South African Avocado Growers' Association Yearbook 1982. 5:36-38

THE INFLUENCE OF FUERTE FRUIT WATER POTENTIAL ON RIPENING

JP BOWER, LJ VAN LELYVELD and ME NEL
CITRUS AND SUBTROPICAL FRUIT RESEARCH INST, NELSPRUIT

Mr J Bower

Mr. John P. Bower is an agricultural research worker, based at the Citrus and Subtropical Fruit Research Institute, Nelspruit South Africa, and holds an M.Sc. degree in horticultural science from the University of Natal.

Mr. Bower is presently involved predominantly in research into horticultural aspects of avocado production, as well as the propagation of subtropical fruit trees by tissue culture.

Of special interest is the physiology of water stress in avocados, as influenced by environmental conditions and stockscion relations, with a view to optimal irrigation scheduling.

OPSOMMING

Avokado vrugte wat die oorsese markte in 'n sagte toestand bereik is 'n probleem wat tot laer pryse aanleiding kan gee. Alhoewel die ver-skepingstemperatuur en die volwassenheid van die vrugte 'n rol speel, is daar ook ander faktore wat van belang kan wees, 'n Ondersoek is gedoen na die ml van waterpotensiaal van die vrug (Ψ,) i gedurende pluktyd.

Vrugte is gepluk van borne in 'n waterspanningstoestand asook van spanningsvrye borne. Die xileem van die vrugsteel se Ψ, is sicrometries bepaal, waarna die vrugte toegedraaien verpak is. Sommige vrugte is dadelik laat rypwordby 22 °C terwyldie res by 5,5°C vir 14 dae opgeberg is.

Tydens rypwording is die sagtheid van die vrugte asook die gaswisseling bepaal. Daar is 'n hoogs betekenisvolle verband tussen Ψ en die tempo van rypwording, alhoewel die fisiologiese aspek van rypwording nie geaffekteer is nie. Dit blyk dat, as gevolg van swak besproeiing of wortelbeskadiging die waterspanningstoestand van die boom aanleiding kan gee tot 'n vinnige rypword van vrugte. Die tyd van die dag wanneer vrugte gepluk word kan ook van belang wees.

SUMMARY

Avocado fruit arriving soft on overseas markets is a problem which may lead to lower prices. While shipment temperature and fruit maturity play a role, other factors also seem to be of importance. The role of fruit water potential *Ψ,* at the time of picking was investigated.

Fruit from stressed and non-stressed trees was picked, and *Ψ*, estimated from the pedicel xylem by the psychrometric method, before being wrapped and packed. Some fruit was immediately ripened at 22 °C, while the rest was first stored for 14 days at 5,5 °C.

During ripening, softness and gas exchange was monitored, A highly significant correlation existed between *Ψ*, and the rate of ripening, but ripening physiology was not affected. It is suggested that tree water stress due to poor irrigation or root damage may result in more rapid ripening. The time of day when fruit is picked may also be important.

INTRODUCTION

One of the quality problems being experienced by exporters is that avocados often arrive in a soft condition on overseas markets. This allows agents less time for sale of the fruit, and consequently lower prices can be expected.

While it is well known that temperatures during storage (Eaks, 1978) and fruit maturity (Wang & Schiffmann-Nadel, 1972; Eaks, 1980) play a role in fruit ripening, and are likely to be contributing factors to the problem of soft fruit, they are clearly not the only causes, as the phenomenon can occur too erratically within consignments.

Adato & Gazit (1974) showed that avocado fruit which was allowed to lose moisture during storage and ripening, softened much faster than fruit which was protected from water loss, or which could absorb water through the cut fruit stalks. The influence of fruit water potential (*Ψ*,) at the time of picking on subsequent ripening has not previously been studied in avocados. However, Fikushima, Yarimizu, Kitamura & Iwata (1980) did show a clear relationship for a number of other fruits. These results, coupled with variations in irrigation efficiency and the altered water relations of *Phytophthora cinnamomi* infected trees (Bower, 1979), could make fruit water relations an important consideration, and it was thus with this in mind that the study was undertaken.

MATERIALS AND METHODS

The experimental fruit was picked during May 1981 from orchards in the Nelspruit area, where the fruit was at the time being picked for export. Fruit was picked from all sides of trees showing no stress symptoms, as well as those showing mild water stress, presumably as a result of *P. cinnamomi* infection. Fruit was all of approximately the same size, in an attempt to maintain a fairly constant degree of maturity.

As soon as possible after picking, *Ψ*, was estimated. So as not to damage the fruit, *Ψ,* measurement was achieved by measuring the xylem water potential of a small section of pedicel adjacent to the fruit. The xylem was excised, and crushed onto a small filter paper disc placed in an envelope of aluminium foil, with a window cut into it to expose the filter paper, in a similar manner as outlined by Savage, de Jager & Cass (1979). This envelope was sealed into a "Wescor L51" leaf psychrometer, and after a 10 minute equilibration period, water potential was measured. A constant 20 second cooling time was used, and the plateau region shown by the micro voltmeter, estimated by eye.

The mass of each fruit was measured before wrapping in cellophane export type wrappers and packing in 4,5 kg export cartons. The fruit was then divided, such that part was allowed to ripen at 22 °C, while the rest was stored for 14 days at 5,5 °C before ripening at 22 °C.

During the ripening phase, percentage ripeness was estimated daily, with the aid of the firmometer described by Swarts (1980). In addition, the carbon dioxide (CO_2) and ethylene (C_2H_4) evolution of the fruit was found by gas chromatography. Each fruit was placed in a 1 ℓ glass container, the open (bottom) end being sealed by the container standing in a saturated solution of ammonium sulphate (Nelson, Isebrands & Rietveld, 1980). Fruit was left for 1 hour, before withdrawal of the gas sample.

Two gas chromatographs were simultaneously used. A "Carlo Erba 4200" model of C_2H_4 was used, with injection temperature of 160 °C, oven temperature 125 °C and detector temperature of 160 °C. Gas flow was: air 300 / µℓ /min; helium (carrier gas) 40 ^I'/min and hydrogen 50 / µℓ /min. A 2 m long activated alumina column with flame ionization detector was used. A gas sample of 1 ml was injected.

CO_2 was detected with a PYE gas chromatograph. The injection temperature was 150 °C, detection temperature 125 °C and column temperature 80 °C. A duel Poropak R 120 to 150 column with thermal conductivity detector was used, with helium at 40 µℓ /min as carrier gas. A 50 µℓ sample was injected.

RESULTS

Fig. 1 indicates the relationship between the estimate of *Ψ* and the days taken at 22 °C to reach ripeness (as indicated by firmometer readings). A linear regression curve fitted the data for fruit stored for 14 days at 5,5 °C before ripening at 22 °C, as well as fruit ripened immediately after picking. Of prime importance, is the high correlation between *Ψ,* and the time taken to ripening. The lower the *Ψ,* (more negative) the faster the fruit ripened. This was, in the case of fruit ripened immediately after picking, significant at the 1% level, while the relationship was significant to the 0,1% level where the fruit had been stored for 14 days.

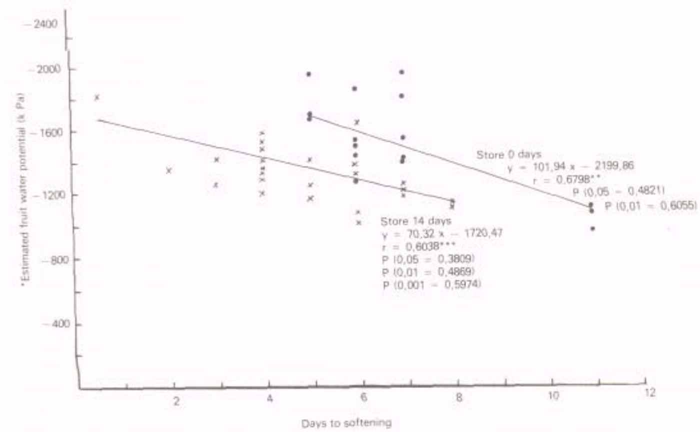

FIG. 1: Relationship between the estimate of fruit water potential and days taken to softening at 22°C after storage at 5,5°C

The mean number of days to ripening for unstored fruit was 7, and the mean softness at the start of ripening was 32,69%. The stored fruit however, took a mean period of 5 days to ripen, and had a softness of 37,66% at the start of the ripening phase (removal from cold store).

The respiratory climacteric as evidenced by CO_2 evolution, occurred close to (usually just before) 100% softness was reached. The work of a number of authors suggests this to be normal (Leopold & Kriedemann, 1975). The actual value of the climacteric peak varied considerably for individual fruit, being 95,45 to 136,97 ml CO_2/kg fruit/h, with a mean of 109,69 ml CO_2/kg fruit/h for unstored fruit, and 57,28 to 150 ml CO_2/kg fruit/h with a mean of 110,02 ml CO_2/kg fruit/h for fruit stored 14 days at 5,5 °C. While the mean climacteric peak values correspond fairly well with those in the literature (Eaks, 1976; Zaubermann & Fuchs, 1981), there was no correlation between *Ψ,* and the value of the climacteric peak.

The evolution of C_2H_4 showed a pattern very similar to that of CO_2. The peak C_2H_4 value usually occurred one day before 100% softness was reached, and at approximately the same time as the respiratory climacteric. The mean value of C_2H_4 evolution for fruit unstored was 81,25 (μℓ /kg fruit/h, and 64,44 / μℓ /kg fruit/h for fruit stored for 14 days. These values are slightly lower than those reported by Eaks (1978), but correspond well with those of Zauberman & Fuchs (1981) *Ψ*, had no influence on the maximum values of ethylene produced by the fruit.

DISCUSSION

The available data indicated that the *Ψ,* at the time of picking does affect the rate of ripening and may well be a contributing factor to the soft fruit problem often experienced. Normal storage techniques were only able to slow down the ripening process. This was confirmed by the work of Zauberman, Schiffmann-Nadel & Yanko (1973) and to some extent by Eaks (1976). This would indicate that the longer the storage period required, the more critical the quality of fruit at the time of picking may be.

The mode of action by which water relations (within the bounds of those measured) affect the rate of ripening, is more difficult to assess. There is no evidence that the basic physiology of the fruit is markedly affected, as the respiratory climacteric and C_2H_4 evolution pattern was normal. C_2H_4 synthesis would however seem to have been stimulated earlier or more rapidly, leading to faster fruit ripening.

Aspects which may need investigation, include the role of calcium in the ripening of such fruit, and the relative oil to water content of slightly stressed fruit. There is good evidence that low fruit calcium affects the ripening of many fruits, including avocados (Tingwa & Young, 1974).

Any decrease (especially over a long period) in tree water uptake is liable to result in a lower fruit calcium content. Avocado ripening has also been shown to be correlated with percentage oil content, this being used in respiration during ripening (Leopold & Kriedemann, 1975). A lower water content (and therefore higher relative oil content) could allow respiration and ripening to proceed more rapidly.

From a managerial point of view, these findings could have profound implications. Poor irrigation resulting in tree stress, would be likely to cause decreased fruit water potentials, with consequently faster ripening. Tree water status also being affected by *P. cinnamomi* infection (Bower, 1979) may cause many orchards to show at least some degree of stress. Especially dangerous in this regard, are liable to be trees in an early stage of infection, as the leaves are still viable and requiring water which the roots can not adequately provide, thus resulting in tree water stress. It could perhaps be advisable to pick fruit from such orchards as soon as possible, or under certain circumstances even to contemplate air freight or sale on local markets.

Finally, Bower (1978) showed there to be considerable diurnal changes in tree water potential, which could become stressful during warm afternoons if trees are poorly irrigated or have *P. cinnamomi* infection. The time of day during which fruit are picked may thus also be important, and work in this regard should be done.

Previous experience includes farm advisory work in citrus and avocados, as well as teaching and research at the University of Natal, in the fields of citrus, subtropical fruits (specializing in avocados), plant propagation and floriculture.

Papers have been published concerning solar radiation and internal water status as stress factors in the avocado, water relations of *Phytophthora* infected trees and their influence on management, biochemical aspects of stock/scion combinations, ecophysiology of avocado trees including techniques of photosynthesis measurement, orchard design and tree spacing, as well as pamphlets for farm advisory work.

LITERATURE CITED

ADATO, I & GAZIT, S, 1974. Water deficit stress, ethylene production and ripening in avocado fruit. *Pl Physiol* 53, 45 - 46.

BOWER, JP, 1978. The effects of shade and water relations in the avocado cv. Edranol. *S Afr Avocado Grower's Association Research Report, 2,* 59 - 61.

BOWER, JP, 1979. Water relations of *Phytophthora* infected trees and their influence on management. *S Afr Avocado Grower's Association Research Report,* 3 25 - 28.

EAKS, IL, 1976. Ripening, chilling injury and respiratory response of Mass and Fuerte avocado fruits at 20 °C following chilling. *J Am Soc hort Sci* 101, 538 - 540.

EAKS, IL, 1978. Ripening, respiration and ethylene production of Hass avocado fruits at 20 °C to 40 °C. *J Am Soc hort Sci* 103, 576 - 578.

EAKS, IL, 1980. Respiratory rate, ethylene production, and ripening response of avocado fruit to ethylene or propylene following harvest at different maturities. *J Am Soc hort Sci* 105, 744 - 747.

FUKUSHIMA, T, YARIMIZU, K, KITAMURA, T & IWATA, T, 1980. The relation between water stress and the climacteric in respiration of some fruits. *Scientia Hortic* 12, 259 - 264.

LEOPOLD, AC & KRIEDEMANN, PE, 1975. Plant growth and development. McGraw-Hill: New York.

NELSON, ND, ISEBRANDS, JG & RIETVELD, WJ, 1980. Ethylene loss from the gas phase container seal systems. *Physiol Plant,* 48 509 - 511.

SAVAGE, MJ, DE JAGER, JM & CASS, A, 1979. Calibration of thermocouple hygrometers using the psychrometric technique. *Agrochemophysica* 11, 51 - 56.

SWARTS, DH, 1980. in Metode vir die bepaling van rypheid by avokado's. *Subtropica* 1(2), 15 - 18.

TINGWA, PO & YOUNG, RE, 1974. The effect of calcium on the ripening of avocado *(Persea americana* Mill.) fruits. *J Am Soc hort Sci* 99, 540 - 542.

WANG, CY & SCHIFFMANN-NADEL, M, 1972. Respiration of whole fruit and seed of avocado at various stages of development. *J Am Soc hort Sci* 97, 313 - 315.

ZAUBERMAN, G & FUCHS, Y, 1981. Effect of wounding on Fuerte avocado ripening. *Hort Science* 16, 496 - 497.

ZAUBERMAN, G, SPHIFFMANN-NADEL, M & YANKO, U, 1973. Susceptibility to chilling injury of three avocado cultivars at various stages of ripening. *Hort Science* 8, 511 - 513.