DAILY VARIATION OF TRANSPIRATION RATE AND STOMATAL RESISTANCE OF
CAPSICUM ANNUUM IN FOUR SUBSTRATES

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Abstract

Capsicum annum plants under summer field conditions were grown in 17 cm plastic pots with different substrates: (1) Peat-Polystyrene (1:1) (v/v), (2) Composted Pine Bark, (3) Composted Grape Refuse-Olote Volcanic Ashes (1:1) (v/v), and (4) Peat-Composted Pine Bark-Perlite (1:1:1) (v/v/v). Transpiration rate and stomatal resistance daily variation depended on irradiance and on substrate water content. Plants with one morning irrigation, 2 l/pot, showed stomatic symptoms of water deficit during the morning, in substrate (3), and in the afternoon in the other media. E.A.W. % vol: (1) 22.7; (2) 21.8; (3) 8.0; and (4) 19.1. Two more irrigations, 1 l/pot each, overcame restrictions of gaseous exchange in substrate (3), increasing transpiration rates and decreasing stomatal resistance substantially. Furthermore in all substrates this three irrigation treatment extended, at least for one hour in the afternoon, the potential gaseous exchange in relation to irradiance assuming photosynthesis and stomatal resistance dependence of photon fluence rate.

1. Introduction

Potted plants have a little substrate volume for water retention and, in field conditions with high irradiance and temperature, water loss may cause stress in plants (Armitage et al. 1983). Under specific daily climatic conditions this risk is related with water retention / water release of substrates and irrigation frequency. Hydric stress causes significant changes in the diurnal course of transpiration, stomatal resistance and CO₂ assimilation, and restricts crop productivity (Schulze & Hall, 1981). The limitation of photosynthesis on water stressed plants is related to an increase in stomatal resistance and a decrease in photosynthetic capacity (Swielitz et al., 1983). Photosynthesis and transpiration are intimately linked and leaf conductance is correlated with photosynthetic capacity indicating a precise regulation of assimilation versus transpiration (Farquhar & Sharkey, 1982). In pepper plants leaf conductance exhibited a weak correlation with net photosynthesis, with the relationship depending upon irradiance, leaf temperature, and vapour pressure difference leaf to air (Ramos & Hall, 1982). In this plant stomatal response to photon fluence rate (I) involves only a small influence of intercellular CO₂ partial pressure (p_i) and is mainly a direct response to I. Photosynthesis (P)

responds to I because of a direct response of P to I with only small effects due to the P response to pi and to the direct influence of I on leaf conductance (Ramos & Hall, 1983).

In field conditions under summer Mediterranean climate, substrate water dynamics can become an important limiting factor on production (Aguilã, 1983). This paper reports an experiment designed to study the effects of different substrates and irrigation regime on transpiration, stomatal resistance and water loss daily course of pepper plants.

2. Material and methods

In order to know the effects of water retention / water release properties of the substrates on the stomatal resistance, an open air trial with *Capsicum annuum* var. "largo de Reus" was designed.

Sweet pepper plantlets grown in Peat-Perlite (1:1) (v/v) were transplanted to 17 cm plastic pots with four substrates:

- (1) Peat-Polystyrene (1:1) (v/v)
- (2) Composted Pine Bark
- (3) Composted Grape Refuse-Olot's Volcanic Ashes (1:1) (v/v)
- (4) Peat-Composted Pine Bark-Perlite (1:1:1) (v/v/v)

Plants were subjected to two fertirrigation regimes by a dripping system: 1 and 3 irrigations/day (experiment A and B respectively). At 17 h. a 30 minutes automatic irrigation (2 l/pot) was carried out on both experiments. Later irrigations in B were at 9:30 h. and 14 h. (1 l/irrigation/pot).

Irrigation dosage was calculated in relation to top water E.C., pepper salt sensitivity and substrate water retention properties. Nutrients in solution were given according to Sonneveld & Arnold Bik levels (1981) adjusting the available top water.

During fruit development stage, porometric and substrate water loss studies were carried out at 1 hour intervals from sunrise to sunset, using a LICOR LI 1600 porometer and weighting procedures.

Air, leaf and substrate temperature, transpiration rate, stomatal conductance, and water content in substrate were measured. Randomized samples (6 pots/substrate) were selected from a 4 x 70 design for each experiment and data were subjected to statistical analyses. Physical properties of the substrates were analyzed according to De Boodt's method (De Boodt 1974).

3. Results and Discussion

Substrates (1), (2) and (4) showed similar values on E.A.W. (%) and W.B.C. (%). Grape refuse-volcanic ashes medium presented a very low content on both parameters (table 1). From preceding data and water release curves (figure 1) a very different behaviour in water status in substrate (3) could be expected according to evapotranspiration in the field.

Climatic factors variation during the day of experiment (figure 2) is indicative for conditions prevailing throughout the trial. High irradiance could be noted near midday and low RH levels during daylight period.

In experiment A (1 irrigation/day transpiration rates and stomatal resistance time-course did not present significant differences between substrates (1), (2) and (4). Porometric variation on plants grown in substrate (1) has been taken as an example (figure 3). Transpiration rate varies according to irradiance. Between 12 h. and 14 h. a decrease in transpiration not fitted with irradiance could be noted. This variation could be explained as a result of an increase in RH % (figure 2) and a slight increase in stomatal resistance.

Stomatal resistance remained very low until midday, and after 15 h. increased exponentially because of water deficit and, later, sunset. This behaviour indicates that water began to be a limiting factor in the afternoon.

In plants grown in substrate (3) (figure 4) maximal transpiration rates and minimal stomatal resistance values were obtained at 9 h. After this time stomatal closure began, and correlatively transpiration rates went down, because of an increasing water deficit in plants (Schulze & Hall, 1981). This situation was imposed by the low percentage of available water in the growing media. It must be noted that only between sunrise and 10 h. plants presented a porometric behaviour compatible with a good assimilation activity taking into account data coming from Swietlitz et al. (1983).

There was no difference in porometric variations between any of the plants in experiment B (3 irrigations/day). In this treatment, data coming from substrate (4) was plotted as an example (figure 5). Transpiration rates were higher than those observed in experiment A because of increased content and availability of water in substrates. Stomatal resistance (with values lower than in experiment A) did not increase firmly until 17 h. in relation to irradiance lower than 300 $\mu\text{E PAR m}^{-2}\text{s}^{-1}$ because of sunset. The anomalous behaviour in plants grown in substrate (3) in experiment A was totally compensated with 3 irrigations/day.

Plotting together stomatal resistances variations in both experiments (figure 6) it could be observed that from sunrise until 15 h. little difference existed between all treatments except for substrate (3) in experiment A. After this time plants in experiment B showed lower values than in A (from 15:30 h. to 16:30 h.).

From these results, it can be assumed that with one irrigation day the water content in substrate becomes a limiting factor in the afternoon reducing, in comparison with 3 irrigations/day, at least for one hour, the potential gaseous exchange in relation to irradiance assuming photosynthesis and stomatal resistance dependence of photon fluence rate (Ramos & Hall, 1983).

Variations in transpiration rates in all treatments (figure 7) followed a similar time-course, but inversely to stomatal resistance. During all daylight period, and especially from 15 h. to 17 h., transpiration was higher in treatment B. Plants grown in all substrates in experiment B showed a significant decrease in transpiration in post-midday time. This fact could be partly attributed to an increase in RH % at this time but mainly to the post-midday stomatal closure, a very frequent phenomenon in summer time in Mediterranean climates (Bradford & Hsiao, 1982). Only substrate (2), with the highest post-midday % water content did not follow this pattern.

Experiment A variations in water content of substrates, expressed in absolute values (figure 8) and in percentages (figure 9), showed

both: a low water retention and a fast water loss in medium (3). Three irrigations/day (figure 10 and 11) allowed to maintain water content throughout the day up to 60% of saturation in all substrates, with maximum values on substrate (2).

Water loss rates in experiment A (figure 12) achieved maximum values near midday in substrates (1), (2), and (4), and earlier in (3). In experiment B (figure 13) water loss was maximal at midday in all substrates.

Substrate temperature variations in experiment A (figure 14) indicated that heating was higher and faster in substrate (3). This medium presented a slight termic buffering capacity in relation to its low water content. Three irrigations (figure 15) decreased temperature in all substrates although in medium (3) the values were higher.

Variations of water status in substrates could be explained according to water retention properties, temperature of media, transpiration and evaporation processes.

4. Conclusion

Stomatal behaviour (transpiration rates and stomatal resistance) of *Capsicum annuum* cultivated under our experimental conditions depends mainly on the time course of irradiance and on water content in growing media. Substrates with low percentage of E.A.W. became satisfactory adjusting irrigation regime. In summer time in Mediterranean countries there is a risk of reducing production of pot plants because of unsuitable gaseous exchange. Porometric and weighting studies in the field can easily diagnose abnormal situations and therefore establish an adequate irrigation for each crop. This must be scheduled taking into account daily irradiance and physical properties of substrate improving gaseous exchange.

5. References

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Table 1- Physical properties of substrates. B.D.(bulk density), T.P.S. (total porosity), A.C. (air capacity), E.A.W. (easily available water), W.B.C. (water buffer capacity).

Substrate	B.D.	T.P.S.	Water avail. vol %		
	g.cm-3	% vol	A.C.	E.A.W.	W.B.C.
1- Peat-Polyest.(1:1)	0.056	82.2	38.8	22.8	5.7
2- Pine bark	0.222	86.8	25.0	21.6	3.8
3- Grape refuse-Volc.ash (1:1)	0.570	73.8	39.8	8.0	2.4
4- Peat-Pine bark-Perlite (1:1:1)	0.205	87.0	34.9	19.1	6.8

Figure 1- Water release curves of substrates: (1) Peat-Polystyrene 1:1 (v/v); (2) Pine bark; (3) Grape refuse-Volcanic ash 1:1 (v/v); and (4) Peat-Pine bark-Perlite 1:1:1 (v/v/v).

Figure 2- Time-course of irradiance (—), RH % (---), and temperature on a summer day in Barcelona (14-VII-83).

Figure 3- Daily variation of stomatal resistance (----) and transpiration rate (.....), in relation to irradiance (—), of *Capsicum annum* grown in substrate treated with one irrigation/day. (Bars indicate standard error of the mean).

Figure 4- Daily variation of stomatal resistance (----) and transpiration rate (.....), in relation to irradiance (—) of *Capsicum annum* grown in substrate (3) subjected to one irrigation/day.

Figure 5- Daily variation of stomatal resistance (----) and transpiration rate (.....), in relation to irradiance (—) of *Capsicum annuum* grown in substrate (4) subjected to three irrigation/day.

Figure 6- Time-course of stomatal resistance variations of *Capsicum annuum* grown in substrates 1, 2, 3, and 4, treated with one (.....) and three (—) irrigation(s)/day.

Figure 7- Time-course of transpiration rates of *Capsicum annuum* grown in substrates 1, 2, 3, and 4, treated with one (.....) and three (—) irrigation(s)/day.

Figure 8- Water losses of pepper pot plants subjected to one irrigation/day. Substrates: 1 (-----); 2 (.....); 3 (-.-.-.-); and 4 (—).

Figure 9- Water content of substrates (%) for pepper pot plants referred to field measured container capacity, with one irrigation/day. Substrates: 1 (-----); 2 (.....); 3 (-.-.-.-); and 4 (———).

Figure 10- Water losses of pepper pot plants subjected to three irrigations/day. Substrates: 1 (-----); 2 (.....); 3 (-.-.-.-); and 4 (———).

Figure 11- Water content of substrates (%) for pepper pot plants referred to field measured container capacity, with one irrigation/day. Substrates: 1 (—•—); 2 (---•---); 3 (.....•.....); and 4 (-.-.-•-.-.-).

Figure 12- Evapotranspiration daily variation of sweet pepper grown in 17 cm. pots subjected to one irrigation day. Substrates: 1 (---); 2 (.....); 3 (-.-.-); and 4 (—).

Figure 13- Evapotranspiration daily variation of sweet pepper grown in 17 cm. pots subjected to three irrigation day. Substrates: 1 (----); 2 (.....); 3 (-.-.-); and 4 (—).

Figure 14- Time-course of substrate temperature with one irrigation/day. Substrates: 1 (----); 2 (.....); 3 (-.-.-); and 4 (—).

Figure 15- Time-course of substrate temperature with three irrigation/day. Substrates: 1 (----); 2 (.....); 3 (-.-.-.-); and 4 (——).