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ScienceDirect
Scientia Horticulturae 110 (2006) 167–174
SCIENTIA HORTICULTURAE
www.elsevier.com/locate/scihorti

Improved fruit retention, yield and fruit quality in mango with exogenous application of polyamines

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Received 1 December 2003; received in revised form 11 May 2006; accepted 30 June 2006

Abstract

Aqueous solutions (0, 0.01, 0.1, 1 mM) of PAs (putrescine, spermine, spermidine) containing a surfactant 'Tween 20' were sprayed onto panicles of mango (*Mangifera indica* L. cv. Kensington Pride) at final fruit set (FFS) stage (when all flowers abscised but remain attached to the panicle) during 1999–2001 to investigate their effects on fruit retention, yield, size, and fruit quality. The optimum time of PA application for improving final fruit retention and fruit yield was determined by spraying different concentrations (0, 0.01, 0.1, 1 mM) of spermine (SPM) containing a surfactant 'Tween 20' at four phenological stages including flower bud differentiation (FBD), 5–8 cm long grown panicles (GP), full bloom (FB) and at initial fruit set (IFS) stage (when 2/3rd of the flowers were abscised but attached to the panicle) during 2000. Exogenous application of PAs at FFS stage did not significantly increase fruit retention. However, compared to control (0.79 and 2.3% fruit retention), PAs treatments resulted in comparatively higher mean fruit retention (1.53 and 2.92%) during 1999–2000 and 2000–2001, respectively. Among three PAs tested, SPM was more effective in increasing mean final fruit retention. Fruit size was not significantly affected by any PA treatment. Among the four application times, SPM (0.01 mM) spray at FB stage resulted in significantly ($P \leq 0.05$) greater fruit retention (4.99%) compared with control (2.1%). However, fruit yield was comparatively higher with SPM (0.01 mM) application at IFS stage or 5–8 cm GP stage compared to the control. Overall FB application was found as the optimum time of application. Application of PAs at FFS stage retarded fruit skin colour development compared to the control. Sugars and total soluble solids (TSS) were generally reduced in PA-treated fruit. Fruit acidity was increased (16.7%) with SPM, whereas it was 11% with PUT treatment as compared to the control. Total carotenoids in pulp were generally improved (49%) with PA treatments, compared to the control. Ascorbic acid concentrations were significantly reduced with spermidine (SPD) (24%) and PUT (20%) treatments, whereas higher concentrations of SPM (1 mM) tended to increase it (12.7%) compared to the control. In conclusion, application of SPM (0.01 mM) at FB stage resulted in the highest fruit retention, whereas SPM (0.01) spray at GP or IFS stage resulted in higher fruit yield. PUT application at FFS stage significantly improved fruit quality by increasing total carotenoid, while reducing acid content of ripe fruit.

Keywords: Polyamines; Fruit drop; Carotenoids; Ascorbic acid; Sugars; Colour

1. Introduction

Mango (*Mangifera indica* L.) is a major fruit crop of the tropical regions of the world. However, its delicious taste, and unique flavour with high nutritional value have made it equally popular across the globe. Over the last decade (1991–2001), despite an increase of 42.5% in mango growing area, there has been only 1.3% increase in average fruit yield (7.5–7.6 t/ha) (FAO, 2003). Heavy fruit drop is an important factor contributing to low fruit yield in mango orchards and sometime only 0.1% of set fruit reach maturity (Chadha, 1993). Research work implicates the role of phytohormones (Bains et al., 1999) and endogenous PAs (Malik and Singh, 2003) in fruit drop of mango. Exogenous application of various plant growth regulators have been reported to have variable success in reducing fruit drop (Chadha and Singh, 1964; Abou Rawash et al., 1998), possibly due to environmental variation and the limited understanding of the complex nature of the abscission phenomenon. On the basis that ethylene biosynthesis increases in fruitlet abscission (Malik et al., 2003), there is substantial evidence to support that ethylene is the main trigger in abscission process (Brown, 1997). Although in some cases abscission can occur without a rise in ethylene (Ruperti et al., 1998). PAs are considered as anti-ethylene substances (Apelbaum et al., 1981), being the likely competitors of precursors of ethylene (*S*-adenosylmethionine: SAMdc). PAs also have the properties of growth promoters (Rugini et al.,

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doi:10.1016/j.scienta.2006.06.028

1986). However, their precise role and relationship with ethylene is not always clear.

Exogenous application of PAs has been reported to improve fruit retention and yield in apple (Costa et al., 1986), olive (Rugini and Mencuccini, 1985), litchi (Stern and Gazit, 2000), and mango (Singh and Singh, 1995; Singh and Janes, 2000). Various reports claim that fruit retention and yield is influenced by both concentration and time of PA application. Although previous investigations did show that exogenous application of PAs increased fruitlet retention in mango, the effects of PAs applied at different times on final fruit retention, yield and fruit size of mango are yet to be investigated.

Maintenance of fruit quality is critical while employing any new technology for increasing production or shelflife (Saltveit, 1999). Although a number of studies demonstrated the significance of PAs in reduing fruit drop and improving yield in various fruit crops, information on their effects on fruit quality is scant. In mango, the effects of exogenous application of PAs on fruit quality are yet to be investigated. The present study reports the effects of PAs on final fruit retention, yield, fruit size, colour and fruit quality of the Australian commercial mango cv. Kensington Pride.

2. Materials and methods

Three experiments were carried out. Experiments 1 and 2 were aimed at evaluating the effects of type, concentration and time of application of PAs on final fruit retention, yield and fruit size, whereas in Experiment 3, we investigated the impact of PAs on fruit quality.

2.1. Plant materials

These investigations were carried out during 1999–2001 on mango (*M. indica* L. cv. Kensington Pride) trees grown at commercial orchards at Gingin (longitude 115°55′E, latitude 31°21′S) and at Chittering (longitude 116°5′E, latitude 31°25′S), Western Australia. Experiments 1 and 3 were performed on 15-year-old trees at Gingin, whereas Experiment 2 was carried out on 14-year-old mango trees at Chittering. The experimental trees at both orchards were spaced at 6 m between rows and 3 m between plants. All the experimental trees received similar cultural practices during the period of investigations (Johnson and Parr, 1998) except for the experimental treatments.

2.2. Experiment 1: effects of type of polyamines on final fruit retention, yield and fruit size

Efficacy of different PAs (PUT, SPD, SPM) at various concentrations (0, 0.01, 0.1, 1 mM) was tested by spraying aqueous solutions of these compounds containing a surfactant Tween 20 (0.01%) at final fruit set stage (when all flowers abscised but remained attached with the panicle) onto the panicles of whole tree to run off. Experimental lay out was randomised block design with two-factor factorial. A single tree was kept as a treatment unit with three replicates. The experiment was conducted during 1999–2001 and PAs were sprayed on 28 November 1999 and 26 November 2000, respectively. The 2 years of data were kept separate, because the error means squares over years were heterogeneous.

2.2.1. Selection of panicles and data collection

Ten uniform and healthy panicles per tree were tagged from all directions at final fruit set (FFS) stage prior to application of treatment. Total number of fruit on tagged panicles of each tree was counted before spray application and then at commercial harvest stage. Final fruit retention was expressed as per cent. Data on final fruit retention were recorded on 3 and 14 March during 2000 and 2001, respectively.

2.2.2. Fruit yield and fruit size

At commercial harvest stage, the total number of fruit present on each tree was counted to record the yield. Fruit size was recorded by measuring the equatorial diameter and length of 10 uniform fruit at random on each tree and the mean values were presented as fruit volume (cm^3), assuming that all fruit were similar in shape. Data on fruit yield and size were recorded on 3 and 14 March during 2000 and 2001, respectively.

2.3. Experiment 2: effects of time of spermine application on final fruit retention, yield and fruit size

An aqueous solution of SPM at various concentrations (0, 0.01, 0.1, 1 mM) containing the surfactant Tween 20 (0.01%) was sprayed at four different phenological stages including flower bud differentiation (FBD), 5–8 cm grown panicles (GP), full bloom (FB) and at the initial fruit set stage (IFS) stage onto the panicles of whole tree to run off during 2000–2001. The experiment was laid out in randomised block design with two-factor factorial. A single tree was kept as a treatment unit and included three replicates. Data on final fruit retention, yield, and size were recorded on 13 March 2001 as explained in Experiment 1.

2.4. Experiment 3: effects of exogenous application of polyamines at final fruit set stage on fruit quality

Uniformly mature, hard green mango fruit at commercial harvest stage (respiration 0.62 ± 0.2 mmol $kg^{-1} h^{-1}$, ethylene not detected, fruit firmness 125 ± 5 N) were picked from mango trees sprayed with different PAs at FFS stage (Experiment 1, year 2000). Fruit were ripened at room temperature (22 ± 1 °C). The ripe fruit at eating soft stage [softness score 4 (Shorter and Joyce, 1998)] were tested for fruit firmness, skin colour, sugars, total soluble solids (TSS), titratable acidity, TSS/acid ratio, and total carotenoids and ascorbic acid in pulp. Treatment unit comprised of 10 fruit per tree with three replicates.

2.4.1. Fruit quality parameters

2.4.1.1. Fruit firmness. At ripe stage, fruit firmness was tested with electronic pressure tester model EPT-1 (Lake City Technical Products Inc., 5-1952 Spall Road, Kelowana, BC, Canada V1Y 4R1) fitted with a plunger of 11 mm diameter. A small slice of skin was removed and fruit firmness was tested