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Preliminary results on fig soil-less culture

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Abstract

A fig soil-less culture was conducted in a greenhouse to get rid off all the inconveniences of traditional farming such as low profitability. The research showed a different way of growing fig trees (*Ficus carica* L.) so that farmers could benefit from it by improving yields.

This type of soil-free culture may allow irrigated farms to boost their fig productions from 4500 kg/ha-year up to 81,000 kg/ha-year; that is an 18-fold yield increase compared to traditional farming. Likewise, water efficiency would also be maximised. A 90% water reduction was achieved by applying this growing technique. Furthermore, fertilisers and pesticide applications, as well as farming costs (hand labour) may be reduced by growing the appropriate fig cultivars. Moreover, the highest fig market demand could be met by scheduling harvesting to provide quality fruit all year round.

Keywords: *Ficus carica*; Syconium; Breba; Fig; Soil-less culture

1. Introduction

Among those fruit crops with low profitability, in Spain, the fig tree (*Ficus carica* L.) stands out with approximately 19,000 ha, an annual production of 43,200 Mt and an average yield of 1660 kg/ha (MAPA, 2001). Whereas most fig orchards are dry farmed, those under irrigation provide quality fruit for fresh market and exports. Under these conditions, fig culture is oriented to both breba and fig quality production using parthenocarpic and biferous cultivars. *Brebas* (first crop on last season growth) are harvested from the end of May to mid July and are highly demanded regardless their high prices. The main crop borne on current season growth is called *fig* and is picked from mid July to the end of September. Sometimes figs are left on the trees because of labour cost.

Annual fig exports and imports have increased in Spain for the last years. During 2002 these were 4384 Mt and 1950 Mt, respectively (MAPA, 2001). On the contrary, the European Union definitively shows a fig shortage: imports of 25,000 Mt/year and exports 6500 Mt/year (Melgarejo, 2000). Consequently, more research is required to cope with Spanish and other countries' demands for *brebas* and *figs*.

Fig cultivation has been associated with low profile and marginal lands. As production costs increased, some farmers quit cultivation while others embraced new culture techniques. Even modern farms hardly keep crop profitability as production costs increase gradually. Harvesting is done by hand and accounts for more than 50% of total production costs (Melgarejo, 2000). So labour cost reduction and yield increase are crucial to definitively keep crop profitability.

Soil-less cultivation for fruit tree species is almost non-existent. Conversely to greenhouse horticulture, there are only small experimental plots for fruit tree soil-less cultivation. Because of lack of information, it is very difficult to adjust the optimal growing conditions to cultivate tree species in this environment. The only previous study for fig culture in Spain was performed by the manuscript authors in 1999. Another research team conducted a similar study in Japan under different growing conditions (Kawamata et al., 2002).

The final aim of this study was to test fig soil-less cultivation under protected conditions. A greenhouse environment would provide the optimal growing conditions to improve fig profitability so that farmers could obtain higher yields and incomes as well.

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2. Materials and methods

2.1. Plant material

Though several fig cultivars were tested, the study mainly focussed on the *Super Fig* 1 variety (SF_1). It is a parthenocarpic and biferous cultivar, with dark colour with greenish hints at ripeness (Fig. 3f) and large fruit size (both brebas and figs). This cultivar hardly shows splitting incidence, a negative trait for international markets. SF_1 also yields fruit with less seeds than the *Colar* cultivar, which is the most planted parthenocarpic and biferous cultivar in Southeastern Spain. Though *Super Fig* 1 fairly yields when traditionally farmed, a greenhouse environment could provide the right conditions to test its agricultural potential.

Plant material was propagated by the research team itself. Tiny hardwood and herbaceous stem cuttings (5 cm) were propagated to produce fig plants (Fig. 3a, b and e). While first crop plants showed an average height of 14.2 cm at planting, second crop ones were 10.41 cm tall (Figs. 1 and 2).

2.2. Growing media and plant density

A randomized block design was chosen to minimize the effect of any interference. Each experimental block either managed plants on sacks or furrows (Fig. 3c and d). The chosen growing media were perlite sacks of 60 and 40 l, and open polypropylene furrows (18 cm high and 25 cm wide) filled with perlite (Fig. 3c and d). The same nutrient solution was applied to all growing containers.

Plant density was different according to the experimental plots. Two fig plants per linear meter were placed in both sacks and furrows. Blocks with two plant rows 1 m apart handle 26,666 plants/ha, and those with three plant rows contain 34,293 plants/ha (Fig. 3e).

2.3. Nutrient solution and irrigation schedule

Several fertilisers were used for plant nutrition. These were calcium nitrate, monopotassium phosphate, potassium and magnesium nitrates, micronutrients mix, iron chelate and nitric acid. The applied nutrient solution showed the following composition:

Anions (mmol/l)					Cations (mmol/l)					pH
NO_3^-	$H_2PO_4^-$	SO_4^{-2}	HCO_3^-	Cl^-	NH_4^+	K^+	Ca^{+2}	Mg^{+2}	Na^+	
12	2	2	0.5	0	0.5	7.5	4	2	0	–

Irrigation was scheduled based on radiation (W/m^2). A computerized weather station located next to the greenhouse provided useful data for irrigation. Plants were first watered at 7:00 a.m., and the rest of daily fertigations were automatically applied depending on the accumulated radiation during the year (during January and February a 5 min. additional irrigation was supplied per every 1000 W/m^2 accumulation; for May and June an additional irrigation every 900 W/m^2 accumulated). Fertilizer tanks were used to fertigate and *Venturi* devices injected fertilizers and nitric acid based on electrical conductivity (3 dS/m) and pH.

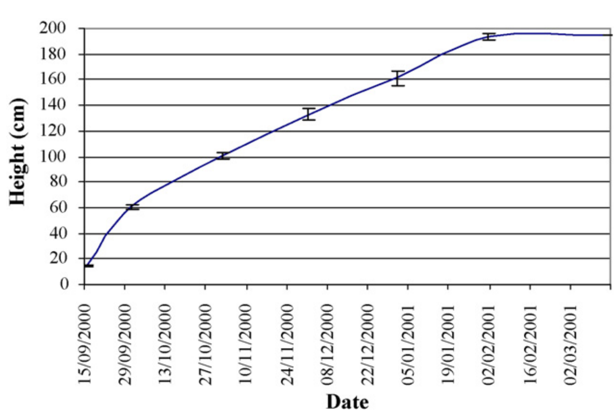

Fig. 1. First crop growth.

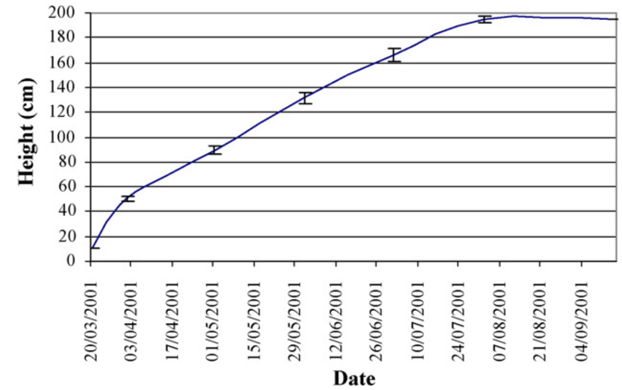

Fig. 2. Second crop growth.

2.4. Greenhouse

A 960 m^2 polycarbonate multi-tunnel greenhouse was used on this study. The soil was covered with a polypropylene layer to prevent weeds from emerging. Greenhouse ventilation was automatically controlled by lateral and upper openings. A water heating system kept night and day temperatures above 10 and 17 °C, respectively, and aerothermal devices also provided temperature control within an optimal range. Pressure compensated drippers of 3.8 l/h with anti-drain feature were used for fertigation purposes; one dripper per plant provided fertilizers and water as well (Fig. 3d). To avoid temperature stress during summer (because of solar radiation), polycarbonate walls and top were whitened with calcium hydroxide sprays.

A pump station was set for greenhouse management. The whole system was computerised from the pumping house. *Ambitrol* and *Agronic C* computer software were used.

2.5. Growing techniques

The following practices were performed:

Fig. 3. (a) Fig stem cuttings on hot beds, (b) sprouted and rooted stem cuttings on hot beds, (c) fig plant just placed in a perlite furrow, (d) fig plant just planted in a 40 l perlite sack, (e) fig plants at a glance and (f) Detail of syconium ripeness.

(a) *Plant guiding*: Fig plants were tied to guiding wires that were 1.95 m above ground level (Fig. 3e). Guiding started when plants were 30–40 cm high. This practice was very similar to that for guiding tomato plants.
(b) *Pruning*: Plants were pruned to eliminate lateral shoots which compete with fruits borne on the main shoot. Sunlight and air circulation were enhanced on lower parts, and main shoots were pruned at 1.95 m height.
(c) *Ointment application*: Breba and fig ointments were also applied. A small olive oil drop was laid over fruit ostioles so that ethylene be released. To appropriately do it, syconium ostioles should be checked to make sure pulp colour starts changing from whitish to red (Melgarejo, 2000). Fruit were harvested 5–6 days after treatment, and labelled and carried to the laboratory for weighing and organoleptic evaluations.
(d) *Pest control*: Pest incidence was periodically monitored. Sticky plates of different colours were used for insect counts. Furthermore, the main pests during cultivation were the twospotted spider mite (Tetranychus urticae Koch) and the grey mold rot (Botrytis cinerea). Several pesticides were applied to control those pathogens: Chlorpyrifos, Fenbutestan, Hexitiazox, Dicofol, Piriproxifen and Feromite. A total of four applications were applied to control spider mite incidence from March–April to October, when the temperature rises. And two treatments

Table 1
Water consumption (m^3/ha) for two annual crops per year

	SF_1 60 l	SF_1 40 l	SF_1 furrow
February	153.11	138.65	189.72
March	184.26	165.83	232.16
April	390.60	347.6	487.5
May	622.45	626.51	765.06
June	1250.33	1105.32	1,575.68
July	1489.64	1340.20	1,816.58
August	1548.80	1490.65	1,873.08
September	611.25	550.46	751.83
October	797.35	722.54	985.41
November	547.20	497.77	689.22
December	484.20	430.75	580.80
January	280.60	252.54	339.40
Yearly total	8359.79	7668.82	10,286.44

SF_1: SF_1 cultivar; 60 l: perlite sack of 60 l; 40 l: perlite sack of 40 l.

against Botrytis were required during winter time because of high relative humidity. Compared to regular fig production (Yablowitz et al., 1998), very few pesticide treatments were needed.

2.6. Plant growth

Plant growth was assessed by taking monthly height measurements in 10 randomly selected plants per crop. The first one ran from September 15, 2000 (planting) to March 15, 2001; the second planting was performed from March 20, 2001 to September 15, 2001, using the same growing media and containers after pulling out the first crop. Collected data from measurements were used to graph plant growth (Figs. 1 and 2). When fig plants were 1.95 m high, their apical meristems were suppressed.

2.7. Harvest quality

A sensory panel of five members evaluated breba and *fig* quality. The following parameters were considered:

– Palatability: normal/low.
– Taste: very sweet/sweet/slightly sweet.
– Internal colour: honey/honey rose/rose/dark rose/reddish rose/red.
– External colour: black/purple black/purple/greenish. black/green/yellowish green.
– Splitting: high/medium/low/none.

2.8. Statistical analysis

Descriptive statistics were used to process and analyse collected data. Mean and standard deviation values were calculated. An analysis of variance (ANOVA) was also performed along with the least significance difference test (95% LSD) to compare and detect any significant difference among treatments.

3. Results and discussion

Two annual crops were obtained for the *Super Fig* 1 cultivar (SF_1). Water consumption on perlite sacks and furrows are shown on Table 1.

Figs. 1 and 2 show the average growth of 10 randomly selected fig plants. The final height was approximately reached 5–6 months after planting.

The average fruit number and weight per plant were 17 and 91 g, respectively, for two annual crops. Only one fruit rose from every leaf axil (rarely two fruits).

Regarding average yield per plant, statistically significant differences could not be established among different growing containers (Table 2).

Table 3 shows a comparative study between traditional and soil-free cultivation. Since irrigation water is a limiting factor in Southeastern Spain and in many large areas of the Mediterranean basin (Melgarejo, 2000), it could be stated that 18 ha of traditional farming are equivalent to 1 ha of soil-less cultivation in terms of production (4500 and 81,384 kg/ha, respectively). Furthermore, soil-less farming demands 10 times less water than traditional cultivation for the same yield (0.126 m^3/kg versus 1.33 m^3/kg).

In addition to those results shown on Table 3, there were other important ones as well. SF_1 may be grown all year round since it did not require any dormancy at all. Based on growing conditions and planting dates, it was possible to schedule harvesting dates; first time ever it was accomplished for fig trees. Moreover, figs were available 3 months right after plantation, and more than two annual crops were obtained with this soil-free culture. Yields of 81 Mt/ha and year were attainable. That is an 18-fold increase compared to traditional farming.

As said previously, SF_1 organoleptic traits were compared to other fig cultivars as *Colar*, the most important parthenocarpic and biferous cultivar in Spain for fresh market and exports. *Super Fig* 1 showed better taste than *Colar*, and its achenium

Table 2
Yield, water consumption and production costs for two annual crops

	SF_1 60 l	SF_1 40 l	SF_1 furrow
Total yield (kg/plant)	3.13 ± 0.087a	3.17 ± 0.08a	3.05 ± 0.084a
Total yield (kg/ha)	83,545.96 ± 2310.91	84,797.5 ± 2148.898	81,383.15 ± 2229.623
Water consumption (m^3/kg)	0.100	0.090	0.126
Water cost (€/kg)[a]	0.0240	0.0216	0.3051

SE: standard error; $n = 10$ plants.
[a] Water cost for irrigation: €0.24 m^{-3}.

Table 3
Comparison between fig traditional and soil-less cultivation

	Traditional	Soil-less
Breba and fig yields (kg/ha)	4500[a]	81,384
Average water consumption (m^3/ha)	6000[a]	10,254.38
Water consumption (m^3/kg)	1.33	0.126
Water cost (€/kg)	0.3197	0.0303

[a] Local average yields and water consumption (Melgarejo, 2000).

number and hardiness were also lower. The overall quality evaluation for SF_1 was: normal palatability, sweet taste, honey-rose internal colour and external greenish black, with no splitting incidence at all.

The goal of this preliminary study was to evaluate SF_1 agricultural potential when grown under protected conditions rather than to assess handling and picking costs. Nonetheless, there are some estimates about time budget. One hour/week was enough for guiding the 660 fig plants handled in this study, and the labour cost was €6 h^{-1}. Pruning was more laborious; 2 h/week was required to perform it. And picking was simple since brebas and figs were easily reached, compared to traditional fig farming where stepladders are required for picking.

Though fig soil-free cultivation seems to be astonishing, further research is required to enhance some aspects as fruit colour and size during summer time. It is essential to find out the optimal plant density as well as the best cultural techniques to guarantee the highest yield with optimal quality.

There are no previous studies on fig soil-less culture but a Japanese one. Kawamata et al. (2002) agreed with the current study and pointed out the potential of fig soil-free cultivation. Traditional farming handicaps as low yields (kg/ha) and profitability got eliminated with this innovative technique, and harvest scheduling was also achievable.

4. Conclusions

The preliminary study yielded the following relevant statements:

- Greenhouse soil-less culture is a great alternative to traditional fig farming.
- Soil-free cultivation allows to not only protect plants and fruit from environmental conditions, but to schedule harvesting so that market demands are met.
- Fig plants yield edible fruits 3 months right after planting.
- Yields and profitability are much higher than traditional farming ones.
- Water consumption per kg of the fruit is much lower than that of traditional cultivation.
- Water, fertiliser and other chemical inputs are optimised by the system, and therefore soil contamination got ameliorated by recirculating drainage solutions.
- Fig plants are continuously grown without any dormancy at all.
- These results must be considered as preliminary ones since not all growing parameters were definitively optimised.

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