AVOIDING APPLE BUD DAMAGE FROM AUTUMN-APPLIED UREA FOR BLACK SPOT (*VENTURIA INAEQUALIS*) CONTROL

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SUMMARY

Three field trials in Hawke's Bay and Pukekohe, which involved the apple cvs Braeburn, Royal Gala, Fuji and Granny Smith, showed that urea applied to trees in autumn for black spot (*Venturia inaequalis*) control at concentrations >5% was associated with death of apple buds the following spring. Urea containing 0.9% biuret caused significantly more bud death than urea with 0.35% biuret, but the toxicity of biuret appeared to be unimportant compared to the toxicity of the urea itself, when urea was applied at concentrations >5%. There was no cumulative bud damage between seasons when urea was applied at 5% in four successive autumns. Multiple applications of urea in a single autumn caused bud death and it appeared that the total amount of urea applied in one year should not exceed 100 kg/ha (equivalent to one application of 5% urea).

Keywords: scab, *Venturia inaequalis*, fungicide, biuret, phytotoxicity.

INTRODUCTION

Urea applied to apple trees during leaf fall suppresses the production of ascospores of the black spot fungus (*Venturia inaequalis*) the following spring and is an important component in the management of black spot in New Zealand apple orchards (Beresford *et al.* 2000). The closer to leaf fall that urea is applied, the more effective the suppression of ascospore production, and therefore 2-3 urea applications are often made during leaf fall. Some detrimental effects from urea have been noted within the New Zealand apple industry, including excessive vegetative vigour, stem-end splitting in Royal Gala (A. Hodson, pers. comm.), colour suppression in Fuji (M. Taylor, pers. comm.) and death of flower buds in spring causing lost production. Orchard management practices, such as timely root pruning or trunk girdling, can minimize excessive vigour and poor colour, but death of fruiting buds is of major concern and needs to be avoided.

Urea is applied to foliage as fertiliser in several crops, e.g. citrus and pineapple, and phytotoxic effects from this practice have been documented (El Zeftwai 1974; Glennie and Parsons 1981; Kiang 1982). The phytotoxicity has often been ascribed to biuret (carbamylurea, C₂H₅N₃O₂) contamination, which is formed by the action of heat on urea and is a by-product of urea produced from methanol. Urea is produced this way at the Petrochem plant in Taranaki.

This study sought to establish urea application protocols, which avoid damage to apple trees, and to determine if bud damage could be linked to the biuret content of urea available in New Zealand.

MATERIALS AND METHODS

Effect of urea rate and biuret content on bud damage in spring

Two sources of urea, differing in their biuret content, were applied at leaf fall at a range of concentrations to cv. Braeburn and cv. Royal Gala apple trees at the HortResearch Crosses Road Research Orchard in Hawke's Bay. Biuret contents were determined from 50-100 g samples taken from the middle of previously unopened containers of urea, placed in airtight containers and sent to Petrochem (Palmer Road,

Kapuni, Hawera) for analysis. The lower-biuret urea (BASF New Zealand Ltd) contained 0.35% biuret and the higher-biuret urea (Petrochem) contained 0.9% biuret.

A single urea application was made to each treatment by knapsack sprayer to the point of run-off (equivalent to 2000 litres/ha) on 4 June 1996 when Royal Gala was at 80% leaf fall and Braeburn at 10% leaf fall. There were five concentrations of lower-biuret urea (2, 5, 10, 20 and 40%), four of higher-biuret urea (2, 5, 10 and 20%) and an untreated control. Each treatment was replicated five times in a randomised complete block design, with each plot consisting of a single major fruiting limb. Percentage of buds on each limb that were dead was assessed at bloom on 25 September 1996 from 100–200 buds on each replicate limb.

Cumulative effect of autumn urea applications over four years

Five percent urea was applied at 50% leaf fall on 1 June 1996, 30 May 1997, 25 May 1998 and 28 May 1999 to cv. Fuji apple trees at the HortResearch Crosses Road Research Orchard in Hawkes Bay. Three treatments, 5% higher-biuret urea, 5% lower-biuret urea and an untreated control, were applied. Each treatment was replicated four times in a randomised complete block design with each plot consisting of a single tree separated by buffer trees. The percentage of dead buds per shoot was assessed on 200 terminal extension shoots per plot at early flowering in 1996, 1997, 1998 and 1999.

Effect of multiple urea applications during leaf fall

Five urea concentrations (0%, 2.5%, 5%, 10% and 20%) were applied to cvs Braeburn, Fuji and Granny Smith apple trees at the Crop & Food Research Pukekohe Research Station, South Auckland, three times during leaf fall: 18 May 1998 (5% Fuji leaf fall), 1 June 1998 (25% Fuji leaf fall) and 15 June 1998 (50% Fuji leaf fall). Each treatment was replicated twice with each plot consisting of eight trees. Urea was applied with an airblast orchard sprayer at 2000 litres/ha. Four trees per plot were assessed on 30 September 1998 (early flowering) for percentage dead buds per shoot on 80 randomly selected terminal extension shoots per plot.

RESULTS

Effect of urea rate and biuret content on bud death in spring

The percentage of dead buds increased as urea concentration increased above 5% (Fig. 1, Table 1). No bud death was recorded at urea concentrations of 5% or less. Although Braeburn appeared to suffer greater damage than Royal Gala (Fig. 1), the difference was not significant for 10%, 20% or 40% urea (Table 1). At equivalent urea application rates, the higher-biuret urea gave significantly more bud damage than the

FIGURE 1: Percentage of buds dead at bloom for Braeburn and Royal Gala in Hawke's Bay in response to different urea concentrations using two sources of urea differing in biuret content. See Table 1 for statistical comparisons.

FIGURE 2: Percentage of buds dead in relation to biuret concentration in the different urea treatments in Hawke’s Bay.

lower-biuret urea (Table 1). However, biuret content was not the major factor causing bud death. Fig. 2 shows percentage dead buds plotted against biuret content for each cultivar × urea treatment. The greatest bud damage in both Braeburn and Royal Gala occurred in the treatments with the greatest urea concentration (40% urea, lower-biuret) and not in those with the greatest biuret concentration (20% urea, higher-biuret) (Fig. 2).

TABLE 1: Percentage of buds dead at full bloom for the 10% and 20% urea concentrations, and the difference between cultivars for the 40% lower-biuret urea. Interactions between factors were not significant. Means presented are square root transformed data with raw means in brackets.

	% dead buds per limb	
Main effect for urea concentration		
urea 10%	1.2	(2.3)
urea 20%	2.8	(9.1)
	P<0.001	
Main effect for cultivar		
Braeburn	2.3	(7.5)
Royal Gala	1.8	(3.9)
	P>0.05	
Main effect for biuret content		
higher-biuret	2.4	(7.2)
lower-biuret	1.6	(4.2)
	P<0.01	
Cultivar comparison for 40% lower-biuret urea		
Braeburn	7.1	(52.2)
Royal Gala	5.7	(32.8)
	P>0.05	

Cumulative effect of autumn urea applications over four years

Applications of 5% urea to Fuji in four consecutive years caused no detectable bud death, for either the higher-biuret urea or the lower-biuret urea, when observations were made at bloom in each of the following springs. This suggests there was no cumulative damage to shoots from repeated urea use.

Effect of multiple urea applications during leaf fall

Percentage bud death in the Pukekohe trial increased with urea concentration, but was variable and there were no significant differences between the cultivars (Fig. 3). The overall amount of bud death was substantially greater in the Pukekohe trial (Fig. 3), where three urea applications were made in autumn, than in Hawke's Bay (Fig. 1), where only one application was made.

FIGURE 3: Percentage of buds dead at full bloom for Braeburn, Fuji and Granny Smith at Pukekohe in response to different urea concentrations.

DISCUSSION

This study showed that autumn-applied urea from two sources differing in their biuret content (Petrochem and BASF) could both be used safely on apples without damage to buds as long as the urea concentration did not exceed 5%. It appears that the total amount of urea in multiple applications during one leaf fall period must not exceed the amount in a single application of 5% urea (100 kg urea/ha), as evidenced by the greater bud damage from three applications at Pukekohe than from one application at Hawke's Bay. The damaging effect of urea did not appear to accumulate between seasons, as the Fuji trees sprayed with 5% urea in autumn for four years showed no bud damage.

Biuret did not appear to be the principle agent causing bud death in this study, even though the higher-biuret Petrochem urea (0.9% biuret) did cause significantly more bud death than the lower-biuret BASF urea (0.35% biuret). The toxicity of the urea itself, when applied at concentrations >5%, was the principle cause of bud death. Biuret levels above which injury has been reported in other crops range from 0.2-0.4% in citrus (El Zeftwai 1974; Kiang 1982) to 2% in pineapples (Glennie and Parsons 1981). It is probable that the bud damage at the high urea rates in our studies was caused

by ammonia toxicity, since urea moves readily into the leaf and is rapidly converted to ammonia and CO₂ (D. Turner, pers. comm.).

In relation to black spot control, the higher the autumn urea application rate, the greater the suppression of ascospore production (Beresford *et al.* 2000). However, application rates of 2-5% urea, which in these studies were shown to avoid bud damage, can still give substantial ascospore suppression and are therefore useful for black spot management.

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