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Technology adaptation and productivity of queen pineapple intercropped with peanut, corn, and taro in the Bicol Region, Philippines

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Abstract—Queen pineapple (*Ananas Comosus*) is one of the primary commodities in the Province of Camarines Norte, Philippines, and is known as the sweetest variety of pineapple. The pineapple-based farming technology package is an integrated cropping model that includes intercropping peanuts (*Arachis hypogaea*), corn (*Zea mays*), and taro (*Colocasia esculenta*) with Queen pineapple. The project aims to enhance the productivity of the Queen pineapple growers in Camarines Norte through the adaptation of intercropping for Queen pineapple. The 80 farmer cooperators' site from Binatagan, San Felipe, Plaridel, Caayunan of Basud; Matanlang, and Lugui of Labo; and Dagotdotan and Maisog of San Lorenzo Ruiz were clustered to ensure the market through technology demonstration and capacity enhancement trainings. As a result, intercropping of Queen pineapple + peanut + corn + taro has significantly gained an additional income as early as 4 – 5 months before harvest of the Queen pineapple, which takes 16 – 18 months' maturity. The ROI per crop gained from peanut was Php 18, 150.00/ hectare (28%); corn was Php 82, 896. 04/ hectare (67%); taro was Php 71, 647.50/ hectare (82%); and for the queen pineapple was Php 179, 780.00/ hectare (84.59%). The overall net income increased by Php 367,468.49 (+79.49%) and yield of 42 MT/ha. The study emphasizes the advantages of intercropping, including increase productivity, enhanced resource efficiency, lower labor and chemical inputs, pest and disease control, and maximizing the area. The study concludes that using this varied farming model can result in more resilient farming methods and sustainable food security.

***Keywords*—Queen Pineapple, Corn, Peanut, Taro, Intercropping Technologies**

INTRODUCTION

Queen pineapple is the sweetest variety in the Philippines and the primary commodity of Camarines Norte, Philippines (DA – HVCDP). The major producers of queen pineapple are the Municipalities of Basud with 916 hectares of production, San Lorenzo Ruiz with 460 hectares, Labo with 156 hectares, and San Vicente with 106 hectares. Other remaining Municipalities have only a share of an area of 0.2% – 4.4% from the total area of queen pineapple production of 1,950 hectares in the province of Camarines Norte. A survey was conducted by the Department of Agriculture - Camarines Norte Lowland-Rainfed Research Station on compendium of queen pineapple industry. The result showed low productivity of queen pineapple production due to lack of capital and financing institutions.

The farmers rely on the traditional knowledge. Only 13% attended training or read production guide manuals, and only 39% are members of organization/association while 69% have no membership. These problems result to poor quality of fruits, uniformed sizes and low return in income (Campita, 2019). According to the Agri Pinoy Trading Center in Vinzons, Camarines Norte, the prevailing farm gate price of good size Queen pineapple in the province is Php 10.00 – 15.00 and Php Php 2.00 for batterball sizes. However, in the Balintawak Market, Quezon City, the "bagsakan" of the fruit ranges from Php 25.00 – Php 30.00 for good size and Php 5.00 for batterball. The marketing arrangement was ladder-type scheme where the bigger the sizes command the higher price. Moreover, the planting density is directly proportional to planting density. The increase in population leads to increase in tonnage yield per hectare of Queen pineapple. (Campita, 2019).

In flower induction the best time was at 10-12 month after planting the fruit. The length, circumference and sugar content were noted as plant matured at the time of flower induction (Obrero, 1999). It also has a highest fruit weight, the lowest crown weight and shorter crown length. (Campita, 2019). This will enable or ensure a significant increase in the yield per hectare of the farmer cooperator. Crop diversification strategy will also be introduced to the pineapple growers to maximize the area and will provide additional income to the farmer. Based on the Participatory Rural Appraisal in Basud, Labo and San Lorenzo Ruiz, the

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identified problem was on the low income of the queen pineapple growers. This was due to the high cost of agricultural inputs, labor intensive and low quality of the produce (Jeromino *et al*., 2022). Queen pineapple is a long maturing plant that takes 18 months before harvesting. This fruit has high dependence on fertilizer that the farmers could not afford or sustain the production expenses. Therefore, most of these farmers borrow capital from the traders who unfortunately dictate the price of the produce. Thus, this project aims to increase the productivity and profitability of the farmer through diversified farming system, develop a planting and harvesting calendar and establish a collective marketing system for a sustainable production of queen pineapple in Camarines Norte.

METHODOLOGY

Courtesy call was conducted at the Local Government Unit (LGU) and Barangay Local Governemnt Unit (BLGU) and to the Local Chief Executive in different top producing municipalities such as San Lorenzo Ruiz, Basud and Labo. The project implementation arrangement and activities were discussed, along with the crafting of a memorandum of agreement (MOA) between the LGU, farmer cooperators, and Department of Agriculture Regional Field Office 5, and ensure the support of using four-wheel tractor during land preparation and the provision of Special Order for the designation of one Agricultural Technician that will assist in providing technical assistance and monitoring of the sites.

Site Selection, Identification and Profiling of Farmer Cooperators

A total of 80 sites were identified, validated and selected as to accessibility, willingness to adapt the technology, and were active members of the pineapple-based cooperative and association. Also, in site selection, open areas or under coconut areas with existing Queen pineapple production was prioritized. The selected areas of the project cooperators were from the Barangay of Binatagan, San Felipe, Plaridel, and Caayunan of Basud, Camarines Norte; Brgy. Maisog and Dagotdotan of San Lorenzo Ruiz, Camarines Norte; and Brgy. Lugui and Matanlang of Labo, Camarines Norte. Each farmer cooperator has allocated a total of 2500 square meter area for Queen pineapple + taro + peanut + corn production.

Establishment of Queen Pineapple Trail Site

Land preparation was done using a four-wheel tractor. Some of the farmers used a hand tractor to control the weeds and prevent the seeds to germinate. Soil sampling was done to determine the right fertilizer and right rate needed by each crop. The planting materials used were suckers with uniform in sizes measuring 1.1 – 1.4 inches in height and 300 – 500 grams. The Queen pineapple suckers were cured by exposing the roots section of the suckers under direct sunlight for drying to prevent from infectious and rotting of the stem. The plant spacing used was double row method with a distance of 100cm between rows 50cm within rows and 30cm between hills for the optimum growth and higher return on investments despite high planting density. It can accommodate a total of 44,400 plants per hectare for open area sites and 35, 777 plants per hectare for under coconut. This planting method had enough space for the intercropping of peanut, corn and taro. During planting, clustering approach was enforced to prevent the simultaneous harvesting. Each barangay consists of eight (8) farmer cooperators were grouped together to form into 10 clusters following the planting calendar. For the weed management, pre-emergence herbicides was applied at 10 days after planting. The succeeding weed control were performed by manual weeding to prevent nutrient competition or before fertilizer application.

Application of the fertilizer was based on the results of the soil analysis per crop. Four types of fertilizers were used such as complete, urea, muriate of potash and ammonium phosphate. This organic fertilizer was recommended for application and applied at 1, 4, 7 and 10 Months After Planting (MAP). Synchronized forced flowering was done through clustering method at 12MAP for a uniform flowering and fruiting to ensure bigger fruit and higher market price. Pineapple plants can be induced to flower from 10-12 MAP (Obrero, 1999). Harvesting of fruits were harvested at 4.5-5 months after flower induction and application of Gibberellic Acid (GA3). Additionally, when fruit reaches maturity index 1 and 2 or the whole fruit is still green and the bottom layer of first and second rows of eyes show signs of yellowing “silay”, it is harvestable (Campita, 2021). This maturity stage is suitable for market because it has prolonged the shelflife of the fruit.

Treatment and Experimental Design

The data gathered were fruit weight, fruit length, crown length, crown weight, fruit circumference (bottom, middle and top), and total soluble solid. The mean and standard deviation were calculated and the cost and return analysis of the farmers practice and techno demo for queen pineapple, peanut, corn, and taro were gathered. The Return of Investment (ROI) were determined and also the effect on the income on the farmer cooperator adapting the intercropping technologies. Moreover, the overall total cost of production and net income were compared.

Establishment of Intercropped Peanut, Corn and Taro

In planting of peanut, corn and taro as an intercrop in between the queen pineapple with distances of 15 cm for peanut, 25 cm for corn and 75 cm for taro, between hills that result to reduction of field maintenance, less labor expenses, pest and disease, and addition farmers’ profit. The rates and time of fertilizer applied was based on soil analysis result for each crop. Pesticide application was applied to protect sweetcorn and peanut to the possible outbreak of insect pest and diseases so as to produce quality fruits. Harvesting of taro setts was harvested in 4 months after planting and in a weekly interval. Corn was harvested when a black layer forms on the grain at the point where it meets the cob. Matured and ready to harvest peanut was determined when leaves have turned to yellow and started to wither and most of the peanut pods have hardened.

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Queen Pineapple Results

The result showed that the highest average fruit weight was from the Barangay Matanlang, Labo, Camarines Norte of which was 1,142kg, while the lowest fruit weight was 747kg in Barangay Lugui, Labo, Camarines Norte. In terms of the fruit sweetness (TSS), the fruit with the highest of 17 °Brix was observed in Brgy. Maisog, San Lorenzo Ruiz, Cam Norte; Binatagan and Caayunan, Basud, Cam Norte and the lowest TSS was 14°Brix in Brgy Lugui, Labo, Cam Norte. The formed clusters were comprised of Brgy. Binatagan, San Felipe, Plaridel and Caayunan Basud, Maisog and Dagotdotan San Lorenzo Ruiz and Matanlang Labo Camarines Norte.

Fruit sampling were gathered right after harvesting. For the yield of queen pineapple, a standard deviation of 1.68 indicates a moderate spread around the mean yield of 39.25 MT/ha. Most cluster yields fall within ±1.68 MT of the average — that is, between 37.57 to 40.93 MT/ha. This implies that the result varies from one site to another due to different environmental factor such as type of soil, climatic condition, and slope or elevation. Nevertheless, the highest yield was on Cluster 8 (41.46 MT/ha) and the lowest was on Cluster 6 (36.59 MT/ha).

Cost and Return Analysis for Queen Pineapple

The ladderized type or Tamanyuhan was mostly used as the marketing scheme in Camarines Norte. The ladder type requires classification into five sizes (jumbo, primera, segunda, tersera and pang apat). The farm gate price of the jumbo, primera, segunda and tersera sizes were sold at a single price ranging from Php 10.00 to Php 13.00. However, the farm gate price of the batterball sizes or below the last type (pang apat) are sold from Php 2.00 - Php 3.00. This classification is not based on the classification of sizes recommended by Bureau of Agriculture and Fisheries Standards (BAFS) of which the extra-large size or jumbo will not depend on the weight of the fruit but on the bigger the fruit harvested on site the higher the price (Campita, 2019).

Most of the Queen pineapple grower's farmer practices in Camarines Norte optimized their area using the single row spacing of 60 cm x 30 cm which can accommodate 55, 200 plants/ha. However, resulting to high cost of production by 5% - 17%, high percentage of mortality and high incidence of batterball. Batterball was discard because it only weighs below 550 grams (Technodigest 2015). In the farmer practices, the return on investment (ROI) was 63% - 85% only. In contrary to the techno demo, by using double row the double row spacing of 100 cm x 50 cm x 30 cm the ROI acquired was 83 – 111%, respectively.

Effects on the Income of the Farmer Co-Operators

Peanut Production

In 1 – 2 months after planting of Queen pineapple, peanut was planted in between the double row. In 1-hectare area, can plant 44,666 hills of peanut. The attained ROI of 28% has gained an additional profit of Php 18,150.00 per hectare compared to the farmer practice which was only Php 10,500.00 and was 19% ROI respectively. Additionally, the yield of peanut attained 1,400 kg per hectare in technodemo while in the farmer practice was 1,100 kg per hectare. The technodemo was higher by 57.85% ROI compared to the farmers' practice.

Table 1. Cost and Return for Peanut Production

	With Intervention	Farmer Practice
Total Cost of Production	65,850.00	55,500.00
Gross Income	84,000.00	66,000.00
Net Income	18,150.00	10,500.00
Return of Investment	28%	19%

Corn Production

The effect on the income to the pineapple growers on the intercropping of Queen pineapple with sweet corn acquired 67% of Return on Investment (ROI) and gained additional profit of Php 82,896.04 per hectare. However, the cost of production was higher due to additional labor cost incurred during manual weeding and crop maintenance. A total of 26,800 corn plants can be intercropped in - between the pineapple plants per hectare. However, in the farmers' practice most farmers utilized a separate area solely for corn production. More incidence of pest was observed resulting to a profit of Php 47,450.24 or low ROI of 41% However, the ROI of the technodemo was higher by 57.24% compared to farmer practice. By using the recommended technology for corn production, such as fertilization based on soil analysis, proper control for weeds and pest and disease results in good quality and marketable produce.

Table 2. Cost and Return for Corn Production

	With Intervention	Farmer Practice
Total Cost of Production	123,350.00	55,500.00
Gross Income	206,246.04	66,000.00
Net Income	82,896.04	10,500.00
Return of Investment	67%	41%

Taro Production

The effect on the income of the Queen pineapple growers intercropping of taro with queen pineapple, cost and return for the taro shown in Table 25 gained an additional income of 82% compared to the farmers' practice of 76% respectively. The increase of the net income is due to the recommended taro variety and the right management for taro production. For one-hectare area of queen pineapple can approximately intercrop 8,978 taro setts.

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Table 3. Cost and Return for Taro Production

	With Intervention	Farmer Practice
Total Cost of Production	87,727.50	66,000.00
Gross Income	159,375.00	115,909.09
Net Income	71,647.50	49,909.09
Return of Investment	82%	76%

Effects on the Income of the Farmer Co-Operator Using the Technology on Pineapple-Based Farming System.

Intercropping strategy considerably increased in the overall income while lowering reliance on chemical inputs and labor costs. Compared to their previous methods, the effect on the farmer cooperators' revenue was significantly increased. The farmer could harvest the short-term crops while waiting for the queen pineapple to mature, which took 16–18 months. The effect on the income of the queen pineapple growers using this technology obtained an additional income in a span of 4 – 5 months. In contrary to the previous practice. Most of the queen pineapple growers optimized their farm only for queen pineapple. Study of Campita *et al*., (2024) highlights that queen pineapple farmers are highly dependent on pineapple as main livelihood and mostly hinders them to crop diversification due to insufficient capital and technical knowhow. The corn, peanut and taro were planted in a separate area.

However, through this technology the area for queen pineapple to be utilized and maximized the in between of the double row by planting peanut, corn and taro. Moreover, using this farming system can help the pineapple growers reduce cost of labor and weed management. As the result, it has incurred a net income of Php 367,468.49 as shown in and has increased the net income of 74%, respectively.

Table 4. Overall Cost and Return for Queen pineapple with Peanut, Corn, and Taro

	With Intervention	Farmer Practice
Queen pineapple		
Total Cost of Production	21,526.00	249,595.00
Gross Income	411,300.95	441,505.72
Net Income	194,774.95	191,910.72
Return of Investment	90%	77%
Corn		
Total Cost of Production	123,350.00	55,500.00
Gross Income	206,246.04	66,000.00
Net Income	82,896.04	10,500.00
Return of Investment	67%	41%
Peanut		
Total Cost of Production	65,850.00	55,500.00
Gross Income	84,000.00	66,000.00
Net Income	18,150.00	10,500.00
Return of Investment	28%	19%
Taro		
Total Cost of Production	87,727.50	66,000.00
Gross Income	159,375.00	115,909.09
Net Income	71,647.50	49,909.09
Return of Investment	82%	76%
Total Cost of Production	493,453.50	487,895.00
Gross Income	860,921.99	787,664.72
Net Income	367,468.49	299,769.72
Return of Investment	74%	61%

Conduct Capacity Enhancement Trainings and Workshops

Series of training were conducted of which aims to equipped the farmer cooperators with technical knowhow and capacitate them to be an active partner in the implementation of the project.

Inception Meeting and MOA Signing

Inception meeting was conducted at the Municipal Hall, Basud; MAO Office, San Lorenzo Ruiz; and Brgy Hall in Lugui, and Matanlang, Labo, Camarines Norte. The activity was participated by the 80 farmer cooperators, Local Government Unit staffs and project team personnel.

Project Launching and Project Demonstration.

Project launching and project demonstration was conducted in each barangay. This activity was attended by 10 farmer cooperators and the Barangay Officials. The purpose of the activity is to capacitate and equip the farmer cooperators on the Package of Technology on Queen pineapple + taro + corn + peanut production. Hands on training and workshop was one of the key strategies to demonstrate the technology to the farmers cooperators by learning through doing and experiencing the process to adapt the technology. Crop demonstrations were conducted in the farmers' sites to showcase the package of technology and to provide understanding of how the technology was done such as in planting, application of fertilizer and herbicide management.

Crop Production and Management Training

Training on Crop Production and Management Training on Peanut, Taro and Corn was conducted participated by the farmer cooperators, research staff and technical experts of Pineapple, Taro, Corn and Peanut. It aims to upgrade the knowledge and skills of the farmer on technical know-how in different package of technologies for crop production and management.

Team Building Activities

Team building activities, such as ice breaker games about collaborative problem-solving and communication, were conducted for farmer cooperators and members of the Cooperatives to enhance their communication skills while building rapport with other farmers from different

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barangays. To develop cooperation with one another and part of the year end assessment of the accomplishments and avenue for the planning for the succeeding activities.

Market Matching and Enterprise Development Training

Market Matching and Enterprise Development Training was participated in by the representative of cooperatives, traders, farmer cooperators, research staff, and technical experts on marketing and enterprise development from DA RFO 5 Agriculture and Marketing Assistance Division (AMAD). The activity aims to develop and support in the direct marketing scheme of queen pineapple and vegetables to avoid middleman and other marketing channels in Camarines Norte. As a result of the activity, the farmer cooperators were linked to the possible market like DOLE Philippines and Dizon Farm. The batterballs were also sell to the pineapple cooperatives and association for processing.

Product and by product of Queen Pineapple and Crop Training

The training on the product and by product processing helped the farmer cooperator improved their knowledge on how to utilize the waste of queen pineapple, taro, peanut, and corn. The waste of the crops was processed into organic fertilizer such as fermented fruit juice, fermented plant juice fertilizer. The leaf was scrapped and processed into piña fiber of which has a high demand in UK Market according to the Labo Progressive Multi-Purpose Cooperative as one of the resource speakers during the training. It helped the farmer cooperators to have an additional income aside from selling the produce.

Market Link Aging

Establishment of market linkages through buyers and trader's forum were encouraged and assisted by the LGUs to develop and support the direct marketing scheme of queen pineapple and vegetables to avoid middleman and other marketing channels. The farmers' produce was linked to the Agri Pinoy Trading Center, Caayunan Multi-Purpose Cooperative, Agrilink, Kadiwa, Tanim mo, Benta Mo Program of LGU Basud and to DOLE Philippines. As the result, the farmers were clustered to sustain the demand of the buyers and ensure a higher price of the produce.

CONCLUSIONS

The study recommends that adaptation of the intercropping technologies for Queen pineapple with peanut, corn, and taro will result in a higher fruit weight of 1,142g and 17°Brix for Queen pineapple. Following the recommended technologies, such as land preparation using four-wheel tractor, curing and fungicide application of the suckers as planting materials, planting using double-row spacing of 100 cm between row, 50 cm between double rows, and 30 cm between hills, fertilization based on soil analysis, proper control of weeds, and pest and diseases, and application of ethephon as flower inducer at 10 - 12 months, attained a 90% ROI. In 1 – 2 months after planting of Queen pineapple, the peanut was planted in between the double row, in which, in one hectare area, 44,666 peanut hills can be planted, generating an ROI of 28% and an additional income of Php 18,150.00. Intercropping of sweetcorn of 26,800 plants per hectare results in 67% ROI and additional income of Php 82,896.04. Intercropping of taro can gain an ROI of 82% in which one hectare of Queen pineapple can approximately intercrop 8,978 taro setts. As an overall result, it has incurred a net income of Php 367,468.49 and has increased the net income by 74 %, respectively. Capability-building activities, technology demonstrations, and market-linking enhanced the skills and improved access to buyers of the Queen pineapple growers. Overall, this integrated cropping model enhanced the productivity, cost efficiency, and additional income for the queen pineapple growers than traditional practices.

SUMMARY OF FINDINGS

Using the technology on intercropping of pineapple with peanut, corn and taro, it has significantly increased the overall net income of 79.49%. This strategy helps reduced the labor and material cost which incurred a total net income of Php 344, 468.49 respectively. The yield of queen pineapple attained the target of 37 – 42 metric ton per hectare.Intercropping of pineapple + peanut + corn + taro has gained additional income to the Queen pineapple growers with 18, 150/ ha for peanut, 82, 896.04/ ha for corn, and 48, 467 for taro or Return on Investment of 28%, 67% and 44%. At 4 – 5 months' Queen pineapple growers can earn an additional income while waiting for the harvest of Queen pineapple. Based on the ROI, we can conclude that peanut, taro, and corn is suitable for weather and soil condition in Camarines Norte. The intercropping technique with queen pineapple, considerably raises farm income and output overall while lowering reliance on chemical inputs and manpower. The study comes to a conclusion that using varied farming strategy can result to more resilient farming methods, enhancing food security and a sustainable development.

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