

**ISSAAS PHILIPPINES**

**NATIONAL CONGRESS 2021**

**EXTENDED ABSTRACTS**

## **SWEET ABULUG POMELO (SAP): The Lucky Fruit of Cagayan Valley, Philippines**

**Marilou B. Agaid**

Department of Agriculture – Northern Cagayan Experiment Station Regional Field Office No. 2  
Maquire, Lucban, Abulug, Cagayan Valley  
Corresponding author email address: agaid60marilou@gmail.com

### **ABSTRACT**

Sweet Abulug Pomelo brought good luck to farmers amidst pandemic. Mother trees are maintained in Foundation Grove of Department of Agriculture - Northern Cagayan Experiment Station, Maquire, Lucban, Abulug, Cagayan and was certified by Bureau of Plant Industry last 2008 as Siamese Abulug Pomelo as NSIC 2008 Pm 04 now popularly known as the Sweet Abulug Pomelo (SAP). After 3-5 years from planting, it can bear as many as 100-300 fruits per tree. The sweetness reaches from 10.9 to 12.5 percent Brix. However, SAP is susceptible to Citrus Rind Borer (CRB) causing ugly appearance although the taste remains sweet. A verification trial on the different control of Citrus Rind Borer (CRB) was conducted and resulted to 90% CRB free damaged coupled with recommended cultural management. After 13 years, SAP Field Day was conducted last August 10, 2021 to showcase and promote SAP and attended by 114 participants and ten (10) partner Government agencies. Hence, the promotion of SAP through field day resulted in generating a net income of Php.1, 017,270.00 / ha / year.

**Key words:** sweet abulug pomelo, citrus rind borer, pandemic, brix

### **INTRODUCTION**

Obtaining sustainable food system in this time of new normal is a challenge to everyone. But in Cagayan Valley, amidst this threat of pandemic, we see an opportunity. The Sweet Siamese Pomelo now popularly known as Sweet Abulug Pomelo (SAP) was registered as NSIC 2008 Pm 04 by Bureau of Plant Industry (BPI) under the administration of Celerina T. Miranda last 2008. Although this high value commodity is already existing long before this pandemic and it seems low promotion with limited market penetration, but this time, it is making its own identity. The demand for its fruit is very high specifically this is a very good source of Vitamin C which everyone needs in boosting immune system to fight Covid19. Likewise, its juiciness and sweetness is comparable to Davao pomelo in spite of its unattractive appearance because it remains green even when ripe.

### **MATERIALS AND METHOD**

Verification on Insect Pest Management was conducted last January 2021 in a 7 years old Fruit Bearing SAP at the NCES Foundation Grove following the Package of Technology for SAP except for the treatments such as:

- 1.) Fruit Bagging – Plastic net with 15 inches' x 45 inches' bag size was used for fruit bagging
- 2.) Chemical Spraying - Parker Neem insecticide was used against Citrus Rind Borer (CRB) and other pest attacking pomelo.  
Frequency of Spraying: From Flushing to Ball size: 2times a month (every 14 days interval)
- 3.) Insect Trapping –super net insect attractant sticker was sprayed to an empty plastic bottle and hanged near the tree using bamboo pole was installed for insect trapping
- 4.) Biological Control Agent – The three Entomopathogenic Fungi (EPF), *Metarhizium spp.*, *Isaria*, *Beauveria bassiana*, were applied to 10 sample trees following the recommended application.

Verification trial on 1-year-old SAP intercropped with various Cash crops with an area of 2,500 sq.m , 39 trees was conducted following the Package of Technology for SAP and cashcrops. Crop used were Corn (IES Glut 4), Upland Rice (Calatrava), Peanut (3 seeded), Sweet Potato (Swerte), Cassava (Golden Yellow), Bush Sitao (Los Banos white) and Pineapple.

Hosting the Field Day with 150 participants

-Farm tour was conducted in the Foundation Grove where the bearing and non-bearing pomelo were maintained. Likewise, the result of the trials on the different technologies was showcased. -The growth and performance of SAP model tree was showcased. -Testimonies from successful SAP growers inspired the participants to venture in SAP production. Packaging and Labelling of the SAP was developed to encourage potential buyers to purchase the product. Awarding and distribution of 6,000 seedlings to FCA was done during the field day

- Online advertising like social media platform (Facebook, Instagram), Direct Marketing, Product giveaways and samples, and branded promotional gifts.

## RESULTS AND DISCUSSION

Result shows that the net income of different Pest Management Practices in controlling the insect pest of SAP especially Citrus Rind Borer (CRB) the gross income derived from the 5 to 7 year-old SAP was Php. 1,248,000.00. Chemical Spraying practice gave the highest net income with 909,570.00 followed by insect trapping with Php. 899,170.00 . The treatments are not different among each other in terms of ROI. Therefore, any of the treatments can be recommended to SAP growers. Cash crops are a viable source of additional income to pomelo growers. Intercropping is a practice to maximize utilization of land use in SAP plantation. Result shows that the top three cash crops used with the highest net income were the Pineapple, Sweet Potato and bush sitao with Php.155,543.00, Php. 81,779.00, and Php. 80,250.00, respectively. The Field day conducted brought a significant impact to the pomelo growers. Farmer's option on Pest Management Practices for SAP was established aside from Chemical Pest Control. The different Pest Management Practices employed against Citrus Rind Borer improved the fruit quality of SAP up to 90% CRB damage free. Various crops were identified that can be grown in between non-bearing pomelo. There was an increase in demand of SAP fruit as source of Vitamin C during the pandemic, as well as planting materials. 6,000 SAP seedlings to Farmer Cooperative/Associations and 1,000 to Municipal Wide Backyard Tree planting in Abulug, Cagayan were distributed to recognize Abulug as the Home of SAP.

## CONCLUSION

Opportunity comes when least expected and even at the midst of hard times. It was in this pandemic, the health crisis brought by COVID-19 that each one struggle to boost one's immune system to combat the virus. The closure of many borders limits the entry of fruits and vegetables as part of essential hence, the supply decreased and the demand is high resulting to increase in price. Now, the hidden treasure of Abulug sparks and shines due to the call of the moment. The DA initiatives with other partner agencies made SAP a lucky fruit of Cagayan Valley, Philippines. The field day conducted at DA-NCES and NVES was carried out successfully in promoting SAP and now adopted as one of the priority crops to consider. This high value crop is now an integrated part as tourist attraction of Cagayan Valley. Government support system played significantly in the promotion of SAP that enable farmers to earn a million of pesos from the sale of fruits. SAP farming is a productive endeavour that keeps farmers alive in the new normal as indicated by the demand of seedlings as well as fruits. Growing fruit trees is environment friendly and minimizes soil erosion.

## ACKNOWLEDGEMENT

I would like to thank all the people who provided technical and financial support and assistance in the conduct of the experiment and field day namely: Regional Executive Director of Department of Agriculture – Regional Field Office No. 02 (DA-RFO 2), Dir. Narciso A. Edillo, Regional Technical Director for Research and Regulatory, Rose Mary G. Aquino, Regional Technical Director for Operations, Roberto C. Busania, Chief of the Research Division, Ms. Lovelyn A. Gaspar and the Research Centers/Experiment Stations of Region 02. I would also thank the different partner agencies like Department of Trade and Industry (DTI) , Department of Tourism (DOT), Department of Science and Technology (DOST), Local Government Units(LGUs) and Philippine Chamber of Commerce and Industry (PCCI), Cagayan Economic Zone Authority (CEZA) and more other agencies for their promotional support. I would also like to acknowledge the DA-NCES R4D and HVCDP Team who made this activity possible. Above all, the Almighty God.

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## **ADAPTATION STRATEGIES AMID THE PANDEMIC AMONG AGRI-TOURISM ENTERPRISES IN LA UNION, PHILIPPINES**

**Alcantara, Precious Angela<sup>1</sup>, P., Depositario, Dinah Pura, T., Baticados,  
Glenn, N., Aquino, Nanette, A., Mojica, Loida, E.**

Department of Agribusiness Management and Entrepreneurship, College of Economics Management, University of  
the Philippines Los Banos, Philippines

<sup>1</sup>Corresponding author: [ppalcantara1@up.edu.ph](mailto:ppalcantara1@up.edu.ph)

### **ABSTRACT**

Prior to the pandemic, agri-tourism was on its rise in the Philippines. It is known as a fusion of Agriculture and tourism, linked to other sectors, including hospitality and transportation. However, travel bans and other restrictions amid the COVID-19 pandemic have adversely affected tourism. This study aimed to describe the pandemic effects on agri-tourism enterprises in the province of La Union, Philippines, and their adaptation strategies. A survey of 16 enterprises was conducted in May 2021. Descriptive and content analysis was employed to analyze the data and information gathered. The pandemic was found to have significantly affected the enterprises' marketing function, resulting in financial losses and adjustments to their business models. Their adaptation strategies were categorized as either survival or sustaining. Survival strategies were the farms' initial coping mechanisms like shifting to a new market, lowered prices, and switching to online marketing. On the other hand, sustaining strategies were also known as long-term solutions like diversification and expansion. The enterprises that adopted both strategies had wider offerings and possessed more than one accreditation. It is recommended that agri-tourism enterprises continue strategizing as the pandemic remains a threat. They should consider employing sustaining strategies for post-pandemic.

### **INTRODUCTION**

The tourism industry of the Philippines has been continuously rising for the past years (Cabiladas, 2020). On the other hand, Agri-tourism's popularity continues to escalate with the passage of Republic Act No. 10816 or the Farm Tourism Development Act of 2016. The sector's development was disrupted when the entire island of Luzon in the Philippines was put under Enhanced Community Quarantine (ECQ) in mid-March 2020. The pandemic negatively affected businesses from various industries that also caused labor disruptions to millions of Filipinos (International Labor Organization, 2020). The United Nations (UN) recognizes the COVID-19 pandemic as a health and humanitarian crisis that threatens the food security and nutrition of the worldwide population (United Nations, 2020). Food security has been the reason for retaining farming. An argument follows that if agri-tourism can make farms more economically feasible and sustainable, it contributes positively to public goals (Schilling et al., 2012). It was fortunate for the agri-tourism enterprises to operate during the pandemic despite travel restrictions. The Inter-Agency Task Force on Emerging Infectious Disease (IATF-EID) approved the unrestricted movement of agriculture workers despite ECQ to ensure food security during the pandemic.

This study sought : 1) to identify the status of the agri-tourism enterprises in La Union, Philippines. 2) To assess the effect of the pandemic on the enterprises' business functions amid the pandemic, and 3) To analyze their adaptation strategies in mitigating the effects of the pandemic.

### **MATERIALS AND METHODS**

The descriptive research design was used to describe the background of the identified agri-tourism sites in La Union. Primary Data and Secondary data were used for this study. A semi-structured questionnaire collected primary data from the sixteen (16) identified respondents, and data collection was from May 1 to 29, 2021. A complete enumeration was employed in selecting the respondents due to their minimal number. The secondary data included government records, existing legislation, related research, and articles from journals. Descriptive statistics were used in presenting the frequency distribution of the results, and a content analysis was used to present and evaluate the relevant parameters from the responses. Non-parametric statistical tools were performed to see the degree of relationship or association among variables—the results of the quantitative analysis and other observations were the basis of the qualitative analysis.

## **RESULTS AND DISCUSSION**

Travel restrictions and suspension of face-to-face activities pushed the farms to stop some of their offerings while some adjusted the prices. Consistent with Liguori & Pittz's (2020) study, the agri-tourism farms in La Union also altered their business model. Regardless of the farm's size and the number of offerings, they did not escape from the pandemic effects. All enterprises experienced a huge drop in their visitor count that greatly affected their operations during the pandemic—employees in the training and food service needed to be in alternative working arrangements sometime. The most affected business function was the enterprises' marketing and logistics functions that had financial implications, too. The total minimum estimated loss due to the pandemic amounted to Php 6.7 million. The pandemic made the owners realize the importance of maintaining liquidity to remain resilient.

This study categorized strategies as survival strategies and sustaining strategies to assess the farms' approaches. These strategies differ in purpose. Survival strategy can be the same as emergency responses described by the International Trade Center (ITC) as the immediate actions taken to withstand a crisis. Meanwhile, some strategies provided long-term economic growth. These strategies were the sustaining strategies or those that consider post-pandemic operations. Survival strategies employed were shifting to a new market, utilizing digital platforms, and cutting expenses. Sustaining strategies included diversification and expansion of operations. A significant association between the level of agri-tourism enterprises and their strategies' classification. It shows that enterprises falling on the higher classification level could most likely implement survival and sustaining strategies. Moreover, it justifies that an enterprise with more offerings could highly survive a pandemic and prepare for post-pandemic. While it is crucial to surviving the pandemic, the enterprises should be prepared when things get back to normal.

## **CONCLUSION**

In general, the pandemic brought negative effects to the agri-tourism enterprises in La Union, Philippines. The strategies imposed by the agri-tourism enterprises also depended on their offerings' uniqueness. Despite measures to lessen the pandemic risks, the pandemic remains a threat to the agri-tourism sector. 4) The agri-tourism farms in La Union are surviving the pandemic and should continue innovating their strategies to remain resilient.

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**PUNGENCY LEVELS OF GARLIC (*ALLIUM SATIVUM*) GROWN FROM VARIOUS AREAS IN THE PHILIPPINES**

**LA Artes, MV Maunahan, JM Resorez and PA Nuevo**

Postharvest Horticulture Training and Research Center, CAFS, UPLB

Corresponding author: Leonisa A. Artes, (phtrc.uplb@up.edu.ph)

**ABSTRACT**

Garlic is a very important spice in the tropics. However, it can only be grown during the dry months of the year. Hence, it is important to make it available the whole year round. This study was done to compare garlic bulbs sourced from various production areas in the country and to determine how long their pungency levels can be maintained. Garlic bulbs taken from various areas in the country were sampled during its harvest season (February–March, 2019) and stored for 6-8 months at ambient conditions (~30C). The total soluble solids (TSS) content and its pungency in terms of pyruvate content were analysed. Bulbs taken from Ilocos Norte and Nueva Vizcaya initially had higher pyruvate content (128-130 ug/g FW) than those from Mindoro (99 ug/g FW) or Batanes (89 ug/g FW). After about 6-8 months under ambient conditions, pyruvate levels generally increased by 7-27 ug/g FW in most samples. Comparison between bulb sizes showed that the bigger ones had usually lower pyruvate content. The average TSS values were about 31°Brix from all samples with slight increment (33°Brix) after storage. Both pyruvate content and TSS values of Philippine garlic were comparable or even higher than those reported by another country.

Key words: pyruvic acid, TSS, ambient storage, various garlic sizes

**INTRODUCTION**

In the Philippines, garlic is a popular spice being used as ingredient in many food preparations. Perception of garlic flavour is closely related to its pungency levels. Garlic pungency is developed when sulphur precursors after tissue disruption, react with the enzyme allinase, liberating numerous volatile sulphur compounds. Pyruvic acid is a secondary product of this reaction and is used as an indirect measure of pungency (Natale and Camargo 2005). Argentina, the second garlic exporter in the world has garlic with 64-97 umol/g pyruvic acid among the following cvs. INTA: Castano, Nieve, Morado, Fuego (Natale and Camargo, 2005). A local maturity study on garlic (Nuevo 1996) showed that when harvested 90 days after planting (immature bulbs), weight loss was high, softening was faster and there was low total soluble solids (TSS) and pyruvate content. Hence, these bulbs must be harvested at least 105 days after planting. Bulbs were also found to be more pungent than its corresponding scapes, which is used in some food preparations (Gonzales et al., 2012). Heat treatments of peeled and unpeeled garlic cloves could control its sprout and root growth also, which was as effective as controlled atmosphere storage (Cantwell et al. 2003). Low temperature storage (4-10C, 60-90% RH) for 120 days resulted in increased allicin content of garlic (Sukkaew and Tira-umphon, 2012). Maximum allicin level (36.5 mM/g DW) was found in bulbs stored at 4-6C, 80-90%RH after 60 days. Only 4-11% weight loss was observed under the said conditions. Locally, there is no study yet on the comparison of garlic pungency. Hence, this study was conducted: 1) to compare the pungency levels of garlic from various growing areas in the county, and 2) to determine the changes in its pyruvate content after prolonged storage under ambient condition.

**MATERIALS AND METHODS**

Garlic grown from various areas in the country was collected at the following places: Itbayat in Batanes, Pasuquin in Ilocos Norte, Bambang in Nueva Vizcaya and Lubang Island in Occidental Mindoro during the harvest season (February –March 2019). Various sizes of garlic in each area were collected (extra-large, large, medium, small, extra-small). Samples were further dried at ambient condition in the laboratory for a month before analyses were done. Total soluble solids (TSS) content and pungency levels were measured initially and after about 6-8 months at ambient conditions (29-33C). Pungency was determined according to Schwimmer and Weston (1961) with some modifications (Gonzalez et. al., 2012). Ten garlic bulbs of each size served as replicates for the chemical analyses. Results were subjected to analysis of variance and Tukey's test at .5% level of significance.

**RESULTS AND DISCUSSION**

Initial TSS levels of garlic ranged from 28 to 34°Brix. Samples from Ilocos Norte had the lowest initial TSS levels (28°Brix), followed by Nueva Vizcaya (31°Brix), Batanes (33°Brix) and then Mindoro (34°Brix). Those from Batanes, Ilocos Norte and Nueva Vizcaya all had decreasing TSS levels as the bulb size increased, unlike those from Occidental Mindoro which showed the opposite pattern. However, after 6-8 months of storage, a slight increase in TSS levels (about 30-35°Brix) was observed in all samples. With respect to sizes, almost same

pattern as the initial observation was noted after storage. Moreover, the TSS values obtained here were slightly higher than those reported in garlic from Spain (25-29<sup>0</sup>Brix) by Pardo et.al., 2007.

The initial pyruvate levels were observed to be highest in samples from Ilocos Norte (128 ug/g FW) and Nueva Vizcaya (130 ug/g FW), while the lowest were in bulbs from Batanes (89 ug/g FW). With respect to bulb sizes, there is increasing pyruvate content (5 to 23 ug/g FW) in general, as the size of bulbs increase from extra-small to extra-large.

After 6-8 months storage at ambient conditions, there was an increase in pyruvate content in most samples except those from Batanes which showed a slight decline (8 ug/g FW). The increase in pyruvate levels in garlic were as follows: from Ilocos (8 ug/g FW), Nueva Vizcaya (7 ug/g FW) and Occidental Mindoro (27 ug/g FW). Both Ilocos Norte and Nueva Vizcaya samples had nearly constant levels compared with those of Occidental Mindoro. It is possible that samples from Mindoro were not properly dried as the other samples were, hence the big difference in pyruvate content over time. However, the pyruvate levels obtained from the local garlic were higher than those previously reported in Argentina having only about 60-97 umol/g (Natale and Camargo, 2005).

The effect of bulb size on pyruvate content cannot be conclusive since garlic from various areas showed either decreasing or increasing trend with respect to garlic size.

### **CONCLUSION**

The study shows that pungency levels of garlic grown from different areas in the country did not show dramatic decline even after 6 to 8 months under ambient condition. Those from Ilocos Norte and Nueva Vizcaya consistently had similar high pungency levels (~136 ug/g FW). This is followed by those from Occidental Mindoro (126 ug/g FW). In contrast, samples from Batanes not only had the lowest pyruvate levels (89 ug/g FW) but were also the only ones that showed slight decline with time (81ug/g FW). Moreover, changes in pyruvate levels with respect to bulb sizes were not consistent in all sources. Except for bulbs from Ilocos and Mindoro, others have increasing pyruvate levels with increase in bulb size. The pyruvate levels of garlic from the Philippines are quite comparable with those from other countries like Argentina. Hence, it may be exported to other countries especially in the sub-temperate regions like Japan and Korea.

### **ACKNOWLEDGEMENT**

The authors wish to thank the Bureau of Plant Industry of the Department of Agriculture which funded the said research.

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## SHOOT AND FRUIT DEVELOPMENT OF CALAMANSI (*Citrus x microcarpa* Bunge) AS INFLUENCED BY FERTILIZER AND VESICULAR-ARBUSCULAR MYCORRHIZA (VAM) TREATMENTS

Maricon M. Amparo<sup>1</sup>, Leslie L. Roces<sup>2</sup>, Calixto M. Protacio<sup>3</sup>, Pompe C. Sta. Cruz<sup>4</sup> and Edna A. Aguilar<sup>5</sup>

<sup>1</sup>Institute of Crop Science, CAFS, UPLB mmamparo@up.edu.ph

### ABSTRACT

The effect of inorganic fertilization and VAM application on shoot and fruit development of calamansi (*Citrus x microcarpa* Bunge) was studied from October 2020 to May 2021. Two-year old potted calamansi trees with calamandarin as rootstock were used. Treatments observed were: (a) unfertilized, uninoculated; (b) fertilized at 100% rate; (c) VAM-inoculated; (d) fertilized at 50% rate, VAM-inoculated, and (e) fertilized at 100% rate, VAM-inoculated. VAM inoculation combined with half the amount of recommended fertilizer application enhanced shoot and fruit development compared with the other trees. Improved shoot growth was due to increased shoot length and number of leaves per shoot, higher change in plant height, wider stem diameter, and greener leaf color. Fruit development was due to optimum NPK uptake in mature leaves and VAM association in roots which resulted to higher number of harvestable fruits. A standard for harvesting calamansi fruits based on their use – as fresh fruit or as processed juice was also established. Fresh market fruit use is recommended to be harvested between Stages 79 (fruits are about 90% of their final size) and 81 (mature green) while processed juice use should be harvested before Stage 83 (breaker) manifest.

Keywords: biofertilizer, calamansi, citrus, mycorrhiza, VAM

### INTRODUCTION

Citrus is the most economically important fruit crop in the world. *Citrus x microcarpa* Bunge, locally known in the Philippines as calamansi, is considered a major crop in the Philippines. As of 2019, the Philippine Statistics Authority has recorded about 8.33 million bearing calamansi trees planted in 19.62 thousand hectares of land and produced a volume of 125.97 thousand metric tons of fruits. Amidst this volume of produced fruits, however, calamansi production decreases at an average annual rate of 5.1 percent from 2015 to 2019. The area planted and the number of bearing trees decreased annually at an average rate of 0.5 and 0.6 percent, respectively. There is a need to revitalize the calamansi industry by improving its production and fruit quality by utilizing proven technologies and management practices. The association of VAM has been observed to be beneficial in fruit crops production including citrus in enhancing growth and ion uptake, improving tolerance to drought and salt stress, and enriching fruit quality. The study sought to determine the effect of fertilizer treatments on shoot growth and fruit yield and quality and determine the effect of VAM biofertilizer inoculation on the indigenous VAM root association.

### MATERIALS AND METHODS

The study was conducted at 14.1804375, 121.1800625 in Brgy. Pansol, Calamba City, Laguna from October 2020 to May 2021. The area is classified to have Type 3 Climate. Sixty (60) healthy and uniform, already fruiting, budded calamansi trees, about 2 years of age, with Calamandarin (*Citrus reticulata* Blanco x *C. madurensis* Lour.) as rootstock, were used in the study. Trees were transferred to larger pots and were acclimatized for 7 weeks. Five (5) treatments with four (4) trees per treatment replicated thrice were done. The treatments were (T1) unfertilized and uninoculated; (T2) fertilized at 100% rate; (T3) VAM-inoculated; (T4) fertilized at 50% rate and VAM-inoculated; and (T5) fertilized at 100% rate and VAM-inoculated. Fertilizers used were urea and complete. Urea was applied at a rate of 7g every 3 weeks for 6 weeks, then 10g every 3 weeks for another 6 weeks. Complete fertilizer was applied at a rate of 15g and repeated every 3 weeks for another 6 weeks. Whereas, for VAM-inoculation, the biofertilizer used is Mykovam™. Other management practices such as pesticide application and weeding were done on a per-need basis. The study was laid out employing the Completely Randomized Design (CRD).

**Effect of fertilizer and VAM inoculation on shoot growth and fruiting of calamansi.** The following data were collected and recorded: *length of shoot and number of leaves, plant height and stem diameter, leaf color*. At the end of the study, four (4) fully expanded leaves from each tree were used to determine the leaf color using the Leaf Color Chart. Other effects evaluated were: nutrient soil content and leaf uptake, mycorrhizal colonization and spore count, and fruits harvested.

## RESULTS AND DISCUSSION

**Plant growth parameters.** For all parameters, T4 is significantly different from the other treatments with an average of 16.23 cm length of shoot, 11 number of leaves per tagged shoot, 18.32% increase in plant height and 20.19% increase in stem diameter. T4 also has the greenest leaves among the treatments.

**NPK soil content and plant uptake.** N content of soil samples did not differ among treatments. All of them however showed an increase from the initial soil N content of 0.02%. For soil P content, T5 has the highest amount with an average of 126 ppm. For soil K content, T2 and T5 have the highest amount with 532 ppm and 557.33 ppm respectively. The N in lemon leaf is 1.9–2.2% (Plessis and Koen 1992). In comparison, T1 and T2 have low N, T3 and T5 have excessive, while T4 has high. Citrus needs more N than any other nutrients as it is a vital part of proteins & chlorophyll. When there is excess N, there is vigorous vegetative growth as observed in T2 and T5 trees. The optimum requirement for P in lemon is 0.11–0.15% (Plessis and Koen 1992) and only T4 attained the norm. Fertilized T2 and T5 were deficient while unfertilized T1 and T3 had excessive levels. Based on Plessis and Koen (1992), K contents of T4 fits the norm (1.1–1.4%). T2 and T5 falls below the norm while T1 and T3 exceeds it.

**Mycorrhizal colonization and spore count.** Root samples have initial VAM colonization of 0-3%. Two months after treatment application, laboratory analysis showed that T1 (unfertilized, uninoculated) has the highest average colonization of 68%. The said treatment is not statistically different with VAM-inoculated T3 (62%) and with fully fertilized T2 (61%). T4 has 57% while T5 has 28%. Five months after inoculation, root colonization generally increased with T3 having the highest rate of 70%, followed by T1 with 67% and T2 with 65%. T1, T2 and T3 almost have the same colonization. T3's result is expected since the trees are unfertilized and inoculated with VAM. The VAM present in uninoculated T1 and T2 may have been due to the endogenous VAM present in the medium since trees were transplanted in unsterilized soil. Mycorrhizal fungi are naturally occurring and as long as there are compatible hosts, they infect the roots. For T4 and T5, both showed colonization as well but is smaller than the other 3 treatments. The presence of fertilizer may have contradicted the colonization of exogenous VAM. Root colonization is highest on inoculated treatment with no N and P applied while lowest in treatment applied with both N and P (Youpensuk, et. al. 2003).

Fertilized T2, T4 and T5 had lower P uptake while unfertilized T1 and T3 had high. There is no statistical difference among treatments in terms of spore count. The application of VAM may have not influenced the population of spores present in the soil and this may be due to AM fungi species, root age, root density, soil moisture, and position of mycorrhizal inoculum.

**Fruits harvested.** T4 had the highest number of fruits (42) among the treatments, followed by T2 (25 pcs; 59.75 g) and T5 (12 pcs; 38.25 g). Both T1 and T3 have no harvest as the majority of plants were still in the shoot development stage.

## CONCLUSION

Inoculation of VAM biofertilizers to trees fertilized at minimal amount (50% rate) indeed enhanced the growth and development of shoots and fruits. T4. Though VAM seemed to have contradicting effects when trees are fully fertilized (as seen in T5), fertilizer is still needed as VAM only enhances the nutrient uptake and cannot provide the nutrients needed by trees as observed in unfertilized trees.

## RECOMMENDATIONS

Various fertilizer levels should be studied to identify the optimum amount needed to elicit the best flowering and fruiting response. For the VAM association, the response of calamansi trees to mycorrhiza in other soil and weather conditions should also be done to fully evaluate the potentials of mycorrhizal associations. Moreover, additional parameters should also be done to support claims on VAM effects. Such includes but are not limited to chemical and physical soil properties, root architecture, dry matter partitioning, and fruit quality. Variations on the age and quality of trees should also be considered.

## LITERATURE CITED

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## EFFECT OF HARVESTING CASSAVA LEAVES AT DIFFERENT PLANT AGE AND FREQUENCY ON CASSAVA LEAF PRODUCTION AND TUBER YIELD

Fides Marciana Z. Tambalo\*<sup>1</sup>, Rosa Buena A. Capuno<sup>1</sup>, Hiyasmin Rose L. Benzon<sup>1</sup>,  
Cyrene D. Estrellana<sup>1</sup>, Jayson F. Garcia<sup>1</sup>, Lizette Sahar N. Arcillas<sup>1</sup>, and Susan T. Bacud<sup>2</sup>

<sup>1</sup>National Institute of Molecular Biology and Biotechnology, University of the Philippines  
Los Baños (UPLB), College, Laguna 4031

<sup>2</sup>Institute of Weed Science, Entomology and Plant Pathology, College of Agriculture  
and Food Science, UPLB, College, Los Baños, Laguna 4031

\*Corresponding author: fztambalo@up.edu.ph

### ABSTRACT

Cassava leaves are rich in protein and other essential nutrients, thus, it has the potential to be an alternative source of protein for human and animal consumption. This study investigated the effect of harvesting cassava leaves at 4, 6, 8, and 10 months after planting (MAP) on the leaf production and tuber yield. Leaf numbers 7-15 were harvested from Binulak, Lakan 1, and Sultan 6 (Year 1) while all the leaves except leaf numbers 1-6 were harvested from Rayong 72, KU 50, and Golden Yellow (Year 2). The results showed that harvesting of cassava leaves starting at 4 MAP had no significant effect on the fresh weight of the harvested leaves as well as on the tuber yield for all the six cassava varieties. Therefore, deleafing every two months did not reduce the production of cassava leaves and tubers. Sultan 6 and Rayong 72 had the highest tuber yield but Binulak and Golden Yellow obtained the highest total fresh weight of harvested leaves. Thus, it can be recommended that the harvest of cassava leaves can be done starting at 4 MAP and every two months thereafter without compromising the tuber yield.

**Key words:** *Manihot esculenta* Crantz, Binulak, Lakan, Sultan, Rayong

### INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is mainly grown for its roots while leaves are mostly considered as a waste. However, cassava leaves are rich in protein, vitamins, and minerals unlike the roots that are essentially carbohydrates. Minerals found in cassava leaves include potassium, calcium, magnesium, phosphorus, sodium, manganese, iron, zinc, and copper. Cassava leaves also contain beta-carotene (vitamin A), thiamine (vitamin B1), riboflavin (vitamin B2), niacin (vitamin B3), and ascorbic acid (vitamin C) (Achidi et al. 2008; Latif and Mulle 2015). Nevertheless, consumption of cassava leaves as a source of essential nutrients is not much explored in the Philippines because of its high level of cyanogens and its antinutritive properties.

This study was conducted to establish best agronomic practices for production and harvesting of cassava leaves that will not compromise the tuber yield. With proper processing techniques, the cyanide content of cassava leaves can be significantly reduced that can be used for food and feed industry. This would increase the income of cassava farmers and would potentially reduce the production cost of feed industry.

### MATERIALS AND METHODS

Six local cassava varieties (ie. Binulak, Lakan 1, Sultan 6, Rayong, KU 50, and Golden Yellow) were selected for field experiment based on cyanide level, availability, and the variety planted by Filipino farmers as a result of the survey conducted in five regions in the Philippines. The frequency of harvest of cassava leaves and maturity of leaves harvested were studied for optimum leaf yield. The effect of leaf harvesting on cassava tuber yield was also investigated. Fifteen (15) healthy plants per plot from each variety were randomly selected for data gathering. Harvesting of leaves at 4, 6, 8, and 10 months after planting (MAP) was done and the tubers were harvested at 10 MAP. The leaves were numbered from the first fully opened one as Leaf 1 and counting sequentially down the stem. Leaf numbers 7-15 were harvested from Binulak, Lakan 1, and Sultan 6 (Year 1) while all the leaves except Leaf numbers 1-6 were harvested from Rayong 72, KU 50, and Golden Yellow (Year 2).

The experiment was composed of four treatments arranged in Split Plot in Randomized Complete Block Design with three replications. Each treatment consisted of 24 plants for each variety with a planting distance of 0.75 m x 0.75 m. The distance between varieties and replications was 1.5 m. Basal application of complete fertilizer (14-14-14) at a rate of 300 kg/ha was done and side dress using urea (46-0-0) at 100 kg/ha followed two months after planting.

## **RESULTS AND DISCUSSION**

The harvest of leaves in Year 1 show that the mean fresh weight of harvested leaves of Binulak and Sultan 6 was significantly higher compared to Lakan 1. For Binulak and Lakan 1, the total weight of harvested leaves starting at 4 MAP was significantly higher than harvests at 6, 8, and 10 MAP. However, for Sultan 6, there was no significant difference in the total weight of harvested leaves among the four treatments. High total yield of leaves was obtained even at 8 and 10 MAP. The differences in the obtained yield may be attributed greatly to varietal differences. It was observed that the mature leaves of Binulak and Lakan 1 started to shed at 8 MAP unlike in Sultan 6 wherein more leaves were produced. Binulak and Lakan 1 have similar structure wherein they only have one major stalk. In contrast, Sultan 6 produces more stalks as it grows making the plant grow wider, laterally, thus producing more leaves.

As for Year 2, the total weight of harvested leaves from Rayong 72, KU 50, and Golden Yellow at 4, 6, and 8 MAP had no significant difference. It was also observed that leaf yield was inversely related to the tuber yield. Golden Yellow obtained the highest leaf yield but had the lowest tuber yield. On the other hand, Rayong 72 had the lowest leaf yield but obtained the highest tuber yield. The results show that for Rayong 72 and Golden Yellow, the harvest of leaves starting at 4 MAP did not significantly reduce the weight of harvested leaves at the succeeding months. But for KU 50, the deleafing frequency had a significant effect on the harvest of leaves. The highest weight of leaves was obtained when the harvest was done starting at 8 MAP.

The harvest of leaves at different plant age and frequency had no significant effect on the tuber yield. Sultan 6 had the highest tuber yield followed by Lakan 1 then Binulak. Similar results were obtained for Year 2 in terms of tuber yield. The harvest of leaves at different plant age and frequency had no significant effect on the tuber yield. Rayong 72 had the highest tuber yield followed by KU 50, then Golden Yellow.

## **CONCLUSION**

Cassava growers may harvest the leaves of Binulak, Lakan 1, Sultan 6, Rayong 72, and Golden Yellow as early as 4 MAP without compromising much the leaf production and tuber yield in the succeeding months. For KU 50, the optimum plant age for deleafing is at 8 MAP. Thus, if cassava leaves would provide additional income for the farmers, it can be recommended that deleafing can be done between 4 to 8 MAP. This would give them the optimum yield of both leaves and tubers. Golden Yellow may have lower tuber yield but it produces significantly higher weight of leaves.

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## **SWEET ABULUG POMELO (SAP): THE LUCKY FRUIT OF CAGAYAN VALLEY, PHILIPPINES**

**Marilou B. Agaid**

Department of Agriculture – Northern Cagayan Experiment Station Regional Field Office No. 2  
Maquire, Lucban, Abulug, Cagayan Valley  
Corresponding author email address: agaid60marilou@gmail.com

### **ABSTRACT**

Sweet Abulug Pomelo brought good luck to farmers amidst pandemic. Mother trees are maintained in Foundation Grove of Department of Agriculture - Northern Cagayan Experiment Station, Maquire, Lucban, Abulug, Cagayan and was certified by Bureau of Plant Industry last 2008 as Siamese Abulug Pomelo as NSIC 2008 Pm 04 now popularly known as the Sweet Abulug Pomelo (SAP). After 3-5 years from planting, it can bear as many as 100-300 fruits per tree. The sweetness reaches from 10.9 to 12.5 percent Brix. However, SAP is susceptible to Citrus Rind Borer (CRB) causing ugly appearance although the taste remains sweet. A verification trial on the different control of Citrus Rind Borer (CRB) was conducted and resulted to 90% CRB free damaged coupled with recommended cultural management. After 13 years, SAP Field Day was conducted last August 10, 2021 to showcase and promote SAP and attended by 114 participants and ten (10) partner Government agencies. Hence, the promotion of SAP through field day resulted in generating a net income of Php.1, 017,270.00 / ha / year.

### **INTRODUCTION**

Obtaining sustainable food system in this time of new normal is a challenge to everyone. But in Cagayan Valley, amidst this threat of pandemic, we see an opportunity. The Sweet Siamese Pomelo now popularly known as Sweet Abulug Pomelo (SAP) was registered as NSIC 2008 Pm 04 by Bureau of Plant Industry (BPI) under the administration of Celerina T. Miranda last 2008. Although this high value commodity is already existing long before this pandemic and it seems low promotion with limited market penetration, but this time, it is making its own identity. The demand for its fruit is very high specifically this is a very good source of Vitamin C which everyone needs in boosting immune system to fight Covid19. Likewise, its juiciness and sweetness is comparable to Davao pomelo in spite of its unattractive appearance because it remains green even when ripe.

### **MATERIALS AND METHOD**

Verification on Insect Pest Management was conducted last January 2021 in a 7 years old Fruit Bearing SAP at the NCES Foundation Grove following the Package of Technology for SAP except for the treatments such as:

- 1) Fruit Bagging – Plastic net with 15 inches' x 45 inches' bag size was used for fruit bagging
- 2) Chemical Spraying - Parker Neem insecticide was used against Citrus Rind Borer (CRB) and other pest attacking pomelo.
- 3) Frequency of Spraying: From Flushing to Ball size: 2times a month (every 14 days interval)
- 4) Insect Trapping –super net insect attractant sticker was sprayed to an empty plastic bottle and hanged near the tree using bamboo pole was installed for insect trapping
- 5) Biological Control Agent – The three Entomopathogenic Fungi (EPF), *Metarhizium spp.*, *Isaria*, *Beauveria bassiana*, were applied. Each specie was applied to 10 sample trees following the recommended application.

Verification trial on 1-year-old SAP intercropped with various Cash crops with an area of 2,500 sq.m , 39 trees was conducted following the Package of Technology for SAP and cashcrops. Crop used were Corn (IES Glut 4), Upland Rice (Calatrava), Peanut (3 seeded), Sweet Potato (Swerte), Cassava (Golden Yellow), Bush Sitao (Los Banos white) and Pineapple.

Hosting the Field Day with 150 participants

-Farm tour was conducted in the Foundation Grove where the bearing and non-bearing pomelo were maintained. Likewise, the result of the trials on the different technologies was showcased. -The growth and performance of SAP model tree was showcased. -Testimonies from successful SAP growers inspired the participants to venture in SAP production. Packaging and Labelling of the SAP was developed to encourage potential buyers to purchase the product. Awarding and distribution of 6,000 seedlings to FCA was done during the field day

- Online advertising like social media platform (Facebook, Instagram), Direct Marketing, Product giveaways and samples, and Branded promotional gifts.

## RESULTS AND DISCUSSION

Result shows that the net income of different Pest Management Practices in controlling the insect pest of SAP especially Citrus Rind Borer (CRB) the gross income derived from the 5 to 7 year-old SAP was Php. 1,248,000.00. Chemical Spraying practice gave the highest net income with 909,570.00 followed by insect trapping with Php. 899,170.00 . The treatments are not different among each other in terms of ROI. Therefore, any of the treatments can be recommended to SAP growers. Cash crops are a viable source of additional income to pomelo growers. Intercropping is a practice to maximize utilization of land use in SAP plantation. Result shows that the top three cash crops used with the highest net income were the Pineapple, Sweet Potato and bush sitao with Php.155,543.00, Php. 81,779.00, and Php. 80,250.00, respectively. The Field day conducted brought a significant impact to the pomelo growers. Farmer's option on Pest Management Practices for SAP was established aside from Chemical Pest Control. The different Pest Management Practices employed against Citrus Rind Borer improved the fruit quality of SAP up to 90% CRB damage free. Various crops were identified that can be grown in between non-bearing pomelo. There was an increase in demand of SAP fruit as source of Vitamin C during the pandemic, as well as planting materials. 6,000 SAP seedlings to Farmer Cooperative/Associations and 1,000 to Municipal Wide Backyard Tree planting in Abulug, Cagayan were distributed to recognize Abulug as the Home of SAP.

## CONCLUSION

Opportunity comes when least expected and even at the midst of hard times. It was in this pandemic, the health crisis brought by COVID-19 that each one struggle to boost one's immune system to combat the virus. The closure of many borders limits the entry of fruits and vegetables as part of essential hence, the supply decreased and the demand is high resulting to increase in price. Now, the hidden treasure of Abulug sparks and shines due to the call of the moment. The DA initiatives with other partner agencies made SAP a lucky fruit of Cagayan Valley, Philippines. The field day conducted at DA-NCES and NVES was carried out successfully in promoting SAP and now adopted as one of the priority crops to consider. This high value crop is now an integrated part as tourist attraction of Cagayan Valley. Government support system played significantly in the promotion of SAP that enable farmers to earn a million of pesos from the sale of fruits. SAP farming is a productive endeavour that keeps farmers alive in the new normal as indicated by the demand of seedlings as well as fruits. Growing fruit trees is environment friendly and minimizes soil erosion.

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## CORN COB AND CORN HUSK BIOCHARS ENHANCE SOIL PROPERTIES AND GROWTH OF CORN (*ZEA MAYS* L.) IN FERTILIZED CLAY LOAM SOIL

Arsenio D. Bulfa, Jr.<sup>1,2\*</sup>, Gina Villegas-Pangga<sup>3</sup>, Amparo DM. Wagan<sup>3</sup>

<sup>1</sup> College of Agriculture, Silliman University, Dumaguete City 6200 Philippines

<sup>2</sup> Graduate School, University of the Philippines Los Baños, College, Laguna 4031 Philippines

<sup>3</sup> Agricultural Systems Institute College of Agriculture and Food Sciences  
University of the Philippines Los Baños, College, Laguna 4031 Philippines

\*Corresponding author: arseniodbulfa@su.edu.ph

### ABSTRACT

Biochar, produced from biomass pyrolysis under a limited oxygen environment, is a carbon (C)-rich material that improves soil quality and increases crop yield. An experiment laid out in split-plot in a completely randomized design (CRD) was conducted to investigate the growth responses of corn to corn cob biochar (CCB) (15 t/ha), and corn husk biochar (CHB) (15 t/ha) in Lipa clay loam (*Typic Eutrudepts*) applied with organic fertilizer (OF) (10 t/ha) and inorganic fertilizer [recommended rate (RR):120 N;60 P<sub>2</sub>O<sub>5</sub>-60; K<sub>2</sub>O per ha]. Results show that CCB and CHB are rich in essential macro and micro-essential elements. Biochars have high average surface area, high pore radius, and pore volume. The field emission-transmission electron microscopy (FE-TEM) and X-ray energy dispersive spectroscopy (EDS) show a very high concentration of C (88-90%) and other elements (Cu, Na, K, Cl, S, Si, P, Ca, O). CCB and CHB applied with organic and inorganic fertilizers improved clay loam soil, such as soil pH, CEC, EC, and nutrient status in the soil, which is evident in the enhanced growth of the plants, such as increased leaf chlorophyll concentration, corn ear biomass, root biomass, and plant height. The CCB and CHB with organic and inorganic fertilizer applications are recommended for clay loam soil to improve soil health and plant growth.

Key words: corn cob biochar, corn husk biochar, biochar properties, fertilizer, clay loam

### INTRODUCTION

One of the challenges nowadays is to feed the growing population while maintaining the integrity and sustainability of our natural resources, such as our soil systems. Biochar improves soil health and enhances plant growth (Lehmann et al. 2011). Biochar is a carbon (C)-rich material produced by biomass pyrolysis under limited oxygen (Lehmann et al. 2011; Villegas-Pangga 2021). It comprises recalcitrant C structures that prevent decomposition and help sequester C in soils, improving soil properties and agronomic properties (Lehmann et al. 2011). It has a large, charged surface area of great potential to adsorb heavy metals and organic contaminants. Its application decreases the bioavailability, toxicity, and mobility of organic and inorganic pollutants. It becomes beneficial to immobilize contaminants with high concentrations, allowing cultivated soils to have improved quality and enhanced crop yields. More studies have stated the benefits of biochar; however, there is limited data about the effects of biochar physico-chemical properties, specifically in clay loam soil and the crops planted in it. This study was conducted to determine the effect of corn cob biochar and corn husk biochar application on the growth of corn grown in clay loam soil with organic and inorganic fertilizers. Specifically, this study hypothesizes that the addition of CCB and CHB with organic and inorganic fertilizers will enhance corn growth.

### MATERIALS AND METHODS

A *Typic Eutrudepts* clay loam soil of volcanic origin was air-dried, cleaned, and sieved (2mm), and potted. The pot with 30cm diameter x 30cm height x 20cm base was perforated to drain excess moisture and filled with 12kg soil. Corn cob and corn husk were air-dried (7 days) and chopped into small pieces (3-5 cm) before heat treatment. The air-dried corn cob and corn husk were pyrolyzed in the biochar-producing cookstove for 60 min and 30 min heating residence time, respectively, at 300-650°C (Villegas-Pangga, 2021).

The chemical analyses of soil, CCB, CHB, OF, and plant tissues were conducted at the Analytical Service Laboratory, UPLB, Laguna, Philippines. The Brunauer–Emmett–Teller (BET) analysis for CCB and CHB were conducted to determine the physical adsorption of gas molecules on their solid surfaces, which serves as the basis for a critical analysis technique for measuring the average surface area, pore size, and pore volume of corn cob and corn husk biochars using the Quanta Chrome Nova 22200BET automated N multilayer physisorption system at the Nanotechnology Laboratory, University of the Philippines Los Baños. The Transmission Electron Microscope (TEM)-TEM Imaging & Energy Dispersive X-ray Spectroscopy (EDS) were performed to determine the composition of C, and other abundant essential elements located in discrete spots of the CCB and CHB surface at

the Industrial Technology Development Institute-Department Science and Technology. The data gathered in this study that was laid out in split-plot in a completely randomized design were analyzed using a two-way analysis of variance and least significant difference through the Statistical Tool for Agricultural Research (STAR) 2.0.1 software developed by the International Rice Research Institute to determine the differences between treatment means at a 5% level of significance.

## **RESULTS AND DISCUSSION**

The CCB and CHB generally have high pH, similar to the pH ranges reported for biochar made from rice straw, water hyacinth, mahogany flower, sugarcane bagasse, sugarbeet, cauliflower leaf, and orange peel wastes (Villegas-Pangga, 2021). It consists of high OC while containing high essential macro-elements (N, P, K Ca, Mg) and micro-elements (Fe, Zn, Cu, Mn). Ash content in biochars ranged from 0.35 to 59.05 %, rich in available nutrients, especially K, Ca, Mg, and Na. High organic C in fresh biochars and its well-developed pore structure may enhance water retention and provide a shelter for soil microorganisms. Both biochars had high porosity that could retain water, consequently increasing water holding capacity and helping infiltrate excess water through larger pores which provide essential sites for sorption and reaction (Xiao et al. 2018) thus increasing soil fertility and yield (Ding et al. 2016). The CCB and CHB samples contained essential elements (C, Cu, Na, K, Cl, S, Si, P, Ca, O). C is 88-90 (wt%). The ash content of biochars is rich in K<sup>+</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup>, and Na<sup>+</sup> (Rajkovich et al. 2012).

Generally, soil parameters such as pH, OC, available P, exchange K, and EC, CEC are improved by biochars mixed with organic and inorganic fertilizer applications in Lipa clay soil. Biochar application could increase pH, which is an essential factor affecting nutrient availability (Wang et al. 2014). Biochar additions could improve CEC by 4-30%. The improvement of soil properties is highly related to high surface area, the magnitude of functional groups, and the liming effect (Ding et al. 2016). Both biochars with fertilizers added significantly improved chlorophyll concentration, upper and lower plant biomass, and root-shoot ratio. In the present study, a 54% increase was recorded at a 15 t/ha application rate. The properties of biochar in this study showed positive responses from the plants.

## **CONCLUSION**

CCB and CHB applied with organic and inorganic fertilizers improved fertility of clay loam soil, such as soil pH, CEC, EC, and nutrient status in the soil, which enhanced growth of the plants, such as increased leaf chlorophyll concentration, corn ear biomass, root biomass, and plant height. The CCB and CHB with organic and inorganic fertilizer applications are better recommended for clay loam soil as these improved both soil health and plant growth.

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## EVALUATION ON THE EFFECTIVENESS OF PHEROMONE TRAPPING AGAINST TWO LEPIDOPTEROUS PESTS OF ONION IN STO. DOMINGO, NUEVA ECIJA

Bonifacio F. Cayabyab<sup>1</sup>, Carl Johnjay A. Ayen<sup>2</sup>, Melvin D. Ebuenga<sup>1</sup>,  
Gideon Aries S. Burgonio<sup>1</sup>, Byron Amadeus G. Cayabyab<sup>1</sup>, and Lyle M. Alforja<sup>1</sup>

<sup>1</sup>National Crop Protection Center, College of Agriculture and Food Science,  
University of the Philippines Los Baños, College, Laguna 4030

<sup>2</sup> Technical Research & Development Head, Agrexplore Corporation, Bay, Laguna 4033  
Corresponding authors: bfcayabyab@yahoo.com; caayen@up.edu.ph

### ABSTRACT

The effectiveness of pheromone trap as part of monitoring of pests in onion was examined by dispensing synthetic female sex pheromone (lure) in three locations at Barangay. Dolores, Sto. Domingo, Nueva Ecija by using one lure per used 6 liters plastic water container with 4 cm water and 1 teaspoon detergent. The set up was replicated four times. Two common pests of onion namely; onion armyworm, *Spodoptera exigua* (Hubner) and cutworm, *Spodoptera litura* (Fabricius) Boursin were detected from Day 1 to Day 45. Consistent with the result, the installed pheromone traps caught significant numbers of onion army worm and cutworm at 1 % level of significance ( $p < 0.01$ ) compared to the traps without pheromone. These results show that the pheromone treatment provides effective monitoring and possible reduction of population thru mass trapping of these two pests in onion. The trap data can also serve as a basis for Pest Alert SMS messages to stakeholders particularly during high catches for intensified field monitoring of eggs and larvae in onion fields and other crops in the area. including the timely application of integrated pest management measures.

Keywords: onion, pheromone trap, *Spodoptera litura*, *Spodoptera exigua*, pest monitoring

### INTRODUCTION

Onion is extensively cultivated in the Philippines and grown in 22 provinces. There is an increasing trend in onion production as well as in farm gate price with an annual average rate of 2% to 7% from 2015 to 2019. Profitability is very attractive with return of investment of 147% in onion multiplier and 197% for bulb onion (PSA 2019). The top 3 major productions of onion in the country in 2019 came from Region III (138,795.26 MT), Region I with 38,827.62 MT) and Region IV-B with 35, 055.30 MT. Onion production is highly dependent on inorganic fertilizers and insecticides. Fertilizer usage is 26 to 30 bags per hectare while pesticide spraying is up to 16 times throughout the growing period. On the other hand, the damage caused by lepidopterous pests in Nueva Ecija was estimated at 20% reduction of the total yield (Cayabyab 1999). As of May 2017, 13 towns in Nueva Ecija have reported the presence of this pest in 1,076 hectares of onion fields (DA-RCPC III 2017) while in Pangasinan four municipalities were affected with a total of 409.4 ha infested (DA-RCPC I 2017). This pest has a short life cycle and may be resistant to insecticides due to non-stop and indiscriminate use. Until now these two pests are still infesting onions in Nueva Ecija and Pangasinan. Field monitoring is necessary for the rapid detection of the presence of onion army worm (OAW) including cutworm and for timely interventions to effectively protect onion while minimizing harm to the environment. Monitoring involves the active tracking of the presence, population assessment, and movement of a pest (FAO and CABI 2019). Pheromones are used in monitoring and belong to a class of semiochemicals that insects and other animals release to communicate with other individuals of the same species (Karlson and Luscher 1959). These signals can be effective in attracting faraway mates and can also be very persistent for days. This study sought to evaluate the effectiveness of selected pheromone traps against two lepidopterous pests in onion crop.

### MATERIALS AND METHODS

Pheromone traps were set-up in three different sites of Brgy. Dolores, Sto. Domingo, Nueva Ecija with four replicates. The onion army worm pheromone lure contains Z9, E12-14:AC (90%) and Z9-14:OH (10%) active ingredients while the cutworm pheromone lure has (Z,E)9,11- Tetradecadien-1-yl acetate. The pheromones on screen wire mesh were attached to a wire and placed at the center of a 6-liter plastic water container with 4 cm water and 1 teaspoon detergent. It was stabilized by using two-bamboo sticks. Adult male moths trap catches were monitored every day for 45 days from June 28, 2019- August 11, 2019. Each trap was checked and captured moths were stored in 70% ethanol. The mean count was analysed for variance (ANOVA) among the three treatments using the Statistical Tool for Agricultural Research (STAR) software in randomized complete block design (RCBD). The repeated measures ANOVA was determined using the Minitab 17 Software.

## RESULTS AND DISCUSSION

Higher density of the cutworm was observed than the onion army worm while no male moths were collected in the treatment without pheromone for all trial in three sites. Over-all, the population of *Spodoptera litura* was recorded with the highest density among the three treatments in the three different sites. At different observation intervals there were significant effects on pheromone trapping to each of lepidopterous onion insect pest but still, variation on mean counts from the different treatments per site (e.g *Spodoptera litura* vs. *Spodoptera exigua* vs. control) were observed. The mean count of *Spodoptera litura* caught in pheromone trap is significantly different from the control and mean count of *Spodoptera exigua* during trapping in all sites. Trapping resulted in detection of *Spodoptera litura* and *Spodoptera exigua*. This monitoring function is the keystone of integrated pest management. In this study, the mean count of *Spodoptera litura* was higher compared to mean count of *Spodoptera exigua* due to off- season of onion crop during the monitoring. However, alternate crops of both pests such as corn and vegetables were planted in the surrounding areas of the sites. Aside from monitoring as the most important application of pheromones, other uses include: mass trapping of insects to remove large numbers of insects from the breeding and feeding population and the disruption of mating in populations of insects. Massive reductions in the population density of pest insects ultimately help to protect the crop since there will be higher number of female cutworms and onion army worms that will not be mated. The normal egg production of adult female *Spodoptera exigua* ranges from 300-500 eggs (Capinera 1999). On the other hand, adult female *Spodoptera litura*'s fecundity varies from 2000 to 2600 eggs, and oviposition days vary from 6 to 8 days (Rao et al., 1989). The total caught adult male *Spodoptera litura* from three sites was 9,752 while the total caught adult male *Spodoptera exigua* was 541. This means that using the pheromone trap, 9752 adult female and potential  $1.9 \times 10^7$ -  $2.4 \times 10^7$  F1 population of *Spodoptera litura* were reduced from the three sites while 541 adult female plus has a potential of 162,300-270,500 F1 population of *Spodoptera exigua* were reduced from three sites. The result of the study is similar with the report of Takai and Wakamura (1995) for the control of beet armyworm, *Spodoptera exigua* (Hübner) in both open field and green house. The rate of mating inhibition in the field and greenhouse were 97% and 20-50% respectively.

## CONCLUSION

The effectiveness of pheromone trapping was evaluated as crucial role for integrated pest management in onion crop. Higher density of cutworm was observed from three sites compared to onion army worm. Pheromone traps can be used to monitor and at same time mass trap the cutworm and onion army worm male moths even before planting onions. Both lepidopterous pest also infest other crops such as some vegetables and corn. The trap data can also serve as a basis for Pest Alert SMS messages to stakeholders particularly during high catches in the traps for intensified field monitoring of eggs and larvae in onion fields and other crops in the area.

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## **GROWTH, YIELD AND ANTIOXIDANT PROPERTY OF LETTUCE (*Lactuca sativa* L.) APPLIED WITH ORGANIC AND CHEMICAL FERTILIZER**

**Sitty Aynah P. Mala**

Agricultural Education and Extension Department, College of Agriculture, Mindanao State University, Marawi  
City, Philippines  
[sittyaynah.mala@msumain.edu.ph](mailto:sittyaynah.mala@msumain.edu.ph)

### **ABSTRACT**

A pot experiment was conducted to determine the effect of organic and chemical fertilizers on lettuce in growth, yield, antioxidant property as well as the occurrence of insect pests and diseases. Randomized Complete Block Design was used in the study with three replications. Seeds were directly sown on the pots with fertilizer and control treatments. Plants grown under organic fertilizer had significantly higher germination percentage compared to plants grown under control and chemical fertilizers. Organic fertilizer produced significantly longer and wider leaves during the first 4 weeks. However, chemically fertilized plants surpassed organically grown plants on the fifth week until harvest but the difference was only significant on the sixth week. Further, plants treated with chemicals had significantly heavier weight resulting to significant higher yield compared to those grown under organic fertilizer and control treatments. In terms of antioxidant property of lettuce particularly vitamin C, plants treated with inorganic fertilizer had significantly higher antioxidant content compared to plants grown organically. Pest and disease damage were not significantly affected by the kinds of fertilizer. Incidence of diseases and pest infestation were recorded low in all treatments.

**Key words:** lettuce, antioxidant, organic, chemical fertilizer

### **INTRODUCTION**

Lettuce production in the Philippines was increasing at an average annual rate of 2.2 percent and 0.3 percent from 2011 to 2015 (Philippine Statistics Authority, 2017). This attests the need to produce more lettuce because of its increasing demand. The knowledge on the higher advantages of lettuce drives the need to study the different management of this crop. This study aimed to determine the effects of two kinds of fertilizer on the growth, yield and antioxidant property of lettuce grown in container. Specifically, it aimed to 1) Determine and compare the growth performance of lettuce applied with organic and chemical fertilizer; 2) Determine and compare the yield performance of lettuce applied with organic and chemical fertilizer; 3) Evaluate and compare the total antioxidant content of lettuce as affected by different fertilizers; 4) Evaluate pest and disease damage; and 5) Determine the economic benefit of growing lettuce in container. The study was limited on identifying the growth parameters of lettuce in terms of germination percentage, length, and width of leaves; and the yield components which are the total weight, and yield per hectare. The antioxidant property of lettuce was also covered by the study. However, the determination of antioxidant was limited to the total activity of vitamin C or ascorbic acid through quantitative analysis using phosphomolybdenum assay.

### **MATERIALS AND METHODS**

Red Rapid variety of lettuce was used in the study with three (3) treatments: vermicompost (T<sub>1</sub>), complete fertilizer (T<sub>2</sub>) and control (T<sub>3</sub>) replicated thrice. Recommended rate of fertilizer was applied. Fifty (50) grams of vermicompost was applied as basal fertilizer and 6.4 grams of complete fertilizer (14-14-14) was applied per pot. The seeds were directly sown in pots filled with ordinary garden soil. All data were statistically analyzed using the Analysis of Variance (ANOVA) for Randomized Complete Block Design (RCBD). The data with significant and highly significant results were subjected to Least Significance Difference (LSD) Test in Statistical Tool in Agricultural Research (STAR) Version: 2.0.1 to determine the significant differences among treatment means.

### **RESULTS AND DISCUSSION**

Plants grown under organic fertilizer had significantly higher germination percentage compared to control and chemical fertilizer treatments. The lowest germination percentage was obtained from chemically treated plants. This may be attributed to soil temperature and moisture. It was observed that the granular chemical fertilizers were not fully decomposed two weeks after application thereby causing high temperature. It was also observed that pots treated chemically were prone to soil clogging. On the other hand, pots treated with vermicompost were moist and well-drained. Organic fertilizer had produced significantly longer and wider leaves during the first 4 weeks. This result is consistent with earlier studies which revealed that lettuce grown in soil amended with inorganic fertilizers

had shorter leaves while the treatments with organic fertilizers increased the length and width of the largest leaves although the differences were not significant (Liu et al. 2014). However, chemically fertilized plants surpassed organically grown plants on the fifth week until harvest but the difference was only significant on the sixth week. This result may be attributed to the availability and accessibility of nutrients necessary for plant growth and development. After 5 weeks of application, the granular chemical fertilizer was fully transformed into soluble form which made them available for plant absorption. On the other hand, the nutrients in vermicompost were utilized at the early stage of lettuce growth. Thus, plants under chemical treatment showed higher increase in leaf length and width. This result conformed with the findings of Hernandez et al (2007) that after 5 weeks, plant growth and development in inorganic exceeded organic which showed a small increase in growth and development during the following 3 weeks. Similarly at harvest, vermicompost had no effect on leaf area (Leon 2012). Plants treated with chemicals had significantly heavier weight resulting to significant higher yield compared to those grown under organic fertilizer and control treatments, which is consistent with the findings of Hernandez et al (2007).

Chemically treated plants significantly contained more antioxidants compared to plants grown organically. This observation agrees with the findings of de Oliveira Pereira et al (2016) that showed conventional lettuce samples had a higher ascorbic acid value than organic and certified organic samples. Organic lettuce showed higher effectiveness in antioxidant capacity and higher levels of phenolic compounds than lettuce produced in the conventional system (Silva et al. 2018). The difference between these results may be attributed to the use of different cultivars and environmental conditions where the experiments were conducted. The exposure of plants to both biotic and abiotic stress may contribute to the greater effects of antioxidant activity. Incidence of diseases and pest infestation were recorded low in all treatments. Pest and disease damage were not significantly affected by the kinds of fertilizer and may be due to the environmental conditions the lettuce crops were exposed to. The site of the field experiment and the pot culture lessened the entry of insect pests. The net shade also protected the crops from heavy rains and from direct heat of the sun which prevented diseases caused by too much sunlight and too much water. The application of either organic or chemical fertilizer is feasible. Organically grown lettuces elicited better return next to chemically treated plants. Negative returns were obtained from unfertilized plants. The profitability of lettuce production is supported by the study of Bureau of Plant Industry - National Crop Research and Development Center which reported that the net profit of lettuce production in a hectare is equivalent to PhP 244,820.00 with an ROI of 182.82%.

## CONCLUSION

The two kinds of fertilizer have positive influence on the growth, yield and antioxidant property of lettuce grown in container. Organic fertilizer performed better during the seed germination and seedling development whereas chemical fertilizer worked better at the later stage of lettuce growth. Thus, higher yield values were obtained from plants under chemical treatments. Further, highest absorbance of vitamin C was reflected in chemically treated plants. Moreover, insect pest management and disease management are easier in container gardening. Lettuce production with the application of fertilizer, whether organic or chemical is profitable.

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## MORPHOMETRIC VARIATION IN ISO-FEMALE REARED MANGO TEPHRITID FLIES, *BACTROCERA DORSALIS* HENDEL

Elaida R. Fiegalan and Jackielyn P. Ponce

Corresponding author: [elaidafiegalan@clsu.edu.ph](mailto:elaidafiegalan@clsu.edu.ph)

### ABSTRACT

The *Bactrocera* tephritid fruit flies, aside from being known pests of mango, are well-known to exhibit crypsis. Identifying the pest species have been difficult due to the morphological variations exhibited by the species. The study aimed to identify the species of tephritid flies pre-emerged from incubated-infested mango fruits, and find out which morphological character varies among the offspring from iso-female rearing. All fruit flies that emerged from incubated mangoes collected from 2014 to early 2017 in selected areas were identified as *Bactrocera dorsalis*. Female fruit flies from mango-growing localities were reared and representative isofemale offsprings were randomly selected. Comparison of the morphological characters of isofemale-reared individuals were measured to determine degree of variability among offspring using lengths of the body, thorax, midtibia, and wing. Measurements and resulting indices of the wing following terminologies of McAlpine (1981) were determined. Differences were evaluated using CRD, and analyzed using ANOVA (SAS v.9.1). All measured characters and most wing indices were not significantly different except for “d” vein and “4v” index; the latter being an index, based on the “d” vein. The study proves that variation among the offspring of *Bactrocera dorsalis* vary on this character, M1 between dm-cu and r-m.

Key words: mango fly pest, *Bactrocera* spp, wing measurements, wing indices, offspring morphometry

### INTRODUCTION

The mango fruit fly is one of the most important insect pests in mango. Fruit fly damage is one of the major causes of our mangoes being banned for export to other countries. Since the 1980's, technologies such as sterile insect technique and male annihilation technique have been used to ensure that the pest is controlled. Determining the fruit fly (Tephritidae) species infesting mangoes is needed in mitigating area-wide pest management strategies effective only as species-specific. New technologies such as the Release of insects carrying dominant lethal or RIDL necessitates that other possible pest species' occurrence is known. Mango fruit fly is one of Philippines' worst horticultural pests due to invasiveness and crypsis (morphologically indistinguishable species). Two species of fruit flies have been reported to infest Philippine mangoes; *Bactrocera dorsalis* and *Bactrocera occipitalis*. These two are mostly observed by the authors to be commonly caught in methyl eugenol traps. *B. occipitalis* has also been reported by Drew in numerous publications as found in mangoes. It is not sure however, whether this was a natural infestation, or mango fruit has been used as a host to rear the species. It has also been proven before that these two species are hard to delineate morphologically (Mahmood 2004a) and Delomen et al. (2013). Comparison of morphological characters of individuals coming from one gravid female or “mother” has never been done before, hence this research. Using the offspring from one female and comparisons amongst offspring of one female may resolve issues on mango fruit fly identification and provide accurate database wherein further investigations on pest profiling could take off. The use of stable characters was duly emphasized by Ernst Mayr, and it was hypothesized that the variable character amongst offspring, between sexes, and among areas would likely be variable and therefore unstable. Unstable characters cannot be used on coming up with keys for identification.

The objectives of the research were to identify the species of Tephritid fruit fly pre-emerged from incubated-infested mango fruits, and find out which morphological character varies among the offspring from iso-female rearing.

### MATERIALS AND METHODS

Sites selected for collection had the highest production of mango in Nueva Ecija and had not been subjected to pesticide application. The sites were located in the municipalities of Cuyapo (15.7861111 °N and 120.65000 °E), San Jose (15.8037018 °N and 120.9991032 °E), and Talavera (15.6136111 °N and 120.9250001 °E). To initiate the culture, purportedly maggot-infested mangoes were collected and placed in emergence canisters. This was done from 2014 to early 2017. Once enough females were emerged, iso-female rearing commenced using one pretreated or disinfested mango fruit (treated by dipping in hot water for twenty minutes) per one gravid female fruit fly. Resulting offspring from the iso-female rearing were allowed to mature, and these were prepared for morphometric examination. A total of 2,128 fruit flies were successfully reared coming from 34 females. Of these, 290 offspring composed of five males and five females from 34 “mother” females were measured using the accompanying software for Optika microscope.

Lengths of the body, thorax, mid-tibia, and wing were taken as well as length of  $a$  (2<sup>nd</sup> costal section between subcostal break and  $R_{2+3}$ ),  $b$  (3<sup>rd</sup> costal section between  $R_{2+3}$  and  $R_{4+5}$ ),  $c$  ( $M_1$  between dm-cu and wing margin),  $d$  ( $M_1$  between rm-cu and dm-cu),  $e$  ( $CuA_1$  between  $M_1$  and wing margin),  $f$  (dm-cu between  $M_1$  and  $CuA_1$ ), and  $i$  (distance between distal end of  $R_{2+3}$  and  $M_1$ ). Wing indices were computed based on the previous measurements:  $C = a/b$ ,  $4c = b/d$ ,  $4v = c/d$ ,  $5x = e/f$ ,  $ac = b/i$  and  $M = e/d$ . Analysis of variance (ANOVA, SAS v.9.1) considered collection sites, mothers, and sex of offspring as factors achieving a multi-level modelling or nested design.

## RESULTS AND DISCUSSION

There was only one species of fruit flies collected from the different collection areas after more than two years of continuously incubating infested mangoes and rearing emerging larvae and pupae to adults from 2014 to early 2017. Succeeding collections were done for verification. The species from the three collection sites in Nueva Ecija was *Bactrocera dorsalis*. In the collection data of researches by Drew (1972; 1989; and 2011) and others, *Bactrocera occipitalis* has been documented from mango. The results of this research proved that *B. occipitalis* was not present in the infested mangoes and had not been reared-out. Further studies on the possible co-existence of *B. dorsalis* and *B. occipitalis* can be done in other mango-growing areas for purpose of area-wide management using newer technologies in pest management

Analysis of variance showed that lengths of body and thorax were significant in three areas, while lengths for midtibia and wings did not vary significantly. Among the letter measurements only  $d$  varied significantly. In the indices, although  $4c$  and  $4v$  were based on  $d$ , only  $4v$  was significantly different based on the sites. In comparing the males and females, body and thorax lengths were significantly different. Taxonomic keys do not rely on lengths of body or thorax in determining identity which was supported by the findings in this research. Wing vein  $d$  was found significant based on sites and sex. This vein  $d$  had been crucial in the morphometric studies conducted by Adsavakulchai et al. (1999), and Delomen et al. (2013). Of the characters used, the most likely to be variable and therefore prove unstable in coming-up with keys even amongst offspring of one female is  $d$ .

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**PROFITABILITY EVALUATION OF RICE-DUCK-KUHOL  
(RIDUKU) FARMING SYSTEM IN KANANGA, LEYTE**

**Bryan Ranches Gapasin**

Visayas State University Main Campus, Baybay City, Leyte  
Corresponding author: bryan.gapasin@vsu.edu.ph

**ABSTRACT**

Rice-Duck-Kuhol (RIDUKU) is an organic farming system that cultivates rice, ducks, and kuhol together. In 2005, the practice was introduced in Kananga, Leyte to substitute the use of agrochemicals in rice farming. However, since its introduction, only one farmer was adopting the farming system. A profitability case study of RIDUKU was conducted to determine its costs and returns, and the results were compared to 30 local farmers who adopted conventional farming. The study also identified problems and constraints, and provide solutions for the adoption of RIDUKU. Results of the study showed that gross revenue in RIDUKU was 40% higher than the conventional farming system, equal to Php149,131.00/ha, and Php60,808.80/ha, respectively; 11% lower in the cost of production equal to Php101,820.57/ha, and Php113,839.22 respectively; and a positive net income of Php47,310.43 against a negative net income of Php (-53,030.32) in the conventional farming. While the adoption of RIDUKU was high (73.3%) among the conventional farmers, it showed a Benefit-Cost ratio of 1.32, and a return on investment equal to 41.18%. The expected net present value was equal to Php127,045.00 at a 12% discount rate. RIDUKU can be a good investment, and an alternative to a more environmentally sustainable rice produce.

Key words: RIDUKU, organic farming system, rice, duck, kuhol

**INTRODUCTION**

Organic agriculture is one of the most dynamic and rapidly-growing sectors of the global food industry of which organic farming is one of its several approaches to sustainable agriculture (FAO 1999) because of its commercial viability, and may provide solutions to the current problems in conventional agriculture (Scialabba 2000). In recent years, several novel species-diversified farming systems such as rice-fish, rice-duck have been documented to be highly effective in controlling crop diseases, insect pests, and weeds in paddy fields with less pesticide and herbicide application. Rice-Duck-Kuhol farming system, also known as RIDUKU is an innovative farming system in rice that integrates duck raising to address problems on kuhol, but uniquely utilizes kuhol (Golden Apple Snail) however, little is known about this new farming system. This study was undertaken to provide insights to farmers on the profitability of the RIDUKU farming system using Net Present Value (NPV) approach, Benefit-Cost Ratio, and Return of Investment (ROI), and identify the problems and constraints associated with the adoption of RIDUKU by rice farmers engaged in conventional farming.

**MATERIALS AND METHODS**

This study was carried out as a case study in March 2019 at Brgy. Montebello, Kananga, Leyte, to determine the profitability of RIDUKU. Since its introduction in 2005, only one farmer was adopting the farming system. He introduced RIDUKU in the area in order to substitute the use of chemical fertilizers and agrochemicals in rice farming. Thirty (30) local farmers engaged in the conventional farming system in rice were also randomly identified from the list provided by the Barangay Captain of Brgy. Montebello. These farmers were utilizing agro-chemicals such as fertilizers and pesticides nevertheless, they were possible adopters of the innovative farming system. A one-on-one interview with the RIDUKU farmer was conducted to know its farm management practices, costs and returns, and profitability, and the results were compared to the 30 local farmers who adopted the conventional farming. A structured questionnaire was used to interview the 30 local farmers. Statistical Package for the Social Sciences (SPSS) version 23 was used in analyzing the collected data, and were presented in tables, analyzed and interpreted using descriptive statistics.

**RESULTS AND DISCUSSION**

RIDUKU farming system included activities like herding of ducks in the paddy rice field for 90 days during land preparation until the growth stage of the rice crop, and breeding of kuhol. Conventional farming system utilizes agro-chemicals like fertilizers and pesticides, often in heavy doses. It relies on its income from harvested and threshed palay. A comparative computation of income of the two farming systems was based on the total yield harvested per production system, on a one-hectare paddy rice field, and multiplying the total harvest on a per sack basis. The prevailing price in the area was P720.00 per sack, average of 48 kilograms of threshed palay. Gross

revenue under the RIDUKU farming system was equal to Php 149,131.00 per hectare. The higher income in the RIDUKU farming system was due to the integration of ducks into its farming system and contributed an additional income from the sales of eggs amounting to Php 48,600.00. It also incurred a non-cash revenue equivalent to Php 15,283.00 since it utilized ducks in the land preparation and in the control of weeds and kuhol rather than hiring laborers. RIDUKU cash requirement was Php 71,880.42, for duck feeds, for a total of 130 days for two cropping seasons while confined for 65 days. It did not incur a non-cash costs since the practitioner payed for hired laborers.

Conventional farming system on the contrary, only relied on its income from harvested paddy rice. Conventional farming system which had a gross revenue of Php 60,808.80 per hectare. It had only Php 42,508.47 cash requirements for the purchase of seeds, fertilizers, chemicals, payment of hired labor, and irrigation fee. It incurred four (4) types of non-cash costs; thresher share, prentdis, landowner share, and harvester or tenant share.

The total production cost for the RIDUKU and conventional farming systems were Php 101,820.57 and Php 113,839.22, respectively. Net income accounted to RIDUKU was equivalent to Php 47,310.43 and a net loss of (-Php 53,030.42) was accounted to the conventional farming system. The expected net present value of RIDUKU was Php 127,045.00. Benefit-Cost ratio was 1.32 which meant that for every one peso invested in RIDUKU, we could expect a benefit of one peso and thirty-two centavos. ROI was equivalent to 41.18%. Conventional farming system did not calculate for NPV since it did not incur any fixed cost that were expecting returns from its used.

Twenty-two or equivalent to 73.3% were not willing to adopt the RIDUKU farming system in their paddy rice fields. According to them, it is expensive and time consuming, more volume of fertilizer was required and inconvenient, and effect is slow.

### **CONCLUSIONS**

Rice-Duck-Kuhol farming system is an alternative method in rice production. It practices an organic way of producing rice by integrating ducks in the production system that can contribute to an additional income, other than rice. Ducks are beneficial not only to the rice crop, the paddy rice soil, but their eggs and meat are good source of additional income. RIDUKU can be a considered as a good investment and an alternative to agro-chemical production of rice that is more environmentally sustainable. On the contrary, the conventional farming system utilizes agro-chemicals like fertilizers and pesticides, often in heavy doses. This type of farming system in rice production relied on its income from harvested and threshed palay.

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## VETIVER (*Vetiveria zizanioides*) AS PHYTOREMEDIATOR ON CHROMIUM AND NICKEL GROWN IN LOWLAND RICE SOILS AFFECTED BY MINING ACTIVITIES

Venus O. Saz<sup>1</sup> and Pearl B. Sanchez<sup>2</sup>

<sup>1</sup>Assistant Professor at Cavite State University, Indang, Cavite 4122, Philippines vosaz@cvsu.edu.ph

<sup>2</sup>Professor at University of the Philippines Los Banos, Laguna 4030, Philippines pbsanchez1@up.edu.ph

Corresponding Author: vosaz@cvsu.edu.ph

### ABSTRACT

The use of vetiver (*Vetiveria zizanioides*) is one of a few plant species meeting all the criteria required for phytoremediation. However, very limited studies have been done to use this plant as phytoremediator in lowland rice soils. The study was conducted to evaluate the Cr and Ni accumulation and translocation factor and to determine the effect of phytoremediation on the soil properties using different time duration of vetiver grown for 3 and 8 months in the field. The field experimental set-up was conducted for two cropping seasons. Results revealed that vetiver had a Bio-accumulation factor of 0.97 for Cr and 1.07 for Ni after 3 months of growth while 1.48 for Cr and 1.38 for Ni after 8 months planted in a contaminated field indicating higher concentration of Cr and Ni in the plant than in the soil. The translocation factors at both 3 and 8 months were below 0.2 mg kg<sup>-1</sup> suggesting that vetiver accumulates Cr and Ni in the roots and very small amount are translocated to the shoots, making the plant safe for forage purposes. Furthermore, the longer the vetiver grown in the field the lesser the amount of Total and Available Cr and Ni were detected in the field thus soil pH and organic matter content were improved.

Key words: bio-accumulation, translocation, phytoremediation, soil pollutants

### INTRODUCTION

Soils polluted with heavy metals have become common across the globe due to geologic and increase in anthropogenic activities like mining. In Philippines, particularly in Santa Cruz, Zambales mining industry has recently been booming due to its abundant deposits of chromite and nickel laterite minerals. Overburden and acid drainage from chromium (Cr) and nickel (Ni mining) industry are transforming productive agricultural lands to unproductive wasteland in some villages of the area. The Environmental Justice Atlas, 2015) reported that agricultural production in the municipality has been affected since mining operations started in 2006. Farmers tried to remedy the contaminated fields by applying more fertilizer, which jacked up their production costs but hardly made a difference.

Based on the identified problem of the area, there is an urgent need to determine cost effective techniques in mitigating Cr and Ni in a lowland rice field. Soil rehabilitation using vetiver as phytoremediator is a practical and low-cost measure that can be used to inhibit the availability of Cr and Ni in the soil and mitigate the metal uptake by the crops due to its high biomass and deep rooted which are more efficient in absorbing certain heavy metals and chemicals. The accumulation of Cr and Ni, particularly in an agricultural soil brings disorder of soil function which, in turn, affects crop growth. These metals can be transferred to crops therefore posing a risk to human health. The study was conducted based on the hypothesis that the removal of these metals will improve soil health. The results of this study can serve as a basis for mitigating heavy metal pollution in the affected area. Thus, it was conducted to evaluate the Cr and Ni accumulation and translocation factor and to determine the effect of phytoremediation on the soil properties using different time duration of vetiver grown for 3 and 8 months in the field.

### MATERIALS AND METHODS

Ocular survey was conducted in the vicinity of a mining area in Santa Cruz, Zambales. The basic criterion for the selection of the study site was the presence of an irrigated rice field. The field experiment was conducted from June 2017 to February 2018 in barangay Lomboy, Santa Cruz, Zambales. For the first cropping season (2017 WS), the area was planted with vetiver. During the second cropping season (2018 DS) the area previously planted with vetiver plant was divided into two (2) sub-blocks. One sub-block was terminated while the other sub-block was remained in the field. Soil sampling was conducted before planting with vetiver and after terminated the plant per cropping season. Samples were analyzed for various soil properties like Soil pH, Organic matter, Total and Available Cr and Total and Available Ni. Plant tissue of vetiver samples were analyzed for Cr and Ni accumulation and translocation.

## **RESULTS AND DISCUSSION**

After 3 months, soil pH increased to 6.21 and soil organic matter content to 2.6%. Total Cr and Available Cr were reduced by 186 mg kg<sup>-1</sup> (4.3%) and 160 mg kg<sup>-1</sup> (8.53%), respectively. Total and available Ni on the other hand were reduced by 261 mg kg<sup>-1</sup> (9.86%) and 246 (14.26%) mg kg<sup>-1</sup>, respectively. Moreover, effect of vetiver grown after 8 months show a continuous increase in soil pH by 7.12 and organic matter to 2.8. Total Cr and available Cr were continually reduced by 307 mg kg<sup>-1</sup> (7.12%) and 287 mg kg<sup>-1</sup> (15.30%). Total and available nickel were reduced by 537 mg kg<sup>-1</sup> (20.28%) and 511mg kg<sup>-1</sup> (29.62%). Results indicate that vetiver is very efficient in increasing soil organic matter content due to the unique characteristics of its root system. It has been considered an ideal plant to build up organic matter in poor or degraded soils (Truong 2007). Moreover, vetiver also significantly reduced the amount of total and available Cr and Ni indicating its potential in the phytoremediation of heavy metals.

The BAF of vetiver after 3 months is 0.97 for Cr and 1.07 for Ni which means that vetiver has the capacity to absorb Cr and Ni from the soil and store them in their system, particularly in the roots. Allowing vetiver to grow for 8 months increased BAF to 1.48 for Cr and 1.38 for Ni indicating higher concentration in the plant than in the soil. This further shows the potential of vetiver in mitigating heavy metal pollution in soils.

The translocation factor (TF) at 3 and 8 months are very low, indicating that vetiver accumulates Cr and Ni in the roots and very small amount of Cr and Ni were translocated to the shoots, making them safe for forage purposes. Higher TF was obtained for Ni as compared to Cr both at 3 and 8 months of growth. These values are below 0.2 mg kg<sup>-1</sup> which is the prescribed limit given by the Codex Standard (2001). Results implied that vetiver is a good phytoremediator due to their extensive rooting system that can take up considerable amounts of heavy metals using ion channels and metal transport proteins in their roots. This type of plant is suited in polluted soils due to its metal accumulating ability coupled with metal tolerance and high shoot biomass (Truong and Baker, 1998; Chen 2000).

## **CONCLUSION**

Based on the results of the study, the rice field was highly contaminated with Cr and Ni due to its naturally occurring mineral from the parent material and the presence of mining activities. Remediation technique using vetiver was ideal and sustainable alternative on the permanent removal of pollutants or recovery to rice paddies. Results showed that the longer the vetiver grown in the field the greater increased in soil pH and percent organic matter with a greater decreased of the amount of total and available Cr and Ni in the field. The bioaccumulation factor indicate that vetiver has the capacity to absorb and store metals on their system particularly the roots. With the continuous cultivation of vetiver in the field higher bio-accumulated metals were observed due to its increasing biomass. However, the translocation factor in both cropping seasons show that it is below 0.02 mg kg<sup>-1</sup> indicating vetiver plant had a lower translocated Cr and Ni to their shoots thus it is safe for forage purposes. Furthermore, it was observed that the longer the time of vetiver in the field the lower is the translocation factor due to that fact that vetiver has high capacity to store and uptake metals according to its bio-availability.

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## EFFECT OF HARVESTING CASSAVA LEAVES AT DIFFERENT PLANT AGE AND FREQUENCY ON CASSAVA LEAF PRODUCTION AND TUBER YIELD

Fides Marciana Z. Tambalo\*<sup>1</sup>, Rosa Buena A. Capuno<sup>1</sup>, Hiyasmin Rose L. Benzon<sup>1</sup>,  
Cyrene D. Estrellana<sup>1</sup>, Jayson F. Garcia<sup>1</sup>, Lizette Sahar N. Arcillas<sup>1</sup>, and Susan T. Bacud<sup>2</sup>

<sup>1</sup>National Institute of Molecular Biology and Biotechnology, University of the Philippines  
Los Baños (UPLB), College, Laguna 4031

<sup>2</sup>Institute of Weed Science, Entomology and Plant Pathology, College of Agriculture  
and Food Science, UPLB, College, Los Baños, Laguna 4031

\*Corresponding author: fztambalo@up.edu.ph

### ABSTRACT

Cassava leaves are rich in protein and other essential nutrients, thus, it has the potential to be an alternative source of protein for human and animal consumption. This study investigated the effect of harvesting cassava leaves at 4, 6, 8, and 10 months after planting (MAP) on the leaf production and tuber yield. Leaf numbers 7-15 were harvested from Binulak, Lakan 1, and Sultan 6 (Year 1) while all the leaves except leaf numbers 1-6 were harvested from Rayong 72, KU 50, and Golden Yellow (Year 2). The results showed that harvesting of cassava leaves starting at 4 MAP had no significant effect on the fresh weight of the harvested leaves as well as on the tuber yield for all the six cassava varieties. Therefore, deleafing every two months did not reduce the production of cassava leaves and tubers. Sultan 6 and Rayong 72 had the highest tuber yield but Binulak and Golden Yellow obtained the highest total fresh weight of harvested leaves. Thus, it can be recommended that the harvest of cassava leaves can be done starting at 4 MAP and every two months thereafter without compromising the tuber yield.

**Key words:** *Manihot esculenta* Crantz, Binulak, Lakan, Sultan, Rayong

### INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is mainly grown for its roots while leaves are mostly considered as a waste. However, cassava leaves are rich in protein, vitamins, and minerals unlike the roots that are essentially carbohydrates. Minerals found in cassava leaves include potassium, calcium, magnesium, phosphorus, sodium, manganese, iron, zinc, and copper. Cassava leaves also contain beta-carotene (vitamin A), thiamine (vitamin B1), riboflavin (vitamin B2), niacin (vitamin B3), and ascorbic acid (vitamin C) (Achidi et al. 2008; Latif and Mulle 2015). Nevertheless, consumption of cassava leaves as a source of essential nutrients is not much explored in the Philippines because of its high level of cyanogens and its antinutritive properties.

This study was conducted to establish best agronomic practices for production and harvesting of cassava leaves that will not compromise the tuber yield. With proper processing techniques, the cyanide content of cassava leaves can be significantly reduced that can be used for food and feed industry. This would increase the income of cassava farmers and would potentially reduce the production cost of feed industry.

### MATERIALS AND METHODS

Six local cassava varieties (ie. Binulak, Lakan 1, Sultan 6, Rayong, KU 50, and Golden Yellow) were selected for field experiment based on cyanide level, availability, and the variety planted by Filipino farmers as a result of the survey conducted in five regions in the Philippines. The frequency of harvest of cassava leaves and maturity of leaves harvested were studied for optimum leaf yield. The effect of leaf harvesting on cassava tuber yield was also investigated. Fifteen (15) healthy plants per plot from each variety were randomly selected for data gathering. Harvesting of leaves at 4, 6, 8, and 10 months after planting (MAP) was done and the tubers were harvested at 10 MAP. The leaves were numbered from the first fully opened one as Leaf 1 and counting sequentially down the stem. Leaf numbers 7-15 were harvested from Binulak, Lakan 1, and Sultan 6 (Year 1) while all the leaves except Leaf numbers 1-6 were harvested from Rayong 72, KU 50, and Golden Yellow (Year 2).

The experiment was composed of four treatments arranged in Split Plot in Randomized Complete Block Design with three replications. Each treatment consisted of 24 plants for each variety with a planting distance of

0.75 m x 0.75 m. The distance between varieties and replications was 1.5 m. Basal application of complete fertilizer (14-14-14) at a rate of 300 kg/ha was done and side dress using urea (46-0-0) at 100 kg/ha followed two months after planting.

## **RESULTS AND DISCUSSION**

The harvest of leaves in Year 1 show that the mean fresh weight of harvested leaves of Binulak and Sultan 6 was significantly higher compared to Lakan 1. For Binulak and Lakan 1, the total weight of harvested leaves starting at 4 MAP was significantly higher than harvests at 6, 8, and 10 MAP. However, for Sultan 6, there was no significant difference in the total weight of harvested leaves among the four treatments. High total yield of leaves was obtained even at 8 and 10 MAP. The differences in the obtained yield may be attributed greatly to varietal differences. It was observed that the mature leaves of Binulak and Lakan 1 started to shed at 8 MAP unlike in Sultan 6 wherein more leaves were produced. Binulak and Lakan 1 have similar structure wherein they only have one major stalk. In contrast, Sultan 6 produces more stalks as it grows making the plant grow wider, laterally, thus producing more leaves.

As for Year 2, the total weight of harvested leaves from Rayong 72, KU 50, and Golden Yellow at 4, 6, and 8 MAP had no significant difference. It was also observed that leaf yield was inversely related to the tuber yield. Golden Yellow obtained the highest leaf yield but had the lowest tuber yield. On the other hand, Rayong 72 had the lowest leaf yield but obtained the highest tuber yield. The results show that for Rayong 72 and Golden Yellow, the harvest of leaves starting at 4 MAP did not significantly reduce the weight of harvested leaves at the succeeding months. But for KU 50, the deleafing frequency had a significant effect on the harvest of leaves. The highest weight of leaves was obtained when the harvest was done starting at 8 MAP.

The harvest of leaves at different plant age and frequency had no significant effect on the tuber yield. Sultan 6 had the highest tuber yield followed by Lakan 1 then Binulak. Similar results were obtained for Year 2 in terms of tuber yield. The harvest of leaves at different plant age and frequency had no significant effect on the tuber yield. Rayong 72 had the highest tuber yield followed by KU 50, then Golden Yellow.

## **CONCLUSION**

Cassava growers may harvest the leaves of Binulak, Lakan 1, Sultan 6, Rayong 72, and Golden Yellow as early as 4 MAP without compromising much the leaf production and tuber yield in the succeeding months. For KU 50, the optimum plant age for deleafing is at 8 MAP. Thus, if cassava leaves would provide additional income for the farmers, it can be recommended that deleafing can be done between 4 to 8 MAP. This would give them the optimum yield of both leaves and tubers. Golden Yellow may have lower tuber yield but it produces significantly higher weight of leaves.

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## INDIGENOUS VEGETABLES IN *BULANGLANG* MIXED VEGETABLE DISHES: SUPPORTING BIODIVERSITY AND PROMOTING NUTRITION

Lorna E. Sister<sup>1</sup>, Hidelisa D. de Chavez<sup>2</sup>, King Philip B. Alcantara<sup>1</sup>, Catherine Hazel M. Aguilar<sup>2</sup>  
and Teresita H. Borromeo<sup>1</sup>

<sup>1</sup>Institute of Crop Science and <sup>2</sup>Institute of Plant Breeding, College of Agriculture and Food Science,  
University of the Philippines Los Baños, College, Laguna, 4031 Philippines

Corresponding author: lesister@up.edu.ph

### ABSTRACT

“*Bulanglang* dishes” are variants of traditional oil-less dishes of boiled Philippine indigenous vegetables (IVs) of which 46 recipes were documented from IV inventories across 20 provinces in 2019-2020: *bulanglang* (Tagalog); *dinengdeng*, *inabraw* (Iluco); *law-uy* (Bisaya); *linapwahan*, *laswa* (Ilonggo); *s’nobow*, *semala lemnaw* (T’boli, B’laan). They indicate potential contributions to nutrition and biodiversity with up to 14 vegetable ingredients per dish. Frequency counts revealed 47 IV species from 19 taxonomic families as ingredients – part of local biodiversity conserved through use. Analysis of 13 representative recipes using *Menu Eval Plus* (DOST-FNRI) online application revealed contributions to macro and micronutrients. Contributions of 10% or more to daily recommended energy intake (REI) and recommended nutrient intake (RNI) of adults 19-29 years old based on the Philippine Dietary Reference Intake per 100g serving were noted from *inabraw* (calcium, iron, vitamin A, niacin, vitamin C); *bulanglang* (vitamin C); *dinengdeng* (calcium, phosphorus, iron, niacin, vitamin C); *law-uy butong nga gulay* (vitamin A, vitamin C); and *laswa* (calcium, phosphorus, vitamin C). Lighter leafy vegetables appeared to contribute less. Nutrition and biodiversity conservation-through-use can be achieved by increasing: 1) the amounts of leafy IVs, 2) level and frequency of consumption, and 3) the diversity of IV ingredients.

**Key words:** *dinengdeng*, *inabraw*, *laswa*, Recommended Energy Intake (REI), Recommended Nutrient Intake (RNI)

### INTRODUCTION

*Bulanglang*, a mixed vegetable dish with variants around the Philippines based on the local preferences and availability of locally adapted, readily-available IV ingredients with a simple basic preparation of boiling the vegetables. In Quezon province, it is usually prepared by boiling vegetables in rice washing, a practice perceived to enhance flavor. *Dinengdeng*, the Ilocano variant, is flavored with *bagoong* or dried shrimps. Leaves are the most utilized plant part, followed by fruits and flowers (Favor 2019) resulting in vitamin A (Gascon and Orr 1973). There are few literatures that mention *bulanglang* and some of its variants, but data is scarce on the IVs ingredients in these dishes. Moreover, data is scarce on the dietary contributions of *bulanglang*-type dishes.

The study aimed to discuss the contributions of *bulanglang*-type dishes to biodiversity and nutrition. Specifically, 1.) to describe the diversity of IVs associated with the mixed vegetables dish *bulanglang* and its variants and assess its contributions to biodiversity; 2.) to assess the contribution of *bulanglang*-type dishes to the daily recommended nutrient/energy intakes of adults 19-29 years old; and, 3.) to make recommendations for policy directions in promoting *bulanglang*-type dishes for health and biodiversity conservation.

### MATERIALS AND METHODS

Six (6) variants or recipes of *bulanglang* from different regions identified during a 2018-2019 Documentation Project were included in the study – *bulanglang* (Southern Luzon), *inabraw* (Northern Luzon), *dinengdeng* (Ilocos Region), *laswa/linapwahan* (Western Visayas), *law-uy* (Central Visayas), and *s’nowbow* and *semala lemnaw* (Mindanao). The source data of the recipes was the Inventory of Indigenous vegetables done in 2018-2019.

To assess the diversity of indigenous vegetables (IV) in *bulanglang* variants, frequency counts of both the species per dish variant and taxonomic families of IV species in *bulanglang* variants were conducted.

To assess the contribution of 100 g serving size of *bulanglang* variants to the daily Recommended Nutrient Intake (RNI)/Recommended Energy Intake (REI) of adults 19-20 years old, 13 representative recipes from the six identified variants were used. Contributions to energy, protein, calcium, phosphorus, iron, vitamin A, thiamin, riboflavin, niacin and vitamin A requirements were computed using the *Menu Eval Plus* online application of the Food and Nutrition Research Institute (FNRI) of the Philippines Department of Science and Technology (DOST).

## RESULTS AND DISCUSSION

**Contributions to biodiversity.** Ingredients of documented *bulanglang* dishes include 47 IV species from 18 taxonomic families. The IV ingredients per recipe ranged from 1 to 14 species. Sustained utilization of IVs in *bulanglang* recipes reflect conservation these species through use. Across all provinces, at least five IV species are ingredients. Fabaceae was the most reported species (9). At least one legume is an ingredient in all recipes documented except in *semala lemnaw*. Legumes serve as a protein source, while growing them allow soil nitrogen fixation to help regenerate the soil, supporting growth of diverse flora and allowing other life forms to thrive. Tree vegetables like *himabao* [*Brousonettia luzonica* (Blanco) Bureau] also contribute ecosystem services that trees provide.

**Nutritional contributions.** The range of contributions of the 13 recipes of different *bulanglang* variants to the REI/RNI of adults with ranges reaching at least 10% upper level were noted: 12% calcium, 7-16% iron, 11-13% vitamin A, 14-16% niacin, 17-20% vitamin C from *inabaraw*; 11-50% vitamin C from *bulanglang*; 2-17% calcium, 2-13% phosphorus, 2-11% iron, 1-10% niacin, 3-37% vitamin C from *dinengdeng*; 12-14% vitamin A, 9-10% vitamin C from *butong nga gulay* recipe for *law-uy*; 11-15% calcium, 7-10% phosphorus, 3-13% vitamin C for *laswa*. The rest contributed <10% to the REI/RNI of an individual, but in general, the recipes registered contributions to the different macro and micronutrients required by the body. Lower percent contribution from *bulanglang* variants with mostly leafy vegetables is expected due to its approximate weight of 40g per cup basis for computation compared to heavier non-leafy vegetables with an weight basis of 240g per cup. Increasing the amounts of vegetables in each dish, increasing the number of servings consumed will enhance nutrition contributions. A lower percent contribution of a specific *bulanglang* variant highlights the importance of diet diversification, including diversification in *bulanglang* ingredients. While a higher percent contribution is favorable, it is also important to note the source of the macro or micronutrient. In the case of *dinengdeng* in Ilocos Norte, the calcium phosphorus contributions of 17% and 13%, respectively, were attributed to fish paste which is high in sodium. High sodium intake for people with heart conditions as well as edema and ascites might exacerbate their conditions; therefore, caution must be taken. Key IVs with relatively high contributions to essential macro and micronutrients effect on the percent contribution of *bulanglang* variants include horseradish tree pods (*Moringa oleifera* Lam.), unripe papaya (*Carica papaya* L.), bottle gourd [*Lagenaria siceraria* (Molina) Standl.], lima bean (*Phaseolus lunatus* L.), okra [*Abelmoschus esculentus* (L.) Moench.], sweetpotato [*Ipomoea batatas* (L.) Lam.], hummingbird tree flowers [*Sesbania grandiflora* (L.) Pers.], amaranths (*Amaranthus viridis* L., *Amaranthus spinosus* L.), morning glory leaves (*Ipomoea triloba* L.), and ricebean [*Vigna umbellata* (Thunb.) Ohwi & H. Ohashi].

## CONCLUSION

*Bulanglang* variants contribute macro and micronutrients based on the amount and type of IV ingredients used. Some of the key vegetables noted to have relatively high effect on the percent contributions of *bulanglang* variants include horseradish tree pod (*Moringa oleifera* Lam.), unripe papaya (*Carica papaya* L.), bottle gourd [*Lagenaria siceraria* (Molina) Standl.], lima bean (*Phaseolus lunatus* L.), okra [*Abelmoschus esculentus* (L.) Moench], sweetpotato [*Ipomoea batatas* (L.) Lam.], hummingbird tree flowers [*Sesbania grandiflora* (L.) Pers.], amaranths (*Amaranthus viridis* L., *Amaranthus spinosus* L.), morning glory leaves (*Ipomoea triloba* L.), and ricebean [*Vigna umbellata* (Thunb.) Ohwi & H. Ohashi]. Lower contribution does not signify inferiority of a particular variant, but rather highlights the importance of diet diversification.

Policy recommendations to promote *bulanglang*-type dishes builds on the observation that IV ingredients are highly adapted to localities, requiring minimal management and the recipes require simple preparation. Thus, their potential for nutrition and biodiversity conservation-through-use can be exploited through recommending: 1) increase in the amounts of leafy IVs, 2) increase in the amounts and frequency of consumption, and 3) increasing the diversity of IV ingredients used as well as the diversity of variants served.

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**ASSESSING THE ACCURACY OF DAILY SOLAR RADIATION FROM  
NASA-POWER REANALYSIS DATASET OVER REGION IV-A, PHILIPPINES**

**Allan T. Tejada, Jr. \*,a, Victor B. Ella b, Rubenito M. Lampayan b, Consoria E. Reaño c**

a Interdisciplinary Studies Center for Water, School of Environmental Science and Management,  
University of the Philippines Los Baños

b Land and Water Resources Engineering Division, Institute of Agricultural and Biosystems Engineering,  
College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños

c Institute of Crop Science, College of Agriculture and Food Science, University of the Philippines Los Baños

\*Corresponding author: [attejada@up.edu.ph](mailto:attejada@up.edu.ph)

**ABSTRACT**

Complete and reliable time series of global solar radiation data ( $R_s$ ) is vital for its applications in meteorology, hydrology, agriculture, and renewable energy. However, in the case of CALABARZON region in the Philippines, solar climatic variables are scarce. Out of seven DOST-PAGASA stations in the region, only UPLB station has the available ground-based solar radiation data with temporal record from 1977 to 2011 (35 years), and for this reason, exploration of other sources of solar radiation data was necessary. One of the most important data types available today that could help overcome scarce ground-based climatic observations is reanalysis and gridded meteorological data derived from global atmospheric models and satellite images. In this study, daily solar radiation data from Goddard Earth Observing System (GEOS) reanalysis datasets that can be accessed through National Aeronautics and Space Administration-Prediction of Worldwide Energy Resource (NASA POWER) were assessed considering different intervals of atmospheric transparency index. The accuracy of NASA-POWER  $R_s$  was compared against the registered ground-based data in the region including the  $R_s$  registered in UPLB station and the deployed automatic weather stations (AWS) of DOST-ASTI and DA-BSWM from period 2012 to 2019. On the average,  $R_s$  of NASA POWER is off by 17.05%, 17.79% and 51.51% to the ground-based data during days with clear, partially cloudy, and cloudy type of sky, respectively. Overall, NASA POWER  $R_s$  reanalysis dataset has an acceptable remark based on the obtained RRMSE and NSE which demonstrated that this data could be a valid substitute in case of missing or availability limitations of  $R_s$  observations in the region.

**INTRODUCTION**

The availability of accurate data of global radiation ( $R_s$ ) at a specific region are highly crucial to regional crop growth modeling, evapotranspiration estimation, and irrigation system development (Zhang et al., 2018). However unlike other meteorological data such as rainfall and temperature,  $R_s$  data is not always available owing to the high cost of measuring equipment, maintenance, and calibration requirement (Cenk et al., 2017; Despotovic et al., 2015). In the case of Region-IVA of the Philippines, solar climatic variables are scarce. Out of seven DOST-PAGASA stations in the region, only UPLB station has the available ground-based solar radiation data with temporal record from 1977 to 2011 (35 years), and for this reason, exploration of other sources of solar radiation data was necessary. One of the most important data types available today that could help overcome scarce ground-based climatic observations is reanalysis and gridded meteorological data derived from global atmospheric models and satellite images (Aboelkhair et al., 2019). In this study, daily solar radiation data from Goddard Earth Observing System (GEOS) reanalysis datasets that can be accessed through National Aeronautics and Space Administration-Prediction of Worldwide Energy Resource (NASA POWER) (<https://power.larc.nasa.gov/data-access-viewer/>) were assessed considering different intervals of atmospheric transparency index.

**MATERIALS AND METHODS**

Aside from the  $R_s$  data of DOST-PAGASA in UPLB station, data acquired from installed Automated Weather Stations (AWS) of DOST-ASTI and DA-BSWM were also used. These AWS were deployed in the region from 2012 to 2019 and were being used in weather forecasting activities and disaster decision-support for agencies and local governments. The  $R_s$  data from these AWS were collected in sub-daily basis and expressed in  $W/m^2$ , thus necessary conversion and validation test were done to ensure that proper information was used as the baseline  $R_s$  data. The quality assurance procedures on AWS-collected  $R_s$  data, consolidated by Estévez et al. (2011) were followed in this study. For general analysis and evaluation of  $R_s$  of NASA POWER against ground-based data, the values of clearness index were regrouped in three ranges of clearness index ( $K_t$ ): clear sky ( $0.70 \leq K_t \leq 0.90$ ), partially cloudy ( $0.30 \leq K_t < 0.70$ ), and cloudy ( $0.03 \leq K_t < 0.30$ ) (Sayago et al., 2019). The data are classified according to data source and type of the day. Overall, the total number of samples considered for evaluation is 20,141 by which 10.72% ( $n=2,159$ ) is under clear sky, 78.20% ( $n=15,750$ ) is partially cloudy, and 11.08% ( $n=2,232$ ) is cloudy.

## RESULTS AND DISCUSSION

The  $R_s$  data of NASA POWER generally tend to underestimate the ground data collected from DOST-PAGASA but overestimate the data from DA-BSWM and DOST-ASTI as indicated with the signs of their average mean error. The values of average  $R_2$ , RMSE, and ME ranged between 0.63 – 0.73, 3.63 – 4.45 MJ/m<sup>2</sup>-day, and -2.29 – 2.27 MJ/m<sup>2</sup>-day, respectively. There is relative consistency on the daily  $R_s$  of NASA-POWER and ground observations over Region IV-A especially on days with clear and partially cloudy skies. These ranges of statistical indicators are consistent with the results of conducted evaluations in other locations. Bai et al. (2010), who evaluated NASA POWER  $R_s$  against 39 weather stations in China, got an average  $R_2$  of 0.8, RMSE of 3.1 MJ/m<sup>2</sup>-day, and ME of 0.7 MJ/m<sup>2</sup>-day, while White et al. (2011) who assessed the data using 295 stations in USA obtained a higher correlation with  $R_2$  of typically 0.85 to 0.95 and RMSE of 2.0 to 3.0 MJ/m<sup>2</sup>-day. More recent publications prove the promising accuracy of NASA-POWER like Negm et al. (2017) who had assessed the  $R_s$  data using 40 stations in Sicily, Italy and obtained a range of  $R_2$  of 0.65 to 0.94, RMSE of from 2.0 to 4.8 MJ/m<sup>2</sup>-day, and ME of -0.67 to 2.6 MJ/m<sup>2</sup>-day. Moreover, Sayago et al. (2019) with 31 meteorological stations across Spain, verified a good fit of the estimates from NASA -POWER with  $R_2$  of 0.85 to 0.96 and RMSE ranging from 1.78 to 4.62 MJ/m<sup>2</sup>-day.

## CONCLUSION

On the average,  $R_s$  of NASA POWER is off by 17.05%, 17.79% and 51.51% to the ground-based data during days with clear, partially cloudy, and cloudy type of sky, respectively. Overall, NASA POWER  $R_s$  reanalysis dataset has an acceptable remark based on the obtained RRMSE and NSE which demonstrated that this data could be a valid substitute in case of missing or availability limitations of  $R_s$  observations in the region. NASA POWER could give historical and real time estimates of  $R_s$  data that could be used for optimization of design of solar energy conversion systems, architecture projects, irrigation projects, among others.

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## **CONIDIAL PRODUCTION OF BEAUVERIA BASSIANA AND METARHIZIUM ANISOPLIAE IN CORN AT DIFFERENT INCUBATION PERIODS**

**Regine Mae M. Cordero, Pamela Grace D. Apostol, Marcela M. Navasero,  
Mario V. Navasero, and Melissa P. Montecalvo**

National Crop Protection Center, College of Agriculture and Food Science,  
University of the Philippines Los Baños, College, Laguna 4030  
Corresponding authors: mpmontecalvo@up.edu.ph

### **ABSTRACT**

Entomopathogenic fungi are promising biological control agents against major insect pests of crops. Production of high yields of infective propagules is essential for field application and formulation. The potential yield and quality of propagules maybe affected by the incubation period of inoculated grain substrates. This paper presents the conidial yield of two entomopathogenic fungi grown in corn substrate incubated at 25-27°C until 28 days. In each 250g substrate, a 10-mm mycelial plug of *Beauveria bassiana* was inoculated in pre-cooked corn while  $1 \times 10^6$  conidia/ml of *Metarhizium anisopliae* was inoculated in corn. Total conidial yield was determined by harvesting dry conidia and washing the substrates with 0.1% Tween 80 solution. Fungal growth in substrate bags was visible at 3-4 days after inoculation. Initial results indicate that conidial yield and germination of these entomopathogenic fungi declined as incubation of inoculated corn substrates was prolonged. Results suggest that optimum conidial production was 7 to 14 days after inoculation. During this period, conidial yield of *B. bassiana* was  $8.38 \times 10^{10}$  to  $9.82 \times 10^{10}$  conidia/kg of corn substrate whereas *M. anisopliae* had  $6.39 \times 10^{11}$  to  $1.07 \times 10^{12}$  conidia/kg of corn substrate with 84-89% conidial germination. These findings highlight the influence of incubation period on the conidial production of the two entomopathogenic fungi.

**Key words:** biological control, entomopathogenic fungi, fermentation, mass production, solid substrate

### **INTRODUCTION**

Mycobiocontrol utilizes fungi to lower the insect population and reduce crop damage. Entomopathogenic fungi (EPF) are effective biological control agents of economically important insect pests of crops with over 750 fungal species that can provoke fungal infections in insect populations (Sandhu et al. 2012). Production of high yields of infective propagules is essential for biological control program (Agale et al. 2018). Infective inocula are necessary for field application and formulation. EPF can be mass produced using liquid or solid state fermentation with a common practice of culturing in solid substrates due to their availability and ease of handling (Jaronski 2014; Sandhu et al. 2012). Some of the most commonly used grains are corn and rice. Substrate production is usually affected by temperature, incubation period and substrate used, among others. The conidial yield and viability are influenced by these factors. Hence, this study was carried out to investigate the conidial yield of *Beauveria bassiana* and *Metarhizium anisopliae* in corn substrate, which is commonly used to mass produce EPF.

### **MATERIALS AND METHODS**

In this experiment, conidial yield of *B. bassiana* and *M. anisopliae* were determined in corn substrate. In each 250g substrate, a 10-mm mycelial plug of *B. bassiana* was inoculated in pre-cooked corn while  $1 \times 10^6$  conidia/ml of *M. anisopliae* was inoculated in corn. Corn substrates were incubated at room temperature for 28 days after inoculation. Conidial yield was determined at 7 days interval using wet and dry method. Corn substrates were dried. Dry conidia were harvested by sieving. To obtain the total yield, the substrate was washed with 0.1% Tween 80 solution after sieving. The following data were gathered: conidial yield in terms of mass of dry conidia and total yield, and conidial germination. Conidial concentration was determined with the use of a hemocytometer. Conidial germination was assessed by spread plating fungal suspension of *B. bassiana* and *M. anisopliae* in potato dextrose agar (PDA) and water agar (WA), respectively. Each treatment was replicated five times. Data was analyzed using one-way ANOVA and treatment means were compared using Tukey's HSD.

### **RESULTS AND DISCUSSION**

Fungal growth in corn substrate was visible at 3-4 days after inoculation. White fungal growth was observed in *B. bassiana*. Total yield of *B. bassiana* declined from  $9.82 \times 10^{10}$  to  $6.50 \times 10^{10}$  conidia/kg of substrate at 7 and 28 days after inoculation, respectively. On the other hand, substrate bags inoculated with *M. anisopliae* were initially with white fungal growth and later turned green during sporulation. The total conidial yield increased at 14 days after inoculation at  $1.07 \times 10^{12}$  conidia/kg of substrate and subsequently declined to  $5.52 \times 10^{10}$  conidia/kg of substrate at 28 days after inoculation. Highest mass of dry conidia of *B. bassiana* was harvested 21

days after inoculation, however, conidial concentration was in declining trend from 7 to 28 days after inoculation. In *M. anisopliae*, dry conidia and concentration peaked at 14 days after inoculation and subsequently declined thereafter. The moisture content in the substrate bags may have affected the resulting weight of dry conidia. Based on these findings, the optimum conidial production is at 7 to 14 days after inoculation with 84-89% conidial germination. The decreasing trend in conidial production in both EPF may be due to the declining nutrition in the substrate as these are fully consumed during prolonged incubation period (Posada-Florez 2008). Likewise, conidia may have germinated due to moist condition in the substrate bags.

Jaronski and Mascarin (2017) noted that the typical production cycle in solid substrate fermentation is 7-14 days followed by drying of the culture and removal of conidia. Posada-Florez (2008) observed that conidial concentration of *B. bassiana* is higher if harvested earlier in rice substrate. Dry conidia can be used in formulation and field application. Since the conidial yield declines after further incubation, dry conidia can be harvested and stored. Proper drying of conidia is essential to maintain good shelflife (Jaronski and Mascarin 2017; Moslim et al. 2005). Recorded conidial yield in this study differ with other findings. Bich et al. (2018) recorded highest sporulation of *B. bassiana* ( $4.62 \times 10^7$  conidia/g) and *M. anisopliae* ( $2.22 \times 10^6$  conidia/g) in rice substrate after four weeks of incubation. On the other hand, Moslim et al. (2005) recorded highest yield of *M. anisopliae* in maize. About less than  $1 \times 10^{10}$  spores/g of *B. bassiana* was recovered in cooked rice (Posada-Florez 2008). Furthermore, Moslim et al. (2005) recommended to harvest conidia between 30-40 days after inoculation. Variation in conidial yield maybe due to differences in inoculum, photoperiod, nutrients, and moisture content during mass production.

### CONCLUSION

The maximum conidial yield can be obtained in *B. bassiana* and *M. anisopliae* up to 14 days after inoculation. Many factors are known to affect conidial yield. Hence, experiments will be conducted to optimize mass production in solid substrate.

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**DEVELOPMENT OF SWEET AND SPICY PALAPA ORGANIC SAKURAB  
(*Allium chinense*)**

**Rhanest Soberano Tilendo and Saidah P. Macaringis**

Cotabato State University, Cotabato City

Corresponding author: [rtilendo19@gmail.com](mailto:rtilendo19@gmail.com)

**ABSTRACT**

Sakurab Scallion Palapa (*Allium chinense*) comes close to the traditional Maranao appetizer, it is made of stewed scallion bulbs. Palapa is hawked in humble eateries and restaurants in almost every corner of the provinces of Lanao. This study was conducted in Cotabato State University, Sinsuat Avenue, Cotabato City, April 2019, Philippines to determine the acceptability of sweet and spicy *Palapa organic Sakurab* in the University. Specifically, it sought to answer the acceptability of *Sweet and Spicy Palapa*, organic sakurab in terms of taste, physical appearance, color and aroma. Experimental research design was used. Descriptive survey method was used and followed with 50 respondents. Data were analysed using percentage and frequency counts. Findings showed that the overall mean rating on the acceptability of sweet and spicy *palapa* in terms of color was 1.34 (very acceptable), in terms of aroma was 1.32 (very acceptable), in terms of taste was 1.28 (very acceptable) in terms of physical appearance was 1.22 (very acceptable). The study concluded that *spicy palapa* is highly acceptable. The research study shall be continued to focus on health advantages, life span of sweet spicy *palapa*, commercialization of the product, and use as a meal appetizer, as well as technical support, and motivation, to the researcher. Some of the people who responded said it was their first time eating organic *sakurab palapa*. It was a good concept or a good product to launch a new business in order to capitalize on a market opportunity and make it successful. A separate study shall be conducted focusing on sakurab farming.

**Key words:** Spicy Palapa, Palapa, Organic sakurab, Marano, *Allium chinense*

**INTRODUCTION**

Salad onion is the common name for scallion green onion (*Allium chinense* L.). It is known as "Sakurab" among the Meranaos and has been transformed into a popular seasoning called "Palapa," which non-Meranaos have adopted. A mature green onion bulb has 47.0 calories, 1.4 grams of protein, 7 mg of sodium, 180 mg of potassium, 32 mg of calcium, 44 mg of phosphorus, 16 mg of magnesium, 70 mg of sulfur, 25 mg of chlorine, and 28 mg of vitamin C. In China, diluted squeezed juice is used to combat pests. Alliums, such as scallion green onions, have a unique thiosulfate that has anti-thrombotic properties, including antioxidant activity, lower serum cholesterol, and improved in vitro antiplatelet action. This latter action is beneficial to cardiovascular health since it reduces the likelihood of platelets clumping together in the blood. It belongs to the same botanical family as garlic and leeks, and its oil is stimulant, diuretic, and expectorant both internally and externally, which increases the peristaltic action of the bulb in the intestines.

A variety of condiments spice up most of the dishes in the southern Philippines, but nothing matches the exceptional taste shigasakurab gives. The taste is unique to your buds, making you crave more rice. Sakurab, or native shallots, is a vegetable that looks like scallions and is used as an atypical Filipino cuisine seasoning. Sakurab is a popular ingredient in the Maranao condiment palapa, which is made with species, salt, and ginger. Sakurab is also utilized in traditional cuisine on the islands of Mindanao and Visayas, where it is more popularly known as sibujing. Palapa sakurab from the Maranao people of Lanao del Sur. Palapa sakurab from the Maranao people of Lanao del Sur is an important cultural symbol of the Maranao people and is an ubiquitous accompaniment at every meal. Sakurab is sold in almost every street and alley in the province, proof that the palapa's existence is intertwined with the history and culture of the people of the lake. A traditional Maranao appetizer that is essential to any meal. Exquisite Marano cuisine and hospitality are palpable. A condiment made of traditionally cultivated spices, locally known as "palapa," is one of their distinctive culinary symbols. It is made of steamed scallion bulbs, or sakurab in marano. The study sought to determine the acceptability of organic sweet and spicy palapa sakurab as a preserve in terms of taste, physical appearance, color, and aroma, and it was determined by comparing it to established products.

## **MATERIALS AND METHODS**

The respondents were six (6) faculty and forty-four (44) students from Cotabato State University, who were interviewed after tasting the products. The data collection instrument used in the study was a questionnaire, and it was used to compare the two products. Respondents were required to indicate whether the samples were very acceptable, acceptable, fairly acceptable, or not acceptable in terms of preferences. To address the study's objectives, the data was analysed using descriptive statistical methods such as percentage, frequency, and means.

## **RESULTS AND DISCUSSION**

The respondents' profile revealed that 84% were between the ages of 19 and 24, 10% are between the ages of 25 and 30, 4% are between the ages of 31 and 36, and 2% are between the ages of 43 and 48. The majority of the respondents were female, with 44 percent being male. The respondents with the highest educational attainment were college graduates (12%) and students (88%). This also reveals that 82 percent of those polled were single, with only 18 percent married. The majority of the respondents (86%) are Muslims, whereas 14% are Roman Catholics. The study also indicated that 88 percent of the respondents are students at Cotabato State University, while 12 percent are faculty.

The sweet and spicy palapa organic sakurab is very acceptable to 40 to 80 percent of respondents, it is new and appealing to their taste. In terms of physical appearance, 40 to 80 percent of respondents were eager to purchase the goods and that it is quite acceptable. The sweet and spicy palapa organic sakurab has a really appealing color. The aroma is also well received with 40% to 80% agreeing that the sweet and spicy palapa organic sakurab are quite satisfactory. Organic sweet and spicy palapa could be marketed. Some of the respondents stated that it was their first time trying sakurab palapa. It was a good concept or product to launch a new business to capitalize on a market opportunity and turn a profit. The sweet and spicy palapa organic sakurab, as well as the normal spicy palapa, were found to be very acceptable because it is new and extraordinarily well accepted in terms of taste, color, aroma, and physical appearance,

## **CONCLUSION**

The sweet and spicy organic palapa sakurab processing has evolved as a result of the addition of new components. The sweet and spicy palapa organic sakurab is very much acceptable. There is no difference in taste or appearance between the organic sweet and spicy palapa and the established salty and spicy palapa. The established salty and spicy palapa and sweet spicy palapa organic sakurab have no color or aroma differences. Organic sweet and spicy palapa was discovered to have the highest percentage of approval and is favoured by respondents.

## **EFFECT OF VARIOUS COMBINATIONS OF LEAF CLIPPING, CYTOKININ APPLICATION, AND TIMING OF FERTILIZATION ON YIELD OF PINEAPPLE**

**Maribeth M. Yadao<sup>1</sup> and \*Cesar A. Limbaga, Jr.<sup>2</sup>**

<sup>1</sup>Soil and Plant Nutrition, Dole Philippines Inc., Polomolok, South Cotabato, Philippines 9504

<sup>2</sup>University of Southeastern Philippines, Apokon, Tagum City, Davao del Norte, Philippines

\*Corresponding author: cesar.limbaga@usep.edu.ph

### **ABSTRACT**

The market demand for pineapple is continuously increasing; hence, research on different production practices is still being done to improve production to take advantage of increasing large-scale markets. Leaf clipping and application of cytokinin increases yield in some crops by increasing the photosynthetic capacity. Proper timing of fertilizer application is important to maximize its benefits. This study explored the potential effects of leaf clipping, cytokinin introduction, and fertilizer scheduling in pineapple production. Leaf clipping or cutting 4 to 6 inches from the leaf tip of pineapple was done 16 weeks after planting. Cytokinin application was 48 hours after leaf clipping. A similar amount of fertilizer was applied to all plants for the whole cropping production but at two different schedules, weekly and bi-monthly. Leaf clipping, cytokinin application, and fertilizer application schedule did not significantly affect the growth parameters, such as plant height, the number of leaves, root length, stumps biomass, and the leaf nutrient content of pineapple plants. Leaf clipping, regardless of cytokinin application and schedule of fertilizer application, increased the Normalized Difference Vegetation Index (NDVI) and improved the yield of pineapple by about 6.04 to 9.17 metric tons/ha, or a 5.11 to 7.94% yield increase. Leaf clipping with bi-monthly fertilizer application resulted in the highest yield of 124.69 metric tons/ha.

**Key words:** assimilates, MD2 cultivar, fertilizer scheduling, Normalized Difference Vegetation Index

### **INTRODUCTION**

The pineapple industry grew and flourished with steady progress. At present, market demand for pineapple continues to increase; however, the current pineapple cultural practices in the country cannot cope with market demand. Hence, work on different production practices is being done to improve production to take advantage of the increasing large-scale markets. The leaf clipping technology may increase the yield of pineapple in conjunction with cytokinin and the timing of fertilizer application. Source tissues are generally responsible for acquiring resources from the outside environment. Greater source capacity leads to poor crop performance as fertilization produces more foliage and reduced productivity. Leaf clipping technology is proven effective in increasing yield in some crops such as rice, sorghum, pearl millet, corn, and soybean (Liu et al. 2017; Srinivasan et al. 2016). Leaf clipping changes the canopy structure resulting in an adequate green leaf area index and effective blade spatial arrangement. This increases the canopy photosynthesis as light transmission to lower canopy strata increases, resulting in improved light conditions within the canopy. Greater light penetration in the canopy results in more assimilates (Dong et al. 2000) and finally brings about higher yield (Hachmann et al. 2014).

Leaf clipping brings wound stress to pineapple; hence cytokinin application may be necessary as it is known to activate dormant buds to allow recovery after injury or damage (Müller et al. 2011). Cytokinin has also increased yield in some crops like maize, cherry tomatoes, winter wheat, and bread wheat (Gao et al. 2017; Shahzad et al. 2016; Yang et al. 2016). Proper timing of fertilizer application increases yield, reduces nutrient losses, increases nutrient use efficiency, and prevents environmental damage (Sela 2018). Dividing the amount of fertilizer required and applying in smaller quantities more frequently during the active growing season is a good practice for better nutrient uptake, rather than applying larger amounts less often (UCANR 2018). This study was undertaken to determine the production (growth and yield) performance of pineapple as affected by leaf clipping, cytokinin application, and timing of fertilization.

### **MATERIALS AND METHODS**

The study was conducted in Polomolok, South Cotabato, from September 2017 to April 2019. The pineapple crown (medium size ranging from 300-350 g) of the MD2 cultivar was used as planting materials. The study was a six-treatment experiment in a Randomized Complete Block Design replicated four times with 164 sample plants. Fisher's Least Significant Difference (LSD) was used to determine differences between and among treatment means.

Leaf clipping at 4 to 6 inches from the leaf tip was done 16 weeks after planting. Application of cytokinin (Fast Gro with 0.04% a.i.) using an automatic knapsack sprayer at a rate of 5.26 L/ha was done within 48 hr after clipping. For fertilizer application, the total monthly rate (following the farm practice) was divided into 2 for the bi-monthly (14 days) application, while the monthly rate was divided into 4 for the weekly (7 days) application. Fertilization was applied foliar using a knapsack sprayer starting 14 days after planting. Forced flowering was done 12 months after planting through spraying of ethephon and harvested 18 months after planting or six months after forcing.

## **RESULTS AND DISCUSSION**

Pineapple plants applied with fertilizer every two weeks without or with leaf clipping and cytokinin application were the tallest plants at eight months after planting (8 MAP). The bi-monthly fertilizer application may have provided the right amount of nutrients for uptake, making the plants grow taller. On the other hand, results indicate that clipping and cytokinin application did not influence the pineapple plant height. Also, leaf production of pineapple was not influenced by clipping of the leaf, cytokinin spraying, and at a closer gap of fertilizer application at seven days. Root length had a significant difference among treatments at four months after planting. Clipped plants fertilized weekly showed the longest root but comparable to clipped plants fertilized weekly and applied with cytokinin. At eight months after planting, root length ranges from 30.8 to 34.7 cm in all treatments, which was insignificant. Root length incremental increase in a span of 4 months is marginal, entailing that root length was not influenced by leaf clipping. Leaf clipping, cytokinin, and timing of fertilizer application did not significantly affect most of the nutrients in the leave of pineapple plants. It is not apparent if cytokinin application and leaf clipping influenced the leaves' N, K, and B contents. Leaves from pineapple plants applied with fertilizer weekly have more N, K, and B content than applied bi-monthly. The weekly foliar application resulted in more nutrients absorbed by the leaves than when applied bi-monthly. Leaf clipping significantly increased the pineapple yield by about 6.04 to 9.17 tons/ha, or a 5.11 to 7.94% yield increase per hectare. Leaf clipping increases yield as it removes competing sinks for assimilates. Moreover, leaf clipping increased the NDVI of pineapple plants which indicates that leaf clipping increased the photosynthetic activity of the plants. The clipping of vegetative organs like leaves allows plants to capture light effectively and use it efficiently by increasing the photosynthetic capacity (Zhu et al. 2004), leading to an increase in net photosynthetic rates (Anderson et al. 2013).

## **CONCLUSION**

Leaf clipping combined with the bi-monthly application of foliar fertilizer effectively increased the yield of pineapple and resulted in higher net income. With this result, leaf clipping technology is proven effective in increasing the yield of pineapple.

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## BANANA BUNCHY TOP VIRUS CAUSED ABACA BUNCHY TOP IN LEYTE, PHILIPPINES

Robelyn T. Piamonte<sup>1,2\*</sup> and Filomena C. Sta Cruz<sup>2</sup>

<sup>1</sup> Current Address: National Abaca Research Center, Visayas State University, Visca, Baybay City, Leyte and <sup>2</sup> Institute of Weed Science, Entomology, and Plant Pathology, College of Agriculture and Food Science, University of the Philippines Los Baños, College, Laguna, Philippines

\*Corresponding author: rtpiamonte@vsu.edu.ph

### ABSTRACT

Bunchy top is a serious constraint to the abaca production, not only in Leyte, but also in all major abaca growing regions in the country. Managing such disease has been so challenging due to the complex nature of the viral pathogen, and its early disease detection and correct virus identification is integral in developing an effective disease management strategy. Hence, this study sought to determine the occurrence and identity of the causative agent of abaca bunchy top in Leyte. Virus isolates from bunchy top infected abaca plants were collected from four different locations in Leyte, analyzed by polymerase chain reaction, and identified via next generation sequencing (NGS). The virus was highly detectable using an optimized PCR conditions using a Banana bunchy top virus (BBTV) specific primer pair BBT1/BBT2 at 10 ng template concentration of Dellaporta-derived DNA extracts. Analyses of full-length genome sequences derived by NGS-Illumina MiSeq platform revealed that the bunchy top virus infecting abaca in Leyte, Philippines is *Banana bunchy top virus* (BBTV). The knowledge generated from this study has important implication in designing PCR primers for specific and sensitive detection of BBTV causing bunchy top of abaca and in virus resistance breeding programs against the disease.

Key words: Dellaporta-derived DNA extracts, polymerase chain reaction (PCR), next generation sequencing (NGS), BBT1/BBT2 primer pair

### INTRODUCTION

The Philippines enjoys the monopoly of supplying about 87.4% of world's demand of abaca fiber (PhilFIDA 2020). However, meeting the increasing demand for abaca fiber has presently been difficult because of the declining abaca productivity due largely to virus diseases, specifically the abaca bunchy top. The disease is caused by *Banana bunchy top virus* (BBTV) (Bajet and Magnaye 2002; Furuya et al. 2006; Magee 1953; Ocfemia 1931) and *Abaca bunchy top virus* (ABTV) (Sharman et al. 2008). It is transmitted by an aphid *Pentalonia nigronervosa* Coquerel (Ocfemia 1927). The data generated from this study will ultimately be useful in the formulation of an effective and durable abaca bunchy top (ABT) management through virus resistance breeding. To attain a durable ABT resistance, the abaca varieties must be bred with resistance to the range of virus species infecting the crop and that must be strategically deployed to areas where they can resist infection which all require a correct and early detection of the virus. Hence, this study aimed to determine the occurrence and identity of the causative agent of bunchy top in Leyte, Philippines, specifically to detect the BBTV or ABTV using optimized PCR conditions, and sequence the genome of the Leyte bunchy top virus (BTV) isolates through next generation sequencing (NGS).

### MATERIALS AND METHODS

The total nucleic acid from bunchy top-infected abaca leaf samples collected from four municipalities of Leyte (Abuyog, Baybay City, Kananga, and Tanauan) was extracted using three different DNA extraction protocols, namely: CTAB DNA extraction (Doyle and Doyle 1990) modified for abaca, PCR Dellaporta Miniprep (Dellaporta et al. 1983), and Sarkosyl method (Su 2000). The total NA extracts at eight concentrations (undiluted, 1000, 100, 10, 1.0, 0.01, 0.001, and 0.0001 ng/uL) were subjected to PCR using four BBTV-specific primers (BBT1/BBT2, CBT3F/CBT3R, CR-SL(F)/CR-SL(R), F3/FPCR4, and JO2/GO1) and seven ABTV specific primers (AbBTVC5A/AbBTVC5B, CRMA/1108C6B, SLCR2/CRMB, 767C1A/767C1B2, 767C2A/CRMB, 1108C3A/1108C3B2, and 1108C4A/1108C4B). The same set of samples were also subjected to PCR using an internal control DNA, a *Musa* sequence tagged microsatellite site with primers AGMI025/AGMI026 (Lagoda et al. 1998; Mansoor et al. 2005) to test the reliability of the virus detection via PCR. The identity of the causative virus of abaca bunchy top in Leyte was confirmed by next generation sequencing (NGS).

### RESULTS AND DISCUSSION

*Optimized PCR Condition for the bunchy top virus (BTV) in Leyte.* The Leyte BTV isolates were highly detectable by PCR using the BBTV-specific primer pair BBT1/BBT2. Among the seven ABTV-specific primers used, only

the SLCR2/CRMB primer pair yielded a single band DNA amplification, but the detection level was way lower than that of BBT1/BBT2 primer pair. The level of virus detection was affected by the DNA extraction method. Dellaporta DNA extracts resulted in the highest virus detection level, indicating that Dellaporta method can yield good quality DNA with no or less PCR inhibitors. This agrees with the report of Bevilacqua (2008) that the method produced quality DNA suitable for subsequent PCR-based applications and other downstream applications (Piamonte and Sta Cruz 2018; Sta Cruz et al. 2016). The sensitivity of virus detection by PCR increases with the dilution of the DNA extracts. The BTV detection was highest at 10 and 1.0 ng/ $\mu$ L DNA template.

*Reliability Test.* The use of internal control DNA in PCR assays will ensure the correct and reliable virus detection. This will lessen, if not avoid, the chance of getting false negatives in PCR results. A sample can be confidently declared negative of the virus when the internal control DNA is positively detected in the sample. The internal control DNA is derived from a DNA sequence of the plant host of the virus and should always be detectable in the DNA extracts of both healthy and virus-infected plants, unless affected by PCR inhibitors. The presence of PCR inhibitors in the DNA extract will also inhibit or reduce the level detection of the internal control DNA. A similar trend of results was obtained in detecting the plant host DNA (internal control DNA) to that of detecting the BTV in the DNA extracts via Dellaporta, Sarkosyl and CTAB methods at eight DNA concentrations. There was no amplification of the host DNA in the undiluted Sarkosyl and CTAB DNA extracts, only in the Dellaporta DNA extracts. The level of detection also increases with the dilution of the DNA extracts. The amplification was obtained when the DNA extracts were diluted. The host DNA was highly detectable by PCR at 100 ng/ $\mu$ L DNA concentration using AGMI025 and AGMI026 primer pair.

*Genome Sequence of BTV in Leyte, Philippines.* The full-length genome sequences of BTV Leyte isolates were derived via NGS - Illumina MiSeq platform at the Philippine Genome Center, University of the Philippines Diliman, Quezon City. The obtained genome sequences were aligned to BBTV (BBTV MS18\_PH\_2008, KM607655.1) (Stainton et al. 2015) and ABTV (Q1108, EF546807.1) (Sharman et al. 2008) reference genomes. To declare whether the BTV Leyte isolates are BBTV or ABTV, the species demarcation set for nanoviruses by Vetten et al. (2004) was used. This is the same species demarcation that Sharman et al. (2008) used in proposing another species of bunchy top virus infecting abaca, naming as *Abaca bunchy top virus* (ABTV). The BBTV and ABTV shared only 54-76% in overall nucleotide sequence identity and 79-81% amino acid sequence identity for putative coat protein, enough to be declared as distinct species (Sharman et al. 2008). In this study, the pairwise nucleotide identity analyses revealed that the BTV Leyte isolates has 98.8% to 99.6% overall nucleotide identities to BBTV and only 70 to 71.3% overall nucleotide identities to ABTV. This confirmed that the bunchy top virus infecting abaca in Leyte is *Banana bunchy top virus* (BBTV). The knowledge generated can be utilized in designing PCR primers for specific and sensitive detection of BBTV causing bunchy top of abaca and in virus resistance breeding programs.

## CONCLUSION

The virus causing bunchy top in Leyte, Philippines was highly detectable using an optimized PCR conditions using a BBTV-specific primer pair BBT1/BBT2 at 10 ng template concentration of Dellaporta-derived DNA extracts. Analyses of sequences derived by NGS-Illumina MiSeq platform revealed that the BTV species infecting abaca in Abuyog, Baybay City, Kananga, and Tanauan municipalities of Leyte, Philippines is BBTV.

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## PLANT GROWTH REGULATORS AGAINST PRE AND POSTHARVEST DISEASES OF MANGO

\*Rowina T. Esconde<sup>1</sup> and Cesar A. Limbaga, Jr.<sup>2</sup>

<sup>1</sup>Provincial Agriculturist Office (PAGRO), Mankilam, Tagum City, Davao del Norte, Philippines 8100

<sup>2</sup>University of Southeastern Philippines, Apokon, Tagum City, Davao del Norte, Philippines

\*Corresponding author: escondekiss@gmail.com

### ABSTRACT

With attention to the risk of improper use of chemicals in the field and after harvest and the consumers' demand for safe and nutritious fruits and fruit products, studies on alternative disease management that reduces the excessive use of fungicide in mango fruit production are essential. Plant hormones play a central role in the regulation of plant immune responses. This study explored the potential of applying plant growth regulators in mango fruit production in controlling the field and postharvest diseases in mango. The farmers' practice of mango fruit production in Davao del Sur was followed but modified by substituting the fungicide application with different combinations of plant growth regulators (PGRs) from panicle elongation (at 14th day from flower induction) until full bloom (at 28th day from flower induction). The PGRs used in the study are auxin, cytokinin, gibberellic acid, and salicylic acid. The application of PGR reduced the severity of blossom blight by 48.33-71.67% compared to farmers' practice, resulting in higher fruit setting and retention. The yield of PGR treated mango trees was 48.14-81.91 kg per tree, which is generally slightly higher than trees following the farmers' practice (54.52 kg). The fruit disease incidence and other postharvest qualities of the fruits from PGR treated trees were comparable to those from other trees following the farmers' practice and integrated crop management system. This study showed that PGRs help increase plant resistance to diseases thus might help reduce the use of fungicide during fruit production.

Keywords: anthracnose, auxin, cytokinin, gibberellic acid, salicylic acid, fungicide

There is intensive use of agrochemicals in mango production, especially during flowering, fruit set, and fruit growth. Diseases such as anthracnose, Alternaria rot, bacterial black spot, blossom blight, and powdery mildew, are the primary production constraints in virtually all areas where mango is grown. Practical strategies for managing these diseases are often limited. The disease management in commercial production relies heavily on synthetic pesticides, primarily where disease-conducive environments exist and when export quality fruit are desired (Ploetz 2004). With attention to the risk of improper use of chemicals in the field and after harvest and the consumers' demand for safe and nutritious fruits and fruit products, studies on alternative disease management that reduces the excessive use of fungicide in mango fruit production are essential. The use of plant growth regulators in mango production may help decrease the heavy dependence on chemical disease control measures. Plant growth regulators (PGR) are chemical substances that govern all the development and growth factors within plants. The application of plant growth regulators to crops modifies hormonal balance and growth, leading to increased yield, enhanced crop tolerance against abiotic stress, and improved physiological traits of crops. The plant hormones ethylene, jasmonic acid, and Salicylic Acid (SA) play a central role in regulating plant immune responses. In addition, other plant hormones such as auxins, abscisic acid (ABA), cytokinins, gibberellins, and brassinosteroids recently emerged as key regulators of plant immunity (Denance et al. 2013). Plants have developed molecular mechanisms to detect pathogens and pests and to activate defense responses, and that plants utilize hormone cross-talk to optimize defenses (Pieterse 2009). This study explored the potential effects of applying plant growth regulators in mango fruit production in controlling the field and postharvest diseases in mango.

The study was conducted in Mabuhay, Bansalan, Davao del Sur, Mindanao, Philippines. The 23 years old 'Carabao' mango trees were used in the experiment. **The Philippine 'Carabao' mango is known worldwide as the best tasting variety of mangoes.** The study was a seven-treatment experiment in a Completely Randomized Design (CRD) replicated six times. Three commercially available PGR products (P) were used in the study. Treatments were the following: T1 – Control (no fungicide and pesticide), T2 – Integrated Crop Management (ICM), T3 – Auxin+ Cytokinin + Gibberellic Acid (GA) (P1), T4 – Auxin + Cytokinin + GA + Calcium Boron (CaB) (P2), T5 - SA + GA + CaB (P3), T6 - P1 and P2 (sequential application), and T7 – Farmers Practice. PGR were used as substitute to fungicide and were applied at panicle elongation, pre-bloom, and full bloom for T3-T5. For T6, the P1 PGR was applied at panicle elongation then P2 applied at pre and full bloom. Paclobutrazol as growth regulator was applied 3 months before flower induction at the rate of 4 mL per linear meter of the mango tree canopy to manipulate uniform and early maturity of the mango leaves in preparation for flower induction. Calcium nitrate was used to induce flowering at a rate of 8 kg per 200 L of water and was sprayed 3 months after

the application of paclobutrazol. Application of pesticides was based on spray schedule, pest population and weather condition. Fruits were bagged and harvested at 50 days and 107 days, respectively, after flower induction.

The exogenous application of PGR, except the sequential application, as a substitute to fungicide following the farmers' practice in mango production effectively reduced the severity of blossom blight. Fruit set at 40 days after flower induction (DAFI), fruit retention at 50 DAFI, and yield of mango trees following farmers' practice and ICM were not statistically different from those applied with PGR. The result implies that the reduced application of fungicide through substituting with PGR is possible with positive effects on the yield of mango trees. The plant hormones SA, auxin, cytokinin, and GA are among the key regulators of plant immunity (Denance et al. 2013). Plants have resistance mechanisms or responses to biotic stress regulated by plant hormones, where their pathways are linked to each other in a complex and ambiguous network. Infection of plants with disease pathogens results in changes in the level of various plant hormones, resulting in changes in the expression of genes and activation of defense responses. The exogenous application of plants with some hormones results in reprogramming the host metabolism, gene expression, and modulation of plant defense responses against microbial challenge (Bari and Jones 2008).

The visual quality and the incidence and severity of anthracnose, stem-end rot, and scab during storage at the ambient condition of mangoes from PGR treated trees were comparable to those mangoes produced using ICM and farmer's practice. Plant growth regulators and even synthetic chemicals did not control the incidence and severity of disease at postharvest. The application of PGR effectively lowers the severity of blossom blight, resulting in comparable fruit set, fruit retention, and yield with those following farmer's practice and ICM. However, the PGR did not control the postharvest disease with similar results to other treatments except control or with no pesticide application. This study showed that PGRs help increase plant resistance to diseases thus might help reduce the use of fungicide during fruit production.

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**COMBINED MYKOPLUS BIOFERTILIZER AND INORGANIC FERTILIZER INCREASED STRAW AND RICE GRAIN YIELD IN TWO FIELD SITES IN NEGROS OCCIDENTAL, AS WELL AS SIGNIFICANTLY INCREASED THE RESIDUAL P AND N CONTENT IN THE SOIL AFTER CROPPING**

**Jocelyn T. Zarate<sup>1</sup> and Carlos V. Jardeniano, Jr<sup>2</sup>**

<sup>1</sup>National Institute of Molecular Biology and Biotechnology (BIOTECH), University of the Philippines Los Baños, College, Laguna and <sup>2</sup>Central Philippine Adventist College, Murcia, Negros Occidental

Corresponding author: [jtzarate@up.edu.ph](mailto:jtzarate@up.edu.ph)

**ABSTRACT**

Agricultural practices rely heavily on chemical inputs that causes deleterious effect. Use of biofertilizers, as good agricultural practice, aims to supplement fertilizers. Efficacy testing of Mykoplus biofertilizer on lowland rice was done in two sites in Negros Occidental, arranged in Randomized Complete Block Design with eight treatments and four replications. Treatments include chemical fertilizer at full recommended rate (100%RR) based on soil analysis, 70%RR and 50%RR, then, same fertilizer rates plus Mykoplus, untreated (Control) and only Mykoplus. Highest straw weight and grain yield was obtained in Mykoplus+100%RR at 17.85 t/ha, and 7.07 t/ha, respectively (Kabangkalan site), and 14.94 t/ha, 6.37 t/ha, respectively (Murcia site). This gave 16% increase in straw yield and 18% increase in grain yield compared to 100%RR alone. Mykoplus+70%RR also gave comparably high straw yield at 15.41 t/ha (Kabangkalan) and 14.6 t/ha (Murcia) but slightly lower grain yield at 5.42 t/ha (Kabangkalan) and 4.83 t/ha (Murcia). Mykoplus alone, significantly out yielded the control in both sites with 33.4% average increase. At end of cropping, microbial count was similar between treatments on Nutrient Agar medium, but Mykoplus treated soil had significantly higher N<sub>2</sub> fixers and P solubilizers. Furthermore, soil in the Mykoplus+100%RR had higher %P (70% in Kabangkalan and 4% in Murcia) and 3% higher %N compared to 100%RR (Murcia).

**Key words:** Rice, Biofertilizer, MykoPlus, Microbial Inoculant, Residual nutrients

**INTRODUCTION**

Rice is the staple food for majority of 105 M Filipinos, and many of the country's work force depends on this commodity. However, for nearly a decade (2011-2020), palay production was not enough to feed the exponentially increasing Philippine population (Statistica, 2021). Bridging this rice yield gap through many biotechnological interventions such as: new high yielding varieties, pest control managements, etc. need further assistance. The use of biological fertilizers or microbial inoculants as supplements to chemical fertilizer has been widely studied to boost yield and preserve the soil, but needs further popularization for greater adoption. Biofertilizers are preparations that contain live or latent cells of efficient strains of microorganisms, which could be nitrogen fixers, phosphorus solubilizers, etc. that accelerate certain microbial processes to release more nutrients for the crop. The objective of this study was to determine the efficacy of biofertilizer Mykoplus in the growth and yield of lowland rice.

**MATERIALS AND METHODS**

Field efficacy testing of biofertilizer Mykoplus was done in 1) Barangay Biniquil, Kabangkalan city and 2) Central Philippine Adventist College, Barangay Alegria, Murcia, both from Negros Occidental, using lowland rice (*Oryza sativa*) NSIC RC 222. Experiments were arranged in a Randomized Complete Block Design (RCBD) with eight treatments and four replications. Treatments were 1) Control (unfertilized and untreated) 2) 100% Recommended Rate (100%RR) based on soil analysis, 3) 70%RR, 4) 50%RR, 5) 100%RR+Mykoplus, 6) 70%RR+Mykoplus, 7) 50%RR+Mykoplus and 8) Mykoplus alone. The 100%RR chemical fertilizer rate were: 30-60-40 kg NPK/ha (Kabangkalan) and 70-40-40 kg NPK/ha (Murcia). Mykoplus was applied at different stages of plant growth (sowing, transplanting and a month after transplanting) by seed coating or spraying, at a recommended rate of nine packs/ha where each pack weighs 300 g. Rice was planted at 20 cm by 20 cm, with plot dimensions of 20 sq m/plot/treatment (4m x 5m), with outer rows (16 plants) for panicle counts, and inner 4 sq m as harvest area (100 plants). At harvest, bacterial count was determined through dilution plate count. Mycorrhizal spores were counted under a stereo microscope after wet-sieving and centrifugation in sucrose solution (Guillen,2021). Soil chemical analysis was done prior to and at end of cropping. Data collected were statistically analyzed using International Rice Research Institute-Statistical Tool for Agricultural Research (IRRI-STAR, version 2.01, 2013)

following RCBD for Analysis of Variance (ANOVA) and Least Significance Difference (LSD) and or Tukey's Honest Significant Difference (HSD) test for mean comparison.

## RESULTS AND DISCUSSION

*Agronomic traits and yield:* Rice plants applied with biofertilizer Mykoplus alone significantly increased straw weight by 17% and grain yield by 33% vs the control. Treatment 100%RR+Mykoplus (T5) had the highest number of panicles (339 panicles/sq m), heaviest straw weight (17.8 t/ha) and highest grain yield (7.07 t/ha) in Kabangkalan site, with an average increase of 16% in straw weight and 19% in grain yield compared to 100%RR (T2) in the two sites. Treatment 70%RR+Mykoplus (T6) also had significantly higher number of panicle and straw weight and grain yield, with an average increase of 19% in straw weight and 6% in grain yield vs 70%RR (T3). Treatment 50%RR+Mykoplus (T7) also increased straw weight with an average of 23% and grain yield by 8% vs 50%RR (T4).

*Economic analysis:* Considering cost of production, gross and net yield, the highest net income was in 100%RR+Mykoplus (T5) at Php 47,520, which also had the highest Return on Investment (ROI) of 98.94% and highest benefit due to Mykoplus inoculation at Php 11,700/ha (Murcia). Similarly, in Kabangkalan site, highest net income was in 100%RR+Mykoplus at Php 53,026, with ROI of 107.15% and benefit due to Mykoplus inoculation of Php 14,296/ha. Treatment 70%RR+Mykoplus (T6) gave the next highest ROI at 81.95% and 75.22%, in both sites.

*Microbial count:* Total bacterial count detected through spread plating in Nutrient agar was not significantly different between treatments in both sites, with average count of  $1.1 \times 10^7$  cfu/g soil. However, in differential medium for nitrogen fixers (Burk's and Mannitol Medium), the control consistently and significantly had the lowest value at  $3.1 \times 10^5$  and  $3.6 \times 10^6$  cfu/g soil, respectively (Kabangkalan site). Meanwhile the highest count was in treatment 70%RR+Mykoplus (T6) at  $9.5 \times 10^5$  cfu/g (Burk's medium),  $9.1 \times 10^6$  cfu/g (Mannitol medium). Best microbial growth in National Botanical Research Institute Phosphate (NBRIP) medium was observed in all treatments with MykoPlus (100%RR, 70%RR, 50%RR) and Mykoplus alone with bacterial count ranging from at  $3.75 \times 10^6$  to  $4.8 \times 10^6$  cfu/g soil. Whereas, bacterial count in the uninoculated control, 100%RR and 70%RR only ranged from  $3.1 \times 10^5$ - $7.4 \times 10^5$  cfu/g soil (Kabangkalan site). This indicates that microorganisms in Mykoplus may have persisted in the soil as shown in the differential medium and assisted in crop growth.

*Mycorrhizal spore count:* Mycorrhizal spore count based on 20 g soil samples per treatment, replicated four times, was not significantly different between treatments. Variety of endomycorrhizal spores were observed in most of the treatments in addition to the endomycorrhizal species in Mykoplus. This could possibly be due to the unsterilized soil used in the field trial. This indicates abundance of natural mycorrhiza in the rice rhizosphere.

*Residual soil nutrients and pH:* Soil pH became more acidic after cropping regardless of treatments. Lowest pH was in treatments receiving 100%RR (T2 and T5), possibly due to high amounts of chemical fertilizer applied. Soil % N after cropping was higher in Mykoplus applied treatments (T5 to T8) and comparable with treatment 100%RR (T2) and 50%RR (T4) in Kabangkalan site. Residual % P was higher in Mykoplus applied treatments vs same rate of chemical fertilizer alone. For example, treatment T5 (100%RR+Mykoplus) had 70% higher %P than T2 (100%RR), T6 (70%RR+Mykoplus) had 4% higher %P vs T3 (70%RR), and T8 (Mykoplus alone) had 11% higher %P vs 1 (control). This indicates greater availability of nitrogen and phosphorus in the soil for next cropping's use.

## CONCLUSION

Beneficial microorganisms in Mykoplus helped in increasing the availability of nutrients for the crop and increasing residual amount in the soil after cropping. Mykoplus applied alone out yielded the control, giving 33% increase in rice grain yield. However, greater and more significant growth promotion and economic benefits were obtained when incorporated with 100%RR and 70%RR. Biofertilizer Mykoplus application can be considered as a good agricultural practice leading towards sustainable farming.

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