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Nitrogen Deficiency Influence On Abscisic Acid in Tomato[1]

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Abstract. **Abscisic acid (ABA) concentrations were significantly higher in young leaves of N-deficient (stressed) plants of tomato *(Lycopersicon esculentum* Mill.) both at day 2 and day 7 after transfer to a N-free Hoagland's solution. In old leaves, N-deficiency significantly increased ABA concentrations after 2 days but not after 7 days.**

Environmental stresses such as drought, salinity, disease, temperature extremes, and nutritional deficiencies increase the ABA content of plants (1, 2, 5, 6, 8, 9, 12), which in turn may hasten the senescence process (4). Nitrogen deprivation likewise accelerates senescence. In this study we investigate the influence of N-deficiency on ABA levels.

Seeds of 'Venus' tomato, were planted in vermiculite and watered with 1/4 strength Hoagland's solution (3). When the seedlings were about 5 cm high, they were transferred to 3.8 liter plastic pots wrapped in aluminum foil which contained 1/4 strength Hoagland's solution. Each pot contained 2 plants and was force-aerated. Three plants were used for each sampling time. After 1 week, the solutions were changed to 1/2 strength Hoagland's solution. The experiment was conducted in a glass house with natural lighting and maintained at 25 ± 2°C. After 3 weeks, one-half of the plants (controls) were transferred to a full-strength Hoagland's solution; the other half were transferred to a nitrogen-free, full-strength Hoagland's solution in which $CaSO_4$ and KSO_4 were substituted for $Ca(NO_3)_2$ and KNO_3 to provide the stressed plants with Ca and K.

The experiment was conducted twice with similar results. In the first experiment samples were taken after 7 days of stress, while in the second experiment samples were taken at the beginning of the experiment before stress was imposed, and again at 2 and 7 days after the start of stress. Results of the second experiment are presented.

At each harvest, the 2 youngest and the 2 oldest leaves and petioles from each of 3 plants were frozen on dry ice and processed for ABA analysis (7). Methylated acidic fractions (diazomethane) were analyzed using a Tracor 222 gas chromatograph equipped with an electron capture detector. Column packing was OV-17 with purified nitrogen at a flow rate of 80 cc/min as the carrier gas. The temperature of the injection port, column oven, and detector were maintained at 250, 225, and 275 C, respectively. Authentic *cis-trans* ABA was used as a standard.

No visual symptoms other than a slight decrease in growth were observed after two days. On day 7, however, the leaves of stressed plants were pale, and the lower sides were purple. On some plants the lower most leaves were totally yellow and apparently dead.

The ABA content in young leaves of control plants increased in a linear manner for 7 days (Fig. 1A) and ABA level was significantly higher at day 7 than at day 0 or 2. A very sharp and significant increase in ABA levels was observed under N deficiency. The increase continued up to day 7 and although the level was significantly higher than at day 2, the rate of increase was not as rapid as during the first 2 days.

Old leaves from control plants yielded a rather sharp and significant increase in ABA during the first 2 days of stress (Fig. 1B), then remained constant. In N-deficient old leaves, ABA increased much more rapidly during the first two days of stress, but had declined by day 7 to a level below that of the controls.

Our results agree with those of several investigators who have reported that stress increases ABA levels. The case is clear for water stress (8). Increased ABA levels associated with salinity or disease may, however, be a form of water stress. Daie et al. (1) reported that suboptimal temperatures increased ABA production in *Lemna;* elevated ABA levels could not have been the result of water stress, because the plants were floating on nutrient solution. High ABA content, as a result of mineral deprivation in experiments where plants are transferred to distilled water, may also be due to a kind of water stress because of a possible osmotic shock and/or membrane disruptions, or it could be the effect of any one or several elements absent in the medium. Our results showed a clear effect of N deficiency on ABA production. Under our experimental conditions, there was no cause for water stress because the N-free solution had approximately the same chemical composition as the original solution.

Higher concentrations of ABA have been reported in younger as opposed to older tissues (10), but our results showed that ABA was higher in older leaves except after 7 days of stress. As the stress was continued beyond 2 days, ABA sharply declined in the old leaves, but not in the young leaves. The ABA level in stressed or non-stressed old leaves and in non-stressed young leaves reached about the same level in seven days. Possible explanations include: (a) mobilization of ABA from old leaves to the young leaves, (b) binding of ABA to compounds such as sugars, or (c)

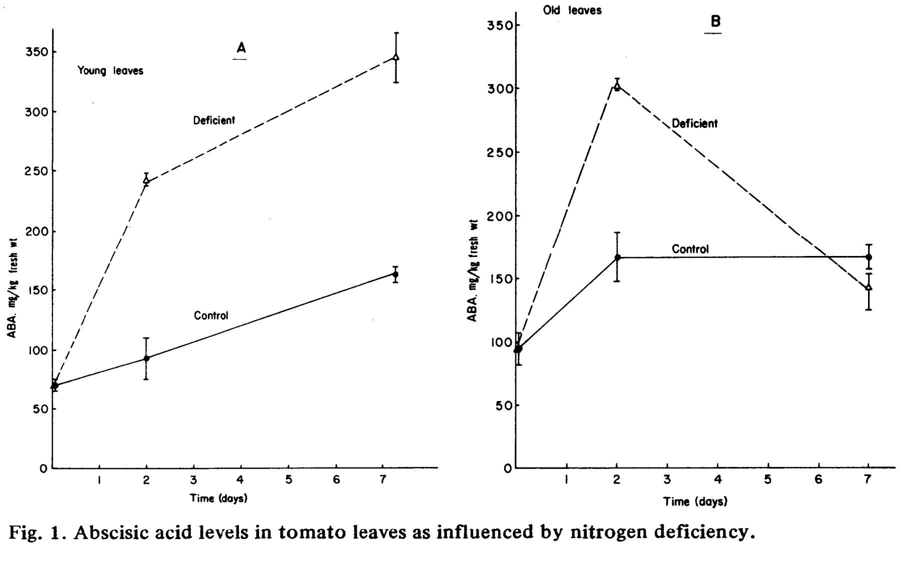

Fig. 1. Abscisic acid levels in tomato leaves as influenced by nitrogen deficiency.

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degradation by a mechanism present in the old leaves but lacking in the young leaves. Apparently, the old leaves reach a steady state sooner than young leaves. The decrease in ABA in old leaves may have adaptive value.

The high ABA contents measured under stress may be due to rapid synthesis in the leaves or to transport from the roots. Goldbach and co-workers (2), however, could not detect any measurable ABA in the sunflower roots or root exudate.

Reports in the literature suggest that cytokinins, which retard senescence, decline under N deficiency (11). Our work demonstrates that N deficiency stimulates ABA accumulation and ABA is a senescence promoter. The plant's mineral supply apparently affects its phytohormone balance. These hormonal changes may exert an important influence on a wide variety of physiological processes such as senescence, ripening, abscission, and flowering, all of which ultimately affect yield.

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The Influence of Training Methods, Light, and Moisture on Acid Content of Tomato Fruits[1]

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Additional index words. Lycopersicon esculentum, pH, soluble solids.

Abstract. **Methods of training plants of tomato, *Lycopersicon esculentum,* Mill. (staked vs. unstaked, or pruned vs. unpruned) or growing under conditions of reduced light or moisture did not alter acid content of fruit sufficiently to cause concern with botulism poisoning from the canned product.**

Concern has been expressed over the risk of botulism poisoning from the consumption of home-canned tomatoes. Decreased acidity attributed to modern garden cultivars along with certain environmental conditions has been blamed for the concern. Although several studies indicate considerable differences in the pH of cultivars (2, 4, 5, 10, 11, 12), there is evidence that the acidity of currently used cultivars is practically the same as that of older cultivars (8, 9). Canning procedures presently recommended are also thought to be adequate (7). The purpose of this study was to determine the influence of plant training methods and certain environmental factors on the pH, % titratable acid, and the soluble solids-titratable acid ratio of tomato fruits.

Quality analyses. Tomato fruits were quartered and blended into a puree with a food blender, and duplicate 60 g samples were used for analysis. The pH and percent titratable acid were determined on the same sample by immersing electrodes into the puree and then titrating with 0.1 N NaOH to a pH 8.1 end point. Titratable acidity was expressed as percent citric acid (3). Soluble solids were determined directly with a hand refractometer.

Field experiment. Four methods of training, (1. staked and pruned to two stems; 2 . staked, unpruned, and tied by the Florida weave method; 3. unpruned, in wire cages; and 4. unpruned, ground-grown with no support), were compared on an Etowah silt loam soil. Each of the 4 treatments were replicated 6 times in a randomized block design. Individual plots consisted of 5 plants of 'Better Boy' cultivar. Three sound fruits were sampled together from each experimental unit on each of 2 harvest dates at 4 stages of maturity; turning, firm ripe, canning ripe, and soft ripe. Fruits harvested inthe turning and firm ripe stages were ripened to the canning ripe stage before analysis.

Table 1 shows training systems had

Table 1. The influence of 4 systems of training plants on acidity and solids-acid ratio of tomatoes.[z]

Training system	pH	Titratable acid (%)	Soluble solids titratable acid ratio
Staked, pruned	4.56 a[y]	0.395 c	13.6 a
Staked, unpruned	4.56 a	0.464 a	12.2 b
Caged, unpruned	4.58 a	0.446 b	12.2 b
Ground grown, unpruned	4.57 a	0.440 b	12.7 b

[z] Each entry is the average of 32 determinations (4 replications x 2 harvest dates x 4 stages of maturity).

[y] Mean separation in columns by Duncan's multiple range test, 5% level.

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