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DAILY TRUNK CONTRACTION IN RELATION TO A BASE LINE AS AN IMPROVED CRITERION FOR IRRIGATION IN AVOCADO

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Maximum daily trunk contraction, calculated through the difference between the maximum and minimum diameter in a certain day, may be considered as a criterion for irrigation. The irrigation strategy in many orchards is based on empirical changes in order to have a minimum daily trunk contraction. Maximum daily trunk contraction does not show full measurement of accumulated stress. In conditions of accumulated stress, the daily maximum contraction increases under a limited range; while in extreme stress conditions, the maximum daily trunk contraction tends to decrease. The criteria for irrigation can be improved in order to be applied under accumulated stress conditions, by establishing a baseline to measure the changes in the trunk diameter. The maximum daily contraction in relation to a baseline will increase in accumulated stress conditions, with the possibility of being used as criterion for irrigation. We found expression of this hypothesis in the poor correlation between the trunk contraction, calculated in the traditional way, and the vapour pressure deficit (VPD) in the atmosphere (R^2=0.63), contrasting with the high correlation with the daily maximum contraction, calculated in relation to the baseline reference (R^2=0.91). The baseline is arbitrarily determined but even a parallel line improves the correlation between VPD and the daily maximum contraction. The determination of the daily maximum trunk contraction in relation to a baseline reference should be included

as a useful parameter to determine irrigation in avocado.

Key words: avocado, trunk, contraction, irrigation, base line

CONTRACCIÓN DIARIA DEL TRONCO EN RELACION A UN PUNTO DE REFERENCIA COMO CRITERIO MEJORADO PARA EL RIEGO DEL AGUACATE

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La contracción diaria máxima del tronco, calculada por la diferencia en diámetro máximo y mínimo en un día determinado, puede ser considerada como un criterio del riego. La estrategia de riego en muchas plantaciones está basada en cambios empíricos, con el objeto de que la contracción diurna sea mínima. En

casos de estrés acumulado, la máxima contracción diurna no expresa una medida integral del estrés. La contracción diaria máxima del tronco aumenta de manera limitada con el aumento del estrés. En casos extremos, la contracción tiende a disminuir con el aumento del estrés, lo que convierte al criterio de contracción diaria máxima del tronco en un aspecto inviable para la toma de decisiones de riego. Es posible mejorar el criterio para también posibilitar su uso en condiciones de estrés acumulado, si los cambios de diámetro del tronco son medidos en relación a un punto de referencia. La máxima contracción diaria del tronco, en relación a una línea de referencia, aumentará en condiciones de estrés acumulado pudiendo entonces servir como criterio también en estas situaciones. Encontramos una expresión de esta hipótesis en la baja correlación entre la contracción diaria del tronco, calculada en la forma regular, y el déficit de presión de vapor (DPV) en la atmósfera (R^2=0.63), en contraste con la alta correlación con la contracción máxima del tronco, calculada en relación a una línea de referencia (R^2=0.91). La línea de referencia es determinada arbitrariamente pudiendo ser paralela al X asís. La determinación de la contracción diaria del tronco en relación a una línea de referencia arbitraria debe ser incluida como un parámetro útil en la determinación del riego del aguacate.

The diameter of different plant organs such leaves, branches, trunk and fruits change during the 24 h day and there is a daily periodical in which those organs contract during day and expand during night becoming maximal in the morning. The contraction during the day is due to a temporary stress of the tree caused mainly by conditions where there is more evapotranspiration of water, than the is capable of suck through the roots. In avocado orchards where the irrigation decisions are based on changes on plant parameters, the maximum daily contraction (MDC) is the parameter used. The MDC is the difference between maximal and minimal diameter of the trunk reached during the day (Fig.1).

Avocado best results in relation to irrigation are achieved applying a non-stress strategy (Adato personal communication, 1997). This hypothesis is based on the positive results achieved in field trials and practical applications in the last 10 years in Israel. This strategy is based on empirical changes in the irrigation that leads to a MDC to a minimum. The MDC changes not only according to the availability of the water in the soil but also is influenced by climatic parameters. The vapor pressure deficit (VPD) in the atmosphere changes with temperature and humidity. The VPD is low at low temperature and high humidity conditions, when there is low evaporation. The VPD increases with the rise in the temperature and lowering the humidity, and at those conditions there is a parallel increase in the evapotranspiration. Conditions that increase the VPD also increase the MDC. Under same range of water deficit the increase in MDS with VPD is higher and it is possible to decrease the MDC with irrigation. At near optimal irrigation conditions the MDC is proportional to VPD and the trunk grow (Fig.1), i.e., the maximal trunk diameter achieved in a determined morning is wider than the morning of the previous day.

Maximum daily trunk contraction do not give full expression of accumulated stress conditions.

The diurnal changes in trunk diameter from 3th of December 2005 till the 1th of February 2006 in an avocado orchard in Israel costal area is shown in figure 2.

During this season the maximum VPD in most days is under 1.5 kilopascal (Kpa) and reaches zero during nights due to the relative low temperature and high relative humidity in the air. Under those conditions the water deficit during day is compensated during night and due to a positive balance of water in the tree the trunk grows (Fig. 1). In extreme conditions of temperature (35 to 40 ^{o}C) and very low relative humidity (10 to 15%) we can reach VPD values of about 6 Kpa in certain regions in Israel. In rainy days the VPD is relatively low and change from zero to 0.5 Kpa and the trunk grow also under those conditions. In days with moderate VPD of maximum 2 Kpa, between rainy periods may cause an non compensable stress because of water deficit caused by no irrigation due to the 'expectation to rain'. In those moderate conditions the water deficit enhances the trunk contraction without a full compensation during night and the trunk do not grow (Fig. 2 – between 14 and 17 of December and 20 to 23 of January). In those conditions the fruit also nulls its growth that is not compensated by further growth abolishing substantially the possible winter growth of the fruit (Figure from the Zikim paper). During nights with relative low humidity and high temperatures the VPD can reach 0.5 to 1 Kpa avoiding the compensation of the water stress created during the day conditions which lead the trunk to shrink instead of growing (Fig. 2 – between 28 of December and 5 of January). One must emphasize that at the dry conditions described above when there is not enough water in the soil, the water deficit in the tree is harder and may be diminished by irrigation.

In the conditions described above on can determine the MDC as the difference between the maximum and minimum diameter in a certain day and to compare with the MDC of the day before, in the standard way used in many orchards where plants parameters are used to determine irrigation (red arrow in Fig. 1). Dry atmosphere conditions during a number of days can bring a shrinkage of the trunk instead of grow because the stress accumulation from day to day. In those conditions there is no full compensation from the daily contraction and sometimes the deficit becomes deeper in conditions favoring evapotranspiration also during the night. Under those conditions maximum daily trunk contraction do not give full expression of accumulated stress.

The criteria for irrigation can be improved to be used also at accumulated stress conditions by stating a base line reference to measure the changes in the trunk diameter in relation to it (Fig. 2). The daily maximum contraction in relation to a base line reference will increase in accumulated stress conditions expressing the stress intensity improving the parameter as criteria for irrigation. It can be seen in detail the difference in the usual way of MDC and the maximal daily contraction if relation to a base line (BLMDC) in relation to VPD in the changes in the changes in trunk diameter between 13 and 18 of December 2005 in the data of an avocado orchard on the coastal region of Israel (Fig.3). The regular way of determining MDC at 15 of December is similar to that in 16 of December (red arrows in Fig. 3). The similar contraction of the trunk in those two days is although we can see a shrinkage of the trunk between 15 and 16 of December (Fig. 3). Contrasting to that, the BLMDC increased in 16 of December expressing the accumulated stress of the tree (Fig. 3). Basement for the better expression of

BLMDC for accumulated stress compared with MDC is the poor correlation between the trunk contraction calculated in the regular way (MDC) and the vapor pressure deficit (VPD) in the atmosphere (R^2=0.63) contrasting with the high correlation with the daily maximum shrinkage calculated in relation to the base line reference (BLMDC) (R^2=0.91) (Fig. 4). The poor correlation of MDC with VPD is related mainly with the periods without regular irrigation during the transient season between autumn to winter or winter to spring, but also during winter between rain events were usually growers tend to save water by waiting for the rain event as described above. Concluding we can say that better decisions of irrigation can be reached by determining the maximal diurnal contraction in relation to a base line. The chose of the base line is arbitrary but even a parallel line improves the correlation between VPD and the daily maximal shrinkage. The reference line slope is constant for the period we are interested to receive relative data, and the line may be changed through different periods. In our opinion determination of the daily trunk contraction in relation to an arbitrary base line (BLMDC) as the parameter for determining the need of irrigation instead or the traditional way of determination (MDC) will improve the irrigation decisions in avocado orchards.

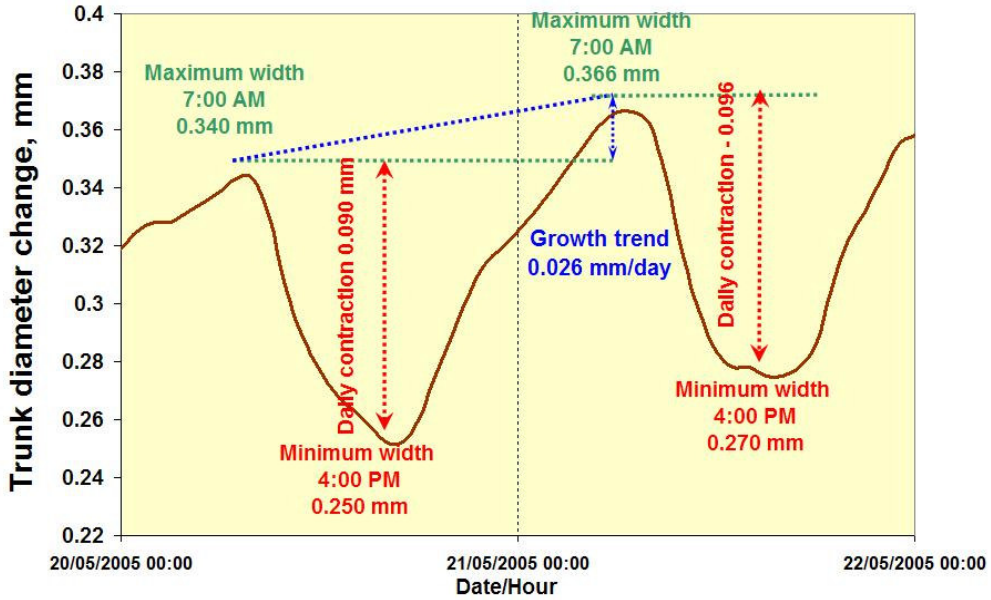

Fig. 1 Change in the trunk diameter between 20 to 22 of May 2005 in an avocado orchard in Zikim, when the Vapor Pressure Deficit in the atmosphere (VPD) is lower than 3 kPa during day and near zero during night

Fig. 1 Cambios en el diámetro del tronco desde 20 hasta 22 de Mayo 2005 en una plantación de aguacate en Zikim, cuando la deficiencia de presión de vapor en la atmósfera (VPD) es menor que 3 kPa durante el día y cerca de cero durante la noche

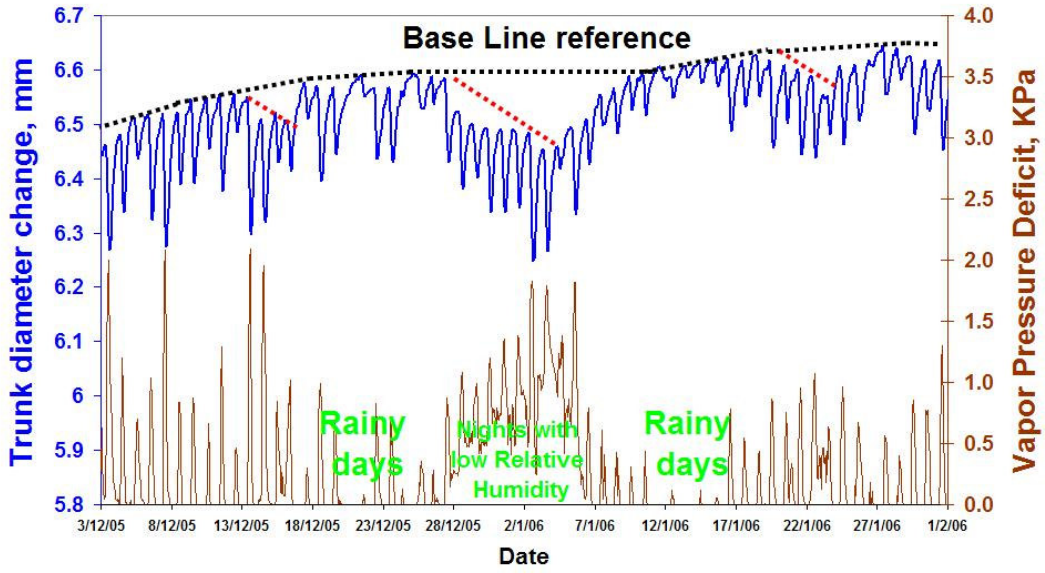

Fig. 2 Change in trunk diameter and Vapor Pressure Deficit in the atmosphere (VPD) in an avocado orchard in the coastal region of Israel between 3 of December 2005 and 1 of February 2006

Fig. 2 Cambios en el diámetro del tronco y en la deficiencia de presión de vapor en la atmósfera (VPD) en una plantación de aguacate en la región costera de Israel desde 3 de Deciembre 2005 hasta 1 de Febrero 2006

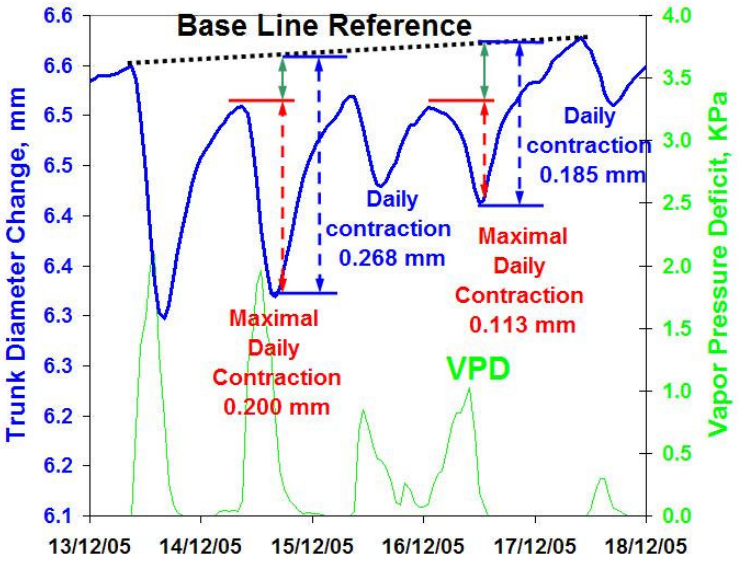

Fig. 3 Change in trunk diameter and Vapor Pressure Deficit (VPD) between 13 to 18 of December 2005 in an avocado orchard in the coastal region of Israel. The daily maximal trunk contraction (MDC) calculated in the standard way is pointed by the red arrows. The maximal daily contraction in relation to a base line (BLMDC) is pointed by the blue arrows

Fig. 3. Cambios en el diámetro del tronco y en la deficiencia de la presión de vapor en la atmósfera (VPD) desde 13 hasta 18 de Deciembre 2005 en una plantación de aguacate en la region costera de Israel. La contracción maxima diaria del tronco calculada en forma estandarte (MDC) es señalada con flechas rojas. La contracción maxima diaria calculada en relacion a una linea de referencia (BLMDC) es señalada con flechas azules

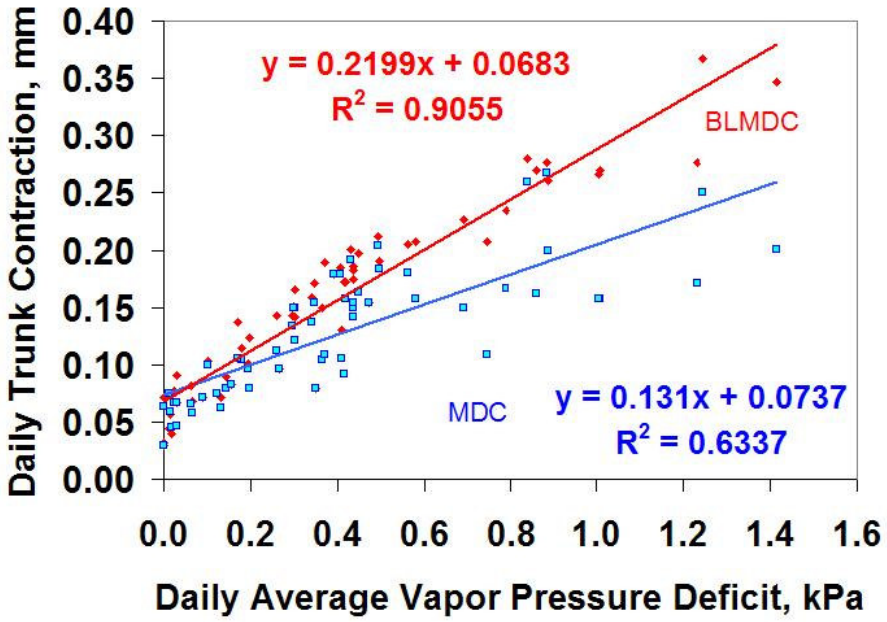

Fig. 4 Coefficient of correlation between the daily average Vapor Pressure Deficit in the atmosphere and maximal daily trunk contraction measured in relation to the maximal diameter of the previous day (MDC - blue line) or the maximal daily trunk contraction measured in relation to a base line (BLMDC - red line). The data are from an avocado orchard in the coastal region of Israel between 3 of December 2005 and 1 of February 2006

Fig. 4 Coeficiente de correlación entre el promedio diario del Déficit de la Presión de Vapor en la atmósfera y la contracción máxima del tronco medida en relación al diámetro máximo del tronco del día anterior a la medida (MDS - línea azul) o la contracción máxima del tronco medida en relación a una línea de referencia (BLMDC - línea roja). Los datos son de una plantación de aguacate en la región costera de Israel desde 3 de Deciembre 2005 hasta 1 de Febrero 2006