Influence of growth regulators upon mineral nutrition, osmotic potential, and incidence of blossom-end rot of tomato fruit*[1/]

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RESUMO

Estudaram-se em condições de casa de vegetação os efeitos da aplicação de reguladores de crescimento na ocorrência da podridão estilar nos frutos de tomateiro cultivar 'Miguel Pereira'. Observou-se que ácido giberélico no concentração de 100 ppm promoveu alta incidência da anomalia fisiológica em plantas tratadas co maltas dosagens de sulfato de amônio. Sob as mesmas condições, tomateiros pulverizados com ácido succínico-2, 2-dimetilhidrazida 4.000 ppm, cloreto de (2-cloroetil) trimetilamônio 2.000 ppm e ácido-3-indolacético 100 ppm, apresentaram baixa incidência de podridão estilar. Efetuaram-se determinações dos teores de macronutrientes nas hastes dos tomateiros. Realizaram-se também determinações do potencial osmótico foliar nas plantas tratadas com reguladores de crescimento. Foi proposto um mecanismo de incidência da podridão estilar em tomateiros.

Introduction

APPLICATIONS of nitrogen in the ammonium form, during fruiting of tomato plants, cause a lowering of calcium in the tissues ot near deficiency. This condition usually causes blossom-end rot (BER) in tomato fruits (27). Ammonium sulphate promotes the occurrence of BER due to an acidification of the soil, fast leaching or remnant calcium in the soil, and effects on the absorption of this element.

The stimulation of growth my ammonium causes the appearance of a sink region for calcium, reducing its availability to fruits (22).

Tomato plants treated with (2-chloroetyl) trimethylammonium chloride (CCC) have reduced growth and transpiration leading to a reduction of ruit cracking. Applications of indole-3-acetic acid (IAA), gibberellic acid (GA), and NAA also caused a reduction in fruit cracking among cultivars susceptible to this physiological disorder (2). Applications of CCC (2,000 and 5,000 ppm) caused a decrease in BER incidence (3).

Tomato plants treaetd with CCC had higher N, P, Ca, and Mg concentration and lower K concentration (14). High levels of P were found in the lower regions of plants sprayed with CCC (4). Treatment with succinic acid-2, 1-dimethylhydrazide (SADH) caused a reduction in the level of Ca, but it did not alter the level of Mg in stems and leaves (14). Application of GA did not alter the absorption and mobilization of Ca and S. It was observed that there was a tendency toward a reduction in the absorption and translocation of nutrients in Ga-treated plants (7). IAA did not alter the translocation of Ca in tomato plants (23).

Application of CCC and SADH caused a reduction in the transpiration of 'Miguel Pereira' tomato plants (5). CCC also caused a reduction of water loss in the leaves whereas the strenght of water retention was 2 atm higher. CCC-treated plants had a high water content in the leaves and high osmotic potential of the cellular fluid after the irrigation period (13). Application of GA stimulates the transpiration rate of plants (15) and the use of 3 mM of IAA may induce the closure of stomata (12).

This present work studies the effects of growth regulations in mineral nutrtio nand leaf osmotic potential and their relationships with the indicence of BER in fruits of tomato (*Lycopersicon esculentum* Mill.).

Material and methods

'Miguel Pereira' tomato plants were sprayed with CCC (2,000 ppm), SADH (4,000 ppm), GA (1000 ppm), and water as a control at 4 leaf stage of development.

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In the sutdy of BER, the ammonium sulphate was applied on the soil at a concentration of 2 g/liter of soil, seven times at weekly intervals. The percentage of BER was evaluated at the time of the single harvest. Levels of Ca in the normal fruits and in the fruits with BER were determined; leaves of normal plants and plants with BER were taken for Ca analyses.

In a second experiment, stems isolated and dried at 80° C for macronutrient analyses. Nitrogen was evaluated by micro Kjeldahl; P by the colorimetric method; K, Ca and Mg by atomic absorption spectrophotometry; and S was determined by the gravimetric method. Statistical analyses (Tukey test at the 5 per cent level) were made for the concentration of N, P, K, Ca, Mg, and S in stems of tomato plants.

In the thrid experiment, leaf osmotic potential was determined by osmometry ("Osmette" osmometer) at 24 hour intervals, a tnoon, over a 4 days period. The first leaf sample was collected when the soil was at pot gradually reduced water levels Treatment with IAA was capacity, and subsequent samples at soil conditions with not used in this experiment Five replicates of four leaves per plant were taken randomly. Leaves were immersed in liquid nitrogen for 2 minutes before squeezing at 10,000 atm for 13 seconds to obtain the leaf juice. Statistic analyses (Tukey test at 5 per cent level) were performed with the osmotic potential data taken during the four-day period

Results and discussion

A variation in the percentage of BER in the fruits of tomato was detected after ammonium sulphate application. The incidence of BER was 10.0 per cent in controls, 2.6 per cent in plants treated with CCC, 1.0 per cent treated with SADH, 20.7 per cent with GA and 4.2 per cent with IAA. Treatments with SADH, CCC and IAA caused a lower incidence of BER in relation to GA and control treatments. GA application increased the incidence of BER in relation to the control

Maynard *et al.* (16) found that the Ca concentration in fruits with BER was 0.04 per cen tand 0.06 per cent in normal fruits. Dechen *at al.* (8) reported levels of 0.15 per cent Ca in normal fruits of 'Kada' tomato. We found intermediate values in our experiments with 'Miguel Pereira' tomato: fruits with BER contained 0.06 per cent Ca and normal fruits contained 0.10 per cent Ca Dechen *et al* (8) suggested the range of 3.11-3.25 per cent of Ca as the normal level for the first upper leaf at 90 days of age in the cultivar 'Kada'. A level of 3.18 per cent Ca was found in leaves of normal plants and 3.08 per cent of Ca in leaves of plants bearing fruits with BER in the cultivar 'Miguel Pereira', in agreement with the literature data.

Treatment with CCC caused an increase in the level of N, Ca and Mg in the stems in relation to the control. Treatments with SADH only caused an increase in the level of N in relation to the control (Table 1).

Table 1.—Average percentage of macronutrients in stems of tomato plant treated with growth regulators (data of four replicates).

Treatment	N	P	K	Ca	Mg	S
Control	1.04 a*	0.47 a	7.85 a	0.65 a	0.46 a	0.20 a
CCC	1.50 b	0.51 a	7.42 a	0.87 b	0.65 b	0.23 a
SDAH	1.31 bc	0.49 a	7.81 a	0.69 a	0.49 a	0.26 a
GA	1.17 ac	0.43 a	7.62 a	0.61 a	0.44 a	0.25 a
IAA	1.17 ac	0.50 a	8.26 a	0.71 a	0.48 a	0.23 a

* Mean separation with n columns by Tukey test, 5% level

Increased levels of N, Ca and Mg were obtained in plants treated with CCC by Knavel (14), but a variation in the level of N after SADH application was not found Chen (7) did not observe any change in the absorption and mobilization of Ca after treatment with GA or IAA. However, Wieneke *et al* (25) noted that the absorption of calcium-45 may be reduced with application of GA Treatment with SADH and IAA increased the translocation of calcium-45 in stems. (25)

Under Conditions of water deficit in the soil, a lower leaf osmotic potential was found in tomatoes sprayed with SADH and GA in relation to control plants and CCC-treated plants (Table 2) Castro (4) observed an increase in the osmotic potential of leaves from IAA-sprayed plants This could be a result of reduced transpiraiton owing to smaller stomatal aperture. SADH can inhibit the synthesis of engogenous IAA (20, 21), and perhaps causes a decrease in the leaf turgidity GA causes an increase in the stomatal aperture (11). The facts discussed above may explain the reduction observed in the leaf osmotic potential of treated tomatoes. Castro and Rossetto (6) noted that GA-treated plants had lower levels of aphid infestation in relation to CCC-treated plants. The feeding rate of aphids can be related to variations of the osmotic

Table 2.—Average leaf osmotic potential in atm in samples collected at noon over four days data of five replicates)

Treatment	May 26	May 27	May 28	May 29
Control	—7.65 a*	—8.17 a	—8.18 a	—8.28 a
CCC	—7.56 a	—7.99 a	—8.23 a	—8.33 a
SADH	—7.62 a	—8.52 a	—8.64 ab	—9.67 b
GA	—7.93 a	—8.98 a	—9.62 b	—9.69 b

* Mean separation within columns by Tukey test, 5% level

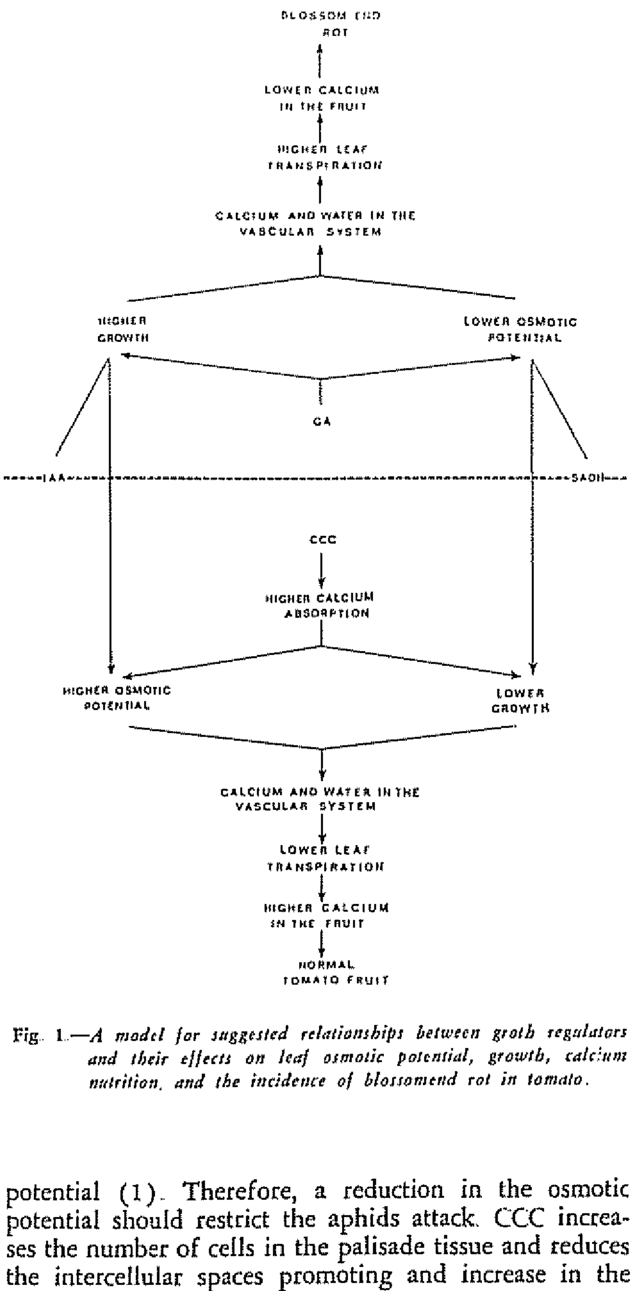

Fig. 1.—*A model for suggested relationships between groth regulators and their effects on leaf osmotic potential, growth, calcium nutrition, and the incidence of blossomend rot in tomato.*

potential (1). Therefore, a reduction in the osmotic potential should restrict the aphids attack. CCC increases the number of cells in the palisade tissue and reduces the intercellular spaces promoting and increase in the efficiency of the water movements in the tissues. CCC can also increase the tolerance of plants to water deficit due to its interference with GA biosynthesis.

The removal of the leaves from apple plants reduced the incidence of a calcium-related disorder in the fruits (9). This can be interpreted as the removal of leaves reduces the transpiration and increases the translocation of Ca to the fruits. Gerard and Hipp (10) reported that a high transpiration rate decreased, and a low transpiration rate increased movement of Ca into tomato fuit. A reduction of soil moisture increased the concentration of leaf Ca and decreased the concentration of fruit Ca in apple (11). It is interpreted that low soil moisture hinders the active absorption which promotes the movement of Ca toward the fruits. Palzkill and Tibbitts (17) noted that the accumulation of calcium-45 in the internal leaves of cabbage increased more than 8 times when the external leaves were under conditions of low transpiration and high active absorption in contrast with conditions that maximized the transpiration and decreased the active absorption.

The higher incidence of BER in fruits of tomato plants treated with GA is considered due to higher growth (29) and a lower leaf osmotic potential, Ca and water in the xylem (19) and phloem (26), higher leaf transpiration (15) and a lower content of Ca in the fruits. Tomato plants treated with CCC had lower incidence of BER due to a higher Ca absorption, lower growth (28), the presence of a high leaf osmotic potential, Ca and water in the vascular system (19, 26), lower leaf transpiration (5), and a higher content of Ca in the fruits. SADH treatment reduced the incidence of BER because it reduced plant growth (18), despite the fact that it reduced leaf osmotic potential. In addition, SADH reduced leaf transpiration (5) and increased the Ca content in the fruits. IAA treatments reduced the incidence of BER because it maintained a high leaf osmotic potential (4) despite the fact it promoted higher growth (24). IAA also reduced the leaf transpiration (12) and increased the Ca content in fruits. The interrelated effects of growth regulators in the incidence of BER, according to the discussion above, are summarized in Fig 1.

Summary

Growth regulators were applied to tomato plants and their effects on mineral nutrition, osmostic potential, and incidence of blossom-end rot (BER) were studied. Gibberellic acid (GA) promoted high incidence of BER in tomato fruits when a high level of ammonium sulphate was used. Under the same conditions, treatment with succinic acid-2, 2-dimethylhydrazide (SADH), indole-3-acetic acid (IAA), or (2-chloroethyl) trimethylammonium chloride (CCC) caused lower incidence of BER. Higher levels of nitrogen, calcium, and magnesium occurred in the stems of plants sprayed with CCC. Treatment with SADH also induced an increase in nitrogen level in the stem. Plants treated with GA and SADH had a lower (more negative) leaf osmotic potential under water deficit in the soil.

Resumen

Se aplicaron reguladores del crecimiento a plantas de tomate, y se estudiaron sus efectos sobre la nutrición mineral, potencial osmótico, e incidencia de la podredumbre apical (BER). El ácido giberélico (GA) promovió una alta incidencia de BER en frutos de tomate cuando se utilizó un nivel alto de sulfato de amonio. En las mismas condiciones, un tratamiento con ácido succínico-2, 2-dimetilhidrozido, 4000 ppm (SADH), ácido 3-indolacético 100 ppm (IAA), o cloruro de (2-cloroetil) trimetilamonio 2000 ppm (CCC), causó una incidencia más baja de BER.

Se presentaron niveles más altos de nitrógeno, calcio, y magnesio en los tallos de plantas rociadas con CCC. El tratamiento con SADH también indujo un aumento en el nivel de nitrógeno en el tallo. Las plantas tratadas con GA y SADH tuvieron potencial osmótico foliar en condiciones de déficit hídrico en el suelo. Se propone un mecanismo de incidencia de la podredumbre apical en el tomate

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