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INFLUENCE OF ROOT TEMPERATURE ON TOMATO GROWTH AND NITROGEN NUTRITION

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Abstract

Young tomato plants were grown in nutrient solution at a constant temperature : 12°C and 22°C.

The tomato reacts strongly to the change in root temperature : at 12°C, plant dry weight and water uptake are less than 70 p. cent of that observed at 22°C.

The poor growth at 12°C is accompanied by a modification of plant nitrogen nutrition. At 12°C, the organic nitrogen and nitrate accumulate in the root, while at 22°C they accumulate in the stem and the petiole. Concurrently the nitrate reductase activity (NAR) in the roots growing at 12°C is always more important than those growing at 22°C. The NAR is more important in the blades and the difference between treatments are low. But the small growth observed at 12°C induces a reduction of total NAR of blades and emphasizes the further growth restriction.

1. Introduction

In the last few years, the growers have disposed of effective cultural technics to modify the root temperature in open field and under glass-house favourising a yield increase and a much earlier yield (Brun, 1968). The increase of root temperature acts favourably on the water and nutrients absorption (Cooper, 1973). Among the nutrients the nitrate, the main substrate of the plant nitrogen nutrition, plays an important role ; the very mechanisms of this absorption by the plant are not known yet with accuracy, but it is an energonic process (Davidian, Salsac, 1979).

The absorption and nitrate reduction are characterised as highly induced process (Skaner Boyer, 1976 ; Breteler Siegerist, 1984). The nitrate reduction would take place especially in the roots or in the leaves according to the species (Pate, 1973 ; Robin et al., 1979).

In the egg-plant and the pepper, the nitrate absorption is much less affected by a low root temperature than its migration toward the shoot (Cornillon, 1984) ; in the barley (Deane Drummond et al., 1980) and the tomato (Gosselin et al., 1984), the nitrate reductase activity (NRA) is higher at low temperature. But Coïc et al. (1966) infer from their observations on maize that the nitrate reductase activity would strongly decrease by cooling roots.

In this paper, we report the experiments on the absorption, migration and the nitrate reduction by tomato.

2. Materials and methods

Plant material

Seeds of tomato cultivar M63-5 were sown on the 20th of september ; the germination took place between the 28th and the 30th and they were planted october 9th into plastic pot containing 1 litre of one half Hoagland solution containing : 6,5 meq NO_3^- , 1,0 meq SO_4^{--} , 0,5 meq H_2PO_4^- , 3,5 meq K^+ , 3,0 meq Ca^{++} , 1,0 meq Mg^{++} and 0,5 meq NH_4^+ .

The choice of 12°C and 22°C root temperatures take previous observations into account and they are applied between the 19th october and the 7th november.

Analysis

The water consumption was read twice a week.

Plant samples were taken at four dates to measure dry matter production, nitrate and kjeldahl nitrogen accumulation.

In the same time, the nitrate reductase activity in vivo is measured with NO_3^- addition (Robin, 1979).

3. Results

3.1. Growth evolution

Dry matter production at 12°C declined on the 3d day of treatment compared at 22°C and the difference increases with the time (fig. 1). The Q_{10} value was 1,37 for the total dry matter production at these two temperatures. The shoot root ratio varies between 5.3 and 8.0 at 12°C and between 5.9 and 7.5 at 22°C. The curve of water consumption shows the negative influence of the low root temperature on plant growth (fig. 2). At 12°C, the water uptake, for the production of 1 gramme dry matter, is equal to 234 ml whereas at 22°C is 271 ml.

3.2. Nitrogen nutrition

The organic nitrogen content in the roots decreases at 22°C while it remains constant at 12°C (fig. 3). On the other hand in the blade the organic nitrogen content remains around 6,1 % for the two treatments throughout the experiment. The organic nitrogen accumulation in the plant is much higher at 22°C since dry matter production is higher.

The root nitrate content is more important at 12°C than at 22°C while in the blades it is the contrary (fig. 4). On the third day of the experiment the nitrate content in the blades is considerably decreased especially for the 12°C treatment.

The nitrate reductase activity in leaves (after a significant decrease on the 3d day) was high and the difference between treatments are little significant. In roots, the activities measured at 12°C are always higher than those measured at 22°C (fig. 5).

The correlation between NR activity and tissues nitrate content is positive : 0.61 in the roots and 0.62 in the blades. But it does not appear that the NR activity and the reduced nitrogen accumulation in the roots are correlated. The quantity of reduced nitrogen is similar at 12°C, 73.0 mg and at 22°C, 83.9 mg in the roots.

When we observe the division of nitrate reductase activity between roots and leaves, we note that shoots represent 90 p. cent of the total activity for most of the experiments. Only the 12°C treatment gives a different repartition with about 45 % and 20 % of the activity in the roots on the 3d and the 7th day experiment.

4. Discussion

The growth change between 12°C and 22°C appears to be related to a change in the plant nitrogen nutrition.

NO_3^- accumulates in the root, showing that no substantial change occurs in the nitrate uptake when the root temperature is low, but the flux from root to shoot is lower.

The root nitrate reductase activity increases when the temperature decreases because NO_3^- accumulates in the root. Gosselin et al. (1984) observed quite similar results during an experiment on tomato, Vendor cultivar.

The root contribution to the total plant nitrate reductase activity may be more important than 10 % we observed and that correspond to the observations of various authors on other species : maize (Wallace, 1973) cotton (Radin, 1978). Effectively in the roots this enzyme do not need light and it can react night and day, all the more as the nitrate absorption is a continuous phenomenon (Miguel, 1981).

The slightest nitrate flux to the shoot gives a lower nitrate concentration in the leaves and stem at 12°C. This lower concentration gives a lower nitrate reductase activity in the blade by weight unit that contributes to the reduction of the synthesis in plants. Gosselin et al. (1984) did not find any influence of the root temperature on the nitrate reductase activity of the tomato blade : this result can be explained by the sampling date since in our experiment the decrease of NRA due to the low temperature can be observed only during the first week of treatment.

This experiment shows the important role of the NO_3^- flux from the nutritive solution to the root and then to the blade in the nitrate reductase activity of this organ and its action on growth reduction observed at 12°C compared to 22°C.

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Fig. 1 - Evolution of tomato plant dry matter weight

Fig. 2 - Influence of root temperature on water uptake

Fig. 3 - Influence of root temperature on nitrogen content of tomato root and blade

Fig. 4 - Influence of root temperature on nitrate content of tomato root and blade

Fig. 5 - Influence of root temperature on nitrate reductase activity of tomato root and blade