Working Paper Series

This Working Paper forms part of the ACIAR project AGB/2012/061 *Improving smallholder farmer incomes through strategic market development in mango supply chains in Southern Vietnam*

Resource: A2.1 Fruit productivity and quality improvements through on farm innovations

Study focus – Diseases of mango

Management of anthracnose and black spot diseases for mango and testing MRL to inform exporting

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Summary

Post-harvest disease is the single biggest limitation for the Vietnamese mango industry to expand its domestic and export market potential. With the industry recently moving to a fruit bagging practice for fruit fly, it has been observed that the bags are providing some level of disease suppression. However, for it to be incorporated into a holistic disease management system there needs to be a greater level of understanding of the most suitable control methods to apply pre bagging.

The aim of the study is to evaluate a number of different chemical control strategies that can be applied for suppressing disease development in the bagged fruit, for the control of bacterial black spot and anthracnose. These were developed from the current list of MARD registered products for mango.

The results indicate the impact that fruit bagging has on reducing disease incidence and severity, combined with chemical treatments such as the antibiotic oxytetracycline hydrochloride, bacterial blackspot can be significantly reduced. Similarly with anthracnose the treatment of Propiconazole + Difenoconazole gave the best results although all of the treatments significantly reduced the level of disease, including the reduction of inoculum on flowers.

It is recommended that, the results from this work be incorporated into a model disease management system that combines orchard inoculum reduction program, post-harvest disease control and cool chain management to demonstrate a holistic approach to post-harvest disease management.

1 Introduction

Post-harvest disease is the single biggest limitation for the Vietnamese mango industry to expand its domestic and export market potential. Particularity in the modern retail sectors where tolerance of fruit rot is very low. For effective disease control a holistic approach is needed that address orchard hygiene, inoculum reduction, cultural practices, infield spraying, protective barriers, postharvest control, and cool chain management. The introduction of the practice of protective bagging is relatively recent in Vietnam primarily they are used for the prevention of fruit fly, but some additional benefits such as reduction in disease levels particularly anthracnose has been observed being associated with the use of fruit bags. If the bags are placed correctly around the fruit, then moisture from rainfall will not come into contact with the fruit surface thus reducing the spread of anthracnose and to some extent bacterial black spot. However, an effective control program needs to be in place prior to fruit bagging which occurs approximately day 60 post fruit set. With a number of fungicides and bactericides currently registered by MARD the industry is unsure which combinations of these treatments combined with fruit bagging will lead to low disease levels at harvest.

Study aims

A series of experiments are aimed to test the effectiveness of different chemicals for the control of anthracnose and black spot diseases on mango, whilst measuring the maximum residue level (MRL) to ensure that they do not exceed the levels accepted by international markets such as Europe, United State of America, Australia, and Japan etc.

Experiment 1 aimed to test the effectiveness of chemicals approved by MARD to control/manage the anthracnose and black spot diseases on Cat Chu variety.

Experiment 2 aimed to test the effectiveness of chemicals approved by MARD, plus micronutrient to reduce flower burning due to anthracnose disease on Cat Chu variety.

Experiment 3 aimed to test the effectiveness of chemical control of anthracnose and black spot combined with fruit bagging on Cat Chu variety.

2 Materials and method

2.1 Site

The experiment was conducted in the main mango production areas at Dong Thap and Tien Giang provinces. The mango varieties used are Cat Chu and Cat Hoa Loc, the main commercial varieties of Vietnam. Participating farmers were selected based on their willingness to cooperate, record practices, and share results.

2.2 Experiment 1. Management of anthracnose and bacterial black spot - on Cat Chu

Timing: From March to September 2021

Experimental design was randomised block six treatments (each agrochemical was one treatment), four replicates (two plants / repetition). Fungicides and bactericides used are listed in Table 1 and 2.

Table 1. Fungicides used for experiment 1 anthracnose control

No	Chemical	Trade Name	Dosage
1	Propiconazole + Difenoconazole	Tilt super 300EC	5ml/8litter
2	Hexaconazole 50g/L	Anvil 5SC	Ratio 1:1
3	Propineb and (Zn++) + adhesives	ANTRACO + Visilon	Labelled dose
4	Azoxystrobin + adhesives	Amistar 250SC.+ Visilon	10^8CFU/ml
5	Metalaxyl M + Mancozeb	Control	700 litter/ha

Source: Author's analysis

Table 2. Bactericides used for experiment 1 bacterial blackspot control

No	Chemical	Trade Name	Dosage
1	Oxytetracycline Hydrochloride	Poner	Company suggested dose (Labelled dose)
2	Kasugamycin	Kasumin	Labelled dose
3	Cuprous Oxide	Cuprous Oxide	Labelled dose
4	Trifloxystrobin + Propineb	Activo Super 648Wp	Labelled dose
5	Farmer treatment	Control	-

Source: Author's analysis

Data recording: Disease ratio (%) and disease severity (%)

Measurements

Disease severity on orchard/farm has a maximum of five grades based on number of leaves and fruits infestation:

- Grade 0: No leaf, fruit infection
- Grade 1: > 0% to equal 10% leaves or fruits infected
- Grade 2: > 10% to equal 20% leaves or fruits infected
- Grade 3: > 20% to equal 60% leaves or fruits infected
- Grade 4: > 60% to equal 80% leaves or fruits infected
- Grade 5: > 80% leaves or fruits infected

Disease severity on orchard is calculated using the following formula:

Disease severity (DS) (%) $=\{\sum[(N_1x1) + (N_2x2) +...+ (N_5 \times 5)]/[N \times 5]\} \times 100$

N_1 is number of leaves or fruits Grade 1; N_2= number of leaves or fruits Grade 2; N_5 = number of leaves or fruits Grade 5; N = number of leaves or fruits surveyed.

2.3 Experiment 2. Fungicides and micronutrients impact on flower damage

Timing: From May to December 2021, on Cat Chu variety

Experimental design, randomized block with five treatments (corresponding to two plant extracts, two fungicides and control-fresh water), four replicates (two plants/replication).

1. Propiconazole + Difenoconazole+ Wash flowers with clean water + Botrate
2. Hexaconazole 50g/L+ Shake the flower branches in early morning +Calcium Boron
3. Propineb and Zn (Zn++) + Wash flowers with clean water + Botrate
4. Azoxystrobin+adhesives+Shake flower branches in early morning+Canlcium Boron
5. Propiconazole + Difenoconazole, Metalaxyl M + Mancozeb

Measurements

Disease ratio (RT) (%) disease present on flowers (from fruit set from flower following treatments)

Disease ratio (RT) (%) disease present on fruit and postharvest fruits (from fruit set following treatments) (as experiment 1)

2.4 Experiment 3. Effectiveness of anthracnose and black spot control combined with fruit bagging

Timing: From March to August 2021, on Cat Hoa Loc variety

The experiment design was complete randomized block design, consisting of five treatments and four repetitions, each repetition is one plant.

- Treatment 1: Best result from above experiment + fruit bag at 60 days after last treatment
- Treatment 2: Best result from above experiment + fruit bag at 60 days after last treatment
- Treatment 3: Best result from above experiment + fruit bag at 70 days after last treatment
- Treatment 4: Best result from above experiment + fruit bag at 70 days after last treatment
- Treatment 5: No fruit bagging

The formulas would be arranged in random blocks designed, three repetitions, five trees each. In addition to the experimental element, the formulas were cared for according to a common procedure. Fruit bags are specialized paper bags for each variety.

Data recording: Disease ratio (DR) (%) & disease severity (DS) (%) (As experiment 1)

3 Results and discussion

3.1 Results

Experiment 1: Bacterial black spot disease management

Table 3. Disease infection ratio before and after fruit bagging

Treatment	Trade Name	Disease infection ratio (%)	
		Before fruit bagging	After fruit bagging
Oxytetracycline Hydrochloride	Poner	2.11 b	9.17 d
Kasumisin	Kasumin	3.04 c	12.43 c
Cuprous Oxide	Cuprous Oxide	5.12 d	14.23 b
Trifloxystrobin + Propineb	Activo Super 648Wp	2.11 b	10.11 d
Current practice	Control	9.50 a	19.47 a
Cv (%)		11.12	16.19
Significance		*	**

Source: Author's analysis

*Note: Raw data has been converted before analysis. In the same column data accompanied by the letter is not significant difference with each other in analysis. ns: is no significant difference between different treatments. ** shown significant difference at 1%*

Results show that prior to fruit bagging the disease infection ratio from the different treatments showed little significant difference (P≥5%) Table 3, and all has a disease suppressing effect over the control, the different treatments were applied at 7 and 14 days before fruit bagging. Post bagging the treatments with oxytetracycline hydrochloride and trifloxystrobin + propineb showed black spot disease infecting ratio much lower/very significant difference (1%) in comparison with the control/farmer treatment. The control post bagging the black spot disease infection ratio at the farmer/control treatment increased to 19.47% whilst treatments using oxytetracycline hydrochloride and trifloxystrobin + propineb the infection ratio was very low at 9 to 10%, being a significant difference to each other.

Figure 1. Treated orchard/trees, Southern Vietnam

Source: Author's image

Figure 2. Bagged mango fruit, Southern Vietnam

Source: Author's image

Results for the anthracnose treatments in Table 4 show that at the pre spray and at 7 days post first spray there was no significant difference in the disease between treatments. From 14 days after first spray then 7 days and 14 days after second spray, there was significant difference between treatments, with all being significant over the control.

Table 4. Effectiveness of fungicides on anthracnose infection ratio

No.	Treatment	Anthracnose disease infecting ratio on young growing shoots (%)				
		Prior spray	7 DAS 1 time	14 DAS 1 time	7 DAS 2 time	14 DAS 2 time
1	Propiconazole + Difenoconazole	10.49	27.63 a	19.02 c	30.13 b	31.52 c
2	Hexaconazole 50g/L	10.60	21.98 c	16.71 c	28.66 c	33.89 b
3	Propineb plus Zn++ and plus adhesive	10.27	27.58 a	19.17 c	25.59 c	38.21 b
4	Azoxystrobin plus adhesive	13.33	23.06 b	27.22 b	38.33 b	39.72 b
5	Current practice	10.25	24.14 b	48.67 a	50.06 a	54.07 a
F		Ns	ns	*	*	*
CV (%)		20.27	23.80	13.92	10.42	14.89

Source: Author's analysis

*Note: DAS: day after spray; In the same column data accompanied by the same letter significant difference with each other in analysis; ns: is no significant difference between different treatments. *significant difference shown as 5%.*

Table 5. Effectiveness of fungicides on anthracnosis disease severity on shoot

No	Treatment	Anthracnose disease infecting severity on young growing shoots (%)				
		Prior spray	7 DAS 1 time	14 DAS 1 time	7 DAS 2 time	14 DAS 2 time
1	Propiconazole + Difenoconazole	2.09	3.81	5.25 d	12.39 c	13.90 c
2	Hexaconazole 50g/L	1.90	5.03	7.42 cd	16.82 bc	19.36 bc
3	Propineb plus Zn++ and plus adhesive	2.39	6.27	11.83 bcd	15.03 bc	20.06 bc
4	Azoxystrobin plus adhesive	1.71	7.72	11.89 bcd	13.12 bc	22.85 bc
5	Current practice	1.98	9.61	16.71 ab	22.77 b	24.47 b
F		ns	ns	**	**	**
CV (%)		22.52	29.15	14.24	15.34	18.78

Source: Author's analysis

*Note: DAS: day after spray; In the same column data accompanied by the same alphabet shows no significant difference with each other in analysis; ns: is no significant difference between different treatments. ** significant difference shown at 1%.*

Results show there was no significant difference between treatments prior spray spraying Table 5 and 7 days after first spray. From day 14 after the first spray, then 7 days and 14 days after second spray there was very significant difference between different treatments.

Experiment 2. Fungicides and micronutrients impact on flower damage

Table 6. Effectiveness of different treatments on disease ratio on flower and young fruit at different recording times

No	Treatment	Disease ratio on mango flower and young fruit at different recording times (%)				
		Pre-spray	7 DAS 1 time	7 DAS 2 time	7 DAS 3 time	7 DAS 4 time
1	I	13.32	17.36 c	34.70 a	35.93 c	43.06 b
2	II	13.64	23.74 b	29.54 c	38.30 b	49.24 b
3	III	12.54	23.65 b	28.70 c	34.68 c	44.78 b
4	IV	13.05	27.19 a	32.24 b	39.06 b	51.68 a
5	V	12.74	23.08 b	35.06 a	43.90 a	51.54 a
F		ns	*	*	*	*
CV (%)		12.94	22.84	26.28	23.66	33.43

Source: Author's analysis

*Note: DAS: day after spray; In the same column data accompanied by the same letter shows no significant difference with each other in analysis; ns: no significant difference between different treatments. * significant difference shown as 5%.*

I. Propiconazole + Difenoconazole, Wash flowers by fresh water + Botrate

II. Hexaconazole 50g/L+ Shake the flower branches in the early morning + Calcium Boron

III. Propineb and Zn (Zn++) + Wash flowers with fresh water + Botrate

IV. Azoxystrobin + adhesives+ shake the flower branches in early morning + Calcium Boron

V. Control treatment as standard practice.

Results show there was no significant difference between treatments prior spraying (see Table 6), at 7 days after first, second, third and fourth spray, the numbers were significantly different between different treatments. The results show that treatment 1, 2 and 3 had a disease suppressive effect after four sprays, however treatment 4 did not differ from the control. Figure 3 and 4 show mango flowers after the treatment.

Figure 3. Mango flowers photos after applying agro-chemicals and micronutrients

Source: Author's image

Figure 4. Mango flowers photos after applying agro-chemicals and micronutrients

Source: Author's image

Table 7. Effectiveness of different treatments on disease severity on flowers and young fruit at different recording times

No	Treatment	Disease severity ratio on mango flower and young fruit at different recording times (%)				
		Prior spray	7 DAS 1 time	7 DAS 2 time	7 DAS 3 time	7 DAS 4 time
1	I	1.48	2.63	6.54 ab	8.32 b	9.60 a
2	II	1.40	2.64	7.21 b	9.29 c	13.79 bc
3	III	1.39	2.63	5.73 a	7.50 a	9.93 a
4	IV	1.45	3.02	8.35 b	9.32 c	14.80 bc
5	V	1.42	2.56	8.12 b	13.74 d	15.40 c
F		ns	Ns	*	**	**
CV (%)		12.31	23.77	23.70	26.51	29.47

Source: Author's analysis

*Note: DAS: day after spray; In the same column data accompanied by the same letter shows no significant difference with each other; ns: is no significant. difference, * shown significant difference at 5%,**…at 1%*

Results show that there was no significant difference between treatments prior spraying (see Table 7), at 7 days and after the first spray. After the second spray treatment three showed a significant reduction in disease severity this continued through the third and fourth spray. Treatment 1 also showed a significant reduction in severity after the third and fourth spray.

Experiment 3. Effectiveness of anthracnose and black spot control combined with fruit bagging

Table 8. Effectiveness of different treatments on disease ratio in fruit before bagging and after harvest

No	Treatment	Disease ratio (%) on fruit at	
		Prior fruit bagging	After harvest
1	Apply Propiconazole + Difenoconazole + Wash flowers with water + Botrate + fruit bag at 60 days after last treatment.	1.7	3.30 c
2	Apply Propineb and Zn (Zn++) + Wash flowers with water + Botrate + fruit bag at 60 days after last treatment	1.3	4.24 b
3	Apply Hexaconazole 50g/L+ Shake the flower branches in the early morning + Calcium Boron + fruit bag at 70 days after last treatment	1.3	4.78 b
4	Apply Azoxystrobin + adhesives+ Shake the flower branches in early morning + Calcium Boron + fruit bag at 70 days after last treatment	1.4	5.54 b
5	Metaxyl + Mancozeb + No fruit bagging	1.8	56.82 a
F		Ns	**
CV (%)		33.43	23.66

Source: Author's analysis

*Note: In the same column data accompanied by the same letter shows no significant difference with each other in analysis; ns: is no significant difference between different treatments, ** shown significant. difference at 1%*

Results show that bagging has a significant impact on reducing disease development Table 8, treatment one. Of the treatments that included bagging, treatment 1 has significantly lower disease ratios that treatment 2, 3, and 4.

Table 9. Effect of different treatments on disease severity ratio on fruit before and after harvest

No	Treatment	Disease severity ratio (%) on fruit at	
		Prior fruit bagging	After harvest
1	Apply Propiconazole + Difenoconazole + Wash flowers by fresh water + Botrate + fruit bag at 60 days after last treatment.	0.41	0.75 b
2	Apply Propineb and Zn (Zn^{++}) + Wash flowers with fresh water + Botrate + fruit bag at 60 days after last treatment	0.40	0.99 b
3	Apply Hexaconazole 50g/L+ Shake the flower branches in the early morning + Calcium Boron + fruit bag at 70 days after last treatment	0.40	0.75 b
4	Apply Azoxystrobin + adhesives+ Shake the flower branches in early morning + Calcium Boron + fruit bag at 70 days after last treatment	0.41	0.92 b
5	Metaxyl + Mancozeb + No fruit bagging	0.42	31.24 a
F		Ns	**
CV (%)		33.43	12.31

Source: Author's analysis

*Note: In the same column data accompanied by the same letter shows no significant difference with each other in analysis; ns: is no significant difference between different treatments, ** shown significant difference at 1%*

Results show bagging has a significant impact on reducing disease severity (see Table 9). All treatments were significantly lower than the control but there was no difference between these treatments. There was no significant difference between bagging at day 60 or day 70 after treatment.

4 Conclusion and recommendations

4.1 Conclusion

The results indicate the impact that fruit bagging has on reducing disease incidence and severity, combined with chemical treatments such as the antibiotic oxytetracycline hydrochloride, bacterial blackspot can be significantly reduced. Similarly with anthracnose the treatment of propiconazole + difenoconazole gave the best results although all the treatments significantly reduced the level of disease, including the reduction of inoculum on flowers. In a commercial spray program, it is prudent to change chemical groups between systemic fungicide spray applications to better manage resistance.

Applications including a calcium/boron additive which is anecdotally reported to reduce fruit drop associated from anthracnose infection. However, from the data analyses in the trials it is not possible to draw any conclusions on this.

It is clear fruit bagging has a major role to play with the management of disease particularly anthracnose. This will greatly help in the reduction of chemical application and therefore reducing the risk of exceeding MRLs. For effective disease management pre harvest suitable fungicides need to be applied during the pre-bagging stage to minimise the inoculum on the surface of the fruit. This combined with a suitable post-harvest disease management program will enable Vietnamese farmers meet the modern retailer's requirements for minimal disease whilst not exceeding MRL's.

4.2 Recommendations

It is recommended that the results from this work be incorporated into a model disease management system that combines orchard inoculum reduction program, post-harvest disease control and cool chain management to demonstrate a holistic approach to post-harvest disease management.