Gartenbauwissenschaft, **67** (1). S. 39–43, 2002, ISSN 0016–478X. © Verlag Eugen Ulmer GmbH & Co., Stuttgart

Preliminary study on transpiration of peaches and nectarines

Erste Untersuchungen über die Transpiration von Pfirsichen und Nektarinen

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Summary

Fruit transpiration was studied on 'Dixired', 'Alexandra', 'Suncrest', 'Opale' peach and 'Big Top' nectarine in climate-controlled chamber and in the field with removed fruits. The rate of water loss from fruit after being taken out from the tree in several hours was constant during at least 7 hours and could be used for estimating its transpiration rate. The intensity of fruit transpiration rate measured on young fruits varied with the cultivars: the strongest was from 'Alexandra' while the weakest was from 'Big Top' and 'Suncrest' among the studied cultivars. The fruit transpiration rate varied diurnally and was maximal at about noon. The intensity of fruit transpiration fluctuated during the growing season, indicating a possible climatic effect. The effect of air relative humidity and temperature was quantified in phytotron. Fruits transpired 30–50 % more at temperature 30 °C and relative humidity 40 % than those at temperature 25 °C and relative humidity 60 %.

Zusammenfassung

Die Transpiration von Pfirsichen der Sorten 'Dixired', 'Alexandra', 'Suncrest', 'Opale' und 'Big Top' (Nektarine) wurde an abgetrennten Früchten in der Klimakammer und auf dem Feld erfasst. Der Wasserverlust bleibt mindestens sieben Stunden nach dem Pflücken konstant und kann zur Schätzung der Transpiration benützt werden. Die Intensität der an jungen Früchten gemessenen Transpiration ist je nach Sorte unterschiedlich, wobei die höchsten Anteile auf 'Alexandra' und die tiefsten auf 'Big Top' und 'Suncrest' fallen. Die Transpiration variiert im Laufe des Tages und ist gegen Mittag am höchsten. Die Transpirationsintensität schwankt während der Wachstumsperiode, was auf einen Klimaeinfluss hindeutet. Der Einfluss der relativen Luftfeuchtigkeit und der Temperatur wurde in der Klimakammer quantitativ bestimmt. Die Transpiration der Früchte, die einer Temperatur von 30 °C und einer relativen Luftfeuchtigkeit von 40 % ausgesetzt waren, erhöhte sich um 30 bis 50 % gegenüber jenen, die bei einer Temperatur von 25 °C und einer relativen Luftfeuchtigkeit von 60 % gelagert waren.

Introduction

Transpiration rate of fruits may have an important effect on fruit quality (GÉNARD and HUGUET 1996). It influences phloem and xylem flows (HUGUET et al. 1998), which transport water, carbohydrates and minerals into the fruit. Increasing relative humidity around the fruit by bagging fruit, which are common practices in Asian countries (KIKUCHI et al. 1997; CHENG et al. 1999), or covering fruit with aluminum foil decreases the fruit transpiration and significantly reduces the dry matter content, either for fruit flesh or for total fruit, and the content of total soluble solids in fruit flesh (MULEO et al. 1994; KIKUCHI et al. 1997; LI et al. 2001). The fruit transpiration rate also influences the calcium content of fruits (CLINE and HANSON 1992; TROMP and VAN VUURE 1993). However, no extensive study has yet been done on the fruit transpiration in the field. The objectives of the present study were to investigate a simple technique for estimating the fruit transpiration rate and to evaluate the intensity of fruit transpiration of peaches and nectarines in the field.

Material and Methods

Experimental site and materials

This study was carried out in the Avignon Center of the Institut National de la Recherche Agronomique (Southern France) and in Gotheron experimental orchard near Valence (120 km north of Avignon) during four growing seasons in 1994, 1995, 1997 and 1999. The following five cultivars of *Prunus persica*, two early ripening 'Dixired' and 'Alexandra', two mid-late ripening 'Suncrest' and 'Big Top', and a late ripening 'Opale', were used in this study. 'Big Top' is a nectarine, and the others are peaches. All the trees were pruned by long pruning method in winter (LI et al. 1994; LI 1996) and hand thinned in early growing season.

Measurement of fruit transpiration

Fruit transpiration was studied in a climate-controlled chamber (Phytotron) and in the field. Fruits were collected at intervals of 8 to 20 days during the growing season. Ten fruits were removed each time for each cul-



Fig. 1. Fruit suspended on the tree in the field to estimate its transpiration rate
Am Baum aufgehängte Frucht zur Bestimmung der Transpiration

tivar. The pedicels of the fruits were sealed immediately with a mastic compound. The fruits were weighed and then suspended in the Phytotron or on the tree by tying their peduncle to a branch with an iron wire (Fig. 1). The weight loss of these fruits during a given time was measured to estimate the transpiration rate, expressed by mg (water) h^{-1} cm^{-2}(fruit surface).

Estimate of fruit surface

In order to estimate the fruit surface area for the calculation of fruit transpiration rate per unit of fruit surface area, some fruits were carefully peeled after being weighed and their skin pieces were stuck on paper and photocopied during the growing season. The surface of these fruits was calculated from the weight of paper covered by the fruit skin based on the weight of the paper per square meter. The relationships between fruit surface and its weight were obtained from these data:

$y = 3.7482x^{0.7018}$, $r^2 = 0.988$ for 'Suncrest';
$y = 3.4813x^{0.7068}$, $r^2 = 0.942$ for 'Dixired';
$y = 3.2583x^{0.7491}$, $r^2 = 0.965$ for 'Big Top';
$y = 3.4321x^{0.7267}$, $r^2 = 0.957$ for 'Alexandra';
$y = 4.206x^{0.6803}$, $r^2 = 0.952$ for 'Opale'.

where y is fruit surface in cm^2 and x is fruit weight in g. In the present study, the fruit surfaces were estimated according to the weight by using the above equations.

Results and Discussion

Trustworthiness of the technique used for estimating fruit transpiration

Transpiration rate was studied in a climate-controlled chamber on 'Suncrest' fruit during about 30 hours after the fruits were taken from the tree. The transpiration rate decreased about 18 % in 30 hours (Fig. 2). However, it was kept around 1.2 mg water cm^{-2} h^{-1} during the first 10 hours after fruits were picked up. Similarly, fruit transpiration rate remained stable for 'Alexandra' (around 2.5 mg water cm^{-2} h^{-1}) and 'Big Top' (1.3 mg water cm^{-2} h^{-1}) in the climate-controlled chamber during 7 hours after fruit removal (Fig. 3). The results obtained on the above 3 cultivars indicate that we can use removed fruits for estimating transpiration rate on the tree during 7 hours after fruit removal. In comparison, LEONARDI et al. (1999) found a progressive reduction of transpiration rate of tomato fruits three hours after detaching, when JONES and HIGGS (1982) found that apple fruits transpire at very similar rates on picking or over two weeks after picking.

General transpiration of fruits

The fruit transpiration rate was significantly different between the varieties (Table 1). In the climate-controlled chamber where the temperature remained at 25 °C and relative humidity at 60 %, the transpiration rate of 3 peaches varied from one cultivar to another. The fruits of 'Alexandra' transpired the most, 2.53 mg water cm^{-2} h^{-1}, while those of 'Suncrest' transpired only 1.152 mg water cm^{-2} h^{-1}. Fruits of 'Opale' were intermediate. As regard to the nectarine 'Big Top', their fruit

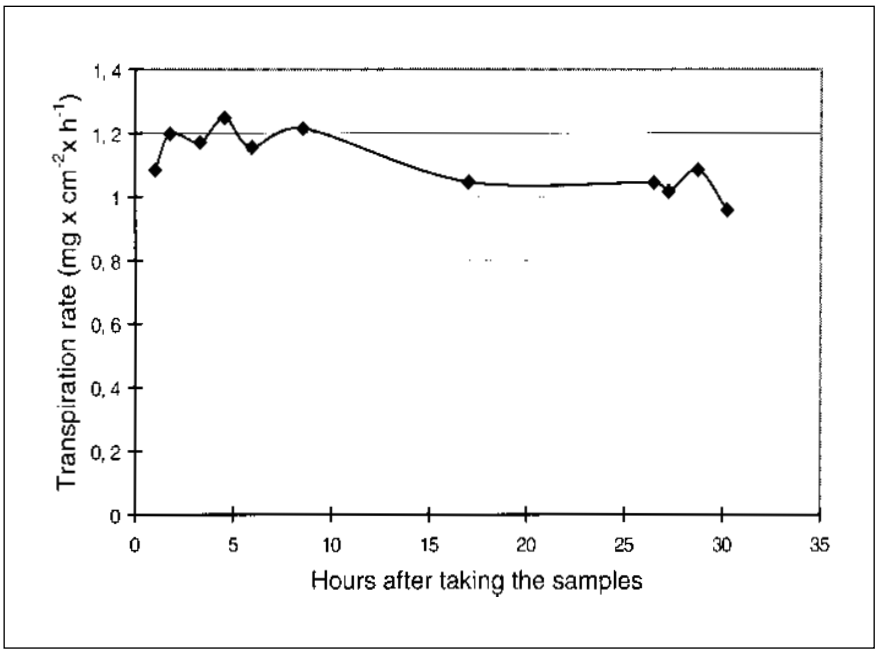


Fig. 2. Changes in fruit transpiration rate of 'Suncrest' peaches after being taken from the tree in the climate-controlled chamber (Temperature: 25 °C, relative humidity 60 %)
Veränderungen der Transpirationsrate von 'Suncrest' Pfirsichen nach ihrer Abnahme vom Baum und ihrer Lagerung in der Klimakammer (Temperatur = 25 °C, relative Luftfeuchtigkeit = 60 %)

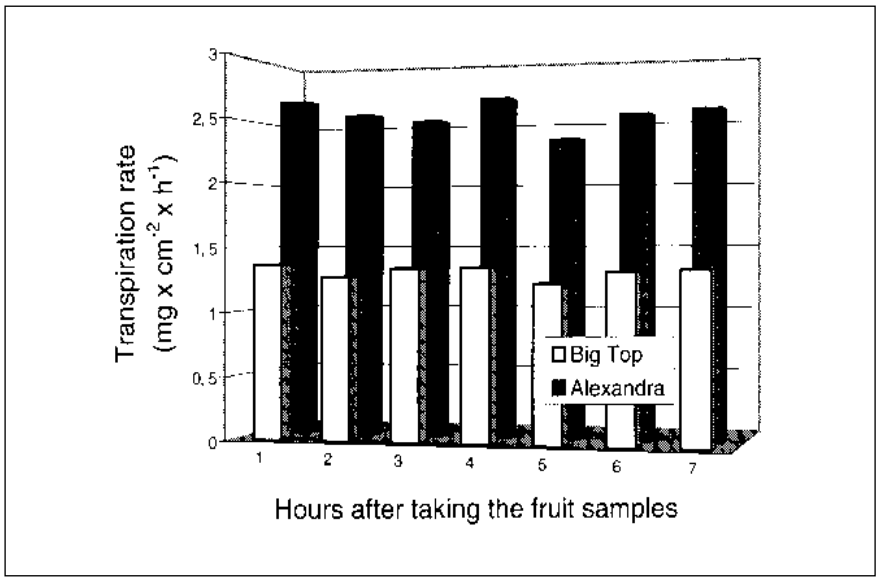


Fig. 3. Changes in fruit transpiration rate of 'Alexandra' peaches and 'Big Top' nectarines after being taken from the tree in the climate-controlled chamber (Temperature: 25 °C, relative humidity 60 %)
Veränderungen der Transpirationsrate von 'Alexandra' Pfirsichen und 'Big Top' Nektarinen nach ihrer Abnahme vom Baum und ihrem Transport in die Klimakammer (Temperatur = 25 °C, relative Luftfeuchtigkeit = 60 %)

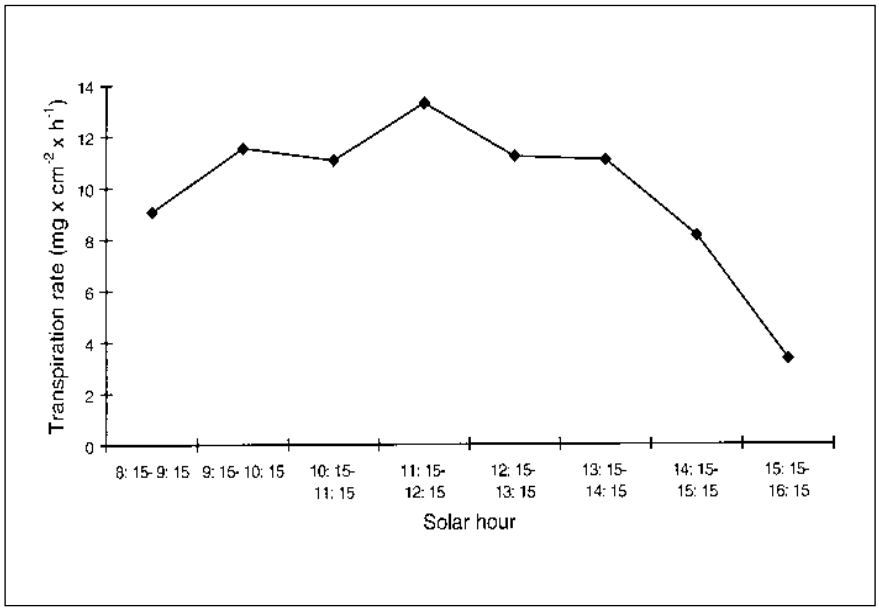


Fig. 4. Diurnal trends of transpiration rate of 'Dixired' peaches on 10 Mai 1994 in the field
Schwankungen der Transpirationsrate von 'Dixired' Pfirsichen im Tagesablauf auf dem Feld

Table 1. Fruit transpiration rate of different varieties in climate-controlled chamber (Temperature: 25 °C, relative humidity 60 %)
In der Klimakammer (Temperatur = 25 °C, relative Luftfeuchtigkeit = 60 %) geschätzte Transpirationsrate von Früchten verschiedener Sorten

Varieties	'Suncrest'	'Opale'	'Big Top'	'Alexandra'
Transpiration rate (mg water $cm^{-2} h^{-1}$)	1.426c [z]	1.754b	1.152c	2.530a

[z] Means followed by the different letters are significantly different at $P=0.001$ level.

had almost the same intensity of fruit transpiration as 'Suncrest'. This result agrees with that of LESCOURRET et al. (2001) on fruit surface conductance for the same cultivars and fruit masses lower than 150 g.

Diurnal and seasonal trends of fruit transpiration

In general, diurnal variation in fruit transpiration depended on the net radiation absorbed by the fruits and relative humidity of the air. There were marked diurnal changes in fruit transpiration rate with a maximum usually occurring around noon (Fig. 4). Fruit transpiration increased in the morning, reached a maximum at midday and decreased in the afternoon. The same pattern was observed for tomato fruits during sunny days (LEONARDI et al. 1999).

LESCOURRET et al. (2001) showed that fruit surface conductance was increasing during the fruit development, with its mass, the heavier having the higher surface conductance. According to these results the fruit transpiration rate would have increased with the fruit development for a given climatic condition. Changes

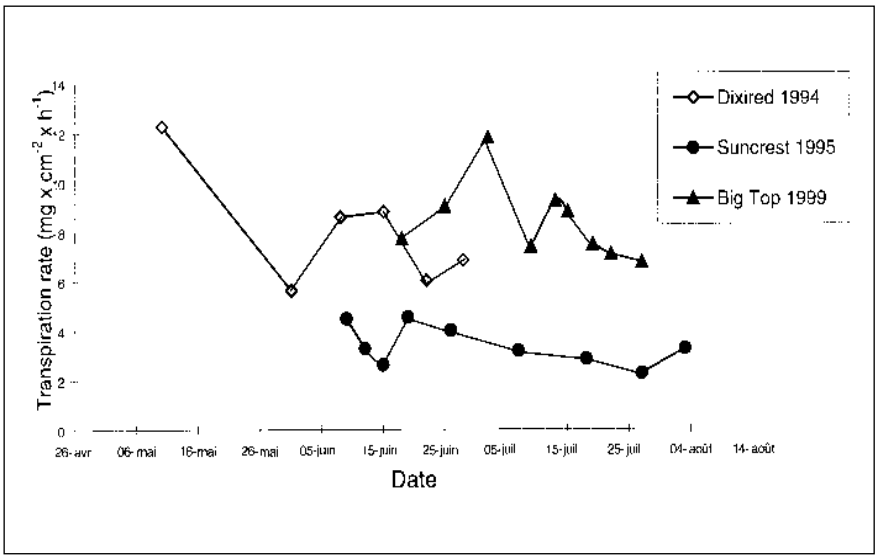


Fig. 5. Seasonal changes in the intensity of fruit transpiration (between 13h and 15h) of 'Dixired' and 'Suncrest' peaches, and 'Big Top' nectarines in the field
Jahreszeitliche Schwankungen der Transpirationsintensität (zwischen 13 und 15 Uhr) von 'Dixired' und 'Suncrest' Pfirsichen und von 'Big Top' Nektarinen in Feldbeobachtungen

Table 2. Fruit transpiration rate responding to the microclimatic conditions in climate-controlled chamber, T: temperature; RH relative humidity
Transpirationsrate von Pfirsichen je nach den mikroklimatischen Verhältnissen der Klimakammer. T = Temperatur, RH = relative Feuchtigkeit

Varieties	'Alexandra'		'Big Top'	
Microclimatic condition in the Phytotron	T 30 °C RH 40 %	T 25 °C RH 60 %	T 30 °C RH 40 %	T 25 °C RH 60 %
Transpiration rate (mg water cm^{-2} h^{-1})	3.572 a [z]	2.530 b	2.513 a	1.301 b

[z] Means within the same variety followed by the different letters for the same cultivar are significantly different at $P=0.01$ level.

in the intensity of fruit transpiration during growing season were studied in the field on 'Dixired', 'Suncrest' and 'Big Top'. As presented in Fig. 5, the early afternoon rates of fruit transpiration were highly variable, but without any clear increase with time. This result indicates, in accordance with HUGUET and GÉNARD (1995), that the intensity of fruit transpiration rate probably fluctuates a lot with the climatic conditions. Indeed, JONES and HIGGS (1982) did not find any clear link between the apple transpiration rate and fruit surface conductance, which can be attributed to a variation of humidity deficit.

To test the influence of climate on fruit transpiration, the rate of fruit transpiration was measured in a climate-controlled chamber at temperature 30 °C and relative humidity 40 %, and temperature 25 °C and relative humidity 60 %. Fruits transpired 30–50 % more at temperature 30 °C and relative humidity 40 % than those at temperature 25 °C and relative humidity 60 % (Table 2). These results are in accordance with those of LEONARDI et al. (1999) who found a positive correlation between transpiration rate of tomato fruits and air temperature and humidity.

This study was made possible due to the funding supported by the Ministry of Education of the People's Republic of China and the Department of Environment and Agronomy INRA of France. We thank Dr. G. Marboutie (Director of INRA Gotheron Experimental Orchard) for the use of the facilities in the experimental orchard and Dr. K.S. Yu (University of Kentucky, USA) for their critical review of the manuscript.

We are grateful to Roswitha Judor for all German translations.

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Eingereicht: 02. 08. 01/08. 10. 01

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