EFFECT OF VARIOUS CONCENTRATIONS OF 2,4-D AND 2,4,5-T ON SEED GERMINATION, DRY MATTER YIELD AND TRANSPIRATION RATE OF SOME ECONOMIC PLANTS

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SUMMARY: The role played by the two applied herbicidal auxins, namely; 2,4-D and 2,4,5-T, when supplied in various concentration on germination, radicle and plumule lengths, dry matter and transpiration of Zea mays, Helianthus annuus, and Vicia faba were studied. The two herbicidal auxins were significantly effective in producing inhibition of germination, radicle and plumule lengths, dry matter and transpiration of the tested plants when supplied in high concentrations (10^{-4} and 10^{-3} M). However, no inhibitory effect on the germination of the treated seeds was displayed in the presence of 10^{-7}M. Moreover a significant stimulatory effect on radicle and plumule growth of sunflower and bean germinating seeds was displayed at 10^{-7} M of any of the two compounds used. At low concentrations the transpiration rate values either approached that of the control or increased it.

Key Words: Herbicidal auxins, germination, dry matter, transpiration, zea mays, helianthus annus, vicia faba.

INTRODUCTION

It is highly likely that practical uses of synthetic auxins will in the future be more extensive and varied than at present. Full realization of their potentialities will, however, not be achieved until our understanding of their absorption, translocation, functions and modes of action in plants is greatly increased. As already stated, the more active and the most widely used synthetic auxins in weed control are 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T).

Apart from the extensive investigations which have been concerned with the growth-inhibitory effects and weed-killing properties of these two compounds, relatively little works have dealt with their effects on seed germination (11, 16); on growth of young seedlings (2,6,21) and on transpiration (12,18).

This work was conducted to study in long-duration (10 days) experiments, the role played by 2, 4-D and 2,4,5-T, when supplied in solution cultures at various concentrations on germination, radicle and plumule lengths, dry matter yield and transpiration of sunflower, broad bean and maize plants.

MATERIALS AND METHODS

Maize (*Zea mays*), sunflower (*Helianthus annuus*) and broad bean (*Vicia faba*) seeds were used in this investigation. The seeds obtained from Assiut University farm were throughly washed with distilled water and germinated as described by Radi, *et al.* (19). The germination experiments were performed as described by Maftoun and Sepaskhah (15). Twenty seeds were placed on absorbant pads in Petri-dishes to which 25mls of the experimental solution (2,4-D and 2,4,5-T) at concentrations ranging between 10^{-7} and 10^{-3} M were added. The percentage germination was followed after a period of 5 days and finally the

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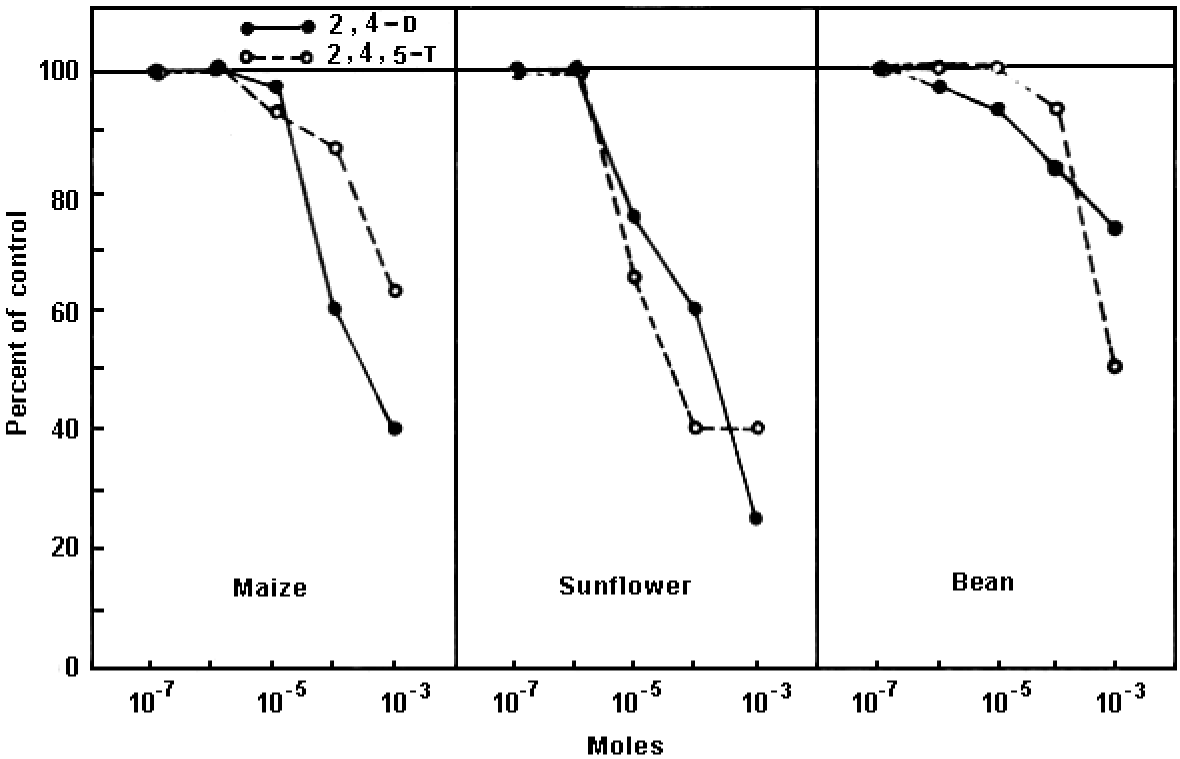
Figure 1: Effect various concentrations 2,4-D and 2,4,5-T on germination.



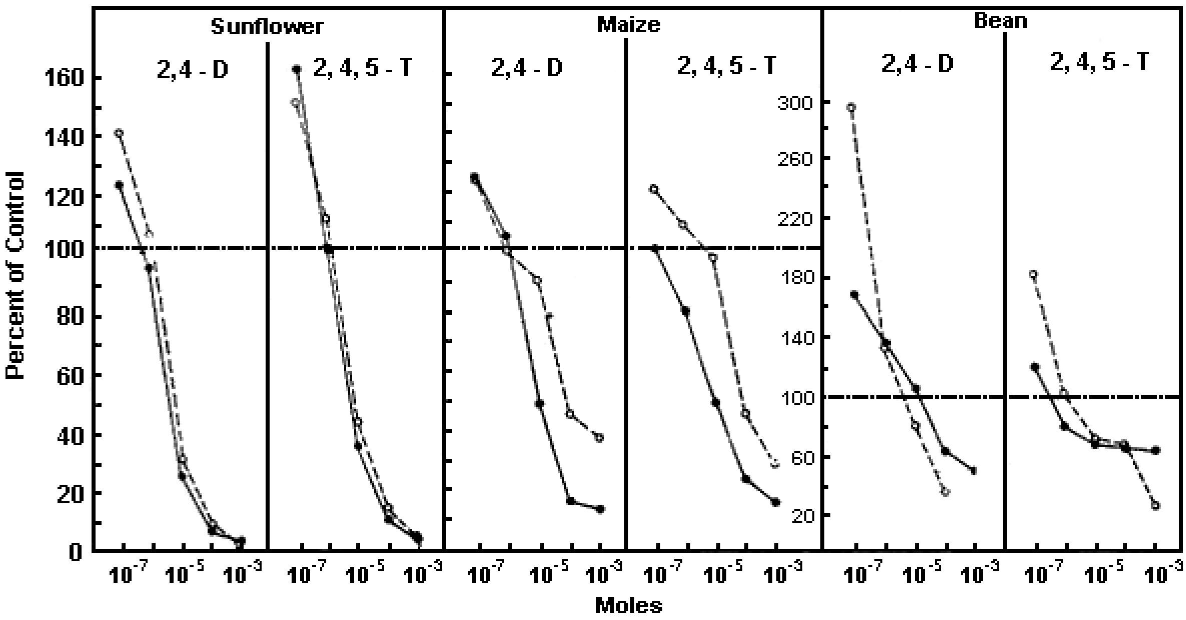
lengths of the radicles and of plumules were measured. Five-day old seedlings were selected for uniformity and transferred for two weeks to freshly prepared 1/2 strength pfeffer's nutrient solution. Micronutrient were supplied to the nutrient solution at concentrations similar to those used by Arnon and Hoagland (1). Dry matter yields were determined at the end of the experimental period (10 days), the freshly harvested organs, viz, roots, stems and leaves were dried in an aerated oven at 70°C. Successive weighing was carried out until the constant dry weight of each sample was reached. Transpiration rate was measured as described by Bozcuk (3).

RESULTS AND DISCUSSION

It was found that 2,4-D or 2,4,5-T in a concentration of 10^{-7} M had no inhibitory effect on the germination of maize, bean and sunflower seeds (Figure 1). The two herbicidal auxins were significantly effective in producing inhibition of germination when supplied in higher levels (10^{-4} and 10^{-3} M). Moreover, the germination of sunflower seeds was much more drastically affected by the high levels of the two applied compounds than was that of either maize or bean seeds. The low percentage germination of the treated seeds, especially at the high concentrations of 2,4-D or 2,4,5-T, is comparable with the results of Mitchell and Marth (16) who indicated that heavy applications of 2,4-D considerably reduced the emergence of grass seedlings of different species from soil sprayed with a water mixture containing 0.1% 2,4-D and 0.5% carbowax 1500.

The possibility of using 2,4-D to destroy germination and seedling growth was also reported by Hamner *et al.* (11). When the acid was applied in solution to the soil, no germination of wheat, cabbage or clover occurred at a concentration of 1 gm (or 0.1 gm of the acid per 4-inch pot of soil). Moreover, at a concantration of 0.01 gm of the acid solution cabbage and clover seeds failed to germinate, however, 85% of wheat germinated, although growth was inhibited somewhat. The results of this study (low percentage germination) and those obtained by other (no germination) suggest that the failure of the treated seeds to germinate, at heavy applications of phenoxyacetic acids may be consequence of retarded water uptake, inhibited cell division, ceased cell elongation, disurpted cell structure and/or imbalanced metabolic

Figure 2: Radicle (•- •) and plumule (0-0) lengths tested plants germinating grains as affected by various concentrations of 2,4-D or 2,4,5-T.



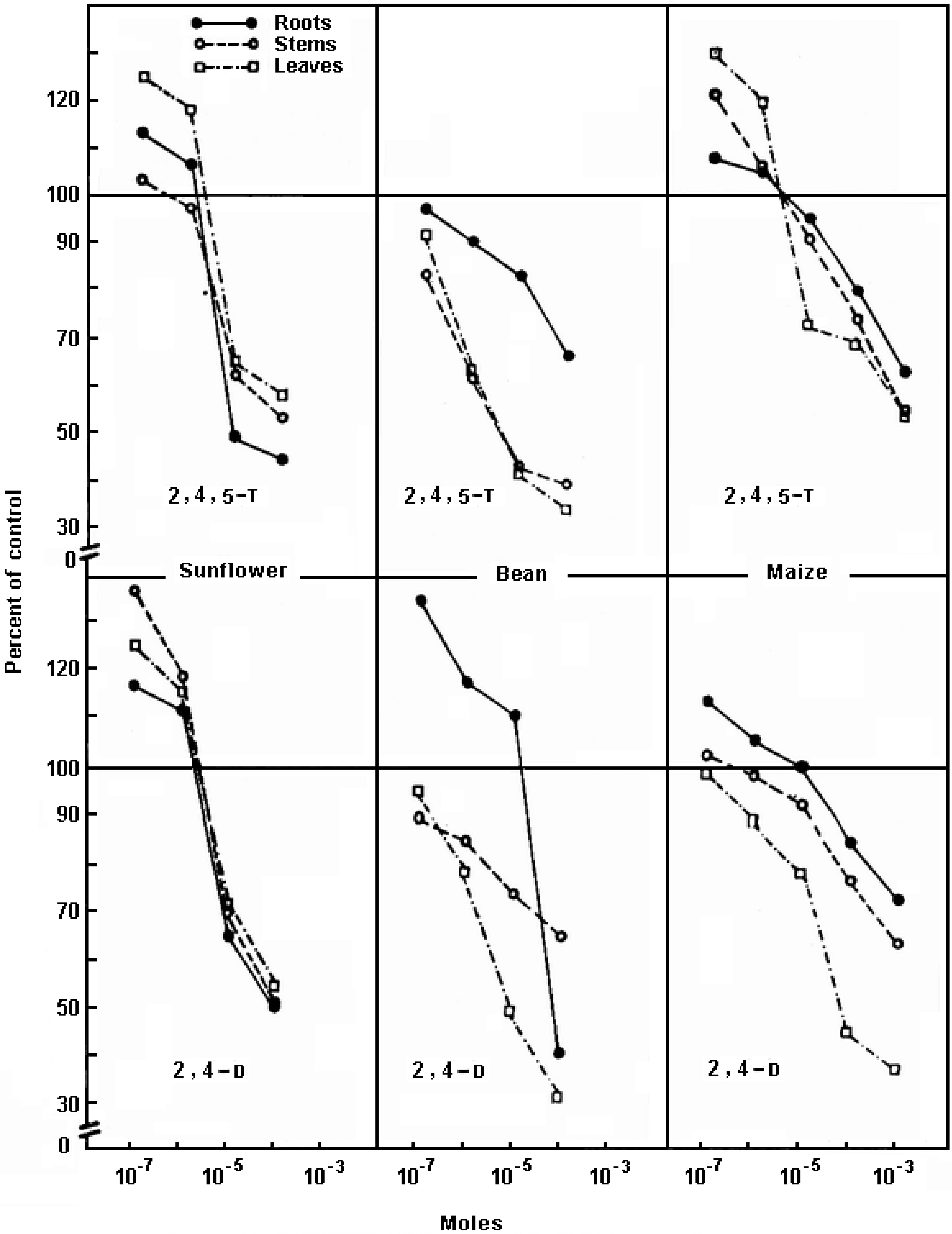
activites which partially or completely inhibit the process of germination. Evidence to support this suggestion may be obtained from the results of various studies on the mode of 2,4-D action. As described by Hanson and Slife (12), when susceptible seedlings are sprayed with 2,4-D the normal growth pattern changes rapidly, meristematic cells cease dividing and elongating cells stop length growth. At the cellular level 2,4-D prevents immature cytoplasm from maturing, and mature cytoplasm reverts to the immature stage.

The role played by 2,4-D and 2,4,5-T supply on radicle and plumule growth was also considered in the present investigation (Figure 2). In this respect, it was found that the radicle and plumule lengths of the germinating seeds were sharply reduced; more prominently at high levels (10^{-4} and 10^{-3} M) of any of the two applied herbicidal auxins. The adverse concentration effects were clearly demonstrated by sunflower germinating seeds treated with 2,4-D or 2,4,5-T at a concentration of 10^{-3} M, where the decrease in radicle or plumule lengths went down to about 97%. Also, at 10^{-3} M 2,4-D the plumule growth of bean germinating seeds was completely inhibited. The advese effects of high concentrations were partially or completely alleviated at lower levels (10^{-5} and 10^{-6} m). Moreover, 10^{-7} M of any of the applied compounds induced significant stimulatory effect on radicle and plumule growth of sunflower and bean germinating seeds. Similarly, in case of maize germinating grains the promotive effects of 2,4-D on radicle and plumule growth and of 2,4,5-T on plumule growth occurred at 10^{-7} M.

The close correspondence between the promotive effects of 2,4-D and 2,4,5-T on the linear growth of radicle and plumule, particularly, at low (10^{-7} M) concentration, and the accordance of their inhibitory effects at high (10^{-3} M) level, suggest that the two compounds are more or less equally effective in stimulating or inhibiting the functional state of the germinating seeds, a prospect which still awaits determination.

There is also a considerable reason to believe that the stimulation and inhibition of linear growth of radicle and plumule, recorded in this work, at low and high concentrations of the applied compounds, may be one aspect of role of the synthetic auxins (2,4-D and 2,4,5-T which are not indole compounds) in the overall phenomenon of plant growth. Evidence to support this suggestion may be obtained from the work of weaver (23), who reported a stimulated and inhibited petiole elongation in soybean plants sprayed with low and high levels of 2,4-D, respectively.

Figure 3: Effect of various concentrations of 2, 4-D and 2,4,5-T on dry matter yields.



The presence of 2,4-D or 2,4,5-T in the culture medium, at a concentration of 10^{-4} M, sharply attenuated the dry matter yields of the different organs of the test plants (Figure 3). The adverse concentration effects of the two applied acids were clearly demonstrated by sunflower and bean plants treated with 2,4-D or 2,4,5-T at a concentration of 10^{-3} M, where the plants exhibited distorted appearance and the leaves collapsed and died by the end of the experimental period.

The harmful effects of synthetic auxins on plant growth were confirmed by other authors. Bhan *et al.* (2) showed that the growth of *Cyperus esculentus* was significantly reduced by 2,4-D, but they claimed that the treated plants were equally sensitive to different rates of 2,4-D. Moreover, the occurrence of a considerable reduction in dry matter gain in the leaves of the test plants under the influence of high concentrations of 2,4-D or 2,4,5-T, is in agreement, with the results of Elliot and Peirson (6), who reported that the reduction in the dry weights of bean leaves increased with increasing 2,4-D concentrations.

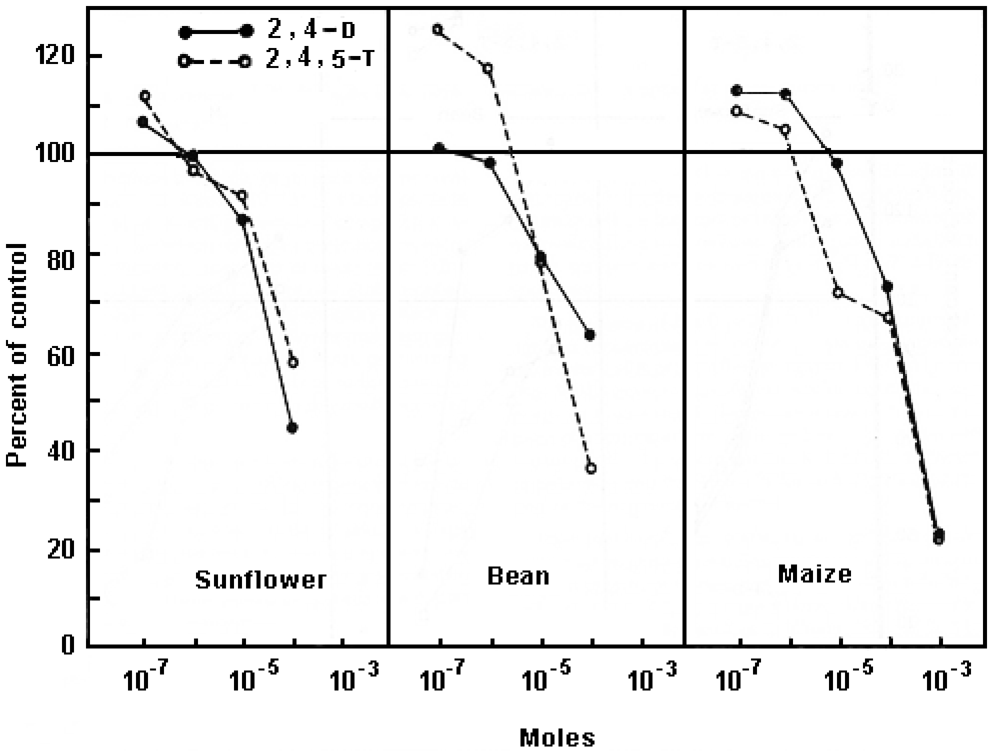
It is worthmentioning that, though all treatments involving 2,4-D or 2,4,5-T, at high concentrations (10^{-4} or 10^{-3} M), strongly inhibited the dry matter gain in the different organs of the test plants, the depressive effects were partially or completely alleviated at the moderate level (10^{-5} M). On the other hand, any of the two applied compounds up to 10^{-6} M failed to hamper the dry matter gain in some organs of the treated plants and contrary to expectation, the growth was stimulated. It appears probable from this response that the two herbicidal auxins, used in this work, are capable of acting as formative agents, if sufficiently lower concentrations were used, a prospect which deserves further consideration.

It should be recalled that:

1. Although the dry matter gain in the different plant organs was more abundant when the test plants were treated with low than with high 2,4-D or 2,4,5-T levels, the effectiveness of the two applied compounds varied in the different test plants.

2. With sunflower and bean plants, the adverse concentration effects of 2,4-D and 2,4,5-T were more pronounced than in case of maize plants. The treatments involving 2,4-D or 2,4,5-T at a concentration of 10^{-3} M led to collapse and withering of the leaves of the two experi-

Figure 4: Effect of various concentrations of 2, 4-D and 2,4,5-T on transpiration rate.



mental dicotyledonous plants and eventual death while in maize the response was reflected in decreased growth. In this respect, none of the extensive investigations concerned with the action of these compounds have provided unequivocal explanation for the death of susceptible plants. The clew to death was explained by Hanson and Slife (12); Gorder and Van Der Zweep (8) and Kiermayer (13), on the basis of abnormal growth responses, which were considered by Van Overbeek (22) to be a consequence of hormonal imbalance. Moreover, Shannon *et al.* (20) reported that death occurs because abnormalities in nucleic acids and protein synthesis preclude normal cell development and function. Cardenas *et al.* (5) attributed the death of the sensitive cocklebur plants to suppression of normal apical growth, failure to produce new root and leaf tissues plus inadequate nutritional maintenance of existing roots and leaves.

Apart from the extensive investigations which have been concerned with the harmful effects of 2,4-D and 2,4,5-T on growth, structure and function of plants, relatively little work had dealt with their role in water relations of plants. In the present investigation, considerable reductions in water loss by the test plants, via transpiration (Figure 4), were induced by the high levels (10^{-4} and 10^{-3} M) of 2,4-D and 2,4,5-T. The retarding effect of any of the two applied acids on transpiration was partially alleviated at the moderate level (10^{-5} M). At lower concentrations (10^{-6} and 10^{-7} M), the transpiration rate values either approached that of the control or increased over it. The effectiveness of the two applied acids varied in the different test plants. With maize the inhibition effects occurred in the following order: 2,4,5-T>2,4-D, while the stimulation effects occurred in a different order: 2,4-D>2,4,5-T. The opposite situation was exhibited by sunflower plants. In case of bean, the inhibition and stimulation effects occurred in the following order: 2,4,5-T>2,4-D.

The inhibitory effects of 2,4-D on transpiration of the test plants, are in agreement, with those reported by Brown (4) with *Phaseouls vulgaris*, Ferri and Mercedes-Rachid (7) with eaves detached from monocotyledonous and dicotyledonous potted plants and Player (18) with castor bean plant. A possible mode of action of 2,4-D or 2,4,5-T may be interference with stomatal function, diffusive resistances of leaves to water vapour transport and/or retarding water uptake by plant roots. The possible impairment of one or more of these parameters, at a certain concentration of 2,4-D or 2,4,5-T, could be attributed to a number of structural changes in the root and leaf cells. Evidence to support this suggestion may be obtained from the results of some studies which were undertaken to secure additional data on the effectiveness of 2,4-D on the fine structure of leaves (9, 10, 14, 24). In the light of their findings, the membrane system of the leaf cells were apparently altered, the leaf cells appeared to be plasmolyzed and disorganized, and the chloroplats were distorted and damaged. All such disruptions may contribute directly or indirectly to the imparinment of the stomatal apparatus function, reflected in decreased water loss via transpiration. The inhibited transpiration, recorded at the high levels of the applied acids should be considered harmful because concomitantly, the potential gradient between leaves and roots which helps in water absorption and translocation should also be affected. Thus, the inhibited transpiration reported here could also be attributed to retarded water absorption. As described by Hanson and Slife (12), when susceptible seedlings are sprayed with 2,4-D the roots lose their ability to absorb water and salts.

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