‘Fantasia’ nectarine: effects of autumn-applied ethephon on blossoming and cropping

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Abstract

Ethephon was tested for its ability to delay blossoming in 'Fantasia' nectarine *(Prunus persica* (L.) Batsch). The effect on harvest date was also examined. Ethephon, at 50, 200, and 400 mg/litre, was applied as a spray either on 5 April or on 25 April 1985. All sprays delayed the onset of blossoming. The delay in reaching full blossom (>90% open blossoms) was 6-15 days for the first spray, and 14-16 days for the second spray. Ethephon, at 200 mg/litre, significantly increased the number of open blossoms on tagged branches. In addition, all ethephon treatments improved initial fruit set; 200 and 400 mg/litre treatments were most effective. Crop yield (in a low-yielding season) was 8 x greater on trees which had received 200 mg/litre ethephon than on non-treated trees. The blossom delay did not result in slower fruit growth, and did not affect the date of harvest maturity.

Keywords *Prunus persica*; 'Fantasia'; nectarine; stone fruit; ethephon; blossom delay; maturity; fruit growth; frost avoidance; fruit set; crop density; crop yield

INTRODUCTION

With the prospect of market access to Australia in 1980, the New Zealand stone fruit industry entered a stage of expansion, which was most rapid in the established growing a of Central Otago, Hawke's Bay, Nelson, and Marlborough. There was also strong interest in stone fruit production in Canterbury, North Otago, Wanganui, and South Auckland. As a result of these developments, stone fruit exports increased from 540 t in 1979-80 to 1700 t in 1984-85, and most went to Australia.

Much of the interest in new plantings is in late peaches and nectarines *(Prunus persica* (L.) Batsch) and, of the latter, the cultivars 'Redgold' and 'Fantasia' are popular. Lateness of harvest is usually obtained by growing in cooler districts but in these districts damaging spring frosts are more frequent. However, frost damage also occurs in Hawke's Bay. Chemical treatments which delay blossoming could provide a method of reducing frost injury in all growing areas.

Several growth regulators have been used to delay blossoming. Gibberellic acid, applied to peach mid-summer (Corgan & Widmoyer 1971), delayed blossom initiation and subsequent bud development. Late summer sprays were also effective in delaying peach and almond bud development (Edgerton 1966; Hicks & Crane 1968; Corgan & Widmoyer 1971). Ethephon, applied in autumn, delayed blossoming in sweet and sour cherry (Dennis I976), plum (Dennis 1976; Webster 1984), and almond (Brown et al. 1978). Delays have also been observed with auxins (Hitchcock & Zimmerman 1943; Mouth et al. 1947) and daminozide (Guerriero et al. 1970) but these effects were small and the chemicals were phytotoxic. Evaporative cooling in spring can effectively delay blossoming in peach (Bauer et al. 1976) but this method is not likely to be suitable for stone fruit cultivars such as 'Fantasia' that are very susceptible to bacterial spot.

Gibberellic acid and ethephon have proved to be the growth regulators that are most effective at delaying blossoming in stone fruit. However, because gibberellic acid is very expensive and ethephon comparatively cheap, ethephon was used in an attempt to delay blossoming in 'Fantasia' nectarine. The effect of blossom delay on harvest date was also determined, because some exporters considered such a harvest delay would complicate packing and transport arrangements.

EXPERIMENTAL

The study was conducted on the Ministry of Agriculture and Fisheries experimental orchard at Himatangi, 5 km north of Foxton in the Manawatu. The 'Fantasia' nectarine trees that were used in the trial were in their third year of growth from a dormant bud and trained to a single leader. The trees were situated in a sheltered block and spaced at 5 x 1.2 m.

Treatments and experimental design

Trees were blocked according to butt circumference 30 cm above ground. Single tree plots were used randomised design with 9 replications. Ethephon ((2-chloroethyl) phosphonic acid, sold as Ethrel®48 (Ivon Watkins-Dow Ltd.) at 50, 200, and 400 mg active ingredient/litre, was sprayed to runoff either on 5 April or on 25 April 1985. The chemical was applied using a knapsack spray unit. A non-ionic wetting agent (0.1 % v/v Agral LN® ICI New Zealand Ltd.) was included. Sprays were applied between 0800 and 1100 h in fine, sunny weather. Although there was no wind at the time of spray application, a plastic sheet was used to prevent chemical drift to adjacent trees. The control trees were not sprayed.

Measurements

In August 1985, two branches per tree, located at breast height and faring the inter-row space, were tagged, and the total number of buds per were counted. From 26 August until 30 September, at weekly intervals, the number of open blossoms present on tagged branches was recorded. On 16 October, initial fruit set was determined as the number of attached swollen fruitlets on tagged branches. Fruitlets were then thinned from the trees to avoid mutual shading and the breaking of branches. No specific crop load was imposed. The fruitlets which were removed were counted.

From 21 October 1985 until 3 February 1986 the diameter of 5 labeled fruits of one replicate tree from each ethephon treatment was measured at weekly intervals. Diameter was recorded at the widest part of the fruit. At harvest (3 February 1986) all trees were strip-picked. Fruit were counted and weighed and the butt cross-sectional areas of trees re-measured. Crop density (fruit numbers per cm^2 butt cross-sectional area) and crop yield (total fruit weight (kg) per cm^2 butt cross-sectional area) were calculated. Fruit firmness was determined from 2-3 measurements per fruit on 7 fruit per tree using an Effegi penetrometer fitted with an 8 mm plunger. Data were analysed as a (3 x 2) + 1 factorial.

RESULTS

Within two weeks of ethephon application, leaf yellowing and defoliation were obvious. Leaf fall was greatest from trees which had received the highest concentration,

whereas there was no fall from the control trees. The lower concentrations of ethephon produced intermediate degrees of leaf fall.
On 16 September 1985, when >90% of blossoms were open on the control trees, there were significantly fewer blossoms open on the treated trees (Table 1). There was no difference in effect of ethephon in the range 50-400 mg/litre, but the 25 April spray was significantly more effective in delaying blossoming than was the 5 April spray. The extent of the delay in blossoming is shown in Table 2. The delays at 50% and 90% bloom were similar in most instances. The only exception was the trees sprayed with 50 mg/litre on 5 April, where the rate of blossom opening declined after 16 September. The greatest delay, about 2 week, was achieved with the 25 April ethephon sprays.

The total number of buds per metre on all tagged branches was similar. The mean and SEM for all treatments was 58.2 ± 1.7. However, the number of open blossoms per metre was influenced both by the concentration of ethephon and by the time of application (Table 1). Mean blossom numbers on trees sprayed with 50 mg/litre on 25 April, 200 mg/litre on 5 or 25 April, and 400 mg/litre on 5 April were significantly higher than those on trees which had received other treatments.

All ethephon sprays improved initial fruit set (Table 1). At thinning, considerably more fruitlets moved from trees which had been treated with ethephon than from unsprayed trees (Table 1). Of the treated trees, significantly more fruitlets were thinned from those which had received 200 mg/litre ethephon.

At harvest, crop density and yield were significantly higher on ethephon-treated trees than on the control trees (Table 3). Trees which had been sprayed with 200 mg/litre were the most productive. As a consequence of the greater crop load on these ethephon-treated trees, mean fruit weight was reduced (Table 3). The relation between average fruit weight in grams (Y) and the number of fruit per cm^2 butt cross-sectional area at harvest (X) for all plots was:

$Y = 5.96(\pm 0.5)X + 146(\pm 3)$ $r^2 = 0.70$, $F = 141.8$, $P<0.001$

Increases in fruit diameter during the season are shown in Fig.1. Differences in fruit size are apparent but there was no correlation between the date of blossoming and final fruit .size.

There was no significant difference in fruit firmness between fruit from the control and ethephon-treated trees at harvest. Mean values ranged from 5.5 to 6.4 kg.

DISCUSSION

These data show that blossoming can be delayed in 'Fantasia' nectarine by autumn application of ethephon. Moreover, the extent of the blossom delay is significant in avoiding frost damage. In this experiment, the delay had no adverse effect on fruit size and date of harvest maturity.

The evidence for the effectiveness of autumn-applied ethephon as a means of delaying blossoming in 'Fantasia' is very good (Tables 1 and 2). The results are consistent with those obtained from other stone fruits (see Introduction).

Climate, especially temperature, is likely to play an important role in determining the success of ethephon as a means of delaying blossoming in other years. Low temperatures, below 12 °C, reduce the biological effects of ethephon (Knight 1982; Jones & Koen 1985). To be effective, ethephon must be applied in autumn when the mean daily temperature is above *c.* 15 ºC. In spring, temperature can also regulate the effect of applied ethephon. In a cool spring, dormancy may terminate early but low temperature might prevent blossom bud break. Ethephon is known to delay the completion of dormancy (Coston et al. 1985), and if low temperature extends the date when bud break occurs, the additional ethephon-induced delay may be masked. Excessively warm temperatures during blossoming can accelerate bud development and negate the effect of the chemical (Gianfagna et al. 1986). However, accelerated bud development would only be detrimental if freezing conditions followed.

Temperatures over the blossoming period (26 August to 30 September 1985) were generally warm. The range in maximum and minimum temperature during blossoming of untreated trees was 12 - 19 °C and -1 – 12 °C, whereas for treated trees, it was 12 - 22°C and -1 -12°C, respectively. Only two screen frosts occurred during blossoming but these were light (-0.5 °C 30 August, -0.8 °C, 9 September). Ground frosts were recorded on 10 occasions. Blossoms on untreated trees experienced all 10 frosts, whereas those on trees treated on the first and second dates experienced 8 and 6 frosts, respectively. Ethephon, therefore, cannot be expected to offer satisfactory frost protection in all years. Clearly, conventional methods of frost protection cannot be dispensed with, but there is the opportunity for reduced use, with commensurate financial saving.

Evidence supporting the view that a 14 -16 day delay in blossoming did not affect the maturity date, is based solely on the fruit firmness data. Firmness and background skin colour are considered the best indices of maturity (Delwiche & Baumgardner 1985; Visagie 1984), but firmness is the primary index.

Other studies have also shown that blossom delays of *c.* 10 days had little influence on fruit maturation. Dekazos (1981) found that aminoethoxyvinylglycine delayed peach blossoming by 10 days but did not affect maturity at harvest. Gianfagna et al. (1986) found only a 3 - 4-day shift in peach harvest (harvest was based on fruit colour) as result of a 7-day delay in blossoming. It would appear that in our, climate and in the climate in which the above studies were conducted, summer temperatures were sufficiently high to overcome the initial developmental delay induced by late blossoming.

This season (1985-86), the untreated `Fantasia' nectarine trees produced small crops. There appear to be two reasons for this. First, and most important few blossom buds opened (Table 1). Second, fruit set was low (Table 1). It is unlikely that 200 mg/litre ethephon caused the initiation of additional blossoms: the chemical was applied well after differentiation. Another interpretation of the blossoming data in Table 1 is that the degree of blossoming was normal in the control, but that ethephon promoted the opening of blossom buds. If this is correct, there appears to be some degree of blossom bud mortality or failure to expand in the spring which 200 mg/litre ethephon has prevented.

In the fruit growing areas of the United States, winter temperatures are much lower than those recorded in the growing areas of the southern North Island. These temperature differences may affect tree physiology. For example, Weinberger (1967) reported that flower bud drop in 'Redglobe' peach was increased when the minimum temperature during December and January (July and August in the Southern Hemisphere) was above 7.5 ºC. This could be a reason for reduced blossoming in the untreated trees, a reduction which ethephon has overcome. In addition, Coston et al. (1985) and Dennis (1976) found 500 mg/litre ethephon killed or caused severe gummosis in peach and other stone fruit trees, and Gianfagna et al. (1986) found 200 mg/litre caused gummosis in peach. During the present experiment, ethephon at concentrations up to 400 mg/litre did not induce gummosis.

The reason for the difference in fruit set between the control and the ethephon-sprayed trees is not known. Although the blossoming period was similar in the 50 mg/litre, 25 April and the 200 mg/litre, 25 April treatments, fruit set was significantly higher in the latter. This suggests that ethephon had some direct influence on fruit set. Gianfagna et al. (1986) found that fruit set in peach was increased by ethephon, but they argue that this arose because blossom density was low when compared with the control and there was reduced competition for resources. Coston et al. (1985) reported that 100 and 200 mg/litre ethephon had no effect on fruit set in peach, but Webster (1984) found that 250 and 500 mg/litre ethephon reduced fruit set in plum. Throughout the blossoming period in the present study weather conditions were generally favorable for pollination, but it is possible that the cool night temperatures during the early blossom period were partly responsible for the poor fruit set on the control trees. Differences in fruit size that appeared as a result of ethephon treatment (Fig. 1, Table 3) were caused by variations in crop load. Crop load was not strictly controlled in this experiment.

Although based on a single season's observations the results obtained in this study indicate that ethephon, applied in autumn, might be an effective means of promoting regular cropping in 'Fantasia' nectarine.

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Table 1 Effect of ethephon (time of application and concentration) on blossoming, initial fruit set, and numbers of fruitlets thinned from trees per cm^2 butt cross-sectional area.

Treatment	Mean blossoms open 16 Sep. (%)	Blossom density (no./m)	Initial fruit set (%)	Fruitlets removed (no./cm2)
Control (no spray)	95	8.3	26	0.5
50 mg/litre, 5 April	50	7.8	65	5
50 mg/litre, 25 April	20	14	74	
200 mg/litre, 5 April	48	17	78	17.1
200 mg/litre, 25 April	6	28	92	
400 mg/litre, 5 April	61	13.5	77	4.7
400 mg/litre, 25 April	3	8.3	87	
$LSD_{0.05}$ [1]	12	6.0	15	3.5

[1] Ethephon significantly reduced the number of blossoms open on 16 September and increased the blossom density, initial fruit set, and the number of fruitlets which had to be removed from treated trees. LSD is for comparison between ethephon treatment means. There was no date of application effect for 'fruitlets removed' data.

Table 2 Delay in blossoming of 'Fantasia' nectarine tree sprayed with ethephon on two dates.

Treatment	Date when 50% blossoms open	Delay (days)	Date when 90% blossoms open	Delay (days)
Control (no spray)	7 Sep 1985	0	14 Sep 1985	0
50 mg/litre, 5 April	16 Sep 1985	9	29 Sep 1985	15
50 mg/litre, 25 April	20 Sep 1985	13	28 Sep 1985	14
200 mg/litre, 5 April	16 Sep 1985	9	20 Sep 1985	6
200 mg/litre, 25 April	23 Sep 1985	16	30 Sep 1985	16
400 mg/litre, 5 April	15 Sep 19B5	5	27 Sep 1985	9
400 mg/litre, 25 April	22 Sep 1985	18	28 .Sep 1985	14

Table 3 Yield components (per cm^2 butt cross-sectional area) and mean fruit weight on ethephon-treated nectarine trees.

Treatment	Crop density (fruits/cm^2)	Crop yield (kg/cm^2)	Mean fruit weight (g)
Control	0.73	0.10	133
50 mg/litre	3.68	0.39	116
200 mg/ litre	8.97	0.81	92
400 mg/litre	2.72	0.34	139
$LSD_{0.05}$[1]	1.87	0.16	18

(1) Ethephon produced a significant increase (5% probability level) in crop density and yield only. LSD is for comparison between ethephon treatment means. There was no significant effect of application date.

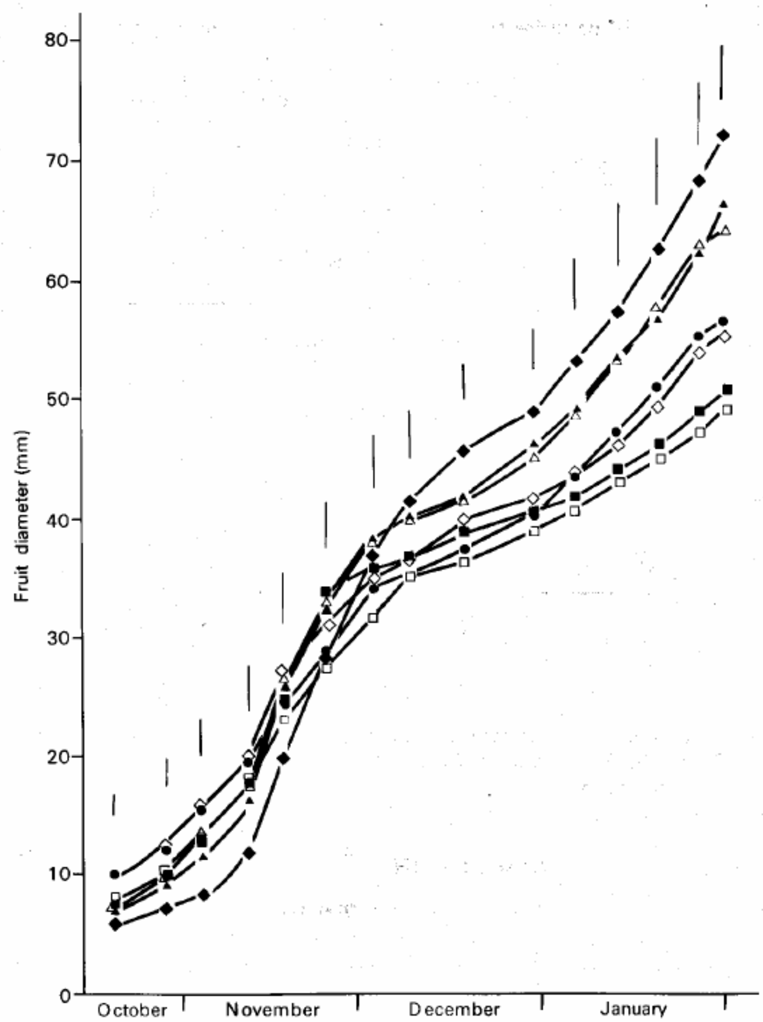

Fig. 1 Influence of ethephon treatment on increase in fruit diameter of 'Fantasia' nectarine. Each symbol represents the mean of 5 fruit and refers to the following treatments: ◆, 400 mg/litre, 25 April; ▲, 50 mg/litre, 25 April; △, 50 mg/litre, 5 April; •, control; ◇, 400 mg/litre, 5 April; ■, 200 mg/litre, 25 April; □, 200 mg/litre, 5 April. The bars represent LSD (5%).