ECONOMIC EFFECTS OF PRUNING AND BAGGING TECHNOLOGIES IN MANGO PRODUCTION IN SELECTED MAJOR PRODUCING AREAS IN THE PHILIPPINES

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ABSTRACT

The effects of pruning and bagging technologies on 332 mango growers in Luzon, Visayas and Mindanao were analyzed in terms of improvement in fruit quality, reduction in the use of chemicals, change in pest management cost, productivity, and net income over pest management cost.

Control of pests and diseases during production was mainly chemical control using active ingredients of varying toxicity. Pruning reduced the volume and cost of chemicals, and decreased the cost of pest management as indicated by the estimated cost function. Pruning is a yield increasing technology based on Cobb-Douglas production function. Net revenue above pest management cost was higher for adopters than for non-adopters of pruning.

While bagging reduced the volume and cost of chemicals, it did not reduce the cost of pest management because bagging is relatively costly. Nonetheless, bagging resulted in higher yield and a higher proportion of yield sold to exporters. Net revenue above pest management cost for adopters in Luzon was higher than for non-adopters by about $10 per tree. The difference was not significant, but represents a big opportunity for growers with limited capital. The technology has important backward linkages in terms of rural labor and recycling of papers as bagging materials but can reduce the use of chemicals.

The technologies have long-term effect on the environment and the "mango-eating" public via reduction in the use of chemicals. The continued adoption of the technologies could minimize environmental pollution and accumulation of the ill-effects of chemicals on the health of workers, households members and consumers.

Keywords: mango, pruning, bagging, cost function, production function, backward linkages

1. INTRODUCTION

Carabao mango, popularly known as Manila Super Mango, is one of the most important fruit crops in the country. In 1999, volume of production reached as high as 803,214 million tons, valued at 9.5 billion Pesos. In the same year, the country earned more than US$ 30 million from exports of fresh and processed mangoes. The major export markets for fresh mangoes are Hong Kong/China, Japan and Singapore. While Philippine mango is a multi-million dollar export industry, it is beset by the problem of supplying quality fruits to maintain its competitiveness in the world market. In today's global trading, the General Agreement on Tariff and Trade (GATT) calls for nations to compete under a multilateral trading system that provides for freer market access among nations. As a result, stiff competition among agricultural products including mango is imminent. It is therefore imperative that the country gears toward global competitiveness and sustainability by putting priority on improving the quality of the country's carabao mango, hence the need to further develop the industry.

The prospect of the mango industry is very bright, but sustaining production of high quality fruits is very important. To achieve this, the agricultural research and development system in the country has conducted numerous studies aimed at improving mango productivity and reducing post harvest losses. These Research and Development efforts have resulted in the development of specific technologies or farm practices that are now being adopted, albeit to varying extent by mango growers and traders. Foremost of these technologies is bagging the fruits to reduce insect infestation and other mechanical damages and pruning the trees to improve productivity. There are no studies which have fully assessed the impact of these on the country's mango industry, particularly on farm income and over all farm efficiency. Thus, this study was conducted to determine the effects of these technologies on productivity and income of mango growers in major production areas in the Philippines. Moreover, the study determined the spill-over benefits of these technologies on the backward industry linkages. Knowledge of the impact of bagging and pruning technologies on the socio-economic well-being of the target clientele groups could serve as navigational beacons to further enhance the development of the mango industry.

2. METHODOLOGY

Local, Data Collection and Sampling Frame

The top 27 producing municipalities form Pangasinan and Zambales in Luzon, Cebu and Guimaras in the Visayas, and Davao del Sur in Mindanao were the study areas. Secondary data gathered from various agriculture offices and National Mango Research and Development Center (NMRDC) were used to draw sampling frame using the formula:

$$n = \frac{N}{1 + Ne^2}$$

n = sample size
N = population size
e = desired margin error set at 0.10 at 90% confidence level

Due to absence of list of growers using bagging technology from the municipal offices, key informants such as contractors and cooperative leaders were asked who among the mango growers in their locality were using the technology. From the list provided sample respondents were identified.

Table 1 shows the number of respondents by group and location. A total of 332 mango growers and contractors were interviewed; 98 from Luzon, 164 from Visayas and 70 from Mindanao. These were classified whether they were pruning and/or bagging adopters or not.

Table 1. Number of respondents by technology adoption and location

Location	Technology Adopters					Non-Adopter
	Pruning Only	Bagging Only	Both Pruning and Bagging	All Pruning Adopter	All Bagging Adopter	
Luzon	17	6	28	45	36	45[1]
Visayas			52	52	164	112[2]
Mindanao			66	66	70	4[2]
Total	**17**	**6**	**148**	**165**	**270**	**159**

[1]Non-adopter of both pruning and bagging
[2]Non-pruning adopter

Data Analysis

Impacts of pruning and bagging

Descriptive analysis of the impacts of pruning and bagging on the cost and use pesticides, cost in pest management, yield, and value of production or sales was conducted for the different groups of respondents. Moreover, the effect of bagging technology on fruit quality as indicated by proportion of fruits accepted for export was determined. Comparative statistics on these variables between groups of respondents was done using Independent Samples T-test and General Linear Model (GLM) procedure of SPSS version 11 for Windows.

Cost and return analysis, the most common method of determining and comparing the profitability of different technologies, was done. Profit is defined as the difference between total revenue (TR) and cost. Pest management is considered one of the most important cost items in mango production. Thus, profit analysis was done over pest management cost (PMC) only.

where:

$$\pi = TR - PMC$$
$$= P_y * Y - \Sigma P_{xi} * X_i$$

where: π = profit over pest management cost
P_y = price of mango per kg
Y = quantity of mango in kg per tree
P_{xi} = price of inputs used in pest management activities
X_i = quantity of inputs used in pest management

To analyze the extent of the effect of pruning on the yield of mango given conventional yield increasing inputs such as labor, chemicals, fertilizer, irrigation, and other factors such as age of tree, size of farm, and location, a production function analysis using Cobb-Douglas form was done. Similarly, the effects of bagging on yield, along with the aforementioned factors were also determined.

The empirical model of the Cobb-Douglas (C-D) production function used was:

$$\text{Ln Qty} = \alpha_0 + \alpha_1 \text{ Location dum} + \alpha_2 \text{ Pruning dum} + \alpha_3 \text{ Bagging dum} + \alpha_4 \text{ Ln Age tree} + \alpha_6 \text{ Ln Total trees} + \alpha_7 \text{Ln Total MD} + \alpha_8 \text{ Irrig dum} + \alpha_9 \text{ Ln Chem} + \alpha_{10} \text{ Ln N} + \alpha_{11} \text{ Ln P} + \alpha_6 \text{ Ln K} + \varepsilon$$

where:

Qty	=	yield in kg per tree
Location dum	=	location dummy, 1 for Luzon and 0 otherwise
Pruning dum	=	pruning dummy, 1 for pruning adopters and 0 otherwise
Bagging dum	=	bagging dummy, 1 for bagging adopters and 0 otherwise
Age tree	=	age of trees in years
Total trees	=	total number of trees grown or managed
Total MD	=	total number of man days reported to perform various management practices
Irrig Dum	=	irrigation dummy, 1 for those who irrigated mango trees and 0 otherwise
Chem	=	amount of pesticides applied in gram active ingredient (g.a.i.)
N	=	amount of nitrogen applied in kg
P	=	amount of phosphorus applied in kg
K	=	amount of potassium applied in kg
α_i	=	estimated coefficients
ε	=	error term

The change in the pest management cost structure for mango as a result of the adoption of the technologies was also determined. A C-D cost function in linear form was used:

$$\text{Ln PMgtCost} = \alpha_0 + \alpha_1 \text{ Location dum} + \alpha_2 \text{ Ln Age tree} + \alpha_3 \text{ Location dum} + \alpha_4 \text{ Ln Bagging lab} + \alpha_5 \text{ Ln Bagging mat} + \alpha_6 \text{ Ln Pruning lab} + \alpha_7 \text{ Pruning mat} + \alpha_8 \text{ Ln Chem lab} + \alpha_9 \text{ Ln Chem mat} + \varepsilon$$

where:

PMgt Cost	=	total cost of pest management, pesos/tree
Location dum	=	location dummy, 1 for Luzon and 0 otherwise
Age tree	=	age of trees in years
Bagging lab	=	cost of labor in bagging, pesos/tree
Bagging mat	=	cost of bagging materials, pesos/tree
Pruning lab	=	cost of labor in pruning, pesos/tree
Pruning mat	=	cost of pruning tools and materials, pesos/tree
Chem lab	=	cost of labor in spraying chemicals, pesos/tree
Chem mat	=	cost of chemicals used, pesos/tree
α_i	=	estimated coefficients
ε	=	error term

Method of estimation of various functions

The production and cost functions were estimated using OLS method. The OLS estimators provided the best linear unbiased estimates under certain assumptions. The expected value of the estimated parameters is equal to the true value of the parameter. The least square estimators are best in the sense that their variance is minimum in the class of linear unbiased estimators. In these sense, the OLS estimators are the most efficient in this class [1]. The F-statistics test was used to measure the goodness of fit of the production and cost functions.

Analysis of backward linkages

The direct backward linkage in mango production and changes that occur on this linkage were analyzed using input-output framework. Input-output framework have been found to be useful in analyzing the economic relationship or linkages among major sectors of an economy, either national or regional [2]. Output in terms of total value of production per tree and input structure in terms of purchases of goods and services from other sectors in order to produce the given value of output were analyzed.

3. RESULTS AND DISCUSSION

Impact of Bagging and Pruning in Mango Production

Changes in Pest Management Practices

The use of chemicals to combat insect pests and diseases was widely adopted by the respondents across locations especially those who are operating in semi-commercial and commercial scale. The control of insect pest common among respondents was based on calendar as shown in Table 2.

On average, bagging adopters in Luzon performed about five (4.4) sprayings of pesticides as compared to seven for non-bagging adopters. The difference is the last two sprayings usually done from fruit development to fruit maturity that occurs from 70 to 90 days after flower induction (DAFI). During this period, pests that attack are fruit flies and seed borers, among others. Thus, bagging protects the fruits from these insects and reduces the number of spraying by about two. Whereas, pruning adopters reported a mean number of spraying of 6.2 while adopters of both pruning and bagging had 5 sprayings.

In Visayas where bagging is widely practiced, five sprayings were also reported (4.71 for pruning adopters and 4.94 among non-pruning adopters). In Mindanao, there were six pre-bagging spraying. However, post bagging spraying was also reported in Visayas and Mindanao when the incidence of insects attacking fruits was relatively high and when the bags were destroyed by rain.

Table 2. Frequency and period of spraying mango trees

Spraying	Crop Phenology	Luzon		Visayas	Mindanao
		Bagging Adopters	Non-Bagging Adopters	Bagging Adopters	Bagging Adopters
		(Days After Flower Induction)			
1st	Bud emergence	11-14	10-12	10-14	10-14
2nd	Bud emergence-elongation	20-25	18-20	18-22	17-21
3rd	Fruit set	32-35	21-30	32-35	31-35
4th	Fruit development (marble size)				
5th	Fruit enlargement	40-45	36-45	38-45	38-42
6th	Fruit development	53-60	50-60	49-53	45-49
7th	Fruit maturity		70-75 90	*	50-60 *

* Post bagging spraying when necessary

Change in chemicals used. To control insect pests active ingredients of varying amounts, frequency and toxicity ranging from less to highly hazardous insecticides (CAT 2 to CAT 4) were used (Tables 3a and 3b). Respondents used relatively the same kind of active ingredients to control both insect pests and diseases. Apparently, mango growers/contractors used the same regardless of technologies practiced. Across locations and groups of respondents, almost all of the targeted leafhoppers, while only a few were used to control twig and tip borers, fruit flies, and mealy bugs. Based on the kind of insecticides used, mango growers/contractors protect mango from damage by hoppers that attack during the early stages of crop phenology.

There were three important diseases of mango that the respondents controlled, namely: anthracnose, scab and powdery mildew. To control diseases, mancozeb and benomyl were commonly used by bagging (including both adopters) adopters in Luzon. Non-bagging adopters used predominantly three fungicides, propineb in addition to mancozeb and benomyl. These were commonly mixed in tank with insecticides and sprayed on mango.

Those who adopt only pruning used 174 gram active ingredient (g.a.i.) of pesticides per tree, 30 g.a.i. or 17 percent lower than the volume used by non-adopters at 204 g.a.i. As a consequence, pruning entailed lower cost of chemical control; P 999 per tree as compared to non-adopters' P 1,050 or a difference of P51 or 5 percent. The difference accrues from lower cost of chemicals (about 1 percent reduction) and cost of labor in spraying (about 14 percent reduction).

Moreover, bagging also helped reduced the volume of chemicals used by 23 percent. Bagging adopters sprayed about 156 g.a.i per tree as compared to non-adopters' 204 g.a.i. With bagging, spraying of chemicals was only necessary during flowering and early fruiting stage. The reduction in the volume of chemicals due to bagging was the result of protecting the fruits from fruit flies, cecid flies, helopeltis, and other scale insects ovipositing on the fruits. With bagging the cost of chemical control was lower at P818 per tree as compared to non-adopters' P1,050 per tree. The reduction of P232 per tree was attributed to lower cost of chemicals (21 % reduction) and labor for spraying (26 % reduction).

Adopters of both pruning and bagging used 160 g.a.i., 44 g.a.i. or 22 percent lower than the non-adopters. As a consequence, they spent lower cost of chemicals (by 13 percent), labor for spraying (by 29 percent), and total cost of chemical control (by 18 percent).

Table 3a. Kinds of chemicals used predominantly by mango growers/ contractors in Luzon

Active Ingredient	Brand Name	CAT	Technology Adopters			Non-Pruning and Bagging Adopters
			Only Pruning	Only Bagging	Both Bagging and Pruning	
			Percent reporting			
Insecticide						
Pymetrozine	Chess	4	47	43	28	42
Deltamethrin	Decis	4	29		7	16
Thiametoxam	Actara	4	12	14	14	13
Imidacloprid	Confidor	3,4	29		4	11
Carbaryl	Sevin	2	18	14	4	13
Malathion	Malathion	3	24		7	9
Fungicide						
Mancozeb	Dithane	4	24	14	21	27
Benomyl	Benlate	4	18	14	10	9
Propineb	Antracol	4				4
	Amistar		12			4

Table 3b. Kinds of chemicals used by mango growers/contractors in Visayas and Mindanao

Active Ingredient	Brand Name	Visayas		Mindanao	
		Bagging and Pruning Adopters	Non-Pruning Adopters	Bagging and Pruning Adopters	Non-Pruning Adopters
		Percent Reporting			
Insecticide					
Pymetrozine	Chess	60	64		
Deltamethrin	Decis				
Thiametoxam	Actara	23	21		
Imidacloprid	Confidor			62	50
Carbaryl	Sevin	23	34		
Malathion	Malathion				
Cypermethrin	Buswack,	23	19		
	Attack	6	19		
Lamdacyhalothrin	Karate	48	48	32	50

Table 3b. Kinds of chemicals used by mango growers/contractors in Visayas and Mindanao (cont.)

Active Ingredient	Brand Name	Visayas		Mindanao	
		Bagging and Pruning Adopters	Non-Pruning Adopters	Bagging and Pruning Adopters	Non-Pruning Adopters
		Percent Reporting			
Chlorpyrifos	Nurelle	15	17		
Chlorpyrifos cypermethrin	Blink			33	
BMPC	Carvil			27	25
CPM				50	25
Fungicide					
Mancozeb	Dithane	31	19	48	75
Benomyl	Benlate	31	43	18	
Propineb	Antracol	33	36	11	

Results showed that those growers/contractors who had adopted bagging and both technologies had numerically higher absolute and proportionate difference in volume and cost of chemical control than those who adopted pruning alone. Moreover, these parameters were all lower than those who adopted neither pruning nor bagging (Figure 1a). The result of univariate analysis showed that the cost of chemicals, labor and total cost of chemical control of bagging adopters was slightly different over non bagging adopters (near 90% confidence level).

In Visayas, pruning adopters used 160 g.a.i., 21 g.a.i. or 12 percent lower than the volume of chemicals used by non-pruning adopters. The reduction in the volume of chemicals used entailed lower total cost of chemical control per tree of about P101.00 or 14 percent. This accrues from lower cost of chemicals and cost of labor in spraying. The cost of chemicals is 5 percent or P24.00 lower, while the cost of labor is reduced by P77 pesos or 60 percent per tree. The removal of unproductive and overlapping branches had decreased the volume of chemicals used and consequently the labor required for chemical control. As a consequence, pruning significantly reduced the cost of labor in spraying in Visayas.

In Mindanao, pruning also reduced the volume of chemicals used in mango production, by 4 g.a.i. or 20 percent per tree. Similarly, the cost of chemicals and labor in spraying was reduced, but by lower percentage than in Visayas.

The numerical difference in the volume of chemicals used and the total cost of chemical control between both technology adopters and non-pruning adopters for Visayas and Mindanao is clearly depicted in Figures 1b and 1c.

The reduction in volume of chemicals and total cost of chemical control was not significant across locations. Pruning allows good light penetration and air circulation. Moreover, the removal of unnecessary as well as branches damaged by insects and diseases creates an environment less favorable to the development of leafhoppers, mealybugs and diseases like anthracnose, stem end rot and scab [3]. With pruning, sources of disease inoculum are removed as well as the breeding ground for insects.

Results showed that bagging and pruning at the farm level across locations given one production data had numerically reduced the volume and cost of chemicals. It could be plausible that in the long run the adoption of both or either of the technologies could significantly reduce the amount and cost of chemicals.

Cost of Bagging and Pruning

The cost of bagging was determined per province to have a better understanding of the cost differences not only between locations but also within a particular location. The cost of bagging was relatively expensive, and it is more expensive in Luzon than in Visayas and Mindanao (Tables 4a and 4b) because of the difference in the wage rate of baggers. There is lower supply of expert baggers in Luzon, hence the higher wage rate. Mango producers from Pangasinan had to import baggers from Zambales, while other growers/contractors from Zambales had to import baggers from Cebu, hence the higher cost of labor.

The average cost of bagging per fruit in both provinces of Luzon was P0.36, but there was a difference between the cost of material and labor in two provinces. In Pangasinan, labor cost of bagging was 8 percent higher than in Zambales because the average rate per day of P250 in Pangasinan was higher than Zambales' rate of P225. Some baggers from Pangasinan were hired from Zambales, hence the higher rate per day. Meanwhile, the average cost of a bag in Pangasinan was 20 percent lower than in Zambales due to lower price of paper, P7.50 per kg in Pangasinan and P10.00 per kg in Zambales. The difference was attributed to the difference in transaction cost due to the difference in distance of Zambales and Pangasinan to the source of paper. Papers sold in Pangasinan were bought predominantly from Manila, whereas those sold in Zambales were bought either from Manila or Pangasinan. Other materials (stapler and plant midrib) and labor to make bags are relatively the same in the two provinces.

Table 4. Cost of bagging per fruit, all locations

Cost	Location				
	Luzon		Visayas		Mindanao
	Pangasinan	*Zambales*	*Cebu*	*Guimaras*	*Davao*
Cost of bagging (P/ fruit)					
Cost of labor	P 0.26	P 0.24	P 0.20	P 0.16	P 0.11
Cost of material	0.10	0.12	0.07	0.08	0.08
Total	P 0.36	P 0.36	P 0.27	P 0.24	P 0.19

In the Visayas, total cost of bagging per fruit was P0.27 in Cebu and P0.24 in Guimaras. In Cebu, baggers were paid from P150 (plus food) to P200 pesos per 1000 fruits or P0.20 per fruit. Whereas, in Guimaras baggers were paid on a daily basis ranging from P200 to P250 or an average of P216 per day. A bagger could bag 1000 to 1500 fruits per day, or an average of 1,350 pieces per day. Hence, the cost of bagging per fruit is lower in Guimaras at P0.16.

Bagging cost was lowest in Mindanao, P0.19 per fruit, due to a relatively lower cost of labor of P0.11 per fruit. Hiring rate per day ranged from P100 to P150 per day, or an average of P 107.

Figure 1a. Comparison of volume and cost of chemical control in mango, Luzon

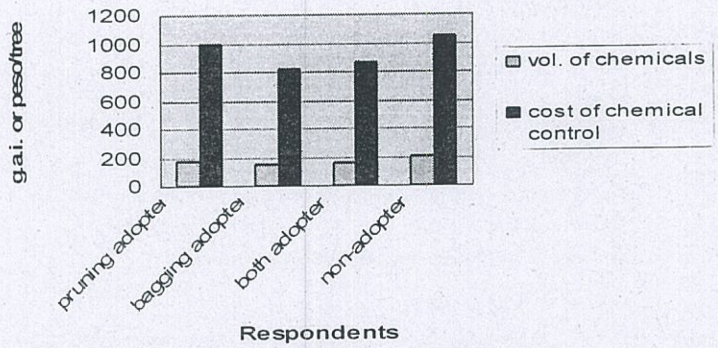


Figure 1b. Comparison of volume and cost of chemical control in mango, Visayas

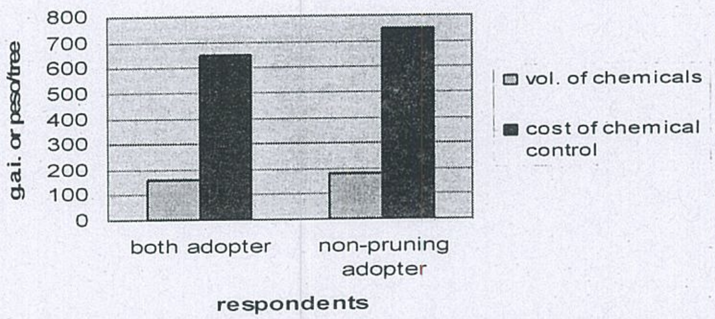
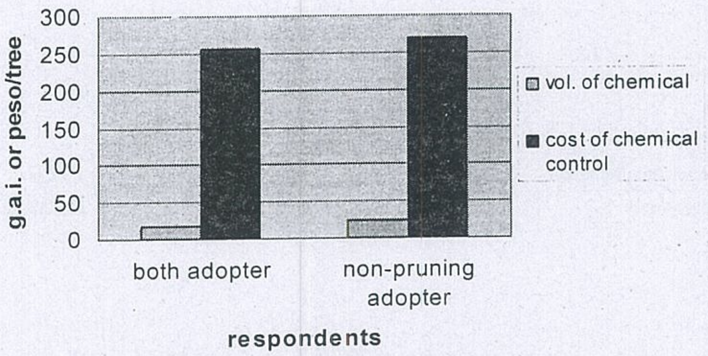


Figure 1c . Comparison of volume and cost of chemical control in mango, Mindanao



On a per tree basis, the cost of bagging among bagging adopters only was about P368 while those adopting both pruning and bagging technologies reported about P379 in Luzon (Table 4a).

In Visayas, the cost of bagging was P439 among pruning adopters and P557 among non-pruning adopters. In Mindanao, cost of bagging was P105 and P127 per tree among pruning and non-pruning adopters, respectively (Table 4b). The cost of bagging differs by location as a result of the differences in the cost of labor and bag and the number of fruits bagged per tree.

Table 4a. Cost of pruning and bagging (P/tree) in mango production (Luzon)

Province	Bagging Adopters	Pruning Adopters	Both Pruning and Bagging Adopters
Cost of bagging (P/tree)			
Cost of labor	245	0	254
Cost of material	123	0	125
Total	368	0	379
Cost of pruning (P/tree)			
Cost of labor	0	43	44
Cost of tools, equipment	0	14	16
Total	0	57	60

Table 4b. Cost of pruning and bagging (P/tree) in mango production (Visayas and Mindanao)

Province	Bagging and Pruning Adopters	Non-Pruning Adopters	Mean Difference
Visayas			
Cost of bagging(P/ tree)			
Cost of labor	318	386	-68 (-18)
Cost of material	120	170*	-50* (-29)
Total	439	557	-118 (-21)
Cost of pruning (P/tree)			
Cost of labor	25	0	
Cost of tools, equipment	23	0	
Total	48	0	
Mindanao			
Cost of bagging (P tree)			
Cost of labor	64	78	-14 (-18)
Cost of material	41	49	-8 (-16)
Total	105	127	-22 (17)
Cost of pruning (P/tree)			
Cost of labor	20	0	
Cost of tools, equipment	8	0	
Total	28	0	

Figures in parentheses are percent reduction (-) relative to non-adoption
* Significant at 90 percent confidence level

Meanwhile, the total cost of pruning was not that expensive, only less than or equal to P60 per tree in Luzon, P48 in Visayas and P28 in Mindanao (Tables 4a and 4b). This consisted of labor cost for pruning and depreciation cost of pruning tools. Pruning tools commonly used were chain saw either powered or manual, bolo, and pruning sheers of various types.

Effect on Cost of Pest Management

One of the major problems in mango production is the incidence of pests and diseases. To address this problem, suitable pest management practices are employed to reduce the damage caused by insect pests and diseases. The management practices employed by mango growers and contractors are bagging, pruning and the use of chemical control.

Pruning adopters incurred a total of P1,056 pest management cost per tree, of which 95 percent or P999 were spent for chemical control and 5 percent or P57 for pruning. Non-adopters only used chemical control, and spent P1,050. Pruning adopters reduced cost of chemical control by 5 percent, but incurred an added cost of P57 for pruning. As a consequence, pruning adopters incurred 0.5 percent higher pest management cost per tree than non-adopters.

Bagging adopters incurred P1,186 for pest management; 69 percent for the cost of chemical control and 31 percent for bagging. Bagging adopters spent less for chemical control (by 22 %) as compared to non-adopters. However, the added cost of bagging had increased total cost of pest management by 13 percent.

Cost of pest management for adopters of both bagging and pruning was P1,303; 66 percent was the cost of chemical control, 29 percent the cost of bagging and 5 percent the cost of pruning. Bagging and pruning had added cost of P439 per tree, but reduced cost of chemical control by 18 percent. The pest management cost of both technology adopters was 24 percent higher than the cost of pest management of non-adopters.

Bagging technology had reduced the cost of chemical control, but the reduction was not sufficient to compensate for the added cost of bagging. Although the difference between pest management cost of groups of respondents was not significant, an added cost of P 62 (between bagging and non-adopters) and P259 per tree (between both adopters and non-adopters) in pest management represents a big burden among mango growers and contractors who had limited capital in mango business. If this is not compensated by increases in yield and price of mango, continued adoption of the technologies can not be ensured.

The difference in the cost of pest management of the different groups of respondents in Luzon is depicted in Figure 2a.

In Visayas, pruning adopters spent a total of P 1,133 in pest management as compared to non-adopters' P 1,304. The difference in pest management cost between pruning and non-pruning adopters was P171, representing 13 percent reduction per tree. In Mindanao pruning adopters spent P28 for pruning per tree, seven percent share of the total pest management cost. Adopters had lower cost of chemical control (5%) and bagging cost (17%), hence lower total cost of pest management of 4 percent.

The effect on pest management cost of pruning differs in magnitude among adopters in Visayas and Mindanao. Both differences were not significant though, but nonetheless are good indicators of the potential benefit of adopting pruning technology.

The comparison of the cost of pest management of both adopters and non-pruning adopters in Visayas and Mindanao are shown in Figures 2b and 2c.

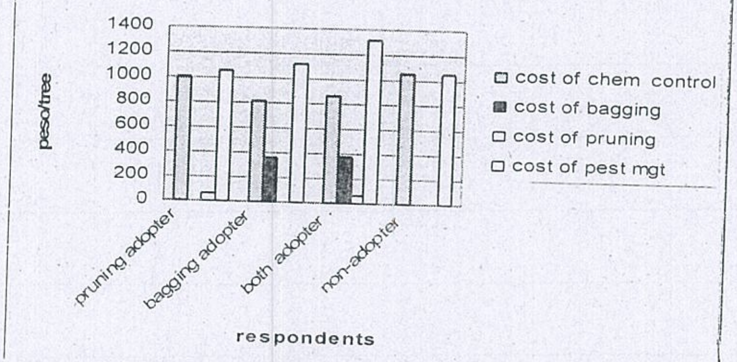


Figure 2a . Comparison of cost of pest management in mango, Luzon

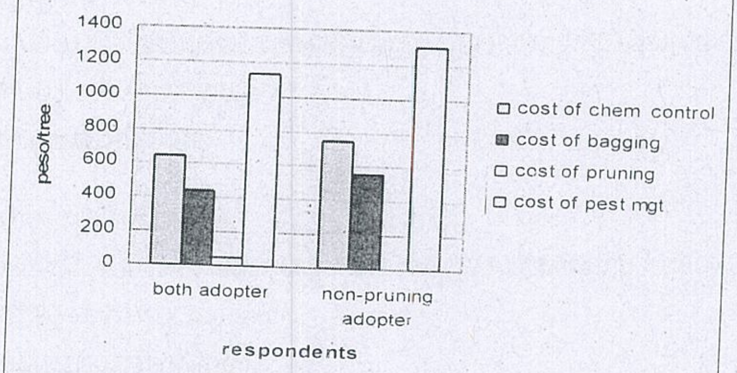


Figure 2b. Comparison of cost of pest management in mango, Visayas

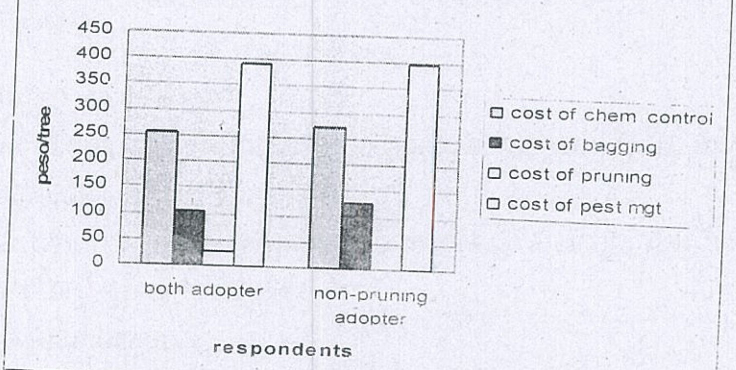


Figure 2c. Comparison of cost of pest management in mango, Mindanao

Cost function

The structure of the cost of pest management for mango was estimated using the various cost items incurred to protect mango from damages by insect pests and diseases. As shown in Table 5, Luzon dummy was positive and significant, which means that location of mango production could have differential effects on cost of pest management. The difference in cost by location could possibly be explained by differences in weather and other environmental condition that have differential effects on the incidence of pests and diseases.

Table 5. Regression results showing the variables explaining the cost function in mango, all locations

Variable	Coefficient	T-value	R^2	F-value
			0.934	152.00
Intercept	2.786**	8.998		
Luzon dummy	0.264***	3.263		
Mindanao dummy	-0.123	-1.507		
Age of tree	0.022	0.566		
Cost of bagging				
Labor cost	0.168**	2.258		
Bagging material	0.059	0.827		
Cost for pruning				
Labor cost	-0.264**	-2.572		
Pruning materials	0.020	1.260		
Cost of chemical control				
Cost of chemicals	0.182***	6.926		
Labor cost for spraying	0.470***	12.390		

Cost of labor in bagging was also significant and positive, along with cost of chemicals and labor in spraying. The cost of chemical control is relatively high and constitutes a significant proportion of the cost of pest management. About 4 to 8 persons, depending on the age and size of tree, are needed to spray a mango tree. Moreover, the price of the chemicals predominantly used are relatively high ranging from P130 to P 2,000 per unit for fungicides and P260 to P1,700 for insecticides across locations.

Cost of labor for bagging is relatively expensive because the activityis risky and require skills in climbing (to avoid accident) and in bagging (to reduce fruit dropping). In all locations, the rate of baggers per day is about P30 to P50 more than the rate for hired labor in rice production. Moreover, 2 to 5 baggers or even more depending on fruit setting and age of tree were needed per tree. Cost of bagging materials relative to the cost of labor was less expensive, which could explain the non significance of its coefficient. Labor cost of pruning was also significant but negative, indicating decreasing effect on pest management cost. Pruning reduced the cost of chemicals and labor for spraying in production of the adopters. This could be explained technically based on the results of studies conducted in the past. Pruning reduces unproductive and unnecessary branches. Moreover, trees pruned properly could provide enough light penetration and good air circulation within canopy. Hence, pruning could result in minimal build up of disease and low insect population particularly leafhoppers [4].

The coefficient of determination is 0.934 which indicates that 93 percent of the changes in the cost of pest management among the sample mango growers and contractors are explained by the factors included in the model.

Change in Production, Quality, Prices and Net Revenue

Over Pest Management Cost

Pruning and bagging technologies increased numerically the level of mango production per tree. Pruning adopters produced 138 kg, 8 kg or 6 percent higher than non-adopters. Bagging adopters had the highest computed yield of 159 kg per tree, 29 kg or 22 percent higher than the computed yield of non-adopters. Result of the univariate analysis showed that the mean difference between yield of bagging adopters and non-adopters was near the significant level of 90 percent confidence. The higher yield of bagging adopters could be attributed to higher fruit formation and development due to lower pest damage particularly during the early fruiting stage. Both technology adopters had the highest computed yield at 154 kg as compared to 130 kg for non-adopters (Table 6a).

Pruning is a yield increasing technology as indicated by a significant and positive Cobb-Douglas production coefficient (Table 7). This result could be used to provide additional evidence to support the view [5] that pruning is a technology that increases productivity. According to Ambanloc *et al.* [6], pruning is an effective way of diverting organic substances, mineral nutrients and water to productive branches. Moreover, pruning also improves light penetration and air circulation in the farm. This could facilitate higher levels of photosynthetic activities for faster flush maturation. With good light and air circulation the build up of pests and diseased is reduced. As a consequence, pruned trees have earlier and more uniform flushing, faster flush maturation, and better response to flower induction. Hence, with pruning there is better fruit sets and higher yield. On the other hand, while bagging was positive it was not found to have significant effects on the yield of mango.

The value of the coefficient of determination was 0.445 percent. Although relatively low, this is acceptable considering the use of cross- section data involving only one production period. Nonetheless, the model has a high and significant F-value that shows the goodness of fit of the estimated model.

Of the total production, a significantly higher proportion of bagged mangoes were sold to exporters at 54 percent as compared to 22 percent of non-adopters. Similarly, the proportion of mangoes for export among both bagging and pruning adopters was higher at 41 percent. Bags provided physical barriers that minimize peel damage of fruits which come in contact with each other, especially during windy period. Moreover, bags prevented insect to oviposit on the fruits. As a result, fruits had smooth peel appearance and lesser physical and insect damage that improved its quality. Also, latex burn was minimized among bagged fruits (Exhibit 1). It is in this context that higher proportion of bagged fruits was accepted for export by buying stations.

Average price received by both pruning and bagging adopters was higher at P24.30 per kg. Pruning adopters reported an average price of P23.69, while bagging adopters reported P23.75 per kg. All prices were numerically higher than the reported price received by non-adopters per kg of mango at P 23.60. With higher production and price, all technology adopters had numerically higher total value of sales than non-adopters. The difference in total revenue between pruning adopters and non-adopters was P201 per tree, between bagging and non-adopters was P708, and P674 between both adopters and counterpart.

Net revenue of the technology adopters were higher than the non-adopters, although the difference varied in proportion (over non-adopters) and actual values ranged from P195 to P572 per tree. The difference between net revenue was lowest between pruning and non-adopters and highest between bagging and non-adopters. The net revenue of bagging adopters represented 28 percent more than the net revenue of non-adopters.

Table 6a. Production, price, total revenue, and net revenue above pest management cost, Luzon

	Technology Adopters			Non-Pruning and Bagging Adopters (d)	Mean Difference[1]		
	Only Pruning (a)	Only Bagging (b)	Both Bagging and Pruning (c)		Pruning vs Non-adopter (a-d)	Bagging vs Non-adopter (b-d)	Both adopter vs Non-adopter (c-d)
Luzon							
Production (kg/tree)	138	159	154	130	8 (6)	29[+] (22)	24 (18)
Proportion sold to exporters (%)	15	54	41	22	-7 (-32)	32* (145)	19 (86)
Price (P/kg)	23.69	23.75	24.30	23.60	0.09 (.40)	0.15 (0.60)	0.70 (3)
Total revenue (P/tree)	3269	3776	3742	3068	201 (6)	708 (23)	674 (22)
Total cost of pest management (P/tree)	1056	1186	1303	1050	6 (0.5)	136 (13)	253 (24)
Net revenue above pest management cost (P/tree)	2213	2590	2439	2018	195 (10)	572 (28)	421 (21)

[1] Figures in parentheses are percent reduction (-) or addition (+) over non-adoption
[+] Nearly significant 90 percent confidence level
* Significant at 90 percent confidence level

Table 6b. Production, price, total revenue, and net revenue above pest management cost, Visayas and Mindanao

Province	Bagging and Pruning Adopters	Non-Pruning Adopters	Mean Difference[1]
Visayas			
Production (kg/tree)	252	230	22 (10)
Proportion sold to exporters (%)	36	40	-4 (-10)
Price (P/kg)	17.70	16.60	1.10 ** (7)
Total revenue (P/tree)	4460	3818	642 (17)
Total cost of pest management (P/tree)	1133	1304	-171 * (-13)
Net revenue above pest management cost (P/tree)	3327	2514	813 (32)
Mindanao			
Production (kg/tree)	96	105	-9 (-9)
Price (P/kg)	16.05	15.75	0.30 (2)
Total revenue (P/tree)	1541	1654	-113 (-7)
Total cost of pest management (P/tree)	390	397	-7 9 (-4)
Net revenue above pest management cost (P/tree)	1151	1257	-106 (-8)

[1] Figures in parentheses are percent reduction (-) or addition (+) over non-adoption

* Nearly significant 90 percent confidence level

** Significant at 95 percent confidence level

The comparison of total revenue, pest management cost and net revenue between groups of respondents in Luzon is shown in Figure 3a, Figure 3b for Visayas and Figure 3c for Mindanao.

Production, prices and value of sales of both adopters are higher than the non-pruning adopters in Visayas. Similarly, the price was significantly higher by P1.10 per kg over the computed average price of non-adopters. With higher production and prices, pruning and bagging adopters had total revenue higher than non-pruning adopters by P642 per tree. Moreover, both adopters incurred lower cost of pest management due to savings in cost of chemicals. As a consequence, pruning adopters had higher net revenue above pest management cost of P813 per tree, 32 percent higher than the non-pruning adopters.

In Mindanao, the yield per tree of pruning adopters was lower than the non-adopters by 9 percent, but the difference was not significant (Table 6b). The average price received by adopters was P16.05 per kg as compared to P15.75 per kg reported by non-adopters. However, the difference in price was relatively small to compensate for the reduction in yield. Hence, total revenue of pruning adopters was lower by P113 or 7 percent per tree. Cost of pest management of pruning adopters was lower by 4 percent, but was still relatively small to create difference between net revenues of both groups of respondents.

Figure 3a . Comparison of pest management cost, total and net revenue in mango, Luzon

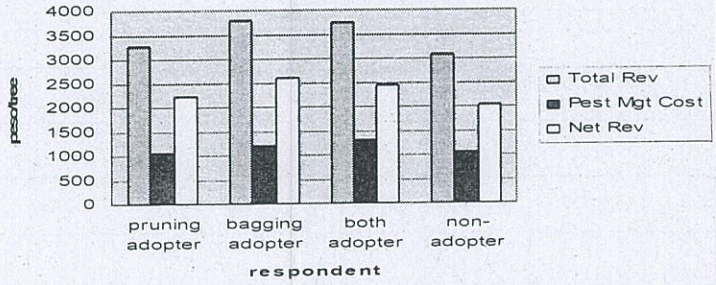


Figure 3b. Comparison of pest management cost, total and net revenue in mango, Visayas

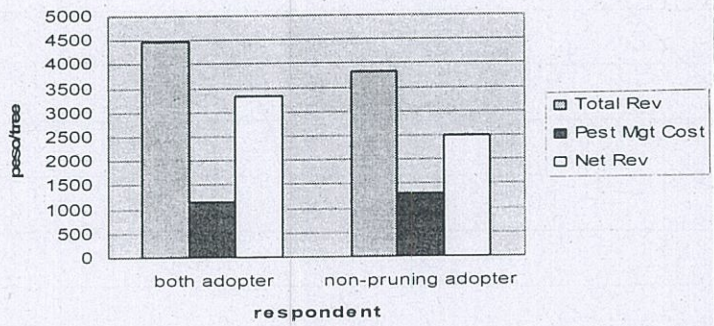


Figure 3c. Comparison of pest management cost, total and net revenue in mango production, Mindanao

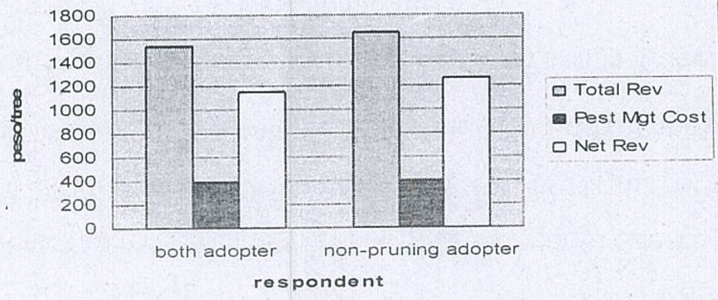


Table 7. Regression results showing the variables affecting yield of mango, all locations

Variable	Coefficient	T-value	R^2	F-value
			0.445	12.46
Intercept	3.781***	6.185		
Luzon dummy	0.132	0.409		
Pruning dummy	0.333**	2.183		
Bagging dummy	0.106	0.288		
Age of tree	0.214**	2.273		
Number of trees	-0.223**	-3.498		
Labor in man-days	0.151	1.290		
Irrigation dummy	-0.405**	-2.278		
Chemicals, in g.a.i	0.217***	3.919		
Nitrogen, in kg	-0.002	-0.021		
Phosphorus, in kg	-0.530	-1.351		
Potassium, in kg	0.604	1.496		

* Significant at 90 percent confidence level
** Significant at 95 percent confidence level
*** Significant at 99 percent confidence level

Output and Input Structure in Mango Production

It has been said that agricultural production as a primary industry in developing countries lacks backward linkages by definition. In addition, because much agricultural production goes directly for home consumption or for export without intermediate processing forward linkages are likely to be weak (Hirschman, 1958 as cited in[7]). However, the modernization of agriculture entails the growing usage by farmers of industrial inputs such as fertilizer, pesticides and simple mechanical aids. Thus, in practice, local data collections (LDCs) agriculture is rarely so primitive as to be entirely without backward linkages with input suppliers.

The adoption of bagging technology has important linkages with respect to both employment and income generation of rural labor. Moreover, it has important inter linkage with suppliers of bagging materials. Wider adoption of the technology could result in development of rural labor and local industries to supply bags. The direct backward linkage in mango production and changes that occur in this linkage was analyzed using input-output framework.

Production of any output like mango requires capital and labor as inputs. Tables 8a and 8b show the output and input structure in terms of purchases of goods and services from other sectors in order to produce a given value of output. This reflects the mango industry's backward linkage.

Among all groups of respondents across locations, the value of other inputs such as labor (except labor for pruning, bagging and spraying chemicals), chemicals for induction, and profit constitutes more than 60 percent. The cost of chemicals comes next (except for Mindanao) that ranged from more than P500 to more than P700 per tree. The tables also show the ratio of the value of inputs purchased per unit value of output. The ratio examines how purchases for each input sector will change in response to changes in the value of production of mango.

In all locations, results showed that the ratio of chemicals to output decreases (numerically) when bagging or pruning (or both) technologies are adopted. This only means that when these technologies are adopted in mango production, the value of purchases to chemical industry will decrease but will require additional purchases from other inputs suppliers like labor and materials for pruning and bagging.

Table 8a. Value of production and input costs in mango production, Luzon

	Technology Adopters						Non-adopters	
	Pruning		*Bagging*		*Both*			
	Value	Ratio*	Value	Ratio*	Value	Ratio*	Value	Ratio*
Value of Output (P/tree)								
Total value of production	3269		3776		3742		3068	
Value of Inputs (P/tree)								
Labor for bagging	0	0	245	0.064	254	0.067	0	0
Bagging materials	0	0	123	0.030	125	0.033	0	0
Labor for pruning	43	0.013	0	0	44	0.012	0	0
Pruning materials	14	0.004	0	0	16	0.004	0	0
Labor for chemicals	268	0.081	233	0.062	222	0.059	313	0.102
Chemicals	731	0.224	585	0.155	642	0.171	737	0.241
Fertilizer	53	0.016	36	0.010	53	0.014		
Other inputs**	2160	0.661	2554	0.676	2386	0.638		

* Ratio to total value of production
** Consists of payment to other factors of production including profit

Table 8b. Value of production and input costs in mango production, Visayas and Mindanao

	Visayas				Mindanao			
	Bagging and Pruning Adopters		Non-pruning Adopters		Bagging and Pruning Adopters		Non-pruning Adopters	
	Value	Ratio*	Value	Ratio*	Value	Ratio*	Value	Ratio*
Value of Output (P/tree)								
Total value of production	4460		3818		1541		1654	
Value of Inputs** (P/tree)								
Labor for bagging	318	0.071	386	0.101	64	0.042	78	0.047
Bagging materials	120	0.027	170	0.044	41	0.027	49	0.030
Labor for pruning	25	0.006	0	0	20	0.013	0	0
Pruning materials	23	0.005	0	0	8	0.005	0	0
Labor for chemicals	129	0.029	206	0.054	212	0.137	217	0.131
Chemicals	517	0.116	541	0.141	45	0.029	53	0.032
Fertilizer	83	0.019	106	0.028	29	0.019	36	0.022
Other inputs**	3245	0.728	2409	0.631	1122	0.728	1221	0.738

* Ratio to total value of production
** Consists of payment to other factors of production including profit

4. SUMMARY, CONCLUSIONS AND POLICY IMPLICATIONS

Control of pests and diseases in mango production is basically of chemical control using a list of active ingredients ranging from CAT 2 to CAT 4. Pruning had reduced the cost of chemicals by 5 percent in Luzon and Mindanao and 14 percent in Visayas. Cost of pruning is relatively small, hence, pest management cost in Visayas had been reduced by 13 percent and in Mindanao by 4 percent. Moreover, pruning had decreasing effect on the cost of pest management as indicated by the estimated cost function. Numerically and statistically, pruning had increased production per tree. Result of the Cobb-Douglas production function shows that the coefficients for pruning was positive and significant, implying that pruning is a yield increasing technology. With pruning, there was better light penetration and pest and diseases had been reduced by destroying unproductive and damaged branches. With increased yield, net revenue above pest management cost was numerically higher among pruning adopters in Luzon and Visayas.

Bagging also offered advantages in mango production. Foremost, it had reduced the number of sprayings by at least two times, hence it resulted in lower volume and cost of chemical control. The reduction in the volume and cost of chemical control due to bagging was 22 percent, while the cost of bagging was 31 percent of the total pest management cost of bagging adopters. In view thereof, bagging did not reduce the cost of pest management as indicated by a positive coefficient in the estimated cost function.

Nonetheless, bagging increased yield, although the coefficient was not significant based on the result of the estimated CD production function. More importantly, bagging improved the quality of fruits by reducing latex burn and other mechanical damage that resulted to higher proportion of harvest sold to exporters in Luzon, not to mention in other two areas. Therefore, net revenue above pest management cost of bagging adopters in Luzon was numerically higher than for non-adopters by P572 per tree. The difference was not significant, but nevertheless represents a big opportunity cost among small farmers with limited capital in production.

Bagging technology in particular has important backward linkages. With the adoption of bagging, results of the study have shown that the purchases of chemicals decreased (numerically) but purchases from other input suppliers like labor and bagging materials had become necessary. This implies that if this technology will be widely adopted, there is reduction in the sale of chemical. However, there will be demand for additional labor and recycling of usable papers as bagging materials.

Mango production spells the use of chemicals in pest control. Bagging and pruning had been proven to reduce the volume of chemicals to a certain degree. But these technologies are not widely practiced, particularly bagging in Luzon. With more pesticides in the environment in mango producing areas in Luzon it could be that the cumulative impact of pesticides in Luzon is higher than in other mango producing areas where bagging is widely adopted.

The use of chemicals was proven to be a highly significant factor in increasing yield in mango. While pruning and bagging had reduced the volume of chemicals used to a certain level, the yield was not sacrificed. In fact pruning had increased yield, and bagging, though not significant, had positive coefficient. While bagging did not reduce the cost of pest management in production it could undoubtedly reduce the effect on the environment and health cost of man. Thus, continued and wider implementation of the technologies in Luzon and in other mango producing areas in the long run, could mean higher net benefit to the society. The impacts on the environment and man's health should be determined in order to assess the long-term benefits and costs to the society of adopting the different technologies.

Bagging is relatively costly. The increasing cost of chemical control in mango would encourage producers to adopt bagging in Luzon. Thus, pricing policy that would improve the ratio of the cost of bagging relative to the cost of chemical control, and pricing policy that would result to better price of fruits both in the local and export market would encourage wider adoption.

Bagging could be a very important measure to reduce the use of chemicals especially if mango importers would require maximum residue limit (MRL) in the future. Thus, continued efforts to further promote the technology and educate farmers should be carried out using effective modality of technology transfer.

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