PRE-HARVEST MANAGEMENT WITH FRUIT RESISTANCE INDUCERS DECREASED ANTHRACNOSE DISEASE IN MANGO

PENGELOLAAN PRA-PANEN DENGAN PENGINDUKSI KETAHANAN BUAH MENURUNAN PENYAKIT ANTRAKNOSA PADA MANGGA

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ABSTRACT

Mango industry has developed significantly worldwide in recent years and there is increasing demand for fresh mangoes (*Mangifera indica* L.). However, postharvest disease anthracnose, caused by *Colletotrichum gloeosporioides,* causes major losses. The objectives of this research were to determine the effect of resistance activators (Bion® and Kasil®) on anthracnose severity and mango fruit ripening. There were four treatments including Bion® (150 mg L^{-1}), Kasil® (200 mg L^{-1} and 1000 mg L^{-1}), and water as control. The treatments were applied 3 times at 3, 2 and 1 month before harvest. Fruit were assessed during storage for disease severity and incidence, skin colour and hand firmness. Results from this research indicated that pre-harvest dips of Bion® and Kasil® significantly reduced anthracnose disease severity in mango fruit, although the fruit were not completely free from anthracnose disease. Bion® and Kasil® treated fruit had significant lower disease severity compared with the control fruit. However, Bion® was not able to significantly reduce anthracnose incidence on the fruit. In addition, Bion® and Kasil® did not significantly affect mango fruit ripening. Further research will be required to confirm the effectiveness of these two defence activators in inducing mango fruit resistance.

Key words: mango, ripening, Anthracnose disease, resistance activators, Bion® and Kasil®

ABSTRAK

Industri mangga berkembang dengan pesat akhir-akhir ini dan permintaan buah mangga segar mengalami peningkatan. Akan tetapi penyakit pasca panen anthraknosa yang disebabkan oleh jamur Colletotrichum gloeosporioides menyebabkan kehilangan produksi buah. Tujuan dari penelitian ini adalah untuk mengkaji pengaruh aktivator ketahanan (Bion® dan Kasil®) terhadap intensitas penyakit anthraknosa dan kematangan buah mangga. Percobaan ini terdiri atas empat perlakuan yaitu Bion® (150 mg L^{-1}), Kasil® (200 mg L^{-1} dan 1000 mg L^{-1}), dan air sebagai Kontrol. Semua perlakuan diaplikasikan tiga kali yaitu 3, 2, dan 1 bulan sebelum panen. Pengamatan intensitas penyakit dan perubahan warna serta tekstur buah dilakukan setiap hari selama penyimpanan. Hasil penelitian ini menunjukkan bahwa perlakuan pra-panen dengan Bion® and Kasil® secara signifikan menurunkan intensitas penyakit pasca panen anthraknosa pada buah mangga meskipun buah tidak bebas dari serangan penyakit anthraknosa. Buah yang diperlakukan dengan Bion® and Kasil® mempunyai intensitas penyakit yang lebih rendah dibandingkan dengan control. Walaupun perlakuan Bion® tidak berpengaruh secara nyata terhadap penurunan persentase buah yang terserang penyakit, buah yang diperlakukan dengan Bion® mempunyai kejadian penyakit yang lebih rendah. Perlakuan Bion® and Kasil® juga tidak berpengaruh terhadap proses kematangan buah mangga. Penelitian lebih lanjut diperlukan untuk membuktikan keefektifan Bion® and Kasil® dalam menginduksi ketahanan buah mangga.

Kata kunci: mangga, kematangan, penyakit anthraknosa, aktivator ketahanan, Bion® dan Kasil®

INTRODUCTION

Anthracnose has caused major economic losses for the mango industry (Singh 2000). The pathogen, *Colletotrichum gloeosporioides*, infects immature fruit in the field, and then enters a quiescent phase. After harvest, when fruit start to ripen, the quiescence is broken and the fungus grows through the peel and pulp tissues causing the characteristic black disease lesions (Coates *et al.* 1993; Coates and Gowanlock 1994).

Anthracnose can be successfully controlled using pre- and postharvest fungicide treatments, heat treatments, or combinations of fungicide and heat treatments. The fungicide Amistar®, which has azoxystrobin as the active ingredient, is a systemic fungicide with broad-spectrum activity against several groups of plant pathogenic fungi. Amistar® is registered for use on mango to control anthracnose (Anonim 1999). Preharvest application of prochloraz and mancozeb, along with postharvest hot water-carbendazim and/or prochloraz treatment have also been registered to control anthracnose (Stovold and Dirou 2004). However, the use of pesticides has become of major public concern on health and environmental grounds. With continuous and heavy use of fungicides, there is also a strong possibility of resistance developing in the target fungus. Thus, controlling diseases by managing the natural resistance of fruit to fungal attack could minimise the use of pesticides.

Acibenzolar (benzo-1,2,3-thiadiazole-7-carbothioic acid S-methyl ester, known as BTH or CGA 245704, trade name Bion® or Actigard®) is a non-toxic synthetic chemical promoted as an effective inducer of systemic resistance in both dicotyledonous and monocotyledonous plant species (Friedrich *et al.* 1996). Induction has been observed in cucumber (Friedrich, Lawton et al. 1996; Benhamou and Belanger 1998), apple seedlings (Brisset *et al.* 2000), pea (Dann and Deverall 2000), passionfruit (Willingham *et al.* 2002), papaya (Zhu *et al.* 2003) and roses (Friedrich, Lawton et al. 1996; Lawton *et al.* 1996; Kunz *et al.* 1997; Kastner *et al.* 1998; Burketova *et al.* 1999; Terry and Joyce 2000; Suo and Leung 2001). The role of this compound in mango fruit resistance is not known.

Soluble silicon is another inducer that activates host resistance against several pathogens such as powdery mildew, *Pythium* root rot, and rice blast (Epstein 1999) by stimulating enzymes associated with defence, such as chitinase, peroxidase and polyphenoloxidase (Cherif *et al.* 1992; Cherif *et al.* 1994; Dann and Muir 2002), or by reducing conidial production (Menzies *et al.* 1991), or spore germination (Seebold *et al.* 2001; Qin and Tian 2005).

The objectives of this study were to determine the effects of the chemical activators, Bion® and Kasil®, on anthracnose disease severity and incidence during ripening of mango fruit.

MATERIALS AND METHOD

Plant Materials

The experiments were conducted in commercial orchards near Gatton (Long. 152°17', Lat. 27°34'), and Brookfield (Long. 152°52', Lat. 27°28') Queensland, in the 2005 fruit season. Nine trees were selected for evenness of bearing. As different treatments were applied to fruit on the same trees, coloured flagging tapes were used to differentiate the treatments.

Pre-harvest Treatments

There were four treatments including Bion® (150 mg L^{-1} active ingredient), Kasil® (200 mg L^{-1} and 1000 mg L^{-1}), and water as control. The treatments were applied three times as pre-harvest dip (10 minutes dip) treatments. A wetting agent, Tween 20 (0.01 % v/v) was added to the Bion®, Kasil® and water (control) solutions.

Fruit Handling

Fruits were harvested by hand when the fruits reached commercial maturity (mature-green stage), as determined by the flesh colour-based picking guide for 'Kensington Pride' (Holmes *et al.* 1990). Upon arrival at the laboratory, fruits were desapped for about 1 h at 22 ℃, washed with warm water and air dried. Thereafter, the fruit were allowed to ripen at 22-23 °C and 65-70% RH for approximately 21 days.

Disease and Ripening Assessments

Fruit were assessed for disease disease severity and incidence, skin colour and hand firmness. Data presented in this paper were data at eating ripe stage. Disease severity was assessed as the percentage of the fruit surface affected by anthracnose lesions. Disease incidence, representing the percentage of infected fruit in the samples for each treatment, was also calculated.

During storage, skin colour was assessed visually, and firmness was assessed by hand pressure (Zainuri *et al.* 2001). Colour ratings were: 1 = 100% green, 2 = 25% yellow, 3 = 50% yellow, 4 = 75% yellow, and 5 = 100% yellow (Figure

5.1e). Hand firmness ratings were: 1 = hard, 2 = firm, 3 = slightly soft (sprung), 4 = soft, and 5 = very soft. Fruit were categorised as 'eating ripe' when they reached skin colour and hand firmness scores of 4.

Experimental Design and Statistical Analysis Fruit Handling

Treatments in the field were arranged in a randomized complete block design (RCBD). There were 3 replications consisting of 3 single tree for each replication. Data were analysed using general linear model ANOVA (Minitab™ Release 13.1). Means were separated using the least significant difference test at the 5% significance level. Disease incidence was analysed using the chi-square test.

RESULTS AND DISCUSSION

Effect of 3 Dips of Bion® or Kasil® on Disease Severity and Disease Incidence

It is widely reported that resistance activators can control diseases in a number of herbaceous plants. Research shows that Bion® increases host natural defences, but most of the plants that respond to Bion® are annual crops such as cucumber, pea or tobacco (Friedrich, Lawton et al. 1996; Benhamou and Belanger 1998; Dann and Deverall 2000). Limited research is published on the effect of Bion® on perennial fruit trees, although apples showed less fire blight when trees were sprayed weekly with Bion® (Maxson-Stein *et al.* 2002). The current experiments were a first attempt to determine the effects of Bion® on mango, a perennial tree crop.

Results from this research shows that pre-harvest dipping applications of Bion® or Kasil® significantly reduce disease development on the fruit (Table 1). As shown on the Table fruit treated with Bion® or Kasil® (200 mg L^{-1} or 1000 mg L^{-1}) had lower mean disease severity values compared with the control fruit. However, Bion® was not able to significantly reduce anthracnose incidence on the fruit (Table 1). The lack of significant reduction in disease incidence may be due to the high variability among the disease incidence data. Increasing the number of replications may help to reduce the variation among samples. In indicated by the high incidence of disease in treated fruit (Table 1). The lack of significant reduction of disease incidence may be due to the high variability among the disease incidence

In addition, perhaps the 3 or 4 week gap between each application was too long. The last dip was applied 3 weeks before harvest, and this is a long time between application of the last activator and time to harvest and disease assessment. It is possible that fruit defence was induced but that it had declined again by the time the pathogen finally infected the fruit. The time between preharvest application of Bion® on plants and disease assessment was much shorter (about 7-14 days) in earlier studies on annual crops (Friedrich, Lawton et al. 1996; Benhamou and Belanger 1998; Dann and Deverall 2000) than in the current study on mango, where about 5 weeks elapsed from the last treatment to when disease assessment was undertaken at the 'eating ripe' stage.

Another resistance activator, Kasil®, has soluble silicon as its active constituent. When Kasil® was applied as a preharvest dip, it resulted in significantly lower disease incidence and disease severity scores in the fruit. Kasil® is a strong inducer of host defence in turfgrass and sweet cherry fruit (Datnoff 2005; Qin and Tian 2005), but the methods of applications were mainly through soil application or trunk injection (Fawe *et al.* 1998; Dann and Muir 2002; Anderson *et al.* 2005). Plants absorb silicon from the soil and deposit it over the cell wall of the outer epidermis (Datnoff 2005). Application by dipping treatment, as in addition, infection from natural pathogens may have taken place before Bion® was applied, and this may interfere with defence induction in the fruit.

Table 1. Effect of Bion® (150 mg L^{-1}), Kasil® (200 mg L^{-1}), Kasil® (1000 mg L^{-1}) or water on disease incidence (% of fruit showing disease lesions) dan disease severity (% lesion surface area showing disease). Means in a column followed by the same letter are not significantly different ($P \leq 0.05$)

Treatments	Disease severity (% lesion surface area showing disease)	Disease incidence (%)
Bion® 150 mg L^{-1}	14.44a	77.78b
Kasil® 1000 mg L^{-1}	8.33a	55.56a
Kasil® 200 mg L^{-1}	12.22a	66.67a
Water	33.89b	100b

Table 2. Effect of Bion® (150 mg L^{-1}), Kasil® (200 mg L^{-1}), Kasil® (1000 mg L^{-1}) or water on time to reach 'eating ripe' (colour and firmness scores of 4), and time to first appearance of disease. Data presented are means and standard errors of means

Treatments	Time to reach eating ripe (days)	Time to first disease appear (days)
Bion® 150 mg L^{-1}	11.0 ± 0.29	16.5 ± 0.76
Kasil® 1000 mg L^{-1}	12.6 ± 0.38	17.2 ± 0.80
Kasil® 200 mg L^{-1}	12.8 ± 0.40	17.1 ± 0.83
Water	13.1 ± 0.51	15.3 ± 0.58

However, Bion® did not completely control the development of anthracnose disease, as this current study, may not be as an effective method for silicon uptake compare to the soil application method as Kasil® treatment did not completely control disease in mango samples. Soil application of Kasil® in mango may lead to better induction of defence in mango fruit.

Effect of 3 Dips of Bion® or Kasil® on Days to Reach Eating Ripe and Days to First Disease Appear

None of the treatments were able to delay fruit ripening (Table 2). In general, fruit ripened about 11 to 13 days after harvest. It was expected that Bion® would alter fruit ripening since it is a functional analogue of salicylic acid and salicylic acid is reported to have an important role in ethylene metabolism (Martinez *et al.* 2001; Rao *et al.* 2002). Disease and ethylene are interrelated, as diseased and infected tissues produce ethylene that may accelerate fruit ripening. In addition, ethylene is also involved in the signalling pathway of induced resistance in plants (Stahmann *et al.* 1966; Martinez, Blanc et al. 2001), so, presumably, when there is an infection, this triggers ethylene production that may lead to further resistance signal activation. However, in the present study, preharvest dip with Bion® did not influence fruit ripening and did not produce significant resistance responses in mango fruit.

There were no lesions recorded on any fruit when the fruit had reached the eating ripe stage. Disease only started to appear about 2 or more days later when fruit were 'over-ripe' (Table 2). Late disease development on all treated fruit may be due to less pathogen level in the orchard in that particular fruit season.

CONCLUSION

Based on the results, it can be concluded that there was some indication that activators had an effect in reducing disease, although the effects were not always significant, which probably due to the large variation in the samples. The chemical activators Bion® and Kasil® were able to reduce anthracnose disease severity and incidence on the fruit, although the fruit were not completely free from disease. Further experiments will be required to find an effective method of applying Bion® and Kasil® to the plant and to confirm the effectiveness of these two defence activators in inducing mango fruit resistance.

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