbean alone	42.00	60.00	83.56	0.16	3.71[a]
Corn + Mungbean	40.67	60.00	79.23	0.14	1.54[b]
CV (%)	0.98	0.00	3.78	34.47	20.58

Means with the same letter in columns are not significantly different at 5% level, HSD

Table 6. Yield and yield components of mungbean under monocropping and intercropping system

Treatments	Number of pods per plant	Number of seeds per pod	Weight of 1,000 seeds (g)	Grain Yield (t ha^{-1})	Harvest Index
Mungbean alone	12.60	6.00	63.57	1.20[a]	0.34
Corn + Mungbean	10.07	5.47	62.90	0.70[b]	0.33
CV (%)	12.45	3.77	2.74	18.37	2.43

Table 7. Agronomic characteristics of peanut under monocropping and intercropping system

Treatments	Days from planting to flowering	Days from planting to maturity	Plant Height (cm)	Leaf Area Index	Fresh Herbage Yield (t ha^{-1})
Peanut alone	33.00	114.00	84.81	1.39	14.35[a]
Corn + Peanut	33.33	114.00	92.34	1.10	5.70[b]
CV (%)	1.23	0.00	7.23	19.62	11.78

Means with the same letter in columns are not significantly different at 5% level, HSD

Table 8. Yield and yield components of peanut under monocropping and intercropping system

Treatments	Number of pods per plant	Number of seeds per pod	Weight of 1,000 seeds (g)	Pod Yield (t ha^{-1})	Harvest Index
Peanut alone	24.60	2.13	495.20	2.27^{a}	0.59^{a}
Corn + Peanut	20.86	1.73	506.40	1.41^{b}	0.29^{b}
CV (%)	14.35	7.31	1.67	15.53	19.32

Means with the same letter in columns are not significantly different at 5% level, HSD

Other Parameters Gathered

The extent of the extra contribution of crop in mixtures to the production per unit area has been measured in terms of land equivalent ratio (LER). It is the land area required for sole crops to produce the same yield achieved in intercropping combination (Armachuelo 1987). It focuses more on the maximum utilization of the land without considering the competitive ability of the different crop components. Corn + mungbean gave an LER value of 1.16 which means that the practice is more productive than growing corn or mungbean as monocrop. Likewise, corn + peanut have an LER value of 1.20 (Table 9) which means corn + peanut planted together is more advantageous over monocultures of corn or peanut.

Likewise, area time equivalent ratio (ATER) measures the productivity and efficiency of the crops in mixture, in terms of utilizing both the land area and time component on the crops occupying the land. ATER value for corn + mungbean (2.80) was lower than corn + peanut (4.87) because peanut matures later than corn and mungbean (Table 9).

Table 9. Land equivalent ratio (LER) and area time equivalent ratio (ATER) of corn + mungbean and corn + peanut under intercropping system

Cropping Systems	LER	ATER
Corn + Mungbean	1.16	2.80
Corn + Peanut	1.20	4.87

Cost and Return Analysis

Results of the economic analysis of the study are presented in Table 10. Peanut alone gave the highest net income of PHP68,836.00, followed by mungbean alone of PHP19,036.00 (Table 9). This cropping system gave a high net income despite the high production cost in land preparation, seeds and fertilizer (organic & inorganic) due to the high market price of peanut and mungbean. Corn alone got a negative income due to the low yield obtained and the lower price of corn grains.

Thus, selection of crops that are adapted to the locality and that provide an acceptable yield level will be recommended to recover the high cost of production and to get high net income. Moreover, monocropping systems for peanut and mungbean gave a high net income, as these commodities command higher market price. Peanut and mungbean planted as monocultures are recommended in Barangay Caticugan, Sta. Rita Samar because peanut and mungbean gave a better yield and have a relatively higher market price thus, resulted to higher net income.

Table 10. Production cost and return analysis of different cropping systems for marginal upland in Barangay Caticugan, Sta. Rita Samar

Cropping Systems	Grain Yield (kg ha^{-1}) Main-crop	Intercrop	Gross Income (PHP ha^{-1})	Production Cost (PHP ha^{-1})	Net Income (PHP ha^{-1})
T1 = Corn Alone	2,270	-	31,780.0	54,848.00	-23,068.00
T2 = Mungbean Alone	-	900	63,000.0	43,964.00	19,036.00
T3 = Peanut Alone	-	2,270	68,100	44,664.00	23,436.0
T4 = Corn + Mungbean	1,310	600	60,340	61,312.00	-972.00
T5 = Corn + Peanut	1,890	1,410	68,760	62,012.00	6,748.00

Market price of corn grains = PHP14.00 per kg; mungbean = PHP70.00 per kg, Peanut fresh pods= PHP30.00 per kg

CONCLUSIONS

Growth and yield characteristics of all crops studied were not significantly (p<0.05) affected by the cropping systems except on fresh herbage yield (t ha^{-1}) and total yield (t ha^{-1}) of corn, peanut and mungbean. Likewise, only harvest index of peanut was significantly affected by the treatments.

In terms of yield, intercropping scheme gave an LER value of more than 1 (1.16 & 1.20), which means that such practice is more productive than growing corn, peanut or mungbean as monocrop. However, economic analysis revealed that peanut and mungbean planted as monocrop were the most profitable cropping systems as it provided a higher net income due to the higher prices of peanut and mungbean crops compared to corn.

RECOMMENDATION

1. Peanut and mungbean planted as monocrops is the promising cropping system because it gave better yield and higher net income.

2. More croppings should be done in the area to select the best cropping systems practice.

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