Revista Internacional de **BOTANICA** EXPERIMENTAL

ΦYTON

International Journal of EXPERIMENTAL **BOTANY**

Fundada en 1951 por Founded 1951 by
Miguel Raggio & Nora Moro-Raggio
Editor: Dr. Miguel Raggio
FUNDACION ROMULO RAGGIO
Gaspar Campos 861, 1638 Vicente López (BA), Argentina

53° ANIVERSARIO 2004: 79-84 53rd ANNIVERSARY

Evaluation of almond shell as a culture substrate for ornamental plants. II. *Ficus benjamina*

(with 3 tables & 2 figures)

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Abstract. Some technical and economic problems currently limit the use of substrates. The main problems include the lack of reciprocal adaptation of the cultivation technics and the substrate, the possible presence of pathogens, and the cost involved. To these we must add the ecological problems of the extraction areas, since there are no short-term renewable resources, especially in peat, the classic substrate. This has motivated the search for substitutes, especially amongst indigenous materials and those easily obtainable locally, such straws cereals, rice husk and cork residuous.

The use of these substrates should be evaluated agronomically for: physical, chemical and cultural properties. The characterisation and use of almond shell (*Prunus dulcis*) as a horticultural substrate substitute for growing ornamental plants were studied.

The study involved 4 almond shell and peat mixtures (20:80,40:60, 60:40 and 80:20 in almond shell and peat volume respectively), as well as those of a control mixture consisting of peat and expanded clay (33.3: 66.6 in volume of expanded clay and peat respectively). The evaluated plant was *Ficus benjamina*. The plants crop in mixture 20:80 present hight height, dry and fresh weight aerial and root zone and nitrogen foliar level.

Key words: Substrate, mixture, peat, expanded clay

Soilless culture can be divided into hydroponic culture and substrate culture (1). The term substrate is applied in horticulture to all solid material different from natural soil *in situ*, composed of synthesis or residual, mineral or organic substances that is placed in a container, in pure form or in a mixture, and which allows the anchorage of the root

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Received 26.V.2003; accepted 30.VI.2003

system, and is able to intervene (chemically active material) or not (inert) in the complex process of the plant's mineral nutrition (2, 3, 4).

Some technical and economic problems currently limit the use of substrates (5, 6). The main problems include the lack of reciprocal adaptation of the cultivation techniques and the substrate, the possible presence of pathogens, and the cost involved. To these we must add the ecological problems of the extraction areas, since there are no short-term renewable resources, especially of peat, the classic substrate. This has motivated the search for substitutes, especially among indigenous materials and those easily obtained locally, such as cereal's straw, rice husk and cork residual (2).

The almond tree, originally from Asia Minor has existed in the Mediterranean basin since before the birth of Christ. At the present time, Spain is the second largest producer (20.33% in the world production) after the USA (32.39%) (7).

The current uses of almond shell are for furfural production, fertilisers made from the residue of previous production, coal and fuels, xylose and xylitol, some bioproducts and mulching in gardens and growth substrates.

MATERIALS & METHODS

Five different mixtures of substrate were prepared, four of them composed of almond shell and peat, in different volumetric ratios, and one formed by expanded clay and peat:

T1: 20% shell + 80% peat; T2: 40% shell + 60% peat; T3: 60% shell + 40% peat; T4: 80% shell + 20% peat; Control: 33,3% expanded clay + 66,6% peat.

Cracked almond shells varying in size from 0.5 to 2 cm were obtained from one of the local companies, and the kernel was cleaned out. The peat used in all the mixtures was of Danish origin and its characteristics guaranteed by the manufacturing firm were: Screening: sifter of 20 mm, pH 6.0 (in water), elements added by m^3: nitrate-N, 63 g; ammonium-N, 11 g; P_20_5, 121 g; K_2O, 142 g; MgO, 35 g; CaO, 300g; and micronutrients, 200 g; FTE 3600 (slow liberation).

The expanded clay used had sizes between 3 and 5 mm.

Growth trial: The experimental design was unifactorial (substrate mixture) with 40 repetitions for each treatment (T_1,$T_{2,}$$T_3$,$T_4$ and control). The trial period in the field was from April 18/ 1997 to June 27/ 1998. Plants of *Ficus benjamina* sp were cultivated in pots of 1.5 L in volume, in a rigid badge multitunnel greenhouse with a transmissibility of 10% and without heating.

Fertirrigation was applied, starting from May 19 with a balance of 2:1:2 N: P_2O_5:K_2O

(1 g L^{-1}) and micronutrients. From June 6 the balance was modified by 3:1:2 N: P_2O_5:K_2O (1 g L^{-1}).

The measured parameters for the plants were height (data were taken weekly) and biomass (at the end of the trial from a sample of 4 plants per treatment). The fresh weight of the aerial and root zone were also determined.

Foliar analysis was carried out on the samples for each treatments according to standard procedures (8). Data were analysed having the analysis variance and means were separated using the least significant difference (LSD) at $p<0.05$.

RESULTS & DISCUSSION

Measure of the height: Table 1 shows the average values and the results of least significant difference test (LSD) at $p<0.05$ of the height, the figure 1 shows the height evolution, both throughout the trial.

A saw tooth shaped (9) growth tendency was observed, with a precocious increase of the height for the control that generates significant differences in this parameter during 3 weeks with the T1 treatment. However, starting from this moment both treatments present a similar growth. The substrates T2, T3 and T4 produced plants of smaller height, diminishing significantly as the volumetric ratio of almond shell in the mixture increased.

Biomass study: The data for fresh and dry weights, aerial and root weights are presented in table 2, The T1 treatment was similar to the control. However, the other treatments had lower biomass. Figure 2 shows the fresh and dry weights of the aerial and the root zones.

Table 1.– Height evolution (cm) of *Ficus benjamina* trough the trial.

Thermic integral	date	DAT*	T1	T2	T3	T4	Control
119	18-apr	7	0,98 a**	0,90 a	0,66 a	0,61 a	0,66 a
238	25-apr	14	0,84 a	0,64 a	0,69 a	0,60 a	0,81 a
362	02-may	21	0,91b	0,74bc	0,66bc	0,60 c	1,25a
499	09-may	28	1,00 b	0,87bc	0,85bc	0,74c	1,87a
637	16-may	35	1,05b	0,96b	0,91b	0,87b	1,90a
774	23-may	42	1,92a	1,27b	1,36b	1,17b	2,02a
911	30-may	49	2,07a	1,52b	1,45b	1,25b	2,20a
1056	06-jun	56	3,15ab	2,92b	2,12c	1,95c	3,55a
1226	13-jun	63	3,35ab	3,06bc	2,79c	2,62c	3,70a
1395	20-jun	70	3,77ab	3,56bc	3,27c	2,80d	4,20a
1564	27-jun	77	4,26ab	3,92bc	3,75c	3,05d	4,49a

* DAT: days after transplanting

**Mean separation in files by LSD (p< 0.05)

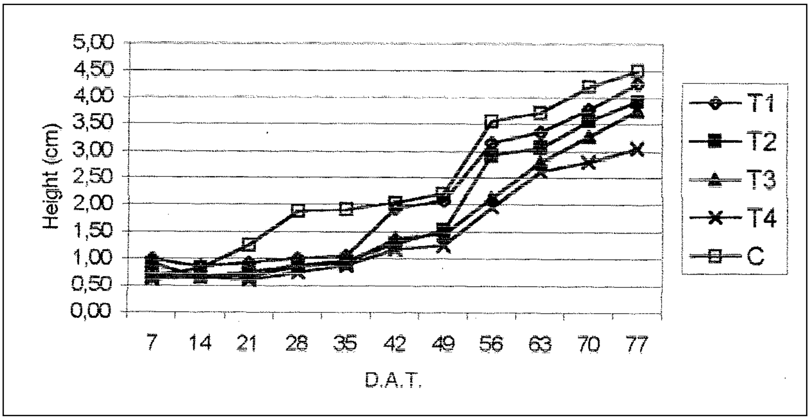

Fig. 1.– Height changes during the trial.

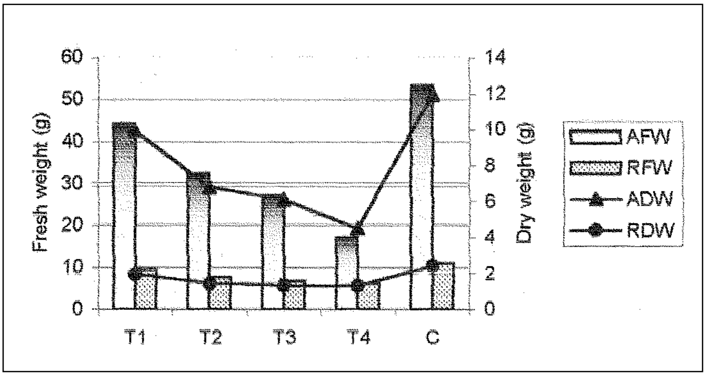

Fig. 2.– Fresh and dry weight of the aerial and root part of plants in different treatments.

Table 2.– Dry (D) and fresh (F) weight (W) aerial (A) and root zone (R) (g). Average ratio between fresh and dry aerial and root zone.

	T1	T2	T3	T4	Control
AFW	44,3 a*	32,2 b	27,1 b	17,2 c	53,3 a
RFW	9,4 a	7,5 b	6,7 b	6,0 b	10,8 a
ADW	9,9 a	6,8 b	6,1 b	4,5 c	11,9 a
RDW	1,9 a	1,4 b	1,3 b	1,3 b	2,4 a
AFW/ADW	4,5	4,7	4,5	3,8	4,5
RFW/RDW	4,9	5,3	5,0	4,6	4,5

* Mean separation in files by LSD ($p < 0.05$)

Table 3. Foliar levels (element % by 100 g of dry matter)

	T1	T2	T3	T4	Control
Nitrogen	2,6 a*	2,3 b	2,2 b	1,1 c	2,6 a
Phosphorus	0,25 ab	0,27 a	0,23	0,17 c	0,25 ab
Magnesium	0,3 b	0,4 a	0,4 a	0,4 a	0,3 b
Potassium	3,4bc	3,8 a	3,6 ab	3,3 c	3,7 a
Calcium	1,7 b	1,7 b	1,7 b	1,7 b	1,8 a

* Mean separation in files by LSD ($p < 0.05$)

Table 2 also shows the ratio between fresh weight and dry weight, in the aerial and root zone, which lower in the aerial fraction. This could be due to water stress because of the great porosity of the substrate in treatments 3 and 4, under similar watering management with all treatments.

Foliar analysis: The following elements were analysed from a representative sample of each treatment and the control: nitrogen, phosphorus, potassium, calcium and magnesium (table 3).

The foliar nitrogen levels in the treatment 1 and the control are within the levels (2.5-4%) considered adequate by Jiménez *et al*. (10). However the level decreased when the shell percentage in the mixture was increased. This result can be due to the “nitrogen hunger” generated by the substrate, and it is related to the C/N ratio, the effect of which was not corrected by basic fertilizers.

The P levels were low in all the treatments and the control compared with the sufficiency range of 0.6-1% (10). This effect may be due to the pH levels of both treatments and control, which may have reduced availability.

The K and Mg levels in all treatments were within the recommended range for cultivation (2.5-5%) and (0.25-0.5%) as well as the levels of Ca.

CONCLUSIONS

The contribution of almond shell in the substrate was to improve its physical and chemical properties and, therefore, this can be the starting point for the design of the substrate´s composition. The *Ficus benjamina* crops with the mixture 20:80 is similar to the culture with the control. The shell of almond is a good substrate component to culture for ornamental plants.

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