

Growth substrates and fig nursery tree production

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ABSTRACT: Pest attack, disease and soil fatigue have always been a great problem in fig (*Ficus carica* L.) nursery tree production, especially when traditional methods that use soil culture are applied. Therefore, as an alternative method, substrate culture could be a sustainable and favorable propagation method for growing healthy nursery fig trees of high quality. No information is available on substrate use and its effect on nursery fig tree production. The present study was aimed to define a favorable substrate to cultivate nursery fig trees in substrate culture, and to examine the effects of substrates on morphological and biochemical characteristics of the fig trees by growing plants in a high-tunnel. Fig cv. “Sarılop” (Calimyrna) cuttings were used in this trial as plant material. Three growth media based on perlite (100%), peat (50%) + perlite (50%), and fine sawdust (100%) were tested using soil as a control. Plants were grown in trough culture from the day of planting cuttings up to the uproot point of fig nursery trees, during eight months, and they were not transplanted into another medium during the growing period. To observe the effect of substrates on the nursery fig trees, some morphological and biochemical characteristics were determined. The use of peat + perlite and perlite led to increased plant growth and quality of fig nursery trees grown in high-tunnel.

Key words: *Ficus carica* L., substrate culture, growing medium, trough culture, propagation

Substratos de crescimento e produção de mudas de figo

RESUMO: O ataque de pragas e de doenças e o esgotamento do solo sempre foram grandes problemas na produção de mudas de figo (*Ficus carica* L.) em estufa, especialmente quando são empregados métodos tradicionais que usam solo como substrato. Por isso o uso de substratos sem solo poderia ser alternativa favorável para obtenção de mudas saudáveis de alta qualidade. Não há informação sobre o uso de substratos e seu efeito sobre a produção de mudas em estufa. No presente estudo procurou-se definir um substrato adequado para obtenção de mudas de figo e examinar os efeitos de substratos sobre características morfológicas e bioquímicas de mudas desenvolvidas em estufa tipo túnel alto. Ramos dos cultivares de figo cv. “Sarılop” (Calimyrna) foram utilizadas em três meios de cultura: perlite (100%), turfa (50%) + perlite (50%), e pó de serra fino (100%) tendo o solo como testemunha. O experimento foi desenvolvido em calhas e se estendeu desde o plantio das ramas até o ponto “uproot”, por oito meses, não tendo as mudas sido transplantadas para outro meio durante a fase experimental. Para observar o efeito dos substratos sobre as plantas, algumas características morfológicas e bioquímicas foram avaliadas. O uso de turfa + perlite e de perlite como substrato em estufa tipo túnel alto aumentou o crescimento das plantas e melhorou sua qualidade.

Palavras-chave: *Ficus carica* L., cultura de substrato, meio de cultura, cultura em calha, propagação

Introduction

Current commercial fig (*Ficus carica* L.) nursery tree production is mainly based on cuttings taken from the mother plant and are placed in a rooting or growing medium, which will eventually produce roots and shoots thus forming a new plant identical to the mother plant (Valio, 1986). Wood cuttings taken from one-year-old shoots are kept in sand for the stratification period and then directly planted in soil to obtain new plants. This is the traditional method for growing fig nursery trees. In commercial fig nursery tree production, rooting is not a problem for growers. However, the most important problem is the loss of plants due to soil pathogens and nematodes (Kiliç et al., 2007). Typical symptoms of nematode infections in nurseries include stunting, yellowing, wilting, and most importantly from an economic standpoint, reduced yields. Therefore, one of the

safer alternatives is soilless cultivation (Burrage, 1999). During the 1980s, the use of soilless cultures and different substrates expanded enormously (Rijck and Schevens, 1998). Many authors have investigated the use of alternative substrates for nursery production (Bugbee et al., 1991; Tyler et al., 1993; Evans et al., 1996; Chong and Lumis, 2000). Most alternative substrate components are promising as they are non-toxic to plants and can be successfully used to amend conventional substrates. However, regional availability and a limited supply of uniform and consistent quality products reduce their widespread usage (Wright et al., 2006).

The objective of this study was to assess the effects of substrates, that can easily be obtained, for the growth and quality of fig nursery trees. A new technology for the production of fig nursery trees is introduced. Due to large losses after transplanting especially in traditional nursery growing methods, plants were grown in

trough culture, i.e., from the planting of the cuttings to the uproot point of fig nursery trees, so they were not transplanted into another medium during the growing period. To the author's knowledge, no study has been made to determine favorable substrates for use in growing fig nursery trees. Therefore, in this research, the aim was to compare favorable substrates for growing fig nursery trees in through culture as well as to examine the effects of different substrates on the quality and growth progress of fig nursery trees by growing plants in a high tunnel. In this way, different substrates were compared in order to optimize the propagation method.

Material and Methods

Hardwood cuttings which had terminal bud of *Ficus carica* L. cv. Sarilop (Calimyrna) were used. The experiment was carried out in a polyethylene covered high tunnel greenhouse in the Aydin Province of Turkey in 2004. Locally available substrates were used in the trial. The following growing media were used: (i) perlite, (ii) 1:1 peat + perlite, and (iii) fine sawdust, (iv) soil as control. The peat was a sphagnum moss peat and the perlite was of horticultural grade. The bulk density of the perlite was 65 kg m^{-3} and particles had a diameter of 2-5 mm. The fine sawdust (0.01-1.0 mm diameter) was obtained from mixed hardwood trees and composted before use.

"Trough culture" was used as one of the substrate culture systems using troughs with 125 L capacity and dimensions of $25 \times 50 \times 100 \text{ cm}$ for each ten fig plants. Drip irrigation system with 4 L h^{-1} flow rate was used for irrigation or for nutrient solution applications. A nutrient tank having 400 L capacity was used, and an electric pump delivered the solutions from the tanks to the laterals.

Hardwood stem cuttings were taken toward the end of February in 2004, from adult fig trees of the collection of the Erbeyli Fig Research Institute. Cuttings were 30 cm long and composed of one-year-old woods. They were kept in sand for stratification for one month and planted on April 15, 2004, in troughs filled with substrates and placed in a high tunnel greenhouse. Cuttings were planted directly on substrates. Spacing was 25 cm between rows and 25 cm between cuttings on the same row.

Troughs filled with substrates allow easy drainage, and prevented cross-contamination between control and other substrates. The fig cuttings were irrigated without supplying any additional nutrients until the first root appeared. Water and nutrient requirements of the plants were supplied through a complete nutrient solution, applied through a drip irrigation system. The chemical composition of the nutrient solution was (in mg L^{-1}): N: 210, P: 31, K: 234, Mg: 48, Ca: 160, S: 64, Fe: 2.5, Mn: 0.5, B: 0.5, Cu: 0.02, Zn: 0.05, and Mo: 0.01 (Hoagland and Arnon, 1950). This formulation included all nutrient elements necessary for the plant vegetation period, and the plants were nourished and irrigated 3-4 times per day in all substrates except soil (control) depending on

the calculated drainage percentage in the previous irrigation applications (Maloupa and Gerasopoulos, 1999; Özzambak and Zeybekoğlu, 2004). The timing and frequency of irrigation were determined by tensiometry and considering drainage and water retention characteristics of different substrate types. Perlite, peat + perlite and sawdust settings were watered more and much more frequently than the soil. The amount of water/nutrient solution was adjusted according to the drainage volume kept around 15-20%, and the surplus solution was allowed to run to waste (open system) (Gül et al., 2007).

The pH value of the irrigation and drainage solutions was measured with a pH meter, EC with an electric conductivity meter. The target pH values of 5.0-6.0, and EC value of $1.80\text{-}2.00 \text{ mmhos cm}^{-1}$ were controlled twice a week and adjusted as needed. For adjusting pH, sulphuric acid was used. The nutrient solution of the collecting tank was renewed whenever the EC value exceeded $2.00 \text{ mmhos cm}^{-1}$.

To observe the effects of the substrates on the growth and quality of the fig nursery trees, at the end of the vegetation period (December 29, 2004) the fig nursery trees were uprooted. After separation of the roots from the substrate, plants were divided into aerial and root parts. The shoot length (SL), shoot diameter (SD), number of nodes (NN), length of the internodes (LIN), root length (RL), number of roots (NR), root fresh weight (RFW), root dry weight (RDW), shoot fresh weight (SFW), stem dry weight (SDW), total sugar content of the stem (TSCS), total sugar content of root (TSCR), total starch content of stem (TStCS), total starch content of the root (TStCR), total carbohydrates content of the stem (TCCS), and total carbohydrates content of the root (TCCR) of the ten uprooted plants per treatment and per replicate were measured. (Dolgun et al., 2005; Kiliç et al., 2007).

For biochemical analysis, root and stem sections of the fig plants were dried at $65\text{-}70^\circ\text{C}$ to constant weight and subsequently ground. The anthrone method, a spectrophotometric method, was used to determine the total sugar and starch contents, constituting the total carbohydrate content in the stems and roots of the fig nursery trees (Morris, 1948). Biochemical analysis was carried out with three replicates.

The study was carried out with three replicates in a randomized blocks design (Açikgöz, 1988). Ten plants, per replicate and per substrate were used. The data were subjected to analysis of variance (ANOVA) by means of the JMP software package (SAS Institute, 1996). In case of significant substrate effects, comparison of means was performed by means of the least significant difference (LSD) test at a significance level of 0.05.

Results and Discussion

As a first step in developing a fig subsector it is necessary to produce sufficient amounts of vigorous and healthy nursery trees. This study has initiated the concept that fig nursery trees can be propagated with substrate cul-

ture, which is a kind of soilless culture. The fig nursery trees were grown successfully with adopting the trough culture, which is the easiest of all the soilless culture methods (Sevgican, 2003). The substrates affected the growth and quality of the trees, and the effects of substrates was pronounced on the fig nursery trees growing.

In this trial, peat + perlite increased in a medium way SL, NN, and LIN when compared with perlite, fine sawdust and control (Tables 1 and 2). SL and NN are very important quality parameters for fig nursery trees growing (Table 1, Figure 1). Moreover, perlite increased the RL and RFW as compared with the other

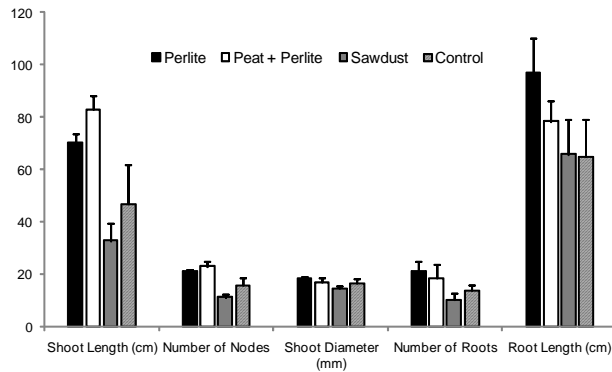


Figure 1 – Effect of substrates on morphological characteristics

Table 1 – Effect of substrates on morphological characteristics.

Substrates	Traits									
	SL	SD	NN	LIN	RL	NR	RFW	RDW	SFW	SDW
	cm	mm		cm			g			
Perlite	70.2 a	18.3	21.0 a	3.3 b	96.8 a	20.9	174.1 a	37.9	90.5	38.9
Peat + Perlite	82.9 a	16.8	22.9 a	3.6 a	78.3 ab	18.5	90.5 b	23.9	95.1	37.1
Sawdust	32.8 c	14.4	11.0 c	2.7 c	65.8 b	10.1	48.0 b	11.7	31.2	11.0
Control	46.8 b	16.4	15.7 b	2.7 c	64.8 b	13.6	100.7 ab	26.8	80.4	30.6
LSD (%5)	12.934**	2.750 ns	2.979**	0.307**	22.949 *	8.163 ns	5.679 *	20.847 ns	63.193 ns	24.936 ns

Different letters in one column indicate differences between substrates (n.s., *, **Nonsignificant or significant at $p \leq 0.05$ or 0.01 respectively). SL: Shoot Length, SD: Shoot Diameter, NN: Number of Nodes, LIN: Length of the Internodes, RL: Root Length, NR: Number of Roots, RFW: Root Fresh Weight, RDW: Root Dry Weight, SFW: Shoot Fresh Weight, SDW: Stem Dry Weight.

Table 2 – Effect of substrates on biochemical characteristics.

Substrates	Traits					
	TSCS	TSCR	TStCS	TStCR	TCCS	TCCR
	g 100 g ⁻¹					
Perlite	6.62 c	3.49	5.61	7.99	12.22	11.48
Peat + Perlite	7.35 b	4.80	5.82	4.79	13.16	9.60
Sawdust	8.41 a	4.49	4.67	4.86	13.07	9.35
Control	8.84 a	5.07	3.76	4.08	12.59	9.16
LSD (%5)	0.660**	1.651 ns	1.812 ns	3.452 ns	1.318 ns	2.501 ns

Different letters in one column indicate differences between substrates (n.s., *, **: No significant or significant at $p \leq 0.05$ or 0.01 respectively). TSCS: Total Sugar Content of the Stem, TSCR: Total Sugar Content of Root, TStCS: Total Starch Content of Stem, TStCR: Total Starch Content of the Root, TCCS: Total Carbohydrates Content of the Stem, TCCR: Total Carbohydrates Content of the Root.

substrates. The highest root and shoot dry weight of fig nursery trees at harvest was found in plants grown in perlite (Figure 2). Perlite is more expensive than other aggregates, which turns out to be a disadvantage in practice, but the same perlite could be used over four times in soilless culture activities (Szmidt et al., 1988). As a growth media, peat + perlite and perlite alone have achieved successful results in most of the studies, especially on vegetable cultures (Verdonck, 1991; Gül and Sevgican, 1992; Gül and Sevgican, 1994; Şirin and Sevgican, 1999; Sevgican, 2003).

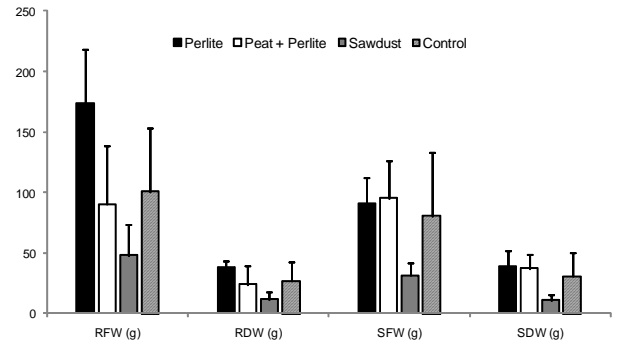


Figure 2 – Effect of substrates on root fresh/dry weight and stem fresh/dry weight. RFW: Root Fresh Weight, RDW: Root Dry Weight, SFW: Shoot Fresh Weight, SDW: Stem Dry Weight.

Perlite has a closed cellular structure, with the majority of water being retained superficially and released slowly at a relatively low tension, providing excellent drainage of the medium and aeration of rhizosphere. Therefore, it requires frequent irrigation to prevent a fast developing water stress (Maloupa et al., 1992). Perlite is physically stable and chemically inert, thus providing a low buffering capacity. Water is retained on the granular surface or in the pore space between the aggregates (Maloupa et al., 1992) and released at relatively low moisture tension (Jackson, 1980). Perlite is usually applied in mixtures to ensure good drainage and to increase air capacity in the substrates (D'Angelo and Titone, 1988).

Actually, peat is used in many different situations as a mulch, substrate and soil structure amendment, for most cropping systems (Lennartsson, 1997). With its specific properties and the diversity of cultivated plants, peat does not perfectly correspond to this diversity. For this it is necessary to use additives to correct the characteristics which become disadvantages in specific situations. For example, a low capacity for wetting is useful for mulching but a disadvantage for substrate making. For this, the addition of a surfactant is necessary to improve the wetting capacity (Guerin et al., 2001). Consequently, a peat + perlite medium was used in this trial.

Plant carbohydrates play an important role in the growth and rooting of a plant and on its resistance to cold. Thus, total carbohydrate content, consisting of sugar and starch contents, was determined in roots and stems. In this study, no differences were observed between tested substrates in respect to TSCR, TStCS, TStCR, TCCS and TCCR (Table 2). However, the use of peat + perlite led to higher TStCS and TCCS when compared with perlite and fine sawdust. Fine sawdust did not produce higher quality trees when compared with peat + perlite, perlite, and the control, except for TSCS, which was higher than those grown in peat + perlite and perlite substrates (Figure 3). Notwithstanding, Worral (1977) reported that composted sawdust had successfully been used to grow fruit trees in a nursery for one year, and to grow most indoor plants and seedlings. In this trial, the fine sawdust was not adequately composted to be used as a growing medium.

Maximum total carbohydrate accumulation in the stem was obtained for peat + perlite. This can be explained by the fact that plants have more nodes and carbohydrate accumulation is much more present at the nodes (Kilinç et al., 2007). From these results on the growth parameters of the fig nursery trees, using peat + perlite as a substrate produced encouraging results. In this respect, the results support the work of several researchers (Verdonck, 1991; Olympios, 1992; Tüzel et al., 2001). Besides, Bohne (2004) stated that in relation to growth of the plants it was equal or better for the peat-reduced and peat-free substrates as compared to peat.

Mixed peat + perlite presented the best performance throughout the growing period. Perlite is very porous,

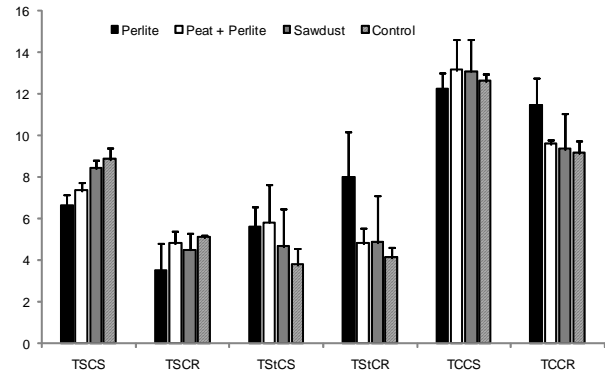


Figure 3 - Effect of substrates on biochemical characteristics. TSCS: Total Sugar Content of the Stem, TSCR: Total Sugar Content of the Root, TStCS: Total Starch Content of the Stem, TStCR: Total Starch Content of the Root, TCCS: Total Carbohydrates Content of the Stem, TCCR: Total Carbohydrates Content of the Root.

has a strong capillary action, and can hold 3-4 times more water than its weight. Roots in perlite are always well aerated and well watered (Olympios, 1992; Kreen et al., 2002). Mixing peat with perlite increased the growth parameters of the trees, more than using perlite alone. High cation exchange capacity is an important advantage of peat (Verdonck, 1991). This effect may be attributed to the increase in the uptake of some nutrients because peat acts as a reservoir, holding elements in its structure for slow release into the rhizosphere.

The findings of the study put forth that vigorous fig nursery trees might be more suitable for growing in peat + perlite and perlite substrates. The highest shoot and root length were obtained, peat + perlite medium with 82.9 cm and perlite medium with 96.8 cm, respectively. The results obtained are in accordance with the previous reporting of Mengel and Kirkby (2001) who stated that potential nutrient uptake of plants is dependent to their root development and vigour. In our study, highest root development was obtained in the perlite medium due to nutrient uptake.

Fig nursery trees growing displayed an increasing trend in perlite-based media. This conclusion can be related to higher water holding capacity of perlite-based media. The results of this study are in accordance with the findings of Gül et al. (2003). Under the light of previous reports of Harland et al. (1999) and Gül et al. (2005), clinoptilolite additions into perlite and tuff was to improve plant growth and yield due to the increase in the uptake of nutrients, especially in organic nutrition.

The use of alternative soilless media for the production of plants requires knowledge of their physical and chemical characteristics to result in the best conditions for plant growth (Chavez et al., 2008). The components of soilless substrates must have stable physical and chemical properties during plant cultivation. The biostability of alternative substrates varies considerably,

which also affects the chemical properties of substrates, their management, and the growth of plants. The most important physical factors affecting plant growth are water retention and aeration of the substrate. These not only determine the availability of water and air, but also affect the thermal properties, biological activity and mineral availability of the medium (Klock, 1997). In addition, the use of substrates contributes to solve the problem of local waste production. Water and air content are the most important physical parameters of substrates (Bunt, 1971). Water must be available in the substrate at the lowest possible energy status, but at the same time sufficient air is necessary in the root zone. A substrate can never contain too much water, but can be deficient in air (Gruda and Schnitzler, 2004). This situation confirms that peat + perlite or perlite alone gives the best results.

The results of the present study can provide potential fundamentals for "trough culture", which can be adapted as a production system in fig nursery trees growing in the coming years. On the other hand, further research is recommended to assess other organic and inorganic substrates and soilless cultivation techniques for the growth of fig nursery trees. The use of alternative substrates requires knowledge of new characteristics for mixing and also for offering best conditions to plant growth during the culture. Also more research is needed to address fertility issues with substrates before it can be recommended.

Alternative substrates, that are well characterized and corrected by suitable mixtures, make it possible to produce plants with a better quality, more rapidly (Calkins et al., 1997) and alternative substrates must be used increasingly to include horticulture in a sustainable agricultural system.

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