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Improving the Productivity of Coconut-Based Farming System through Adoption of Suitable Upland Rice-Legume Combinations

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Abstract- The need to maximize farm productivity through efficient use of light energy and soil resource is necessary in attempts to increase food production and mitigate climate change. This study evaluated the productivity of traditional upland rice and legume intercrops planted singly and in combinations under a coconut-based farming system. A split-plot design composed of two factors with three replications was used. The main plots were traditional upland rice varieties (*Kalutak, Malido, Mansanaya, San Pedro,* and PSB Rc 10 as check variety) while sub-plots were legume intercrops (peanut, mungbean, soybean, and no intercrop as control). Growth and yield of crops and return on investment (ROI) were gathered to determine productivity. Results revealed that *Malido* with no intercrop produced the tallest plant, while most tillers were from plots without intercrop. Highest dry grain yield of rice (1.42 t ha^{-1}) was taken from plots grown to *San Pedro* with no intercrop. Highest dry grain yield of legumes was from plots with *Mansanaya* + soybean (0.94 t ha^{-1}) and PSB Rc 10 + mungbean (0.92 t ha^{-1}). Highest ROI (344.40%) was from plots with PSB Rc 10 + mungbean.

Index Terms- productivity, coconut-based farming system, traditional upland rice, legume intercrops

I. Introduction

Coconut-based farming system is a dominant production system in the agriculture sector (*www.fao.org*). This has been described by various literatures which range from monoculture system to multiple intercropping systems. The monoculture system is usually observed in most coconut areas of the Philippines where the palms are in pure stand. In these areas, coconut palms have existed for years that light energy impinging between coconut stands has been wasted. In order to maximize the productivity of the area in terms of utilizing both the solar energy and the available nutrients in the soil, these vacant spaces can be planted with other crops (Magat, 1990).

Rice is “life” being the staple food of Asia; however it is also the single biggest user of freshwater (*www.irri.org*). The declining availability and increasing costs of water brought about by climate change threaten the traditional way of growing rice under irrigated conditions. There is therefore a need to utilize upland rice which can thrive under drought conditions.

De Datta (1975) pointed out that inbred upland rice yields are generally low of about 0.5-1.5 t/ha. One of the causes for this low yield is the adaptability to the agro-climatic conditions of the area. Upland farmers instead grow traditional upland rice which is adapted to the local climatic conditions, though their yield potential is not yet established.

Various intercrop combinations were described by Espino et al. (1988) which provide additional income for coconut farmers. Data however, on the productivity of coconut-based farming systems with traditional upland rice and legume combinations are still deficient. Hence, this study was conducted to evaluate the production performance of different varieties of traditional upland rice and legume intercrops under coconut-based farming system. Results of this study will assist policy makers in formulating measures to mitigate the effects of global problem on climate change and provide more meaningful efforts for the development of the agriculture sector.

II. METHODOLOGY

A. Experimental Area, Design and Treatments

The study was conducted at the Coconut Breeding Trials Unit in Mambusao, Capiz, Philippines with coordinates of 11^0 26’ north to 122^0 32’ east and an elevation of 174 feet above sea level. The area is slightly sloping (10%) and dominated by clay loam to heavy clay soil with an average annual rainfall of 3,021 mm. Fifty stands of coconut consisting of dwarf variety *Catigan* and hybrid variety WAT x TAC planted in diagonal pattern were considered. The height of palms ranged from 9 m to 15 m with a canopy of 6 m.

The experiment was laid out in 5 x 4 factors in split-plot design with three replications. The field was divided into three blocks and each block was randomly divided into five main plots spaced 50 cm from each other. Each main plot was further randomly divided into four subplots with a spacing of 25 cm from each other. A total of 20 subplots for each block were made; each having a dimension of 3m x 4m.

The main plots were varieties of traditional upland rice, namely: *Kalutak, Malido, Mansanaya* and *San Pedro,* and PSB Rc 10 as check variety. The sub-plots were legume intercrops such as peanut, mungbean, and soybean, and a control with no intercrop. The various intercrops of traditional upland rice were established by planting them every after two rows of rice plants.

B. Cultural Practices

The experimental area was thoroughly prepared by plowing and harrowing. Rice was planted by dibbling at the rate of 4 to 5 seeds per hill at a distance of 20 cm between rows and 20 cm between hills. The seeds were covered with fine soil at 2 to 3 cm deep. For the legume species, 4-5 seeds of peanut, mungbean and soybean were drilled in furrows at 50 cm between rows and 30 cm between hills. The seeds were covered with fine soil at approximately 2 to 3 cm deep.

One week after germination, missing hills were replanted following the recommended practices for the various crops. Similarly, thinning was done maintaining 3 seedlings per hill. Pests were controlled employing inter-row cultivation and application of pesticides. Harvesting of crops in the harvestable area was done at physiological maturity. Drying was done to attain 14% moisture content (MC).

C. Data Gathering and Analysis

Growth and yield components gathered from 10 sample rice plants were plant height and productive tiller count. Dry grain yield data for rice and legumes at 14% MC was obtained from plants within the harvestable area. All growth and yield data were subjected to ANOVA, while DMRT was employed to test significant differences among means. Return on investment (%ROI) was used to determine profitability.

III. RESULTS AND DISCUSSION

Plant Height of Rice

Comparing the heights of rice varieties in Table 1, tallest rice plants were *Malido* while the shortest were PSB Rc 10. *Kalutak, Mansanaya* and *San Pedro* were medium-statured plants. In contrast to these findings, relatively shorter PSB Rc 10 plants under open field conditions was reported by DA-RFU 6 (undated). The plant heights of traditional upland rice obtained from this study were also higher than those obtained from the research project of Gregorio et al. (2011a). Several field trials made by Baranda et al. (2011) and Launio and Gregorio (2011a) also showed shorter plants. In terms of intercropping legumes to rice, plots without intercrop and those plots intercropped with peanut and mungbean showed taller rice plants. Intercropping soybean to rice produced the shorter rice plants.

A significant interaction effect between varieties and legume intercrops on the plant height of upland rice was also evident in Table 1. Plots grown to *Malido* alone produced the tallest rice plants. This manifests that under monocropping system, *Malido* was the tallest plant. Similar findings were obtained by Villaruz (1994) wherein PSB upland rice grown in pure stand was significantly taller than those intercropped with legumes. Those plots planted with *Malido* + peanut and *Malido* + soybean also showed taller rice plants. Shortest rice plants were observed from plots grown to PSB Rc 10 + soybean. Plots where PSB Rc 10 + peanut, PSB Rc 10 + mungbean, and PSB alone were grown had also shorter rice plants.

These results imply that each variety tested has different genetic characteristics. In particular, the inherent potential on height was best manifested when the rice plants were grown alone. However, it was evident for *Malido* to tolerate shading when intercropped with legumes and has the ability to compete for the various growth factors with other intercrops.

Table 1. Plant height (cm) at harvest of traditional upland rice varieties grown with legume intercrops under coconut-based farming system.

VARIETY	LEGUME INTERCROPS				MEAN**
	None	Peanut	Mungbean	Soybean	
Kalutak	191.13*c*	187.47*d*	180.43*f*	184.37*ef*	185.85*b*
Malido	198.18*a*	194.4*b*	191.08*c*	193.90*b*	194.40*a*
Mansanaya	187.47*d*	182.27*f*	185.37*de*	168.46*h*	180.89*b*
San Pedro	184.61*ef*	178.98*fg*	185.45*de*	178.70*g*	181.94*b*
PSB Rc 10	88.96*i*	86.72*i*	86.88*i*	82.58*j*	86.29*c*
MEAN**	170.07*a*	165.97*a*	165.84*a*	161.60*b*	

Means in column and row having the same letter are not different at 5% level by DMRT.

Productive Tiller Count of Rice

The productive tiller count among rice varieties did not differ (Table 2). Productive tiller counts of the different varieties ranged from nine to 11 tillers per plant. Higher number of productive tillers was obtained by Baranda et al. (2011), Gregorio et al. (2011b) and Launio and Gregorio (2011b) compared to the findings in this study. DA-RFU 6 (undated) also found higher number of productive tiller for PSB Rc 10. The development of productive tillers somehow depended on different planting densities used for these various studies.

Productive tiller count of rice however varied when intercropped with legumes as shown in Table 2. The most number of productive tillers was recorded from plants with no intercrop. Lesser number of productive tillers was obtained from rice plants with legume intercrops. In this result, it was evident that monocropping had relatively more number of productive tillers compared to intercropping system. Villaruz (1994) had similar findings which can be attributed to plant spacing wherein monocropping provides more space for plant to proliferate while plant spacing is limited in intercropping because of maximum land area utilization with the presence of other crops. Also, the presence of legume intercrops with relatively wider leaves and bushy growth had competed with rice in intercepting light energy; hence least tillers were possibly developed.

Table 2. Productive tiller count of traditional upland rice varieties grown with legume intercrops in coconut-based farming system.

VARIETY	LEGUME INTERCROPS				MEAN^{ns}
	None	Peanut	Mungbean	Soybean	
Kalutak	10.02	8.88	9.56	9.83	9.57
Malido	12.76	9.39	9.69	9.94	10.45
Mansanaya	10.80	9.96	9.64	9.37	9.94
San Pedro	11.42	11.76	10.75	9.38	10.83
PSB Rc 10	12.04	10.93	11.16	10.28	11.10
MEAN**	11.41*a*	10.18*b*	10.16*b*	9.76*c*	10.38

*** = highly significant; ns = not significant; means followed by a common letter are not different at 5% level by DMRT.*

Dry Grain Yield of Rice

As shown in Table 3, the grain yield varied among the varieties grown. Regardless of intercrops, *San Pedro*, PSB Rc 10 and *Mansanaya* produced the highest grain yield. *San Pedro* and *Mansanaya* tolerated competition with intercrops since the latter are relatively of short height than the main crop. PSB Rc 10 which matured earlier was able to tolerate competition with mungbean. Being an improved variety also, PSB Rc 10 could contain superior genes for higher yield. This possibly indicates that PSB Rc 10 is more efficient in converting raw materials into food products and consequently into grains.

It is also shown that the grain yield of rice varied as different legume intercrops are planted with it. The highest dry grain yield was obtained when rice was grown without intercrop, while the lowest dry grain yield was produced by plots intercropped with peanut.

Table 3. Dry grain yield (t ha^{-1}) of traditional upland rice varieties grown with legume intercrops under coconut-based farming system.

VARIETY	LEGUME INTERCROPS				MEAN**
	None	Peanut	Mungbean	Soybean	
Kalutak	0.46*h*	0.14*o*	0.20*n*	0.40*j*	0.30*c*
Malido	0.31*m*	0.16*o*	0.93*e*	0.45*h*	0.46*b*
Mansanaya	1.05*c*	0.32*lm*	0.68*f*	0.35*k*	0.60*ab*
San Pedro	1.42*a*	0.50*g*	0.49*g*	0.34*kl*	0.69*a*
PSB Rc 10	1.12*b*	0.19*n*	0.97*d*	0.41*i*	0.67*a*
MEAN**	0.87*a*	0.26*d*	0.65*b*	0.39*c*	

Means in column and row having the same letter are not different at 5% level by DMRT.

It is interesting to note also that both factors had interacted to affect the dry grain yield of rice. *San Pedro* when grown without intercrop yielded most. Plots grown with PSB Rc 10 alone also produced higher yields though DA-RFU 6 (undated) had higher yield of PSB Rc 10 under open field conditions. The highest grain yield obtained in this study was within the range of 0.5-1.5 t/ha, the yield which upland rice generally obtained according to De Datta (1975). These grain yield data however were relatively lower than those found by Gregorio, et al. (2011a) where the study was made in an open field under monocropping system.

These results imply that each variety differed in terms of their intercropping potential and intercrop suitability. Indeed, the presence of intercrop had influenced the growth of rice and consequently affected the yield. Villaruz (1994) had similar results wherein legume intercrops significantly affected the yield of PSB upland rice.

Dry Grain Yield of Legumes

As indicated in Table 4, dry grain yield of legumes varied among the rice varieties tested. Highest legume grain yield was obtained from plots grown to PSB Rc 10, *Malido* and *Mansanaya*. The lowest legume grain yield was recorded from plots grown to *San Pedro* and *Kalutak*. Villaruz (1994) had different results where statistical analysis of data revealed that the bean yield of legume intercrops was not affected by PSB upland rice varieties.

Similarly, Table 4 presents that the dry grain yield of legumes significantly varied. Soybean and mungbean produced the highest grain yield; peanut yielded the least. Again, these findings were different from those obtained by Villaruz (1994) wherein bean yield of legume intercrops was the same.

Table 4. Dry grain yield (t ha^{-1}) of legumes as intercrops to traditional upland rice under coconut-based farming system.

VARIETY	LEGUME INTERCROPS			MEAN**
	Peanut	Mungbean	Soybean	
Kalutak	0.16*h*	0.38*e*	0.45*d*	0.33*b*
Malido	0.31*f*	0.43*d*	0.69*b*	0.48*a*
Mansanaya	0.18*h*	0.26*g*	0.94*a*	0.46*a*
San Pedro	0.16*h*	0.51*c*	0.24*g*	0.30*b*
PSB Rc 10	0.26*g*	0.92*a*	0.36*e*	0.51*a*
MEAN**	0.21*b*	0.50*a*	0.54*a*	

Means in column and row with the same letter are not different at 5% level by DMRT.

Table 4 further presents the significant interaction effect between rice varieties and legume intercrops on the grain yield of legume crops. Using soybean as intercropped to *Mansanaya*, and mungbean as intercropped to PSB Rc 10 produced the highest legume grain yield. Soybean possibly resisted the stress posed by *Mansanaya* which had a moderate height. Mungbean was also able to withstand competition with PSB Rc 10 since this variety matured earlier with relatively shorter height. Plots with *Kalutak* + peanut, *Mansanaya* + peanut, and *San Pedro* + peanut comparably gave the lowest yield.

Return on Investment (ROI)

In terms of ROI, Table 5 shows that PSB Rc 10 had the highest ROI of 73.15%. As to the legume intercrops, growing mungbean with rice had the highest ROI of 173.58%. Considering the various crop combinations, PSB Rc 10 + mungbean was the most profitable crop combination realizing an ROI of 344.40%. The claim of Baines (1980) holds true with these findings stating that generally, intercropping does not reduce the yield of the main crop, but instead gives greater cash returns and higher income per unit area than growing crop in pure stand. In addition, these results agree to PCARR (1987) report noting that in cereals and legume crop combination, intercrop gave greater income of peasant farmers in the tropical countries. Negative returns on investment (in parenthesis) were also noted in some crop combinations indicating that these combinations are losing and not profitable to pursue.

Results of this economic analysis imply that generally, intercropping mungbean was a positive contributor in increasing net income and consequently higher return on investment. Although intercropping entailed additional expense, the composite yield of the main crop and the intercrop resulted to a more profitable production endeavor.

Table 5. Return on investment (%) in the production of traditional upland rice intercropped with legumes under grown-up coconuts.

VARIETY	LEGUME INTERCROPS				MEAN
	None	Peanut	Mungbean	Soybean	
Kalutak	(36.05)	(41.14)	87.83	63.06	18.42
Malido	(64.38)	(1.52)	181.04	118.78	58.48
Mansanaya	21.53	(21.92)	83.44	172.22	63.82
San Pedro	64.58	(10.95)	171.19	(4.21)	55.15
PSB Rc 10	(41.83)	(20.63)	344.40	10.66	73.15
MEAN	(11.23)	(19.23)	173.58	72.10	

IV. CONCLUSION

In conclusion, the rice varieties tested varied in most agronomic parameters. Legume intercrops influenced the production performance of rice. PSB Rc 10 + mungbean combination resulted to higher return on investment.

These results generally imply higher productivity of coconut-based farming system with upland rice and legume intercropping combinations.

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