PHYSIOLOGICAL STUDIES ON DROUGHT RESISTANCE IN TOMATO

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بسم الله الرحمن الرحيم

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I. INTRODUCTION

Tomato (*Lycopersicum esculentum*, Mill.) is one of the most important vegetable crops grown in Egypt. This crop is produced for local consumption as well as for exportation. The average total area cultivated by tomato in Egypt in the last recent years was about 241,098 feddan. It is highly desirable to obtain higher yield of tomato plant using the least possible quantity of water for irrigation.

On the other hand, the concept that drought-resistance is a property developed during ontogenesis made possible the development of a method for increasing the resistance to drought. This method, known as pre-sowing drought hardening or Henckel's method, is done by soaking the seeds in water for a certain period of time and then air-drying.

The pre-sowing drought hardening method was shown to raise the yield of tomatoes at drought. Nevertheless, such a relationship ought to be retested regarding variations amongst varieties as well as between drought levels. This is necessary because the above-mentioned conclusion was unfortunately deduced from a limited number of observations. Such a position seems to be insufficient to draw sharp-cut conclusions about the efficiency of Henckel's method is increasing the yield production in case of tomatoes at moisture tension, particulary as the possibility that such a pre-sowing treatment could be without effect in this regard for some crops, at least under certain conditions, has been reported in literature.

In view of this, the present investigation was carried out, aiming mainly to determine to what extent could the Henckel's method be regarded as an effective treatment for improving the growth and yield of tomatoes under moisture stress conditions. In addition, the same investigation aimed to show how could such a method modify the levels of certain chemical constituents in plant tissues under the same conditions, recognizing that the data available in literature in this connection with regard to tomatoes are conspicuously deficient.

II. REVIEW OF LITERATURE

As mentioned in the "Introduction", the present investigation aimed to determine how could the Henckel's method affect the growth, yield and certain chemical aspects in tomatoes under drought conditions. Therefore, for the presentation of the appropriate literature, it could be thought advisable to comprise herein only studies carried out in two main fields, one for the response of plants to drought, and the other - for their response to the pre-sowing drought hardening carried out according to Henckel's method. With regard to the former area of research, it is well known that the effects of soil moisture stress on plants have been described for several species; hence for reviewing the literature in this concern, records dealing with tomatoes only were presented, though there were certain aspects (namely, concerning the chemical composition) that appeared to be comparatively less studied than others. With respect to the use of Henckel's method , however, it should be recognized that the records available at present are conspicuously deficient, hence the pertaining review of literature should preferably deal even with species other than tomato.

A. Effect of soil moisture stress on growth, yield and some chemical aspects in tomato plants :

1) Growth and yield :

Bacher (1940) suggested that tomato plants should be planted in damp soil and not be watered at all until the fruits begin to grow; small quantities of water should then be given until fruit picking starts after which watering should be liberal to increase both yield and size of fruits.

Went (1944), growing tomatoes in gravel cultures under carefully controlled environmental conditions, came to the conclusion that the water supply did not limit growth of the tomato plant except when moisture approached the permanent wilting point.

Schleusener et al. (1949) obtained high tomato yields in experiments in Michigan by allowing 50 per cent of the available water to be sused before irrigation.

Felföldy (1951) found that the different tomato varieties may respond differently to soil moisture conditions.

Kerr (1952) suggested that up to 30 per cent of the available water might be allowed to be used up before the necessity of watering glasshouse tomatoes became urgent.

Lambeth (1954), working in Missouri, found that tomato yields fell progressively when the crop was not irrigated until

25, 50 and 75 per cent of the available water had been used up.

Salter (1954a) showed that both vegetative growth and yield of glasshouse tomatoes were adversely affected when irrigation of established plants was delayed until as little as 5 per cent of the available water had been used and this was confirmed by other experiments on tomato plants grown in beds (Salter, 1954 b). However, Rose and Dermott (1953), failed to obtain the same results with post-grown plants under similar water regimes.

Fröhlich (1955), after many years' work in Germany, suggested that optimum conditions for the tomato plant are provided when the soil moisture is kept above 70 per cent of the water-holding capacity of the soil.

Gates (1955) described the effects of short periods of acute water shortage on the growth of young tomato plants and concluded that the changes occurring in response to moisture stress were initiated relatively early in the drying cycle. He found further that leaf weight increase was slowed down while stem weight increase was increased; and that, after recovery from wilting, growth rates of moderately to slightly wilted plants soon increased above the growth rate of controls.

Salter (1957) indicated that when tomatoes were planted in about twenty-five inches of sandy loam soil at field capacity, further applications of water to the plants before fruiting reduced final yield of fruit. After fruiting had started, maximum growth and yield had been obtained from plants growing in soil maintained near field capacity. Changing the water-regime when fruit picking commenced resulted in reduced growth and yield. Furthermore, it was shown that tomato plants, when planted in soil at field capacity, did not seem to respond to irrigation until their roots had fully occupied the available rooting zone. In addition, a larger average size of fruit was produced under the wettest regime.

Salter (1958) carried out an investigation to determine the effect of soil moisture conditions on the relationship between vegetative growth and fruit development of the tomato plant under glasshouse conditions. It appeared that greatest vegetative growth was obtained with a small fruit load under conditions of high soil moisture. Conversely, weakest vegetative growth was found with a large fruit load under conditions where the soil was allowed to dry out between irrigation nearly to the permanent wilting point.

Cannell et al. (1960), working with tomato plants grown on different types of soil, noticed that total dry-weight yields increased with decreased soil suction.

Carolus et al. (1965), in studies with tomato plants, found that as available soil moisture increased from low (20%) to high (85%), under high atmospheric stress, fruit number increased (47%) and fruit size 49%; under low atmospheric stress, fruit did not vary significantly in size and 23% fewer fruits were produced.

Duranti (1967) carried out some experiments with certain tomato varieties; The daily consumption of water was replenished either in full or in part (70% and 40%). The driest regime resulted in retarded growth, pale colouring of the plants, small leaves, reduced branching, early flowering, reduced fruit set and retarded ripening, compared with the full water supply. Highly significant differences between the 3 regimes were shown in fresh and dry weight figures for the whole plant and its constituent parts. Leaf and fruit number were also positively related to water supply. The plant parts most adversely affected by shortage of water appeared to depend upon the type of variety studied.

Thorup (1969) studied the effect of soil moisture tension upon root growth of tomato plants using a split-root technique. Root systems were developed in soil maintained at three different moisture levels - one well below PWP, another slightly below PWP, and a third within the "available" range. Root growth was very restricted at the lowest level of soil moisture - attaining a maximum length of 20 mm

At the level slightly below PWP, roots grew to a length of 90 mm, with substantial secondary root development. Maximum growth was attained at the moisture level maintained above PWP. At this level roots reached a length of 150 mm and exhibited extensive secondary branching.

2) Chemical composition :

As mentioned earlier, relatively little attention has been paid to the study of chemical composition of tomato plants under drought conditions. Thus, with regard to carbohydrates content, Woodhams and Kozlowski (1954) studied the effects of different degrees of moisture stress on reserves of such compounds in tomato. Plants were analyzed for starch and sugars at three periods : 1) just before soil reached wilting percentage for the first time, 2) after plants had remained in soil at wilting percentage for 24 hr. and were re-irrigated and remained at field capacity for 24 hr., 3) at the end of 8 wk. growth during which time plants were subjected to 4 periods of moisture stress and re-irrigated to field capacity after the first three droughts. Samples were then taken at the end of the fourth drought which was not followed by irrigation. It appeared that, before plants had reached the permanent wilting percentage for the first time, sugars and starch decreased in root, stems and leaves.

Following irrigation there was a rapid and marked starch increase but no corresponding increase in reducing and nonreducing sugars. At the end of 8 wk. growth during which plants were subjected to several severe droughts, total reserve carbohydrates were much less than at any other period.

With regard to the field of response of mineral composition to moisture stress, the work of Emmert (1936) might be mentioned. In such investigation, it was found that tomato leaves grown under relatively low soil moisture conditions were higher in N and K and lower in P than those grown under moist conditions. Thomas et al. (1942) studied also the relationship between moisture treatments and various fertilizer levels in tomato leaves. It appeared that nitrogen and P were increased with decreasing soil moisture, but a variable effect was found on the K content. Furthermore, Cannell et al. (1960) noticed that, in certain types of soil, the drier the soil the greater was the concentration of N, P and K in tomato leaf tissue. However, in another type of soil, the authors found that the percentage of P in leaf tissue decreased significantly as soil suction was increased, though the percentage of K increased significantly under such conditions. In the same area of research, Kozlowski (1964) reported that nitrogen contents of tomato were increased in plants under stress; though, during wilting, N as well as P were reduced.