Quality of Mango (*Mangifera indica* 'Carabao') Grown in Farms Subjected to Site-Specific Pest Management Strategies

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Abstract

The 'Carabao' mango, a commercially important fruit crop, is prone to attacks of pests and diseases in all stages of development. The judicious use of pesticides must often be complemented with other control measures. Site-specific pest management programs were drawn for three mango farms in Mati, Davao Oriental, Philippines. These included calendar spraying, no bagging, bagging (with or without insecticide-impregnated plastic strips), and pesticide spray decision tool. The mango leafhopper population was controlled while panicle and blossom blight was slight in the three farms. Yields did not statistically vary. Foliar application tended to improve yields while bagging with insectide-impregnated plastic strips reduced scale/mealy bug damage in farm 2. In farm 1, no yield increase was noted when a second application of flower inducer was done. Increases in percentages of grade 1 fruit as well as reductions in rejects were distinctly exhibited in harvested produce from the three farms. Size quality profile of two farms showed increases in percentage of medium or large fruit while another farm showed a reduction in super small fruit. Prevalent quality defects observed were misshapen, scab, undersized, windscar, and veins. Postharvest infection due to anthracnose was slight while stem end rot was nil. Visual quality and shelf life appeared better in fruit harvested from trees protected from pests using spray decision tool and bagging. Further, the reduction in pesticide costs ranged from 4% to 42%.

Keywords: bagging; fruit quality; *Mangifera indica* L.; pest management

Abbreviations:

IPM – integrated pest management
DOSCST – Davao Oriental State College of Science and Technology
DAFI – days after flower induction
TRS – table ripe stage
DMRT – Duncan's multiple range test
ANOVA – analysis of variance

Introduction

Mango (*Mangifera indica* L.) is one of the commercially important high-value fruit crops in the Philippines. The fruit is grown practically all over the country. Southern Mindanao is a growth area in terms of the production of this high-value crop. The crop is prone to attacks of insect pests and diseases in all stages of development (Mango Technical Committee, 1994). Yield is considerably reduced when damage occurs during the flowering and fruiting stages. Without an effective pest management strategy, few, if any, quality fruits can be produced.

Pesticide application is the most widely used control measure against insect pests and diseases. However, there are some drawbacks with excessive use of pesticides. For sustainability, judicious use of pesticides should be complemented with other control measures such as cultural, physical, biological, and proper tree management.

Integrated pest management (IPM) is the proper selection and use of suitable pest management actions to reduce pest and disease injuries at levels below those causing significant loss. Pest management is the most visible activity in the IPM system for mango. The reduction of the initial pest inocula or pest population and reduction of the rate of disease infection or pest reproduction are common strategies. It aims to reduce the amount of pesticides applied to crops (Medina and Opina, 2005). It improves sustainability by reducing the deleterious effects of pesticides such as pesticide residues (Singh et al., 2008), pesticide resistance, and hazards to people and environment. Sampling and the determination of the economic threshold are important in IPM (Peña et al., 1998, Peña, 2004). By reducing pest population/disease inocula, the cost of pest management is reduced, with improved fruit yield and quality often resulting in increased profit (Chowdhury and Rahim, 2009).

To reduce the cost of crop protection and improve fruit quality, site-specific pest management strategies were formulated in each of the three mango farms in Mati, Davao Oriental, Philippines (Figure 1).

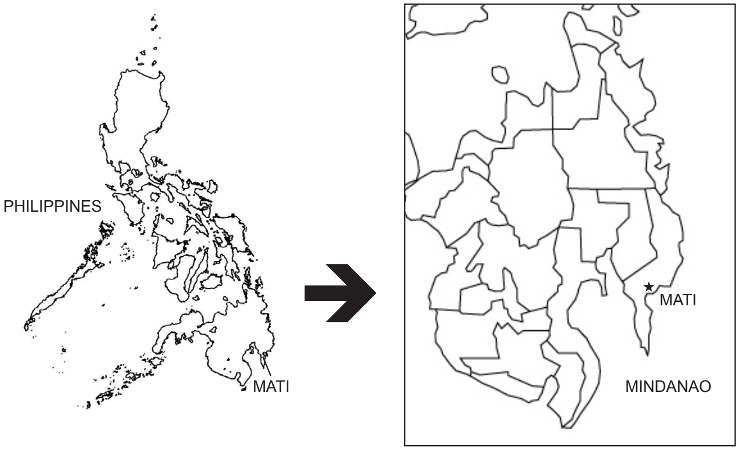

Figure 1. Map showing the location of Mati, Davao Oriental, Philippines

Materials and Methods

Three grower of 'Carabao' mango were identified after their attendance in a mango training workshop at the Davao Oriental State College of Science and Technology (DOSCST) in Mati, Davao Oriental in Southern Mindanao. Trainors and experts visited the respective farms and, together with the growers, planned suitable action research studies for each farm to improve yields and fruit quality. Thereafter, uniformly aged (10–12 years) trees were identified per farm and subjected to the treatments initially agreed upon (Table 1). Farms 1 and 2 were subjected to three treatments each while farm 3 had two treatments only. Five trees were tagged as replicates per treatment for each farm. The treatments were based on the regular cultural practices of the farmer. Field bagging using pieces of newspaper was done at 55 to 60 days after flower induction (DAFI) when the fruits were the size of a chicken egg. The spray decision tool consisted of pesticide application by the grower based on his monitoring of panicle and fruit for specific mango pests. The control trees were given calendar spraying and no field bagging. In addition, farm 1 was applied with foliar fertilizer as practiced by the grower. The trees were managed by the growers themselves. This included the maintenance of sanitation in the farm. The growers also executed the treatments agreed upon by the experts and them. Except for the insecticide-impregnated plastic strips, all inputs were provided by the growers.

The project assistant closely monitored any treatment application on the three farms. Leafhopper, tipborer, corn silk beetle, and cecid fly damage were assessed on 25 randomly tagged panicles at various regular intervals until 45 DAFI. Panicle and blossom blight severity was assessed at 28 DAFI using a 1

Table 1. The different site-specific pest management treatments employed in the three mango farms in Mati, Davao Oriental, Philippines

Treatment	Farm 1	Farm 2	Farm 3
1	Calendar-based spraying; no bagging; second application of flower inducer	Calendar-based spraying; no bagging	Calendar-based spraying; no bagging
2	Calendar-based spraying; bagging; second application of flower inducer	Calendar-based spraying; bagging; foliar fertilizer application at 10, 21, and 35 DAFI	Spray decision tool; bagging with insecticide-impregnated plastic strips
3	Spray decision tool; bagging with insecticide-impregnated plastic strips	Spray decision tool; bagging with insecticide-impregnated plastic strips; foliar fertilizer at 10, 21, and 35 DAFI	

to 4 scale with 4 as "severe." At harvest, fruit yields per tree and fruit quality profile (i.e., size classification, percentage of grade 1 fruit, type and kinds of rejects) were obtained following the methodology of Bayogan et al. (2006). Size classification consisted of the following: super small, 160–199 g; small, 200–249 g; medium, 250–299 g; large, 300–349 g; and extra large, 350 g and above. For the postharvest evaluation, 25 mature and medium fruit from each treatment were held under ambient conditions. The visual quality rating used a scale of 9 to 1 (9 - excellent, field fresh, no symptom of deterioration; 5 - fair, 4 - defects moderate; 1 - poor, severely deteriorated). Weight loss was obtained at the table ripe stage (TRS) when the fruit was full yellow and moderately soft. Anthracnose and stem-end rot were observed daily. Shelf life of the fruit was terminated when disease covered 10% or shrivelling of the fruit surface area reached 40%–59%. Analysis of variance (ANOVA), *t*-test, and Duncan's multiple range test (DMRT) were used in statistically analyzing the data.

Results and Discussion

Pest and Disease Incidence

In the three farms, there were no incidence of tipborer at 10, 14, and 30 DAFI; cornsilk beetle at 20 and 28 DAFI; and cecid fly at 35 and 45 DAFI (data not shown), and thus, damage due to these pests were absent (data not shown). Mango leafhoppers, also referred to as blossom leafhoppers (Mango Technical Committee, 1994), were observed in the three farms. Leafhoppers did not pose a big problem except in farm 1 at 15 DAFI. This was generally controlled at 24 DAFI in the three farms. Panicle and blossom blight differed among treatments in farm 1 (Table 2).

Yield

Yields in the three farms ranged from 112 kg to 178 kg per tree (Table 2). Yields did not significantly vary, but the highest yields were observed in farm 2. Additionally, the increases in yields in treatment 2 (calendar-based spraying and bagging) and treatment 3 (spray decision and bagging) were 29% and 34%, respectively, better than in treatment 1 (control treatment) This can be attributed to the application of foliar fertilizers at 10, 21, and 35 DAFI. In Western Visayas, 85% of growers in Guimaras and 32% in Iloilo

Table 2. Pest and disease incidence, yield, and % reduction in pesticide cost over treatment 1 of 'Carabao' mango from three farms subjected to various site-specific pest management treatments in Mati, Davao Oriental, Philippines

Treatment	Adult leafhopper infestation		Panicle and blossom blight severity, 28 DAFI	Total number of pesticide application	Mean yield (kg per tree)	Mean % reduction in pesticide cost over T1
	15 DAFI	24 DAFI				
Farm no. 1						
1	1.94[a]	0.59[a]	2.18[a]	10	115.0[a]	-
2	1.44[b]	0.21[a]	1.92[ab]	11	125.0[a]	0.00
3	0.98[c]	0.38[a]	1.77[b]	7	128.6[a]	42.00
	**		*			
Farm no. 2						
1	0.37[a]	0.30[a]	1.76[a]	9	132.4[a]	-
2	0.36[a]	0.24[a]	1.76[a]	9	171.6[a]	3.90
3	0.42[a]	0.29[a]	1.75[a]	7	178.4[a]	39.00
Farm no. 3						
1	0.79	0.73	1.77	9	111.8	-
2	0.58	0.28	1.69	6	115.4	7.20

Notes: For farms 1 and 2, means with common letters are not significantly different (p = 0.05) using DMRT. For farm 3, *t*-test was used.
** Significant at 1%
* Significant at 5%

commonly applied foliar fertilizers (PCARRD, 2010). Likewise, the spraying of flower inducer was done by 85% of these growers. The other practices that significantly influenced mango production in Western Visayas were fruit bagging, irrigation, fertilizer application, and crop protection.

Mean Reduction in Pesticide Cost

The number of pesticide applications throughout the flowering and fruiting period in the three farms ranged from 6 to 11 (Table 2). The total number of applications in the treatment for spray decision tool and bagging with insecticide-impregnated plastic strips was 6 for farm 3 and 7 for farms 1 and 2. The pesticide costs using the latter were reduced by 7.2% to 42.0% relative to the calendar-based treatment.

Size Classification and Grade 1 Fruit

Spray decision and bagging led to increases in percentages of medium fruit for farm 1 and large fruit for farm 3 (Table 3). Likewise, a reduction in super small fruit for farms 2 and 3 translates to additional income as bigger fruit command better prices. There was a general increase in percentages of grade 1 fruit, reducing loss due to unacceptable fruit quality. In farm 1, the increases in percentage of medium-sized fruit were observed in treatments 2 and 3. Produce from the control trees consisted of more small rather than medium fruit. This was followed by the percentage of large fruit. Relative to treatment 1, increases of 20.8 and 39.8% in grade 1 fruit were obtained for treatments 2 and 3, respectively. For farm 2 produce, small fruit were consistently highest among all fruit sizes. A greater percentage of grade 1 fruit were observed in treatment 3 relative to the control treatment, but not for treatment 2. There was an increase in the percentage of large fruit in the produce of farm 3. A greater percentage of grade 1 fruit was, however, produced by the trees given treatment 2.

Types of Rejects at Harvest

Regardless of treatment, when fruit damage (defect and injury) at harvest were identified and ranked, scab, misshapen, and undersized fruit emerged either as first or second in prevalence (Table 4). These were followed by windscar, veins, sooty mold, scale/mealy bugs, preharvest cracks, and latex burn. This finding validates an earlier report in 'Carabao' mango grown in Davao Oriental (Bayogan et al., 2006). Apart from breakage during harvest, two major factors that were identified as causes of non-marketability in mangoes in Guimaras and Iloilo, mango producing provinces in Western Visayas, were pest incidence and small size (PCARRD, 2010). These damages have also been documented by PNS/BAFPS (2004). Scab is caused by *Elsinoe mangifera* (Golez et al., 2000). Patches of fissured corky tissue that are grayish brown with dark irregular margins are observed on the peel of fruit with scab.

Table 3. Percentages of varying fruit sizes and grade 1 'Carabao' mango fruit from trees subjected to various site-specific pest management treatments in Mati, Davao Oriental, Philippines

Size	Farm 1		Farm 2		Farm 3	
	% fruit based on size	% grade 1 fruit	% fruit based on size	% grade 1 fruit	% fruit based on size	% grade 1 fruit
Treatment 1						
Extra large	8.0	0.6	0.0	0.0	0.0	0.0
Large	24.1	6.2	15.0	2.5	15.0	4.2
Medium	25.9	10.5	33.0	9.2	33.3	13.3
Small	38.3	6.2	35.0	7.5	40.0	15.0
Super small	3.7	0.0	17.0	0.0	11.7	0.0
Total	100.0	23.5	100.0	19.2	100.0	32.5
Treatment 2						
Extra large	6.9	2.5	0.0	0.0	0.0	0.0
Large	17.1	8.9	8.3	0.0	20.8	13.3
Medium	36.1	15.8	31.7	3.3	35.8	19.2
Small	32.3	17.1	46.7	9.2	35.9	18.3
Super small	7.6	0.0	13.3	0.0	7.5	0.0
Total	100.0	44.3	100.0	12.5	100.0	50.8
Treatment 3						
Extra large	5.7	2.8	0.0	0.0	-	-
Large	21.8	16.5	14.2	5.0	-	-
Medium	38.7	24.2	26.7	9.2	-	-
Small	29.0	19.8	48.3	18.3	-	-
Super small	4.8	0.0	10.8	0	-	-
Total	100.0	63.3	100.0	32.5	-	-

Note: The size of the fruit is usually correlated with its weight. Hence, the following size categories are based on the weight of the fruit: extra large, 350 g or more; large, 300–349 g; medium, 250–299 g; small, 200–249 g; super small, 160–199 g.

Table 4. Top 3 most prevalent fruit damage (defect and injury) at harvest in 'Carabao' mango fruit produced from trees subjected to various site-specific pest management strategies in Mati, Davao Oriental, Philippines

Treatment	Rank 1	%	Rank 2	%	Rank 3	%
Farm no. 1						
1	Scab	17.3	Undersized	5.5	Veins	4.3
	Misshapen	17.3	Windscar	5.5		
			Sooty mold	5.5		
2	Scab	22.3	Windscar	8.8	Undersized	6.3
3	Misshapen	17.3	Scab	11.7	Undersized	4.8
Farm no. 2						
1	Undersized	17.3	Misshapen	15.8	Scab	10.8
2	Windscar	33.3	Scale/Mealy bugs	22.5	Undersized	13.3
					Misshapen	13.3
3	Misshapen	14.2	Scab, Undersized	10.8	Veins	8.3
Farm no. 3						
1	Scab	16.7	Misshapen	11.7	Windscar	5.8
			Undersized	11.7	Preharvest cracks	5.8
2	Misshapen	14.2	Scab	8.3	Latex burn	3.3
					Preharvest cracks	3.3

These lesions do not expand after harvest. A misshapen fruit has an abnormal shape that materially affects its appearance (PNS/BAFPS, 2004). Undersized fruit are those that weighed less than 160 g. Undersized fruit is a common cause of rejection by middlemen followed by misshapen, preharvest cracks, fruit borer damage, and bruising. Fruit with a netted appearance due to prominent veins is another defect. Sooty mold is identified by the appearance of a black velvety covering on the fruit. Mealy bug damage leave white stains on the fruit due to white flour-like substance. Damaged parts are also usually covered with black sooty mold growing on the honey dew produced by the mealy bug. Scale insect damage consists of feeding punctures left by scale insects resulting in whitish to yellowish spots on the peel. There is a reduction in rejects in bagged fruit due to insect damage (Oosthuyse, 1997; Bugante et al., 1997) when insecticide-impregnated plastic strip was added. In Pakistan, the the combined cultural, mechanical, and chemical measures effectively reduced mealy bug population in mango trees (Ishaq et al., 2004; Karar et al., 2009). A preharvest crack is a split on the fruit prior to harvest that makes the fruit pulp slightly visible.

Some Postharvest Characteristics

Visual quality at 7 days after harvest was better in the spray decision tool and bagging treatment in farms 1 and 3, but not in farm 2 (Table 5). Weight loss at table ripe stage (TRS) and the number of days to TRS tended to be lesser in fruit from trees given the spray decision tool and bagging treatment. In another study, Shorter et al. (1997) reported no apparent influence of paper bags on weight loss and ripening characteristics of 'Sensation' mango bagged 7 weeks before harvest.

Fruit shelf life under the ambient conditions of Mati, Davao Oriental, ranged from 7.4 to 11.6 days. The shelf life of fruit varied in farms 1 and 2. Though all the fruit used for the postharvest evaluation were not hot water–treated at harvest (Bugante et al., 1997), anthracnose and stem-end rot were low in farms 1 and 3 (data not shown) and moderate (i.e., less than 10% of the fruit surface infected) in fruit harvested from trees in farm 2. This moderate infection in fruit from farm 2 resulted in poorer visual quality (i.e., fair, defects moderate) and shorter shelf life. Better visual quality and

Table 5. Visual quality rating, weight loss at table ripe stage (TRS), days to TRS, and shelf life of 'Carabao' mango fruit produced from trees subjected to site-specific pest management strategies in Mati, Davao Oriental, Philippines

Treatment	Visual quality at day 7	Weight loss at TRS (%)	Days to TRS	Shelf life (in days)
Farm no. 1				
1	6.3[b]	10.4[ab]	7.1[ab]	10.4[b]
2	6.5[ab]	10.8[a]	7.9[a]	10.4[b]
3	7.1[ab]	9.6[b]	6.3[b]	11.6[a]
	**	*	*	**
Farm no. 2				
1	5.6[a]	10.2[a]	7.6[a]	9.0[a]
2	4.3[b]	10.0[a]	7.3[a]	8.1[ab]
3	4.4[b]	9.9[a]	6.2[a]	7.4[a]
	**			**
Farm no. 3				
1	5.2	10.7	7.8	9.3
2	6.1	9.8	7.7	9.3
	**			

Notes: For farms 1 and 2, means with common letters are not significantly different (p = 0.05) using DMRT. For farm 3, t-test was used.
** Significant at 1%
* Significant at 5%

lower weight loss were generally exhibited by IPM-grown fruit held further in ambient conditions.

Conclusion

There is a good demand for mango of high quality. As mango is one of the export crops of the Philippines, success in exporting our mangoes hinges on improving produce quality to the extent of high acceptability. In the evaluation of specific treatments for each of the three farms, it was found that yields did not differ because leafhopper population and panicle and blossom blight were suitably controlled early on. Foliar application, however, increased yields in farm 2 by over 31.5%, but the second application of flower inducer in farm 1 did not produce increases in yield. Bagging with insecticide-impregnated plastic strips reduced scale/mealy bug damage. Quality was affected by the various pest management strategies employed. Increases in percentages of grade 1 fruit as well as reductions in rejects were distinctly exhibited in the harvest. Size quality profile of two farms showed increases in percentages of medium and large fruit. Common quality defects and injury were misshapen, scab, undersized, windscar and veins. Visual quality and shelf life appeared better in fruit harvested from trees protected from pests using spray decision and bagging. Further, pesticide costs were reduced from 4% to 42% when employing spray decision tool and bagging.

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