Chapter 7

Water Relations of Peanut Plants

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In many agricultural areas, supplemental watering allows farmers to avoid disastrous yield losses in a "drought year". However, watering regimes for a particular crop must be built around an understanding of the physiology of the species in question. Too little emphasis has been put on careful studies of how water status of peanut plants relates to growth and yield.

There are several reasons for a lack of research on water relations of peanut plants. They are grown, for the most part, under natural rainfall in areas where researchers are concerned with problems other than water and where research in all areas of plant physiology has been not especially vigorous. Perhaps more important is the fact that it has only been in the past decade or so that accurate assessments of plant water status could be conveniently made. This chapter will review briefly the published research and will point out several areas where research is needed.

Water status invariably affects plant growth and development. About 80 percent of plant fresh weight is water. Reduction of the plant water status much below this level causes visible wilting and affects the rate of many plant functions. When young roots and shoots grow, most of the added volume is water, which becomes part of the large central vacuole characteristic of mature plant cells. Water enters the vacuole from

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regions with a water potential[2] higher than the cell vacuole and pushes the cell walls outward. Turgor pressure causes tissue expansion. If soil moisture is low, sufficient water does not enter the elongation zone of roots to give a high rate of elongation. Thus, there is a shortening of those regions of the root with surfaces most permeable to water and minerals. Roots growing in dry soil, therefore, have less fresh tissue in contact with newly-explored areas of soil. The inevitable result of a reduction in root growth is a reduction in water- and nutrient-supplying power of root systems and a consequent reduction in shoot growth. Droughted plants have been shown (Lin *et al.*, 1963) to have smaller tops, fewer branches, and fewer flowers. Even though both leaf number and stem length are reduced, the latter decreases more markedly so that the leaves are arranged more compactly on the stems (Prevot and Ollagnier, 1957; Ochs and Wormer, 1959). Smaller thicker leaves have been reported (Lin *et al.*, 1963) as well as smaller numbers of stomates and differences in the size and number of water-conducting cells (Ilyina, 1959). Calcium and boron deficiency symptoms can occur with severe drought (Gillier, 1969).

Few observations have been made on root growth and development under drought conditions. Data of Lin *et al.* (1963) indicate that drought may increase rooting depth very slightly (5 to 10%) but reduces the radius of root distribution to about two-thirds of the values for check plants. Slatyer (1955) reported the extent of the root system of peanut plants to be intermediate between grain sorghum, which had many roots, and cotton, which had the least of the three crops. Furthermore, reduction in growth rate during a drought occurred first for cotton, second for peanut and third for grain sorghum. From this it would appear that the extent of the root system is an important factor in drought resistance. Thus, it is somewhat surprising that the drought resistance of certain peanut varieties does not result from a better development of their root systems (Billaz, 1962).

Water entering roots proximal to the elongation zone moves upward and replaces transpirational losses. The entry of water depends on (1) the water potential gradient from the soil into the root and (2) the permeability of the root tissues to water. For most crops, more than 95 per cent of the water absorbed is lost; only a very small proportion remains as a part of plant tissues. The transpiration ratio (grams of water lost per gram of dry matter fixed) has not been accurately determined for peanuts.

Stomates are the primary avenue of water loss from most plants. Peanuts are amphistomatous, having approximately equal numbers of stomates on the upper and lower epidermis (Ilyina, 1959). A strong Ivanoff effect (*i.e.*, rapid opening of stomates in response to sudden wilting of the leaf) has been reported (Shimshi, 1967a); however, the practical significance of this effect, which normally is observed only following such experimental procedures as leaf excision, is not at all clear. Stomates are closed at night and open during the day with the maximum level of opening being in the middle of the day (Wormer and Ochs, 1959). Transpiration rates of plants in soil at the wilting percentage are relatively high (66 percent of the maximum rate) and the stomates are still partially open (Wormer and Ochs, 1959). Peanuts can maintain a higher leaf water content in dry soil and can continue to carry on photosynthesis at a lower leaf content than barley, wheat and soybeans (Iyama and Murata, 1961).

When stomates close with wilting, carbon dioxide fixation will be reduced. Furthermore, wilting probably reduces the rate of translocation of photosynthate to

[2]Water potential is numerically equal to, but opposite in sign to, the diffusion pressure deficit. It is the plant property which corresponds to the total soil moisture stress or the soil water potential.

growing areas (roots, gynophores, seeds, etc.). Measurements of radiocarbon fixation and translocation have not been reported for peanuts at measured levels of plant water stress, but almost certainly such studies would show that drought lowers yield at least in part by decreasing rates of both photosynthesis and translocation. Effects of plant water status on the protein, oil, and flavor content of nuts has not been delineated.

Several stages in the plant life cycle might be expected to be sensitive to drought, particularly (1) early vegetative growth, (2) flowering and pegging down, and (3) nut maturation. Some of these have been found to be more sensitive to water deficits than others, but none of them can proceed normally below some minimal plant water content. Research can clarify the limits of tolerance to water deficit for each of these phases of development. Considerable work has been concerned with the problem of which of these stages is most sensitive to water stress, but unfortunately, plant water status has rarely been measured; often soil moisture was neither controlled nor measured. Since the plant water status is the result of a balance between water taken up from the soil and water lost to the atmosphere, it is a very dynamic property and must be monitored in definitive experiments. Gautreau (1969) has shown that suction pressure (plant water potential) is closely related to aerial environmental conditions; this has generally been found true for other crops. More measurements of plant water potential, which is considered to be a physiologically-significant property, should be made on peanuts under various drought conditions.

All investigators agree that the period of greatest sensitivity to drought occurs about six to eight weeks after sowing. This is the period of vigorous flowering. Prevot and Ollagnier (1957) put the period of greatest sensitivity to drought at 30 to 50 days after sowing, Fourrier and Prevot (1958) at 35 to 60 days, Wormer and Ochs (1959) at 30 to 60 days, Billaz and Ochs (1961) at 50 to 80 days, Su *et al.* (1964) at 50 days or peak flowering, and Su and Lu (1963) at peak flowering to early fruiting or 30-60 days. There is not such complete agreement on how the other stages compare in their sensitivity to drought, but differences in experimental techniques and in local soil and climatic conditions could cause somewhat different results. Generally, very early growth has been found to be not especially sensitive to drought, and pegging down and nut maturation are less sensitive than the peak flowering stage. The water absorbed during the first month after sowing is small compared to the quantity required during the second month (Su *et al.,* 1964). This difference may explain why early growth is not as sensitive to drought as is later growth. The fact that peak flowering and maximum sensitivity to drought coincide could be a result of the increased demand for water by the growing top or it might be caused by the fact that the root system is less efficient during flowering. For some species, flowering can lead to a temporary depression of root growth so that the root system is less efficient during flowering than either before or afterwards, but no one has investigated this problem for peanut plants.

Peanuts have an unusual relationship with soil in that soil must supply water to roots and also must allow penetration of the gynophore. Experiments such as those of Cox (1962) with soil water in the fruiting zone separately controlled from that in the rooting zone should clarify the water relations of the pegging-down process. However, it is certain that the turgor of elongating cells in the gynophore supplies force for the pentration process so that pegging may be sensitive to soil water levels in the rooting zone. How the water content of the fruiting zone affects pegging is as yet uncertain. It seems unlikely that much water could be absorbed by the gynophore once it is in the soil, but the quantity absorbed has not been established.

There are many unanswered questions about water relations of peanut plants, but the major thing which should be done in future experiments is to measure plant water status as well as soil and aerial conditions.

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