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PLANT WATER STATUS OF APPLE TREES AND ITS MEASUREMENT IN THE FIELD. 6. DIURNAL VARIATIONS IN THE WATER POTENTIAL OF APPLE LEAVES AND FRUITS OF THREE VARIETIES AT TWO STRESS LEVELS

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SUMMARY

Diurnal measurements of water potential in apple leaves and fruits were made concurrently on three apple varieties—Delicious, Jonathan and Granny Smith.

Compared with leaf water potentials, fruit potentials showed much less diurnal variation, and it seems that fruits may be able to exercise better control over water balance than leaves. Fruits do not seem to be a sensitive indicator of plant water stress, and therefore would seem to be of limited use for irrigation indexing.

Evidence accumulated as early as 1935 shows that apple fruit growth rate is not a sensitive indicator of plant water deficits. This would seem to tie in with the ability of fruits to exercise good control over their internal water balance.

Factors such as variety, fruit size, maturity, crop loading, tree foliage display and the relationship between fruit and leaf potentials may influence the pattern of diurnal variations in fruits and leaves. These plant factors which interact with soil and atmospheric variables require further investigation.

I. INTRODUCTION

Diurnal variations in water deficits of leaves have been reported by a number of workers, including Slatyer (1955), Begg *et al.* (1964) and Slatyer (1967). With apple fruits, while marked diurnal changes in fruit volume, in response to transpiration, have been observed by Magness, Degman and Furr (1935), diurnal changes in water potential of fruits do not seem to have been reported.

In this paper concurrent diurnal observations of water potentials in apple leaves and fruits are presented and the development, recovery and magnitude of such potentials are discussed. All observations were made on three apple varieties—Delicious, Jonathan and Granny Smith.

II. MATERIALS AND METHODS

To depict the diurnal fluctuations in water potentials of apple leaves and fruits of the three varieties, six sampling times at 4-hour intervals (7.00 a.m., 11.00 a.m., 3.00 p.m., 7.00 p.m., 11.00 p.m., and 3.00 a.m.) were chosen. Three field replicates, of single tree plots, were utilized for each variety. Seven fully expanded, exposed, terminal spur leaves and two exposed fruits were sampled at a height of 5 ft above ground level from each replicate on each occasion.

In the laboratory, water potentials were determined on leaves and fruits by the dye techniques described by Chapman (1970*a*, 1970*b*).

The diurnal variations in water potential were recorded for Delicious and Jonathan on two occasions, and once for Granny Smith. The two occasions were used to compare diurnal trends following two different early morning residual stresses.

III. RESULTS AND DISCUSSION

Figures 1–3 show diurnal variations in water potential of apple leaves and fruits of Delicious, Jonathan and Granny Smith, respectively.

For Delicious on both occasions, daytime leaf water potentials were lower than values at night and in the early morning. Recovery to zero potential did not occur on either occasion. A levelling off at the lowest potentials reached was evident and this probably resulted from stomatal closure.

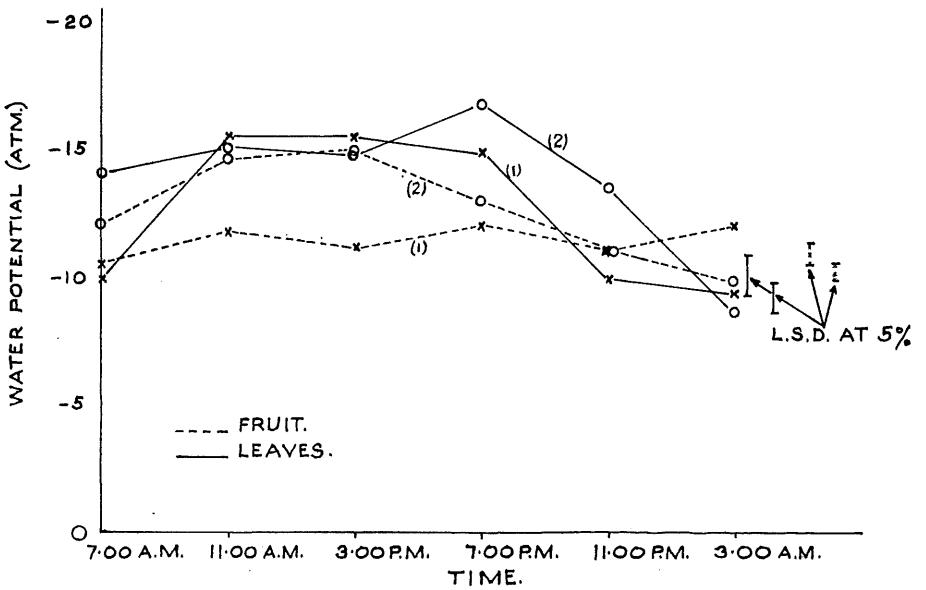

Fig. 1.—Diurnal variations in the water potential of leaves and fruits of Delicious on two occasions.

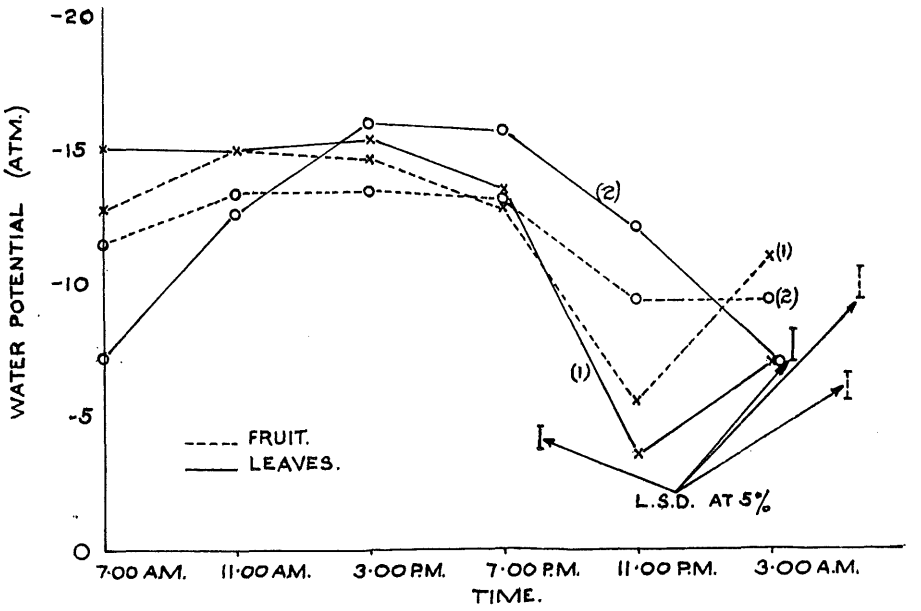

Fig. 2.—Diurnal variations in the water potential of leaves and fruits of Jonathan on two occasions.

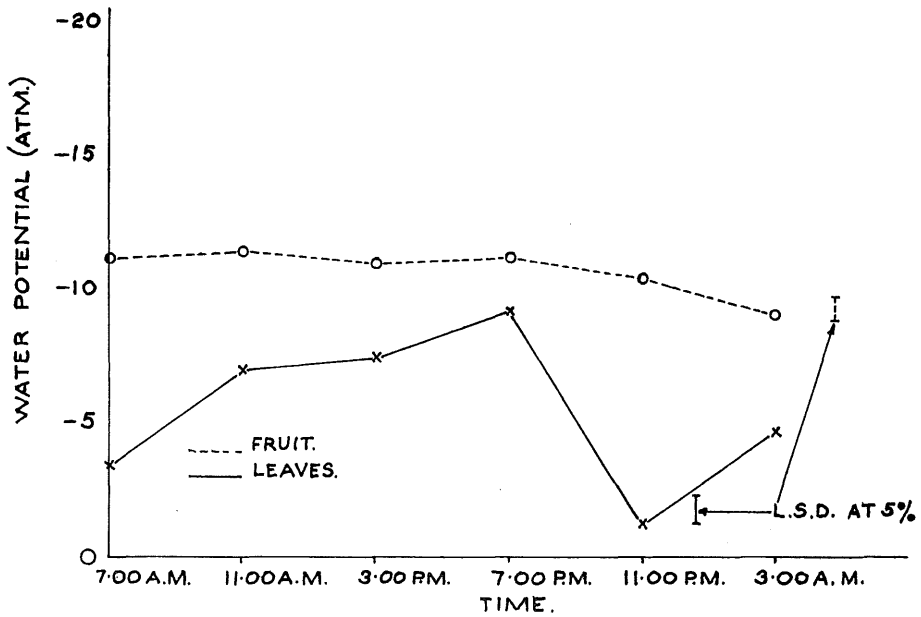

Fig. 3.—Diurnal variations in the water potential of leaves and fruits of Granny Smith.

With Jonathan, both occasions showed similar diurnal amplitudes, with a levelling out at the lower leaf potentials during the daylight hours, as was the case for Delicious. However, on occasion 1, fluctuations in water potential during the daytime were small, and lowest potentials reached closely resembled the initial potentials at 7.00 a.m. The fall in water potential between 11.00 p.m. and 3.00 a.m. is difficult to explain but may have resulted from internal redistributions of water and solutes between plant parts (Slatyer 1967).

Granny Smith showed a marked diurnal trend in leaf water potential, but the amplitude was less than for the other varieties, and values were also higher. A similar effect to that with Jonathan (occasion 1) was noted between 11.00 p.m. and 3.00 a.m.

For all three varieties, early morning leaf water potentials at 7.00 a.m. approximated those of the soil (separately determined) on the two occasions on which they were measured. Values for leaves were generally slightly lower than those for the soil.

Significant diurnal variations in fruit water potential occurred with all varieties. Amplitudes of variation were large on some occasions, while others were smaller, and these probably resulted from differing daytime evaporative demand and different residual stresses at the outset.

For Delicious and Jonathan, on occasion 1, a significant fall in fruit water potential between 11.00 p.m. and 3.00 a.m. was noted, while a significant rise between the same hours was recorded for Delicious (occasion 2) and Granny Smith. Again, the fall in potential can presumably be related to internal redistribution of water and solutes, while a rise in potential may be attributed to normal recovery of the absorption lag, which may have been reinforced with the absorption of dew by aerial plant parts.

Table 1 shows the diurnal amplitudes of water potential, for leaves and fruits of the three varieties, on the various occasions when leaf and fruit potentials were measured concurrently.

TABLE 1

DIURNAL AMPLITUDE OF WATER POTENTIAL (atm) FOR LEAVES AND FRUITS OF THREE APPLE VARIETIES ON DIFFERENT OCCASIONS

Variety	Occasion	Diurnal Water Potential Amplitude	
		Leaves	Fruits
Delicious	1	6·03	1·16
	2	8·21	5·10
Jonathan	1	11·75	9·40
	2	9·10	4·05
Granny Smith ..	1	7·95	2·25

Compared with leaf water potentials, fruit potentials showed much less diurnal variation in amplitude. It seems that fruits are less susceptible to diurnal variations in water potential than leaves and may therefore be able to exercise better control over water balance than leaves. The relationship between relative water content and water potential of fruits may differ from that of leaves and this relationship may govern the ultimate effect of a given potential on fruit growth and development. However, Magness, Degman and Furr (1935) considered that apple fruit growth rate was not a sensitive indicator of plant water deficit, and this ties in with the above findings relating to fruit water potential.

It is possible that while diurnal fluctuations in fruit and leaf water potentials occur, factors such as variety, fruit size, maturity, crop loading, tree foliage development and the relationship between fruit and leaf water potential could influence the pattern of such variations. Further to this, soil and atmospheric factors will interact with these plant factors to determine the diurnal pattern. More detailed studies will be required to assess the significance of these plant factors in relation to soil and atmospheric environmental conditions.

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