Sustainable Mango Production in Central Luzon, Philippines as Affected by Community-Based Model Farms Of Improved Crop Management.

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Abstract. In a society filled with technology and advancement in the quest for convenience, food production is unlikely to be disregarded as the world continue to find means on securing adequate supply to nourish nations. This study aims to increase production efficiency and profitability of one of the most sought after commodities, mango. A technology demonstration on the application of ICM in the nine (9) community-based model farms was established. As a result of the adopted technology innovations demonstrated by mango farmers in their respective mango farms, the study revealed significant findings on the increase in yield and income by 440% and 586.65%, respectively, after ICM application. It is therefore recommended that the system be institutionalized by LGUs, and appropriate policies be implemented to further provide assistance to small players that comprised the mango industry in the country.

1. Introduction
Mango is one of the most important and widely-cultivated fruits in tropical as well as in sub-tropical regions. There have been a number of recent developments with the potential to improve crop yields and quality [1]. In the Philippines, ‘Carabao’ mango is the major cultivar for domestic and export markets both in fresh and processed forms [2].

Mango industry in the Philippines, despite of its demand and competitiveness in the world market, has been confronted with major production challenges and issues, such as declining fruit yield and quality, occurrence of destructive pests and diseases, high cost of production, low profit margin, and unstable production [3].
The Philippines had experienced a decreasing volume of production for carabao mango from 902,739.40 MT in 2015 to 737,032.43 MT in 2017. The volume of production in Bataan also decreased from 3,792.00 MT in 2015 to 3,609.18 MT in 2017. The value of mango production was observed from P16,254.640 in 2015 to P13,270.940 in 2017. The recorded average production yield of 3.96 MT per ha in 2017 was 277% lower from the 11.0 MT desired yield per ha [4]. Apparently, these performance could affect the sustainability of the production supply, both in the domestic and international markets. Further, the production management and technology gaps generally affected the yield performance and productivity of mango in the past [3].

To bring back the industry from continuous downfall, the rolling out of technology and innovations has been eyed as the vibrant solutions in bringing back the mango sectors’ development. The technology demonstrations of Improved Crop Management (ICM) is seen to be the solution to improve the production practices and productivity of mango farmers.

Besides, the need to transform the primitive perspective of farmers into agri-entrepreneurial mindset is necessary in sustaining the production of existing mango orchards.

Objectives of research is to improve the production efficiency and productivity of mango sectors through farmer-participatory approach using the Improve Crop Management (ICM) in the Community-Based Model Farms.

2. Materials and Methods

2.1. Project Sites
The community-based model farms (CBMF) consisted of nine (9) mango orchards with a total of 50 trees (20-25 year old trees) per participating techno-demo farm were established in the District 1 of Bataan, Philippines. The CBMFs project which offered insight into the real world application of the improved crop management was demonstrated under actual field conditions. However, several variables were still considered for the site selection including the age and height of trees, strain, land feature, elevation, temperature, ecosystems, and the efficiency of farmers to adopt the set of interventions. The project was carried out from May 2017 to December 2018.

2.2. Application of Improved Crop Management in the Community-Based Model Farms
The cultural management practices on mango production system from each techno-demo site of CBMFs are summarized in Table 1. The CBMFs for mango production was standardized in all farm sites following the Improved Crop Management (ICM) protocol of Philippine Council Agriculture, Aquatic, Resources, Research and Development.

2.3. Sanitary and Center Pruning
Tagging of trees was done to ensure that the production performance of the trees as to flushing, response to flower induction, flowering, fruit retention and yield was religiously recorded. Sanitary and center pruning were done through the removal of overlap branches, diseased and pests-infected stems and branches. The purposes of this method are to improve sunlight penetration and stimulate flushing. The period of pruning was recorded to ensure the appropriate time for the application of a growth regulator.

2.4. Field Sanitation
Field sanitation was observed by making the demo farms free from weeds throughout production period, particularly at the onset of flowers. Grass cutting was done when grasses and weeds reached the 30 cm in height. The cut grasses were collected and put around the tree as natural mulch. Mulch was drenched with effective microorganism activated solution (EMAS) at the rate of 10ml per litre of water, twice a week to hasten the decomposition of the materials and encourage presence of beneficial microorganisms in the soil.

2.5. Fertilization
The nutrients in soil were analysed using a soil test kit for NPK. Improvement on soil fertility was done through the application of inorganic fertilizers including urea (46-0-0) and complete fertilizer (14-14-
14) at a rate of 5.0 kg and 2.0 kg per tree, respectively, immediately after harvest. Whereas, the same fertilizers (1.0 kg urea, 3.0 kg complete fertilizer and 15.0 kg organic fertilizers were applied during the flowering stage.

2.6. Soil Analysis
Representative soil samples from every techno-demo farm were subjected to complete soil analysis at the Soil Testing Laboratory of Department of Agriculture, Regional Field Unit-III, City of San Fernando, Pampanga, Philippines.

2.7. Flush Management
The removal of unwanted waterspouts in trees branches and thinning of excessive or unhealthy flushes was done in the experimental trees. Spray of fungicide and insecticide (mancozeb and carbaryl) was done upon onset of flushes.

2.8. Paclobutrazol Application
Paclobutrazol is a chemical substance that retards the vegetative growth of mango trees. This enhances the flowering intensity of mango. The desired amount of Paclobutrazol (1 g a.i.; 4ml formulated product) per linear meter of canopy diameter) was diluted in sufficient amount of tap water and drench the trees within the active root zone.

2.9. Flower Induction
To break the normal fruiting habit, mango trees were induced to promote profuse flowering and fruiting anytime of the year. The 2-3% KNO3 or Ca (NO3)2 was applied preferably in the afternoon. Higher concentration was recommended during off-season and lower rates during on-season. Follow-up spray of low dose (1.0 to 1.5%), three (3) days after flower induction, was also done in order to improve the flowering response, especially during off-season production.

2.10. Need-Based Spray of Pesticides
It was observed through careful selection of pesticides to be applied and the right time and frequency of application dilution rate for the target pests at vegetative and reproductive stages.

2.11. Bagging
It reduces fruit rejects from 60% to 20% of the total harvest. A paper bag made from newsprints, old telephone directory and magazines that measures 20cm x 15cm was used for the bagging of young developing fruits. Bagging is observed when fruits have attained the corn kernel size or about 45-50 days from flower induction.

2.12. Data Analyses
The yields per CBMFs were recorded and evaluated for profitability analysis. The mean yield, production cost, gross income, cost per tree, cost per kg of fruit were compared before and after the interventions. The initial data on production cost and gains of the farmers practice and with interventions were also compared using percent difference.

3. Results and Discussion
Table 1. Summary of the adopted interventions before and after the implementation of Integrated Crop Management (ICM) to the nine participating mango farms (1 ha each) in Bataan, Philippines.

| ICM Protocol                        | Before ICM | After ICM |
|-------------------------------------|------------|-----------|
| Tagging                             | 0%         | 100%      |
| Sanitary and Center-Canopy Pruning  | 44%        | 100%      |
| Basal Fertilization                 | 33%        | 100%      |
| Field Sanitation                    | 44%        | 100%      |
Before this project, the participating farmers have limited knowledge and skills in the appropriate application of key activities of ICM. Simple, yet effective methods of ICM including tagging, painting of the cut branches, flush induction, flush management, and mulching, were not practiced in the previous management (Table 1). Seven (7) out of 12 sets of ICM strategies were fully implemented by farmers in all participating techno-demonstration farms; protocol in flush induction was the least performed (Table 1).

The interventions applied in techno-demonstration farms resulted to 199.88 % increase in total mean operational cost (Table 2). This occurred mainly due to additional expenses incurred in the acquisition of paclobutrazol, pesticides, flower inducer and fertilizers, and labor costs for pruning, field sanitation and spraying [5]. From a total of 50 experimental trees, around 78% flushing rate was observed and consequently, 84.60% produced flowers. This validates the result of an experimental study conducted in Indonesia that paclobutrazol accelerated the induction of flowering, significantly seen in a number of flowering plants, faster rate of flower emergence and observed with more petals [6], [7]. The result discloses that the rate of flushes has directly influenced the flowering response of trees. According to Ref.[8], flowering is a decisive factor in the productivity of mango, thereby control of flowering allows growers to harvest their crops at the most profitable times.

This study revealed a much higher rate compared to previous records of flushing (43%) and flower intensity (50%). The observation is attributed to the effect of the interventions employed after harvest which include, sanitary pruning, fertilization and spray of urea [9]. The results indicate that yield improvement at the lower cost can be achieved by sanitary pruning [10]. In spite of the reduced price of mango fruit in the local market (-30.77%) and increased operational expenses, mean yield and mean gross income considerably increased at 340%, and 486.66%, respectively (Table 2). Net income increased to about 1,060.41% after ICM application. The rise in profit corresponds to the increase in yield (Figure 1). When properly implemented, ICM protocol is cost-efficient for mango production.

**Table 2.** Economic performance of the project (1$ = PhP 52) before and after the techno-demonstration trial in none participating farms in Bataan, Philippines.

| Economic Parameters ($) | Before ICM | After ICM |
|-------------------------|------------|-----------|
| Average Operational Expenses ($) | 490.2 | 1,470 |
| Gross Income ($) | 735.3 | 4,313.70 |
| Cost per tree ($) | 9.8 | 29.41 |
| Cost per kg of fruit ($) | 0.39 | 0.27 |
Figure 1. Mean yield (bar) and net income (line) of nine participating mango farms before and after the implementation of Integrated Crop Management for mango production in Bataan, Philippines.

4. Discussion
The adoption of Integrated Crop Management (ICM) is being eyed to boost the mango industry in the Philippines [11]. With the study aiming at the improvement of the production efficiency and productivity of mango sectors in Central Luzon, the application and practice of ICM protocols in community-based farms relatively increased operational and overhead costs but revealed a significant increase in yield and profit.

Though the farmers have traditional/cultural practices that resemble ICM Protocols, the knowledge of the local farmers was observed to be limited. With the project’s introduction to tagging, flush Induction, flush management, mulching, and other science-based techniques and strategies, along with the farmers’ willingness to change, try and adopt the science and technology interventions provided for by the research team, the study was able to provide solutions to address the gaps of low production output on mango production.

As the study reckons its findings, it is recommended that community-based model farming systems be institutionalized as a continuing extension program of local government units on mango production. Further, legislators should be encouraged to formulate policies that may support the access of mango farmers to financial credits, markets and post-harvest facilities.

References
[1] Galan, Victor S. (2019). Achieving sustainable cultivation of mangoes. Department of Engineering, Information Technology and Environment, Charles Darwin University. Accessed at https://researchers.cdu.edu.au/en/publications/achieving-sustainable-cultivation-of-mangoes, 15 August 2019.
[2] Montecalvo, M. P., Opina, O. S., Dalisay, T. U., & Esguerra, E. B. (2019). Efficacy of Postharvest Treatments in Reducing Stem End Rot of ‘Carabao’ Mango (Mangifera indica L.) Fruit. Philippine Journal of Crop Science (PICS), 44(1), 36-43.
[3] Paguia, H. M. et al (2019). Effects of community-based farming on the productivity and profitability of mango (mangifera indica, linn.) in Bataan, Philippines. International Journal on Agricultural Innovations and Research (IJAIR) ISSN (online)2319-1473
[4] Philippine Statistics Authority (PSA). (2018). Crop Statistics of the Philippines 2011-2015 (National and Regional). Quezon City Philippines. 248 pages.
[5] Shu, Z. H. (1999). Effect of temperature on the flowering biology and fertilization of mangoes (Mangifera indica L.). Appl Hort., 1(2): 79-86.
[6] Protacio, C.M., Bugante Jr., R.D., Quinto, J. E., Molinyawe, G, & Paelmo, G. (2000). Regulation of flowering in ‘carabao’ mango trees by paclobutrazol. Philippine Journal of Crop Science 25(2) 27-33.

[7] Husen, S., Kuswanto, Ashari, S., & Basuki, N. (2012). Induction of Flowering and Yield of Mango Hybrids Using Paclobutrazol. Journal of Agriculture and Food Technology. 2(9)153-158.

[8] Jameel, A., Naik, R., Madhumathi, C., Reddy, S., & Venkataramana, K., (2018). Physiology of Flowering in Mango. Journal of Pharmacognosy and Phytochemistry. E-ISSN: 2278-41367(6): 2375-2382

[9] Protacio, C.M., Serano, E. P., Rodriguez, F. M., & Quinto, J. E. (2004). Unravelling the role of KNO3 in mango flowering. Department of Horticulture, University of the Philippines-Los Banos, Laguna, Philippines. Philippine Journal of Crop Science. ISSN: 0115-463X

[10] Gross, Emil R. (1997). Pruning mango to increase yield. Acta Hortic. 455, 538-542 DOI: 10.17660/ActaHortic.1997.455.70. https://doi.org/10.17660/ActaHortic.1997.455.70

[11] Yap, J. (2017). Boosting and yielding the quality of mango industry in the Philippines. Retrieved on August 15, 2019 from https://www.agriculture.com.ph/2017/11/16/addressing-mango-yield-and-quality-issues/

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