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Effect of chlormequat (CCC) on the accumulation of ethephon in tomatoes and on ethephon-stimulated ripening

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Abstract

In greenhouse experiment, tomato seedlings were treated with CCC (250 $mg \cdot l^{-1}$) twice before transplanting. When about 10% of fruits were showing signs of ripening (pink fruits), ethephon solution (960 $mg \cdot l^{-1}$) was applied either to leaves only or to fruits only, in order to make ripening more uniform. CCC treatment delayed the process of fruit ripening and lowered the ethephon accumulation in ripe fruits as compared to the control (CCC untreated plants). The results were similar when ethephon was applied to leaves only or to fruits only.

INTRODUCTION

Among the most widely used plant growth regulators is ethephon (2-chloroethylphosphonic acid) an active ingredient of the preparation Ethrel. Its biological action on tomato ripening has been described in numerous reports (Sims, 1969; Iwahori and Lyons, 1970). The use of Ethrel is allowed in Poland in tomato culture to achieve greater uniformity of ripening of mechanically harvested tomatoes used for processing. A plant growth regulator that reduces stem length in cereal crops, chlormequat, (2-chloroethyl)-trimethylammonium chloride (CCC) has also become an important factor in the production of tomato transplants. Twice repeated application of CCC at low concentration (125 or 250 $mg \cdot l^{-1}$) to the seedlings before transplantation makes them more compact when being transplanted, prevents them from lodging and suffering from drought (Borkowski, 1980; Borkowski and Jankiewicz, 1983). Therefore, CCC-treated plants are more suitable for mechanical planting.

It was observed earlier (Czapski et al., 1983) that CCC treatment of tomato seedlings before planting markedly decreased residues of ethephon in tomato fruits after application of Ethrel.

The experiment described here was aimed at examining more fully the effect of CCC treatment of tomato seedlings on fruit ripening after ethephon application, and on the pattern of ethephon accumulation in ripe fruits.

MATERIALS AND METHODS

Tomato seeds, cultivar Revermun, were germinated in a greenhouse in a peat-sand mixture. The seedlings were transferred to pots 10 cm in diameter. A group of 24 seedlings was treated by spraying twice with Antywylegacz (98% chlormequat) solution at a concentration of 250 $mg \cdot l^{-1}$, first when seedlings were at the 4-leaf stage (February 20th) and a second time 8 days later. A second group of seedlings remained untreated with CCC. On March 10th, plants of both groups were individually transferred to 10-liter pots with a potting medium composed of peat, chalk (10 $kg \cdot m^{-3}$) and a standard component fertilizer – MIS (4 $kg \cdot m^{-3}$) produced in Poland. The plants were grown in a greenhouse with mean day and night temperatures of 24 and 17°C, respectively. Flowers of each cluster were sprayed with 5 $cm^3 \cdot l^{-1}$ Betokson (containing 1% β-naphthoxyacetic acid) solution, in order to induce parthenocarpy and to stimulate growth of fruits. When about 10% of the fruits on the first cluster were showing sings of ripening (pink fruits) the plants of both groups (CCC treated and CCC untreated) were treated with Ethrel:

1. Spraying fruits only;
2. Spraying leaves only;
3. Control plants not sprayed with Ethrel or CCC (Control "1").

Ethrel was applied at a concentration of 2000 $mg \cdot l^{-1}$ which corresponds to 960 mg of ethephon per liter.

Leaves or fruits were sprayed by a small "spray gun" using 100 cm^3 of Ethrel solution per plant. When only leaves were sprayed, the fruits were covered with plastic bags, which were removed after the spray had dried. Each treatment consisted of 4 pots as replicates. Control plants "2" (seedlings treated with CCC and untreated with Ethrel) were sprayed with water only. No surfactant was added to the Ethrel solution.

The ethephon content was determined in red-ripe fruits only, using the method described by Hurter et al. (1978), modified in part in our laboratory (Czapski et al., 1983). Daily inspection of tomatoes after treatment with Ethrel was made. Ripening was recorded as the number of red-ripe fruits at each consecutive period of time. Rate of ripening (R) was the difference (percent per day) in the cumulative number of red-ripe fruits (N_i and N_{i-1}) at two consecutive periods of measurements t_i and t_{i-1}:

$$R = \frac{(N_i - N_{i-1}) \cdot 100}{(t_i - t_{i-1}) \cdot T},$$

where t_i and t_{i-1} were expressed in days after treatments and T means the total number of fruits on a plant.

The statistical evaluation of results was done with analysis of variance using the t-test for significance.

RESULTS

Ethrel accelerated the ripening of fruits, both in plants treated and untereated with CCC in comparison to control "1" (Figs. 1 and 3). The patterns of the curves for CCC-treated and CCC-untreated plants are similar, but CCC pronouncedly delayed ripening. The maximum value of the rate of ripening in response to CCC-treatment occurred 3 days later than that for CCC-untreated plants (Fig. 1). The greatest increase in the rate of ripening

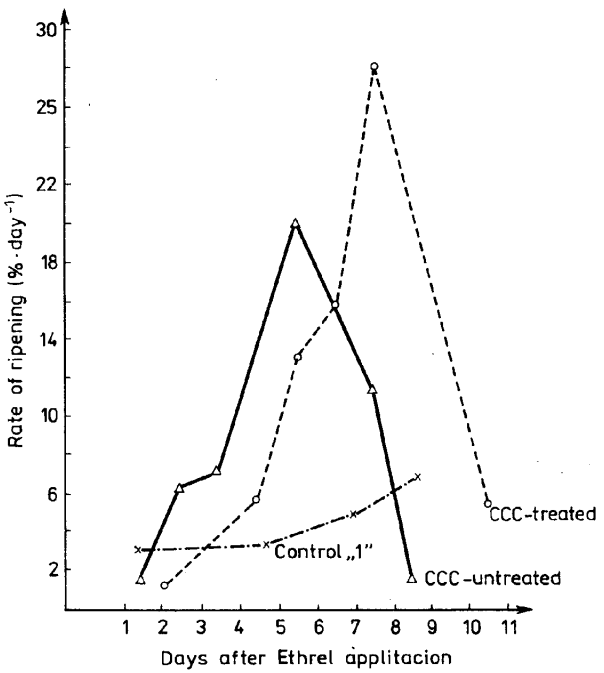

Fig. 1. The effect of CCC on the rate of ripening of tomato fruits after application of Ethrel to leaves only. (Control "1" = plants untreated with CCC or Ethrel)

was preceded by a short plateau on the 3-4th days for untreated plants and on the 6-7ths day for CCC-treated ones.

The rate of change of the ethephon content (Fig. 2) in CCC-untreated plants was rapid, rising to a maximum value of 9.3 $mg \cdot kg^{-1}$ and falling to about half of that on the 6th day after Ethrel treatment. Ethephon accumulation in ripe tomato fruits of CCC-treated plants differed from that of CCC-untreated ones (Fig. 2); the increase in the ethephon content was not so rapid (0 to 5.5 $mg \cdot kg^{-1}$) on the 4th day, and also the content of ethephon remained on a relatively constant level of 5.5 $mg \cdot kg^{-1}$ during the 4-7 days. Afterwards on the 8th day, the ethephon content decreased abruptly. The

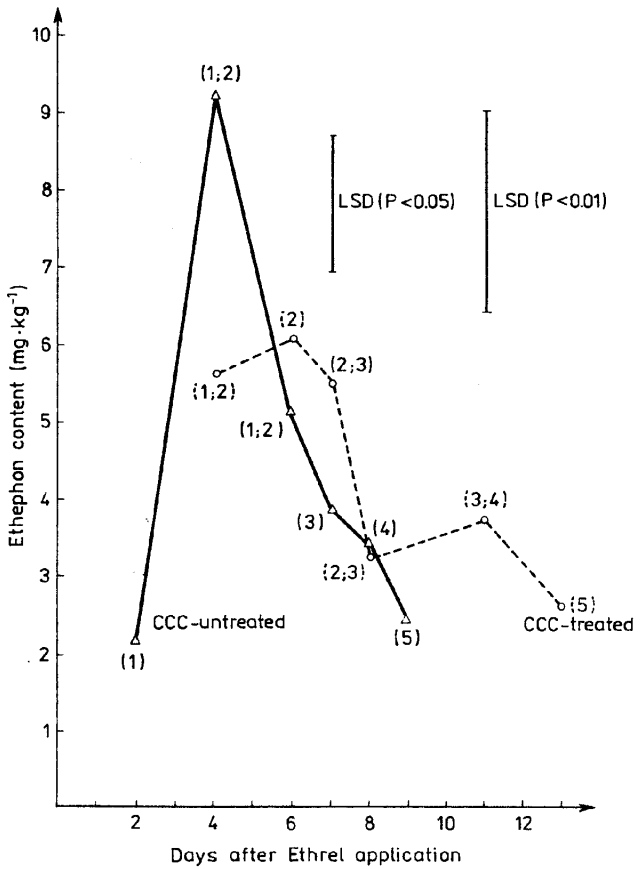

Fig. 2. The effect of CCC on accumulation of ethephon in ripe tomato fruits after application of Ethrel to leaves only. In parentheses the number of clusters from which the fruits were taken for analysis

rapid decline in the ethephon content occurred at the time of maximum rate of ripening (Figs. 1 and 2) as well in CCC-treated as in CCC-untreated plants.

For the plants in which only fruits were treated with ethephon (Figs. 3 and 4), the results were similar to those described above (Figs. 1 and 2). The rate of ripening attained lower values than in plants in which only leaves were ethephon-treated, and the mentioned small plateau did not occur (Fig. 3). In respect to the ethephon accumulation in the fruits it is seen from Figure 4 that it reached lower values both in CCC-treated and CCC-untreated plants in comparison to the plants where only leaves were treated with ethephon.

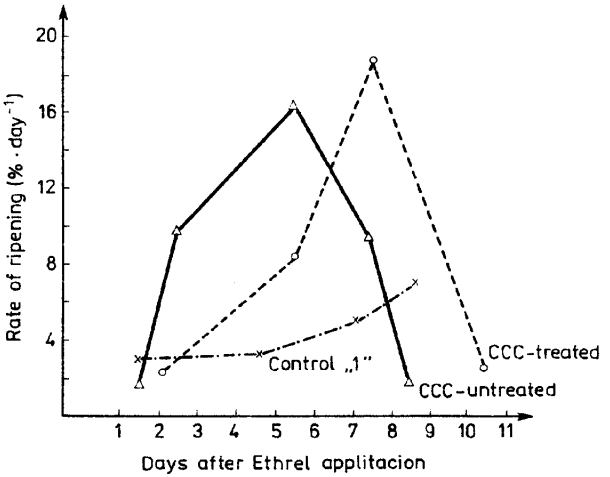

Fig. 3. The effect of CCC on the rate of ripening of tomato fruits after application of Ethrel to fruits only. (Control "1" = plants untreated with CCC or Ethrel)

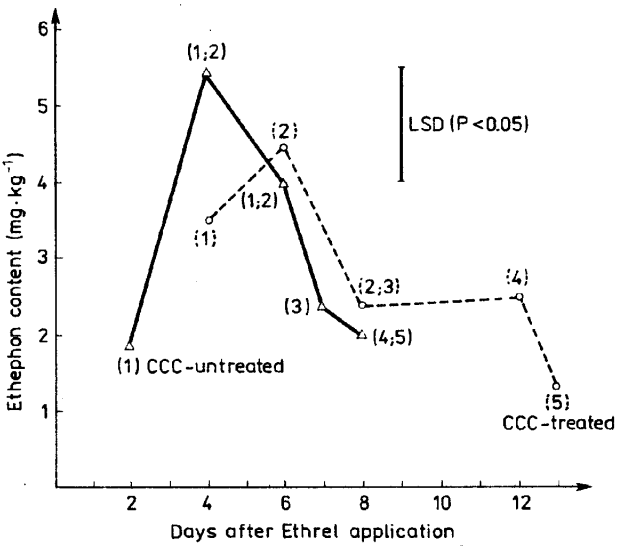

Fig. 4. The effect of CCC on accumulation of ethephon in ripe tomato fruits after application of Ethrel to fruits only. In parentheses the number of clusters from which the fruits were taken for analysis

DISCUSSION

The treatment of tomato seedlings with CCC delayed the process of fruit ripening stimulated by Ethrel both when only leaves or only fruits were treated. In the leaf-treated plants maximum accumulation of ethephon in fruits (Fig. 2) corresponded to a short plateau in the rate of fruit ripening (Fig. 1) and declined rapidly at the time of maximum rate of ripening. These phenomena were observed both in the CCC-treated and untreated plants. These findings support the suggestion of Iwahori and Lyons (1970) that ethephon trrigers a maturation mechanism which affects ripening processes but not ripening itself.

The changes in the ethephon content in the case of fruits sprayed with Ethrel are a reflection of the interaction of the accumulation of ethephon and its decomposition processes. This is probably related to the time required for ethephon to penetrate into the inner part of a fruit where the pH is favourable for ethephon degradation. It is known that ethephon is translocated from leaf to fruit and within the fruit and its action has been attributed to its decomposition product, ethylene (Yamaguchi et al., 1971).

The substantial differences that occurred among CCC-treated and untreated plants concerning the effects of Ethrel suggest that CCC probably influences the processes connected with transport, penetration into fruit and/or breakdown of ethephon in tomates. As far as we know the effect of CCC on the results of ethephon treatment were not investigated by other authors.

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Wpływ chlormekwatu (CCC) na akumulację etefonu w pomidorach i na stymulowane etefonem dojrzewanie

Streszczenie

Podczas szklarniowego eksperymentu rozsadę pomidorów przed przesadzeniem traktowano dwukrotnie CCC (250 $mg \cdot l^{-1}$). Gdy 10% owoców było „zapalonych", zastosowano roztwór etefonu (960 $mg \cdot l^{-1}$) opryskując oddzielnie owoce i liście, w celu uzyskania bardziej jednoczesnego dojrzewania. CCC opóźnił dojrzewanie owoców i obniżył akumulację etefonu w dojrzałych pomidorach w porównaniu z roślinami nie traktowanymi CCC. Uzyskano rezultaty podobne, tak w przypadku dolistnego zastosowania etefonu, jak również gdy opryskano nim tylko owoce.