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WATER RELATIONS OF *PHYTOPHTHORA* INFECTED FUERTE TREES AND THEIR INFLUENCE ON MANAGEMENT

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OPSOMMING

Die water verwantskap van agteruitgaande en effens worte/vrot besmette Fuerte borne, om die effek op besproeiing en ander boordbeheer, is ondersoek.

Die verwantskap tussen die huidmondjie diffusieweerstand (R_s), en blaarwaterpotensiaal (Ψℓ) vir die effens besmette boom, was omtrent dieselfde as die vir onbesmette borne. Die huidmondjies h et by ongeveer -400 kPa Ψℓ begin sluit, en was by -900 Ψℓ kPa (heeltemal toe. Die swak boom bet geen verwantskap gewys nie.

Effens besmette borne kon nie genoeg water teen -55kPa Ψℓ grond opneem nie. Sigbare waterkort by normale besproeiingstyd 1-50 kPa Ψℓ grondl kan miskien wortelbeskadiging aandui, en die kweker moet tydig optree om verdere agteruitgang te verhoed.

SUMMARY

The water relations of advanced and slightly root rot infected Fuerte avocado trees were investigated, in order to examine the effect on irrigation and other management.

The stomatal resistance (R_s) and leaf water potent/a/ (Ψℓ) relationship for the slightly affected tree was similar to healthy trees, stomatal closure beginning at approximately -400 kPa Ψℓ, with final closure at -900 kPa Ψℓ. The badly affected tree showed no relationship.

Slightly affected trees were unable to absorb sufficient moisture at -55kPa Ψℓ soil. Visible stress at normal irrigation (-50 kPa Ψℓ soil) could indicate root damage, allowing the grower to take timeous remedial action.

INTRODUCTION

The avocado tree decline caused by *Phytophthora cinnamomi* is one of the greatest problems facing the avocado farmer in South Africa. There is virtually no chance that the fungus can be eradicated. Therefore, satisfactory means of living with the fungus must be found. This includes the correct choice of soil type and management (Wolstenholme, BN. 1977), the use of fungicides where necessary, and the extremely important factor of correct irrigation management.

The avocado tree is well known to be sensitive to drought stress, the stomata closing at a relatively high (less negative) leaf water potential ($\Psi\ell$) when compared to many other crops. Avocado roots are very sensitive to oxygen status in the soil (Wager, VA 1942; Zentmyer, GA, AO Paulus, CD Gustafson, JM Wallace & RM Burns. 1965; Stolzy, LH, GA Zentmyer, LJ Klotz & CK Labanauskas. 1967). Low oxygen status causes large scale root destruction. These conditions also favour attack by the root rot fungus *P. cinnamomi.* The farmer is therefore forced to maintain a precise irrigation schedule in order to maintain soil moisture between these two extremes if high production and longevity of the trees is to be assured.

The presence of root damage must eventually affect tree water relations (as evidenced by wilting in advanced cases of root damaged trees). It is therefore necessary to investigate these effects, before it can be decided when and what alterations, in irrigation and other orchard management are required to maintain tree production and longevity. In an attempt to clarify the question, the water relations of *P, cinnamomi* infected orchard trees were studied.

MATERIALS AND METHODS

Two Fuerte avocado trees in the avocado orchard at Ukulinga experimental farm in Natal were used in the study. Both were in the same row, were approximately nine years old and irrigated by a drag line system. The soil was of the Westleigh series, with an effective rooting depth of approximately 500 mm, and predisposed to water logging. One tree was severely wilted throughout the experimental period (approximately two months), while the healthier tree showed almost no stress symptoms to begin with. It was however, surrounded by trees in an advanced stage of decline, and some root destruction appeared evident.

Stomatal resistance (RJ and leaf water potential ($\Psi\ell$) were measured during a drying cycle. Mature, fully expanded leaves were chosen from a height of approximately 2 m above ground level, so as to eliminate as far as possible variation in $\Psi\ell$ due to tree height (Miller, BD & OT Denmead. 1976). The readings were all taken as close as possible to 14hOO to eliminate diurnal $\Psi\ell$ (and possibly RJ variations (Bower, JP. 1978). R_s was measured with a previously calibrated Lambda diffusive resistance meter as originally designed by Van Bavel, CH, LS Nakayama & WL Ehler (1965), and modified by Kanemasu, ET, GN Thyrtell & CB Tanner (1969). Leaf temperature was measured using a Bat 4 direct temperature reading thermocouple. Directly after R_s measurement, each leaf was placed in a P.M.S. pressure chamber for $\Psi\ell$ determination. Before sealing, approximately 10 mm of the petiole end was removed to eliminate errors due to air entry during leaf preparation. The pressure of the chamber was slowly increased until a droplet of xylem sap just appeared at the petiole surface, in accordance with recommendations of Slavik, B (1974), Rutherford, RJ & JM de Jager (1965). Sterne, RE, MR Kaufmann & GA Zentmyer (1977) confirm this to be a realistic estimate of $\Psi\ell$ in the avocado.

Soil moisture potential (Ψ soil) was determined by means of tensiometers placed just inside the drip line on the north-western side of the tree. The ceramic cup was placed such that one tensiometer measured Ψ soil at the 300 mm depth, and another at 500 mm (effective maximum feeder root depth as confirmed by soil cores). Readings were taken at the same time as the R_s and Ψℓ measurements.

Environmental evaporative demand was monitored by means of air temperature and relative humidity measurements, as these factors can affect Stomatal reactions (Meidner, H & DW Sheriff. 1976; Ackerson, RG & DR Krieg. 1977).

RESULTS

Fig. 1 shows the relationship between R_s and Ψℓ for the tree which at first appeared normal. No stomatal closure was evident with decreasing Ψℓ until Ψℓ had decreased to approximately -400 kPa. Thereafter, stomatal closure began, as evidenced by increasing stomatal resistance, becoming more rapid with decreasing Ψℓ until final closure in the region of -900 kPa Ψℓ.

The reaction of the stomates to decreasing Ψ soil followed a similar pattern (Fig. 2). With decreasing (more negative) Ψ soil, little or no stomatal reaction occurred until approximately -25 kPa to -30 kPa. As Ψ soil decreased further, stomatal closure began, with final closure at approximately -55 kPa. The Ψ soil readings used were those at 300 mm, the 500 mm deep tensiometers showing virtually no difference.

In the case of the obviously badly root rot affected tree, stomatal condition was such that meaningful curves of R_s Ψℓ and Ψ soil were impossible to plot. However it may be important to note that during the whole experimental period, the mean R_s was 11,02 scm^{-1}, with many leaves being far above this towards the end of the experimental period. The Ψℓ measured showed very little relation to R_s. The tensiometer readings however, indicated a Ψ soil which never became more negative than -10 kPa. Virtually waterlogged conditions thus prevailed in this region.

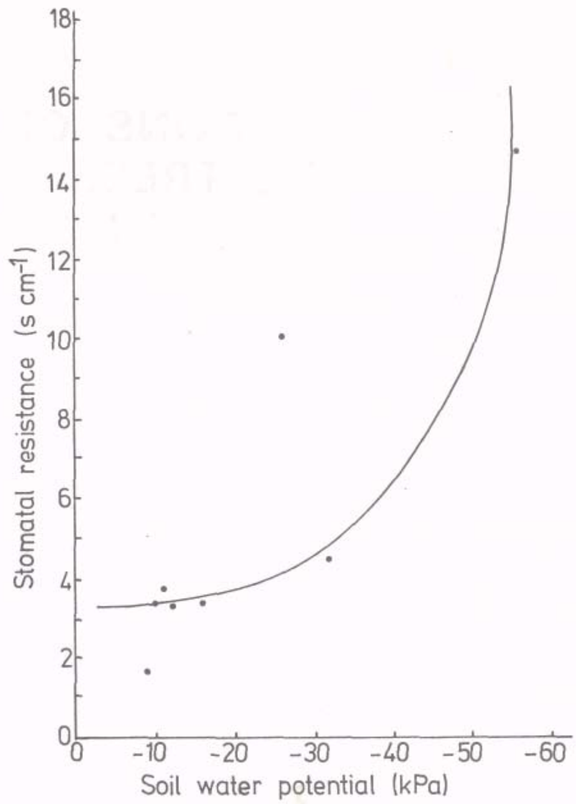

FIG. 2: Stomatal resistance vs soil water potential

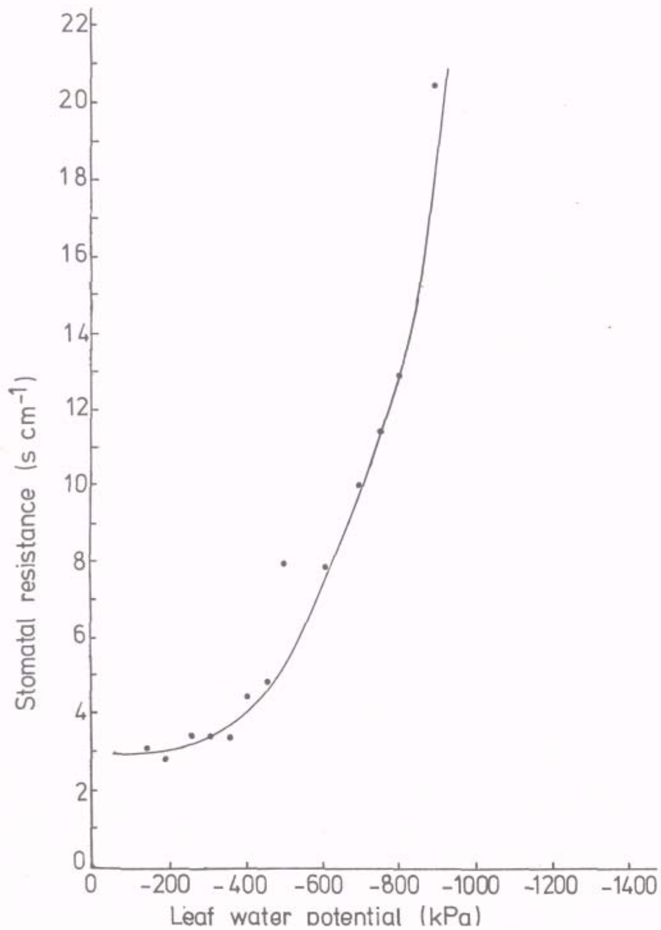

FIG. 1: Stomatal resistance vs leaf water potential

DISCUSSION AND CONCLUSIONS

An important aspect in this work, is shown by Fig. 1. This curve of R_s against $\Psi\ell$ shows a similar pattern and threshold value to that found in many crops, for example -700 kPa to -900 kPa for tomatoes (Duniway, JM. 1971), -1050 kPa for potatoes (Rutherford, RJ & JM de Jager. 1965) and —1300 kPa for vine leaves (Liu, WT, R Pool, W Wenkert & PE Kriedemann. 1977). The curve was also extremely close to that found in two year old pot plant Fuerte avocados (Bower, JP. 1978). This means that not only do older trees probably react physiologically to water stress in the same way, but so do trees which are suffering mild root rot.

The reaction of the stomata to decreasing Ψ soil (as shown in Fig. 2) was however not as similar to that previously found for completely healthy plants (Bower, JP. 1978). While it was previously found that stomata became fully closed at Ψ soil of approximately -70 kPa, root rot trees appear unable to take up sufficient water at this soil moisture tension and moderate environmental conditions. This serves to illustrate the importance of precise irrigation management. Recommendations whereby Ψ soil should be maintained between approximately -25 kPa and -60 kPa, with irrigation beginning not later than -50 kPa, values of i/soil which were confirmed by long term irrigation trials in Israel (Lahav, E & JD Kalmar. 1977; Lahav, E. 1979), can still be advocated. However, should trees show signs of stress by -50 kPa for no apparent reason, root damage should be investigated, and drastic action such as cutting back, application of fungicides, and possibly removal of fruit (which is a severe drain on tree reserves and is also in the author's observation affected in quality, perhaps leading to post harvest problems), should be carried out.)

If no action is taken, trees are soon liable to degenerate to the state of the experimental tree with severe root rot symptoms. Physiological destruction of the leaves was evidenced by chlorophyll destruction. Evidence from the literature (Kriedemann, PE, BR Loveys, GL Fuller & AC Leopold. 1972; Beardsell, MF & D Cohen. 1975) indicates that abscisic acid levels in these leaves would be high enough to prevent stomatal opening, even under favourable $\Psi\ell$ conditions. This would explain the lack of expected relationship between R_s and $\Psi\ell$.

If the mean stomatal resistance of the severely declining tree during the experimental period is taken as an indication of tree condition, and compared with the photosynthetic reaction to stomatal closure (Bower, JP. 1978), then indications are that a tree in this condition could not exceed 20 per cent of the potential net photosynthetic rate. This could not support a crop, would result in the mobilization of reserves to the fruit which is normally a strong metabolic sink (Leopold, AG & PE Kriedemann. 1975), and probably cause a lack of ability to regenerate root tissue. The prognosis for such a tree, even if drastic managerial action is later taken, is probably not good. It is thus essential that action is taken before this stage.

It is hoped that the data presented can be used, together with a careful monitoring of tree and tensiometer conditions as an early warning of root damage, and that the farmer will therefore be able to take the timeous (even if drastic) action necessary to save his trees and investment.

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