9 - 90

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Effects of Some Pre-harvest Treatments of Potassium and Hormones on Fruit Core Tissue Deterioration and Internal Browning of Pineapple under Cold Storage

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ABSTRACT. *A field experiment followed by cold storage investigations were carried out to test the hypothesis that pineapple fruit-core tissue deterioration results from mobilization of potassium ions from core tissues to the crown leaves during cold storage. The treatments arranged in a split plot design, consisted of three concentrations of potassium salts (3 to 8% as K_2SO_4 or KCl) in combination with α - naphthalene acetic acid (α - NAA) and Ethrel (Ethephon) sprays onto the fruits 1, 2, 3 and 4 weeks before commercial harvesting. Immediately after harvest, fruits were packed in corrugated paper cartons and stored in a cold-room (10°C and 80-85%) in simulated sea freight reefer container conditions for periods of 1, 2, 3 and 4 weeks.*

Results showed that the response to potassium concentrations in combination with flowering hormones, and periods of storage was highly significant. Spraying of K_2SO_4 solution (50 ml, 5% w/v) plus 10 ppm flowering hormones (α - NAA and Ethrel) significantly increased the potassium ion concentration of the fruits and significantly decreased the internal browning (IB) symptoms by 60-70% in the core tissues and the flesh of pineapple fruit.

INTRODUCTION

For many years in the past, excessive use of nitrogen fertilizer, specially urea, sucker management and irrigation practices have been used to

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enhance flowering and fruit set, increase fruit size and stimulate sucker vigor in pineapple. However, when the fruit size is large and suckers are over-vigorous, potassium concentration in the fruit of pineapple as well as in the leaves of crown is diluted and the nitrogen to potassium ratio (N : K) becomes too high. This may lead to a high incidence of fruit disorders and poor fruit quality in pineapple (Nanayakkara, 1993).

The proper use of K sprays with flowering hormones is one cultural technique used by the farmers to maintain K concentration at an adequate level in the fruit of pineapple at pre-harvesting. In particular, alpha naphthalene acetic acid or ethephon enhances vegetative growth of fruit as well as of crown leaves. Additional supply of K will increase K supply to the crown as well as to fruit by sink competition (Nanayakkara, 1990). During the fruit growing season, K uptake and transport to the fruit may be affected according to its availability in the soil, soil water status, evaporative demands and stomatal behaviour in crown leaves and in bracts of pineapple fruits (Nanayakkara *et al.*, 1992).

The purpose of this study was to examine the benefits of K sprays plus flowering hormones at pre-harvesting stage, for the control of fruit core tissue deterioration and internal browning (IB) and to improve of fruit quality of pineapples during cold storage conditions.

MATERIALS AND METHODS

From 23 March 1992 to 12 May 1992, pineapple fruits var. Mauritius at two different locations in the Kurunegala and Gampaha Districts, were sprayed with two different potassium salts (5% K_2SO_4 and KCl) plus flowering hormones [alpha naphthalene acetic acid (α – NAA) and ethephon]. One spray was made four weeks before harvesting and the other after harvest before cold storage. Pineapple suckers at the Kurunegala and Gampaha sites were approximately 10-12 months old. The randomly assigned treatments, including the unsprayed controls were replicated four times. K salts at 5% (w/v) concentration in combination with two hormone solutions were applied by a hand sprayer at the rate of 50 ml spray per plant in the morning until run-off, at one week intervals until late April in 1992.

Potential spray injury to crown leaves and fruit was observed after spray. Ten fruits per treatment were harvested and placed in cold air storage at approximately 10°C and 80-85% RH. The crown, flesh and core of fruits

were then analyzed for K^+ and malic acid contents as well as evaluated for quality parameters, including symptoms of internal browning (IB) and core-tissue deterioration by a tasting panel.

The fruits at 5% ripe stage were harvested early morning and transported immediately to the laboratory at Horticultural Research and Development Institute, Gannoruwa, Peradeniya, Sri Lanka. The cut end of the stalk was dipped in a 0.5% benlate suspension to control soft rot caused by *Thelaviopsis paradoxa* infection. Fruits were stored in corrugated paper cartons in a cold room at 8-10°C and 80-85% RH for periods of 1, 2, 3 and 4 weeks. They were removed at one week intervals and held for a week at 28°C for final observations. The control fruits were stored at 28°C.

Determination of intensity of core deterioration and IB, total soluble solids (TSS), acidity, potassium contents in the core, flesh, and in the crown leaves and flesh pH were made as follows: Fruits were cut longitudinally during the inspections into two halves and the internal breakdown of core and flesh was determined visually using the scale modified by Teisson (1979). IB intensity was scored using a scale of 0-5 as reported by Abdullah and Rohaya (1983). pH was determined by a Beckmen digital pH meter. Determination of potassium ions was made using a flame photometer (Ranganna, 1977).

Fruit firmness was determined by driving a probe with a 8 mm diameter into plant tissues at the rate of 16.8 mm min^{-1} using a motorized penetrometer (Topping, 1981). Firmness was taken as the force required to initiate the crack. Ten pineapples were randomly selected from each 20 fruit sample immediately after harvest, subjected to cold storage at 10°C and 85% RH. A 15 mm thick equatorial slice was taken from each pineapple and four 15 mm diameter plugs were then removed from just under the peel of each slice. The firmness of two plugs was measured immediately and that of the other two after immersion in 10 ml of 200 mol l^{-1} potassium acetate + 200 mol l^{-1} glycerol in 100 mol l^{-1} Tris buffer, pH 8.0, holding at 15 kPa for 10 min in a vacuum desiccator followed by 15 min at atmospheric pressure.

Twenty fruits were used at each assessment, and two additional plugs were cut from the equatorial discs. These were infiltrated with 500 mol l^{-1} glycerol in 100 mol l^{-1} tris buffer, pH 8.0.

RESULTS AND DISCUSSION

Treatments of K_2SO_4 alone and with a flowering hormone increased K concentrations in fruit core, flesh and in the crown leaves over the control, at four weeks before harvesting at both locations (Table 1). K_2SO_4 plus ethephon sprays slightly increased fruit size. Internal browning and core deterioration were most reduced by spraying K_2SO_4 plus ethephon four weeks before harvesting.

Table 1. Effects of K_2SO_4 sprays on concentration of K on crown leaves, fruit core and flesh of pineapple fruit during cold storage.

Spray treatment	Rate per 100 ml water	K in fruit (mg/100 ml)			Fruit-Core Internal Browning (IB) 2-3 weeks after storage
		Flesh	Core	Crown leaves	
Unsprayed control	None	2.18	2.94	0.64	60-80%
K_2SO_4	5 g	4.36*	4.25*	0.73*	40-50%
K_2SO_4 + α-NAA	5 g + 10 ppm	6.43**	6.34**	0.82*	25-35%
K_2SO_4 + Ethrel	5 g + 10 ppm	6.82**	6.42**	0.86**	22-28%

* significant at 0.05% ** significant at 0.01%

Firmness of tissue plugs (flesh and core) declined with delayed harvest. Infiltration with K at 4 weeks before and at harvest increased firmness of tissue, but after 3-4 weeks at 10°C storage, there was no difference.

In this study, tissue from pineapples at 10°C reached a constant firmness value, which suggests the existence of a cohesive force that is not affected by ripening process. Factors other than potassium loss from the middle core and flesh could have contributed to softening.

Table 2. Effects of K_2SO_4 sprays on fruit quality.

Spray treatments	Rate per 100 ml water	Firmness (lbs)	Soluble Solids Flesh	Total acids (mg/100 ml) Flesh
Unsprayed control	None	8.34	10.56	1.26
K_2SO_4	5 g	10.24**	14.34**	2.45**
K_2SO_4 + α-NAA	5 g + 10 ppm	10.10**	14.10**	2.12**
K_2SO_4 + Ethrel	5 g + 10 ppm	11.12**	14.86**	2.87**

* significant at 0.05% ** significant at 0.01%

Intensity of fruit core tissue deterioration and internal browning (IB)

Table 1 shows the development of fruit core tissue deterioration and internal browning after cold storage from 1 to 4 weeks. There were no sign of browning damage in the flesh or core before cold storage. Low K containing fruits may soften faster during and following storage and develop more internal browning and fruit core tissue deterioration. Since core deterioration is promoted by maturation and ripening of pineapple, K deficiency is sufficient to cause early ripening, while environmental conditions such as insufficient sunlight will be conducive to water core development. Therefore low K containing fruits may develop internal browning at a higher frequency and intensity than fruits with sufficient K during cold storage.

Potassium ion content

K_2SO_4 spray increased potassium concentrations in fruit core and flesh by over 100% and in crown leaves by 10-25% at both locations (Table 1). K salt sprays alone did not reduce fruit size, but K salts plus hormone sprays increased fruit size and crown size. Fruit core tissue deterioration and internal browning were less on fruits receiving the K salt sprays. Spraying K onto the whole fruit four weeks before harvesting slightly improved the ability to control moisture loss. Fruit firmness was greatly increased by K_2SO_4 spray, than both

KCl spray and control, at both locations (Table 2).

CONCLUSIONS

The results of this experiment, indicate that fruit core tissue deterioration and internal browning in pineapple could be decreased significantly by spraying 5% K_2SO_4 plus 10 ppm α – NAA (flowering hormone) onto the whole fruit at four weeks before harvesting.

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