Yield of tomato and maize in response to foliar and root applications of triacontanol

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Abstract. Triacontanol applied to tomato plants as a foliar spray caused a significant increase in total yield and yield per plant. When triacontantol was added to the growth medium, only a temporary increase in yield and number of fruits was observed. The yield of maize was unaffected by triacontanol, either applied to the leaves or to the growth substrate. These results support an earlier observation that a reduction in photorespiration is involved in the regulatory function of triacontanol, since only the yield of tomato, a C_3 plant, was increased. The application method was an important factor in it's effectiveness.

Introduction

Foliar spraying of field crops with growth regulators, pesticides, etc. is a common practice. Triacontantol (TRIA), both the natural and synthetic forms, applied as a foliar spray has been shown to increase the yield of several field crops [4]. Foliage spray and application of TRIA in nutrient medium increased the dry weight of rice seedlings, corn, barley and tomato plants [5]. However, it has also been found that TRIA increased the height of corn shoots, but not the weight [6]. We have observed in previous experiments that TRIA applied in the nutrient solution in which tomato plants were grown enhanced their vegetative growth, photosynthetic rate and decreased the rate of photorespiration. However, TRIA showed no effect on the vegetative growth, nor photosynthesis of maize [2].

The purpose of this study was to determine the effect of TRIA on the yield of tomato (C_3 plant) and maize (C_4 plant) when applied by two different methods.

Material and methods

Seeds of tomato (*Lycopersicon esculentum* Mill. var. Virosa) and maize (*Zea mays* L. var. Seneca) were sown in vermiculite. After 25 and 14 days tomato and maize seedlings, respectively, were transferred to plastic pots (6 l) containing Grodan rockwool (A/S Grodania, Denmark) as growth substrate. Nutrient solution, 0.1% (w/v) Superba, Sweden and 0.05% (w/v)

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$Ca(NO_3)_2$, was added three times a week. The composition of the nutrient solution was: 9.7 mM NO_3^-, 1.0 mM NH_4^+, 1.3 mM P, 5.3 mM K, 1.4 mM Mg, 1.4 mM S, 2.5 mM Ca, 0.04 mM Fe and micronutrients. The plants were cultivated in a greenhouse with its natural light and 16 h additional light from sodium high pressure lamps (General Electric Lucalox 400 W) with irradiance of 45 Wm^{-2}. On sunny days the irradiance was 460 Wm^{-2}. The night temperature was maintained at 18 °C, while the day temperature reached 25 °C on sunny days. The plants were divided into three groups consisting of 20 plants each. One group served as control and the other two groups received TRIA either in the growth substrate (T1) or as a foliar spray (T2).

A solution of TRIA in chloroform (1 mg ml^{-1}) was mixed with aqueous Tween 80 (1 ml l^{-1}), giving a final TRIA concentration of 2.3×10^{-6} M. Ten ml of this solution (10 ug TRIA) was added to the rockwool of each pot or applied with a chromatographic sprayer on the upper and lower surfaces of each leaf. Mask and gloves were used when spraying TRIA solution, because of the toxicity of chloroform. The plants were treated three times in this manner, once at the initiation of flowering, then six and twelve days later.

Tomato plants were decapitated and the growth in length stopped 3 days before harvesting began when the mean height was 1.6 m. Fruits were removed from the tomato plants as they became ripe, counted and the fresh and dry weights determined. Harvesting of tomatoes continued for 2½ months. Maize was harvested when the ears were ripe. The Student t-test [7] was used to determine significance of the results.

Results and discussion

TRIA applied as a foliar spray (T2) to tomato plants increased the total yield by 12% and the number of fruits from all plants by 25% as compared to the control group. However, TRIA added to the growth medium (T1) increased total yield by only 6% and the number of fruits by 3%. The T2 group produced the largest number of fruits per plant and gave the highest yield per plant. This increase was significantly higher than both the control and the T1 group (Table 1). The percent dry matter of the fruits was not significantly different, which indicates that the increase in fresh weight was not due to an increase in water uptake. TRIA-stimulated increase in tobacco callus was shown to be due to an increase in cell number and not simply caused by water uptake and cell enlargement [3].

Figure 1 shows the yield at various intervals during the harvesting period. The yield of the T2 group was higher than that of the control group throughout the entire harvesting period and was higher than the T1 group in all but the first period. During the first harvesting period the T1 group yield was higher than both the T2 and the control groups. This difference in TRIA

Table 1. Yield of tomato (fresh weight and number of fruits per plant) when TRIA was applied either as a foliar spray or in the growth substrate. Statistical significance (*) > 99% as compared to C and T1

Application method	Yield per plant		
	Fresh weight, kg	Number	% Dry matter
C. Control	2.4 ± 0.6	72.2 ± 20.2	4.6 ± 0.4
T1. Growth substrate	2.5 ± 0.6	74.1 ± 15.7	4.5 ± 0.4
T2. Foliar spray	2.9* ± 0.4	90.3* ± 15.4	4.5 ± 0.3

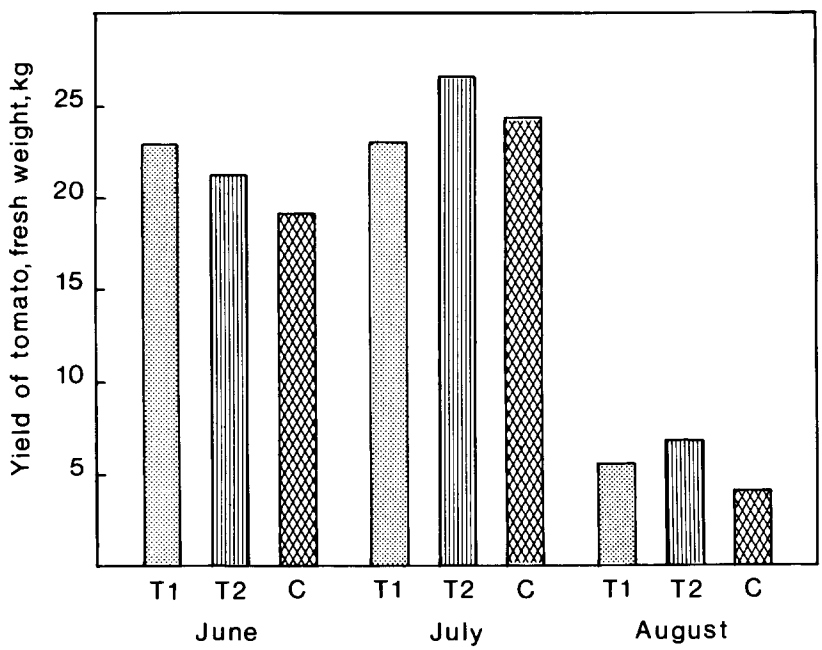

Figure 1. Total yield of tomato during the harvesting period. TRIA applied as to the growth substrate (T1), as a foliar spray (T2), and without TRIA (C).

effect may be due to differences in the availability of TRIA to the plants. When TRIA was applied in the growth substrate, it could have formed complex bindings with the rockwool or leaching caused by watering between applications could have reduced its availability. This situation was avoided when TRIA was applied as a foliar spray. The effectiveness of foliage spraying of TRIA is supported by the observation that it resulted in an increase in nitrogen content of sweet potato leaves and yield of other crops [4].

The results in Table 2 show that maize was unaffected by TRIA treatment. Tomato is a C_3 plant, which loses a large amount of photosynthetic products through photorespiration, while maize is a C_4 plant in which photorespiration is negligible. Recently, it has been shown that TRIA affects the balance

Table 2. Yield of maize (fresh weight and number of ears for all plants and fresh weight of ears per plant) when TRIA was applied either as a foliar spray or in the growth medium

Application method	Yield		
	Total fresh wt., kg	Total number	Fresh wt/plant, g
C. Control	2.2	19	110 ± 81
T1. Growth substrate	2.4	20	121 ± 59
T2. Foliar spray	2.5	20	124 ± 63

between photosynthesis and photorespiration in tomato. The net photosynthesis increased and photorespiration decreased, which resulted in enhanced growth and a 30% higher dry weight of tomato [2]. We suggest that this also may be the explanation for the increased yield in tomato and the absence of an increase in yield of maize.

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