Seed Quality and Fruit Ripening of Tomato (*Lycopersicon esculentum* Mill.) as Influenced by Preharvest Treatment with Ethephon[1]

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ABSTRACT

Ethephon ((2-chlorethyl) phosphonic acid), an ethylene-releasing compound, is sometimes used to enhance the uniformity and rate of tomato fruit ripening for mechanical harvesting. The effects of this practice on seed quality, however, have not been well documented. In this investigation, two varieties of tomato (*Lycopersicon esculentum* Mill. cvs. UC82B and VF145B-7879) were treated with three concentrations of ethephon (250, 750, and 1250 ppm) on three spraying dates (10, 16 and 22 days before harvest). Seeds were extracted, fermented, dried and germinated at alternating 20/30°C. Initial (5 day) and final (10 day) germination counts were recorded. As expected, ethephon treatment increased the percentage of ripe fruits at harvest. However, initial germination percentages were reduced significantly from 81 ± 2% in the control to 71 ± 4% when averaged over all concentrations, spraying dates and varieties, and final germination fell from 95 ± 0.5% to 91 ± 0.5%. Both varieties showed a linear reduction in initial germination percentage as the time between spraying and harvesting was shortened. For VF145B-7879, the same trend was evident in final germination percentage, while for UC82B, the trend was reversed. The data indicate that some reduction in seed vigor and viability can result from preharvest ethephon applications to tomato crops.

Additional Index Words: seed germination, seed vigor, fruit ripening, (2-chloroethyl) phosphonic acid, ethylene

INTRODUCTION

The ethylene-releasing compound ethephon ((2-chloroethyl) phosphonic acid) is sometimes used to enhance uniformity of fruit coloration, accelerate fruit ripening and increase the yield of ripe fruit for destructive mechanical harvesting of processing tomatoes (Kretchman and Short, 1974; Robinson, et al., 1968; Sims, et al., 1979). The compound is applied when 5 to 30% of the fruits are red and pink and there are sufficient mature green fruit to give the desired yield (Read, 1982). The ethylene released from ethephon initiates ripening of mature green fruits and can cause immature fruit to mature more rapidly (Iwahori and Lyons, 1969; Sims and Kasmire, 1972; Sims et al., 1979). Ethephon treatment could adversely affect seed development by prematurely initiating ripening or maturation. Since tomato seed of open-pollinated varieties is often collected at the processing plant, the quality of commercial seed lots could be affected by preharvest ethephon treatments. The following investigation was conducted to evaluate the influence of ethephon applications at various stages of fruit development on the vigor and viability of tomato seeds.

MATERIALS AND METHODS

Two varieties of processing tomato (*Lycopersicon esculentum* Mill. cvs. UC82B and VF145B-7879) were planted in four blocks in a split plot design with varieties as the main plots and ethephon treatments as the sub-plots. Ethephon application was begun approximately one month after peak flowering. The first spraying was done on August 23, the second on August 29, and the last on September 4, 1983 (22, 16 and 10 days before harvest). Treatment concentrations were 0, 1000, 3000, or 5000 ppm of Ethrel® (Union Carbide Co.) (0, 250, 750, and 1250 ppm of ethephon), which were diluted with distilled water. The ethephon solutions were freshly prepared and sprayed on tomato fruits and foliage with a compressed gas powered (25 psi) hand sprayer at 4:00 to 6:00 p.m. of each spraying date.

At harvest on September 14, 1983, the fruits from 5 plants in each treatment and replication were separated into maturity classes of ripe, breaker, mature green and immature. The data are presented as the percent of the total fruit weight in a given class. A bulk harvest of ripe fruit was also made from each plot for seed extraction. The fruits were crushed and the pulp separated from the seeds and juice by a mechanical extractor. The seeds were fermented in the juice for 24 hr (Kerr, 1962) to free them from locular material, then rinsed 3 to 5 times in tap water to remove debris and light floating seeds. After drying at 30 C for 18 hr in a rotating forced air drier, each seed lot was sealed in a paper envelope and stored at 6 C and a relative humidity of 30 to 35%.

Germination was tested according to AOSA rules (Anonymous, 1981). Four 100-seed samples were germinated on rolled paper towels under alternating 30 C-light (8hr) and 20 C-dark (16 hr) conditions. The samples were evaluated as to normal seedlings, abnormal seedlings, and ungerminated seeds after 5 and 10 days. Contaminated seeds were

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removed as dead seeds during the initial count to prevent subsequent infestation of healthy seedlings. All germination data refer only to normal seedlings.

Statistical analyses were done by analysis of variance. The mean germination percentage of the four samples was used to represent the individual plots in the experimental design. These were then entered into the overall analysis of variance. Simple effects of treatments and interactions were subjected to orthogonal single degree of freedom F-tests where appropriate (Steel and Torrie, 1960). The range of percentages was sufficiently narrow that transformation of the percentages was not required (Little and Hills, 1972).

RESULTS

Fruit Ripening

Ethephon increased the percentage of ripe fruits at harvest, as expected (Figs. 1, 2). The most effective treatment was 16 days before harvest (termed DBH) with 1250 ppm ethephon, which increased the percentage of ripe fruits by 20 and 30% for 'UC82B' (termed 'UC82') and 'VF145B-7879' (termed 'VF145'), respectively. The reciprocal relationship between increases in ripe fruit and decreases in mature green fruit is apparent at the higher ethephon concentrations (Figs. 1, 2). The percentages of breaker and immature fruit at harvest were small and unaffected by ethephon treatment (Kwon, 1984).

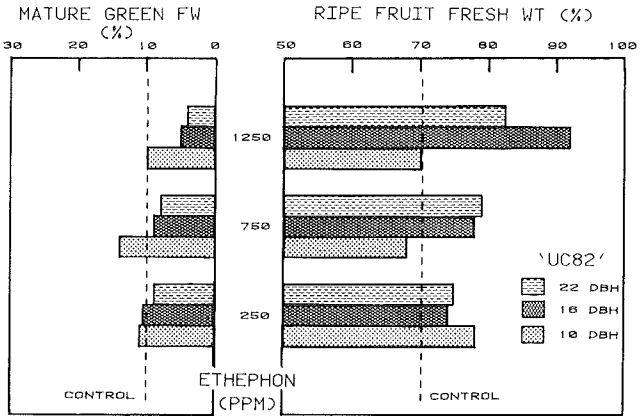


Figure 1. Effects of ethephon treatments on fruit ripening of 'UC82' tomato. Percentage (by weight) of mature green fruit (left) and ripe fruit (right) as influenced by ethephon concentration (ppm) and spray date (DBH = days before harvest). Broken lines represent the respective percentages in untreated control plots.

Seed Quality

Initial Percent Germination. The speed of germination is an indication of seed vigor, and an early count of germination can be used as a simple vigor test (Anonymous, 1983). The overall effect of ethephon was to significantly reduce the initial germination percentage when averaged

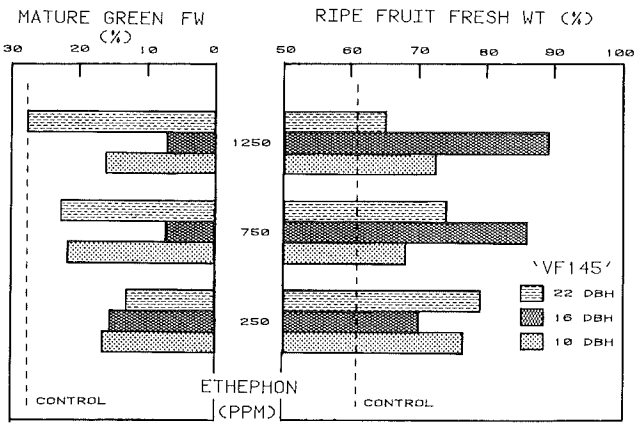


Figure 2. Effects of ethephon treatments on fruit ripening of 'VF145' tomato. Percentage (by weight) of mature green fruit (left) and ripe fruit (right) as influenced by ethephon concentration (ppm) and spray date (DBH = days before harvest). Broken lines represent the respective percentages in untreated control plots.

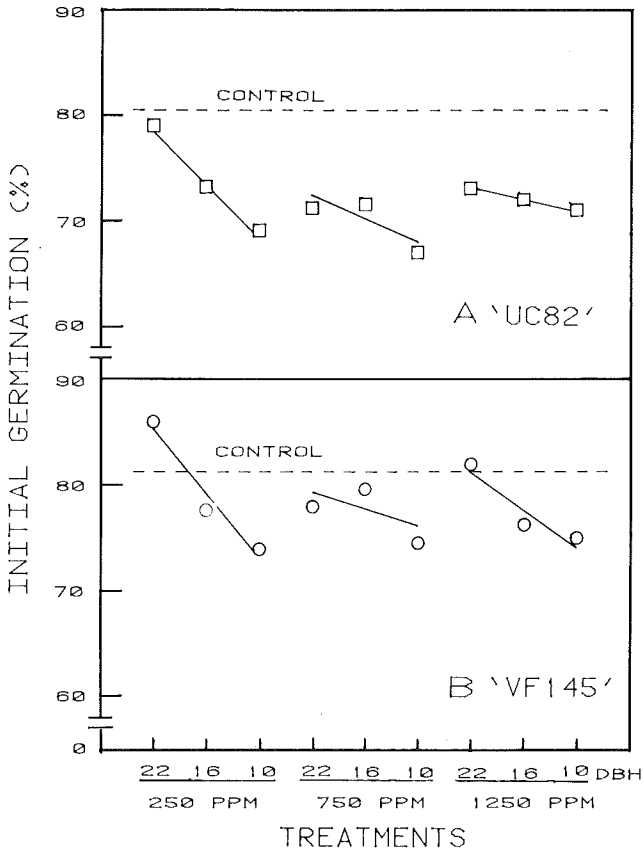


Figure 3. Effect of ethephon treatments on initial (5-day) germination of bulk harvested seeds. (A) 'UC82'. (B) 'VF145'. Broken lines represent the mean germination percentage of the control. Analysis of variance indicates that the overall effect of ethephon treatment was highly significant ($p < 0.01$). Within the ethephon treatments, there was also a highly significant linear effect of spray date across all concentrations.

over all varieties, concentrations and spray dates (Fig. 3). The varieties differed in the magnitude of the effect, with initial germination falling from 80.3 to 71.7% in 'UC82', while that of 'VF145' was only reduced from 81.7 to 78.1%. Within the ethephon treatments, there was little response to concentration but a highly significant linear response to spray date. In both varieties, initial germination percentage declined as the time between spraying and harvesting was reduced (Fig. 3). In effect, later spraying of more mature plants was more detrimental to seed vigor than was earlier spraying. Although the magnitude of the reduction in initial germination differed between varieties, both responded similarly to the ethephon treatments.

Final Percent Germination. The final percent germination indicates the viability of the seed lot without respect to the speed of germination. Again, the overall effect of ethephon was highly significant, reducing the final germination from 95.9 to 90.2% for 'UC82' and from 94.6 to 91.8% for 'VF145' (Fig. 4). In addition, the differences between varieties in response to ethephon, concentration and spray date were all significant. The major interaction was between varieties and spray dates. As for initial germination, 'VF145' showed a linear decline in final germination percentage as spray date neared the harvest date (Fig. 4b). In 'UC82', however, final germination either remained constant or increased with later spraying (Fig. 4a). Thus, while initial and final germination were affected similarily by ethephon in 'VF145', in 'UC82' these components of seed quality showed contrasting trends with respect to treatment timing (Fig. 3, 4).

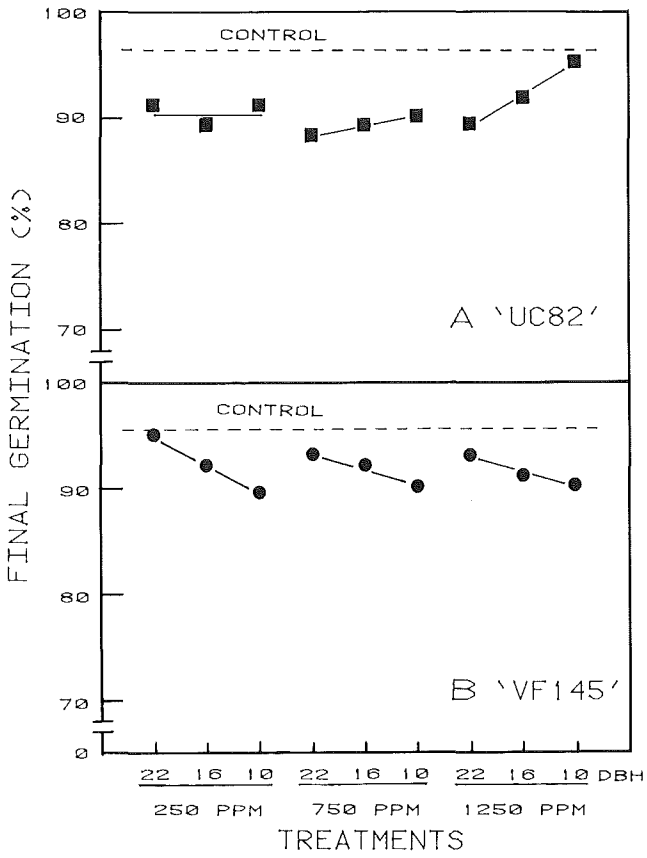


Figure 4. Effect of ethephon treatments on final germination of bulk harvested seeds. (A) 'UC82'. (B) 'VF145'. Broken lines represent the mean germination percentage of the control. Analysis of variance indicates that the overall effect of ethephon treatment was highly significant ($p < 0.01$). Interactions between varieties and treatments were also significant, the major one being the variety × spray date interaction which had a highly significant linear trend. This can be seen in the contrasting response to spray date between the two varieties.

DISCUSSION

Ethephon acts by being converted to ethylene, which triggers the endogenous synthesis of ethylene and initiates the ripening process in fruits which have reached maturity but have not yet begun to ripen. The reduction in mature green and increase in ripe fruit percentage observed here (Figs. 1, 2) is consistent with this mechanism and with previous reports (Iwahori and Lyons, 1969; Kretchman and Short, 1974; Robinson et al., 1968; Sims and Kasmire, 1972; Sims et al., 1979). Kerr (1962) reported that tomato seeds from mature green fruits germinated as rapidly as those from ripe fruits, but that germination percentage was reduced in seeds from overripe fruits. Since seeds are apparently fully developed in mature green fruit and ethephon only triggers the natural ripening process, the compound might be expected to have little influence on seed quality. During fruit ripening, seeds would normally be exposed to endogenously synthesized ethylene, so that ethlyene itself would be unlikely to harm seeds. However, as was noted by Kerr (1962) and confirmed by us in a separate study (Kwon, 1984), seed quality declines after reaching a maximum at about the time the fruit begin to ripen. Thus, the reductions in seed quality observed here (Fig. 3, 4) may be due to the advancement of ripening which may accentuate this natural decline in seed quality. However, the linear effects of spray date on seed quality (Figs. 3, 4) do not correlate well with the effectiveness of the treatments in promoting ripening (Figs. 1, 2). The decline in seed quality may therefore be due to effects unrelated to fruit ripening. On the other hand, the two varieties may simply differ in their genetic potential for expression of initial seed vigor after treatment with ethephon (Wu, et al., 1983). While the mechanism underlying the ethephon effect remains uncertain, the results indicate that caution should be exercised when applying ethephon near harvest to tomatoes destined for seed production.

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