THE SCIENCE AND ART OF PALAYAMANAN PLUS

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FOREWORD

We want happy farmers.

We help realize this goal by coming up with strategies and technologies that will enable farmers to have a decent income.

The success of Palayamanan paved the way for PalayPlus, which was our major program from 2014 to 2017. PhilRice has adequately explored the PalayPlus framework. We implemented the program in 8 sites: Nueva Ecija, and in our 7 branch stations located in strategic areas across the country.

This book documents the diverse experiences of our implementers, and communicates a wide range of ideas to anyone who will be interested in the concepts of integration, diversification, and intensification in their farms. It contains plenty of innovations and strategies for your rice farms and also presents simple math on the cost and earnings from this venture.

While we share experiences, look at this book as our effort to contribute to the conversations in the areas of agriculture, as we are fully aware that many players may well be ahead of us. And just like in any conversation, the uniqueness of the experiences and the innovations made by our implementers make this book valuable.

Our hope is that the evolving PalayPlus initiative gains more following through the help of this book.

SAILILA E. ABDULA
Acting Executive Director, DA-PhilRice

ABOUT THE BOOK

The concepts of crop diversification, integration, and intensification are not new. Academically, these are well-discussed and debated upon. Written success stories among farmers who have actualized these concepts also abound. This book will shed light on the same concepts and more. As will be discussed in Chapter 1, PhilRice embarked on a project called Palayamanan Plus (PalayPlus) that generally aimed to mainstream the practice of crop diversification, integration, and intensification to enhance the nutrition and income of farm families. The usual criticism about initiatives similar to this is that they better be shown first; that they should go beyond narrations on paper. The more skeptical contend that certain farming systems "probably work on the laptop but actually sink in the mud". Hence, that is what the PalayPlus team at PhilRice did; it tried the concepts first at the Institute, and this book will narrate the experiences. What will you, as reader, get from this book?

- **Reflections on the PalayPlus practices.** In Chapter 1, the general concepts will be laid down. As you read through, you will learn that the branch stations located across the country implemented different combinations of components. This book explains the reasons for these choices. Thus, the lesson that the PalayPlus approach is location-and context-specific is highlighted.

- **Innovations on PalayPlus.** You will notice that two or more stations implemented a common component differently. For instance, all stations adopted the mushroom component but this book features the innovations and adaptations that each station did to suit specific conditions.

- **Interactive discussions.** Treat this book as an act of storytelling about PalayPlus. It highlights practices that did and didn't work as well as some simple economic analyses so you can better evaluate your choices should you decide to venture into PalayPlus. It is interactive as you can very well reflect on the practices yourself; you can redo the computations as you see fit.

- **Inspiration.** This book is a work-in-progress. You will benefit from the wisdom of the PalayPlus implementers who made full use of the resources available to them as well as their farming conditions in general. The message is that you, too, can do it! Sky is the limit as to combinations of components that you can adopt as well as modifications of the base technologies that you will use. The book inspires rather than instructs!

While this book does tackle some how-to's of the technologies that were used, you will benefit more from reading other publications written solely for the how-to's. This book is more about highlighting practices that worked and those that didn't. More comprehensive how-to's are available elsewhere.

The book starts with the general concepts of PalayPlus. Chapter 1 talks about Intensified Rice-Based Agribiosystems, the PhilRice program that executes the project. The components and principles of PalayPlus are also discussed. Chapter 2 expounds on how the project was carried out in Luzon (Batac, Bicol, Isabela, Los Baños, Central Experiment Station). Chapter 3 describes project implementation in the Visayas and Mindanao branch stations (Negros, Agusan, Midsayap). Chapter 4 summarizes the ripples and learnings in each implementing unit. The various initiatives, collaborations, and other fruits of this project are presented.

CHAPTER 1

The Palayamanan Plus Project

Rizal Ganiban Corales & Aurora V. Mauro-Corales

General Concepts

The Intensified Rice-Based Agribiosystems (IRBAS) program aims to develop rice-based production models that are more resilient to climate change, can increase productivity, improve resource-use efficiency, reduce costs and environmental impacts; draw up mathematical rice-based production models that can generate an income of ₱1Million/ha/year; enhance value-adding with the development of rice-based products and explore market opportunities; and conduct capacity-building and enhancement.

Palayamanan Plus (PalayPlus) is a rice-based production system project under IRBAS aimed at increasing productivity and profitability in the rice environments through purposive integration, intensification, and diversification of certain farming components, and at developing agri-enterprises to enhance crop productivity, resource-use efficiency, value-adding, and marketing. The overarching goal is to sustainably increase farmers' income, and tighten food and nutrition security.

Evolution of Palayamanan

Palayamanan evolved as a development platform to help address food security, poverty, and climate change risks in the unfavorable rice environments. It is a diversified, integrated rice-based farming system. Rice is integrated with other farming ventures in a synergistic manner, and the whole system is managed by the farm family based on the resources available to them. The system aims to assist the members of the farm family to attain their goals and aspirations. The concept is drawn from the "Bahay Kubo" (folk song) formula of crop diversification. It combines indigenous wisdom with research-generated knowledge to enhance the ecological sustainability of rice farms. In the process, the system supports increasing biological diversity, expanding productivity, improving input efficiency, and reducing environmental and health risks thus ensuring farm household food security and economic stability (Corales et al. 2005).

"Palayamanan" comes from the Filipino words "Palay" (Rice) and "Kayamanan" (Wealth) connected to mean "Prosperity with rice farming". The "PALA" literally translated as "work" means "meaningful employment". The "KAALAMAN" as indicated by the "MAN" at the middle (PalayaMANan) represents "knowledge and skills" to become better decisionmakers. The suffix "AN" (PalayamanAN) stands for "KABUHAYAN", which refers to farming ventures such as "HalamanAN" (Crop Production), "PaghahayupAN" (Livestock), "PalaisdaAN" (Aquaculture), "KakahuyAN" (Forest, Fruit, and Vegetable Trees), "at iba pang pagkakakitaAN" (and other sources of income). The concept envisions the attainment of the ultimate goal of "KAYAMANAN" (prosperity).

Palayamanan as a concept embodies the "BE RICH" principle: **B**etter resource allocation; **E**nhanced biodiversity and ecological balance; **R**educed production risks; **I**ncreased cropping intensity, productivity and sustainability; **C**ontinuous supply of nutritious food; and **H**igher and more stable income.

Palayamanan adheres to the principles of:

- **diversification** to increase productivity and profitability, diversify income sources, reduce financial risks, and address climate change issues of agricultural systems (Delgado & Siamwalla, 1997; Altierie, 1999; Parry et al., 2005; Howden et al., 2007; Rota and Sperandini, 2010; Lin, 2011; Metocha et al., 2012, Corales & Rasco, 2015; Corales et al., 2016);
- **intensification** to increase farm productivity in time and space by altering the crop geometry and improving resource efficiency (Tilman et al., 2011; FAO, 2011; Smith 2013; Campbell et al., 2014, Corales & Rasco, 2015); and
- **integration** to make farming more profitable and dependable (Behera et al., 2004; Howden et al., 2007; Ismail, 2009; Scherr et al., 2012; Seyer et al., 2013, Corales & Rasco 2015; Corales et al., 2016). The closed-loop biomass resource recovery system is also instituted to optimize resource- use efficiency through nutrient cycling. This forms part of an agricultural practice that preserves the nutrient and carbon levels within the soil and allows farming to be sustainably carried out (Corales et al., 2005).

Palayamanan Components

Crop Production Component

Rice serves as the main crop of this component. Cash crops such as corn, onion, garlic, peanut, sweet potato, melons, mungbean, and vegetables are planted during the dry season from October to May. Vegetables are also planted on paddy bunds and canals. Trees (forest, fruit, and vegetable) are grown around the Palayamanan perimeter. The trees and shrubs also serve ecological and aesthetic functions to the system.

Livestock Component

This component plays key and multiple roles in the functioning of the farm through its products such as meat, milk, eggs, wool, and hide that can be converted into cash (Delgado et al., 1999). It includes fowls such as chicken and duck, hog, goat, cow, and dairy buffalo. Other animals can also be integrated. The system for livestock production includes the fowl modified free range; hog, goat, and fattening and breeding; rice + duck production system; and dairy buffalo production.

Aquaculture Component

Aquaculture includes the production of fish, crustaceans, and snails. It intensifies the use of natural resources in a sustainable manner through species diversification and nutrient cycling. It generates additional income, and it is an important source of protein for the nutrition of the family.

The component is feasible in low-lying rice, saline, or even in rainfed or pump-irrigated areas. It can be waged in ponds or in cages, small farm reservoirs (SFRs), or small water-impounding projects (SWIPs) in the rainfed areas. Fish is normally integrated with the rice culture.

Rice + Fish production is synergistic because the rice environment provides good habitat for the fish, and the fish feeds on young weeds and insects, helps in the nutrient-cycling process, and its movements enhance aeration for better root development.

Forest, Fruit, Vegetable, and Forage Trees Component

Trees contribute to the aesthetics and viability of a farm system. They are usually planted around the perimeter of the area. They provide food, feeds, wood, and other marketable products, and offer shade and protection. They provide habitat and refuge for birds and other vertebrates. They also enhance soil fertility, clean the aquifer by extracting nutrients from the surrounding areas and deeper soil layers, and serve as land marks on boundary lines.

The tree components are: forest trees and shrubs such as mahogany, mangium, paper tree, *ipil-ipil, madre de cacao,* and neem trees; vegetable trees such as *katuray, malunggay, kamansi, alukon,* and *papaya*; and fruit trees such as mango, tamarind, citrus, jack fruit, avocado, and banana.

Biomass Recovery System

Closed-loop agriculture is a farming practice that recycles all nutrients and organic matter back to the soil. This forms part of an agricultural practice that preserves the nutrient and carbon levels within the soil and allows farming to be sustainably carried out.

Closed-loop biomass conversion technologies enhance the processing and utilization of biomass resources, producing valuable products such as organic fertilizers, soil conditioners, feed supplements, and microbial inoculants; providing additional income and job opportunities to rural communities; and reducing environmental impacts and health hazards (Corales et al., 2005)

Effective Microorganisms (EM) technology through the fermentation-decomposition process helps decompose crop residues such as rice straw, corn stover, grass clippings, tree trimmings, and kitchen garbage to produce organic fertilizer and feed supplement. Other biomass recovery systems include carbonization, combustion, and gasification where rice hull and other farm biomass are converted into carbonized rice hull (CRH) or biochar. The heat energy generated during the carbonization process is used for cooking, pasteurizing, drying, and water pumping. CRH and other biochars are used as substrates in producing organic fertilizer, ingredients for animal feeds, soil conditioner, and for waste water purification.

Other Farming Ventures

Food processing, cottage industries, marketing, plant propagation and floriculture, mushroom production, and vermiculture are other ventures.

Palayamanan Models

Over the years, several Palayamanan models have been designed and adapted for different rice environments. There are models for rainfed, upland, saline, and flood-prone conditions. Institutional models have also been developed such as the *Palayamanan sa Paaralan, sa Bilangguan, at Kampo Militar*. Other models are for the Indigenous Peoples (IPs) and insurgency rehabilitation areas. The farm established at the PhilRice Central Experiment Station is a Homestead Farm Model. Recognizing its relevance as a development platform, community-based models of Palayamanan have also been developed.

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CHAPTER 2

PalayPlus Experiences in Luzon

This chapter documents the implementation of PalayPlus in PhilRice branch stations in:

- Batac
- Bicol
- Isabela
- Los Baños
- Nueva Ecija (Central Experiment Station)

PALAYPLUS EXPERIENCES IN BATAC

Bethzaida M. Catudan, Mae Rose M. Maoirat-Abad, Sonia V. Pojas, Leo G. Inocencio, Frank S. Diza, Christopher S. Cabañog, Evangeline P. Agres, Reynaldo C. Castro, Fidela P. Bongat, and Mary Ann U. Baradi

Highlights

- PhilRice Batac implemented four PalayPlus components: cropping sequence, oyster mushroom production, vermicomposting, and cattle fattening.
- Even with limited water, the station produced more than 6t/ha of palay/season.
- Mushroom production proved to be a lucrative and popular enterprise. Many individuals, organizations, and even schools requested for training programs so they can produce mushroom on their own. The Batac city government sponsored a cookfest showcasing different recipes for oyster mushroom.
- The mushroom component was the most intensively researched. Aside from using bigger fruiting bags, a modified pasteurization method was established. The variation in mushroom productivity according to the months of production was likewise documented.

Site profile

Ilocos Norte province located on the northernmost edge of western Luzon is composed of two component cities and 21 municipalities. The City of Batac is at its mid-southwestern portion. It comprises 43 barangays (29 rural and 14 urban) covering 16,101 hectares of flat, rolling, hilly, and steep terrains. Agricultural lands for annual crops occupy 5,618 hectares, 74% of which is planted with wet season (WS) rice. The 4,151 hectares WS rice area shrinks to only 220 hectares in the dry season (DS). Water for irrigated rice is supplied by communal irrigation systems, many of which can only sustain WS rice production.

PhilRice Batac is 2.5km west of the city proper, within the Mariano Marcos State University campus. The station is the Center for Dryland Agriculture of PhilRice and operates 6 hectares of experimental, demonstration, and rice seed production areas. Demonstration farms for rice and vegetable technologies are maintained year-round, which serve as learning fields of students and farmers who undergo training at the station. Irrigation water comes from shallow tube wells and small farm reservoirs during DS. The station owns various production and postharvest machines, equipment, and facilities to cater to its field operations, and rice seed processing and storage. Rice is grown only during WS, and various cash crops, particularly yellow corn, are raised during DS. The station produces foundation and registered seeds of rice varieties popular in the locality that it sells to seed growers and ordinary farmers.

Batac has Type I climate based on the Corona classification; two pronounced seasons, dry from November to April and wet from May to October. Typhoons and storms occasionally pass through the province during the southwest monsoon season. Historically, annual rainfall is around 2000mm. Heavy rainfall used to start in June and peak in August. During the implementation of the project, however, total rainfall was far below normal in 2014 and 2016, coupled with yearly shifts of the peak month (World Weather Online, 2017). The rainy season arrived late in 2015 and 2016, pushing planting to later dates. Likewise, temperature levels had been climbing up in recent years. Maximum temperature in May at 33°C consistently rose by 1°C annually since 2012. While it leveled off in 2015 and 2016, the hottest month shifted to June. Similarly, lowest temperature in January remained at 22°C until 2014, increased by 1°C in 2015, then climbed to 26°C in 2016.

Soil types in low-lying areas of Batac include Bantay (52%), San Manuel (18%), Bantog (15%), and San Fernando (8%) series (PhilRice, 2017a). High-elevation areas have Faraon and Cervantes soils; the station itself has a dominantly San Fernando soil. This soil type has low organic matter and poor drainage, but very high nutrient and water retention.

While rice is grown in paddies during WS, corn and vegetables are likewise raised in small scale in unbunded fields. Most paddies that cannot sustain rice production during the DS are planted with corn, vegetables, garlic, multiplier onion, mungbean, peanut, and sweet potato. Majority of the WS corn is the open-pollinated variety (OPV) white type; hybrid yellow corn during the DS. The most planted all-season vegetables are tomato, string beans, finger pepper, eggplant, and bitter gourd (Batac CAO, 2017).

Batac is a 5th class city based on income level (PSA, 2017a) and the second most populous, next to Laoag City. The PSA census in 2015 counted 55,201 residents in Batac, which was 9.3% of the total population of Ilocos Norte. Its 12,797 households had 4 members, on average. Those with 3 to 5 members comprised 55% of the total households in the City. Annual population growth was 0.58% (PSA, 2017b).

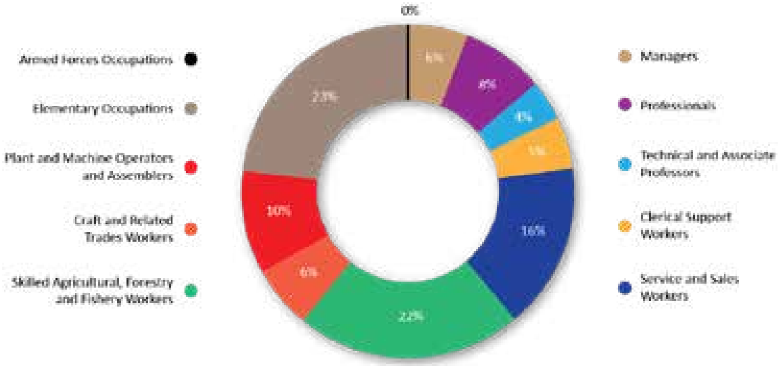

Figure 1. Sources of income of Batac residents by occupation group, 2015.
Source: Philippine Statistics Authority (PSA), 2015 Census of Population

Batac income is earned from 10 occupation groups. Most predominant income sources in 2015 were elementary occupations (23%) and skilled agricultural, forestry and fishery (AFF) works (Fig. 1). Elementary occupations involve low-skill manual works; majority of the skilled were at least 40 years old (71%) and males (66%). The proportion of those employed in other occupations, except the professionals, decreased when they turned 40; that of the AFF sectors consistently increased with age. Some 58% of the income earners of Batac aged 65 years and older worked under the AFF industries (PSA, 2017b). This implies that those who left or retired from other occupations may have been shifting to these sectors as they aged.

Batac posted a 10.9% poverty incidence in 2012 (PSA, 2016c); Ilocos Norte's record in the same year was only 9.9%, the lowest among the four provinces in Region 1. It dropped to 5.3% in 2015, much lower than the 13.1% average poverty incidence of Region 1 and the 21.6% level nationwide (PSA, 2016c). While a few households in Ilocos Norte were under the poverty line in 2015, all households were able to provide for their basic food requirements. Annual per capita poverty threshold of the province was ₱20, 615.

Using the data of Region 1 (the most disaggregated statistics on household income available) as proxy for household incomes of Ilocos Norte in general and Batac in particular, more than half of the households (52.8%) were each earning ₱100,000-249,999 annually (Fig. 2). It implies that this predominant income group earned 1.1-2.8 times the amount they needed to meet their basic needs.

Batac posted 4.57t/ha average rice yield in 2016 WS and 5.75t/ha in 2017 DS (Batac CAO, 2017). This translates to 18,970 tons annual contribution of the City to domestic production, valued at ₱354.1M. Using the ₱12.29 average cost of production/kg palay of Ilocos Norte in 2012 (PhilRice, 2017b), Batac farmers averaged around ₱23,700 net income per hectare from rice production.

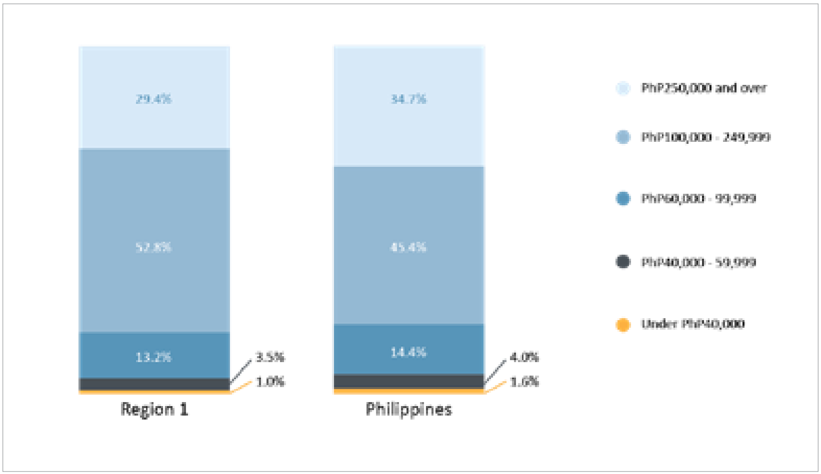

Figure 2. Distribution of households by income group, 2015.
Source: PSA, 2015 Family Income and Expenditure Survey

PalayPlus Components Implemented

I. Crops

Cropping sequence

Cropping sequence is one component of PalayPlus where PhilRice Batac has the widest elbow room for decisions. The very distinct DS in Batac City afforded a wide range of crop options and growing schedules. Nevertheless, the scarcity of irrigation water sources during the latter part of the DS was consciously noted. Likewise, the potential profit, perishability, and price stability of each component crop were considered. Lastly, the technical skills of the focal person in managing a specific crop were assessed.

Glutinous white corn, watermelon, and sweet potato were planted after rice. The cropping sequences in 2015 were chosen (Fig. 3) then fine-tuned in 2016. A portion (1.28 ha) of the production area of the Business Development Unit (BDU) at the station was allocated for the crop component of PalayPlus.

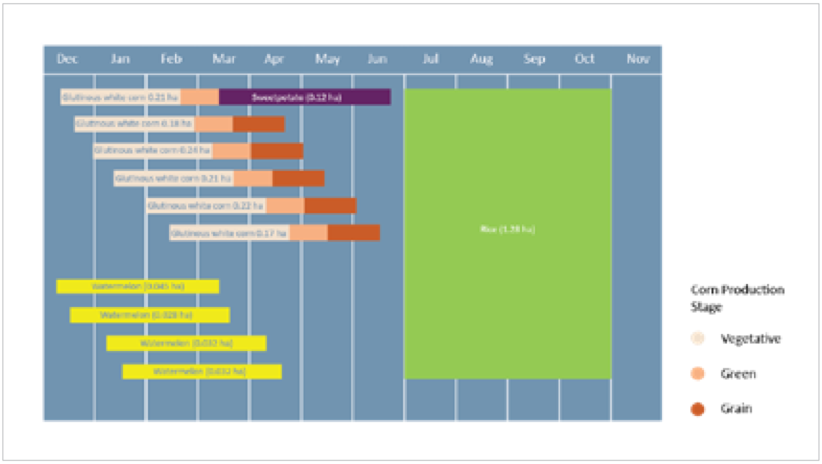

Figure 3. Cropping calendar of the PalayPlus crop component, PhilRice Batac, 2015.

Walk-in guests appreciating the commercial rice NSIC Rc 352 during the 2016 WS.

Rice seed production

In 2014 and 2015, the rice component of the cropping sequence focused on seed production to maximize income. Its management in 2014, however, was still included in the station BDU seed production operation. In 2015, it was separated from BDU to allow the focal person full control in implementing the package of technologies (POT) for fine-tuning. Varieties NSIC Rc29, Rc160, Rc274, and Rc336 which are suitable to Ilocos conditions were transplanted in mid-July and harvested in late October. In 2016, Rc352 was planted for commercial production 3-4 weeks late when the rains came.

The fine-tuned POT used in rice seed production in 2015 is shown in Table 1. The same POT was adopted in 2016, except for practices exclusive for seed production.

Table 1. Rice seed production technology, PhilRice Batac, 2015.

Technology Component	Practice
Land preparation	• 1x dry-plowing; 2x puddling; 1x leveling
Varieties	• NSIC Rc 29, Rc 160, Rc 274, Rc 336
Crop establishment	• 40kg/ha seeding rate; soak seeds for 24hr and incubate for another 24hr • Transplant 20-day-old or younger seedlings in straight row at 2-3 plants per hill, 20cm x 20cm distance
Water management	• Observe alternate wet and dry (AWD); maintain required water level during critical stages of the crop; irrigate every after fertilizer application
Nutrient management	• Apply 10 bags vermicompost on 400m^2 seedbed • Apply 175-42-42kg NPK per hectare; apply all P and K and a portion of N plus 28 bags organic fertilizer per ha as basal; topdress remaining N thrice during the active vegetative stage
Pest management	• Monitor field regularly • Manage weeds with post-emergence broad-spectrum herbicide before and spot weeding after crop establishment • Apply pesticide only if the critical level is reached
Roguing	• Rogue periodically from tillering to grain filling
Harvesting	• Harvest at 80-85% mature grains; use combine harvester, clean machine before and after use
Postharvest and processing	• Dry produce immediately after harvest; use seed cleaner machine • Pack certified seeds in laminated sacks

In 2015, NSIC Rc 29 yielded highest (5.9t/ha); Rc336 (4.8t/ha). Rc 274 and Rc 160 did not yield high at less than 3t/ha. Given that not all farmers can adopt rice seed production practices, NSIC Rc 352 was planted for commercial production in 2016 (6.1t/ha *palay* yield).

The rice straw from the PalayPlus setup was used in the oyster mushroom and vermicomposting components of the project. The *palay* harvested in 2016 was sold to a highest-bidding local buyer. The BDU sold the certified seeds produced from 1.28 hectares in 2015 and earned a gross margin of ₱65,129 or ₱50,882 per hectare (Table 2).

Table 2. Returns over variable costs (₱) of certified seed production, PhilRice Batac, 2015 WS.

Item	Actual (1.28ha)	Per hectare
Materials	47,362	37,002
Labor	31,989	24,991
Total Variable Costs	79,351	61,993
Gross Income	144,480	112,875
Production (kg)	4,128	3,225
Gross Margin	65,129	50,882

The profitability of commercial rice in 2016 is reflected in Table 3. NSIC Rc 352 performed well, providing a gross margin of ₱119,576 from only 1.68 hectares or ₱71,176 per hectare. The 6.1t/ha yield was much higher than the 4.5t/ha average of farmers in Batac from tagged inbred seeds largely due to the refinement of the POT. Irrigation water and fertilizers were applied at the proper amount and timing. Insect pests and diseases were not a problem. The vermicompost applied in the field for 2 consecutive years seemed to have created positive effects on the soil.

Table 3. Returns over variable costs (₱) of commercial rice production, PhilRice Batac, 2016 WS.

Item	Actual (1.68ha)	Per hectare
Total Variable Costs	75,168	44,743
Gross Income	194,744	115,919
Production(kg)	10,250	6,101
Gross Margin	119,576	71,176

Two concerns confronted rice seed production. One, planting many varieties for seed purposes demands more time to manage them to avoid risking the purity of the seeds. Two, given that harvesting schedules were close to each other, extra vigilance was required to preclude mixtures during postharvest activities. A maximum of two varieties are manageable for an ordinary farmer. All the varieties are suitable in the locality but they differ in productivity levels. A seed grower who wants to maximize profit should plant a variety that has high demand and yield potential.

Corn production

For ease in harvesting and marketing green corn ears, glutinous white corn was planted in 1.15 hectares in staggered planting schedules. Green corn earns better income than grain corn. However, it requires more labor for the daily harvesting of marketable ears within the maximum 10-day green corn window. The ears that overaged were allowed to mature and harvested for grains.

In 2015 DS, green corn was planted in six staggered schedules at 10 days interval, starting in mid-December. The last two schedules of planting in 2016 were aborted owing to limited water. Table 4 sketches the fine-tuned technology adopted for corn production. The local variety was chosen because it has an established market in green and grain forms alike. The field was properly tilled before furrowing. Seeds were dibbled on the furrows.

Harvesting green corn by buyers themselves started in mid-February at 1-3 days interval. It was a win-win situation as the buyers could control the quality of the ears they bought, and the project saved on labor cost for harvesting. The bulk of the green corn harvest, however, was sold in cooked form. In 2015 and 2016, raw green corn was ₱3.00 per ear; ₱4.50 when cooked in 2015 and ₱5.66 in 2016. Hence, the harvesting interval was shortened, and more cooked green corn was sold from 78% to 91% in 2016. Local assemblers bought raw green corn while the ready-to-eat food was marketed at the station. The grain corn was sold to local *cornik* manufacturers that buy only the local variety to suit their unique processing method. The stover was used as an additional substrate for the vermicomposting component of PalayPlus.

Table 4. Glutinous white corn production technology, PhilRice Batac, 2016.

Technology Component	Practice
Variety	• Open pollinated variety (OPV) glutinous white (local variety)
Land preparation	• 1x rotovation • Furrow field at 80-cm row distance, 8-10-cm deep
Planting	• Dibble 2-3 seeds per hill, spaced 25cm along rows • Seeding rate: 45kg/ha
Water management	• Hill-to-hill irrigation at 14 DAP • Furrow irrigation after off-barring and hilling-up • Irrigate every after fertilizer application
Nutrient management	• Apply 90-21-51kg NPK per hectare; apply all P and K and a portion of N as basal; side-dress remaining N during the active vegetative stage
Pest management	• Spray chemicals to manage insect pests and diseases • Manage weeds by off-barring and hilling-up at 2 weeks interval; spot-weed when necessary
Harvesting	• Harvest green corn ears from 70 to 80 DAP

The productivity of glutinous white corn is much lower than hybrid yellow corn. White corn averaged only 2.3t/ha in 2016 DS; 4.6t/ha for yellow (Batac CAO, 2017). White corn, however, commanded a better price in Ilocos Norte during the DS harvest months in 2015 and 2016 with an advantage of ₱1.71-9.86 (CountrySTAT, 2017). But, the monthly price levels of white corn fluctuated by ₱5.55 against ₱0.55 for yellow corn. Green corn price was also relatively more stable during the same period. Selling the corn in its green form was a deliberate strategy of the project to outsmart the risks of unstable grain corn prices.

The average financial performance of white corn in 2015 and 2016 is reflected in Table 5. The gross margin realized from the 1.15 ha production area was ₱18,761 or ₱16,314 per ha. Corn is grown on a larger scale than most of the other cash crops because it requires a much lesser production cost per unit area. It is a suitable crop for farmers with large farms but with limited capital and household labor.

Table 5. Returns over variable costs (₱) of glutinous white corn production, PhilRice Batac, 2015 and 2016 DS.

Item	Actual (1.15ha)	₱/ha
Total Variable Cost	39,649	34,478
Gross Income	58,410	50,792
Green corn (ears)	5,215	4,535
Grain corn (kg)	1,612	1,402
Gross Margin	18,761	16,314

Corn production.

Watermelon production

Watermelon was planted in staggered schedules starting in mid-December 2015 at 10-14 days interval. It is commonly grown locally, has several varieties available in the market, and has potential to provide high income. Sweet Gold variety was planted for its price premium over other varieties due to its yellow-colored flesh and superior sweetness. Its medium-sized fruit is likewise an advantage as buyers prefer a fruit that can be entirely consumed once cut. The variety is less susceptible to production problems.

The PalayPlus watermelon POT used in 2015 and 2016 (Table 6) evolved from those developed a decade ago by PhilRice Batac and the JICA Technical Cooperation Project 3. In 2016, Orange Delight was resorted to because of shortage of Sweet Gold seeds in Ilocos Norte. It was planted in 0.15 hectares in three schedules. Sweet Gold was planted in 0.14 hectares in four staggered schedules in 2015.

Table 6. Watermelon production technology, PhilRice Batac, 2015.

Technology Component	Practice
Land preparation	• Rotovate 2x only the planting plots; space 1-m-wide double plots 0.6m apart, and the adjacent double rows 4m away • Leave the spaces between plots undisturbed
Variety	• Sweet Gold
Raising seedlings	• 30g seeds for 1000m^2 production area • Pre-germinate seeds by soaking in clean water for 30min, spreading them on clean wet cloth, rolling the cloth and placing it in a safe dark place until the radicles come out • Use seedling trays with 100-104 holes (or seedling bags and small plastic containers; fill holes with compacted seedling media composed of 4:2:1 ratio of carbonized rice hull (CRH), rice straw compost, and processed chicken manure (PCM) • Sow 1 seed per hole, 1.5-cm deep • Place the seedling receptacles on a platform in a simple nursery shed • Keep the seedling media moist by covering seedling receptacles with old newspaper, plastic sack, or rice straw; water regularly with a fine-nozzle sprinkler, preferably early morning or late afternoon • Remove cover when seeds start to sprout
Construction of planting plots	• Remove any plant debris from the rotovated areas; break large soil clods; level the soil and apply the basal fertilizers • Cover each plot with plastic mulch, secure the mulch with thin bamboo slats • Make 10-cm-diameter holes, 1m apart, along each plot

Table 6. (continuation)

Technology Component	Practice
Transplanting	• Before transplanting, irrigate the plots by applying water between the double plots to dissolve the basal fertilizers • Transplant a 12-15 day-old seedling per hole, preferably late afternoon
Nutrient management	• Apply 1 kg of vermicompost and 1 kg 16-20-0 per 10LM of plots as basal • Dibble 1tbsp (15g) of 46-0-0 per hill at 21 DAT • Dibble 1tbsp (15 g) of 0-0-60 per hill at 42 DAT
Water management	• Irrigate as necessary at vegetative stage • Irrigate every after fertilizer application • Furrow-irrigate weekly when the fruits start to develop • Stop irrigation when the fruits are fully developed (2 weeks before harvesting)
Pruning, vine-training, pollination, and fruit-thinning	• Pinch off the main shoot at the 4th node; allow 3 major vines to develop • Remove all fruit buds below the 10th node of the main vines • Remove all side shoots that appear below the retained fruits • Pollinate manually the 2nd and 3rd female flowers that develop on a main vine by rubbing the stamen of a male flower to the pistil of the female flower • Retain 2 fruits per hill; nip off all extra fruits • Train the vines toward the 4-m-wide crawling space between double plots by clipping them with thin bamboo slats • Apply rice-straw mulch on the crawling space to serve as anchor of tendrils and cushion of fruits
Pest management	• Apply chemical pesticide to manage insect pests and diseases
Turning of fruits	• Turn the fruits when they nearly reach full size to even out the color of the rind
Harvesting	• Harvest the fruits at 56-65 DAT, preferably early morning

Sweet Gold yielded 21.7t/ha in 2015, slightly higher than the average yield of all varieties grown in Batac. Aside from the suitability of Sweet Gold to Batac conditions, the POT was fine-tuned specifically for the variety. Orange Delight yielded only 10t/ha in 2016. The fruits were sold to individual customers at the station and to wholesalers at the public market of Batac City.

Sweet Gold watermelon on its way to the Batac City public market.

Watermelon production provided the highest income per unit area among all DS crops included in the crop component of the project in 2015. Since Orange Delight was a temporary replacement of Sweet Gold, it was not included in the financial performance analysis. The 0.14 hectare planted with Sweet Gold in 2015 earned ₱ 30,208 gross margin, or ₱ 205,036 per hectare (Table 7).

Table 7. Returns over variable costs (₱) of watermelon production, PhilRice Batac, 2015 DS.

Item	Actual (0.14ha)	Per hectare
Total Variable Costs	16,000	114,286
Gross Income	46,208	330,057
production(kg)	3,032	21,657
Gross Margin	30,208	215,771

Sweet potato production

Sweet potato was another PalayPlus crop planted after the first batch of the 2015 white corn. Established late in March, it yielded only 3.0t/ha, far below the recorded average yield of 5.7t/ha in Batac, chiefly due to the very late planting. Farmers in Batac normally plant sweet potato in November and December to take advantage of the cooler weather and the occasional rains until early February. The station's soil is clayey, which is not suitable for root crop production. In 2016, area for sweet potato was reduced to 0.07 hectare. At 4.4t/ha, the produce was higher but infested with weevil.

II. Mushroom

Oyster mushroom production (OMP) can be a lucrative venture in Batac City as it serves as a good substitute for the wild *Volvariella* mushrooms, which are popular among Ilocanos. The wild mushrooms grow only for a short period during the peak of the rainy season.

PhilRice Batac has adequate facilities for OMP. The fruiting area is at the basement of the office complex and can accommodate 1,680 fruiting bags. The new pasteurization facility can hold 160 fruiting bags. The laboratory room is equipped with an isolation chamber, a 2-door refrigerator, and open shelves to store the inoculated fruiting bags as well as a 40-L-capacity autoclave and a 2-burner gas stove.

Mushroom production.

At the start of project implementation in 2014, the generic OMP technology except for the size of the fruiting bags was strictly followed. The station used bigger polypropylene (PP) bags (8x18in) filled with 1.25kg pre-soaked substrate. The weight of a regular fruiting bag is 0.75kg. The station opted for the bigger fruiting bags given that their production cycle is longer.

Various plant biomass abundant in the locality were tested as solo substrate and in combination with other materials. The 7:3 combination of rice straw and sawdust was adopted based on higher yield, thus higher biological efficiency, owing to more pinheads yet still comparable stalk length and cap diameter. The rice straw requirement for OMP was partly supplied by the rice areas of the station, which can only grow rice during WS in its 5-ha paddies. The rice straw was also used in the vermicomposting component. For OMP, only clean rice straw was used. However, rice straw could not be stored for long as it would harbor various organisms that may contaminate the fruiting bags. Additional rice straw was sourced out from farms in Batac where DS rice is grown.

The free sawdust obtained from a furniture shop in Batac was expectedly a mixture of various types of wood. Hence, in the soaking phase, 200g of brown sugar and 100g of agricultural lime were mixed to every 27kg of sawdust. Such lime regulates pH and the sugar helps decompose sawdust.

The moist sawdust and rice straw were mixed thoroughly and packed in the PP bags. When a fruiting bag was filled with roughly 1.25kg of the compacted substrates, its open end was inserted into a 1-inch-long Polyvenyl chloride (PVC) pipe, turned outward, and secured with a rubber band below the PVC pipe.

Before the pasteurization facility was built, two 200-L-capacity steel drums were used to sterilize 128 fruiting bags. The high contamination of the bags at the start of project implementation necessitated the fine-tuning of the pasteurization process being used. After a number of trials, the new process not only reduced contamination but also shortened pasteurization from 6 to 4 hours by increasing the temperature inside the drum (80-85°C to 90-95°C). With zero contamination in the bags, the same procedure for the new pasteurization chamber was adopted. However, more fruiting bags were contaminated when the chamber was filled to its 160-bag capacity. Further trials established that the optimum capacity of the chamber was 120 fruiting bags.

The fruiting bags were inoculated with grain spawn within 24 hours after pasteurization while the substrate was still moist since dry substrate stunts mycelial growth. The inoculated bags were then kept on open shelves inside the mushroom laboratory until they were fully colonized with mushroom mycelia within a month.
The colonized bags were transferred to the fruiting room to be stacked on suspended rope cradles. About 3-cm-thick carbonized rice hull (CRH) was spread on the floor directly below the cradles to regulate the room temperature and humidity. After arranging the fruiting bags with their tied ends positioned on one side, the tied ends were cut off including the PVC neck. The opened bags and CRH were sprinkled once daily with water to keep them moist; twice during the hot months.

The mushroom laboratory facility produced pure and sub-cultures of oyster mushroom mycelia. Pure culture was produced in flat bottles through tissue culture using potato sucrose agar as culture media. Sub-culture was also produced in flat bottles using the pure culture as inoculant. The flat bottles were kept in a refrigerator inside the laboratory and were tested periodically for viability. For the production of grain spawn, cooked rough rice was used as substrate. One flat bottle of sub-culture could inoculate roughly 10 square-bottomed bottles of grains for spawn production. The grain substrate in one bottle is equivalent to 0.35kg of dried *palay*. One bottle of grain spawn could inoculate 100-120 fruiting bags.

It costs ₱13.25 to produce one oyster mushroom fruiting bag if the 128-bag-capacity steel drums are used for pasteurization (Table 8). To maintain the same number of fruiting bags for OMP, an additional labor cost of ₱5.59 per bag was required.

On average, one fruiting bag produced 291g fresh oyster mushrooms throughout the 4-month production period. Some bags continued to produce fruiting bodies longer but the remaining harvest was a mere 1-8% of the total production. The fresh oyster mushroom produced was turned over to the station BDU for sale at ₱150 per kg. Unsold fresh oyster mushrooms were air-dried, packed in sealed plastic bags, and sold at ₱1,000 per kg. Five kilograms of fresh oyster mushroom convert to one kilogram of dried mushroom.

Harvested fresh oyster mushroom.

Air-drying of fresh oyster mushroom was adopted at the station as a result of a series of experiments on different drying methods. Oven-drying was found expensive while sun-drying discolored mushroom; hence, air-drying was adopted. It takes 3-5 days to air-dry fresh oyster mushrooms on fair weather. It is, however, not favorable to air-dry during the rainy season.

The oyster mushroom setup became a popular destination of visitors and field day participants. As a result, requests for hands-on training poured in from various sectors including high schools, state colleges and universities, local government units, and socio-civic organizations such as 4Ps recipients. A cookfest was also initiated in partnership with the City Government of Batac highlighting oyster mushroom as ingredient of snacks and meal recipes. Consequently, some schools (e.g. San Nicolas and Batac National High Schools) became centers of research on mushroom production and some trainees engaged in OMP. A trainee became a resource person in the Alternative Learning System (ALS) of the Department of Education (DepEd).

Mushroom production training for 4Ps beneficiaries.

Although the station intended to produce fruiting bags for its sole use, some of the bags were given away to trainees as part of their starter kits. Some bags were sold at ₱40 per piece to training graduates. Certain trainees chose to buy grain spawn that were supposed to be for project use only. Consequently, the station mass-produced grain spawn, and sold at ₱60 and ₱100 each respectively for round and square-bottomed bottles.

Table 8. Fruiting bags and fresh mushroom production, PhilRice Batac, 2014-2016.

Item	Value (₱)	
	Fruiting bags	Fresh Mushroom
Materials	708.57	1,696.57
Labor	988.00	715.00
Total Variable Costs	1,696.57	2,411.57
Cost per bag	13.25	18.84

**see Appendix Tables 1 and 2 (page 128-129) for more details.*

III. Vermicomposting

In 2014, an existing 3-bed vermicomposting facility of the station was initially used before the 12-bin facility was constructed in mid-2015. From 2014 to 2017, the vermicomposting technology for rice straw and buffalo manure as substrates was fine-tuned (Table 9). For every 70kg of rice straw and 30kg buffalo manure combination, 71kg of vermicompost was harvested.

Vermicomposting facility.

Table 9. Vermicomposting technology, PhilRice Batac, 2014-2017.

Technology Component	Practice
Substrate ratio	• 70:30 rice straw and buffalo manure
Pre-decomposition	• Shred rice straw • Stack 15kg of buffalo manure and top it with 35kg of rice straw • Drench the rice straw with water mixed with 10% Effective Microorganism Activated Solution (EMAS) • Repeat procedure to add one layer more of each of the substrates • Cover the stacked substrates with tarpaulin or plastic sheet to create an anaerobic environment for the substrates to be pre-decomposed • Make other batches of stacked substrates following the same procedure
Stocking the pre-decomposed substrates in the vermi-bin	• After 2 weeks, put one batch of the pre-decomposed substrates in the vermi-bin • Deploy 2kg of African night crawlers (ANC) in each bin
Maintenance	• Keep the substrates moist by watering them regularly
Harvesting	• Harvest the vermicompost after 4-6 weeks • Sift the vermicompost with a wire screen to remove clumps, debris, and undecomposed materials • Bag the vermicompost in sacks and stack them in a shaded and dry place

Corn-husk substrate for vermicomposting.

With the limited rice straw supply at the station, the potential of the corn stover as an alternative plant substrate was explored. Corn husk, however, has lignocellulosic biomass, which makes it more difficult to decompose than rice straw. Using a 60:40 corn husk and buffalo manure combination, it took 110 days to produce vermicompost from the mixture under the same procedure as when using rice straw. For every 100kg of the substrate combination, 69 kg of vermicompost was harvested. Although the corn stover showed potential as substrate in vermicomposting, it still needs further adjustments to hasten decomposition. It costs ₱143.42 to produce a 50-kg bag of vermicompost using rice straw and buffalo manure as substrates, which can be sold at ₱300 per bag (Table 10).

Table 10. Returns over variable costs (₱) of producing 50kg of vermicompost, PhilRice Batac, 2014-2017.

Item	Value (₱)
Materials	85.42
Labor	58.00
Total Variable Costs	143.42
Gross Income	300.00
Gross Margin	156.58

**see Appendix Table 2 (page 129) for details.*

Vermicompost from rice-straw and buffalo-manure substrates.

Integration of Components

Learning from almost 4 years of project execution, PhilRice Batac designed a 1-ha PalayPlus model that integrates all viable components: 1 hectare commercial rice production during WS; and 0.8 hectare white corn, and 0.2 hectare watermelon production during DS. The area for watermelon in the model was patterned after the average farm size managed by farmers in Batac. Rice straw is used as substrates in OMP and vermicomposting. Some of it covers the crawling area of watermelon.

Commercial rice is preferred in the model over seed production as it has a sure market and requires less management. Watermelon is more profitable than white corn but is labor-intensive and requires almost four times labor man-days than corn. And on a larger scale, the quality of management can be jeopardized, which may result in a decline in productivity. Likewise, it requires a relatively high capital investment, which may not be afforded by a resource-poor farmer. Similarly, OMP is set at a scale that can be easily managed by the farmers' households and at the same time assures sufficient volume of produce to be marketed every harvest schedule. Vermicomposting can absorb the bulk of the rice straw as there is a ready market for the output and can likewise be used for the crop components of the model. The spent mushroom substrate can also be used as a supplementary substrate in vermicomposting.

The productivity of oyster mushroom is affected by ambient temperature and humidity in the fruiting room. Hence, the station established in 2017 a series of setups with 120 fruiting bags per batch to observe the fruiting performance of oyster mushroom. Performance monitoring commenced in early March, and eight batches completed their production cycles by the end of November. It was found that oyster mushroom was generally most productive during the first month, except in May, due to high temperature. The two batches established in May became most productive in June. Further, the productivity of the fruiting bags declined with the use of 4-month-old rice straw (Fig. 4).

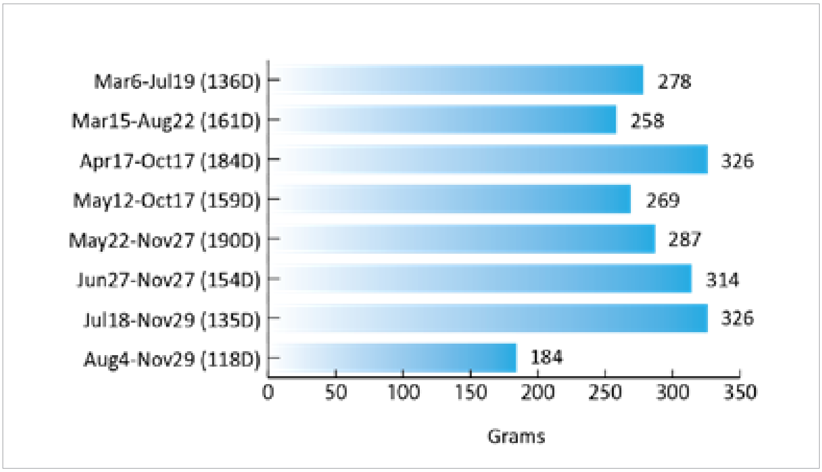

Figure 4. Comparative productivity of one oyster mushroom fruiting bag as affected by time, PhilRice Batac, 2017.

The 1-ha integrated model farm with five component enterprises can provide ₱158,861 yearly gross margin (₱13,238 monthly) to a farmer who adopts the technologies developed at PhilRice Batac (Table 11). Income can grow further if the corn stover is used as substrate for vermicomposting.

Table 11. Returns over variable costs (₱) from 1-ha PalayPlus model, PhilRice Batac, 2017.

Item	WS Rice	DS White Corn	DS Watermelon	Oyster Mushroom	Vermicom-posting	Total
Production level	1.0 ha	0.8 ha	0.2 ha	1000 bags	3000 kg	
Variable Cost	44,743	27,582	22,857	18,840	6,110	120,132
Gross Income	115,919	40,633	66,011	43,650	12,780	278,994
yield (kg)	6,101	1,121	4,331	291	2,130	
yield (ears)		3,628				
Gross Margin	71,176	13,051	43,154	24,810	6,670	158,861

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PALAYPLUS EXPERIENCES IN BICOL

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Highlights

- PhilRice Bicol implemented the PalayPlus project from 2014 to 2017 with seven rice and rice-based components: rice and rice seed production, vermicomposting, oyster mushroom, duck egg, azolla, tilapia, and vegetable production.
- Rice-rice production grossed the highest margin but mushroom production can also be a good rice-based enterprise.
- Lack of facilities and equipment for mushroom production led to the conception of new techniques and innovations to operationalize the enterprise.
- Innovations that worked in oyster mushroom production include the (1) use of rubber band to close the fruiting bag which is easier, cheaper, and more effective in reducing contamination and moisture loss; (2) prolonging the pasteurization time for 4-5 hours using plastic cover to seal and prevent steam from escaping; (3) pasteurization using the steam-sharing technique conserves excess steam from the main pasteurizing drum.

Site profile

PhilRice Bicol was established beginning in 2010 to develop and disseminate strategies and technologies that will make farming more resilient to climate change. The station is located in Purok 6, Brgy. Batang, Ligao City, Albay which is at the center of the 3rd Congressional District of the Province, approximately 500km south of Manila.

Ligao City has a total land area of 24,640 hectares, 23% of which are fertile flatlands suitable for high-value crops; 76.95% are mountainous and hilly with potential for agriculture and traversed by secondary rivers. Rice is the second most widely cultivated crop in the province spread over 55,494 hectares. Rice-

rice is the prevailing cropping system in the area. In 2015, Albay posted the lowest poverty incidence of 25.1% in the whole Bicol Region (PSA, 2016).

Prevailing climate is Type 4: rainfall is more or less evenly distributed throughout the year. Soil type is sandy loam to sandy clay loam. The area is irrigated but water is still a problem since the soil drains easily. Market is very accessible and the station is situated along the national highway.

The total physical area on-station is 8.9 hectares with 3.60 hectares devoted for seed production; 2.08 hectares for experiments, and 3.22 hectares for building and other facilities. The station has two buildings: the Administration and Business Development Division office cum warehouse and R&D office cum dormitory with training room.

Among its agricultural facilities are: seed processing shed, seed drying facility with flatbed dryer, solar dryer, seed warehouse, old warehouse temporarily used as storage for waste materials and fertilizers, vermicomposting bins, mushroom house, and edible garden. Farm machines include four-wheel tractor, combine harvester, turtle tiller, microtiller, seed cleaner, thresher, micromill, mini blower, shredder, grass cutter, and water pump.

PalayPlus Components Implemented

From 2014 to 2017, the station pursued rice and mushroom production, vermicomposting, and production of duck eggs, azolla, high-value vegetables, and tilapia. Rice and mushroom production were fine-tuned and successfully carried out following the integration, intensification, and diversification strategies.

Figure 1 presents the integration of rice and other components in the PalayPlus model of PhilRice Bicol. Rice production was the main component integrated with a semi-poultry duck egg production to boost the income from the rice-rice cropping system, and to utilize ducks in controlling pests. About 20% of the rice harvest was used as feed for the ducks during the lean season (reproductive to grain-filling phases). Rice straw generated from the system provided substrate for oyster mushroom production. Spent mushroom substrates were then subjected to value-adding using the vermicomposting technology. To sum it up, the vermicast and vermicompost produced were used as fertilizer in rice and vegetable production.

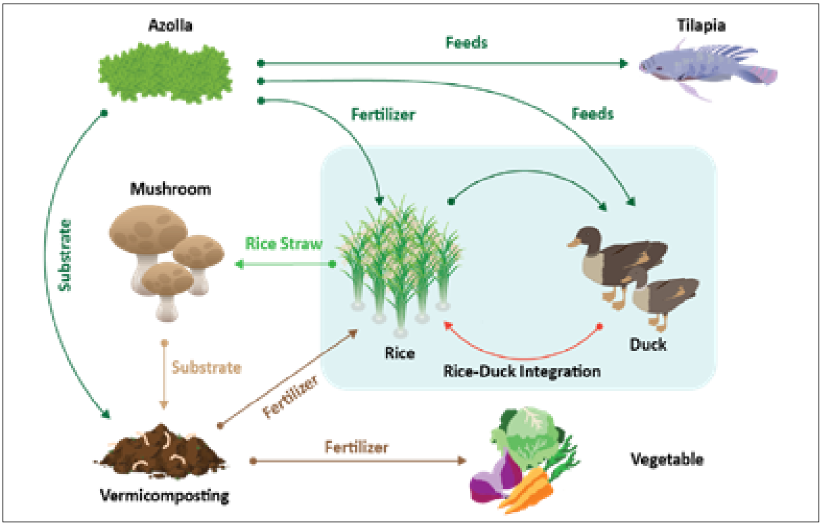

Figure 1. Palayamanan Plus model, PhilRice Bicol.

Azolla production was accommodated as one component because of its natural abundance in the ricefields. Azolla was used as substrate for vermicomposting and feed for ducks and tilapia. To showcase this component, azolla ponds were established to create more awareness on how it contributes to nutrient supply in the soil, especially N, and the overall benefits of its integration into the rice-based production system. The high-value vegetable component was established separately to utilize the upland areas on-station to augment the income although integration with the rice production system was not captured. Tilapia production was also established in ponds to utilize deep, waterlogged rice paddies.

Azolla production.


Mallard duck production.


Vegetable production.

I. Crops

Rice seed production

The 1ha rice production component was implemented during WS 2014 and DS 2015, which is a part of the rice seed production area of the station. As station area is limited, all rice production operations were entrusted to the Business Development Division (BDD) seed production unit from WS 2015 to WS 2016. In DS/WS 2017, the rice production component was returned to the PalayPlus project. Upland areas were replotted and prepared as lowland rice production areas.

In WS 2014, NSIC Rc 204H (Mestiso 20) was planted; for 2015 DS, Rc 222 was planted as the station had to augment its supply of registered seeds. In DS 2017, 0.60 hectare was devoted for certified seed production of Rc 358; in WS 2017, 0.70 hectare produced registered seeds of 5 varieties (PSB Rc 82, NSIC Rc 160, Rc 222, Rc 300, and Rc 308). The different varieties educated visitors, especially farmers, seed growers, and other stakeholders, about varieties that may thrive best in their respective areas.

Rice seed production.

Crop management practices were founded on the PalayCheck System, but fertilizer was based on growth phases (early, mid, and maximum tillering) of the rice crop with basal complete fertilizer and 3-split nitrogen (N) applications. It was found that more installments of N (4-5 times at 7-10 days interval) were more efficient than only 3 splits. An extra bag of 0-0-60 per hectare improved grain filling thus increasing yield. The use of a wooden planting guide with teeth spaced 20cm apart ensured the exact 20cm x 20cm recommended planting distance. The WS 2014 crop was manually harvested; in DS 2015, a rice reaper did it; in DS/ WS 2017, a rice combine harvester hastened operations.

Production. An adjusted yield (14% moisture content) of 3.95t/ha (Mestiso 20) was attained in WS 2014; 4.45 t/ha (Rc 222) in DS 2015; 6.32t/ha (Rc 358) in DS 2017. In WS 2017, the yields obtained are presented in Table 1.

Table 1. Yields of lowland rice varieties, PhilRice Bicol, 2017 WS.

Variety (FS)	Area planted (m^2)	Actual yield (t)	Adjusted yield (t/ha) at 14% MC
PSB Rc 82	2,350	1.03	4.13
NSIC Rc 160	1,760	0.93	4.96
NSIC Rc 222	825	0.36	4.14
NSIC Rc 300	1,070	0.57	5.00
NSIC Rc 308	1,000	0.41	3.89
Total	7,005	3.30	4.42

Commercial milled rice was sold mainly to staff members, while certified and registered seeds were respectively sold to farmers and seed growers.

The rice seed production component incurred a high variable cost of ₱57,953 during the DS 2017 due mainly to labor cost, with fertilizer inputs adding up to total expenses. Yet, the high yield of 6.32t/ha compensated for the big cost of production and provided a gross margin of ₱147,447 (Table 2).

Table 2. Returns over variable costs (₱) in seed production, PhilRice Bicol, 2017.

Item	Value (₱)	
	DS	WS
Materials	23,629	16,493
Labor	34,324	33,944
Total Variable Costs	57,953	50,437
Gross Income	205,400	187,850
Gross Margin	147,447	137,413

**see Appendix Table 1 (page 130) for details.*

Average WS 2017 yield (4.47 t/ha) from five varieties planted was lower than in DS. The total variable cost of ₱50,437 was mainly attributed to labor and fertilizer costs. Even with lower average yield, gross margin was still high at ₱137,413 (Table 2).

II. Mushroom

The inclusion of mushroom production as PalayPlus component was prompted by the persistent problem of rice straw-burning amid the ongoing implementation of a local ordinance against it. Farmers do not know much about mushroom production that uses rice straw as substrate. They do not even scatter rice straw on the rice field.

A small 4m x 3m mushroom production facility with a shed made of light materials and a housing capacity of 2,000 fruiting bags (for 6x12 PP bags) or 1,000 bags (for 10x14 PP bags) was constructed. A soaking tank with no flowing water was also built for overnight soaking of rice straw. For lack of laboratory and equipment, mushroom spawns were procured from DA-RFO 5 and some local producers.

Simplified techniques for mushroom production were developed and tested for growing *Pleurotus sp*. (white and gray oyster strains), *Volvariella volvaceae* (paddy-straw mushroom), *Calocybe indica* (milky mushroom), and *Ganoderma lucidum* (Ganoderma mushroom). Through these innovations and techniques, labor and material costs were greatly reduced, and processes and equipment were localized to suit the conditions in the station.

Oyster mushroom.

Paddy-straw mushroom.

Milky mushroom.

Ganoderma mushroom.

Grain spawn production

Second-generation mushroom grain spawns were propagated in the station for oyster, milky, and ganoderma species to minimize cost. A bottle of first-generation or mother spawn (100g) can make at least 30 bottles (100g each) of second-generation spawn. Mother spawn is produced using inoculum from a pure culture while second-generation uses inoculum from the mother spawn. A bottle of spawn can be planted in 20-30 fruiting bags (1.5kg capacity). In 2017, tissue to grain mushroom-spawn propagation was done to hasten the spawn production process. However, contamination rate was high at 20-30% since the station did not have an autoclave and had to rely on the pasteurization tank for fruiting bags. Spawns produced were each sold only at ₱50 to visiting farmers and individuals interested in producing mushroom.

Oyster mushroom production (OMP)

On a 3-day interval with 200 fruiting bags (using the 10 x 14 PP bags), 3-4kg fresh oyster mushroom can be produced during the first month; only 1-2kg in the second month. More was produced during colder months (October to February), as fruiting bags with one-month viability tend to dry up faster during the hot months. To remedy this problem, the mouth of the fruiting bags was not opened entirely to slow down the drying of the substrate. Produce was sold to PhilRice staff members at ₱140 per kg. In 2015, 3-5kg mushroom was sold daily to a mushroom processor. After 2 weeks, the station ran out of supply.

After the introduction of mushroom production, many farmers, students, and other stakeholders benefitted from free mushroom training programs conducted by the station. A client established his mushroom production and processing business by partnering with PhilRice.


Fruiting bag inoculation during mushroom training.

The cost and projected income of OMP are presented in Table 3. Material (₱2,852.93) and labor (₱1,386.50) costs were incurred in producing 150 fruiting bags (3-month cycle). Producing a fruiting bag costs ₱9.31 (excluding labor). A yield of 78.75kg and net income of ₱8,172.08 can be achieved from 150 fruiting bags at a selling price of ₱140 per kg of fresh mushroom.

Table 3. Projected returns over variable costs (₱) for oyster mushroom production, PhilRice Bicol.

Item	Amount (₱)
Material	2,852.93
Labor	1,386.50
Total variable costs	4,239.43
Cost per fruiting bag	19.02
Cost per fruiting bag (labor not included)	9.31
Yield (kg)*	78.75
Gross Income**	11,025.00
Gross Margin	8,172.08

**Assuming 30% of weight of substrate (1.75kg)*
***Price per kg @ P140.00*

• *see Appendix Table 2 (page 132) for details*

PALAYPLUS EXPERIENCES IN ISABELA

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Highlights

- PhilRice Isabela implemented five components: Rice-mungbean, vegetable, and mushroom production, vermicomposting, and livestock production.
- Rice-mungbean production after rice is the most feasible because of its wide acceptability and adaptability in the area.
- Mushroom production is a potential rice-based enterprise because of its wide adaptability and acceptability, and availability of substrates in the area. While oyster mushroom has already gained popularity, sustainability of supply seems a pressing issue.
- Vermicomposting is a necessary component of PalayPlus because it utilizes all biomass from the system and converts them into useful products that can be re-used.
- The vegetable component needs intensive labor but it sustains the daily food and cash source of the farming family.
- Unless the system focuses on piglet production, the animal component is likely to drain the operational budget of the project.

Site profile

San Mateo in southwestern Isabela is composed of 33 barangays with a total area of 12,059.83 hectares—of which 10,813.42 hectares or 90% is devoted for agriculture, with a rice area of 8,353 hectares. It is one of the prime irrigated rice areas in Cagayan Valley, thanks to the Magat River Irrigation System that also supplies electricity to some parts of the Cordilleras.

PhilRice Isabela in Malasin, San Mateo has a total area of 24 hectares covering office buildings, warehouses and screenhouses, and experimental and seed production areas serviced by the Magat Dam. The station devoted two ha for PalayPlus.

Serving as a research, information, and training hub on rice for Region 2 and the Cordillera Administrative Region (CAR), the station is under Type III climate. The area has no pronounced maximum rain period, with 1- 3 months of dry season (DS) that supports the rice-rice-mungbean cropping system. Annual rainfall is around 1700 mm and usually starts in July through December, with temperature ranging from 29°C to 35°C (highest at 38.2°C). Soil type is 50% Sta. Rita clay loam, which is suited for lowland crops such as rice, tobacco, and mungbean. Other soil types are Bago (26.04%), San Manuel (9.87%), Peñaranda (2.31%), Agustin (7.95%), and river wash gravel (3.95%) series.

San Mateo is a first-class municipality generally financed by agriculture - rice, corn, and mungbean. Vegetables are also grown side by side with rice in some villages. Backyard animals such as water buffalo, cattle, goat, and hog are also raised. Other sources of income are salaries and remittances of family members abroad, which are usually allocated for farm and household expenses. It has a total population of 64,905 (PSA 2015).

PalayPlus Components Implemented

I. Crops

Rice-mungbean cropping system

To optimize income from rice, 1 hectare was devoted for producing foundation and registered seeds and special rice varieties. The rice-rice-mungbean cropping pattern is June-October for the WS and November-March for the DS. March to May is for mungbean alone. The fine-tuned package of technologies (POT) used in rice seed production is shown in Table 1. The straw from the rice component was used in the oyster mushroom and vermicomposting components.

Rice-mungbean production system.

Table 1. Rice seed production technology, PhilRice Isabela.

Technology Component	Practice
Land preparation	• 1x plowing; 2x harrowing; 1x leveling
Varieties	• NSIC Rc 222, Rc 218, Rc 19
Crop establishment	• 40kg/ha seeding rate; soak seeds for 24hr and incubate for another 24hr • Transplant 20-day-old seedlings in straight row at 1-2 plants per hill in 20cm x 20cm distance
Water management	• Maintain 2-3cm standing water up to 2 weeks before harvest
Nutrient management	• 139-35-35kg NPK per ha; apply all P and K and a portion of N as basal; topdress remaining 33% N during mid-tillering; and 67% N during maximum tillering
Pest management	• Monitor field regularly • Manage weeds with post-emergence broad-spectrum herbicides before crop establishment, and spot-weeding after establishment • Apply chemical pesticide only when critical level is reached • Practice ecological engineering
Roguing	• Rogue periodically from tillering to grain filling
Harvesting	• Harvest at 80-85% mature grains
Postharvest and processing	• Dry produce immediately after harvest; pack certified seeds in laminated sacks

Mungbean was broadcasted at 20kg seeds/ha, after which the field was rotavated using mini tractor for better germination. Foliar fertilizer was sprayed at 25-30 days after planting (DAP) and after 1st and 2nd primings. When the critical pest level is reached, chemical pesticide is applied. To control bean fly (wilting and presence of pin-holes in leaves at seedling stage are common symptoms), appropriate insecticides were sprayed. Selective post-emergence herbicide was sprayed during instances of high weed population. Leaf folders and pod borers were managed by spraying contact insecticide at vegetative (10-15 DAP), flowering (20-30 DAP), and after every pod-priming. Powdery mildew and *Cercospora* leaf spot diseases were managed with appropriate fungicides starting from flowering stage. Mosaic-infected plants were rogued/uprooted and burned to avoid disease spread.

Harvesting mungbean is at 45-65 DAP when pods turn brown or black, and the leaves yellow. Handpicking the pods either early morning or late afternoon was the preferred method as it minimized shattering. Priming was done up to five times depending on the maturity of the pods. The recommendation is to attain three primings and harvest over a 1-week interval. Table 2 shows the technology package for mungbean production.

Table 2. Mungbean production technology, PhilRice Isabela.

Technology Component	Practice
Land preparation	• Zero tillage
Varieties	• Australian; Pag-asa 7; Pag-asa 19
Crop establishment	• 20kg/ha seeding rate; • Broadcast method was employed
Water management	• Use of residual moisture
Nutrient management	• Sprayed with foliar fertilizer at 25-30 DAP
Pest management	• Apply chemical pesticide only when critical level is reached
Harvesting	• Harvesting at 45-65 DAP when pods turn brown or black
Postharvest & processing	• Dry produce immediately after harvest

Table 3. Returns over variable costs (₱) of mungbean, vegetable, and seedling production, PhilRice Isabela.

Item	Mungbean	Vegetable	Seedling
Materials	4,080	600	675
Labor	16,520	1,470	947
Total Variable Costs	20,600	2,070	1,622
Gross Income	90,000	9,000	3,600
Gross Margin	69,400	6,930	1,977.5

see Appendix Tables 1-3 (pages 134-135) for details

Vegetable production.

Vegetable production

Vegetables, which are essential to the Ilocano diet, grow on any type of soil even in small parcels of land, pots, or containers. Major vegetables are generally grown during the DS, which is ideal for most crops, but certain varieties can be grown during the off-season when market prices are high.

The PalayPlus model raised vegetables in paddies and dikes. Legumes such as string, winged, and kidney beans were planted along pond and paddy dikes to optimize the area without encroaching on rice. Vegetable sales ranged from ₱1,000 to ₱2,000 per growing season. Solanaceous vegetables such as eggplant, pepper, and tomato were also planted on dikes and along farm roads, as well as on a 250m^2 area devoted for vegetable production. During the DS fallow period, some rice areas were planted with mungbean that averaged 450kg /ha, earning an additional income of ₱28,000 annually.

The produced vermicompost was mixed with soil and carbonized rice hull at a 1:1:1 ratio to serve as growing medium for various vegetables. About 150ml of vermitea was mixed with a pail of water (8-10L) to drench vegetables. Rice straw was used as mulching material to reduce water loss. Vegetable rejects were used as substrates in the vermicomposting component. Vegetable sales helped sustain the other requirements of PalayPlus.

Table 3 shows additional household income can be gained from vegetables, not to mention the ready supply of food. The small area earned an extra ₱3,000-4,000 for the growing season or some ₱ 1,000 monthly. Vegetable sales can help make ends meet while waiting for the rice crop to be harvested.

Table 3 sketches an alternative source of income for farming households, which can be pursued by younger members and is not time-consuming. Vegetable seedling production earns in 3–4 weeks after sowing. With the increasing awareness on eating organic food, backyard vegetable producers are also growing in number. They would just buy a few seedlings rather than a whole pack of seeds that they cannot all use. Seedling trays may be costly but they can be re-used.

Table 4. Problems encountered and solutions undertaken in vegetable production, PhilRice Isabela.

Problems encountered	Solutions undertaken
Transplanting shock among vegetable seedlings	Seedlings were produced at the improvised nursery to reduce transplanting shock and allow more uniform plant growth.
High cost of commercial fertilizers	Vermicompost was used as soil ameliorant, and vermitea from the component was used as foliar spray.
Unavailability of mulching film	Rice straw was used as mulch.
Lower sales because several kinds of vegetables were produced	Produce just one kind of vegetable.

II. Livestock

The station raised fatteners and breeder sows, with the fattened pigs sustaining the sows. After 4 months, they were slaughtered and sold as pork. The breeder sow was bred 6-7 months. Piglets produced were grown in the system for continuous and sustained production.

Breeder production (Table 5) is more profitable than one or two fatteners. An average monthly income of ₱3,000 can be gained from one-sow-level breeder production. The manure was used for vermicomposting.

Table 5. Returns over variable costs (₱) for hog production, PhilRice Isabela.

Item	Fattener (1 head)	Breeder (14 litters/farrowing)
Materials	8,620	29,470
Labor	-	1,000
Total Variable Costs	8,620	30,470
Gross Income	8,925	39,270
Gross Margin	305	18,705

**see Appendix Table 4 (page 135) for details*

Breeder sow.

Table 6. Problems encountered and solutions undertaken in breeder production, PhilRice Isabela.

Problems encountered	Solutions undertaken
High cost of feeds	Crops such as *kangkong, kamote,* and others can be incorporated into their feed
Unpleasant odor	Spraying indigenous microorganisms (IMO) helped contain the unpleasant odor

III. Mushroom

The station's 6m x 6m mushroom house made of *sawali* and *kugon* has 500 fruiting bags per month, a laboratory for inoculation and incubation, and a soaking area for growing substrates.

With available rice straw and relatively good weather conditions, tropical mushrooms *Pleurotus* sp. and *Volvariella volvaceae* were produced. Pure culture, sub-culture, grain spawn, fruiting bags, and fresh oyster mushroom were produced. Potato dextrose agar was used in tissue culture production to avoid contamination and save time in preparing the pure culture. Sorghum was used as substrate in producing grain spawn because it is easier and faster for mycelia to colonize within two weeks. The mixture of substrate was 50% rice straw and 50% sawdust. Rice straw was soaked for 7hr, drained, piled, and covered with plastic sheets for 2 to 3 days for composting. The compost was shred and mixed with sawdust. Mixed substrates were packed in 6 x 12in PP bag, closed, and secured with a rubber band. Fruiting bags were pasteurized in a metal drum (180 pcs/drum) at 60-80˚C for 6hr.

Fruiting bags were inoculated with grain spawn within 24hr after pasteurization while the substrate was still moist, as dry substrate is not suitable for mycelial growth. The bags were next incubated in open shelves inside the mushroom laboratory until they were fully colonized with mycelia within 3 to 4 weeks.

Oyster mushroom production.

The colonized bags were then placed in the growing house and hung on ropes. After arranging the bags, their top ends were opened using a clean cutter. The bags were watered daily using a sprinkler to keep them moist. After 3-5 days of opening the bags, mushroom fruits were ready for harvest.

For *Volvariella*, good-quality spawn from a reputable source was acquired. Beds were dimensioned 2m x 45cm x 15cm. Rice straw and dried banana leaves were used as substrates, respectively soaked for 3-4 and 10-12hr. The substrates were arranged on the bed foundation and made up 3-4 layers during the DS and 5-7 layers during the WS. The 300g spawn were distributed to each layer of 2m x 45m x 15cm bed. The entire bed was then covered with plastic sheet to ensure temperature buildup and to retain the moisture required for the mycelia to grow and develop into fully matured fruiting bodies or mushrooms.

Paddy-straw mushroom production in banana leaves.

Table 7. Returns over variable costs for oyster mushroom production (1000 fruiting bags), PhilRice Isabela.

Item	Value (₱)
Fruiting Bag Production	
Materials	8,128
Labor	6,720
Cost of producing one fruiting bag	14.85
Oyster Mushroom Fruit Production	
Materials	14,848
Labor	3,360
Cost of oyster mushroom fruit production per bag	18.21

see Appendix Table 5 (page 136) for details.

Table 8. Problems encountered and solutions undertaken in mushroom production, PhilRice Isabela.

Problems encountered	Solutions undertaken
Too hot temperature lowers yield	
High rate of contamination of fruiting bags due to improper handling of the grain spawn acquired outside the station while in transit.	The station produced its own grain spawn to ensure purity and non- contamination.
High rate of contamination of pure culture.	Commercial potato dextrose agar (PDA) was used in tissue culture production to avoid contamination and to save time in preparing the pure culture.

Vermicompost production.

III. Vermicomposting

Semi-concrete vermihouse and bins were constructed for this component. The floor area was 6 x 24m where the vermi beds and processing area were housed. *Vermi beds* were made of hollow blocks. African night crawler (ANC) or *Lumbicus terrestis* earthworms were used as decomposing agents. Each compartment with 400-600kg substrate was inoculated with 2kg ANC, enough to act on the partially decomposed substrates for 2 weeks. Screens and other safeguards on the bed and in the shed were put in place to protect the ANCs from predators. Rice straw and other farm biomass were used as substrates with the following composition: 25% banana trunks, 25% rice straw, and 50% animal manure.

Table 9. Returns over variable costs for vermicomposting, PhilRice Isabela.

Item	Value (₱)
Materials	2,945.00
Labor	1,960.00
Total Variable Costs	4,905.00
Gross Income	9,000.00
Gross Margin	4,095.00

**see Appendix Table 6 (page 137) for details.*

Table 10. Problems encountered and solutions undertaken in the vermicomposting component, PhilRice Isabela.

Problem encountered	Solutions undertaken
Presence of natural enemies such as ants, insects, and chickens.	Beds were covered with plastic sheets; to protect the worms from predators

Integration of Components

The various components of the system are connected as follows: straw from the rice crop is used in the production of oyster mushroom as substrate. The spent mushroom substrate (SMS) are used as substrate in vermicomposting aside from other agricultural wastes from other components. The vermicompost produced are used as soil ameliorants in rice and vegetable production.

PALAYPLUS EXPERIENCES IN LOS BAÑOS

Ferdinand S. Aguilar, Caesar Joventino M. Tado, and Diego G. Ramos (+)

Highlights

- PhilRice Los Baños planted NSIC Rc 160 and two heirloom rice varieties — *Calatrava black rice* and red rice, considered as Special Quality Rice (SQR); all were grown for brown rice production for the higher price.
- Most of the materials used in PalayPlus were ordinary and locally available, thus the setup can be easily replicated.
- Partnerships with the Philippine Carabao Center (PCC) in Los Baños; Green Wrigglers, which retails and wholesales African night crawler earthworms, vermicompost, ornamentals, fruit-bearing trees, seeds, and related products; and a mushroom expert in the area were founded out of this project.
- The innovative use of a *vermitea* concoction as foliar fertilizer, biological control agent, and rapid decomposing agent on rice-straw substrates was initiated.

Site profile

Los Baños, the country's only Nature and Science City, is home to key offices of several national and international research-for-development institutions. A knowledge hub, it has easy access to Laguna de Bay, the country's largest lake, and to Mt. Makiling, and is well-connected to Metro Manila and nearby Calamba and Sta. Rosa cities. This means that the town has plenty of potential markets for agricultural products. It is also home to UP Los Baños (UPLB) that hosts a good mix of people from all over the country, many of whom are experts in agriculture. As of 2015, there are 112,008 people reside in its 14 barangays.

Los Baños has Type I climate (dry from November to April and wet during the rest of the year). Its soil type falls under the Lipa clay loam series with fine sandy, having nitrogen and potassium as limiting nutrients. Its wet season

(WS) is from June to October, and dry season (DS) is from December to April, with a cropping pattern of rice – rice. The town, which has both irrigated and rainfed ecosystems, sources its water from the gravity-type piping irrigation system in UPLB and Mabacan-Masaya-Puypuy Irrigation System. Major rice pests observed are green leaf hoppers, rice black bugs, golden apple snails, and birds.

PhilRice Los Baños based at UPLB is the Institute's principal office doubling as a branch station. It sits on a 29-hectare land area borrowed from UPLB. It implements rice and rice-based projects in Cavite, Laguna, Batangas, Rizal & Quezon (CALABARZON) and Mindoro, Marinduque, Romblon & Palawan (MIMAROPA) regions in close collaboration with its research-giant neighbors - the International Rice Research Institute (IRRI) and UPLB. It also works well with the Regional Field Offices of the DA (DA-RFOs) and the Agricultural Training Institute (ATI) as well as the provincial and municipal local governments (P/MLGUs) in the two regions. The station focuses its work on the development and packaging of location-specific technologies for rainfed and upland areas. It has activities on plant breeding, crop protection, agronomy and soils, rice chemistry and food science, and technology promotion and development. It is also in-charge of the hybrid nucleus and breeder seed production initiatives of PhilRice, even as it does work on inbred seed production and several research studies. It is instrumental in the diversification of the germplasm base of the rice breeding program by using wild rice species.

The station's strong partnership with the Los Baños Science Community and its surrounding LGUs has resulted in a number of location–specific technologies and innovations, the most popular being the Minus–One Element Technique, a diagnostic tool to determine soil nutrient deficiency. The station allocated 1.03 hectares for PalayPlus: 1 ha for rice production, 200m^2 for vermicomposting, and 100m^2 for mushroom production.

PalayPlus Components Implemented

Special-quality rice production.

I. Crops

Rice production

Being the main component of its PalayPlus system, it planted high-value rice varieties that gave higher income to farmers. NSIC Rc 160, black rice and red rice, were grown for brown rice production. Rc 160 was planted in 5000 m^2; 2500m^2 each for black and red rices. For black and red rices, the general production protocol was followed except that no synthetic fertilizer was applied. During harrowing and final leveling, 30 bags of vermicompost was incorporated into the soil. Vermitea was also sprayed weekly as foliar fertilizer and as a biocontrol agent from seedling up to the hard dough stages.

The 21-day-old seedlings were transplanted on a very well-leveled field plot at a distance of 21cm x 21cm with one seedling per hill. Inorganic complete fertilizer (14-14-14 NPK + S) was incorporated in the Rc 160 plots as basal 7 days after transplanting (DAT) followed by urea (46-0-0) during maximum tillering to booting stages, and urea and muriate of potash (0-0-60) during the flowering stage. Rc 160 plots were irrigated weekly until maturity stage at a depth of 3-5cm. Flush irrigation, a water-saving technology that does not flood rice fields, was applied on the black and red varieties to simulate the upland ecosystem where they are usually grown.

Manual harvesting was done at 80-85% matured grains based on the PalayCheck System, to minimize postharvest losses and attain the ideal moisture of the grains; mechanical threshing was employed. Red rice had the longest straw, which is favorable for biomass conversion as substrate in vermicomposting and mushroom production.

Brown rice has more nutrients, minerals, and fiber than white. Engaging in its production was a strategic decision considering that the station sits in a community where most people can afford to buy the product more expensive than white rice. Specialty-quality rices are priced ₱45 to 65 per kg.

Profitability of the rice component is shown in the table below. Some 1,462kg Rc 160, 670kg black rice, and 595kg red rice were harvested; Rc 160 was sold at ₱45 per kg and the pigmented rices at ₱65 per kg. A gross income of ₱460, 480 is possible from this component with a total gross margin of ₱226,920 per ha. It clearly shows that high-value products mean higher productivity.

Table 1. Returns over variable costs of special-quality rice, PhilRice Los Baños.

ITEM	Value (₱)		
	Rc 160	**Calatrava Black Rice**	**Red Rice**
Materials	23,430	13,520	13,520
Labor	47,378	67,856	67,856
Total variable costs	70,808	81,376	81,376
Gross Income	131,580	174,200	154,700
Gross margin	**60,772**	**92,824**	**73,324**

**see Appendix Table 1 (page 138) for details.*

II. Mushroom

While it is beneficial to return rice straw in the field, farmers opt to burn it. Straw from the rice component was used as substrate in producing mushrooms, mixed with sawdust at 70:30 ratio. The system's mushroom component proved to be a strategic choice given the middle-class and health-conscious community in Los Baños.

Oyster mushroom production.

Volvariella volvacea (paddy-straw mushroom), *Pleurotus florida* (oyster), and *Calocybe indica* (milky) were the species planted. Paddy-straw mushroom was the easiest to cultivate but was highly perishable; milky was promising and had longer shelf-life than oyster. More people have yet to familiarize themselves with milky mushroom, thus the oyster species proved to be the most feasible as it is highly adaptable to the growing conditions in the station.

A low-cost mushroom facility was constructed, and the space beside the station's service building was utilized. The mushroom-growing house was made of 3-level hollow block wall sidings with a dimension of 5mx5m; on top was a welded wire matting (2.5cm x 2.5cm). Roofing was corrugated galvanized iron sheet, with wooden braces. The growing house has a capacity of 2000 fruiting bags that could be hung downwards. A cemented soaking tank (1.5m x 5m x 2.5m) was also constructed beside the growing house.

Given that the station has no laboratory for tissue culture, the grain spawn bags were bought from private growers.

Collected rice straw was piled in a shaded area beside the warehouse, forming a *mandala* (mound pile). After 7 to 14 days, the straw was ready for use as substrate either by chopping or mechanical shredding. It was soaked in the tank for 1 hour, hauled, and placed in the draining area until its moisture was ready for substrate-mixing. This is determined by grabbing a handful of rice straw and squeezing it hard until no water is seen dripping.

Composted sawdust was mixed with the rice straw and placed in a special 6x12in PP bag, with a cut PVC above it that served as the opening. A cotton plug was then put on the PVC neck, covered with used paper, and tied with a rubber band. Two metal drums of 200-L capacity placed above the cemented oven were used to pasteurize 200 fruiting bags per batch. A jute sack was placed inside the wall of the drums to minimize damage on the bags during pasteurization for 6 hours and absorb the remaining heat, from 8:00am to 5:00pm maximum time or until the temperature cooled down.

The pasteurized fruiting bags were left to cool down overnight, then inoculated with grain spawn of oyster mushroom using an isolation chamber in the cleaned room. The protocol on the proper disinfection of the chamber, the tools and the grain spawn materials to be used was followed to lessen the chance of possible contamination of the fruiting bags. The bags were sealed with paper and tied again with rubber bands, and placed in a cool and dry area for 30 days or more until the substrates were fully coated with mushroom mycelia. After the incubation period, the bags were transferred to the growing house and hung together until the first flushing of fruiting bodies or mushrooms. Harvesting was done early in the morning to maintain the freshness of the mushroom. Watering of the bags followed to avoid wilting. A single fruiting bag containing almost 1 kg of substrates yielded 150-175g in 1-month production cycle. Harvested mushroom was delivered to the Business Development Division (BDD) for selling at ₱250 per kg to staff members and walk-in visitors.

As rice-straw substrates were limited, production of oyster mushroom was intensified only during the rice harvest period. As shown in Table 2, this strategy would help attain the gross margin of ₱9,789 for the two component products. Using locally available materials, oyster mushroom production can be a lucrative business provided there is sufficient supply of rice-straw substrates. Alternatively, other plant biomass can also be used as substrates such as banana stalks, pure sawdust, as well as corn stubbles and corn cobs.

Table 2. Returns over variable costs of fruiting bag and fresh oyster mushroom production, PhilRice Los Baños.

Item	Value (₱)	
	fruiting bag	fresh oyster mushroom
Materials	6,220	7,850
Labor	10,309	20,127
Total Variable Costs	16,529	27,977
Gross Income	20,895	33,400
Gross Margin	**4,366**	**5,423**

see Appendix Table 2 (page 139) for details.

III. Vermicomposting

Using rice straw as substrates, wastes from mushroom spent were recycled together with carabao manure. Collapsible vermi beds (3m x 1m x 20cm) were constructed for the purpose.

Vermicompost production.

Rice straw was collected, mechanically shred, piled, and covered for 7-14 days to initiate natural composting. On the 7th day, the pile was turned to ensure equal composting. After 14 days, the substrates were ready for use as initial stocking material for vermicomposting. Each vermi bin was provided with 40kg of decomposed rice straw as substrate material. The following day, 1 to 2kg of African night crawler earthworms were placed in each bed and fed every 2 weeks with 40kg fresh buffalo manure hauled from PCC. The beds were watered with 5L of vermitea daily. The substrates were turned after 14 days. After 30 days, another 40kg of composted rice straw per bed was added; turned after 14 days. On day 60, the vermi worms and vermicompost were manually harvested. The ANCs were trapped by feeding them on one side of the bed with fresh manure. Vermicompost was manually winnowed and bagged in 50-kg-capacity sacks, and stored in a cool dry place. The process was repeated for the succeeding production. A single bed can yield 100kg of vermicompost and 100% of vermi worms upon initial stocking. Vermicompost as soil ameliorant has direct benefits on the soil when properly incorporated.

Vermicompost products were turned over to BDD for selling at P7 per kg; ANC at P150-250 per kg. Most clients were visiting rice farmers and stakeholders who know the products. The station also applied vermi tea, a by-product of vermicomposting through the brewing process, as a biocontrol agent and as an organic foliar fertilizer sprayed on the rice plants from seedling to maturity. Vermi tea was also sprayed at the vermicomposting bins to hasten the decomposition of the substrates.

With the 35 bins used in organic fertilizer production, the project yielded 1,127kg of vermicompost and 66kg of ANC in one year. At ₱7 per kg organic fertilizer and ₱350 per kg vermi worms, this component grossed ₱66,250 (Table 3). Based on profitability analysis, if use of locally available materials and labor costs were factored in, gross margin would be ₱22,903 in one year.

Table 3. Returns over variable costs of vermicomposting, PhilRice Los Baños.

Item	Value (₱)
Materials	23,220
Labor	20,127
Total Variable Costs	43,347
Gross Income	66,250
Gross Margin	**22,903**

**see Appendix Table 3 (page 139) for details*

Integration of Components

PhilRice Los Baños' PalayPlus case clearly showed the interrelationships among production components. Rice biomass was used chiefly as substrates in mushroom and vermicomposting production. Mushroom spent substrate was also fed to vermi worms that was transformed later into high-quality organic fertilizer; incorporated into the soil during land preparation, ending up as added organic matter needed by rice and vegetables.

PALAYPLUS EXPERIENCES IN PHILRICE CENTRAL EXPERIMENT STATION (CES)

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Highlights

- PalayPlus was implemented from 2015 to 2017, with the following components:
    - Crop component was composed of 3.5-ha foundation and registered rice seed production and the 1.0-ha rice-cash crop production;
    - Livestock component had 5 heads dairy buffalo, ducks and chickens;
    - Mushroom component had grain spawn, fruiting bags, and fresh oyster mushroom production;
    - Vermicomposting
- PalayPlus generated an average total annual gross margin of ₱2,240,000 from the 3.5-ha seed production with ₱1,360,306.35; from the 1.0-ha cash crop and vegetables production ₱109,432.97; from livestock with ₱123,000; and from mushroom with ₱650,000 per year.
- It served as a training venue for farmers, entrepreneurs, students, extension workers, researchers, non-government development workers, local government units, and other stakeholders on rice and rice-based farming systems.
- Convergence demonstration for knowledge-sharing with partner government agencies such as the Philippine Carabao Center (PCC), Bureau of Fisheries and Aquatic Resources (BFAR), private seed companies, and EM Research Philippines, Inc. (EMRPI).
- Sites in the development, promotion, and dissemination of PalayPlus models focused on diversification, intensification, and integration for increasing income and food and nutrition security.

Site profile

PhilRice CES leads and coordinates national efforts in rice research for development (R4D). The total land area is 120 hectares, where 78 hectares are for rice R4D; 31 hectares for rice seed production; and 11 hectares for infrastructure.

The Science City of Muñoz that hosts CES in Maligaya is composed of 37 barangays spread over 16,305 hectares. The agricultural land covers 9,819 hectares where 8, 415 hectares are irrigated and 327 hectares rainfed. In 2016, average rice yields were 5.39t/ha (irrigated) and 3.96t/ha (rainfed) (LGU Munoz, 2017). Sources of irrigation for rice production in the City are the Upper Pampanga River Irrigation Service System of the National Irrigation Administration (NIA-UPRISS) and the Casecnan River Irrigation System. Supplemental irrigation is coming from nearby rivers and creeks, and shallow tube wells (STW).

The Science City of Munoz is home to academic and major government institutions such as the Central Luzon State University (CLSU), Philippine Carabao Center (PCC), Philippine Center for Postharvest Development and Mechanization (PHilMech), Philippine-Sino Center for Agricultural Technology (PhilSCAT), National Irrigation Administration (NIA), Department of Science and Technology (DOST), National Power Corporation (NPC), Department of Environment and Natural Resources (DENR), and PhilRice.

The climate is under Type I with pronounced dry season (DS) from November to April and wet season (WS) from May to October. Based on agrometeorological data gathered at the PhilRice CES Weather Station, the City accumulates an average rainfall of 1,850mm annually. The soil types, classified under the Awayan series, consist of Maligaya clay loam/clay, and Quinqua silt loam (BSWM, 2017). It is one of the major rice-producing areas in the province with rice-rice as the dominant cropping pattern. Onion, corn, sweet potato, watermelon, and vegetables are likewise grown in the City.

Muñoz is a 4^{th} class city with a population of 75,462 based on the 2015 census. The common sources of livelihood, aside from salaries and wages, are farming, trading of palay, onion, and rice; marketing of rice seeds, farm machinery, and agricultural supplies; lending; and livestock and poultry-raising. The poverty incidence among families in Nueva Ecija is 24.6% while the per capita poverty threshold is ₱11,644 (PSA, 2015).

PalayPlus Components Implemented

The four components are: crops, livestock, mushroom, and vermicompost production.

Rice seed production.

I. Crops

Rice seed production

Showcasing the profitability of producing rice seeds, it is a value-adding strategy for farmers to increase their income in rice production. Growing seeds is advantageous because the prices are higher than paddy rice.

Target yields for seed production are 5t/ha (DS) and 4t/ha (WS) clean seeds. The component produced FS and RS in 3.5 hectares. Good land preparation is extremely important in seed production to reduce mixtures from dropped seeds. The area must be prepared at least 1 month before transplanting; plowed once then harrowed two times at a weekly interval. The field must be levelled 1 day before transplanting.

Seedbeds must also be prepared well. The required seedbed area for 1 hectare is around 400m^2. Raised seedbeds 1m wide were constructed at least 1 day before seed-sowing with canalets in between. Organic fertilizer, compost or carbonized rice hull (CRH) can be mixed into the seedbed to enhance seedling growth and facilitate pulling of seedlings.

Rice seeds for multiplication must be procured from registered and reliable seed growers or institutions. The seed requirement for seed production is 20kg/ha. Seeds must be washed three times or more to remove unfilled grains and other foreign matters before soaking. Soak the seeds in water for 24hr. The water must be replaced every 12hr to avoid the accumulation of carbon dioxide that may affect seed germination. After soaking, wash the seeds again three times then let the water drain before incubation. Place the soaked seeds in a tied plastic sack to incubate for about 24hr, or until a cottony white growth becomes visible at one end of the seed. Cover the seeds lightly during incubation to warm them up to enhance germination. Thick cover can heat up the seeds thus killing them. After pre-germination, open the sack to let the seeds cool down before sowing.

Level the seedbed thoroughly, then sow the pre-germinated seeds evenly at a rate of 50g seeds/m^2. After sowing, cover the seeds lightly with CRH or compost. Maintain water on the canalets around the seedbeds to ensure that they are always saturated. Gradually increase the water level to 2-3cm starting 5 days after sowing (DAS). Apply 5 kg urea for the 400m^2 seedbed area. Seedlings are ready for transplanting 18-21 DAS.

Normally seedlings are pulled 1 day before transplanting but it would be better to pull them at the same date of planting to reduce stress and seedling shock. The planting distance for seed production is 20 x 20cm at 1 to 2 seedlings/hill. Remaining seedlings must be planted around the bunds for replanting the missing hills later. Water level at planting time should be at least 2cm to hasten seedling recovery and reduce snail damage. Molluscicide must be applied immediately after transplanting to control snail damage. Pre-emergence herbicide must be applied 1-3 days after transplanting (DAT). Replant missing hills not later than 7 DAT to ensure uniformity of crop maturity. Follow-up early post-emergence herbicide must be applied 15 DAT if necessary. Hand-weed the remaining weeds in the later crop growth stages.

Water level must be increased gradually starting from 5 DAT up to crop maturity or 2 weeks before harvest. Letting the field dry up and crack a little at maximum tillering (30-35DAT) is a good practice to make the plants sturdy, enhance more tillers, and improve root development. Fertilizer rate is 120-40-40 kg NPK/ha for DS and 90-40-40 kg NPK/ha for WS. It is applied in 3 splits, at early vegetative stage (7-10 DAT), tillering stage (20-25 DAT), and before panicle initiation at 40-45 DAT. Insect pests and diseases are regularly monitored and control measures are employed as necessary. Common insect pests are stemborer and brown plant hopper. Bacterial leaf blight and rice blast diseases are common during the WS. Rats and birds may also be problems.

Roguing is the key to successful seed production as it ensures high seed quality. Off-types were rogued at least four times from tillering up to the ripening stages. Off-types are plants that differ from the majority in height, base color, leaf structure, panicles that head early or late. The combine harvester was used at 85% maturity or about 20-25% moisture content (MC) during WS and 18 to 21% during DS. The harvested rice seeds were dried using a mechanical dryer and processed not later than 3 weeks after drying. Samples were collected and submitted to NSQCS for analysis.

In 2015WS - 2017WS, the 4.5-ha WS seed production area averaged 3.5t/ha cleans seeds; the 3.5-ha DS area averaged 4.8t/ha clean seeds. The actual yields fell short of the targets due to typhoons, rice stemborer, rat, and brown planthopper damages. Yet, the component earned an average annual income of ₱1,360,306.35. Its returns over variable costs are presented in Table 1.

Table 1. Returns over variable costs in rice seed production, PhilRice CES, 2015-2017.

Item	Value /ha (₱)	
	WS (4.5ha)	DS (3.5ha)
Materials	18,718.50	16,811
Labor	43,821	40,999
Total Variable Costs	62,539.50	57,810
Gross Income	223,126.50	246,019.50
Gross Margin	**160,587**	**188,209.50**

Vegetables along rice paddy bunds

One important feature of PalayPlus is diversification of the production system. Planting vegetables while growing rice provides the farmer and his family a source of additional food and income for their daily needs. The vegetables also serve as habitat for beneficial organisms that help contain pests.

Paddy bunds were 75-cm-wide and 30-cm-high to allow the planting of vegetables such as okra, cowpea, and bush and string beans immediately after transplanting rice. Harvest started 45 DAP. Taro (*gabi)* was also planted at 40cm distance in between hills to replace the line of rice plants used in replanting the missing hills. Trellis was also constructed above the water canals for the vine vegetables. Gabi was planted inside the canals. The growth and productivity of vegetables were sometimes affected by the application of herbicides at the mid or later rice stages. The sample analysis for a season of vegetable production on paddy bunds is shown in Table 2. Some 250 gabi plants per 100 linear meters (LM) grew along the paddy bunds. At P5 per plant, after 4 months, it generated an income of ₱1,250/100LM.

Vegetable production along paddy bunds and canals.

Table 2. Vegetable production on paddy bunds, PhilRice CES, 2016.

Crops	Area (Linear meter)	Yield (kg)	Income (₱)
String beans	100	90.69	2,267.25
Cowpea	300	54.15	1,624.50
Okra	400	40.27	1,006.75
Total	**800**		**4,898.50**

Cash crops and vegetables production

Various cash crops and vegetables were grown on a hectare during the DS. Their economic analysis is presented in Table 3. The area was plowed 3 to 4 weeks after the rice harvest or when dry tillage using tractor-rotovator or disc plow is applicable. It was again rotovated after 1 week to pulverize the soil and prepare it for planting. For corn production, furrows 75cm in between hills were constructed where corn seeds were drilled at 20cm between hills, needing 8-12kg/ha. The newly planted seeds were furrow-irrigated using water pump when the moisture was inadequate. Corn was irrigated four times during the growing period.

Fertilizers per hectare were 4 bags 14-14-14 applied at 7-10 days after emergence (DAE), followed by 2 bags urea at 30-35 DAE. Weeds were controlled by hilling-up at 15-20 DAP and spot weeding at the latter crop stages. Common pests of corn were defoliators and corn borers, which were controlled with insecticide whenever needed. The crop was harvested green 65-70 DAP. Two corn production cycles can be completed during the DS: November to January, then February to April. Yield averaged 5.0t/ha; lower in April due to windy conditions and sometimes limited water supply. Biomass generated ranged from 5.0 to 6.0t/ha per cropping; green corn was sold at ₱20 per kg.

The production of young or baby corn was also explored, which technology was similar with green corn but no fertilizer was applied. Harvesting was done earlier than scheduled - 40 to 45 DAP. Young cobs that bore the young or baby corn were harvested; yield was about 2.0t/ha sold at ₱100/kg. Biomass produced ranged from 10.0 to 15.0t/ha, which is essential to the PalayPlus farm because it is used as feeds for the dairy component.

Sweet potato was grown from November to March. After dry land preparation, furrows at 60cm were constructed where planting stocks were planted 30cm apart. Four bags of complete fertilizer (14–14–14) were drilled inside the furrows before planting. Urea at 2 bags/ha was drilled along the furrows at 30 DAP before hilling-up. Sweet potato was harvested after 4 months and sold at ₱30/kg.

Tomato production.

Broadcasting mungbean on rice paddies after harvest is done in certain areas of the Philippines. This was tried at PalayPlus but it failed because of the clayey soil type, which dries up and hardens fast. But mungbean was grown on well-prepared soil, with seeds drilled in furrows 60cm apart at a rate of

35kg/ha. About 1 bag 14-14-14 fertilizer was applied before hilling-up at 30 DAP. While mungbean is drought-resistant, it needs to be irrigated when growth is stunted. It is sprayed with Carbaryll insecticide during flowering to protect its young pods from insect pests. It was harvested 60 DAP, with ripe pods handpicked, sundried, then threshed manually. Three primings maximized harvest; yield was 1.5 to 2.0t/ha sold at ₱80/kg.


Cash crop and vegetable production.

Garlic was also planted in a 1,500m^2 area. After harvest, the rice stubbles were cut at ground level, applied with 4 bags 14-14-14/ha before the area was mulched with rice straw, then irrigated. After a day, the area was planted with garlic cloves 20 x 20cm apart. After 10-15 days, the area was sprayed with Onecide herbicide to kill the germinated drop seeds, with the survivors handweeded. The area was applied with 2 bags urea/ha after 30 days, then irrigated again. The same rate of urea was applied at 60 DAP. Garlic is normally irrigated every 2 weeks or when soil moisture reaches field capacity. Last irrigation is usually done 2 days before harvest to facilitate uprooting of the bulbs. The harvested bulbs were sundried with the bulbs covered to prevent damage. The economic analysis of garlic production is shown in Table 3.

Tomato and pepper were planted in furrows at a distance of 75 to 80cm; planting was 40 to 50cm apart. Fertilizer rate per hectare was 6 bags 14-14-14 applied basal and 2 bags urea applied 30 DAP, and 1 bag 0-0-60 at flowering stage. The returns over variable costs of tomato and pepper production are shown in Table 3.

Table 3. Returns over variable costs of cash crop and vegetable production, PhilRice CES, 2015-2016 DS.

Crops	Area (m^2)	Yield (kg)	Gross Income (₱)	Variable Cost (₱)	Gross Margin (₱)
Corn	2,500	1,200	24,000	10,605.76	13,394.24
Sweet Potato	1,500	1,097	32,910	8,836.93	24,073.07
Mungbean	2,500	375	30,000	4,479.16	25,520.84
Garlic	1,500	385	57,092	33,964	23,128
Tomato	1,000	1,800	36,000	21,084.28	14,915.72
Pepper	1,000	1,091	27,275	18,873.90	8,401.10
Total	**10,000**		**207,277**	**97,844.03**	**109,432.97**

Forage crops, shrubs, and trees

Forage crops such as napier (*Pennisetum purpureum*) and Mulato grasses (*Brachiaria sp.)* were planted along the PalayPlus area perimeter. Mahogany, mangium, paper tree, madre cacao, mango, jackfruit, calamansi, guava, and banana were planted along the pathways, pond embankment, and perimeter. They served as windbreaks, food sources, and animal feeds.

II. Livestock

The livestock component consisted of dairy buffalo, rice + duck production system, duck egg production, and chicken production.

Dairy Buffalo production

Five Italian-breed dairy buffaloes were provided by the Philippine Carabao Center (PCC) in June 2016 as part of the livestock component. They gave birth to five female calves in December 2016, but two of them died due to infection and abnormalities. They produced just enough milk for their calves because of limited supply of feeds. The normal feed requirement of one buffalo is around 50kg/head/day consisting of 50% rice straw and 50% forage, and other feed supplements to sustain normal milk production. However, the project could only provide around 30kg/head/day that affected the general health and milk production capabilities of the buffaloes. The limited amount of feeds stemmed from less rice straw collected as a result of the use of the combine harvester that returned only about 20% of the total rice produced, as against more than 30% from manual harvesting and mechanical threshing. The forages planted were young and the area was also very limited. To have more feeds, the following strategies were employed: a) more intensive rice straw collection and storage; b) planting of more forage in the farm; c) planting of more green and young corn during the DS to be processed into silage; and d) cut-and-carry collection of grasses. No milk was produced but the estimated value of the calves in 2017 was ₱90,000.

Dairy buffalo production.

Rice + Duck Production System

A traditional practice in China and now also adopted in Japan, Korea, and other Asian countries, the system produces rice, and duck meat and eggs in the same area. Rice develops a symbiotic relationship with the ducks, which eat the snails, weeds, and insects available in the paddies. By doing so, the ducks pamper the rice crop by controlling the pests and aerating and puddling the soil. The system utilizes the 500 to 1000 heads per hectare stocking density. It works under both conventional rice farming (but no pesticide application) and organic-based farming approaches using either inbred, hybrid, or special-quality rice (SQR) varieties.

The component was established in a 1,000m^2 area stocked with 100 heads Mallard ducks, enclosed with 0.50-m-high plastic net to confine the flock. A 4 x 4m^2 portion of the ricefield was elevated and isolated with 1m-high plastic net for the duck cage and feeding area. The 2 x 2m duck cage was made of welded wire matting with metal sheet roof to secure the ducks at night.

Rice crop establishment followed the standard procedure of preparing land at least 3 weeks and manually transplanting 21-day-old seedlings 20 x 20cm between hills. Rice + Duck can also be established in mechanically transplanted rice with 30 x 15cm planting distance. Organic or conventional nutrient management can be adopted but pesticides and rat baits are strictly prohibited. The recommended water level is 2 to 3cm during the vegetative growth, and 5 to 7cm during the reproductive stage. The ducklings were released in the rice field 10 DAT and withdrawn at heading stage (60-70DAT). The field was drained 2 weeks before harvest (85% of grains matured).

Rice + duck production.

Day-old Mallard ducklings are usually bought from hatcheries, and are brooded for 15 days before they are released in the field to ensure faster adaptability and higher survival chances.

It is important to train the ducklings to acclimatize them in their new environment. They were allowed to roam the field for 1 to 2hr in the morning and afternoon for the first 5 days of release. Their exposure time was gradually increased every week until they were 1-month-old. The ducklings were caged every night for a month to ensure their safety. After which, they were allowed to freely roam around the field. They were also provided with commercial feeds for 1 month, in the morning before they were set free; and in the afternoon before they were caged. In the succeeding month, chopped *kangkong* or Azolla and rice bran were mixed with the commercial feeds. The system facilitated their retrieval from the field later. Clean water was provided daily especially during feeding time.

The weight of the ducks at withdrawal from field was around 800g per head, with 8 to 10% mortality rate. Pullets were sold at around ₱150 per head; drakes at ₱75 per head. The pullets were reared for another 4 months for egg production at a female-male ratio of 10:1. The layer ducks were fed with layer pellets at 100g/head/day supplemented with rice grains and snails. The egg-laying period lasts for about 7 months, during which rice straw is provided for nesting.

The returns over variable costs of a 1,000m^2 Rice + Duck production area where the ducks were sold as pullets after withdrawing them from the field are presented in Table 4. Monoculture of rice produces a gross margin of around ₱60,000/ha/season, and ducks can add about 40% more to the income; even bigger with egg production. Value-adding like processing them into salted eggs can earn more income.

Table 4. Returns over variable costs of the rice + duck system, PhilRice CES, 2015.

Item	Value (₱)			
	2015 DS	**2015 WS**	**Annual**	**Mean**
Rice Production				
Materials	1,439.50	1,068.80	2,508.30	1,254.20
Labor	3,753.60	3,106	6,859.60	3,429.80
Total Variable Costs	5,303.50	4,391	9,69.450	4,847.30
Gross Income	13,800	7,852	21,652	10,826
Gross Margin	8,496.50	3,461	11,957.50	5,978.70
Duck Production				
Materials	9,847.40	9,951.90	19,799.30	9,899.60
Labor	1,300	1,300	2,600	1,300
Total Variable Costs	11,147.40	11,251.90	22,399.30	11,196
Gross Income	13,800	13,500	27,300	13,650
Gross Margin	2,652.60	2,248.10	4,901	2,454
Total Gross Margin			**16,858.50**	**8,432.70**

Poultry Production

The modified grazing technology is the innovation showcased in this sub-component. *Kabir* and *Sunshine* chicken strains were selected because they grow fast, have good meat and egg production qualities. The grazing area of 100m^2 was enclosed with plastic net 1.5m high. A mound of rice straw (mandala) about 6m high and 5m diameter was established inside the grazing area as one source of food for the 100 chickens. In search of grains, the chickens scratched the rice straw, which in the process gradually spread over the grazing area. The scattered and decomposing rice straw is a rich niche of decomposers that the chickens also ate. The young chickens were fed with commercial feeds during the first month of production, then supplemented with chopped kangkong or azolla mixed with rice bran given twice a day. The chickens averaged 2.0kg per head after 4 months and were sold at ₱150 per kg, grossing ₱30,000 (Table 5). Given that the chickens were grazed and supplemented with homemade feeds, the production cost was very low resulting in a gross margin of ₱17,260.

Modified-grazing poultry production.

Table 5. Returns over variable costs of chicken production, PhilRice CES, 2015.

Item	Value (₱)
Material	10,000
Labor	2,740.60
Total Variable Costs	12,740
Gross Income	30,000
Production total (kg)	200
Gross Margin	17,260

III. Mushroom

Mushroom production is a value-adding component that guarantees the full utilization of rice straw. The facilities included a mushroom-growing house with a capacity of 7,200 fruiting bags; an incubation room and a small laboratory for isolation, culture, and inoculation; twio concrete soaking tanks (6.2 x 5.4m); a gender-friendly box-type pasteurizer attached to a continuous rice hull carbonizer assembly with 570 fruiting bags capacity per operation; a working shed, shredding machine, and a freezer.

The oyster mushroom (*Pleurotus)* is grown commercially at PalayPlus CES because it grows vigorously under the local conditions. Being grown for experimental purposes are *Calocybe, Volvariella,* and *Ganoderma* mushrooms.

Milky mushroom production in polypropylene bags.

Rice-paddy mushroom grown in rice straw.

Ganoderma mushroom.

Rice straw was collected from the field immediately after harvest, then piled in a mound or *mandal*a for storage to ensure the availability of substrates for mushroom culture. Three mounds of rice straw per season, about 6m high and 5m diameter were usually reserved for mushroom production.

Pure mushroom culture was produced through the tissue culture technique using the potato sucrose agar (PSA) media. The pure culture was used in the production of grain spawn.

Grain Spawn Production

Grain spawn is the mushroom planting material. It is produced using 500g of partially cooked rice grains placed in polypropylene bags sealed with rubber band for sterilization in an autoclave for 30min at 121°C and 15psi. The sterilized grains are inoculated with pure culture of oyster mushroom and incubated for 2 weeks, or until the substrate is fully ramified.

The production cost for each 500-gram bag of grain spawn was ₱40.09 (Table 6). Most of the spawns were used at the station; the rest were sold to mushroom growers in Nueva Ecija, Tarlac, and Pangasinan at ₱150 per bag.

Table 6. Returns over variable costs of producing grain spawns and fruiting bags, PhilRice CES, 2017.

Item	Value (₱)	
	Grain Spawn	Fruiting Bag
Materials	614.27	1546.98
Labor	187.50	1375.00
Total Variable Costs	801.77	2921.98
Cost per bag	40.09	5.84

**see Appendix Tables 1 and 2 (pages 140-141) for details.*

Fruiting bag production

The production of fruiting bags adhered to the standard procedure with minor modifications (see Appendix A, pages 142-145). In soaking the rice-straw substrates, 4hr are enough for old stocks; 12hr for new or fresh rice straw that takes more time to absorb water and soften. The soaked straw was drained and composted for 4 days before shredding. The standard mixture of 7 parts rice straw and 3 parts sawdust (7:3) with a moisture content of around 60% was followed. The fruiting bag weighed around 0.75kg using the 6 x 12in PP bags. The bags were sealed with rubber bands before being pasteurized for 8hr, cooled, then removed from the pasteurizer the following day. The pasteurized bags were inoculated with grain spawn inside the inoculation room, placed in the incubation room for 1 month to fully ramify (bag filled with mushroom mycelia growth). The ramified bags were transferred to the mushroom-growing house for fruiting or sold to customers. The production cost of one fruiting bag was ₱5.84 (Table 6) sold at ₱20 to ₱25 per bag.

Incubation room for oyster mushroom.

Growing house for oyster mushroom.

Oyster Mushroom Production

Oyster mushroom is the easiest to grow under Philippine conditions because it is adapted to tropical climate, using different substrates including rice straw.

The cost and return analysis of OMP is shown in Table 7, with annual gross income of ₱653,930. Fresh mushroom was sold to PhilRice employees or at the Muñoz Public Market at ₱160 per kg. Data show that an additional monthly income of ₱36,000 is possible from mushroom production.

Table 7. Returns over variable costs of producing oyster mushroom, PhilRice CES, 2016.

Item	Value (₱)
Total Variable Costs	261,229.02
Gross Income	653,930.00
Gross Margin	392,700.98

**see Appendix Table 3 (page 142) for details.*

IV. Vermicomposting

The other components of PalayPlus produced considerable amounts of organic materials such as plant residues, spent mushroom substrates, and animal manure, all good materials for vermicomposting that supports the crop production component.

One substrate for vermicomposting is the mixture of spent mushroom substrate (70%) and carabao manure (30%). One composting bin (4m x 1m) was loaded with 500kg mixed substrate then inoculated with 1kg African night crawler earthworms (*Eudrilus eugeniae*). To hasten decomposition, EM-Activated Solution (EMAS) and EM Microbial-based Inoculant (EMBI) were also added to the substrate. The moisture content of the substrate during the 1-month composting process was maintained at 60%. Compost recovery was around 60%.

Vermicomposting facility.

CHAPTER 3

PalayPlus Experiences in the Visayas and Mindanao

This chapter discusses the implementation of PalayPlus in PhilRice stations in:

- Negros
- Agusan
- Midsayap

PALAYPLUS EXPERIENCES IN NEGROS

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Highlights

- The station banked on organic food production in support of the key priorities in agriculture of the provincial government of Negros Occidental.
- PhilRice Negros stepped up implementation by investing on infrastructure and other needed facilities. This way, it was able to show leadership in practicing farming technologies and strategies.
- PalayPlus components served as training and learning grounds for visitors and students who participated in the Rice Boot Camp and on-the-job training at the station.
- In a 2016 field day, operations of all PalayPlus components were showcased during the *Capacity Enhancement in Rice Production in Southeast Asia under Organic Farming System Final Meeting and Reporting*. Almost 200 farmers and visitors from ASEAN countries were present.

Site profile

PhilRice Negros is in Murcia, Negros Occidental, which is within the vicinity of the cities of Talisay, Silay, San Carlos, and Bacolod (16.5km from Bacolod, 25.3km from the Silay International Airport).

A first-class municipality composed of 15 barangays with a total land area of 28, 455 hectares, its total population is 81, 286 (PSA, 2015). The spoken and written languages in the town are Hiligaynon, Ilonggo, Pilipino, and English. With an almost-flat topography, its major crops are sugarcane, pineapple, banana, papaya, and rice. It is also famous for its flowers.

The Station is 6km away from the nearest barangay of Bacolod City. While the road leading to the station is paved, public utility vehicles are scarce.

Of the station's 90 hectares property, 60 hectares are for inbred rice seed production while 8 hectares are for research and technology demonstration. Soil type is clay loam with dark grayish to brown, to almost-black surface soil, and climate is Type III under the Corona classification. Its seasons are not well-pronounced: November to April is relatively dry; wet during the rest of the year. The station receives an average annual rainfall of 155mm; 27°C temperature, with 10hr of sunshine duration (PhiRice Negros AgroMet, 2014). While the National Irrigation Administration brings water, supply is scarce because the station sits at the tail-end of the irrigation system.

PhilRice Negros covers Region 6 (Panay Island and Negros Occidental) and Region 7 (Bohol, Cebu, and Negros Oriental).

PalayPlus Components Implemented

The station's PalayPlus is anchored on producing organic products in support of the province's aim to become the *"Organic Food Bowl of Asia"*. The demand for organically grown products is increasing because they are preferred by the health-conscious and financially stable individuals. This trend opens opportunities for farmers as these products command higher prices.

PhilRice Negros pursued crop production (organic rice seeds and vegetables), livestock (swine, goat, and mallard ducks production); aquaculture with tilapia production, mushroom culture, and vermicomposting.

Organic rice seed production.

I. Crops

Organic rice seed production

To address the demand for seeds by organic rice producers in the Visayas and to take advantage of their high prices, three traditional varieties were planted: Dinorado, a pigmented aromatic variety with good eating quality; Calatrava, a slightly glutinous black rice sometimes used in cooking native delicacies; and BR 261, a black rice, all Special-Quality Rices (SQR). Area for Dinorado was 4.5 hectares; 0.5 hectare each for Calatrava and BR 261.

During land preparation, rice straw was incorporated back into the field, with 15-ton mudpress and 200kg vermicompost per hectare applied during final harrowing. At 7 days after transplanting (DAT), vermi leachate was applied at 60L/ha. Irrigation water passed through a filter pond before it was used. The dug-out pond with a dimension of 50m x 5m x 1m was planted with water hyacinth as a bioremediation or filtering agent.

Ducks helped reduce insect pests, snails, and weeds. For 2-3hr daily from 15 to 30 DAT, 15-day-old mallard ducklings were herded to the ricefield. Adult ducks were allowed to graze in the field from 7:00am to 4:30pm until the maximum tillering phase, then after harvest. Handweeding and roguing were done at all crop stages to ensure seed purity. Harvested manually and threshed mechanically, clean seed yields per hectare were 3,673kg for Dinorado; 1,714kg for Calatrava; and 1,996kg for BR 261, sold at ₱40/kg. Tungro disease, high stemborer and rice bug infestations, and water shortages pulled yield levels down.

Table 1. Returns over variable costs of organic rice seed; and vegetable production, PhilRice Negros 2017.

Item	Value (₱)	
	Rice	Vegetables
Materials (vegetable seeds)	9,360	350
Labor (3hrs/day for vegetables only)	12,526.67	7,200
Total Variable Costs	21,886.67	7,550
Gross Income	100,000	8,955
Gross Margin	**78,113.33**	**1,405**

**see Appendix Table 1 (page 146) for details.*

Table 1 shows that despite generally low yields, organic rice seed production (2017 DS) is an economically feasible farming enterprise.

Sorjan vegetable production.

Sorjan vegetable production

Started in 2014, two raised beds measuring 270m^2 were planted with upland *kangkong* while the three deep sinks were stocked with tilapia. The *kangkong* was watered with a rainboat, which is a water pump installed on a small boat-like floater that draws and sprinkles water from the sorjan sink. *Kangkong* was harvested within 28 days after seeding; its regrowth was harvested every 4 days. Some 1,900kg of *kangkong* was produced in 7 months, earning ₱ 38,000 at ₱ 20/kg. Okra, tomato, and eggplant were also planted but productivity was low because of high clay content of the beds. Soil amendments such as carbonized rice hull (CRH), mudpress, vermicompost, composted animal manure, and fresh rice hull were incorporated on a regular basis.

Table 1 attests that while income generated was generally low, the vegetables provided some of the food requirements and incidental expenses of the family.

II. Livestock

Goat production

A goat house with an area of 20m^2 was constructed in 2015 for 10 goats for fattening. With the males castrated, the confined goats were fed through the cut-and-carry feeding system. They ate mostly paragrass (*Brachiaria mutica*), *Madre de Agua* (*Trichantera gigantea*), kakawate (*Gliricidia sepium*), and *ipil-*

ipil (*Leucaena glauca*) leaves sometimes. They were also provided with salt lick composed of 90% rock salt and 10% molasses. The goats were sold at ₱1,700 per head.

Goat production.

To improve the existing breed, a purebred female Anglo Nubian and a purebred Boer buck were borrowed from the Provincial Agriculture Training Center Office in 2016. The couple produced one female hybrid. Unfortunately, the purebreds were infected with parasites that killed them.

Another animal shed with manure and waste depository tank measuring 140 m^2 was constructed in 2016 to accommodate 40 hogs, 20 goats, and 500 mallard ducks. The effluent from the tank automatically overflowed into the rice field. The solid particles were removed weekly and were used to fertilize the banana plants along the animal shed.

In 2016, 21 more goats were purchased that grew into 32 in just two months as many were pregnant and most of them bore twins. By the second quarter of 2017, ten more goats were added to the herd but many died during the rainy season. Goat meat was ₱350/kg and live weight price was ₱90/kg.

In a 1-year cycle, the economic analysis of goat production with an initial stock of 21 heads, including the remaining stocks, shows that a gross income of ₱121,500 is possible (Table 2). Variable cost is ₱78,000, and gross margin is ₱43,500. The high demand for goat meat, abundance of feed resources, and good market price make goat production a lucrative enterprise in Negros.

Table 2. Returns over variable costs of goat production, PhilRice Negros, 2016- 2017.

Item	Value (₱)
Materials (*stocks, salt, molasses*)	40, 500
Labor *(4hr/day)*	37,500
Total Variable Costs	78,000
Gross Income	121,500
Gross Margin	**43,500**

Swine Fattening

Ten-month-old piglets were acquired from trusted backyard raisers within the locality. The concrete pigpen was 1m-high, had a double-span metal roofing, and a floor area of $80m^2$. The pigs were fed with commercial feeds three times a day, with fresh water supplied daily. With cut old car tires used as feeders and drinkers, the pen was cleaned every day or as necessary. After 120 days, the pigs were slaughtered, packed according to orders and reservations, and sold at ₱190/kg. The main clients were residents near the station, employees, and some walk-ins.

The next production cycle raised 10 heads adopting the Korean pig production model. The 1.5-meter-thick flooring was a mixture of banana pseudostems, 100 bags of rice hull, and 50 bags of CRH. A bathe pond was constructed inside the pen; old car tires cut into halves were used as feeders. The pigs were sold after 120 days with an average dressed weight of 67kg/head. The ***Pesada scheme*** was explored, wherein the buyer slaughters the pig and pays ₱160/kg only for the carcass excluding the head, feet, and entrails. While this scheme may be simpler, it sometimes entails additional cost of feeding and managing the remaining pigs because of the staggered disposal based on market demand. It also earned less profit.

Hog fattener.

Due to some constraints, only two swine production cycles were realized. The pigs were sold after 120 days with an average carcass weight of 67kg/head. Economic analyses based on the two marketing schemes show that the gross income of the operator's scheme is ₱12,730 with a variable cost of ₱8,581 and a gross margin of ₱4,149/head (Table 3). The Pesada scheme made ₱1,851/head only. Swine production generated 80 bags of organic fertilizer at 30kg/bag from one production cycle.

Table 3. Returns over variable costs of swine production based on two modes of marketing, PhilRice Negros.

Item	Marketing Scheme	
	Operator's (₱)*	**Pesada (₱)****
Materials	7,400	7,400
Labor	1,181	1,469
Total Variable Costs	8,581	8,869
Gross Income PhilRice: 67kg x ₱190/kg Pesada: 67kg x ₱160/kg	12,730	10,720
Gross Margin	**4,149**	**1,851**

**see Appendix Table 2 (page 146) for details.*

Duck-egg production

Started in 2015, it aimed at complementing organic rice seed production at the station as the ducks helped to control snails, weeds, and insect pests. They also helped in maintaining seed purity by consuming the unwanted rice seeds that fell in the field.

A 10-m^2 duck area near the goat house was enclosed with plastic net; its brooder was made of corrugated metal sheets. At ₱20 each, 500 mallard ducklings were purchased from a local supplier; brooded for 15 days before releasing them in the rice field. Brooding conditioned the ducklings and reduced mortality. The ducklings ate pure chick-booster feeds during their first 30 days; chick-starter feeds for another month, after which the ducks were fed only with rice grains and bran to supplement what they grazed in the ricefield. After the excess male ducks were sold, only 300 heads remained for egg production.

Mallard duck-egg production.

In 2016, 500 additional 7-day-old ducklings were purchased at the same price, and were fed like the first batch. The older ducks were fed with a mixture of rice bran and copra meal in the morning before releasing them, and in the afternoon before they were enclosed into their pen. Also, 100 heads of Peking ducks were acquired through barter: 1 duck for 10 station-grown banana suckers.

The ducks laid 12,644 eggs in 2015 and 2016, with at most 178 eggs in a day. Egg production was low in March-May due to limited water supply. By June 2017, only 250 Mallard and 30 Peking ducks remained. Some of the ducks were used during the station's special activities; others were shared to PhilRice Agusan and Midsayap for rearing. Many died during rainy days, some were lost to poachers and predation when they were herded in the rice fields.

Analysis of the duck production component shows that gross income is ₱87,616 from the sale of male ducks at ₱75/head; female ducks at ₱100 to ₱130/head; and eggs at ₱5 to 6/piece. Variable cost is ₱53,400, and gross margin is ₱34,216 (Table 4). The figures show that duck production is quite profitable and is also a good complement of organic rice seed production. This means that aside from providing economic benefits, it is also environment-friendly and sustainable.

Table 4. Returns over variable costs of PalayPlus components, PhilRice Negros, 2015-2017.

Item	Value (₱)		
	Duck	Tilapia	Vermicomposting
Materials	30,900	13,500	2,700
Labor	22,500	10,000	10,000
Total Variable Costs	53,400	23,500	12,700
Gross Income	87,616	33,100	24,000
Gross Margin	**34,216**	**19,600**	**11,300**

**see Appendix Tables 3 and 4 (page 147) for details.*

III. Aquaculture

Fish production

It started in 2015 with the acquisition of 1,500 male and 1,500 female tilapia breeder stocks from the Bureau of Fisheries and Aquatic Resources in the Science City of Muñoz, Nueva Ecija. The fingerlings were stocked in a 400-m^2 pond while awaiting the construction of two breeding tanks. Each tank was later stocked with 25 breeders at 4:1 female-male ratio.

Additional 10 breeding and 18 fry tanks were constructed to accommodate the expanding tilapia-breeding operation. Six of the breeding tanks measure 5m^2 and 4 tanks 25m^2. Each fry tank measures 2m^2, which were used for conditioning the fingerlings before selling or releasing them into the grow-out ponds.

Average production was 966 fingerlings per month from June 2016 to April 2017, sold at ₱1.50/piece. Located at the station's spillway, grow-out tilapia production was harvested over a 6-month period and sold at ₱120/kg. Some of the smaller fish were processed as *Tilanggit* (Tilapia sliced into halves, salted, and sun-dried) sold at ₱250/kg.

Tilapia breeding.

Tilapia production that combines breeding, grow-out, and processing can provide substantial additional income to rice farmers especially in an organic production system. It can support the water-filtering system required for organic rice production. Notwithstanding the lack of trained personnel on fish production and management, and limitations on water supply, a decent income from this enterprise was still attained (₱33,100 with a variable cost of ₱23,500). The gross margin is ₱19,600 (Table 4).

IV. Vermicomposting

In September 2016, the buffalo shed of the PalayPlus complex was temporarily used for vermicomposting. Eight 7-m^2 vermi beds made of hollow blocks were constructed. Substrate was a mixture of 50% rice straw, 10% banana pseudostem, 30% spent mushroom substrate, and 10% animal manure. The beds were lined with plastic sheet to trap the leachate from vermicomposting. The 50 African night crawler (ANC)-earthworm initial stock was provided by the Central Philippine Adventist Church (CPAC), a university nearby. It produced 10kg vermicompost after 3 months, and additional 10kg ANC was purchased.

Some 3,500kg vermicompost and 400L of leachate were collected after 8 months, most of which were used in the organic rice seed and vegetable production. Excess vermicompost was sold at ₱250/bag. ANC were used over native worms because when given the right environment, they grow and reproduce more quickly. They are also voracious eaters and release large castings; can tolerate high temperature.

Vermicomposting facility.

The vermicomposting component complemented the organic rice seed production. A gross sale of ₱24,000 (Table 4) can be generated over an 8-month period with a variable cost of ₱12,700, mainly from labor fees. A gross margin of more than ₱11,000 can be realized, not to mention that it is a practical and relatively cheap process of utilizing and value-adding farm biomass in an environment- friendly and sustainable manner.

Integration of Components

The station's PalayPlus model involved organic rice seed/duck/fish production, vermicomposting, and vegetable/goat/swine production.

Organic rice seed production was the banner component, which was complemented by duck-herding to help control snails, insect pests, and weeds. Duck manure was fertilizer, and they also helped in conditioning the soil during their grazing and feeding activities. Water from fish production was recycled for rice production. Manure from goat and swine production was used as substrate in vermicomposting,while the rest was directly used as organic fertilizer and soil amendment for vegetable production. Vermicompost fertilized rice and vegetables.

Rice straw was used as substrate in vermicomposting; unfilled and half-filled rice grains as feed supplement for the ducks and pigs; rice bran as feed for ducks, fish, and pigs. Rice hull was used as bedding for the pigs and goats, fuel for drying palay, and as soil amendment in vegetable production. CRH was used as bedding mixture for the livestock, and as soil amendment and potting mix for vegetables. Grasses growing within and around the rice farms also served as feed for the goats.

The diversification and integration of different farming enterprises increase farm income and profit; they also enhance food and nutrition security. The bigger income enhances the purchasing power of farm families to meet their daily needs (Table 5). The continuous and regular flow of income stabilizes the economic status of families. The diversification-integration strategy ensures that losses from poorly performing components are compensated by the high-performing ones. It also provides avenues for employment to other people in the community.

Table 5. Income of all components implemented.

Component	Gross Margin (₱)
I. Crops	
Organic Rice Seed Production	78,113.33
Sorjan Vegetable Production	1,405
II. Livestock Production	
Goat	43,500
Swine-fattening	
Operator's	4,149
Pesada	1,851
Duck Production	34,216
III. Aquaculture	
Fish Production	19,600
IV. Vermicomposting	11,300

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PALAYPLUS EXPERIENCES IN AGUSAN

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Highlights

- PhilRice Agusan implemented four PalayPlus components: rice + duck farming system, mushroom production, vermicomposting, and swine raising.
- Mushroom production was the most successful, grossing ₱28,476.68 in 2015; ₱115,583.20 in 2016; and ₱157,740.80 in 2017. The local government unit of Cabadbaran City and PhilRice collaborated on mushroom production in barangays Sanghan and La Union. The project drew interest from different stakeholders as evidenced by the requests for training that the station received.
- The integration and diversification of crop, livestock, and mushroom production proved to be a good combination in terms of reducing production costs, thus making the overall system efficient and profitable.

Site profile

The town of Remedios Trinidad Romualdez (RTR) in Agusan Del Norte, where PhilRice Agusan is located, has eight barangays spread across 8,700 hectares. RTR is a 5th-class municipality with a population of 16,058 based on the 2015 Census of the Philippine Statistics Authority (Community-Based Monitoring Survey, 2015). Close to 56% of its households are living below the poverty threshold—twice the national average of 24.45% (official website of RTR). Of the 56,248 households surveyed in 2015, 24,314 had income below the food threshold. Some 5.05% or 2,840 households experienced food shortage.

RTR is a rice-producing town with 1,742 hectares, the granary of the province, and is rich in forest, quarry, and mineral resources. Rice yield in the Caraga Region, which is 2.3-3.5t/ha, is lower than the national average as a result of low solar radiation and frequent rainfall, prevalence of white stemborer, bacterial leaf blight, and zinc deficiency. The average monthly rainfall is 171.29mm (6.744in) while average annual temperature is 28°C (82°F). Climate is Type II; no definite wet and dry seasons. The rainy season starts in November and peaks in January. For many, Agusan del Norte is wet and very wet all-year-round. The dominant soil type is San Miguel Clay Loam, which is suitable for growing crops.

PhilRice Agusan covers the northern regions of Mindanao: Region 10 (Bukidnon, Misamis Oriental/Occidental, and Lanao del Norte); Region 11 (Davao Oriental/del Norte and Compostela Valley); and Region 13 (Agusan del Norte/Sur, Surigao del Norte/ Sur, and Dinagat Islands). Its mandate is to develop location-specific research for development projects, and to produce quality rice seeds to cater to the needs of its area of coverage. The station was established on 8 August 1990 with an initial area of 12.8 hectares purchased from the late Gov. Consuelo V. Calo of Agusan del Norte. The station now devotes 36.6 hectares for rice—9.5 hectares are for research experiments, while 1 hectare is for PalayPlus. It also has 31.1 hectares for seed production in Sanghan, Cabadbaran City; in Ampayon, Butuan City; and within RTR town.

PalayPlus Components Implemented

Rice+duck farming system, mushroom production, vermiculture, and swine production were developed and practiced in the station. The intensified and diversified crop production, livestock integration, and mushroom production ensured the availability of farm biomass such as rice straw, crop residues, manure, and spent mushroom substrates (SMS). These forms of rice biomass reduce production costs, and improve soil quality.

I. Crops

Rice Seed Production

This component has enabled the station to continue responding to the needs for registered seeds among rice farmers in Caraga especially those near RTR. Market for the produce was never an issue. In fact, in the past, farmers had always been willing to buy the produce of the station sans the certification tags from National Seed Quality Control Services.

Dry season cropping is from January to April while wet season is from July to October. There were no aggressive promotional activities for the registered seeds as PhilRice is already known for producing high-quality seeds in the area. In selling the rice seeds, the DA-mandated price of ₱30/kg was used.

The PalayCheck System was followed from land preparation until harvesting as shown in Table 1. Before planting, the field was prepared within 30 days in 3 harrowing operations. The field was incorporated with organic fertilizer during the final harrowing. The field was well-levelled, with no high or low soil spots before planting for equal distribution of water and nutrients. Seedlings (20-25-day-old) were transplanted at a distance of 20cm x 20cm for wet season and 15cm x 20cm between rows and hills for dry season to manage weeds and pests, and also to avoid crop damage during herding of ducks.

Rice seed production.

In terms of nutrients, 50% organic and 50% inorganic fertilizers with complete source of NPK and other micronutrients were applied to optimize crop growth and lessen the use of expensive inorganic fertilizers. Water management plays a big role in the rice field; thus, saturated soil is ideal for active tillering. Water depth of 5-7cm was maintained during the reproductive phase for the photosynthetic activity of the plants. The field was drained 2 weeks before harvesting. The combine harvester was used as it requires fewer personnel complement and finishes the operations faster. Its use also results in reduced postharvest losses. Seeds produced were sold to farmer-clients and seed producers.

Table 1. Rice production technology, PhilRice Agusan, 2016.

Technology component	Practices
Land preparation	• Rotovation, 3 harrowing operations; organic fertilizer incorporated during final harrowing; well-levelled field
Seed class	• Registered seeds
Rice seedlings and planting distance	• 20-25-day-old seedlings transplanted; distance between rows and hills: 20cm x 20cm for wet season; 15cm x 20cm for dry season

Table 1. (continuation)

Technology component	Practices
Fertilizer application	• 50% organic and 50% inorganic fertilizers with complete source of NPK and other micronutrients
Water management	• Saturated soil for active tillering; 5-7cm water depth during reproductive phase; drained 2 weeks before harvesting
Pest management	• Use of biological control agents such as fungal microbial, *Metarhizium anisopliae and parasitoids, Trichogramma japonicum* against white stem borer
Harvesting	• Combine harvester
Crop residues	• Rice straw as substrate for growing mushroom; half-filled grains as food for ducks.

The rice production component grossed ₱154,935.51 in two cropping seasons, mainly from seeds (Table 2). Total variable costs amounted to ₱77,384.87 which included expenses for materials, labor, machine rental, and overhead expenses. Gross margin was ₱77,550.64.

Table 2. Returns over variable costs of rice seed production in PhilRice Agusan, January to December 2016.

Item	Value (₱)
Materials	5,203.18
Labor	72,181.69
Irrigation (2x times)	2,388.54
Pest management	14,331.21
Harvesting	5,573.25
Postharvest activities	5,573.25
Total Variable Costs	77,384.87
Gross Income	154,935.51
Gross Margin	77,550.64

see Appendix Table 1 (page 148) for details.

II. Livestock

Rice + duck Farming Integration

The biggest rice+duck areas in Mindanao are in the Zamboanga Peninsula. This practice has many advantages considering the highly symbiotic relationship between ducks and rice in the irrigated ecosystem. Ducks feed on weeds, snails, and other rice pests in the field while their manure serves as organic fertilizer. Biological control agents are used against white stemborers. The rice crop provides a good environment for the ducks.

Rice+duck production.

This component integrated ducks in the rice farm for yield-enhancing and cost-reducing production of rice seeds to serve as model. The practice produced registered rice seeds and duck eggs sold at prevailing retail prices. Brochures and/or leaflets on the nutritional and health benefits of consuming duck eggs were distributed to customers and walk-in visitors . Every cropping season in a 1-ha rice field, the ducks were herded starting at 14 days after transplanting (DAT) early in the morning and late in the afternoon before feeding them with commercial feeds.

The PalayCheck System was adopted, minus the chemical pesticides. The ducks were withdrawn from the field for egg-laying at the onset of rice heading or flowering. The ratio of male to female ducks was 100:400. They were fed with rice bran and half-filled grains at least once a day to make the flock more tamed and healthy. Viable eggs were set aside for hatching, otherwise these were sold to staff members and walk-in buyers. The component grossed ₱49,621 in 1 year, mostly from fresh eggs (Table 3). Total variable costs amounted to ₱39,320 which included materials and labor expenses.

Table 3. Returns over variable costs of rice + duck and swine production, PhilRice Agusan, January to December 2016.

Item	Value (₱)	
	Rice + duck	Swine
Materials (duck production)	16,820	351,535.20
Labor	22,500	122,890.65
Total Variable Costs	39,320	474,425.85
Gross Income	49,621	555,699
Gross Margin	10,301	81,273.15

**see Appendix Table 2 (page 149) for details.*

Swine Production

Raising pigs allows farmers to earn extra income, and optimizes their time and farm resources. Field wastes are used as feed or bedding of the piggery. Swine waste and used bedding can be recycled as substrates for vermicomposting.

Swine production.

The swine pen was constructed using galvanized iron roof and bamboo walls. The bedding was composed of carbonized rice hull (2%) at the bottom layer, another layer of rice hull (40%), and a top layer of sawdust (40%). The housing had six pens, each measuring $5m^2$ that could accommodate a total of 30 swine heads. Each pen was provided with a nipple drinker to ensure continuous water supply for the hogs. The pork was sold to the staff and private buyers from the neighboring barangays at ₱100 to ₱130/kg, when live weight reached at least 30kg.

Around 50 bags of swine manure compost was gathered from the six pens after 6 months. A portion was used as substrate mixture for vermicomposting while some were sold at ₱100/bag. The total variable cost was ₱474,425.85, which covered the cost of feeds, veterinary supplies, labor, and other expenses (Table 3). A gross margin of ₱81,273.15 was realized from the swine enterprise.

III. Mushroom

This component generated additional income, maximized the use of rice straw, developed new products, and enhanced the use of other resources in the rice environment. An unused shed was improved and utilized for oyster mushroom production (OMP) with a dimension of 6m x 3.5m to contain 5,000 fruiting bags per month. Other facilities and equipment were a small laboratory (8.5m x 3m), burner-top autoclave, double-burner gas stove, fabricated isolation chamber, pasteurizer, and a soaking tank with free-flowing water supply. Half of the 10t of rice straw produced in the station every season was collected from the field by a tractor trailer and stored near the soaking tank for mushroom use.

The tropical mushrooms oyster (*Pleurotus florida*) and paddy straw (*Volvariella volvacea)* were grown using rice straw and other substrates such as kakawate (*madre de cacao*) and dried banana leaves. Pure, sub-culture, and grain spawns, fruiting bags, and fresh mushrooms were produced. Pure culture production followed the tissue culture method involving plated potato dextrose agar (PDA) culture media. Rice-grain substrate packed in polypropylene (PP) bags was used in the production of grain spawn that averaged 250g per bag. One bag was used to inoculate 80-100 mushroom fruiting bags. Produced were 30 grain spawn bags every 2 months at ₱31.22 each as shown in Table 4.

Table 4. Returns over variable costs in oyster mushroom production, PhilRice Agusan, 2016.

ITEM	VALUE (₱)		
	Grain Spawn	Fruiting Bags	Fresh Mushroom
Materials	171.99	2,613.20	5,812.50
Labor	452.50	1,250	3,865
Total Variable Costs	624.49	3,863.20	9,677.50
Cost per Bag	31.22	7.73	

**see Appendix Tables 3, 4 and 5 (pages 150-152) for details.*

The substrate used in OMP was a mixture of 70% rice straw + 30% sawdust. Fruiting bags were 30cm x 15cm size PP bags weighing 750g/bag. Some 1,500 fruiting bags were produced per month with 3 to 5% contamination rate. Around 25kg of fresh mushroom were produced from 100 fruiting bags, averaging 0.80kg/day. March and October were highly productive; February and August were the opposite. Fresh mushroom that staff members could not buy was sold in Cabadbaran or Butuan at ₱120/kg. Some of the fruiting bags and grain spawns were sold to individual farmer-producers, farmers' associations, and other private entities.

Substrate for paddy-straw mushroom spawn was 40% rice straw, 40% *kakawate* leaves, and 20% sawdust. This was done using two fruiting bags (650g/bag) as planting materials. Dried banana leaves soaked in flowing water were used as bedding material (0.75m x 3m) in growing paddy-straw mushroom. The beds were covered with plastic sheet to preserve moisture and the necessary temperature of 30-32°C.

Additional income was earned from sold fresh mushrooms, fruiting bags, grain spawns, and spent mushroom substrates. Gross income was ₱122,601.40 from the 9,495 bags produced in 2016 (Table 5).

Table 5. Returns over variable costs of mushroom component in PhilRice Agusan, January to December 2016.

Item	Value (₱)
Total Variable Costs	92,549.20
Gross Income	122,601.40
Gross Margin	30,052.20

**see Appendix Table 6 (page 152) for details.*

IV. Vermicomposting

Vermicompost production.

The abundance of farm biomass such as rice straw, banana leaves, azolla, and animal manure made it feasible to engage in vermicomposting. This component was established side by side with mushroom production. Three concrete vermicomposting bins (3m x 1m) were constructed, each with a capacity of 4,000kg. The mixed substrate was pre-decomposed for 15 days before it was placed in the bin and inoculated with 4kg African night crawlers (ANC). The substrate was moistened twice a day to maintain 60% moisture. Additional substrates were dumped in the bins on a staggered basis to ensure continuous source of food for the worms. The composting period usually takes 4 to 6 months depending on the substrates used. In harvesting the vermicompost, the worms were separated by sieving the compost. Another method was providing new substrate at the other side of the bin and letting the worms feed on it, while harvesting the abandoned vermicompost. Some 21 bags of vermicompost (50kg/bag) were produced per bin within 6 months. Most of the produce was used at the station; the rest were sold to staff members, farmers, and private individuals at ₱500/bag. The low maintenance cost as indicated in the variable costs and high gross margin (Table 6) makes vermicomposting an economically viable enterprise in rice-based communities.

Table 6. Returns over variable costs of vermicompost production, PhilRice Agusan, 2016.

Item	Value (₱)
Materials	6,050
Labor	3,560
Total Variable Costs	9,610
Gross Income	15,750
Gross Margin	6,140

see Appendix Table 7 (page 153) for details.

The PalayPlus components rice seed production+duck farming system, mushroom production, vermicomposting, and swine production proved technically and economically feasible under the conditions of the station. Certain issues (Appendix Tables 8-11, pages 153-157) regarding their operation and implementation were manageable. The gross income of the whole model amounted to ₱1,730,248 (Table 7) showing that diversification and intensification of farming ventures evidently can increase income. The gross margin of ₱618,656.67 shows that the model is profitable. Adaptation of this model at the community level can increase income, improve the living conditions of the farmer-stakeholders while efficiently managing agricultural wastes in the area.

Table 7. Comparative analysis of PalayPlus components in PhilRice Agusan, 2016.

Components	Gross Income (₱)	Gross Margin (₱)
Rice seed production+duck farming system	1,043,216	501,045
Swine production	555,699	81,273.15
Mushroom production	115,583.20	30,198.52
Vermicomposting	15,750	6,140
Total	**1,730,248**	**618,656.67**


NSIC Rc224

PALAYPLUS EXPERIENCES IN MIDSAYAP

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Highlights

- PalayPlus in PhilRice Midsayap served as learning and training center for students, farmers, teachers, and Citizen Armed Forces Geographical Unit (CAFGU) members.
- The integrated components gave the station a net income of ₱222, 967.96 in one year.
- Partnerships with local organizations are now being cooked up as a result of this initiative.

Site profile

PhilRice Midsayap in North Cotabato is nestled on a physical land area of about 96 hectaewa and is mandated to develop and promote location-specific rice and rice-based production technologies in Regions 9, 11, 12, and ARMM. The prevalence of pest outbreaks in the area made pest management as its research-development and extension thrust. The station develops and produces high-yielding, pest-resistant, and high-quality rice varieties, integrated pest management options and decision tools, and effective and cost-efficient technologies to address rice production constraints in its covered areas.

Midsayap is surrounded by the municipalities of Libungan, Rio Grande de Mindanao, Aleosan and Pikit, and Kabuntalan. It is one of the centers for business and agricultural trading because of its strategic position. The agricultural products from nearby municipalities are sold in bulk to business traders in Midsayap. It is also near the major cities in Mindanao such as Cotabato, Davao, and Kidapawan offering plenty of market opportunities for agricultural products.

Typhoons are uncommon in Midsayap, with heaviest rain recorded at only 6.95mm on average. Climate is Type IV; distribution of rainfall throughout the year is even. Approximately 72% of its plain and hilly land are for agriculture, particularly rice production. Fruit-bearing trees, vegetables, corn, coconut, and banana are also widely grown. Diverse crops thrive well probably due to the different soil types that include Kabacan Clay Loam (37.52%); Kudarangan Clay Loam (24.24%); San Manuel Silty Clay Loam (6%); and Hydrosol (32.24%). These areas are waterlogged, as they straddle the Rio Grande de Mindanao, the second largest river system in the country.

Midsayap is one food basket of the province; hence, agriculture is the top priority of the local government. Lowland rice is planted all year-round and serviced by the Libungan River Irrigation System (LIBRIS). Few farmers plant watermelon or mungbean after rice especially when drought is long or if irrigation supply is delayed for a few months.

PalayPlus Components Implemented

Some 70% of the station's total area is for producing registered and certified rice seeds, where PalayPlus occupied approximately 3.5 hectares to implement the following components: (1) rice seed production in 3 hectares, with vegetables nearby, (2) small-scale mushroom production in a growing house with two rooms for 1,000–1,500 fruiting bags, (3) production of vermicompost with 16 vermi beds (3m x 0.75m) and 4 vermi beds (3m x 2m), and (4) small-scale vegetable production.

I. Crops

Rice seed production

This enterprise was established to encourage more farmers to venture into inbred seed production, a good form of agricultural business as seeds command higher prices than commercial palay (₱18/kg against ₱42.50/kg registered seeds). As of now, there are only two active seed growers' cooperatives and two independent seed growers in Midsayap, even as more farmers are choosing to plant certified seeds.

Rice seed production.

Table 1. Rice seed production technology, PhilRice Midsayap, 2016-2017.

Technology Component	Practice
Land preparation	• 2x puddling; 1x harrowing; 1x levelling and marking
Varieties	• NSIC Rc 222, Rc 238, and Rc 128
Crop establishment	• Use 20kg/ha seeding rate; soak seeds for 24hr and incubate for another 12-14hr • Establishment of rat trap using plastic cellophane • Transplant 21-day-old seedlings in straight row at 2-3 plants per hill in a 20m x 20m distance
Water management	• Construct small ditches in the middle of the paddy; maintain required water level during critical stages of the crop; irrigate every after fertilizer application
Nutrient management	• 1st application 15 days after transplanting (DAT)- 2 bags of 14-14-14, 1 bag each of 21-0-0 and 16-20-0/ha • 2nd application at 45 DAT - 1-2 bags of 21-0-0 and 1 bag of 16-20-0 • 3rd application at 75 DAT- 1 bag each of 21-0-0 and 0-0-60
Pest management	• Monitor field regularly • Draining the field 3 days before and after full moon reduced RBB occurrence • Pesticide application done only as the need arises
Roguing	• Rogue off-types periodically from the tillering to ripening phases
Harvesting	• Harvest when 80% of the rice panicles turned golden yellow; with 20-25% MC during WS and 18-21% for DS; use combine harvester
Postharvest & processing	• Rice seeds were sun-dried and processed not later than 3 weeks after harvest • Submit to laboratory for seed testing and certification • Pack and label RS in laminated sacks

Following the PalayCheck system, Foundation Seeds of NSIC Rc 222, Rc 238, and Rc 128 were transplanted at a rate of 20kg/ha, distanced 20cm x 20cm. First fertilizer application was at 15 days after transplanting (DAT) with 2 bags of 14-14-14, and 1 bag each of 21-0-0 and 16-20-0/ha; second application at 45 DAT with 1 to 2 bags of 21-0-0 and 1 bag of 16-20-0; third fertilier application at 75 DAT with 1 bag each of 21-0-0 and 0-0-60. No basal fertilizer, but 21-0-0 was applied 10 days after seeding at 2.5kg for 1m x 16m seedbed. Spraying diluted zinc sulfate early in the morning effectively reduced zinc deficiency as the plants easily absorbed the fertilizer.

Rice black bugs (RBB) and rice stemborers (RSB) occur every season in Midsayap but pesticides were applied only as needed. Draining the field 3 days before and after full moon reduced RBB occurrence. Pre-emergence herbicide and molluscicide were applied respectively at 5-7 DAT and immediately after transplanting.

A combine harvester was mobilized when 85% of the rice grains turned golden yellow with 20 to 25% moisture content (MC) during the wet season (WS) and 18 to 21% for dry season (DS). Rice seeds were sun-dried and processed not later than 3 weeks after harvest to avoid increase in grain MC. The package of technologies (POT) described in Table 1 was implemented.

The returns over cash expenses of farmer-seed grower per season are presented in Table 2. A farmer producing RS could net around ₱194,000 during DS and ₱184,000 during WS, or about 58% higher than farmers selling their produce as commercial paddy rice. To achieve this net income, a seed grower should aim to yield at least 4.7t/ha; for commercial paddy rice, a farmer should yield 5.4t/ha. This enterprise also highlights the use of the mechanical harvester. While manual and mechanical harvesting do not significantly differ in cost, the latter ensures a better-quality produce as grains go straight to the sacks; losses are also minimized. Manual harvesters do not abound in the area.

Table 2. Returns over variable costs (₱) of rice seed production per hectare, PhilRice Midsayap, 2016 – 2017.

Item	DS*	WS*
Materials	29, 218.36	30, 365.51
Labor	7, 500	7, 600
Total Variable Costs	36, 718.36	37, 966.51
Gross Income	230, 892	222, 435.81
production RS seeds (kg)	5,432.78	5, 233.78
Gross Margin	194, 174.63	184, 469.30

**Data were computed/ha from the average of 2 dry seasons and 2 wet seasons*

***see Appendix Table 1 (page 158-159) for details.*

Vegetable production

Of the different strategies to increase profitability, growing vegetables is the most common. Vegetable production was established to demonstrate that farmers can generate additional income by optimizing their land area. For this component, idle areas near the rice production site such as dikes, lining of irrigation canals, used laminated sacks, and some indigenous materials were utilized. Different vegetables were planted following the POT presented in Table 3, such as cucumber and string beans (30LM); bitter gourd (20) all with trellis made up of bamboo (tie wire and thread were used in sewing sacks); and lady's finger (20LM) planted on paddy dikes. Eggplant, tomato, radish, and pechay were planted in a 15m x 3m vacant lot near the vermicomposting house. Ginger was planted in laminated sacks with approximately 5kg soil per sack. Vegetables were grown twice a year.

Vegetables are not hard to establish, and the harvest is also marketable especially if people know that they are organically grown and pesticide-free. Indigenous or used materials can be recycled. For example, ginger or hot pepper can be planted in used laminated sacks; pechay in cut bamboos or damaged steel drums; and radish or pechay in emptied bottles of 1L mineral water. Our vegetables on paddy dikes were adversely affected by herbicide sprayed on rice.

Bitter gourd production.

Tomato production.

Income from vegetables in a 1-year cycle was around ₱8,450; could have been higher had cost of production been reduced. For example, ratooning eggplant every 6 months could make it still productive rather than replacing it with another batch of seedlings.

Table 3. Package of technologies for vegetable production, PhilRice Midsayap,2016-2017.

Technology	Practices
Sowing	• Vegetable seeds were sown in seedling trays using compost as medium • Hardening of the plant for 1-2 weeks after emergence of cotyledon
Planting and Management	• Complete fertilizer (2g) was used as basal before transplanting • Trellis was established 2 weeks after transplanting (WAT) to guide the vines • For bitter gourd *(ampalaya),* de-leafing was done 3 WAT by detaching the leaves and branches that emerged 2-3ft above the ground • For tomato, de-leafing of matured and unhealthy leaves was done during early fruit development • For eggplant, ratooning (cutting of stem) was practiced every 6 months and de – leafing was done as needed. Ratooning can be done up to 2 years. For lady's finger *(okra),* de-leafing was conducted every month
Nutrient Management	• 2 grams of ammonium sulfate was applied 2 WAT by broadcasting 6-8in away from the hill • At early flowering stage of the crop, diluted 100g of 21-0-0 with 20L water and 100g of 0-0-60 with 20L water was drenched on every plant (1L each)

Table 3. (continuation)

Harvesting	• Bitter gourd - harvesting of fruit done every after 5 days • For other vegetables, harvesting can be done every after 3 days • Sell the vegetable immediately or while it is still fresh

Table 4. Returns over variable costs of vegetable production, PhilRice Midsayap.

Item	Amount (₱)
Supplies and Materials cost	2, 360
Labor cost	2, 057
Total Variable Costs	4, 416
Gross Income	230, 892
production total (kg)	951.70
Gross Margin	4, 850

**see Appendix Tables 2 and 3 (page 160) for details.*

II. Mushroom

Small-scale mushroom enterprise - oyster (*Pleurotus* spp.) and paddy (*Volvariella*)- demonstrated the importance of rice and other crop biomass such as rice straw, *madre de cacao*, and dried banana leaves. Table 5 shows the technologies used. Remarkably, mushroom production drew attention from various stakeholders such as students, religious groups, farmers, and service auxiliary men because they were convinced it was a good source of additional income. People were also fascinated with the physical appearance of cultured mushroom making them request for mushroom production training.

Gray oyster mushroom production.

Table 5. Package of technologies in spawn production, PhilRice Midsayap, 2016-2017.

Technology component	Practices
Culture media; pure culture and spawn preparation	**Medium preparation:** Dilute 39g of potato dextrose agar (PDA) powder with 1L of hot water • Sterilize the solution with the materials needed for isolation process such as scalpel/ blade holder, wire loop, beaker, bottles or petri plates • Dispense PDA into bottles/petri plates while it is still warm and cover with cotton plug. Set aside for 5min to turn the solution into gel • Turn the slant into upside down position
	Pure culture preparation: • Disinfect the isolation chamber or the whole room as possible using 10% NaClOH or 70% isopropyl alcohol. Repeat this procedure for 3 times before working in the laboratory. • Conduct isolation process or tissue-planting inside the isolation chamber using all materials needed (alcohol lamp with denatured gas, wire loop/transfer needle, scalpel with surgical blade attached, fresh mushroom tissue, alcohol, tissue paper, slant) • Incubate the inoculums for 2-3 weeks in a clean and disinfected storage room to produce pure culture **Spawn preparation**: • **Oyster mushroom**- wash rice filled grains and cook for 30min or until grains crack • Drain the water, pack the seeds using plastic cellophane or bottles, cut PVC pipe (¼ diameter), and cotton plug • Sterilize packed grains using autoclave/pressure cooker at 15psi for 30min • Cool and inoculate with pure culture of oyster mushroom in clean and disinfected inoculation chamber • Incubate the inoculum for 3-4 weeks in a clean and well-ventilated room • **Paddy mushroom**- Collect dried cardava leaves that are still attached to the pseudo stem • Soak the leaves in clean water for 24hr • Chop the leaves and wash in clean water • Dry the leaves and mix with dried "*kakawate*" leaves (at least 3% of the amount of the cardava leaves) • Pack the substrate in plastic cellophane or bottles • Sterilize the packed substrate using autoclave/pressure cooker at 15 psi for 30min • Cool and inoculate with pure culture of paddy mushroom in clean and disinfected inoculation chamber • Incubate the inoculum for 3-4 weeks in a clean and well-ventilated room

Table 5.1. Package of technologies on mushroom production, PhilRice Midsayap, 2016-2017.

Oyster mushroom establishment	• Wash, dry with at least 45% moisture content and chop or shred the rice straw • Pack in plastic bag (6x12in) and pasteurize for 6-8hr • Cool and inoculate with grain spawn and incubate for 30-45 days • After opening the bag, water the bags 3x a day • Harvest the fruiting body after 3-4 days from opening the bags. • The substrate can be harvested up to 3-6 months under good maintenance
Paddy mushroom establishment	• Arrange the leaves at 2-4in thick across the wooden pallet with 8-10in and 1m length • Cut the leaves with a width of 8-10in • Pile the cutting and plant spawn at the top of each layer; repeat the steps until 5 layers of beddings are formed • Incubate the bedding for 10-15 days • Harvest the buttons 2-3 days after sprouting

Oyster mushroom production (OMP)

The station had the following equipment and facilities for OMP: (1) isolation room with fabricated inoculating chamber made with glass and aluminum for pure culture and spawn production (a 200g rice grain spawn can inoculate 100 fruiting bags); (2) soaking tank (2000L capacity) for substrates preparation; (3) working shed built with coco lumber and galvanized roof with a dimension of 3mx 2m for processing the substrate; (4) 2 steel drums for pasteurization with a 70-80 fruiting bags capacity; (5) deep well and water pump to ensure water availability; and (6) concrete growing house with two rooms each having an area of $12m^2$. The growing rooms were used for incubating the inoculated fruiting bags left hanging inside with wet carbonized rice hull (CRH) spread on the floor (3-4in thick) and wet jute sack hanging on the walls, which provided a suitable environment. Ideally, room temperature should be 25^0C. The fruiting bags, CRH, and jute sacks were watered daily. Every quarter, approximately 250kg of rice straw were utilized to produce 500 fruiting bags.

To ensure success in OMP, here are some observations and practices drawn from PhilRice Midsayap's experience: (1) better production/yield of oyster mushroom was obtained when pure rice straw was used as media for fruiting bags rather than a mix of rice straw and sawdust; (2) fruiting bags using pure rice straw incurred less contamination and had faster growth of mycelium; (3) faster and easier inoculation of spawn on the fruiting bags if done outside the inoculation chamber; (4) continuous fire for 4-6 hours during pasteurization significantly reduced contamination; (5) inoculation of spawn should be done immediately and must not exceed 3 days to avoid contamination; hence, scheduling of pasteurization is crucial; (6) watering oyster mushroom during harvesting may lead to wilting; and (7) oyster mushroom is best harvested 2-3 days after the appearance of pinheads. The returns over cash expenses for this enterprise are presented in Table 6. The table highlights that mushroom production could be an excellent alternative source of income for farmers without intensifying land use. Interestingly, the net income could be increased by approximately ₱12-15,000/ person. For oyster mushroom alone, around ₱12-13,000 can be added to farmers' income from the sale of fresh mushroom and fruiting bags.

Table 6. Returns over variable costs for oyster mushroom production, PhiRice Midsayap, 2016-2017.

Item	Amount (₱)
Materials	1, 962.50
Labor	1, 670.50
Total Variable Costs	3, 633
Gross Income	16, 290
production fruits (kg) @₱180/kg	90.50
Gross Margin	12, 657
<u>*If sold as fruiting bags*</u>	
Gross Income	17, 500
Production of fruiting bags @₱180/kg	500
Gross Margin	13, 867
Cost of production per kg	32.58

**The cost of production and net income are based on 500 fruiting bags.*

***see Appendix Table 4 (page 161) for details.*

Paddy mushroom production (PMP)

For *Volvariella* production, an area of $20m^2$ was prepared outside, and adjacent to the vermicompost production site. Similar to oyster mushroom, PMP also requires a soaking tank and a good source of water. Paddy mushrooms were grown in layers of dried cardava banana and fresh *kakawate* leaves. Mixed 250g dried banana and 5% *kakawate* leaves could produce a 1LM of paddy mushroom, but better growth of spawn is achieved when grown in 90-95% dried banana and 5-10% *madre de cacao* leaves. It is not advisable to grow paddy mushroom on pure rice straw because it is fibrous; neither on rice bran. Paddy mushroom is best harvested at 11-15 days after the pinheads appear.

Paddy-straw mushroom production in banana leaves.

Paddy mushroom can generate a net income of ₱1, 372 for every 10LM setup as shown in Table 7. Production can be done monthly, if one is already good at it. PhilRice Midsayap promoted the produce by introducing them to friends or walk-in clients. They suggest some recipes such as mushroom tempura (good appetizer) and mushroom patty, and promote the enterprise during training programs. Local restaurants are getting to know more about mushrooms.

Table 7. Returns over variable costs for paddy mushroom production, PhilRice Midsayap, 2016-2017.

Item	Amount (₱)
Materials	614
Labor	514
Total Variable Costs	1, 128
Gross Income	2, 500
Production fresh weight (kg) @₱100/kg	
Gross Margin	1, 372
Cost of production per kg	45.12

**The cost of production and net income are based on 10 linear meters.*

***see Appendix Table 4 (page 161) for details.*

III. Vermicomposting

The component was pursued to show another way of utilizing farm biomass (rice straw) and other farm wastes (mushroom spent substrate). Vermicompost production was established with a shaded structure to avoid direct exposure of the vermi beds to sunlight that can kill the worms. The station established 16 vermi beds (3m x 0.75m) and another 4 beds (3m x 2m), which were isolated and not in a water-submerged area to avoid losing the worms. The deep well constructed for mushroom production also benefitted this enterprise.

Every season, an average of 4.7t of substrate (mixtures of rice straw, banana leaves and bracts, carabao manure, rotten vegetables, and mushroom spent substrates) were placed into the vermi beds with 1kg/m^2 of worms (less worms slow down decomposition) covered with either nylon nets or banana pseudostems to protect the worms from predation. This proportion yielded some 5.3t of vermicompost per year.

Harvesting was done every quarter by heaping the harvestable compost on one side of the beds. The empty portion of the bed was filled up with new substrate, and the worms moved freely from the harvestable compost onto the new substrate. A fine screen was also used to completely isolate the worms from the compost. The harvested compost was air-dried for at least 10 days and sieved in 2mm wire screen, packed using fish bag and field sack to conserve moisture, and was properly labelled. The compost was mostly used as organic fertilizer for the station's vegetables and for the growing medium for seedling production in trays.

Some problems were encountered such as (1) compacted and fully filled composting beds produced less compost as decomposition of organic materials was slowed down, making the worms abandon the beds; (2) use of mango leaves and rice hull produced less compost because these materials are fibrous; (3) presence of other mixtures in the composting beds like fresh substrates invited ants, rats, frogs, and other predators; (4) failure to water the bed for 3 days dried up the substrate and delayed decomposition; and (5) leaving the beds without protective coverings such as net or banana pseudostem attracted predators. Table 8 presents the cost of production and income from vermicomposting, pointing to an additional earning of ₱14,767 per cycle.

Table 8. Returns over variable costs for vermicompost production[1], PhilRice Midsayap, 2016-2017.

Item	VALUE (₱)	
	vermicompost production for a 1-year cycle[1]	**50kg of vermicompost from rice[2]**
Materials	6, 015	58.15
Labor	3, 598	48.50
Total Variable Costs	9, 613	106.65
Gross Income	230, 892	230
production (kg) @₱230/bag	5,300	
Gross Margin	14, 767	123.34

[1]*Data are from the averages of production cost and yield for 2 years.*

[2]*see Appendix Table 5 (page 162) for details.*

Table 8 also presents the variable costs and income of producing 50kg of vermicompost from scrap resources available, implying a significant income and profit from this enterprise. The package of technologies applied is presented in Table 9.

Table 9. Vermicompost production technology, PhilRice Midsayap, 2016-2017.

Technology Component	Practice
Substrate ratio	• 60:40 rice straw and carabao manure
Pre- decomposition	• Pre-decompose rice straw by stacking 250kg exposing to sun and rain for 1 month • Mixture of mushroom spent substrate and rotten vegetables can be added to vermi bed as another source of food for the vermi worms
Stocking pre-decomposed substrates in the vermi-bin	• Place 75kg rice straw 50kg of dried carabao manure • Deploy 1kg of African night crawlers in each bin with 1mx3m dimension
Maintenance	• Keep the substrate moist by watering the bin
Harvesting	• Harvest the vermicompost after 8-12 weeks • Heap the harvestable compost on one side of the bed and fill up the other side with new substrate, attracting the worms to move freely into the new substrate • Air-dry the compost and sieve using fine screen (at least 2mm) to separate undecomposed materials • Bag the vermicompost in sacks with cellophane inside and stack in a shaded and dry area

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REGION
White Oyster Mushroom
(Pleurotus florida)
Yellow Oyster Mushroom
(Pleurotus citrinopileatus)

CHAPTER 4

Learnings and ripples

PalayPlus in PhilRice Batac

Several insights can be gleaned from the PalayPlus project in the station. First, the model can be replicated by farmers who have similar agro-climatic conditions to PhilRice Batac. Farmers need to have the capital to finance the production requirements of all enterprises. Further, additional investment on facilities is vital to be able to engage in oyster mushroom production and vermicomposting. The facilities do not need to be sophisticated or expensive. An initial investment for vermi-worm stock is also needed. The vermi-worms can become another source of income when the stock grows and exceeds the requirement of the vermicomposting operation.

As long as there are ready markets for all component enterprises, and the prices of the products are at levels where the farmer-adopters realize acceptable profits, then the integrated system can be sustained. The farmers likewise need to have the skills in processing the perishable products, specifically the mushrooms. A portion of the vermicompost should also be returned to the farm to keep or improve soil fertility and structure.

PalayPlus in PhilRice Bicol

The station aimed at testing the different rice-based models that could help maximize productivity and profitability of rice-based farmers in the Bicol region. It worked to inform farmers about the importance of diversification, intensification, and integration in sustaining their farms. During the course of implementation, not only farmers but also other stakeholders expressed interest to learn about the PalayPlus concept, more specifically on mushroom production because of its uniqueness. Inquiries from returning OFWs (Overseas Filipino Workers) about the possibility of conducting training programs on mushroom production were received and responded to.

PalayPlus magneted more visitors to the station. On-the-job trainees (OJTs), individuals, and groups of farmers came to ask about mushroom and azolla production. National agencies in Albay such as the National Irrigation Administration and the Department of Agrarian Reform invited PhilRice PalayPlus focal persons to present the concept in their respective offices.

The station's PalayPlus model farm was also launched as an agri-tourism model farm. Mrs. Josephine Costales of the Costales Farms in Majayjay, Laguna, the pioneer of agri-tourism in the Philippines, came and talked about transforming ordinary farms into agri-tourism farms and on doubling income of smallholder farmers through agri-tourism.

PalayPlus in PhilRice Isabela

The PalayPlus mushroom production component was successfully showcased in the station. Three training programs were conducted and many entrepreneurs have established their own mushroom production enterprises. Among them were 15 teachers from secondary schools who eventually conducted training programs in their respective schools. Five farmers in Tabuk City and other towns of Kalinga have since been regularly purchasing vermicast, vermicompost, and ANC produced by the station. Staff members also bought much of the produce.

PalayPlus in PhilRice Los Baños

Partnership and collaboration is a way of life in the Los Baños Science Community. PalayPlus created avenues to involve several local experts. For instance, in mushroom production, the spawn was outsourced from one of the experts in this field, Dr. Emer Borromeo, a retired UPLB professor. Borromeo also gave insights on growing mushrooms, as well as the different substrates that can be used. He also provided contacts for sawdust suppliers in the area.

For vermicompost production, the site of Mr. Michael Lubigan Cagas, owner of Green Wrigglers in Puypuy, Bay, Laguna was visited. For 10 years now, he has been using banana trunk as a source of biomass and feeding stocks for vermi worms. He also involves the community in producing vermicompost and worms. Brgy. Puypuy is known in Laguna as a supplier of vermicast and vermicompost (₱500 per sack), and ANCs (₱800-1,000 per kg).

PalayPlus has heightened the interest of the community to make money from their rice straw. As in other rice-farming communities, farmers in Los Baños usually burn their rice straw toward the end of the crop cycle. With the many uses of rice straw as demonstrated in the PalayPlus model, things are likely to change in the future.

The station also partnered with the Philippine Carabao Center in Los Baños to ensure adequate and stable supply of animal manure. Several requests for training programs on the components have also been received and acted upon.

PalayPlus in PhilRice Central Experiment Station (CES)

The PalayPlus model demonstrated how various farming components are interrelated (Fig. 1). From the rice plant, straw is used as mulching material for crops, feeds for livestock, and substrate for culturing mushroom. The system is able to support, diversify, and intensify the income sources of the farm. The output of these integrated enterprises translated into higher productivity and income of the farm. Moreover, biomass from the crops were used as feeds for the livestock or as substrates for vermicomposting in addition to the livestock manure and spent mushroom substrates. The vermicompost generated was plowed back to the production system as nutrient source for the crops, including rice, thus reducing the need for external sources of nutrients.

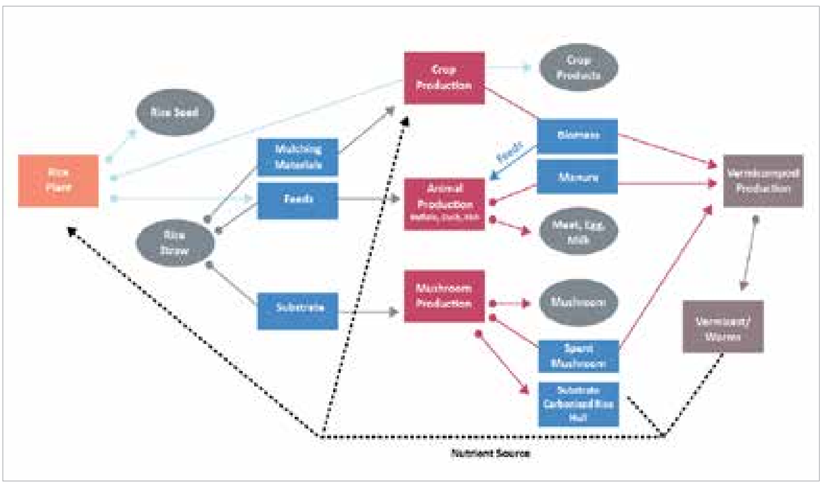

Figure 1. Interrelatedness of rice with the different Palayamanan Plus components, PhilRice CES.

With the diversified, intensified, and integrated production system in the model, the income generated is much higher and more stable; the costs are way lower despite some production-related risks such as extreme weather events, and pests and diseases.

The learnings from the implementation of the concept provided some insights and inspiration to farmers and other stakeholders who may want to establish their own Palayamanan farm. The mushroom enterprise attracted the most interest, and different groups were trained on the technology.

Rice farmers and other individuals who would like to venture into integrated farming systems could easily replicate the model developed at the station including the approaches, innovations, and technologies per component. Starting with at least two components is best, the income of which will help finance expansion.

PalayPlus in PhilRice Agusan

On top of other noteworthy achievements, the mushroom component seemed to have generated the most favorable outcome. The station noted the sharp increase in demand for mushroom fruiting bags from 125 to 450 pieces per week. Many farmers and groups signified interest to be trained on mushroom production as it even capitalizes on available biomass in the rice environment.

The 46-member Avanceña Beneficiaries Farmers Multipurpose Cooperative (ABFMC) based in Sanghan, Cabadbaran City collaborated with the station for mushroom production and vermiculture. The station conducted three training programs for ABFMC (35 farmers) and AgriDOC (32 trainees/ agricultural extension workers).

The station also educated visitors, mostly individual farmers and members of irrigators' associations, from Regions 11, 12, and 13 by holding seminars and lectures on PalayPlus. Various stakeholders including on-the-job trainees (students), extension workers, and farmers requested and were granted training on mushroom production.

PalayPlus in PhilRice Midsayap

The model successfully showed how all components are intertwined. For example, biomass from rice seed production was used in mushroom as substrate for growing spawn and as bedding for vermicompost production; compost was used as fertilizer in the vegetable enterprise (Figure 2). Furthermore, it has also established that the integration of the components can earn more profitable and sustainable income than the conventional way of farming. Even if a farmer adopts just one of the components, it is possible to realize a higher income than rice-rice cropping system.

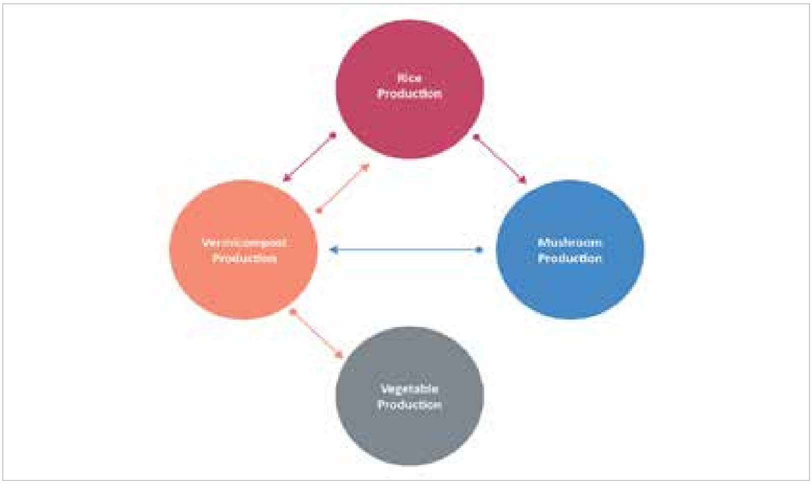

Figure 2. Usage interrelation of each component, PhilRice Midsayap.

PalayPlus in Midsayap has motivated farmers to practice crop diversification, intensification, and integration. This farming system promotes and enables sustainable farming and livelihood as it allows farmers to not just earn from this enterprise but also to produce their own food. It also helps strengthen resilience for both farmers and the agro-ecosystem, which is important in an increasingly changing environment for rice-based farming.

PhilRice Midsayap's mushroom component has awakened interest among various stakeholders. The station supported groups that expressed interest to learn about PalayPlus, among which is the Salunayan National High School (SNHS) in Midsayap. Key officials and students of the school were oriented on mushroom production, which eventually led to the school establishing its own PalayPlus farm. In 2016, SNHS won the grand prize at the national level in the *Best in Gulayan sa Paaralan* contest by the Department of Education. The school closely coordinates with PhilRice Midsayap to enhance its strategies on improving its PalayPlus setup. PhilRice sees this opportunity to promote rice technologies and encourage young people to pursue agriculture as a career option.

Aside from the youth, the religious group leaders (Ulama in Midsayap) were also engaged. PalayPlus was presented to them as a potential way of augmenting a household's income. Some members of the community trained on mushroom production were hired abroad as mushroom pickers. Even members of the Citizen Armed Forces Geographical Unit (CAFGU) or volunteer peace corps in North Cotabato were educated on mushroom production.

APPENDICES

PHILRICE BATAC EXPERIENCES

Appendix Table 1. Detailed oyster mushroom production costs, 128 fruiting bags (1.25kg) per batch, PhilRice Batac, 2014-2016.

A. Fruiting Bag Production			
1. Material Cost		Quantity	Value (₱)
Substrates			
rice straw	21	kg	21
sawdust	22	kg	22
Bagging Materials			
plastic bag, PP, 8″x18″	128	pc	243.20
PVC pipe, 3/4″ [a]	1	pc	10
rubber band	3	bx	15
cotton waste	0.30	kg	11.70
Pasteurization Materials			
steel drum [b]	4	unit	68
fuel wood	0.16	m^3	170.72
cheesecloth [c]	6	pcs	2
Inoculation Materials			
grain spawn [d]	2	bot	120
alcohol	100	ml	15
denatured alcohol	60	ml	5.45
disposable face mask	1	pc	1
gloves	1	pair	3.50
Total Material Cost for Fruiting Bag Production			708.57
2. Labor Cost		MD	Value (₱)
Substrate preparation		0.50	130
Bagging of substrates		1.86	484.25
Pasteurization		0.81	211.25
Inoculation		0.63	162.50
Total Labor Cost for Fruiting Bag Production			988
Cost of producing 1 fruiting bag			**13.25**

Appendix Table 1. (continuation)

B. Oyster Mushroom Fruit Production			
1. Material Cost		Quantity	Value (₱)
fruiting bags [e]	128	bg	1,696.57
2. Labor Cost		MD	Value (₱)
Opening of bags		0.06	16.25
Application of mist, 1-2x a day		1.25	325
Production & application of CRH mulch		0.19	48.75
Harvesting, sorting and selling		1.25	325
Total Labor Cost for Oyster Mushroom Production			715
Cost of oyster mushroom fruit production per bag			**18.84**

Appendix Table 2. Returns above variable costs of producing 50kg of vermicompost, PhilRice Batac, 2014-2017.

Item	Value (₱)
Materials	
Rice straw	49.30
Buffalo manure	21.13
EMAS	3.50
Sack	10
Nylon twine	1.50
Total Material Cost	85.42
Labor	
Collection of substrates	14
Pre-decomposition of substrates	7.50
Stocking of substrates	6
Watering & monitoring	5
Harvesting of vermicompost	25.50
Total Labor Cost	58
Total Variable Costs	**143.42**
Gross Income	**300**
Gross Margin	**156.58**

a – PVC pipe can be used 10 times
b – steel drum can be used for 35 pasteurization batches
c – cheesecloth can be used 15 times
d – 1 bottle of grain spawn can inoculate 70 fruiting bags
e – cost of producing fruiting bags from item A

Appendix Table 1. Detailed returns over variable costs in rice seed production, PhilRice Bicol, 2017.

Item	Value (₱)	
	DS	WS
Materials	**23,629**	**16,493**
Seeds	1,700	1,600
Fertilizers	17,179	11,563
Pesticides	-	-
Fuel	-	-
Sacks	4,750	3,330
Others	-	-
Labor	**34,324**	**33,944**
Seedbed preparation	1,920	1,920
Seedling management	300	300
Land preparation	8,280	8,520
Crop establishment	6,000	6,000
Fertilizer application (6 and 5 times)	1,440	1,200
Irrigation (10 times)	2,400	2,400
Pest management	5,280	5,280
Harvesting	6,000	6,000
Postharvest activities	2,704	2,324
Total Variable Costs	**57,953**	**50,437**
Gross Income	**205,400**	**187,850**
Gross Margin	**147,447**	**137,413**

Appendix Table 2. Projected returns over variable costs for oyster mushroom production (150 fruiting bags for a 3-month cycle), PhilRice Bicol.

Item	Man-Day (MD)	Amount (₱)
Labor		
Hauling of rice straw	0.125	29.50
Hauling of sawdust	0.125	29.50
Cleaning sawdust	0.25	59
Chopping of rice straw	1	236
Soaking and draining	0.125	29.50
Mixing of substrate	0.25	59
Preparation of fruiting bags	3	708
Pasteurization	0.5	118
Inoculation	0.5	118
Subtotal		1,386.50
Material		
PP plastic (10"x14")		180.60
Rubber band		40
Fire-wood		150
Mushroom spawn		960
Subtotal		1,330.60
Cost for 5% contamination rate		135.83
Total cost		**2,852.93**
Cost per fruiting bag		19.02
Cost per fruiting bag (labor not included)		9.31
Yield (kg)*		**78.75**
Gross income**		**11,025**
Gross Margin		**8,172.08**

Appendix Table 3. Technical issues encountered in rice production and solutions/recommendations undertaken, PhilRice Bicol.

Problem/Issue	Solution	Remarks
Delayed seeds acquisition which eventually resulted in delays in crop establishment, and, by extension, irrigation issues especially during the critical stages of the rice crop.	The station must be prompt in procuring seeds to enable planting synchronously with the other farmers in the community. Also, the area should be near a water source, or supplemental irrigation must be made available.	Farmers upstream hoard water, causing insufficient water on a significant portion of the seed production area of the station.
Fixed-time fertilizer application was inefficient as the soil on-station is sandy loam.	Conducted 4-5 times split application, especially of N fertilizer.	
Post-production losses due to unfavorable weather toward the harvesting months of November and December.	Proper drying and storage of harvested palay.	Flatbed dryer was not operational.

Appendix Table 4. Technical issues encountered in mushroom production and solutions undertaken, PhilRice Bicol.

Problem/Issue	Solution/Innovation	Remarks
Oyster Mushroom		
Use of PVC neck with cotton plug to close the fruiting bag was time-consuming. It was also more prone to contamination due to water absorption by the cotton during pasteurization, and it entailed additional cost.	Rubber band was used to seal the fruiting bag, which was easier and effective in reducing contamination and moisture loss.	
Difficult to pack substrate mixture (rice straw + sawdust) using 6″x12″ PP plastic.	10″x14″ or 8″x12″ PP plastic was used instead, without chopping the rice straw into smaller sizes.	Time consumed in packing was the same with 6″x12″ PP plastic but the bigger size contained more substrate in one pack (1.5 to 1.75kg per plastic against only 0.75 to 0.8kg for 6″x12″).
The use of conventional pasteurization technique (usually 6-8 hours) required more firewood, time, and labor.	Pasteurization time was reduced to 4-5hr using plastic cover to seal and prevent steam from escaping, thereby maintaining temperature inside the metal drum.	The innovation resulted in reduced pasteurization time, firewood used, and labor.

Appendix Table 4. (continuation)

Problem/Issue	Solution/Innovation	Remarks
Pasteurizing in steel drum using single heat source required plenty of firewood.	Pasteurization using the steam-sharing pasteurization technique can also be used to conserve excess steam from the main pasteurizing drum.	
Limited availability of mushroom spawn.	The spawns bought by the station from private producers were expensive; hence, F1 planting spawns were used instead.	To reduce cost, use of mother spawn to produce F2 planting spawn proved to be a good alternative.
No inoculation facility to produce own mushroom spawn and incubation room to store inoculated fruiting bags.	The station converted a room in the old building for these purposes.	
Volvariella Mushroom		
Use of outdoor bed-type technique was tedious, prone to contamination, and subject to extreme environmental conditions which resulted in abortion of pinheads.	The simplified production process using the laundry basket technique was used. It reduced labor on substrate preparation because rice straw was not prepared in bundles.	
	Space-saving modified bed-type indoor mushroom production using steel or wood as cabinet for incubation process was employed.	
Milky Mushroom		
Use of bed-type technique required bigger space and was more prone to contamination.	The production process was simplified using conventional fruiting bags to reduce cost on materials especially on the construction of beds. Fruiting can be done by opening fruiting bags upright and putting 3-4cm thick vermicast casing on top.	
Ganoderma Mushroom		
Rice straw as substrate is inappropriate as it results in small mushroom fruiting bodies.	Use of 78% hardwood sawdust + 20% rice bran + 1% lime + 1% brown sugar as substrate resulted in bigger fruiting bodies and longer duration of fruiting bags.	

PHILRICE ISABELA EXPERIENCES

Appendix Table 1. Detailed returns over variable costs of mungbean production per hectare, PhilRice Isabela.

Item	Value (₱)
Materials	
Seeds	2,400
Foliar fertilizer	380
Insecticides	900
Gasoline	400
Total Material Cost	4,080
Labor	
Puddling of rice stubbles and flush irrigation	2,800
Spraying	1,680
Harvesting	8,400
Threshing and cleaning	2,800
Drying and storing	840
Total Labor Cost	16,520
Total Variable Costs	**20,600**
Gross Income	**90,000**
Gross Margin	**69,400**

Appendix Table 2. Detailed returns over cash expenses for vegetable production ($200m^2$ area), PhilRice Isabela.

Item	Value (₱)
Materials	
Seeds	50
Fertilizers and chemicals	330
Fuel	35
Contingency (10%)	185.50
Total Material Cost	600
Labor	
Seed sowing	70
Land preparation	280
Crop care (transplanting, watering, weeding, fertilizer application, spraying)	840
Harvesting	280
Total Labor Cost	1,470
Total Variable Costs	**2,070**
Gross Income	**9,000**
Gross Margin	**6,930**

**Farmgate price*

Appendix Table 3. Detailed returns over cash expenses for vegetable and seedling production (6 weeks/cycle), PhilRice Isabela.

Item	Value (₱)
Materials	
Seeds (one per crop)	50
Seedling tray (105 holes)***	450
Vermicompost	75
Calcium	100
Total Material Cost	675
Labor	
Soil mix preparation	140
Sowing	560
Miscellaneous (15%)	247.50
Total Labor Cost	947.50
Total Variable Costs	**1,622.50**
Gross Income	**3,600**
Gross Margin	**1,977.50**

**** Seedling trays can be used several times*

Appendix Table 4. Detailed returns over cash expenses for swine production, PhilRice Isabela.

Item	Fattener Value (₱) 1 head	Breeder Value (₱) 14 litters/farrowing
Materials		
Starter feeds	1,100	6,500
Grower feeds	150	4,200
Finisher feeds	500	1,200
Gestating feeds	500	2,000
Lactating feeds	200	1,000
Vaccination	500	800
Total Material Cost	8,620	29,470
Labor		
Care and maintenance		1,000
Total Labor Cost		1,000
Total Variable Costs	**8,620**	**30,470**
Gross Income	**8,925**	**39,270**
Gross Margin	**305**	**18,705**

Appendix Table 5. Detailed returns over variable costs for oyster mushroom production (1000 fruiting bags), PhilRice Isabela.

A. Fruiting Bag Production			
1. Material Cost		Quantity	Value (₱)
Substrates			
Rice bran	3	kg	45
Sawdust	3	bag	75
Bagging Materials			
Polypropylene bag, 6″x12″	10	pack	2,000
PVC pipe, 3/4″	7	pc	2,100
Rubber band	2	kg	100
Cotton	10	pack	2,000
Pasteurization Materials			
Steel drum	4	unit	68
Inoculation Materials			
Grain spawn	40	bot	2,400
Alcohol	2	bot	200
Denatured alcohol	2	bot	140
Total Material Cost for Fruiting Bag Production			8,128
2. Labor Cost		MD	Value (₱)
Substrate preparation		8	2,240
Bagging of substrates		10	2,800
Pasteurization		3	840
Inoculation		3	840
Total Labor Cost for Fruiting Bag Production			6,720
Cost of producing 1 fruiting bag			14.85
B. Fresh Oyster Mushroom Production			
1. Material Cost		Quantity	Value (₱)
Fruiting bags	1000	bag	14,848
2. Labor Cost		MD	Value (₱)
Opening of bags		3	840
Watering		4	1,120
Harvesting, sorting, and selling		5	1,400
Total Labor Cost for Oyster Mushroom Production			**3,360**
Cost of oyster mushroom fruit production per bag			**18.21**

a – PVC pipe can be used 10 times
b – steel drum can be used for 35 pasteurization batches
c – cheesecloth can be used 15 times
d – 1 bottle of grain spawn can inoculate 70 fruiting bags
e – cost of producing fruiting bags from item A

Appendix Table 6. Detailed returns over variable costs for vermicomposting*, PhilRice Isabela.

Item	Value (₱)
Materials	
Manure	500
African Night Crawler earthworms	2,000
Sack and plastic	320
Fuel	125
Total Material Cost	2,945
Labor	
Hauling and filling of substrates into the beds	840
Harvesting and packaging	1,120
Total Labor Cost	1,960
Total Variable Costs	**4,905**
Gross Income	**9,000**
Gross Margin	**4,095**

*4 - 2m^2 vermi beds at 2 weeks/cycle

PHILRICE LOS BAÑOS EXPERIENCES

Appendix Table 1. Detailed returns over variable costs of special-quality rice production, PhilRice Los Baños.

Item	Value (₱)		
	Rc 160	**Black Rice**	**Red Rice**
Materials	23,430	13,520	13,520
Seeds	1,360	1,600	1,600
Fertilizers	20,170	11,920	11,920
Pesticides	1,900	0	0
Labor	47,378	67,856	67,856
Seedbed preparation	1,080	2,160	2,160
Seedling management	5,891	11,782	11,782
Land preparation	10,464	20,927	20,927
Crop establishment	14,900	14,900	14,900
Fertilizer application	3,044	6,087	6,087
Irrigation (x times)	3,500	3,500	3,500
Harvesting	8,500	8,500	8,500
Total Variable Costs	70,808	81,376	81,376
Gross Income	131,580	174,200	154,700
Gross Margin	60,772	92,824	73,324

Appendix Table 2. Detailed returns over variable costs of oyster mushroom and fruiting bag production, PhilRice Los Baños.

Item	Value (₱)	
	oyster mushroom fruiting bag	oyster mushroom
Materials	6,220	7,850
Fruiting bag materials	5,060	7,430
Fuel	1,160	420
Labor	10,309	20,127
Hauling of rice straw	2,455	2,455
Shredding	1,473	2,455
Bagging	2,455	3,927
Pasteurization	2,455	3,927
Planting of grain spawn	1,473	2,455
Harvesting	0	4,909
Total variable costs	16,529	27,977
Gross income	20,895	33,400
Gross margin	4,366	5,423

Appendix Table 3. Detailed returns over variable costs of vermicomposting, PhilRice Los Baños.

Item	Value (₱)
Materials	23,220
Vermicomposting materials	20,700
Fuel	2,520
Labor	20,127
Hauling of rice straw	2,455
Shredding	2,455
Hauling of carabao manure	3,927
Material stocking	3,927
Harvesting and winnowing	2,455
Bagging	4,909
Total Variable Costs	43,347
Gross Income	66,250
Gross Margin	22,903

Appendix Table 1. Returns over variable costs in producing grain spawns, PhilRice CES, 2017.

A. Labor Cost		**Man-Days**	**Wage Per Day**	**Amount (₱)**
Preparing grains, cooking, bagging, sterilization		0.5	250	125
Inoculation		0.25	250	62.50
Subtotal				**187.5**
B. Materials	**Quantity**	**Unit**	**Unit Price**	**Amount (₱)**
Polypropylene bags	20	pc	0.545	10.90
PVC pipe	0.08	pc	75	6
Cotton waste	0.06	kg	35	2.10
Rubber band	0.01	kg	155	1.55
Isopropyl alcohol	0.25	bot.	72	18.00
Face mask	1	pc	6	6
Denatured alcohol	0.1	bot.	20	2
Zonrox	0.2	bot.	15	3
Hand gloves	2	pc	35	70
Rice Grain	9	kg	18	162
Pure Culture	1	bot.	300	300
LPG	1	per use	11.36	11.36
Power	1.5	kw/h	14.24	21.36
Subtotal				**614.27**
Total Variable Costs				**801.77**
Cost per Bag				**40.09**

Appendix Table 2. Returns over variable costs in producing fruiting bags, PhilRice CES, 2017.

A. Labor Cost		**Man-Days**	**Wage Per Day**	**Amount (₱)**
Hauling of Rice straw		0.5	250	125
Soaking of Rice Straw		0.5	250	125
Shredding of Rice Straw & Mixing		0.5	250	125
Bagging		2	250	500
Sterilization		1	250	250
Inoculation		0.5	250	125
Hauling and Hanging of FB		0.5	250	125
Subtotal				**1375**
B. Materials	**Quantity**	**Unit**	**Unit Price**	**Amount (₱)**
Polypropylene bags	500	pc	0.545	272.50
Rubber band	0.25	kg	155	38.750
Isopropyl alcohol	0.6	bot.	72	43.20
Face mask	4	pc	6	24
Denatured alcohol	0.5	bot.	20	10
Zonrox	0.5	bot.	15	7.50
Hand gloves	2	pc	35	70
Grain spawn	3	bag	150	450
Plastic sack	5	pc	8	40
Sawdust	3.75	sack	37.5	140.625
Rice hull	8	bag	13.8	110.40
Rice straw	1.5	truckload	200	300
Fuel	1	li	40	40
Subtotal				**1546.975**
Total Variable Costs				**2921.98**
Cost per Fruiting Bag				**5.84**

Appendix Table 3. Returns over variable costs in producing oyster mushroom, PhilRice CES, 2016.

A. Cost of Production	Quantity	Unit	Unit Price (₱)	Amount (₱)
Fruiting Bag (FB)	31147	bag	5.84	181,898.48
Grain spawn	1006	bag	40.09	40,330.54
Harvesting mushroom (labor)	12	month	250/day (26 half days / month)	39,000
Total Variable Costs				**261,229.02**
B. Sales	**Quantity**	**Unit**	**Unit Price (₱)**	**Amount**
Fruiting Bag	6925	Bag	20	138,500
Fresh Oyster mushroom	2478	Kg	160	396,480
Grain spawn	793	Bag	150	118,950
Gross Income				**653,930**
Gross Margin				**392,700.98**

Appendix A

OYSTER MUSHROOM CULTIVATION TECHNOLOGY

PREPARING THE MUSHROOM CULTURE MEDIA

The simplest and most commonly used mushroom culture media is the potato sucrose agar (PSA) or potato sucrose gelatin (PSG) because it is cheap and readily available.

1. In producing the mushroom culture media, prepare 250g peeled and cubed potatoes, 10g table sugar, and 20g agar or shredded gelatin, and 20 clean flat bottles.
2. Boil the potatoes in 1liter of water until tender.
3. Collect the broth then add water until the volume reaches 1L.
4. Boil the broth again, slowly add the table sugar followed by the agar or gelatin.
5. Continue boiling while stirring until the agar or gelatin melts.
6. Dispense approximately 50ml culture media in each clean flat bottle using a funnel. The broth can fill around 20 flat bottles.
7. Plug each flat bottle with rolled cotton then cover it with a piece of paper secured with rubber band to prevent the cotton from absorbing moisture during sterilization.
8. Sterilize the flat bottles with the culture media in an autoclave at 15psi, $121^{0}C$ for 30min.
9. Turn off the autoclave after sterilization, and then wait for the pressure to go down to zero before opening it.
10. Remove the flat bottles with the sterilized media from the autoclave then arrange them in slanting position. Care must be taken to ensure that they do not touch the cotton plug.
11. Allow the sterilized media to solidify before inoculating it or storing it for future use.

PREPARING THE MUSHROOM TISSUE CULTURE

1. Choose a large, healthy and mature mushroom fruiting body for tissue culture.
2. Put the chosen mushroom in a clean, open container lined with tissue paper. Place it in a well-ventilated room for 1hr to reduce the moisture content.
3. Disinfect the inoculation chamber by wiping it with tissue paper or cotton moistened with rubbing alcohol.
4. Place the chosen mushroom inside the inoculation chamber, and the flat bottles of slant culture medium, alcohol lamp, match, inoculating needle, and scalpel.
5. Disinfect your hands and arms with rubbing alcohol before inserting them inside the inoculation chamber.
6. Light the alcohol lamp then flame-sterilize the inoculating needle and scalpel.
7. Split the mushroom fruiting body in half to expose the middle part. Be careful not to come in contact with the exposed middle part to avoid contamination.
8. Slice a square millimeter tissue of the exposed middle part of the mushroom with the sterile scalpel.
9. Pick the sliced mushroom tissue using the sterile inoculating needle.
10. Hold the bottom of the flat bottle slant culture medium with one hand, then remove the cotton plug with the little and ring fingers of the other hand holding the inoculating needle with the sliced mushroom tissue.
11. Flame-sterilize the opening of the flat bottle slant culture medium with the alcohol lamp.
12. Place the sliced mushroom tissue carefully into the center of the slant culture medium inside the flat bottle, then flame-sterilize again the opening of the bottle with the alcohol lamp.
13. Seal the flat bottle of inoculated culture media with the cotton plug.
14. Properly label the inoculated flat bottles of culture media with the date of inoculation and type of mushroom.
15. Repeat the procedure until the desired number of tissue culture has been met.
16. Incubate the inoculated culture media at room temperature, preferably 25-30^{0}C for about 10 days.

PREPARING THE MUSHROOM PURE CULTURE

1. Disinfect the inoculation chamber by wiping it with tissue paper or cotton moistened with rubbing alcohol.
2. Place the alcohol lamp inside the inoculation chamber, and the match, flat bottle of tissue culture stock, flat bottle of culture media, and inoculating needle.
3. Disinfect your hands and arms with rubbing alcohol before inserting them inside the inoculation chamber.
4. Light the alcohol lamp. Remove the cotton plug of the flat bottle of tissue culture stock, then pass the opening of the bottle under the flame of the alcohol lamp.
5. Flame-sterilize the inoculating needle with the alcohol lamp. Slice a square-millimeter mycelial block from the tissue culture stock with the sterilized inoculating needle.
6. Pinch the sliced mycelial block with the sterilized inoculating needle, then take it out carefully avoiding contact with any surface.

7. Flame-sterilize again the opening of the bottle of tissue culture stock, then seal it with cotton plug before setting it aside.
8. Hold the flat bottle of culture media with the other hand, then remove the cotton plug with the middle and ring fingers of the hand holding the inoculating needle with the sliced mycelial block.
9. Flame-sterilize the opening of the flat bottle of culture media over the alcohol lamp, then carefully place the mycelial block at the center of the culture media inside the flat bottle.
10. Flame-sterilize again the opening of the flat bottle of inoculated culture media, then seal it with the cotton plug.
11. Properly label the flat bottles of inoculated culture media with the date of inoculation and type of mushroom.
12. Incubate the inoculated culture media at room temperature (25-30°C) for about 10 days.

PREPARING THE GRAIN SPAWN

1. Prepare 10kg rough rice, sorghum or cracked corn seeds, then wash them 2-3 times or until the foreign materials are removed and the water becomes clear.
2. Boil the seeds to soften the outer layer. Do not overcook or let the grains crack to prevent them from becoming sticky.
3. Drain the boiled grains until the moisture content is about 65% or no water dripping between the fingers when the substrate is squeezed, which is ideal for mycelial growth.
4. Fill each polypropylene (PP) bag (size 6 x 12in) with approximately 500g of boiled grains. Close the PP bags with a rubber band.
5. Sterilize the PP bags filled with grains in an autoclave at 121^0C, 15psi for 30min.
6. After sterilization, switch off the autoclave then wait for the temperature to drop to zero before opening it.
7. Remove the sterilized PP bags filled with grains from the autoclave, and place them in the inoculation room to cool down.
8. Flame-sterilize the inoculating needle with the alcohol lamp.
9. Slice a square-millimeter mycelial block from the pure culture stock with the sterilized inoculating needle, then inoculate it into the sterilized grains in the PP bags.
10. Repeat the procedure until the desired number of PP bags with grains are inoculated. Properly label the flat bottles of inoculated culture media with the date of inoculation and type of mushroom.
11. Incubate the newly inoculated PP bags of grains at 25-30^0C for 2 weeks until the mycelial growth reaches the bottom of the PP bag, or until the mycelium colonizes the substrate.

PREPARING THE RICE-STRAW FRUITING BAGS

1. Soak the rice straw in the soaking tank to soften it (fresh straw for 12hr and 3hr for old straw). Remove the soaked rice straw from the tank then pile it on an elevated platform to drain the excess water.
2. Cover the rice straw with plastic sheet for 5 to 7 days to enhance the decomposition process and release of bioactive substances.
3. Chop the partially composted rice straw with a bolo 2 to 3in long or shred it with a shredding

machine.

4. Mix 3 parts sawdust (p/v) to 7 parts (p/v) of the chopped composted rice straw.
5. Adjust the moisture content of the substrate mixture to around 65% or no water dripping between the fingers when the substrate is squeezed.
6. Insert the molder in the 6 x 12in PP bag, then fill it with the rice straw-sawdust substrate mixture.
7. Compress the substrate mixture by pounding it with the end of a GI pipe (1-inch-diameter x 2-feet-long) until the PP bag is about 90% filled, then remove the molder. One fruiting bag weighs 750 to 1,000g.
8. Secure the opening of the PP fruiting bag by tying it with a rubber band.
9. Pasteurize the fruiting bags at 60-80^{0}C for 6 to 8hr to eliminate contaminants. Allow the fruiting bags to cool down before transferring them to the inoculation room for spawn inoculation.

INOCULATING OR SPAWNING FRUITING BAGS

Spawn is the general term for mushroom seeds used in inoculating mushroom substrates or fruiting bags.

1. Disinfect hands and arms with rubbing alcohol before spawning.
2. Crumble the grain spawn bag to separate the grains covered with mycelia.
3. Open the grain spawn bag.
4. Open the fruiting bag by removing the rubber band, then place 3 to 5g of grain spawn inside the fruiting bag.
5. Close the fruiting bag by securing it with a rubber band.
6. Repeat the process until all fruiting bags have been inoculated or spawned.
7. Inoculated fruiting bags are incubated in the incubation room. Temperature range is 25 to 30°C with subdued light for 3 to 4 weeks, or until mycelia cover the entire substrate in the fruiting bag.

FRUITING AND HARVESTING

1. Transfer the fully ramified fruiting bags to the growing house.
2. Arrange the fruiting bags in hanging ropes inside the growing house.
3. Open one end of or make several slits on the fruiting bag with a clean sharp cutter or knife. The fruiting bodies or pin heads start to grow three (3) days after opening or slitting the fruiting bags.
4. The oyster mushroom is ready for harvest 3 to 5 days after the appearance of the pin heads.
5. To harvest, pull the cluster of mushroom growth with your bare hands.
6. After harvesting, scrape any mushroom remnants on the opening or slit of the fruiting bag.
7. Spray the opening of the fruiting bags with clean water to prevent them from drying. Spray 2 times or more per day during hot and dry weather.
8. To maintain the relative humidity of the growing house, spray water regularly but avoid spraying on the mushrooms directly. You can also wet the floor or leave open containers with water in the growing house.

Appendix Table 1. Detailed returns over variable costs of 6-ha organic rice seed production, PhiLRice Negros, DS 2017.

Item	Value (₱)
Materials	
Seeds (RS)	1,600
Fertilizers	3,750
Sacks	4,000
Others	10
Labor	**12,526.67**
Seedbed preparation *(2_md)*	1,080
Seedling management	81.67
Land preparation *(per ha)*	1,688.33
Crop establishment *(per ha)*	1,000
Fertilizer application	-
Irrigation	1,225
Pest management *(per ha)*	1,150
Roguing *(per ha)*	735
Harvesting *(per ha)*	1,166.67
Postharvest activities *(per bag)*	4,400
Total Variable Costs	**21,886.67**
Gross Income	**100,000**
Gross Margin	**78,113.33**

Appendix Table 2. Detailed returns over variable costs of swine production (1 head) based on two modes of marketing, 4-month cycle, PhilRice Negros.

Item	Marketing Scheme	
	Operator's (₱)*	**Pesada (₱)****
Materials	**7,400**	**7,400**
Feeds	4,900	4,900
Piglet	2,500	2,500
Gasoline	300	300
Water	150	150
Labor	**1,468.70**	**1,469**
Maintenance and Feeding	1,181	1,468.70
Total Variable Costs	8,581	8,869
Gross Income		
PhilRice: 67kg x ₱190.00/kg	**12,730**	**10,720**
Pesada: 67kg x ₱160.00/kg		
Gross Margin	**4,149**	**1,851**

Appendix Table 3. Detailed returns over variable costs of duck and tilapia production, PhilRice Negros, 2015-2017.

Item	Value (₱)	
	Duck	Tilapia
Materials	**30,900**	**13,500**
Ducklings *(1000 heads)*	20,000	
Feeds *(rice bran, starter/ grower feeds, copra meal); (tilapia booster, starter, grower feeds)*	10,900	13,500
Labor	**22,500**	**10,000**
Feeding and Maintenance	22,500	10,000
Total Variable Costs	**53,400**	**23,500**
Gross Income	**87,616**	**33,100**
Gross Margin	**34,216**	**19,600**

Appendix Table 4. Detailed returns over variable costs of vermicomposting, Sep 2016-May 2017, PhilRice Negros.

Item	Value (₱)
Materials	**2,700**
Vermi earthworms (ANC)	2,500
Water	200
Labor	**10,000**
Substrate Preparation and Harvesting	12,700
Total Variable Costs	**12,700**
Gross Income	**24,000**
Gross Margin	**11,300**

Appendix Table 1. Detailed returns over variable costs of rice seed production, PhilRice Agusan, January to December 2016.

ITEM	VALUE (₱)
Materials	**5,203.18**
Seeds	1,700
Fertilizers	1,990.45
Pesticides	-
Fuel	955.41
Sacks	557.32
Labor	**72,181.69**
Seedbed preparation	6,090.92
Seedling management	3,821.66
Land preparation	4,633.76
Crop establishment	5,573.25
Fertilizer application	3,392.99
Others	20,802.87
Irrigation (twice)	**2,388.54**
Pest management	**14,331.21**
Harvesting	**5,573.25**
Postharvest activities	**5,573.25**
Total Variable Costs	77,384.87
Gross Income	154,935.51
Gross Margin	77,550.64

Appendix Table 2. Detailed returns over variable costs of rice+duck farming and swine production, PhilRice Agusan, January to December 2016.

ITEM	VALUE (₱)	
	Rice+Duck	Swine
Materials (duck production)	**16,820**	**351,535.20**
Half-filled rice grains	5,000	
Rice bran	10,000	
Mesh net	1,200	
Egg tray	250	
Plastic cellophane	370	
Feeds and veterinary supplies (swine)		351,535.20
Labor	**22,500**	**122,890.65**
Herding of ducks and preparation of feedstuff	11,250	
Harvesting and packaging of eggs	5,625	
Installation of net fence and repair of duck house	5,625	
Feeding, cleaning, and maintenance		107,329
Indirect cost		15,561.65
Total Variable Costs	**39,320**	**474,425.85**
Gross Income	**49,621**	**555,699**
Gross Margin	**10,301**	**81,273.15**

Appendix Table 3. Detailed returns over variable costs in producing grain spawn, PhilRice Agusan, 2016.

A. Labor Cost		Man-Days	Wage Per Day	Amount (₱)
Mushroom tissue culture		0.06	250	15
Preparation, sterilization and plating of culture media		0.50	250	125
Preparation of grains, cooking, bagging and sterilization and inoculation		0.75	250	187.50
Inoculation of fruiting bags		0.50	250	125
Subtotal				452.50
B. Materials	**Quantity**	**Unit**	**Unit Price (₱)**	**Amount (₱)**
Plastic bag, PP, 6″x10″	20	pc	0.90	18
Rice grains	4	kg	18	72
Rubber band	0.25	box	25	6.25
Face mask	1	pc	6	6
Hand gloves	2	pc	3.50	7
LPG	1	per use	11.36	11.36
Power (electricity)	1.5	kw/h	14.25	21.38
Alcohol technical, 95%	0.25	liter	120	30
Subtotal				171.99
Total Variable Costs				**624.49**
Cost per Bag				**31.22**

Appendix Table 4. Detailed returns over variable costs in producing fruiting bags, PhilRice Agusan, January to December 2016.

Labor Cost		Man-Days	Wage Per Day	Amount (₱)
Collection and hauling of rice straw		0.50	250	125
Soaking of rice-straw substrates		0.50	250	125
Shredding and soaking of rice straw		0.50	250	125
Bagging		2	250	500
Sterilization and inoculation		1	250	250
Hauling and hanging of fruiting bags		0.50	250	125
Subtotal				**1,250**
Materials	**Quantity**	**Unit**	**Unit Price (₱)**	**Amount (₱)**
Rice straw	1	truck load	150	150
Plastic bag, PP, 6"x12"	500	pc	0.90	450
PVC pipe, 3/4 diameter	1	length	120	120
Rubber band, small	5	box	25	125
Cotton waste	4	kg	40	160
Steel drum	1	pc	850	850
Wood	0.5	truck load	200	100
Grain spawn	5	bag	100	500
Alcohol, 95%	0.5	li	120	60
Match	0.1	box	2	0.20
Isopropyl alcohol, 70%	0.2	bottle	65	13
Plastic sacks	3	pc	15	45
Fuel	1	li	40	40
Subtotal				2,613.20
Total Variable Costs				**3,863.20**
Cost per fruiting bag				**7.73**

Appendix Table 5. Detailed returns over variable costs in producing fresh mushroom fruit, PhilRice Agusan, January to December 2016.

A. Labor Cost		**Man-Days**	**Wage Per Day**	**Amount (₱)**
Opening of bags		1	250	250
Application of mist, 1-2x a day		0.25	250	62.50
Harvesting, processing, and packaging		22	250	5,500
Subtotal				5,812.50
B. Material cost	**Quantity**	**Unit**	**Unit Price**	**Amount (₱)**
Fruiting bags	500	bag	7.73	3,865
Subtotal				**3,865**
Total Variable Costs				**9,677.50**
Cost of mushroom fruit production per bag				**19.36**

Appendix Table 6. Detailed returns over variable costs of mushroom production, PhilRice Agusan, January to December 2016.

Cost of Production	**Quantity**	**Unit**	**Unit Price (₱)**	**Amount (₱)**
Fruiting bags	9,495	bag	7.73	73,396.35
Grain spawn	148	bag	31.22	4,620.56
Harvesting of mushroom *(spent 2 hours per day)*	58.13	day	250	14,532.29
Total Variable Costs				**92,549.20**
Sales	Quantity	Unit	Unit Price (₱)	Amount (₱)
Fruiting bag	2,941	bag	15	44,115
Grain spawn	85	bag	100	8,500
Fresh Oyster mushroom	583.22	kg	120	69,986.40
Gross Income				**122,601.40**
Gross Margin				**30,052.20**

Appendix Table 7. Detailed returns over variable costs of vermiculture production, PhilRice Agusan, 2016.

ITEMS	Value (₱)
Materials	**6,050**
Vermiworm	4,000
Substrates	1,500
Sacks	250
Others	300
Labor	**3,560**
Processing of different substrates	2,000
Harvesting of vermicompost & vermicast	1,560
Total Variable Costs	**9,610**
Gross Income	**15,750**
Gross Margin	**6,140**

Appendix Table 8. Technical issues encountered in rice+duck production and solutions undertaken, PhilRice Agusan.

Problem/Issue	Solutions	Remarks
A. Site selection	An area in the irrigated lowland is preferable for easy access to irrigation	
B. Establishment of duck house	Provision of a duck shed and use of light materials such as bamboo and nipa for roofing	Unavailability of duck shed upon acquisition resulted in higher mortality
C. Crop establishment	Rotovation of the area in 3 passings to properly level the field, and application of organic fertilizer during the final harrowing to improve the fertility of the soil to increase rice yield	Less than three passings during rotovation favored fast growth of weeds
D. Nutrient management	50:50 basal application of organic and inorganic fertilizers lessens the use of expensive inorganic fertilizers	Application of nitrogen fertilizer more than 90kg/ha makes the rice crop susceptible to insect pests and diseases
E. Pest management	Application of biological control agents such as fungal microbial *(M. anisopliae)* and parasitoids *(T. japonicum)* against white stemborer reduced insect population	
F. Postharvest	Use of mechanical or combine harvester lessened personnel requirement and hastened postharvest operations	

Appendix Table 8. (continuation)

Problem/Issue	Solutions	Remarks
G. Herding of ducklings	Herding of 10 to 15-day-old ducklings over 15-day-old rice seedlings helped control golden apple snails and prevented weed infestation	Matured ducks herded in newly transplanted rice caused damaged to plants
H. Duck egg production	Ensuring that ducks laid eggs in dry areas facilitated egg collection	Allowing ducks to lay eggs in irrigated field damaged the eggs
I. Harvesting of duck eggs	Collection and harvest of duck eggs every morning to avoid cracking	Unavailability of incubators prevented hatching of commonly known Pateros ducks
J. Duck feed formulation	Use of azolla (freshly collected), half-filled rice grains, rice bran, kangkong, and golden apple snails as sources of protein for daily duck feed proved economical	

Appendix Table 9. Technical issues encountered in mushroom production and solutions undertaken, PhilRice Agusan.

Problem/Issue	Solutions	Remarks
Oyster mushroom *(P. florida)*		
A. Soaking of rice straw	Soaking and composting of fresh rice-straw substrates for 7 days in flowing water resulted in good-quality substrate for oyster mushroom	Soaking and composting of rice-straw substrates in stagnant water resulted in poor-quality substrate
B. Source of water	Deep-flowing water system near the soaking tank facilitated processing of the substrates	Poor water supply from the sources delayed processing of the substrates
C. Formulation of substrates	Composted rice straw must have 60% moisture content (no water comes out when pressed by hand) and placed in PP or heat-resistant plastic bags	Sterilization of fruiting bags for only 2 hours resulted in high contamination; recommended duration is 6-8 hours
D. Bagging of substrates	Use of folded paper as alternative for PVC in fruiting bags to save on cost	

Appendix Table 9. (continuation)

Problem/Issue	Solutions	Remarks
E. Pasteurization	Pasteurize fruiting bags 6-8 hours to fully sterilize the substrates	Fruiting bags of mushroom harvested after 2-3 days became matured fruit and dried easily
F. Inoculation of grain spawn	Inoculate fruiting bags aseptically in an improvised isolation chamber to avoid contamination	
G. Harvesting of mushroom	Fresh mushroom fruiting bodies harvested in bunch to avoid drying of the remaining part of growing mushroom	
H. Processing of mushroom	Pack fresh mushrooms properly with small holes on plastic cellophane to avoid moisture accumulation that results in bacterial contamination	
I. Preparation of grain spawn	Pack grain spawn in PP plastic cellophane and tie it with rubber band for ease in inoculation	Seed separation is difficult if grain spawn is placed in bottled jars and covered with cotton
Paddy mushroom (*Volvariella volvacea*)		
A. Preparation of culture substrates	Use of culture substrates like dried banana leaves enhances mushroom growth and harvest of mushroom	Too much substrate in the fruiting bag suppresses growth of paddy mushroom
B. Personnel	Pooling of personnel facilitated substrates preparation	Delays in preparation and collection of substrates due to unavailability of personnel

Appendix Table 10. Technical issues encountered in vermiculture and composting, and solutions undertaken, PhilRice Agusan.

Problem/Issue	Solutions	Remarks
A. Establishment of vermi bin	Must have a vermi shed to protect the worms (ANC) from rain or direct sunlight; also to prevent them from escaping	
B. Production of vermi worm, compost and vermicast	Establishment of two temporary vermi bins (4m x 1m) to produce vermicompost and vermicast	Vermi bin established in a low-lying area is prone to flooding
C. Feeding of African Night Crawlers (ANC)	Ensuring that substrates needed to feed the ANC are available and sufficient, so they do not to escape from the vermi bin	
D. Care and maintenance	Feeding the worms with pre-decomposed substrates such as vegetable waste (3%), kakawate leaves (17%), water lettuce, *P. stratiotes* (3%), banana bract (3%), rice straw (3%), swine compost (3%), cattle waste (17%) and mushroom waste (17%), manure (15%), grasses (17%) and banana peeling (17%) as source of N, P & K for vermicompost production	Fresh manure and other sources of N and K should not be fed directly to the worms as they might cause the temperature to rise in the vermi bin that might kill them
E. Harvesting of vermicast	Provision of a nylon net cover prevented predators such as birds, millipedes, and frogs from eating the vermiworms	
F. Processing of organic fertilizer	Separating vermicast from vermicompost resulted in high-quality vermicast sold at a high price	
G. Water management	Moistening the substrates in the bin every day at 60-80% MC to enhance decomposition and production of vermicast and compost	

Appendix Table 11. Technical issues encountered in livestock production and solutions undertaken, PhilRice Agusan.

Problem/Issue	Solutions	Remarks
A. Shed establishment	Establishment of a piggery shed with bedding composed of 20% carbonized rice hull (bottom layer), 40% rice hull (middle), and 40% sawdust (top) to produce swine manure with additional sawdust after every 2 weeks	
B. Harvesting of manure	Harvested swine manure should be composted for 6 months before using it to feed the worms or as soil conditioner to improve organic matter	Failure to add sawdust in piggery pen resulted in unpleasant odor
C. Water management	Installation of water tank and provision of nipple drinker to ensure continuous water supply for the pigs	Providing water on a basin was laborious and prone to contamination
D. Care and maintenance	Feeding newly weaned piglets twice a day with high-protein commercial feeds (pre-starter feeds) resulted in faster growth	Feeding the piglets once a day with low-protein content resulted in slow growth
E. Feeding ratio	Changing of feeding rations from time to time is important depending on the age and desired weight of the swine; use of bananas as feedstuff for growing-finishing hogs as substitute for commercial feeds	Restricting feeding to starter feeds all throughout the growing period
F. Vaccination	Prescribing veterinary drugs to prevent the occurrence of any disease infections and presence of parasites	
G. Collection of wastes	Ensuring that the bedding is changed or removed prior to placing another stock to avoid unpleasant odor	

Appendix Table 1. Detailed returns over variable costs of rice seed production, PhilRice Midsayap, 2016-2017.

	Contract Rate (P)				Unit	No. Of person hired				Amount				Total Amount
I.I. Labor cost	DS'2016	WS'2016	DS'2017	WS'2017		DS'2016	WS'2016	DS'2017	WS'2017	DS'2016	WS'2016	DS'2017	WS'2017	
Land preparation (pakyaw system-ready for planting)										5000	5100	5000	5000	5,025.00
Manual transplanting (pakyaw system)										6500	7000	7000	7000	6,875.00
Sub-total														₱ 11,900.00
I.II. Supplies and Materials	Quantity				Unit	Unit Price				Amount				Total Amount
	DS'2016	WS'2016	DS'2017	WS'2017		DS'2016	WS'2016	DS'2017	WS'2017	DS'2016	WS'2016	DS'2017	WS'2017	
Seeds (Foundation seeds)	40	40	40	30	kg	80	80	80	80	3,200.00	3,200.00	3,200.00	2,400.00	3,000.00
Fertilizer														
Complete (14-14-14)	2	2	2	2	bag	1,145.00	1,145.00	1,000.00	1,000.00	2,290.00	2,290.00	2,000.00	2,000.00	2,145.00
Ammonium phosphate (16-20-0)	1	1	1	1	bag	1,400.00	1,400.00	830.00	830.00	1,400.00	1,400.00	830.00	830.00	1,115.00
Ammonium sulfate (21-0-0-125)	1	1	1	1	bag	520.00	520.00	520.00	520.00	520.00	520.00	520.00	520.00	520.00
MOP (0-0-60)	1	1	1	1	bag	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00
Sub-total			₱											7,980.00
I.III. Herbicide and Molluscicide	Quantity				unit	Unit Price				Amount				Total Amount
	DS'2016	WS'2016	DS'2017	WS'2017		DS'2016	WS'2016	DS'2017	WS'2017	DS'2016	WS'2016	DS'2017	WS'2017	
Grassedge	1	1	1	1	quart	700	700	650	650	700.00	700.00	650.00	650.00	675.00
Gramoxone	1	1	1	1	gal	2500	2500	2500	2500	2,500.00	2,500.00	2,500.00	2,500.00	2,500.00
Bayluscide	1	1	1	1	quart	1000	1000	1050	1050	1,000.00	1,000.00	1,050.00	1,050.00	1,025.00
Sub-total			₱											4,200.00
I.IV. Fuel	Quantity				Unit	Unit Price				Amount				Total Amount
	DS'2016	WS'2016	DS'2017	WS'2017		DS'2016	WS'2016	DS'2017	WS'2017	DS'2016	WS'2016	DS'2017	WS'2017	
Gasoline	10	10	10	10	li	32	34.00	36	36	320.00	340.00	360.00	360.00	345.00
Diesel	15	15	15	15	li	30	32.00	34	34	450.00	480.00	510.00	510.00	487.50
Sub-total			₱											832.50

Appendix Table 1. (continuation)

I.V. Irrigation fee	1	1	1	1	ha	1500	1400	1,400.00	1,400.00	1,500.00	1,400.00	1,400.00	1,400.00	1,425.00
Sub-total														**1,425.00**
A. Harvesting Cost	Contract rate				Unit	total fresh wt/no. Of bags				Amount				Total Amount
	DS'2016	WS'2016	DS'2017	WS'2017		DS'2016	WS'2016	DS'2017	WS'2017	DS'2016	WS'2016	DS'2017	WS'2017	
Combine Harvester (Sharing)	9%	8.9%	8.9%			5079.625	5,460.68	3,988.24	5,078.23	7,771.83	8,748.02	6,389.15		7,636.33
Manual Harvesting and threshing share	-	-	-	9,000.00									9,000.00	9,000.00
Field sacks	15	15	15	15	pcs	88.00	95.00	68.00	60.00	1,320.00	1425	1,020.00	900	1,166.25
Hauling and drying	25.5	25.5	33.5	33.5	bag	88.00	95.00	68.00	60.00	2244	2422.5	2,278.00	2010	2,238.63
B. Post Harvest Operation Cost														
Processing WS' 2016	5.25	5.5	5.5	5.5	bag	119.00	118.00	148.00	137.00	624.75	649	814	753.5	710.31
Laminated sacks	25	25	25	25	pcs	119.00	118.00	148.00	137.00	2,975.00	2950	3,700.00	3425	3,262.50
Sub-total (mechanical)			₱											**15,014.02**
Total Cost			₱											**41,351.52**
C. Economic Analysis	Quantity (kg)				Total yield (kg)	Prevailing price (P)				Amount (P)				Total
	DS'2016	WS'2016	DS'2017	WS'2017		DS'2016	WS'2016	DS'2017	WS'2017	DS'2016	WS'2016	DS'2017	WS'2017	
Fresh weight	5,079.63	5,460.68	3,988.24	5,078.23	4,901.70									
Registered seeds	3,954.17	3,873.24	2,957.22	2,721.09	3,376.43	42.5	42.50	42.5	42.5	168,052.08	164,612.68	125,681.82	115,646.26	**143,498.21**
Shrinkage losses from paddy to processed seeds (kg)	1,125.46	1,587.44	1,031.02	2,357.14	1,525.27									
Shrinkage losses (%)														**31.12**
Gross income														**143,498.21**
NET income														**102,146.69**
Cost of production/kg														**12.25**
Benefit cost ratio														**3.47**

Appendix Table 2. Detailed cost of production per 50 hills of bitter gourd, string beans, cucumber and squash; 50 hills of eggplant, tomato, and lady finger; 25 hills of ginger, PhilRice Midsayap, 2016-2017.

Item	Value (₱)		
	Bitter gourd etc.	Eggplant etc.	Ginger
Materials	**90.2**	**69.4**	**114.2**
Seeds	55	55	
Bamboo pole	16	0	
Wire	9	0	
Thread	5	0	
Sowing/seedling tray	5.20	5.20	
Compost	9.20	9.20	
Planting material (ginger)			100
Used sack (printed, ginger)			5
Compost			9.2
Labor	**104.41**	**104.41**	**104.41**
Sowing of seeds	16.06	16.06	16.06
Transplanting	16.06	16.06	16.06
Watering of plants	64.25	64.25	64.25
Harvesting	8.03	8.03	8.03
Total Variable Costs	**126.96**	**127.54**	**218.61**
Total yield cost per hill	**2.54**	**2.55**	**8.74**

Appendix Table 3. Detailed cost of production for pechay and radish planted in a 1m x 1m area, PhilRice Midsayap, 2016-2017.

Item	Value (₱)
Materials	**64.2**
Seeds	55
Compost	9.2
Labor	**88.34**
Sowing	16.06
Watering	64.25
Harvesting	8.03
Total Variable Costs	**76.27**

Appendix Table 4. Detailed returns over variable costs for the production of one mushroom fruiting bag, PhilRice Midsayap, 2016-2017.

A. Oyster mushroom production		Quantity	Amount (₱)
Substrate			
Rice straw (P1/kg)			0.25
Bagging material			
Rubber band	fruiting bag	1	0.64
PVC pipes (1/4 diameter)	fruiting bag	1	0.875
Cotton	fruiting bag	1	0.25
Mesh cloth	fruiting bag	1	0.16
Grain	fruiting bag	1	0.5
Costs for bagging material of fruiting bag			**3.285**
Pasteurization of fruiting bags (per piece)			
Steel drum (can be used up to 2yr)			0.15
Fuel wood			0.625
Material Costs			**1**
Labor Cost (200kg rice-straw 500 fruiting bags)			
Collection of substrate and soaking	MD	1	1.028
Washing and drying of rice straw	MD	1	1.028
Shredding and packing 100 bags/day	MD	1	2.57
Pasteurization (160 bags/day)	MD	1	2.57
Inoculation (200 bags/day)	MD	1	1.285
Labor costs for production of 1 fruiting bag			**8.48**
Total			12.54
B. Paddy mushroom production			
Bedding material			
Spawn (270g/pack)	pack	2	50
Fertilizer for supplement (16-20-0)	g	5	0.09
Fish bag	piece	2	20
Material costs			**70**
Labor			
Collection and soaking of dried cardava leaves	md	0.5	16.0625
Establishment of beddings	md	0.5	16.0625
Labor costs			**32.125**
Total cost of producing 1LM paddy mushroom with 7 layers			**102**

Appendix Table 5. Detailed returns above variable costs of producing 50kg of vermicompost from rice straw mixed with banana leaves, rotten vegetables and carabao-manure substrates, PhilRice Midsayap, 2016-2017.

Item	Value (₱)
Materials	**58.15**
Sack	13
Carabao manure	30
Fish bag	15
Lambo (nylon thread)	0.15
Labor	**48.50**
Collection of substrate	9.63
Stocking of substrate	4.17
Watering and monitoring	8.03
Harvesting of vermicompost	10.60
Sieving and packing of compost	16.06
Total Variable Costs	**106.65**
Gross Income	**230.00**
Gross Margin	**123.34**

LEARNINGS AND RIPPLES (MIDSAYAP)

Table 1. Comparative gross margin between PalayPlus and conventional farming, PhilRice Midsayap.

Components	Gross Income (₱)
PalayPlus System	
Rice Enterprise	189, 321.96
Mushroom Enterprise	14, 029
Vermicompost Enterprise	14, 767
Vegetable Enterprise	4, 850
Total Gross Margin	222, 967.96
Conventional Farming with	
Rice Production only @P19/kg	81, 245
Difference in gross margin	141, 722.96
Percentage increase in gross margin	63.50%

Table 2. Comparative gross margin between PalayPlus with two components and conventional farming, PhilRice Midsayap.

Components	Gross Income (₱)
Palayamanan Plus	
Rice seeds + Mushroom production	203,350.96
Rice seeds + Vermicompost production	204,088.96
Rice seeds + Vegetable production	194,171.96
Conventional Farming	**81, 245.00**

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