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Influence of Intercropping on the Growth and Yield Performance of Upland Rice (*Oryza sativa* L. var. *zambales*) and Peanut (*Arachis hypogaea* L.)

Birlikte Ekimin Kır Çeltiği (*Oryza sativa* L. var. *zambales*) ve Yer Fıstığı (*Arachis hypogaea* L.)'nın Gelişme ve Verim Performansı Üzerine Etkisi

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ABSTRACT

Intercropping is one way of increasing productivity per unit area per unit time. This study aimed to (1) evaluate the effects of timing of planting on the growth and yield of upland rice and peanut under the intercropping scheme, (2) determine the appropriate timing of planting of upland rice and peanut that would give optimum yield, and (3) assess the profitability of upland rice and peanut production under the intercropping scheme as influenced by the timing of planting. The experimental area was laid out in a randomized complete block design with three replications. The treatments were as follows: T_1—upland rice + peanut planted simultaneously, T_2—upland rice planted 1 week ahead than peanut, T_3—upland rice planted 2 weeks ahead than peanut, T_4—peanut planted 1 week ahead than upland rice, and T_5—peanut planted 2 weeks ahead than upland rice. Results showed that upland rice planted 2 weeks ahead of peanut (T_3) and those planted simultaneously with peanut (T_1) headed and matured earlier than the other treatments. Likewise, T3 and T5 obtained the heaviest panicles/0.50 linear meter. Similarly, peanut var. BPI-Pn9 planted 2 weeks ahead of upland rice (T_5) flowered and matured earlier than the other treatments. The highest land equivalent ratio and area time equivalent ratio values of 1.50 and 2.02, respectively, were obtained from T_5 (peanut planted 2 weeks ahead of upland rice). The highest combined yield of upland rice (2.42 t/ha) and peanut (1.47 t/ha) was also obtained from T5, which resulted in the highest gross margin of PhP86,867.02/ha.

Keywords: Area time equivalent ratio, growth and yield, intercropping scheme, land equivalent ratio, timing of planting the crops

ÖZ

Birlikte ekim, birim zamanda birim alan başına verimliliği artırmanın bir yoludur. Bu çalışmanın amacı: (1) birlikte ekim şeması altında kır çeltiği ve yer fıstığının büyümesi ve verimi üzerindeki dikim zamanlamasının etkilerini değerlendirmek, (2) optimum verim verecek kır çeltiği ve yer fıstığının uygun ekim zamanlamasını belirlemek ve (3) birlikte ekim planı kapsamında kır çeltiği ve yer fıstığı üretiminin karlılığını değerlendirmek. Deneme alanı tesadüf blokları deneme desenine göre üç tekerrürlü olarak kurulmuştur. Uygulamalar şu şekilde yapılmıştır: T_1—kır çeltiği+aynı anda ekilen yer fıstığı, T_2—yer fıstığından 1 hafta önce ekilen kır çeltiği, T_3—yer fıstığından 2 hafta önce ekilen kır çeltiği, T_4—kır çeltiğinden 1 hafta önce ekilen yer fıstığı ve T_5—kır çeltiğinden 2 hafta önce ekilen yer fıstığı.

Sonuçlar, kır çeltiğinin yer fıstığından 2 hafta önce (T_3) ve yer fıstığı ile aynı anda (T_1) ekildiğinde, diğer uygulamalara göre daha erken hasat olgunluğuna ulaştığını göstermiştir. Benzer şekilde, T_3 ve T_5 uygulamalarından en ağır salkımlar elde edilmiştir. Yine, kır çeltiğinden 2 hafta önce ekilen yer fıstığı var. BPI-Pn9 diğer uygulamalardan daha önce çiçeklenmiş ve olgunlaşmıştır. En yüksek alan ve alan zaman eşdeğer oranları sırasıyla 1,50 ve 2.02 olarak T% (kır çeltiğinden 2 hafta önce ekilen yer fıstığı) uygulamasından elde edilmiştir. En yüksek toplam verim (2,42 t/ha kır çeltiği + 1,47 t/ha yer fıstığı)) T5 uygulamasından elde edilmiş ve bu da PhP86.867,02/ha ile en yüksek brüt kar sağlamıştır.

Anahtar Kelimeler: Alan zaman eşdeğer oranı, gelişme ve verim, birlikte ekim planı, ekim zamanı

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Introduction

Rice (*Oryza sativa* L.) is the main staple crop in the Philippines. It is considered the most important food crop in the country. In 2010, nearly 20.7 million metric tons of rice were produced, which contributed 21.86% of the gross value added and 2.37% of the country's GNP (Gross National Product). In 2017, the population consumed 11.7 million tons of rice (Jeruto, 2017) and the rice production met 93% of the country's annual rice requirement. The greater demand for food, especially rice, makes it imperative to increase its production due to the rapid population. This can be attained by expanding the area cultivated, utilizing upland areas, and increasing the yield per unit area (Daniel, 2004).

Jeruto (2017) mentioned that many producers and researchers carry out intercropping of annual cereals with legumes to increase productivity and sustainability. Intercropping cereals with legumes has been popular in tropical upland areas due to its beneficial effects on soil conservation and weed control (Dhima et al., 2007). Zhang and Long (2003) reported that intercropping improves soil and water quality by providing year-round ground cover or a more extended period of protecting the soil from drying up. It also minimizes erosion by growing more than one crop in the same field.

To further maximize land use and ensure higher crop productivity, profitability, and sustainability in upland rice production, crop diversification like intercropping should be practiced. This system is profitable because of the reduced cost of weed control as the canopy of the intercrop and the main crop`s canopy covers the ground. Moreover, the soil's physical and chemical properties are improved upon the decomposition of the residues (Dordas, 2011). He added that more benefits could be derived when two or more crops are planted together in the same season, provided that light, nutrients, moisture, and proper management are taken into consideration. The growth and yield of upland rice and peanut under the intercropping system would be affected by light, relative humidity, air exchange, and temperature. In this case, the planting time must be adjusted to minimize shading and enable the plants to have adequate light for photosynthesis. Mandal (2014) pointed out that one way to minimize competition between plants for light is to determine the best planting timing.

Studies on the timing of planting of the component crops in upland rice and intercropping peanut scheme still need further evaluation. Hence, this study was conducted from December to April 2020 to evaluate the effects of timing of planting on the growth and yield of upland rice and peanut and assess the profitability of upland rice and peanut production under the intercropping scheme as influenced by the timing of planting.

Methods

An area of 263.5 m^2 was thoroughly plowed and harrowed alternately using tractor-drawn implements. These farm operations were done twice to remove weeds, pulverize the soil, and level the field. After the last harrowing, six furrows at a distance of 0.75 m for intercropping and 0.50 m for monoculture were made for both upland rice and peanut crops. Drainage canals were constructed around the experimental area and between replications to drain excess water during heavy rains.

One kilogram of composite sample was brought to the Central Analytical Services Laboratory at PhilRootcrops, Visayas State University, Visca, Baybay City, Leyte. These were analyzed for soil pH, % organic matter content (modified Walkley–Black method), total N, extractable phosphorous (Olsen's sodium bicarbonate extraction), and exchangeable potassium. After harvest, five soil samples were collected from the harvestable area in each treatment plot to analyze the same parameters mentioned above.

The experimental area was laid out in a randomized complete block design with five treatments replicated three times. Each replication was divided into five plots measuring 3 m × 4.5 m (13.5 m^2). Alleyways of 1.0 m between replication and 0.5 m between treatment plots were provided to facilitate farm operations and data gathering. Peanut was planted in between the rows of upland rice and spaced at 20 cm between hills at two seeds/hill. The treatments used were as follows: T_1—upland rice and peanut planted simultaneously, T_2—upland rice planted 1 week ahead of peanut, T_3—upland rice planted 2 weeks ahead of peanut, T_4—peanut planted 1 week ahead of upland rice, T_5—peanut planted 2 weeks ahead of upland rice. Monocultures of both upland rice and peanut were established at a distance of 0.50 m between rows as superimposed treatments for determining the land equivalent ratio (LER). Seeds of upland rice var. Zambales were drilled in the furrows at the rate of 60 kg/ha or 81 g/13.5 m^2 plot, while peanut seeds (BPI-Pn9) were planted in between the rows of upland rice at three seeds per hill at a distance of 20 cm between hills. Two weeks after planting, the seedlings were thinned to 2 plants per hill. Monoculture peanut was also planted at the distance of 50 cm between rows and 20 cm between hills and was thinned to 2 plants/hill 2 weeks after planting.

Inorganic fertilizer was applied at the rate of 120-60-60 kg/ha N, P_2O_5, K_2O to upland rice. Half of the amount of N and full amounts of P_2O_5 and K_2O were applied using complete fertilizer. The remaining 60 kg of N was applied 45 days after planting upland rice using urea. For monoculture and intercrop peanuts, the fertilizer rate was 30-30-30 kg/ha N, P_2O_5, and K_2O. This was applied a day before planting of peanut. To control rice bugs of upland rice, Lannate was applied at the rate of 20 g/16 L of water (2 tbsp/1 tank load) at the heading stage. Harvesting upland rice was done when 90% of the grains had matured as manifested by its yellow and hard grains. Yield data were taken from the four inner rows, excluding the two border rows on each side and 0.5 m at each end of the row. The panicles were harvested by cutting at the base using a sickle. The sample plants within the harvestable area (7.7 m^2) in each treatment plot were threshed, cleaned, and sundried separately. Weighing of grains was done after drying at 14% moisture content using a seed moisture meter.

On the other hand, peanut was harvested when 90% of the plants within the harvestable area (7.7 m^2), excluding two border rows on each side and 0.4 m (two hills of peanut) plants end of the row in each treatment plot, had reached maturity. At this stage, the leaves turned yellow, and the pods were firm. Harvesting was done by uprooting the plants within the harvestable area in each treatment plot with the aid of a bolo.

The following data were gathered for agronomic characteristics of upland rice such as days from planting to heading, days from planting to maturity**,** plant height (cm), leaf area index**,** and fresh

straw yield (t/ha)**.** For yield and yield components: number of productive tiller per hill, number of unfilled grains, number of filled grains, (%) filled grains, number of panicles/ 0.50 linear meter, weight (g) of panicles/.50 linear meter, weight (g) of 1000 grains, and total grain yield (t/ha) as well as harvest index (HI). Peanut's agronomic characteristics were number of days from planting to flowering, number of days from planting to maturity, plant height (cm), and fresh herbage yield (t/ha). For yield and yield components: numbers of pods per plant, weight (g) of pods per hill, number of seeds per pod, weight (g) of pods per plot.

Other Parameters Gathered
Efficiency parameters included LER and area time equivalent ratio (ATER), cost and return of upland rice, and peanut production per hectare.

Land Equivalent Ratio
This was the sum of a fraction of the intercrop yield relative to the monoculture yield. This was determined by getting the yield of the crop combinations and their yield in monoculture under the same level of management. The crop LER in the mixture was added to give the LER (Etji, 1982). Below is the formula for how to get the land equivalent ratio:

$$LER = \frac{X_1}{X_2} + \frac{Y_1}{Y_2}$$

where X_1 is the yield of upland rice in a crop combination, X_2 is the yield of upland rice in monoculture, Y_1 is the yield of peanut in combination, and Y_2 is the yield of peanut in monoculture.

An LER of more than 1.0 means that the practice of intercropping is more productive than sole cropping, and LER of less than 1.0 indicates that monocropping is more advantageous than the intercropping scheme, while LER of equal 1.0 means that the productivity of intercropping and sole cropping will be the same.

Area Time Equivalent Ratio
Area time equivalent ratio provides a comparison of the yield advantage of intercropping over mono-cropping in terms of time taken by component crops in the intercropping systems. Area time equivalent ratio was calculated using the formula developed by Hiebsch (2017).

$$ATER = \frac{(RYa \times Ta) + (RYb \times Tb)}{T}$$

where RYa is the relative yield of upland rice in a mixture, Ta is the duration (in weeks) of upland rice, RYb is the relative yield of peanut in a mixture, Tb is the duration (in weeks) of component B (peanut), and T is the total duration of the intercropping system (in weeks).

Incidence of Insect Pest and Diseases Infestation
This was determined using a scale from 1 to 5. One is the lowest or no infestation of pests and diseases present in the field. Five is the highest, indicating severe infestation of pests and diseases in the field.

Cost and Return Analysis
Gross income = yield (kg/ha) × prevailing market price/kg

Net income = gross income–total cost of production

Statistical Analysis
All data collected were analyzed using the Statistical Tool for Agricultural Research. Comparison of means was made using the least significant difference.

Results and Discussion

Soil Chemical Properties
Initial soil analysis showed that the experimental area had a soil pH of 6.38 with 1.324% organic matter, 0.131% total nitrogen, 19.726 mg/kg extractable P, and 0.68 me 100/g exchangeable potassium contents (Table 1). These results suggest that the area was slightly acidic, with a meager amount of organic matter, low total nitrogen content, high available phosphorus, and a high amount of exchangeable K (Landon, 1991).

In the final soil analysis, the soil pH and % OM (Organic Matter) were decreased. This could be due to the presence of intercrop that reduced soil acidity and increased exchangeable potassium. The decrease in the organic matter might be due to the crop residues that were not yet thoroughly decomposed. However, a slight decrease in total N and available phosphorous could be due to heavy rainfall that caused these nutrient elements' leaching. The nitrogen fixed by peanut might have been used up by the peanut plants during vegetative and reproductive stages (Tosas, 1988).

Agronomic Characteristics of Upland Rice
The agronomic characteristics of upland rice var. Zambales intercropped with peanut at different timing of planting are shown in Table 2. Analysis of variance revealed that the different timing of planting upland rice and peanut in an intercropping scheme significantly affected the number of days from sowing to heading and maturity and the height (cm) of upland rice.

Upland rice planted 2 weeks ahead of peanut (T_3) and upland rice + peanut planted simultaneously (T_1) headed earlier than the other treatments. In terms of maturity, T_1, T_3, and T_2 (upland rice planted 1 week ahead of peanut) matured earlier than the other treatments. These results can be attributed to the early development of upland rice when it was planted ahead or at the same time with peanut, which resulted in reduced competition with the peanut intercrop for its growth and development.

Table 1.
Soil Chemical Analyses of the Experimental Area Before and After Planting Upland Rice and Peanut Intercrop as Influenced by Timing of Planting

Treatments	Soil pH (1 : 2.5)	OM (%)	Total, N (%)	Avail P (mg/kg)	Exchangeable K (me100/g)
Initial Analysis	6.38	1.324	0.131	19.726	0.68
Final Analysis					
T_1	6.43	1.414	0.114	10.997	1.02
T_2	6.27	1.481	0.111	11.432	0.91
T_3	6.15	1.424	0.117	10.604	0.94
T_4	6.23	1.424	0.120	9.383	0.98
T_5	6.43	0.096	0.096	13.236	0.95
Mean	6.25	1.167	0.129	11.130	0.96

Note: T_1 = upland rice + peanut planted simultaneously; T_2 = upland rice planted 1 week ahead of peanut; T_3 = upland rice planted 2 weeks ahead of peanut; T_4 = peanut planted 1 week ahead of upland rice; T_5 = peanut planted 2 weeks ahead of upland rice.

Table 2.
Agronomic Characteristics of Upland Rice Intercropped with Peanut as Influenced by the Timing of Planting

Treatment	No. of Days from Sowing to		Plant Height (cm)	Leaf Area Index	Fresh Straw Yield (t/ha)
	Heading	Maturity			
T_1	95.33b	129.33bc	120.80b	4.095a	11.11
T_2	96.67a	127.33cd	128.75a	2.67c	10.11
T_3	94.67b	125.33d	129.50a	2.99c	13.90
T_4	96.67a	132.00a	125.23ab	3.18b	11.13
T_5	96.67a	131.33ab	131.10a	2.920c	10.05
CV (%)	0.53	1.09	2.25	27.52	12.69

Note: Means with the same and without letters in a column are not significantly different at 5% level of HSD.
T_1 = upland rice + peanut planted simultaneously; T_2 = upland rice planted 1 week ahead of peanut; T_3 = upland rice planted 2 weeks ahead of peanut; T_4 = Peanut planted 1 week ahead of upland rice; T_5 = Peanut planted 2 weeks ahead of upland rice.

On the other hand, when peanuts were planted 1 or 2 weeks ahead of upland rice (T_4 and T_5), the rice plants flowered late and eventually matured late. These results can be attributed to the competition effect between peanut and upland rice when peanut was planted 1 or 2 weeks ahead of upland rice. This finding conformed to Sarcol and Cagasan (2016) study, which showed that the canopy of peanuts planted ahead of sweetpotato covered the main crop during the seedling stage, hindering its photosynthetic activity.

In terms of plant height, upland rice planted 1–2 weeks ahead of peanut (T_2 and T_3) were taller than the upland rice in T_1 (upland rice + peanut planted simultaneously). This is expected since the upland rice in T_2 and T_3 were able to develop ahead of the intercrop. However, results also showed that upland rice planted After 1 or 2 weeks peanut (T_4 and T_5) were also taller than the upland rice in T_1 (upland rice + peanut planted simultaneously). According to Belel et al. (2014), this could be because, in a cereal-legume intercropping scheme, "the cereal component has advanced growth rate, height advantage, and a more widespread rooting system which gives it upper hand in competition with associated legumes."

Yield and Yield Components and Harvest Index of Upland Rice
The yield and yield components and harvest index of upland rice intercropped with peanut at different planting timing are presented in Tables 3 and 4. No significant differences were observed in the yield and yield components except in the weight of panicles/0.50 linear meter. Upland rice in T_5 (peanut planted 2 weeks ahead of upland rice) obtained the heaviest weight of panicles/0.50 linear meter (209.0 g), which was comparable to T_3 (upland rice planted 2 weeks ahead of peanut) with 207.33 g. The results can be attributed to the less competition between the component peanut crop, which was planted 2 weeks before the rice plant. The early development of upland rice enabled it to absorb more nutrients from the soil and capture more solar radiation for the photosynthesis process. On the other hand, in T_5, the planting of peanuts 2 weeks ahead may have allowed the legume to fix nitrogen in the soil, which later became available to the upland rice planted 2 weeks later. According to Fukai et al. (2014), legumes, which include peanuts, and a shared component of an intercrop, and their ability fix nitrogen through rhizobium bacteria that lead to often support the productivity of the intercrop.

Table 3.
Number and Weight (g) of Grains/Panicle, No. of Productive Tillers, Number, and Weight/0.50 Linear Meter of Upland Rice Intercropped with Peanut as Influenced by the Timing of Planting

Treatment	Number of Grains/Panicle		No. of Productive Tillers/0.50 Linear Meter	Panicles/0.50 Linear Meter	
	Filled	Unfilled		Number	Weight (g)
T_1	200.83	33.57	61.00	67.33	149.00b
T_2	179.27	34.93	43.00	52.33	151.00b
T_3	197.30	56.03	51.33	44.33	207.33a
T_4	180.60	40.20	54.67	55.67	131.00b
T_5	199.27	25.97	67.00	59.00	209.00a
CV (%)	10.43	40.69	0 18.20	15.85	9.70

Note: Means with the same and without letters in a column are not significantly different at 5% level of HSD.
T_1 = upland rice + peanut planted simultaneously; T_2 = upland rice planted 1 week ahead of peanut; T_3 = upland rice planted 2 weeks ahead of peanut; T_4 = peanut planted 1 week ahead of upland rice; T_5 = peanut planted 2 weeks ahead of upland rice.

Table 4.
Percentage Filled Grains, Weight (g) of 1000 Grains, Grain Yield (t/ha), and Harvest Index of Upland Rice Intercropped with Peanut as Influenced by the Timing of Planting

Treatment	Percentage Filled Grains (%)	Wt. (g) of 1000 Grains	Grain Yield (t/ha)	Harvest Index (HI)
T_1	85.94	32.87	2.08	0.25
T_2	83.69	32.67	1.99	0.28
T_3	78.38	34.87	1.78	0.27
T_4	81.79	35.77	2.15	0.31
T_5	82.69	33.83	2.42	0.26
CV (%)	5.68	6.24	21.91	21.91

Note: Means without a letter in a column are not significantly different at 5% level, HSD
T_1 = upland rice + peanut planted simultaneously; T_2 = upland rice planted 1 week ahead of peanut; T_3 = upland rice planted 2 weeks ahead of peanut; T_4 = peanut planted 1 week ahead of upland rice; T_5 = peanut planted 2 weeks ahead of upland rice.

Treatments at T_1, T_2, and T_4 had lighter weights of panicles/0.50 linear meter due to competition between upland rice and peanut when they were planted simultaneously and at a shorter time gap of 1 week. According to Mandal (2014), severe competition for growth factors could result in the low weight of panicle and total grain yield (t/ha).

Agronomic Characteristics of Peanut
The agronomic characteristics of peanut planted at different timing as intercrop to upland rice are shown in Table 5.

Analysis of variance revealed that the different timing of planting the intercrop did not significantly affect peanut's agronomic parameters except in the number of days from sowing to maturity. When peanuts were planted 1 or 2 weeks later than upland rice (T_2 and T_3), it matured later than the other treatments' peanuts. This could be because planting upland rice 1–2 weeks ahead of peanut (T_2 and T_3) caused shading of the peanut intercrop by rice, which hindered the plants' photosynthetic activity. On the other hand, when the peanut was planted ahead of upland rice, as in T_4 and T_5, the plants flowered and matured earlier than the peanuts in the other treatments. This result could be attributed

Table 5.
No. of Days from Sowing to Flowering and Maturity, Plant Height (cm), and Fresh Herbage Yield (t/ha) of Peanut Intercrop as Influenced by the Timing of Planting

Treatment	No. of Days from Sowing to		Plant Height (cm)	Fresh Herbage Yield (t/ha)
	Flowering	Maturity		
T_1	27.67	103.33b	54.90	9.29g
T_2	28.00	105.00ab	59.43	12.63
T_3	28.67	109.33a	57.28	14.24
T_4	27.67	97.67c	59.55	15.15b
T_5	27.33	5.33c	59.90	12.72
CV (%)	2.97	2.55	5.97S	25.01

Note: Means with the same and without a letter in a column are not significantly different at 5% level, HSD
Note: T_1 = upland rice + peanut planted simultaneously; T_2 = upland rice planted 1 week ahead of peanut; T_3 = upland rice planted 2 weeks ahead of peanut; T_4 = peanut planted 1 week ahead of upland rice; T_5 = peanut planted 2 weeks ahead of upland rice.

to less competition between the upland rice and peanut for growth factors such as light, space, and nutrients. This result conformed to Dordas (2011) findings that the timing of planting is critical to reduce competition between the two crops planted in an association.

Yield and Yield Components of Peanut

The yield and yield components of peanut planted at different timing as intercrop to upland rice are shown in Table 6. Analysis of variance revealed that the different timing of planting the peanut intercrop significantly affected pod yield (t/ha) but not the number and weight of pods per hill and the number of seeds per pod. Peanuts in T_1 (upland rice + peanut planted simultaneously), T_4 (peanuts planted 1 week ahead of upland rice), and T_5 (peanuts planted 2 weeks ahead of upland rice) had comparable yields of 1.40 t/ha, 1.32 t/ha, and 1.47 t/ha, respectively, which were significantly higher than the yields of peanuts in T_2 (peanuts planted 1 week later than upland rice) and T_3 (peanuts planted 2 weeks later than upland rice).

This means that planting peanuts either at the same time or 1–2 weeks ahead of upland rice can give better pod yield than planting it later than upland rice. This could be because under these intercropping schemes, peanuts experience lesser competition with upland rice in space, solar radiation, utilization of nutrients in the soil, and other growth factors since it was planted ahead of upland rice (Alcober et al., 2014).

Table 6.
Number of Pods Per Hill, Seeds Per Pod, Weight (g) of Pods, and Seeds Per Hill of Peanut Intercrop as Influenced by the Timing of Planting

Treatment	No. of Pods/ Hill	No. of Seeds/Pod	Weight (g) of Pods/Hill	Pod Yield (t/ha)
T_1	15.83	2.80	32.90	1.40a
T_2	18.23	3.03	39.23	1.03bc
T_3	19.77	2.70	36.20	0.89c
T_4	19.47	2.97	39.90	1.32ab
T_5	21.23	2.93	41.53	1.47a
CV%	15.99	15.51	30.60	24.63

Note: Means with the same and without a letter in a column are not significantly different at 5% level, HSD
Note: T_1 = upland rice + peanut planted simultaneously; T_2 = upland rice planted 1 week ahead of peanut; T_3 = upland rice planted 2 weeks ahead of peanut; T_4 = peanut planted 1 week ahead of upland rice; T_5 = peanut planted 2 weeks ahead of upland rice.

Table 7.
LER and ATER of Upland Rice and Peanut Intercropping as Influenced by the Timing of Planting

Treatment	LER	ATER
T_1—upland rice+ peanut planted simultaneously	1.36	1.77
T_2—upland rice planted 1 week ahead than peanut	0.96	1.22
T_3—upland rice planted 2 weeks ahead than peanut	0.97	1.31
T_4—peanut planted 1 week ahead than upland rice	1.34	1.79
T_5—peanut planted 2 weeks ahead than upland rice	1.50	2.02

Note: LER = land equivalent ratio; ATER = area time equivalent ratios.

Land Equivalent Ratio

As shown in Table 7, T_1 (upland rice + peanut planted simultaneously), T_4 (peanuts planted 1 week ahead of upland rice), and T_5 (peanuts planted 2 weeks ahead of upland rice) had LER values of more than 1.0, which means that these intercropping schemes have yield advantage than monocropping (Jeruto 2017). For instance, the highest LER value of 1.50 obtained from T_5 means that 50% more land (5000 m^2) is needed in monoculture to give the same combined yield of upland rice and peanut under this intercropping system. These results suggest that upland rice and peanut planted simultaneously and the planting of peanuts 1–2 weeks ahead of upland rice can be the more appropriate timing of planting for optimum crop production. These results confirmed Ndunguro et al.'s (1980) findings that growing crops in an association is more productive than using the crop in pure stand. The advantage of planting peanuts ahead of rice can be explained by the ability of peanuts to fix nitrogen in the soil, making it available for use by upland rice, which is planted later (Fukai, 1993 as cited by Belel et al., 2014).

Area Time Equivalent Ratio

The area time equivalent ratios (ATERs) of the different upland rice-peanut intercropping treatments are also shown in Table 7. It can be observed that all treatments had ATER values of more than 1.0. This means that considering the time taken by component crops, all of the intercropping schemes considered in this study have a yield advantage over monocropping. Consistent with the LER computation results, T_5, T_4, and T_1 had ATER values higher than T_2 and T_3. This suggests that planting upland rice and peanut simultaneously (T_1), and planting peanuts 1–2 weeks ahead of upland rice may be the appropriate timing of planting the component crops to maximize crop yield per unit area per unit time. Again, the advantage of planting peanuts ahead of rice can be explained by the ability of peanuts to capture atmospheric nitrogen through rhizobium bacteria in the soil, making it available for use by upland rice that is planted later (Sarcol & Cagasan, 2016). Also, when peanuts are planted ahead of rice, it can be harvested earlier, freeing the upland from competition as it continues to fully develop its grains, resulting in higher grain yield.

Incidence of Insect Pest Infestation in Peanut

Table 8 shows the ratings for the insect pest infestation in peanuts 45 days after emergence. It can be observed that T_5 had the least pest infestation rating of 1.0, which causes leaf damage of 1%–20%. T_2 and T_4 had the highest pest infestation rating of 2.0,

Table 8.
Incidence of Insect Pest Infestation in Peanut Planted at Different Timing of Planting as Intercrop to Upland Rice

Treatment	Ratings
T_1—upland rice + peanut planted simultaneously	1.67
T_2—upland rice planted 1 week ahead than peanut	2.00
T_3—upland rice planted 2 weeks ahead than peanut	1.33
T_4—peanut planted 1 week ahead than upland rice	2.00
T_5—peanut planted 2 weeks ahead than upland rice	1.00

which was equivalent to 21%–40% leaf damage. However, the plants in T_2 and T_4 were able to recover as the plants grow older.

Legend: Ratings

Damage Index	*Percent (%) Leaf Damage*	*Reaction*
1	*1–20*	*Highly resistant*
2	*21–40*	*Moderately resistant*
3	*41–60*	*Moderately susceptible*
4	*61–80*	*Susceptible*
5	*81–100*	*Highly susceptible*

Cost and Return Analysis

Table 9 presents the cost and return of upland rice intercropped with peanut as influenced by different timing of planting. Among the intercropping schemes, T_5 (peanut planted 2 weeks ahead of upland rice) gave the highest combined gross margin of Php86,867.02/ha. It was followed by T_1 (upland rice + peanut planted simultaneously) with a combined gross margin of Php76,822.02 and T_4 with a combined gross margin Php73,232.02/ha. Rice monoculture had the lowest gross margin of Php24,682.14, while peanut mococulture had the highest gross margin of Php90,524.88. The high gross margin of peanut monoculture could be attributed to the high market price of peanut. However, if the purpose is to produce rice for food and at the same time to earn income from intercrop is desired, planting peanuts 2 weeks ahead of upland rice may be a good option as it gave the second-highest gross margin of Php86,867.02/ha.

Table 9.
Cost and Return Analysis Per Hectare of Upland Rice and Peanut Intercropping as Influenced by Timing of Planting

Treatment	Yield (t/ha) Upland Rice Peanut		Gross Income (PhP)	Total Variable Cost (PhP)	Gross Margin (PhP)
	Grain	Pods			
MCR	3.50	-	63,000.00	38,317.86	24,682.14
MCP	-	1.80	126,000.00	35,475.12	90,524.88
T_1	2.08	1.40	135,440.00	58,617.98	76,822.02
T_2	1.37	1.03	96,760.00	56,867.98	39,892.02
T_3	1.68	0.89	92,540.00	56,367.98	36,178.02
T_4	2.15	1.32	131,100.00	57,867.98	73,232.02
T_5	2.42	1.47	146,460.00	59,867.98	86,867.02

Note: Calculation of gross income is based on the current price of dried palay at PhP 18/kg and peanut at PhP 70/ kg.
MCR = monoculture rice; MCP = monoculture peanut; T_1 = upland rice + peanut planted simultaneously; T_2 = upland rice planted 1 week ahead of peanut; T_3 = upland rice planted 2 weeks ahead of peanut; T_4 = peanut planted 1 week ahead of upland rice; T_5 = peanut planted 2 weeks ahead of upland rice.

Conclusion and Recommendations

Timing of planting the intercrops can significantly influence some of the agronomic yield and yield characteristics of upland rice and peanuts. The number of days from sowing to heading and maturity, plant height, and weight of panicles/0.50 linear meter were increased when the upland rice was planted ahead of peanut intercrop. This allowed the rice plants to grow taller and mature earlier but planting upland rice 2 weeks later than peanut enabled it to have a heavier weight of panicles/0.50 linear meter. Peanuts planted 1–2 weeks ahead of rice (T_4 and T_5) matured earlier and had higher pod yield (t/ha) than those planted simultaneously or later than upland rice.

In upland rice–peanut intercropping scheme, planting peanut intercrop 1–2 weeks ahead of upland rice or at the same time with upland rice appeared to be the most appropriate timing of planting the component crops. Although the crop yield (upland rice) did not significantly differ among treatments, peanuts produced significantly higher pod yields than the peanuts planted later than rice. These resulted in a higher combined yield of the two-component crops. Among the intercropping treatments, planting peanuts 2 weeks ahead of upland rice is the most profitable timing of planting the component crops as it gave the highest gross margin of Php 86,867.02.

Recommendations

Considering the results of this study, the following recommendations are put forward:

1. To obtain an optimum combined production and profit of upland rice and peanut under an intercropping scheme, peanut may be planted 1–2 weeks ahead of upland rice or simultaneously with upland rice.
2. To verify further, the results of this study at the same level of management especially the same planting distance with monocrop and the intercropping scheme.

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