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Sustainable Production of Banana, *Musa acuminata × balbisiana* Colla (ABB Group) cv 'Cardaba' through integrated crop management

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Abstract

Integrated crop management technology is a compilation of technologies for disease management and cultural practices for cardaba banana. To evaluate the fitness of the ICM technology to local conditions, on-site evaluation on the effectiveness and efficiency of the technology was conducted in banana-growing communities. The results reveal that most cardaba banana farmers do not adopt technologies for cultural management. They have no experience in fertilization, sucker removal, irrigation and drainage and the use of tissue-cultured planting materials. They, however, implemented basic practices such as weeding and deleafing. In the on-farm experiment, bananas in plots receiving ICM technology intervention have significant advantage over those under the Farmers' Practice. In general, bananas with technology intervention are taller and sturdier with more functional leaves. The same trend was noted in the reproductive performance, which resulted to higher income. However, the cost-benefit ratio in the 1st year of production is not significantly different between the area with technology intervention and Farmers' Practice. Sustaining the practice until 5 years when replanting is required can be more economically rewarding.

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Introduction

The market outlook of Philippine bananas is still promising despite the challenges brought about by diseases and climate change impacts (HVCDP, 2012). The production of banana chips is one of the important industries in the country particularly in the southern island of Mindanao. Banana chips have become one of the key products in the Mindanao region for the export market. Banana cv 'Cardaba' is the raw material for banana chips production. Unlike the Cavendish banana, this variety is mainly produced in small-hold farms. Small producers of cardaba banana usually encountered problems on diseases, particularly "bugtok" that hampered production. Bugtok is a bacterial disease that affects both the pith and fruit of banana.

It is caused by *Ralstonia solanacearum* species complex (Sequeira, 1998). Studies on the etiology and epidemiology of the disease have been undertaken to understand its nature and spread as basis for planning the disease management (Soguilon, *et al*. 1995). With the knowledge on how the disease starts and spreads, disease management techniques have been developed. Utilizing this information, the technique of bagging the inflorescence of cardaba banana was investigated. The results indicated that bagging is effective in preventing bugtok occurrence in Caraga Region (Janoplo, 2002).

Cardaba banana farms in Mindanao need to be rehabilitated to supply the required volume to sustain the banana chips production. Since the 1990s, researches on the control and prevention of 'bugtok' and cultural management practices of cardaba banana have been conducted to help farmers achieve better yields.

The demand for cardaba banana as raw materials for banana chips is very high, thus the need for intensification of banana production. Caraga Region, located in northeastern Mindanao, has a negative growth in production volume and area for banana production due to the attack of bugtok in the 1990s and early 2000 (Min DA, 2011).

Thus rehabilitation of the cardaba banana production needs to be done adopting the integrated crop management (ICM). To evaluate the effectiveness and efficiency of ICM, community-based field testing was done in in banana growing areas to improve production and quality of cardaba banana. The aim is to sustainable Cardaba banana production to supply the required raw materials for banana chips.

Materials and methods

Baseline Assessment of Cardaba Banana Farming in Caraga Region

A survey about cardaba banana farming in key areas in the region was made. Data such as the socioeconomic status of banana farmers, the farming systems adopted, economics of banana production, and issues on banana production were gathered to serve as basis for the introduction of ICM technology. In Butuan City, two (2) community-based demonstration sites were selected.

Establishment of the Community-Based Demonstration Farms

An inception meeting was conducted prior to the actual implementation of the community-based ICM on-farm demonstration. During the meeting, the farmer-cooperators and village officials including the personnel of the Agriculture Office of the local government units (LGU) were oriented on the nature and purpose of the project. Likewise, briefing on the Terms of Reference concerning the project implementation was done to make them aware of the commitments of all parties involved in the project implementation.

The community-based technology demonstration was conducted in 4-hectare demonstration farm. Tissue-cultured cardaba banana plantlets were provided to the farmer cooperators to ensure that the planting materials are disease-free. Along with the planting materials, the cardaba banana ICM package was provided. The ICM package is a bundle of

technologies on banana cultural management generated from various researches in the past.

This is compared to the traditional farmers' practice in cardaba banana farming. To determine the effects of ICM in banana production, preliminary data such as farm ecological attributes (terrain, neighboring vegetation and drainage) and soil characteristics of the demonstration farm were taken. In the demonstration farm, the farmer-cooperators manage the day-to-day activities while the Project Management Team conducts the monitoring and data gathering every 2 weeks from the start of the project implementation until harvest.

Farmers and the support groups (eg. agricultural technicians and village officials) who are the direct stakeholders of cardaba banana production in Caraga Region were trained on ICM package of technology. Prior to the actual project implementation, the farmers and other stakeholders were oriented about the project and the technology package to be tested in the technology demonstration farms.

The training-workshop on the technology package allowed sharing of experiences among banana farmers. Farmers' Forum and Farmers' Field Day were also conducted primarily to showcase the community-based demonstration farms and to enable farmers and technicians to interact with cardaba banana experts, banana chips processors and among each other to share information and experiences on banana farming. Likewise, these activities were done to allow farmers and technicians to evaluate the performance of the cardaba banana technology package in the various sites in Caraga Region.

Community-Based ICM Technology Demonstration

The community-based technology demonstration for cardaba banana production was conducted in selected farmers' fields in 2 locations. The 2 treatments (with ICM intervention and Farmers' Practice) were laid out in the demonstration farms by establishing 2 hectares of cardaba bananas for each site. These were planted side by side, with the production management of one hectare following the ICM technology, while the other one hectare adopted the Farmers' Practice.

The performance of the community-based demonstration farms were evaluated from the time of planting to harvest. The evaluation focused on the vegetative and yield performance of banana. The vegetative aspect includes the plant height, stem diameter, number of functional leaves and leaf area. For the reproductive performance of banana, the bunch weight, bunch length, number of hands per bunch, number of fingers per hand and the size of the middle finger were determined.

Statistical analysis

The data were analyzed using t-test in Microsoft Excel Data Analysis. All parameters were analyzed for the vegetative and reproductive performance of cardaba banana to compare those under ICM technology intervention and Farmer's Practice.

Results and discussion

Baseline Assessment of Cardaba Banana Farming in Caraga Region

The majority of cardaba banana farmers is small-hold, with a farm size of 3.5 hectares or smaller based on the the baseline data on banana farming (Table 1). Cardaba banana farming is generally a secondary job because the majority of farmers also plant rice and other crops, while 25% have other 8-hour jobs. All farmers are literate and have attended farming seminars conducted by various government agencies.

The older farmers have been into farming for 25 years or more while the younger ones have started farming at least 6 years ago. Most farmers own their farms and only family members provided for the labor, except when there is a need for weeding and slashing that some hired hands provided labor on contract basis. These characteristics indicate a good potential for the introduction of technology intervention. The relatively high level of educational attainment suggests that learning new methods especially in farming can be easy. Nonetheless, awareness among farmers on the economics of banana production

needs to be enhanced to appreciate the value of bananas in the market and for livelihood.

Table 1. Profile of farmers growing cardaba banana in Caraga Region[1].

Factor	Characteristics of Cardaba Farmers
Married	80-90%
Age	30 – 74 years old
Educational attainment	30% Elementary level; 45% High School Level; 15% College Level; 10% College Graduate
Gender	85% are male
Household size	2-7 members
Banana farm size	0.3-3.5 hectares
Farming experience	6-34 years
Tenurial status	70% are farmer-owners; 15% tenanted; 15% leasehold agreement
Other sources of income	75% are rice or corn farmers and tree farmers; 25% have other 8-hour jobs

[1]Based on responses of 100 respondents per sampling site.

The profile of cardaba banana farms (Table 2) is used as baseline in the technology demonstration. Of these, the majority has undulating terrain and the land preparation is manually done. All farms rely on rain for irrigation. Inasmuch as rainfall is very high in the region, water scarcity is not a problem. In fact, water logging has caused problems to farmers due to the heavy rains that affected their plantings. Banana farmers generally adopt intercropping system with either coconut (*Cocos nucifera* L.) or Falcata (*Paraserianthes falcataria* L. Nielsen. Intercropping is considered beneficial by many farmers not only due to the added income derived from the crop sales but also in the overall benefits from the interaction of intercropped plants such as pest management, nutrient cycling and modification of microclimate to suit the needs of the plants. Zhang and Li (2003) reported inter-specific facilitation that maximized yield in the intercropped species. They revealed that maize improves iron nutrition in intercropped peanut, faba bean enhances nitrogen and phosphorus uptake by intercropped maize, and chickpea facilitates P uptake by associated wheat from phytate P. Furthermore, intercropping reduced the nitrate content in the soil profile as intercropping uses soil nutrients more efficiently than sole cropping. However, there are certain criteria in selecting plant species to be used in intercropping. Machado (2009) specified that the success of an intercrop system depends on understanding the physiology of the species to be grown together, their growth habits, canopy and root architecture, and water and nutrient use because plants compete for light above ground and for water and nutrients below grown.

The farms are close to the farmers' residence, with the farthest at 2 km but usually far from the town center where the local market is situated. This shows the promise of cardaba banana farming to contribute to economic development. Thus, cardaba banana farming needs to be given high priority in Caraga Region due to its vast potential as source of livelihood.

Table 2. Profile of cardaba banana farms in Caraga Region[1].

Factor	Characteristics of Cardaba Farms
Soil type	clay; clay loam
Topography	flat to undulating terrain
Farming system	generally intercropped with coconut or trees
Source of planting material	from neighbor
Variety planted	Cardaba; Latundan; few Lakatan
Source of labor	family members
Distance from farm to house	0.02 – 2km
Distance from farm to road	0.06-2km

Distance from farm to market	5-20km

[1]Based on responses of 100 respondents per sampling site.

In Caraga Region, the majority of banana farmers do not adopt technologies for cultural management. Almost all of the cardaba farmers have no experience in banana fertilization, sucker removal, irrigation and drainage and the use of tissue-cultured planting materials (Table 3).

Only the very basic weeding, deleafing and fruit obstacle removal have been conducted by the farmers but not regularly done.

For 'bugtok' control, which involves the removal of the male bud and bagging, some farmers already heard about it but none of the farmers have started using the technology. This information is necessary for the integrated crop management to be properly disseminated. Social preparation can be crucial because of the tendency for humans to be skeptical to new concepts.

Table 3. Technology adoption on integrated crop management among cardaba banana farmers in Caraga Region[1].

Package of Technology	Farmers' responses
Use of tissue-cultured planting material	Never done
Fertilizer application	Never done
Irrigation and drainage	Never done
Desuckering	Never done
Stem and mat sanitation	Done but not regularly
Leaf pruning	Done but not regularly
Weeding	Done but not regularly
Fruit obstacle removal	Done but not regularly
Bunch spray	Never done
Removal of style and male bud	Never done
Bagging	Never done
Control of insect pest	Never done
Disease control	Never done

[1] Based on responses of 100 respondents per province.

Evaluation of ICM in the Community-Based Demonstration Farms

Cardaba Banana S &T-based ICM Demonstration in Tiniwisan, Butuan City

Cardaba bananas in the fields with ICM intervention are taller and bigger with more functional leaves than those in the farmers' practice in the 2 demonstration farms, namely: Tabelon and Legaspo Demo farms (Table 4). As shown in Fig. 1, the plants in plots with ICM intervention appeared vigorous and sturdy. The statistical analysis using t-test shows that bananas in plots receiving intervention have significant advantage over plants under the Farmers' Practice in terms of plant height, stem diameter and number of functional leaves. The results manifest better vegetative performance of cardaba bananas in plots applied with ICM intervention as compared to those in plots adopting the farmers' practice in the Tabelon Demo farm. The same trend was also noted in Legaspo Demo farm. Pests and diseases are among the major reasons for the failure of the banana chips factory in Caraga Region.

High incidence of pests and diseases also reduces banana yield in Oriental Mindoro. Through the adoption of site-specific Integrated Pest Management (IPM) and dissemination of information on banana pests and diseases and their control, the effects of these infestations would be minimized (Bathan and Lantican, 2010). In addition, banana is highly sensitive to environmental changes. Phenotypic plasticity was observed for plants growing in different fields at a same location and across locations (Blomme *et al*, 2005). They noted that soil structure, soil fertility and water regime can have significant effects on Musa spp. plant productivity and that comparison of growth performance of different varieties can only be done for plants grown under exactly the same conditions. Soil type and distance between hills also significantly influenced banana yield at 1 and 5 percent probability level, respectively

(Bathan and Lantican, 2010). The positive sign of the coefficients means that banana growers with farms having clay loam or sandy clay loam soil or adopting a distance between hills of equal or greater than 20 m2 have greater yield than their counterparts.

These ideal farm-specific characteristics will enable the soil to maintain the right amount of moisture and provide proper drainage and
the banana plant to have abundant exposure to sunlight, which are required to improve the yield of banana.

Table 4. Vegetative performance of cardaba banana with S&T intervention and the traditional farmers' practice in Tabelon and Legaspo Demofarms, Tiniwisan, Butuan City[1].

Characteristics	Tabelon Farm		Legaspo Farm	
	With ICM Intervention	Farmers' Practice	With ICM Intervention	Farmers' Practice
Plant Height (cm)*	359.65	339.12	381.02	323.28
Stem Girth (cm)*	78.20	66.01	84.45	69.87
No. of Functional Leaves*	10.30	7.32	10.35	8.03
No. of Days to Flower Initiation*	246.15	288.87	251.04	273.25
No. of Days to Harvest*	296.30	341.00	308.81	333.00

[1] based on 25 samples per plot * significant at 5% t-test.

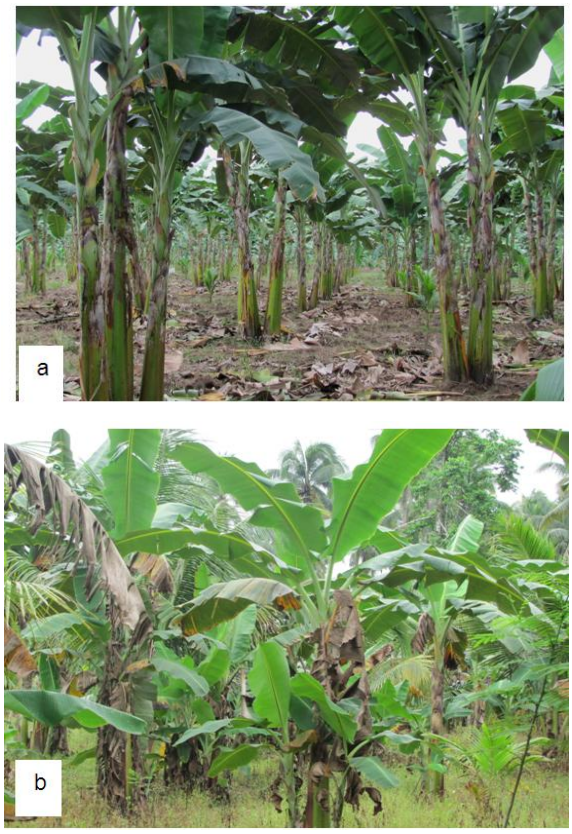

Fig. 1. Demofarms adopting a) ICM technology and b) Farmers' Practice in Tiniwisan, Butuan City.

The reproductive performance of banana was generally better in plots with ICM technology intervention than those under Farmers' Practice (Table 5). Bananas on fields with ICM intervention have higher yield than those in fields that followed the farmers' practice as measured by the number of hands/bunch, weight of the bunch, weight of the banana hands as well as on the number of fingers per bunch.

The difference of the various parameters was highly significant as shown by the t-test results. The application of fertilizer, proper spacing, sanitation and removal of excess suckers contributed to the overall improvement of the productivity of the cardaba bananas.

The increase of about 6-7 kg in bunch weight in bananas exposed to ICM intervention is an evidence of the effects of good agricultural practices. The proper spacing, weeding and removal of excess suckers freed the bananas from competition for light, water and nutrients. Likewise, these also limit the entry of diseases due to the removal of plants and weeds that serve as alternate hosts.

In addition, deleafing removed the senescent leaves which harbor insects that are potential vectors of microorganisms causing bugtok. Besides, removal of old leaves can reduce the energy requirements of banana inasmuch as these aging leaves are still physiologically active but no longer as functional as the younger leaves in photosynthesis.

Faylon *et al*. (2003) reported that correct fertilization, irrigation and drainage facilitate acquiring of the necessary nutrients that plant needs, while sucker pruning, stem and mat sanitation, leaf pruning/ thrashing, and fruit care protect the bananas from insect pests.

Likewise, excessive rainfall and extremely high temperature can reduce banana productivity while the production is also small when both rainfall and temperature are very low with poor humidity (Salau *et al*, 2016).

On the average, the findings show that a mean temperature of about 26°C and average rainfall of around 1891mm with relative humidity of approximately 77% will lead to good annual banana production above 61,000 tons in Ondo State.

Table 5. Reproductive performance of cardaba banana with S&T intervention and the traditional farmers' practice in Tabelon and Legaspo Demofarms, Tiniwisan, Butuan City[1].

Characteristics	Tabelon Farm		Legaspo Farm	
	With ICM Intervention	Farmers' Practice	With ICM Intervention	Farmers' Practice
Bunch Weight (kg)*	15.76	9.65	18.22	10.98
No. of Hands/Bunch^{ns}	7.75	5.46	8.49	6.10
No. of Fingers/Bunch*	117.95	95.23	140.33	121.36
Middle Hand Weight (kg)*	1.95	1.35	2.36	1.68
Number of Fingers/ Middle Hand^{ns}	15.65	14.00	16.73	14.98
Fruit Length (cm)*	12.17	12.00	12.51	12.15
Fruit Diameter (cm)*	4.81	4.30	5.08	4.58
Fruit Weight (g)*	125.48	105.3	132.15	118.45

[1] based on 25 samples per plot

* significant at 5% t-test

In Butuan City, where flooding is experienced during the wet season, drainage is always a challenge to banana farmers.

In managing cardaba banana, farmers need to establish canals to drain the excess water. However, only the enterprising banana farmers do this inasmuch as canal construction is expensive due mainly to high labor rates. Nonetheless, proper water management is a component of the technology for banana production.

This is due largely to the role of water in plant nutrition as well as on the movement of disease-causing microorganisms within the banana farm. In the two (2) demonstration farms in Tiniwisan, Butuan City, drainage canals were established to facilitate water movement from the farm considering the high rainfall in the area.

Cost and Return Analysis of Cardaba Production Adopting ICM and Farmers' Practice

The harvest from the plots with ICM intervention is increased by an average of 7 kg per bunch. This is higher than the weight of bunches harvested from fields adopting the farmers' practice.

At the prevailing price of USD 0.18 per kg, this resulted to an increase of USD1.26 per bunch (Table 6). On a per hectare basis, this resulted to an average increase of USD434.49 and USD514.84, respectively for bananas with ICM intervention in Tabelon's and Legaspo's demofarms per harvest considering only

one bearing banana per mat.

On the 2nd year wherein 1 bunch of the 3 plants per mat can be harvested every quarter, or 4 bunches every year, then the additional income per hectare can reach up to USD1,737.96 and USD2,059.38 for Tabelon's and Legaspo's demofarms, respectively.

Table 6. Income derived from fruit sales of Cardaba banana harvested from fields with and without ICM intervention in Tabelon and Legaspo Demofarms, Tiniwisan, Butuan City[1].

Characteristics	Tabelon Farm		Legaspo Farm	
	With Intervention	Farmers' Practice	With Intervention	Farmers' Practice
Bunch Weight (kg)*	15.76	9.65	18.22	10.98
Income Derived from Cardaba Sales Per Bunch (USD)*	2.80	1.72	3.24	1.95
Income Derived from Cardaba Sales Per Hectare (USD)	1,120.71	857.78	1,295.64	976.00
Total Expenses Per Hectare (USD)	536.00	378.67	536	378.67
Cost-Benefit Ratio (%)	52.17	55.85	58.63	61.20
Income difference between the 2 practices from sales of cardaba per bunch (USD)	1.08		1.29	
Computed income difference between the 2 practices from sales of cardaba per hectare every harvest (USD)	262.93		319.64	

[1]based on the prevailing market price of cardaba banana at USD 0.18/kg. *significant at 5% t-test

The cost-benefit ratio (CBR) of banana farming in either of the two (2) farming practices is remarkable, with an average of 52-61%. The bananas under farmers' practice had higher cost-benefit ratio resulting from the lower production cost due to the absence of the cost for tissue-cultured planting materials and some labor cost. Nonetheless, this calculation is based only on the 1st year of harvest. In the 2nd to the 5th year, the return of investment in banana farms with ICM intervention can be higher due to the distribution of the initial investment to every bunch harvested through time. However, with the prevailing practice wherein the banana farmers have no information about pricing, they just accept whatever price is offered to them. In general, small farmers lack access to reliable price information, thus farmers will accept any farm gate price offered by traders (de los Reyes and Pelupessy, 2009). In fact, practically all smallholder banana growers in Luzon claimed that buyers set the price (Lantican, 2008). In addition, banana farmers receive the same prices for their bananas regardless of size and quality; hence, there is no incentive for them to improve the quality or to standardize their produce.

Conclusion

Farmer education through on-farm demonstration is essential in the sustainable production of cardaba banana.

Obtaining a positive cost-benefit ratio (CBR) provides the motivation for farmers to engage in technology-based agricultural production. The on-farm demonstration of integrated crop management is a step forward to educate farmers that banana farming can be truly a source of livelihood. Cardaba banana production, if given the right attention like other crops, by adopting technologies such as fertilization, use of disease-free planting materials, weed management, drainage and farm sanitation, sustainable livelihood can be developed.

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