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Significance of the modifications of some physiological responses of *Lycopersicum esculentum* resulting from foliar sprays of maleic hydrazide*

by

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Synopsis: In this paper are presented some of the modifications of physiological responses in tomato (*Lycopersicum esculentum*) resulting from foliar sprays of maleic hydrazide and their significance.

Interest in maleic hydrazide (MH) as a growth inhibitor was aroused in agricultural research since Schoene and Hoffmann (1949) reported the responses of plants to its applications. However, the manner in which MH acts as a growth inhibitor is only imperfectly understood. The retarding effect it exerts on plant respiration is often correlated to its inhibiting property (Isenberg 1954; Naylor & Davis 1949, 1951). Besides influencing respiration, MH applications are known to affect such physiological processes as photosynthesis and transpiration (Callagan & Van Norman 1956; Zukel 1957). It appears that a study of alteration of physiological responses ensuring MH treatments in quite a number of plants may provide a line of approach in comprehending the mechanism of its action as well as in interpreting plant responses elicited.

Influence of foliar sprays of MH on general growth responses in tomato: The purpose of the experiment was to study the influence of MH on growth of tomato when applied at a concentration and stage, where its inhibiting properties could be best evaluated by visible responses. It was found that a concentration of 1000 p. p. m. of MH applied to 47 days old seedlings was best suited for the purpose. Other concentrations tried were 10 and 100 p.p.m. Seedlings were grown in six inches pot filled with sand. Each pot accommodated a single seedling. Measured quantities of water and nutrient solutions were provided throughout the experiment. Prior to application of MH, seedlings that were not uniform in size were removed. Non treated plants were provided for comparative measurements and they served as controls. Fifteen plants were allotted per treatment and each single plant was considered a replicate. The treatments were randomised on the green house benches.

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The growth responses elicited by foliar applications of MH in tomato, clearly indicated that it will inhibit the plant growth. The chief responses observed were :

1. Rate of stem elongation was retarded,
2. Stem diameter was increased,
3. The number of leaves per plant was reduced,
4. The length of the leaf was decreased,
5. The colour, texture and venation of leaves were altered, i. e., leaves becoming dark green, leathery and brittle with poorly marked veins,
6. Root elongation was inhibited,
7. Root hairs were few and roots were injured,
8. At the highest concentration (1000 p. p. m.) flowering was completely inhibited, the terminal meristem of shoot injured and lateral buds activated, and
9. Dry weights of shoots were decreased.

The alteration in growth and appearance induced by application of MH (1000 p. p. m.) as compared to non treated plants grown under similar environment is provided in figure 1.

FIG. 1.

Left : Control Right : Treated with MH.

MH applied as an aqueous whole plant spray at 1,000 parts per million to 47 days old seedlings. Photograph taken one month after application.

Accumulation of some important Nutrient Elements in MH treated Tomato plants: Since growth and development of plants were affected by foliar sprays of MH, it was of interest to know to what extent accumulation of nutrient elements were influenced. An analysis of plant samples were undertaken for this. Standard procedures for sampling, drying and analysis were adopted (Anon. 1955; Conner and Bass 1960). Nitrogen was estimated by Kjeldahl's method, potassium by flame photometric procedures and calcium, magnesium, phosphorus, boron, manganese and copper spectrographically. After estimation all content of nutrient elements were expressed in milli or micrograms based on the dry weight of plants (Table 1).

TABLE 1.

Contents of nutrient elements in shoots and roots of MH treated tomato plants determined one month after application. MH applied as a foliar spray to 47 days old seedlings.

Nutrient Element	MH (1000 p. p. m.)			Control		
	Shoot	Root	Total	Shoot	Root	Total
Nitrogen	45·70	10·64	56·34	52·63	17·67	70·30
Potassium	106·10	19·48	125·58	142·80	42·63	185·43
Calcium	71·99	10·36	82·35	84·46	17·98	102·44
Magnesium	24·73	5·70	30·43	25·30	10·70	36·00
Phosphorus	7·20	2·47	9·67	9·38	4·65	14·03
Boron	84·51	19·95	104·46	110·16	43·40	153·56
Manganese	100·16	37·05	137·21	142·80	82·15	224·95
Copper	84·51	34·20	118·71	110·16	83·70	193·86

Boron, copper, manganese, expressed in micrograms while nitrogen, phosphorus, potassium, calcium and magnesium are expressed in milligrams.

As can be seen from the Table 2, applications of MH retarded accumulation of almost all the important nutrient elements in both shoots and roots as compared to non treated controls grown under similar manner.

Effect of foliar Sprays of MH on Root Hairs and Root Respiration in Tomato: As accumulation of essential nutrient elements were retarded by foliar sprays of MH, it was necessary to ascertain the influence of MH on root hairs and root respiration. This being, roots are organs of absorption of nutrients from the media, and if they are affected it is conceivable that uptake and accumulation of nutrients could be interfered with.

Root respiration studies were carried out with the help of Warburg Respirometer by using standard manometric techniques (Umbreit *et. al.* 1959). Oxygen uptake was recorded in microlitre per milligram dry weight of root tips. Twenty root tips of 1 centimeter in length were used per replication of treatments. Such a kind of study indicated that foliar applications of MH will retard rate of respiration in roots considerably.

A study of the nature of root hairs in MH treated plants revealed that the number and location of root hairs were affected by treatments. Root hairs were fewer in number as compared to controls, and they were located at the very tip of the roots instead of in the zone of maturation. Moreover many root tips of treated plants showed signs of injury as well as necrosis.

Discussion : Foliar applications of MH (1000 p. p. m.) to young tomato plants altered their growth and development significantly. The vegetative and reproductive growth were inhibited. These observations are in agreement with those of others who have reported on inhibition of growth in tomato and other plants ensuing foliar applications of MH (Crafts *et. al.* 1950; Currier *et. al.* 1951; Greulach 1951; Isenberg 1954; Naylor and Davis 1950).

The external changes observed in growth and development of tomato seedlings following foliar applications of maleic hydrazide are possibly the reflections of alteration in their physiological activity. Such an assumption appears to be logical when the accumulation of nutrient elements, root growth, extent and nature of root hairs and root tips present and respiration of roots in treated plants are all considered.

Following foliar applications of maleic hydrazide in tomatoes the root elongation was inhibited, and the root tips were found to show injuries as well as necrosis. The chemical appeared to act as a root pruning agent. Root pruning is known to reduce vegetative growth and favour accumulation of carbohydrates. One of the probable reasons for inhibition of vegetative growth and accumulation of carbohydrates in maleic hydrazide treated plants, which has been frequently reported, could be due to its effect on the root tips and roots in general.

Maleic hydrazide treated plants were found to have fewer root hairs as compared to the non-treated plants. The root hairs instead of being present a few millimeters behind the root tips in the 'zone of maturation', appeared at the very tip of the roots. Either the region of elongation was reduced to such an extent as to make the root hairs in the 'zone of maturation' come closer to the root tips or the location of root hairs were possibly altered.

The root hairs play a vital role in the absorption of water and the nutrient elements. When the number and location of root hairs appeared to be altered, it is conceivable that the uptake of nutrient elements could be affected. The experiments on the accumulation of some important nutrient elements following foliar applications of maleic hydrazide to the tomato plants showed that they accumulated lesser amounts of nitrogen, potassium, phosphorus, magnesium, boron, manganese and copper as compared to the non-treated plants.

Reduced accumulation of nutrient elements observed in the treated plants in the present experiments can be considered to reflect the efficiency of uptake of nutrients by the roots, from the media. It then suggests that factors associated with the absorption of nutrients, such as membrane permeability, osmotic pressure and exchange capacity of the roots are likely to be influenced.

Since uptake of nutrient elements are affected by treatment with maleic hydrazide, some of the growth responses resulting by its application could be secondary effects not attributable to the chemical alone.

The inhibition of respiration in higher plants is frequently accompanied by cessation of growth or undesirable morphological changes (Isenberg 1954). Hence the inhibition of growth in the tomato plants treated with maleic hydrazide observed, could be attributable to its effect on root respiration.

Maleic hydrazide accumulates in actively growing meristem, affecting cell division and growth (Carlson 1954; Zukel 1957). In the shoots of a young tomato plant, the most active meristem is the apical meristem. On the other hand in roots for every root tip we have an active root meristem and roots being more in number it can be expected that the chemical exerts a greater influence on the roots than on any other organ.

The physiological changes observed in tomatoes following foliar applications of maleic hydrazide appears to be mainly due to its effect on the root growth, root hairs, root tips, root meristems and roots in general.

Summary: Foliar applications of solutions of 1,000 p. p. m. of maleic hydrazide to young tomato seedlings resulted in the inhibition of their vegetative and reproductive growth. The most notable effects were retardations of stem and root elongation, increase in stem diameter, smaller number of leaves per plant and decreased length of leaves. Alteration in colour, texture and venation of leaves were also noted.

Maleic hydrazide treated plants tend to accumulate lesser amounts of some important nutrient elements such as nitrogen, potassium, phosphorus, calcium, magnesium, boron, copper and manganese.

Foliar applications of maleic hydrazide to young tomato seedlings influenced the root - tips, root hairs, and respiration of roots. Many root-tips showed injury as well as necrosis. Root hairs were few and appeared at the very tip of the root. Root elongation and respiration of roots were also inhibited. Hence it is believed that maleic hydrazide alters the physiology of tomato plants and induces inhibition of growth by affecting the root tips, roots hairs, roots and respiration of the roots.

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