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Propagation

Advances in propagation of *Ficus carica* L.

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Abstract - Fig tree (*Ficus carica* L.) stands out due to its range of cultivation and easy adaptation to diverse edaphoclimatic conditions. In addition to its adaptability, fruits have nutraceutical characteristics and are used in industry and for fresh consumption, widely appreciated by the world cuisine. Due to lack of manpower and phytosanitary problems, the area planted in Brazil has decreased recently. To overcome these obstacles, the production of quality seedlings is the first step to obtaining productive and healthy orchards. Therefore, the aim of the present literature review was to gather data referring to advances in research related to the fig tree propagation. Currently, the methods found for fig tree propagation consist of seedling production, where entomophilic or vegetative pollination occurs. Commercially, the propagation method by cutting is still the most used for this crop; however, other methods can also be used, such as the use of burrs or plunging and grafting techniques and tissue culture. Although there is a diversity of propagation methods and new technologies being developed, cuttings remain the most feasible method. In addition, obtaining healthy and quality seedlings is one of the main problems currently found in ficiculture, since, in addition to the scarcity of studies related to propagation, the use of resistant cultivars and pathogen-free substrates should be prioritized due to susceptibility of fig trees to nematodes. Thus, further studies should be carried out in order to seek new information on the cultivars most adapted to each locality, as well as improvements in propagation and cultivation techniques.

Index terms: Fig, seedling production, fruit tree, pomology.

Avanços na propagação da Figueira

Resumo - A figueira (*Ficus carica* L.) se destaca mundialmente devido sua amplitude de cultivo e fácil adaptação as diversas condições edafoclimáticas. Além de sua adaptabilidade, os frutos produzidos possuem características nutracêuticas e são utilizados na indústria e no consumo in natura, muito apreciado pela culinária mundial. Devido à falta de mão de obra e problemas fitossanitários a área plantada no Brasil vem diminuindo. E, para superar esses entraves, a produção de mudas de qualidade é o primeiro passo para obtenção de pomares produtivos e sadios. Portanto, objetivou-se com a presente revisão de literatura, levantar os dados referentes aos avanços nas pesquisas relacionadas à propagação da figueira. Atualmente, os métodos encontrados para propagação da figueira, consiste na produção de mudas por sementes, aonde ocorre a polinização entomófila, ou vegetativamente. Comercialmente o método propagativo por estaquia ainda é o mais empregado para essa cultura, entretanto, outros métodos também poder ser utilizados, como uso de rebentões ou técnicas de mergulhia, enxertia e cultura de tecidos. Embora haja diversidade de métodos propagativos e novas tecnologias sendo desenvolvidas, a estaquia, permanece sendo o método mais viável. Ainda assim, a obtenção de mudas sadias e de qualidade é um dos principais problemas encontrados atualmente na ficicultura, visto que, além da escassez de estudos relacionados à propagação, o uso de cultivares resistentes e substratos isentos de patógenos devem ser priorizados, devido a suscetibilidade da figueira a nematoides. Com isso, podemos concluir, que a continuidade nas pesquisas de modo a buscar sempre novas informações sobre as cultivares mais adaptadas para cada localidade, bem como melhorias das técnicas de propagação e cultivo, devem ser encorajadas.

Termos para indexação: *Ficus carica* L., produção de mudas, frutífera, fruticultura.

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Production of fig tree seedlings

Fig tree (*Ficus carica* L.) was one of the first plants grown by humans for fresh or dehydrated consumption. It belongs to the family Moraceae, rich in edible species and characterized by the production of latex in its parenchyma cells. This fruit tree has been highlighted by its biological activities, such as antibacterial (LAZREG-AREF et al., 2012), antiviral and antioxidant.

In addition, the modern pharmaceutical industry is directing more attention to medicinal plants in order to rediscover that plants are almost an infinite resource for the development of medicine and new drugs (CAVERO et al., 2013).

In this way, fig crop has gained worldwide prominence due to its nutritional and medicinal characteristics, being able to be consumed fresh (ripe) and green (industry standard) (CZAJA et al., 2016; CAETANO et al., 2017).

Since it is widely cultivated worldwide due to its easy adaptation to soil and climate (CZAJA et al., 2016), the implantation of fig orchards and research related to the improvement of techniques of fig tree seedling production is of paramount importance for the development of healthy, productive and profitable fig orchards.

Obtaining quality and healthy seedlings for the implantation of fig tree crop is currently one of the main problems, since there is a shortage of research regarding the crop propagation, in addition to its susceptibility to the attack of pests, mainly nematodes, and resistant rootstocks and substrates free from these organisms must be used.

According to Brum (2001) and Pio (2002), the orchard structuring requires the use of quality seedlings, and the high productivity and longevity of the orchard are closely linked to the high quality of seedlings responsible for plant vigor and production.

Quality seedlings can be produced by seeds, when the purpose is the genetic improvement, and by propagation, a technique most widely used for the large-scale production of healthy and vigorous seedlings.

Production of Seedlings by Seeds- The production of fig seedlings using seeds is exclusive for the development of research on genetic improvement of the species.

In Brazil, seedlings produced by seeds are not used due to the absence of *Blastophaga psenes* (L) (FERREIRA et al., 2009), the natural pollinator the fig tree (ANJAM et al., 2017), which is and not found in the country.

When it is possible to obtain seeds, they have physiological dormancy, mainly in Bursa Siyahi and Sarilop varieties. Çalişkan et al. (2012) observed that seed dormancy can be broken using gibberellic acid (GA^3) at concentrations of 500 and 1000 mg L^{-1}, favoring the germination and emergence of seedlings.

Reinforcing the use of seeds for hybridization studies, Yakushiji et al. (2012) performed artificial pollination in *Ficus carica* L. plants using Ficus erecta Thunb pollen and observed that plants generated had high resistance to *Ceratocystis fimbriata* Ellis pathogen, contributing to studies to obtain plants resistant to diseases.

Production of Seedling by Propagation -The propagation method is the most widely used in the production of fig tree seedlings, which can be performed through the use of burrs, plunging, grafting, tissue culture and, especially cutting, the most commercially used (FRAGUÁS et al., 2004; 2011).

Propagation occurs through mechanisms of cell division and differentiation. It is based on the principles of totipotentiality, as cells contain all the genetic information necessary for the perpetuation of the species, and the regeneration of somatic cells and tissues, which have the capacity to regenerate adventitious organs (HARTMANN et al., 2011).

In propagation, regeneration occurs from organs, whether cuttings (from shoot or root), buds, specialized structures, meristems, stem apices, calluses and embryos, without altering the plant genotype due to mitotic multiplication (HARTMANN et al., 2011).

Burrs - Burrs originate from buds present in roots, forming seedlings that develop around the main stem. These seedlings are more precocious in relation to the others; however, since they are in direct contact with the soil, they can be carriers of nematodes (CORRÊA; BOLIANI, 1999; SOUZA; LEONEL, 2011).

Plunging - Plunging is a technique used in fruit growing, especially in plants that have problems of multiplication by other clonal methods or even by seeds, as is the case of the fig tree. In this process, the seedling receives water and nutrients continuously through xylem, and is only detached from the mother plant after the formation of its own root system (HARTMANN et al., 2011).

In fig tree, plunging and air layering are the most viable techniques (DOLGUN; TEKINTAS, 2008). However, the plunging technique has not been used due to the risk of the seedling being attacked by nematodes (*Meloidogyne* spp.) due to the accumulation of soil at the plant base.

According to Bisi et al. (2016), studies using the air layering technique in fig tree have shown high callus formation (above 70%) in “Troiano” and “Roxo de Valinhos” cultivars. However, although this technique is possible, it has not presented practical interest due to the hard labor involved.

Another negative point is the possibility of breaking branches, as observed by Daneluz et al. (2009). The authors recommended the use of the air layering technique in the middle portion of fig tree branches, not in the apical portion, because despite the good results, they observed the breakage of some branches due to the excessive weight at their end.

According to studies carried out by Chalfun et al. (2002), despite the plant phenology, the air layering technique must be carried out between the end of the harvest and beginning of plant dormancy, concentrating between the months of March and April, not harming the productive period of plants.

In relation to the occurrence of lesions in branches during the preparation of air layered branches, Daneluz et al. (2009) found that, with absence of injury (all-perimeter girdle 3 cm long) and only one cut (removal of part of the branch with 3 cm in length and 1 cm in width), there was a higher percentage of formation of calluses and roots. In addition, the use of pine bark as a substrate and the application of 1000 mg L^{-1} of AIB provided higher percentage of rooted air layered branches and number of roots per air layered branch (Figure 1A and 1B).

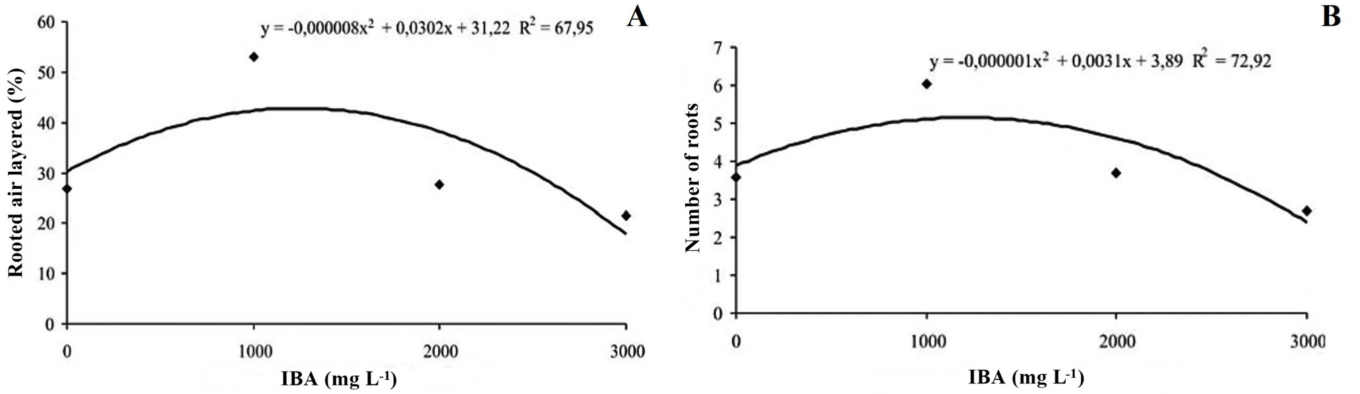

Figure 1 - (A) Percentage of rooted air layered branches of 'Roxo de Valinhos' fig trees submitted to different AIB concentrations. (B) Average number of roots per air layered branch of 'Roxo de Valinhos' fig trees exposed to different AIB concentrations. Marechal Cândido Rondon-PR, UNIOESTE, 2007. Source: Adapted from Daneluz et al. (2009).

Chalfun et al. (2002) reported that June and July were the best months for the removal of air layered branches during the winter pruning, since in fig trees, drastic pruning of the branches produced in the previous cycle is adopted.

Although plunging and air layering are techniques that can be used in fig tree, these methods have low yield and are recommended only when the interest is for the production of few seedlings. In these methods, one must also take into consideration the substrate to be used, which should be free from nematodes and pathogens.

Grafting - Grafting is a technique widely used in the production of seedlings of fruit trees of commercial interest, and is composed of the rootstock, responsible for the production of the root system, and the graft, which will constitute the crown, productive part of interest.

For Kotz et al. (2011), the introduction of varieties or species of the genus *Ficus* tolerant to nematodes is essential, as well as to test the potential propagation of the other resistant species found in Brazil, and new canopy varieties, for the diversification of the Brazilian ficiculture.

The cultivars that can be used as rootstocks should be rigorously analyzed, since the attack of nematodes (*Meloidogyne* spp.) has caused serious problems for fig cultivation (EL-BORAI; DUNCAN, 2005). It should be considered that the control of these parasites is difficult in perennial crops such as fig, and the alternative of using nematicides is not performed, since there are no products registered for this culture in Brazil (COSTA et al., 2015).

In this sense, Costa et al. (2015) investigated White Adriatic, Caprifigo IAC, Celeste IAC, Genoveso IAC and Roxo de Valinhos cultivars that could present resistance to *Meloidogyne enterolobii*, *M. javanica* and *M. incognita*. The authors concluded that even species of *Meloidogyne* presenting attack variations in the cultivars studied, their susceptibility showed their inability to be used as rootstocks. Thus, further studies on the resistance of fig cultivars to nematodes should be carried out, in addition to the acquisition of free seedlings and the prevention of the area, avoiding the presence of these parasites.

Souza (2008) considers grafting as a way to increase fig production and table grafting with rootstock rooting after cleft grafting can be an efficient process for the rapid formation of seedlings. The author also concluded that table grafting by plunging and cleft grafting are viable techniques to be used in the production process of Smyrna, Troyana or Palestino, and Roxo de Valinhos fig cultivars, reporting 100% of survival rate of cuttings grafted by plunging and cleft grafting for the above cultivars.

The process the union of the two plant tissue portions originating a new plant requires good contact between the cambial regions of both grafted parts.

Studies carried out by Silva (2010) also confirmed the feasibility of grafting methods by plunging in Genoveso cultivar, which presented the highest percentages of survival at 20 days after grafting (plate plunging), and in Troyano cultivar, which at 60 days showed the highest percentages of survival, rooting, number of leaves and number of roots.

The grafting of "Roxo de Valinhos" fig tree can be done by plunging and cleft grafting. Plunging should be performed in August by the normal "T" method, which coincides with the beginning of budding of branches of plants in the field, that is, the end of the dormancy period. For grafting by cleft graft method, as can be seen in Table 1, cuttings should be treated with AIB and forks should be protected for 60 days with transparent plastic bags (18 x 3 cm), for better percentages of sprouted forks and average sprout length (KOTZ, 2011).

Table 1 - Percentage of forked sprouts and average sprout length of 'Roxo de Valinhos' fig trees (*Ficus carica* L.) grafted by grafting on cuttings (without leaves), treated or not with AIB (2000 mg L^{-1}) depending on the fork protection time.

Fork protection time	Sprouted forks (%)				Average sprout length (mm)			
	60 days		120 days		60 days		120 days	
	AIB (mg L^{-1})				AIB (mg L^{-1})			
	0	2.000	0	2.000	0	2.000	0	2.000
0	0Ac*	0Ac	0Ac	0Ac	0Ac	0Ab	0Ab	0Ab
15	0Ac	5.0Ac	0Ac	15.0Ac	0Ac	3.0Ab	0Ab	7.8Ab
30	10.0Bc	55.0Ab	10.0Bc	60.0Ab	5.6Bb	14.8Aa	7.0Bb	37.7Aa
45	50.0Bb	65.0Ab	50.0Bb	70.0Ab	18.4Aa	22.2Aa	34.0Aa	43.0Aa
60	70.0Ba	100.0Aa	70.0Ba	100.0Aa	19.2Aa	19.3Aa	38.3Aa	43.1Aa
V.C. (%)	25.18		26.73		22.11		21.11	

*Averages followed by the same uppercase letter in the line and the same lowercase letter in the column, do not differ from each other by the Tukey test at 5% probability. Source: Kotz et al. (2011)

Grafting by cleft graft method in 'Roxo de Valinhos' fig tree, Kotz et al. (2011) obtained adequate results in relation to the percentage of live grafts (81.7%), demonstrating satisfactory development of seedlings and good morphophysiological compatibility.

The fig tree productivity is essentially related to the rootstock and to the grafting method. Casaroti (2010) observed high fruit production mainly during the off-season when the Bonato variety was used as a rootstock and 'Roxo de Valinhos' variety.

In studies related to the development and production of 'Roxo de Valinhos' fig fruits on different rootstocks, Silva (2010) found that there was an effect of Turco and Palestino rootstocks on the production of green figs, and Bonato IAC and Caprifigo IAC on the production of ripe fruits, providing high productivity and quality.

Cutting - According to Fachinello et al. (2005) and Hartmann et al. (2011), cutting is the propagation method in which the induction of adventitious rooting occurs in segments of the mother plant, which, once submitted to favorable conditions, give rise to a seedling.

This technique has the advantage of guaranteeing the selection of superior genotypes, in addition to the greater production of seedlings in shorter time. The disadvantages include the difficulty of inducing the production of adventitious roots in many species, as well as the reduction of the rooting capacity (NEVES et al., 2006).

Cutting has been the most commonly used method for the cloning of woody plants on a large scale, and depends on the rooting ability of each species, the quality of the root system and the later plant development (GRATIERI-SOSSELLA et al., 2008 , NEVES et al., 2006).

This is the main technique used for the production of fig tree seedlings on a commercial scale; however, even with the efficacy of the method described in literature, it must be considered that each cultivar presents a different rhizogenic potential (ALJANE; NAHDI, 2014; BISI et al. , 2016).

Some factors may directly influence the rooting of fig cuttings, such as harvest time, lignification status, use of plant regulators, type of substrates and cultivation environment (HAN et al., 2009), contributing to the production of high quality seedlings and orchard productivity.

To be considered ideal, the harvest time must be related to the amount of carbohydrates of cuttings. In studies on the influence of the diameter of fig cuttings on rooting, Dias et al. (2013) verified that cuttings that exhibited larger diameter values presented better development of shoots, probably because cuttings with larger diameters contain larger reserves of carbohydrates. However, the same authors did not observe influence of the diameter of cuttings on rooting.

The material used for woody cuttings should be woody stem cuttings collected from the basal and median portions of branches originating from winter pruning (July-September) (ARAÚJO, 2005; ALVARENGA et al., 2007; SOUSA et al., 2013).

Nava et al. (2014) also affirmed that the woody cutting of 'Roxo de Valinhos' variety should be done in an environment protected with transparent plastic film, since this influences the rooting process of cuttings. In addition, the authors reported that the rooting process does not depend on position, depth and coverage of the substrate, and sand of medium granulometry is recommended for the latter.

Regarding the use of plant regulators in the woody cutting method, Nogueira et al. (2007) do not recommend their use to propitiate the rooting of woody fig cuttings when they are propagated under suitable conditions. However, Pio et al. (2006) and Ohland et al. (2009) observed significant increases in survival rate and rooting values using 2000 mg L^{-1} of AIB on 'Roxo de Valinhos' cuttings when compared to material that was not immersed in the solution.

In relation to the sprouting and rooting percentage, Ohland et al. (2009) in studies with 'Roxo de Valinhos' cultivar, observed values of 81.7 and 77.4%, respectively. However, Bisi et al. (2016) did not obtain good results of these variables with 'Três num Prato' and 'Pingo de Mel' cultivars.

Comparing woody and herbaceous fig tree cuttings, Bisi et al. (2016) observed that the sprouting and rooting percentage of the cuttings of Lemon, 'Bêbara Branca' and 'Pingo de Mel' cultivars were superior in the herbaceous cuttings, which demonstrates the viability of the method for crop propagation (NOGUEIRA et al., 2007).

Pio et al. (2004) found that the herbaceous cuttings of ' Roxo de Valinhos' fig cultivar showed higher rooting and sprouting percentages and higher number of shoots in the presence of leaves. Figure 2 illustrates the herbaceous cuttings of rooted fig trees from the sprouting, presented by Pio et al. (2005).

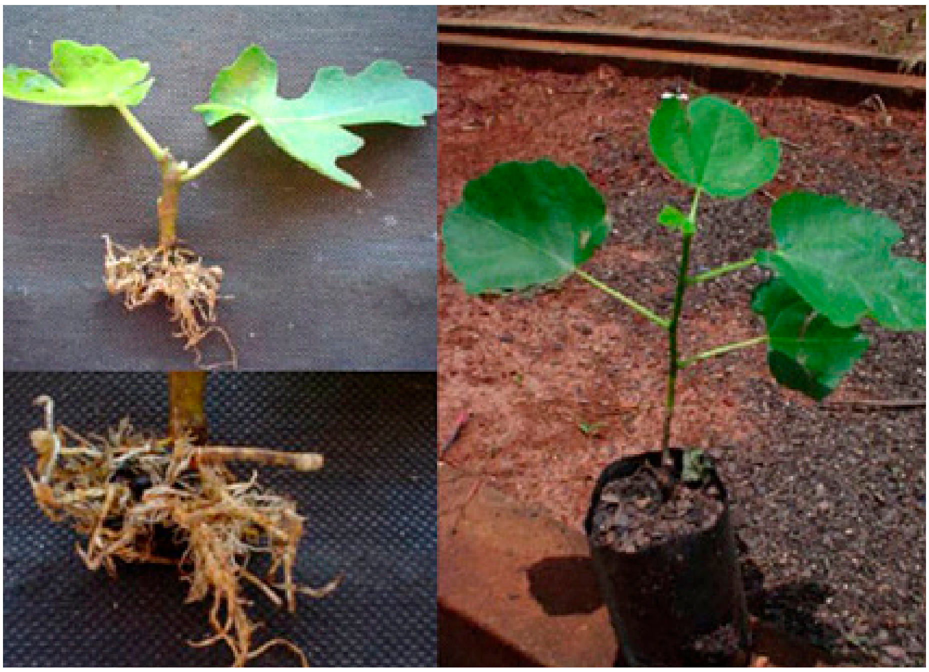

Figure 2 - Herbaceous rooted fig cutting 'Roxo de Valinhos' cultivar originated from the sprouting (A); Detail of the root system formed (B); Plant derived from herbaceous cuttings after 3 months of transplantation ready to be taken to the field (C). ESALQ / USP, Piracicaba-SP, 2003. Source: Pio et al. (2005).

Paula et al. (2009) and Sousa et al. (2013) also verified that herbaceous cuttings of 'Roxo de Valinhos' fig tree presented better propagation results, allowing a longer period for the cutting accomplishment.

According to Paula et al. (2009), September and January are the best seasons for herbaceous fig cutting without the use of AIB because under these conditions, the best results were obtained for the percentage of rooted cuttings.

Testing fig cuttings collected in different positions of the branch and the best container for its establishment, Pio et al. (2006) concluded that the apical position, in relation to the median and basal positions, provided higher rooting rates, number of roots, mean length of roots and shoots, and number of shoots.

Evaluating the timing of semi-woody fig cutting and AIB application, Ramos et al. (2008), in Botucatu / SP, verified that the month of August corresponded to the worst season for cutting without the use of bioregulator (Table 2). In contrast, the month of September showed to be the most feasible for the collection of crop cuttings because greater rooting percentage was observed.

With the use of AIB, prepared with talc, at concentration of 2,500 mg Kg^{-1}, the rooting percentage increased significantly from 20% to 90%, while cuttings from branches pruned in September and October did not require AIB treatment (RAMOS et al., 2008) (Table 2).

Table 2 - Rooting percentage, length of the longest root and root dry mass at different AIB concentrations and at different cutting seasons. Botucatu (SP), 2007.

AIB (mg Kg^{-1})	Rooting rate (%)			Length of the longest root (cm)			Root dry mass (mg $cutting^{-1}$)		
	AUG	SEP	OCT	AUG	SEP	OCT	AUG	SEP	OCT
0	20.0Db*	95.0Aa	90.0Aa	4.8Cc	10.9Aa	8.2Ab	26.2Ec	560.5Aa	343.9Bb
2.500	90.0Aa	95.0Aa	90.0Aa	5.2Bc	8.5Ba	6.1Bb	544.4Ba	460.3Cb	325.4Cc
5.000	77.5Bb	100.0Aa	92.5Aa	6.2Ab	7.9Ca	6.2Bb	570.0Aa	507.3Bb	383.1Ac
7.500	45.0Cc	97.5Aa	80.0Bb	4.8BCb	5.5Da	5.2Ca	293.1Cc	333.3Ea	310.3Db
10.000	52.5Cc	92.5Aa	72.5Bb	3.8Dc	5.3Da	4.4Db	179.8Dc	447.0Da	195.6Eb
VC (%)		6.09			2.86			0.75	

*Averages followed by the same capital letter in the column and lowercase in the line do not differ by the Tukey test at 5% probability. Source: Ramos et al. (2008).

In addition to the influence of the type of cuttings on the formation of adventitious roots, Costa Júnior (2000) and Oliveira (2000) reported that there may be correlation with the presence of leaves in cuttings due to their contribution with photoassimilates and plant hormones, favoring rooting, or even damaging this process by the dehydration of the material caused by transpiration.

In addition to the influence of the presence of leaves on the rooting of cuttings, the presence or absence of fruits in plants can also influence the rooting of cuttings, as observed by Nogueira et al. (2007), in a study carried out with rooting of fig cuttings with and without leaves, from plants with and without fruits, and different AIB concentrations, concluding that higher rooting rates were obtained from cuttings collected without fruits and not treated with AIB. These authors also suggested that there is production anticipation when seedlings from herbaceous cuttings from mother plants under production are used.

According to Bitencourt et al. (2010), the substrate is the medium where roots develop and for it to contribute to a good rooting of cuttings, the material must have good physicochemical characteristics and economic viability. It is important the use of criteria in the selection of the substrate, since this should be free from soil pathogens, thus avoiding the contamination of the root system of cuttings by nematoids, the main soil pest for the fig tree crop.

Regarding the propagation of herbaceous cuttings of 'Roxo de Valinhos' fig cultivar, from the cuttings, Pio et al. (2005) recommended substrates coconut fiber and Plantmax® for the good rooting of this material. As for the rooting of woody cuttings of Sarilop cultivar, Sirin et al. (2010) determined that perlite and peat + perlite are alternative substrates for the good formation of the root system of fig cuttings.

In work with herbaceous cuttings of ‘Roxo de Valinhos’ fig trees under intermittent nebulization in different substrates, Corte (2004) reported that the most viable materials were vermiculite, Plantimax®, and carbonized rice hulls, and the first one provided, after 35 days of cutting, better survival rates and rooting.

An alternative in the propagation of the fig tree would be the previous rooting of cuttings in greenhouse using cuttings of smaller diameter and length. This technique would facilitate the management of seedlings in the nursery and promote the selection of quality plants and planting in the rainy season, allowing obtaining a uniform and vigorous orchard (PIO et al., 2010).

Pio et al. (2006) observed that cuttings conditioned in plastic bags, when compared to those propagated in a bed, obtained better rooting results, a method that facilitates the transportation and selection of seedlings with higher quality.

Testing shading levels, cutting seasons and types of fig cuttings in the municipality of Ilha Solteira / SP, Souza (2008) verified that the best results were found in softwood - type cuttings with 30% shading when performed in August. The same author also states that woody and semi-softwood cuttings, the material must be submitted to 50% shading in the month of February.

In addition to the factors tested by Souza (2008), the conservation of the vegetative material in a cold chamber may allow cutting staggering, which plays a very important role in the physiological activities within cuttings. The same author concluded that the storage of figs at low temperature (8°C) allows maintaining good rooting potential for a period of up to 45 days, allowing storage and not interfering in the survival rate and rooting of the material.

When evaluating the effect of wet cold stratification and AIB treatment on the rooting of apical cuttings of ‘Roxo de Valinhos’ fig tree, Pio et al. (2010) observed that the cuttings wet cold stratified for 30 days and later treated with 2,000 mg L^{-1} of AIB presented high rhizogenic capacity.

These studies showed the importance of the propagation method by cuttings in the production of quality fig tree seedlings, as it stands out from other techniques in relation to the rooting speed and amount of vegetal material obtained from the winter pruning.

Tissue culture

Plant tissue culture is an alternative for the production of seedlings and conservation of aseptic species and controlled conditions of nutrition, luminosity, photoperiod and temperature (GUTIÉRREZ et al., 2011).

The application of this technique has become common in the market, aiming to supply the demand for a more technological fruit growing activity, producing healthy and pathogen-free seedlings at any time of the year in reduced time and physical space, with high genetic fidelity, uniformity and performance in the field (REIS et al., 2008).

This method has provided significant results in the main cultivated fruits, such as banana, pineapple, grapevine and citrus, mainly in breeding, cloning and large-scale production of certified seedlings.

According to Souza and Leonel (2011), works carried out in Brazil using this method for the production of fig seedlings, mainly for ‘Roxo de Valinhos’ cultivar are still scarce, but with promising results.

In this seedling production method, several factors can influence plant growth during the *in vitro* species establishment, such as environmental conditions, culture medium, salt concentrations, presence of activated carbon and especially explant the selection.

In plant tissue culture, there are different culture media such as MS (MURASHIGE; SKOOG, 1962), WPM (LLOYD; MCCOWN, 1980), B5 (GAMBORG et al., 1968), among others. The WPM medium has been especially designed for being more suitable for tree and woody species besides being economically cheaper.

According to Palú et al. (2014), WPM and MS / 2 culture media provide the highest percentage of apical fig buds (Table 3).

Table 3 - Apical fig buds (*Ficus carica* L.) ‘Roxo de Valinhos’ cultivar grown after incubation in different culture media. Ilha Solteira - SP, 2010.

Culture media	Apical buds developed (%)
MS	52 b*
MS/2	68 a
WPM	72 a
WPM/2	36 c

* Values followed by equal vertical letters do not differ from one another by the Scott Knott test ($p < 0.05$). Source: Palú et al. (2014).

In order to achieve greater savings in the use of salts to prepare the culture media, Fraguás (2003) tested different concentrations of the WPM medium (50, 100 and 200%) in the micropropagation of the 'Roxo de Valinhos' cultivar, and concluded that the standard WPM concentration (100%) was the most efficient for the development of explants.

Ferreira and Pasqual (2008) sought to optimize the micropropagation protocol of 'Roxo de Valinhos' fig tree cultivar and also recommended the use of WPM culture medium without addition of kinetin and segments with one or two buds for the production of shoots.

In addition to the influence of the culture media and the concentration of salts on the development and growth of plants, the use of plant regulators can also accelerate the process of *in vitro* seedling production.

With AIB concentrations on rooting and mean number of *in vitro* fig roots, Barbosa et al. (2008) reported that Uruguay and Celeste cultivars, when compared to 'Roxo de Valinhos' and 'Kadotta' cultivars, showed better performance in the parameters analyzed when submitted to the highest AIB concentrations. For the highest rooting of 'Roxo de Valinhos' cultivar, the best AIB concentration in the culture medium was 5.0 mg L^{-1}, whereas for 'Kadotta', 'Uruguay' and 'Celeste' cultivars, the best AIB concentration was 6.0 mg L^{-1}.

Kinetin is a cytokinin widely used in tissue culture. Rocha et al. (2009) attributed the development of new sprouts possibly to the increase of cytokinin concentration, as it is responsible for cell division. Thus, Ferreira and Pasqual (2008) and Fraguás et al. (2004) indicated that, in order to obtain a larger number of larger and well-formed shoots, 0.5 mg L^{-1} of the regulator should be added to the WPM medium, using segments with three buds.

In a study on the *in vitro* multiplication of fig tree, Palú (2011) verified a tendency of increase in the production of shoots with increased doses of cytokinin benzylaminopurine (BAP) added to the culture medium, and maximum production of shoots was reached with the addition of 2 and 4 mg L^{-1} of BAP to the culture medium.

Another regulator that can also be used in tissue culture is gibberellic acid. According to Fraguás et al. (2004), its use in the fig tree micropropagation decreases the formation and multiplication of shoots and induces seeding, vitrification, chlorosis and apical necrosis of seedlings. However, Palú (2011) reported that up to 2 mg L^{-1} of GA_3 added to the WPM medium (100% of salts) contributed to the elongation of shoots, with no problems with chlorotic, vitrified or apical necrosis plants.

International research on native fig cultivars may serve as a basis for future research with national cultivars, as in the case of 'Roxo de Valinhos', the most commercialized in the Brazilian market.

Bayoudh et al. (2015) worked with the adaptation of apical meristem multiplication protocols (Figure 3) in 'Smyrna' (Zither and Soltani) and 'San Pedro' fig cultivars (Bither and Adiadh) and with rare and recalcitrant pollinating cultivars such as Assafri, for the purpose of seedling sanitation, indicating that in apical buds with 0.5 mm in length, multiplication is favored mainly using the MS medium added of 0.5 mg L^{-1} BAP + 0.1 mg L^{-1} naphthalene acetic acid (NAA) and 0.1 mg L^{-1} GA_3.

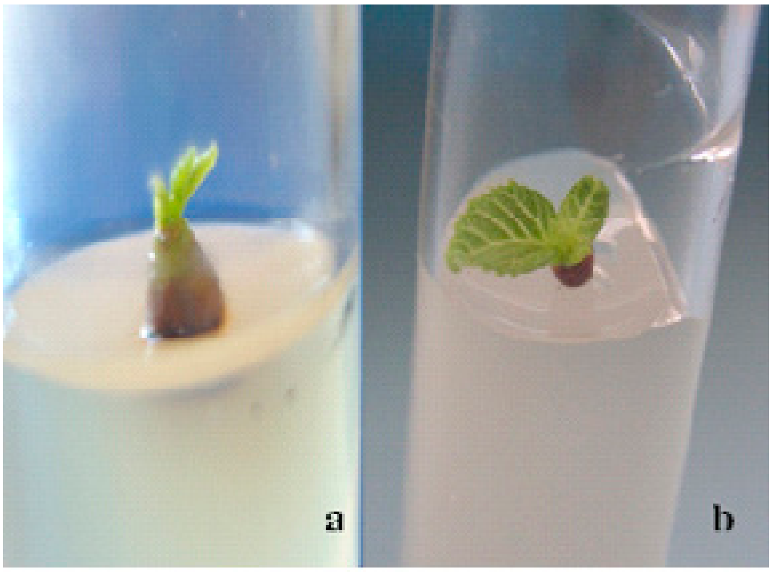

Figure 3 - (A) Apical meristem of fig tree; (B) Beginning of budding of the apical meristem of fig tree in MS culture medium added of 0.5 mg L^{-1} BAP + 0.1 mg L^{-1} NAA + 0.1 mg L^{-1} GA_3. Source: Bayoudh et al. (2015).

In addition to the use of nodal segments or apical buds, Kim et al. (2007) (Figure 4), identified several factors of paramount importance to improve plant sprouting and regeneration from segments of fig leaves. They reported that floroglucinol added to the medium delays the exudation of phenolic substances and the combination of AIB and TDZ increase the frequency and number of multiple shoots per explant.

Figure 4 - Development of apical buds of *Ficus carica* L. Seungjung Dauphine cultivar. (A) Cultivation of apical buds, (B) development of shoots from apical buds, and (C) mother plant used for the study. Source: Adapted from Kim et al. (2007).

After *in vitro* multiplication, a barrier to tissue culture is the acclimatization of micropropagated plants, where loss is quite high. Thus, the use of acclimatization methods, substrates and environments to favor and increase the survival rate of these plants is of great importance.

Bayoudh et al. (2015) optimized a micropropagation and acclimatization protocol, reporting high rates of *ex vitro* rooting of plants (90%) when peat was used as substrate, resulting in healthy roots and reduction of the *in vitro* plant period.

Regarding the acclimatization of fig tree seedlings on different substrates, Chirinéa et al. (2012) reported that plants grown for 30 days in WPM medium without growth regulators and acclimated to Plantmax® substrate showed good acclimation and development. Studying the foliar anatomy of micropropagated plants, the same authors also pointed out that leaf tissues show little differentiation and have a large number of stomata compared to acclimated plants, demonstrating that there is a reduction in the number of stomata during the acclimation process.

Figure 5 shows the development and production of *Ficus carica* L. seedlings obtained by Kim et al. (2007) from leaf segments. Plants were rooted in MS medium (> 90% rooting) and then transferred to substrate based on vermiculite and perlite (1:1) for acclimatization under greenhouse conditions. No changes were detected in the morphological characteristics and growth habits of plants produced.

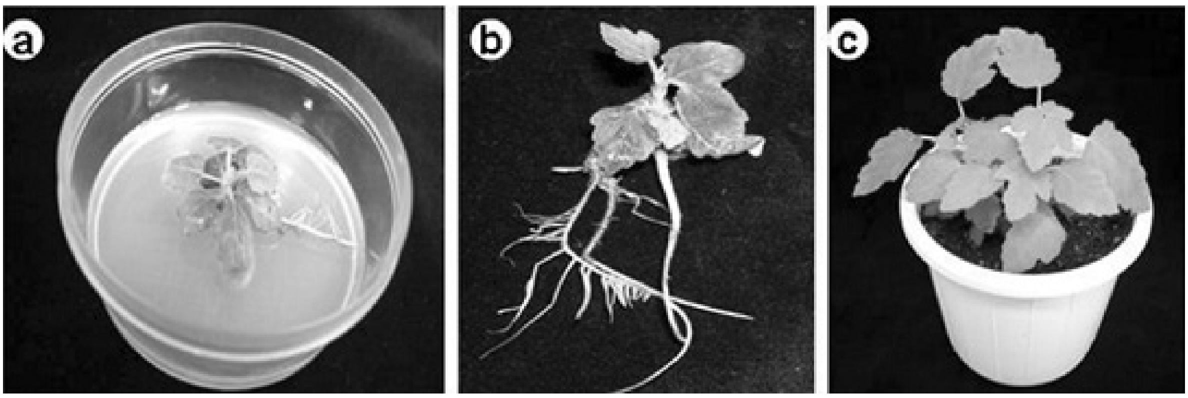

Figure 5. Production of *Ficus carica* L. seedlings from leaf segments (A) *in vitro* plant regenerated, (B) plant with well-developed root system, and (C) plant growing under greenhouse conditions. Source: Kim et al. (2007).

In recent works, Sharma et al. (2015) propose that the encapsulation of nodal segments could significantly help the exchange and conservation of fig germplasm, in addition to being easily adapted for commercial cultivation on a large scale.

Although it is a very important method for genetic improvement studies, tissue culture still encounters some obstacles. Barbosa et al. (2008) reported that figs originally micropropagated took up to 4 years to produce the first fruits, probably indicating the occurrence of juvenile occurrence of micropropagated plants via meristem culture.

Despite the disadvantages observed in literature, propagation by tissue culture of the fig tree can become an important technique for the production of healthy seedlings and, mainly, for the genetic improvement of species in search of hybrid materials with quality fruits and high productivity, resistance to pests and diseases, and large-scale seedling production.

Conclusions

Due to the importance of ficiculture for Brazil, it is of fundamental importance to develop propagation techniques that provide producers in addition to quality figs, quality seedlings, that is, free of pests or diseases and with such vigor to allow producers to form an orchard that guarantees good productivity and, consequently, significant income.

Studies have been carried out to maximize the production of figs in Brazil, and some in the field of seedling production, as better concentrations of plant regulators; environmentally safe for cutting development; protocols to obtain higher number of shoots. These are some of the studies that have been carried out to optimize the process of fig tree multiplication.

Finally, in order for these works to be actually validated, seedlings obtained in these propagation processes should be implanted in the field and accompanied until the production of fruits.

References

ALJANE, F.; NAHDI, S. Propagation of some local fig (*Ficus carica* L.) cultivars by hardwood cuttings under the field conditions in Tunisia. **International Scholarly Research Notices**, New York, v.2014, p.1-5, 2014.

ALVARENGA, A. A.; ABRAHÃO, E.; FRAGUÁS, J. C.; CARVALHO, V. L.; SILVA, R. A.; SANTA CECILIA, L. V. C.; CUNHA, R. L.; SILVA, V. J. Figo (*Ficus carica* L.). In: TRAZILBO JUNIOR, J. P.; MADELAINE V. (Org.). **101 culturas:** manual de tecnologias agrícolas. Belo Horizonte: EPAMIG, 2007. p.365-372.

ANJAM, K.; KHADIVI-KHUB, A.; SARKHOSH, A. The potential of caprifig genotypes for sheltering *Blastophaga psenes* L. for caprification of edible figs. **Erwerbs-Obstbau**, Heidelberg, v.59, n.1, p.45-49, 2017.

ARAÚJO, J. P. C.; PIO, R.; SCARPARE FILHO, J. A.; MOURÃO FILHO, F. A.; ALVES, A. S. R. Propagação da figueira por estaquia tratadas com AIB. **Bioscience Journal**, Uberlândia, v.21, n.2, p.59-63, 2005.

BARBOSA, W.; PIO, R.; VEIGA, R. F. A.; CHAGAS, E. A.; FELDBERG, N. P.; CAMPAGNOLO, M. A.; DALASTRA, I. M. Efeito de concentrações do AIB no enraizamento *in vitro* de cultivares de figueira. **Bioscience Journal**, Uberlândia, v.24, n.2, p.1-6, 2008.

BAYOUDH, C.H.; LABIDI, R.; MAJDOUB, A.; MARS, M. *In vitro* propagation of caprifig and female fig varieties (*Ficus carica* L.) from shoot-tips. **Journal of Agricultural Science and Technology**, Libertyville, v.17, p.1597-1608, 2015.

BISI, R. B.; LOCATELLI, G.; BARBOSA, C. M. A.; PIO, R.; BALBI, R. V. Rooting of stem segments from fig tree cultivars. **Acta Scientiarum Agronomy**, Maringá, v.38, n.3, p.379-385, 2016.

BITENCOURT, J.; ZUFFELLATO-RIBAS, K. C; KOEHLER, H. S. Estaquia de *Ginkgo biloba* L. utilizando três substratos. **Revista Brasileira de Plantas Medicinais**, Botucatu, v.12, n.2, p.135-140, 2010.

BRUM, G. R. **Micropropagação da figueira (*Ficus carica* L.) 'Roxo de valinhos'**. 2001. 41f. Dissertação (Mestrado em Agronomia) – Universidade Federal de Lavras, Lavras, 2001.

CAETANO, P. K.; VIEITES, R. L.; DAIUTO, E. R.; MOURA, S. C. S. R. Processamento e qualidade de compotas de figo diet e convencional. **Brazilian Journal of Food Technology**, Campinas, v.20, p.1-8, 2017.

ÇALIŞKAN, O.; MAVI, K.; POLAT, A. Influences of presowing treatments on the germination and emergence of fig seeds (*Ficus carica* L.). **Acta Scientiarum. Agronomy**, Maringá, v.34, n.3, p.293-297, 2012.

CASAROTI, B. G. **Efeito de diferentes porta-enxertos sobre o desenvolvimento e produção de figo verde, pela variedade Roxo de Valinhos**. 2010. Trabalho de Conclusão de Curso (Graduação em Agronomia) - Faculdade de Engenharia de Ilha Solteira, Universidade Estadual Paulista, Ilha Solteira, 2010.

CAVERO, R. Y; AKERRETA, S; CALVO, M. I. Medicinal plants used for dermatological affections in Navarra and their pharmacological validation. **Journal of Ethnopharmacology**, New York, v.149, n.2, p.42-533, 2013.

CHALFUN, N. N. J.; ABRAHÃO, E.; ALVARENGA, A. A.; REGINA, M. A.; PIO, R. **Poda e condução da figueira**. Lavras: UFLA, 2002. 12p. (Boletim Técnico, 104).

CHIRINÉA, C. F.; PASQUAL, M.; ARAUJO, A. G.; PEREIRA, A. R.; CASTRO, E. M. Acclimatization and leaf anatomy of micropropagated fig plantlets. **Revista Brasileira de Fruticultura**, Jaboticabal, v.34, n.4, p.1180-1188, 2012.

CORRÊA, L. S.; BOLIANI, A. C. **Cultura da figueira:** do plantio à comercialização. Jaboticabal: FUNEP, 1999. 259 p.

CORTE, F. C. **Efeitos de substratos e regulador vegetal no enraizamento de estacas herbáceas de figueira (*Ficus carica* L.), sob nebulização intermitente**. 2004. 27f. Trabalho de Graduação (Graduação em Agronomia) – Faculdade de Engenharia de Ilha Solteira, Universidade Estadual Paulista, Ilha Solteira, 2004.

COSTA JÚNIOR, W. H. **Enraizamento de estacas de goiabeiras: influência de fatores disiológicos e mesológicos**. Piracicaba, 2000. 66f. Dissertação (Mestrado em Agronomia) – Escola Superior de Agricultura Luiz de Queiroz, Universidade de São Paulo, Piracicaba, 2000.

COSTA, M. G. S.; CORREIA, E. C. S. S.; REIS, L. L.; WILCKEN, S. R. S. Reação de figueiras a três espécies de nematoides-das-galhas. **Revista Brasileira de Fruticultura**, Jaboticabal, v.37, n.3, p.617-622, 2015.

CZAJA, E. A. R.; MOREIRA, R. R.; ROZWALKA, L. C.; FIGUEIREDO, J. A. G.; MIO, L. L. M. Gray mold in immature fig fruit: pathogenicity and growth temperature. **Ciência Rural**, Santa Maria, v.46, n.9, p.1524-1527, 2016.

DANELUZ, S; PIO R.; CHAGAS E. A.; BARBOSA W.; OHLAND T.; KOTZ T. E. Propagação da figueira 'Roxo de Valinhos' por alporquia. **Revista Brasileira de Fruticultura**, Jaboticabal, v.31, n.1, p.285-290, 2009.

DIAS, J. P. T.; TAKATA, W. H. S.; TAKAHASHI, K.; ONO, E. O. Propagação de figueira com estacas de diferentes diâmetros. **Revista Trópica - Ciências Agrárias e Biológicas**, Maranhão, v.7, n.1, p.52-57, 2013.

DOLGUN, O.; TEKINTAS, F. E. Production of fig (*Ficus carica* L.) Nursery plants by stem layering method. **Agriculturae Conspectus Scientificus**, Zagreb, v.73, n.3, p.157-160, 2008.

EL-BORAI, F. E.; DUNCAN, L. W. Nematode parasites of subtropical and tropical fruit tree crops. In: LUC, M.; SIKORA, R. A.; BRIDGE, J. **Plant parasitic nematodes in subtropical and tropical agriculture**. 2^{nd} ed. Washington: CAB International, 2005. p.467-492.

FACHINELLO, J. C.; HOFFMANN, A.; NACHTIGAL, J. C.; KERSTEN, E. Propagação vegetativa por estaquia. In: FACHINELLO, J. C.; HOFFMANN, A.; NACHTIGAL, J. C. (Ed.). **Propagação de plantas frutíferas**. Brasília, DF: Embrapa Informação Tecnológica, 2005. cap.4, p.69-109.

FERREIRA, E. A.; PASQUAL, M. Otimização de protocolo para micropropagação da figueira "Roxo de Valinhos". **Ciência Rural**, Santa Maria, v.38, n.4, p.1149-1153, 2008.

FERREIRA, E. A.; PASQUAL, M.; TULMANN NETO, A. *In vitro* sensitivy of fig plantlets to gamma ray. **Scientia Agricola**, Piracicaba, v.66, n.4, p.540-542, 2009.

FRAGUÁS, C. B. **Micropropagação e aspectos da anatomia foliar da figueira "Roxo de Valinhos" em diferentes ambientes**. 2003. 110f. Dissertação (Mestrado em Fitotecnia) - Universidade Federal de Lavras, Lavras, 2003.

FRAGUÁS, C. B.; PASQUAL, M.; PEREIRA, A. R. Multiplicação *in vitro* de *Ficus carica* L.: efeito da cinetina e do ácido giberélico. **Ciência Agrotecnologia**, Lavras, v.28, n.1, p.49-55, 2004.

GAMBORG, O.; MILLER, R.; OJIMA, K. Nutrient requirement suspensions cultures of soybean root cells. **Experimental Cell Research**, New York, v.50, n.1, p.151-158, 1968.

GRATIERI-SOSSELLA, A.; PETRY, C.; NIENOW, A. A. Propagação da corticeira do banhado (*Erythrina crista-galli* L.) (Fabaceae) pelo processo de estaquia. **Revista Árvore**, Viçosa, MG, v.32, n.1, p.163-171, 2008.

GUTIÉRREZ, I. E. M.; NEPOMUCENO, C. F.; LEDO, C. A. S.; SANTANA, J. R. F. Regeneração *in vitro* via organogênese direta de *Bauhinia cheilantha*. **Ciência Rural**, Santa Maria, v.41, n.2, p.260-265, 2011.

HAN, H.; ZHANG, S.; SUN, X. A review on the molecular mechanism of plants rooting modulated by auxin. **African Journal of Biotechnology**, Nairobi, v.8, n.3, p.348-353, 2009.

HARTMANN, H.T.; HUDSON, T.; KESTER, D.E.; DALE, E K.; DAVIES JUNIOR, F.T.; GENEVE, R. L. **Plant propagation**: principles e practices. 8th ed. Boston: Prentice Hall, 2011. 928p.

KIM, K. M; KIM, M. Y.; YUN, P. Y.; CHANDRASEKHAR, T.; LEE, H. Y.; SONG, P. S. Production of multiple shoots and plant regeneration from leaf segments of fig tree (*Ficus carica* L.). **Journal of Plant Biology**, New York, v.50, n.4, p.440-446, 2007.

KOTZ, T. E.; PIO, R.; CAMPAGNOLO, M. A.; CHAGAS, E. A.; DALASTRA, I. M. Enxertia em figueira 'Roxo de Valinhos' por borbulhia e garfagem. **Bragantia**, Campinas, v.70, n.2, p.344-348, 2011.

LAZREG-AREF, H; MARS, M; FEKIH, A; AOUNI, M; SAID, K. Chemical composition and antibacterial activity of a hexane extract of Tunisian caprifig latex from the unripe fruit of *Ficus carica*. **Pharmaceutical Biology**, Philadelphia, v.50, n.4, p.407-412, 2012.

LLOYD, G.; MCCOWN, B. Commercially feasible micropropagation of montain laurel, *Kalmia latifolia*, by use of shoot tip culture. **Combined Proceedings International Plant Propagators Society**, Sealtle, v.30, p.421-327, 1980.

MURASHIGE, T.; SKOOG, F. A revised medium for rapid growth and bioassays with tabacco tissue culture. **Physiologia Plantarum**, Bratislava, v.15, n.3, p.473-497, 1962.

NAVA, G. A.; WAGNER JÚNIOR, A.; MEZALIRA, E. J.; CASSOL, D. A.; ALEGRETTI, A. L. Rooting of hardwood cuttings of Roxo de Valinhos fig (*Ficus carica* L.) with different propagation strategies. **Revista Ceres**, Viçosa, MG, v.61, n.6, p.989-996, 2014.

NEVES, T. S.; CARPANEZZI, A. A.; ZUFFELLATO-RIBAS, K. C.; MARENCO, R. A. Enraizamento de corticeira-da-serra em função do tipo de estaca e variações sazonais. **Pesquisa Agropecuária Brasileira**, Brasília, DF, v.41, n.12, p.1699-1705, 2006.

NOGUEIRA, A. M; CHALFUN, N. N. J.; DUTRA, L. F.; VILLA, F. Propagação de figueira (*Ficus carica* L.) por meio de estacas retiradas durante o período vegetativo. **Ciência e Agrotecnologia**, Lavras, v.31, n.3, p.914-920, 2007.

OHLAND, T.; PIO, R.; CHAGAS, E. A.; BARBOSA, W.; DALASTRA, I. M.; KOTZ, T. E. Enraizamento de estacas apicais lenhosas de figueira 'Roxo de Valinhos' com aplicação de AIB e cianamida hidrogenada. **Revista Brasileira de Fruticultura**, Jaboticabal, v.31, n.1, p.273-279, 2009.

OLIVEIRA, J. A. **Efeito dos substratos artificiais no enraizamento e no desenvolvimento de maracujazeiro-azedo e doce por estaquias**. 2000. 71f. Dissertação (Mestrado em Agronomia) – Faculdade de Agronomia e Medicina Veterinária, Universidade de Brasília, Brasília, 2000.

PALÚ, E. G. **Micropropagação da Figueira (*Ficus carica* L.): Estabelecimento, Multiplicação e Enraizamento *in vitro***. 2011. 102f. Tese (Doutorado em Sistemas de Produção) – Faculdade de Engenharia de Ilha Solteira, Universidade Estadual Paulista, Ilha Solteira, 2011.

PALÚ, E. G.; KRAUSE, S.; SILVA, L. M.; HUNHOFF, V. L.; DALBOSCO, E. Z. Meios nutritivos no estabelecimento *in vitro* de figueira. **Enciclopédia Biosfera**, Goiânia, v.10, n.19, p.1280-1286, 2014.

PAULA, L. A.; CORRÊA, L. S.; BOLIANI, A. C.; SANTOS, P. C. Efeito do ácido indolbutírico e épocas de estaqueamento sobre o enraizamento de estacas herbáceas de figueira (*Ficus carica* L.). **Acta Scientiarum Agronomy**, Maringá, v.31, n.1, p.87-92, 2009.

PIO, R. **Ácido indolbutírico e sacarose no enraizamento de estacas apicais e desenvolvimento inicial da figueira (*Ficus carica* L.)**. Lavras, 2002. 109f. Dissertação (Mestrado em Agronomia) - Universidade Federal de Lavras, Lavras, 2002.

PIO, R.; ARAÚJO, J. P. C.; BASTOS, D. C.; ALVES, A. S. R.; ENTELMANN, F. A.; SCARPARE FILHO, J. A.; MOURÃO FILHO, F. A. A. Substratos no enraizamento de estacas herbáceas de figueira oriundas da desbrota. **Ciência e Agrotecnologia**, Lavras, v.29, n.3, p.604-609, 2005.

PIO, R.; CHALFUN, N. N. J.; RAMOS, J. D.; GONTIJO, T. C. A.; TOLEDO, M.; CARRIJO, E. P. Presença de folhas e gema apical no enraizamento de estacas herbáceas de figueira oriundas da desbrota. **Revista Brasileira Agrociência**, Pelotas, v.10, n.1, p.51-54, 2004.

PIO, R.; OHLAND, T.; CHAGAS, E. A.; BARBOSA, W.; DALASTRA, I. M.; CAMPAGNOLO, M. A.; BETTIOL NETO, J. E. Enraizamento de estacas apicais de figueira Roxo de Valinhos submetidas à estratificação a frio úmido e AIB. **Revista Ceres**, Viçosa, MG, v.57, n.3, p.401-404, 2010.

PIO, R.; RAMOS, J. D.; CHALFUN, N. N. J.; GONTIJO, T. C. A.; MENDONÇA, V.; CARRIJO, E. P.; CHAGAS, E. A. Propagação de estacas apicais de figueira: diferentes ambientes, ácido indolbutírico e tipo de estaca. **Ciência e Agrotecnologia**, Lavras, v.30, n.5, p.1021-1026, 2006.

RAMOS, D. P.; LEONEL, S.; DAMATTO JÚNIOR, E. R. Avaliação da época de estaquia e uso de bioregulador no enraizamento de estacas de figueira. **Revista Brasileira de Fruticultura**, Jaboticabal, v.30, n.3, p.748-753, 2008.

REIS, E. S.; PINTO, J. E. B. P.; ROSADO, L. D. S.; CORRÊA, R. M. Influência do meio de cultura na germinação de sementes *in vitro* e taxa de multiplicação de *Melissa officinalis* L. **Revista Ceres**, Viçosa, MG, v.55, n.3, p.160-167, 2008.

ROCHA, P. S.; SCHUCH, M. W.; BIANCHI, V. J.; FACHINELLO, J. C. multiplicação e alongamento *in vitro* do porta-enxerto de prunus. **Bioscience Journal**, Uberlândia, v.25, n.1, p.69-74, 2009.

SHARMA, S.; SHAHZAD, A.; MAHMOOD, S.; SAEED, T. High-frequency clonal propagation, encapsulation of nodal segments for short-term storage and germplasm exchange of *Ficus carica* L. **Trees**, London, v.29, n.1; p.345-353, 2015.

SILVA, E. A. **Enxertia e Testes de Resistência à *Ceratocystis fimbriata* em variedades de Figueira (*Ficus carica* L).** 2010. 88f. Tese (Doutorado em Sistemas de Produção) – Faculdade de Engenharia, Universidade Estadual Paulista, Ilha Solteira, 2010.

SIRIN, U.; ERTAN, E.; ERTAN, B. Growth substrates and fig nursery tree production. **Scientia Agricola**, Piracicaba, v.67, n.6, p.633-638, 2010.

SOUSA, M. S.; BUSQUET, R. N.; VASCONCELLOS, M. A. S.; MIRANDA, R. M. Effects of auxin and misting on the rooting of herbaceous and hardwood cuttings from the fig tree. **Revista Ciência Agronômica**, Fortaleza, v.44, n.2, p.334-338, 2013.

SOUZA, C. S. S. **Estudo de ambientes de enraizamento, tempo de imersão em AIB, estratificação a frio e enxertia de mesa na figueira.** 2008. 101f. Tese (Doutorado em Sistemas de Produção) – Faculdade de Engenharia, Universidade Estadual Paulista, Ilha Solteira, 2008.

SOUZA, M. E.; LEONEL, S. Propagação da figueira. In: LEONEL, S.; SAMPAIO, A. C. (Org.). **A figueira**. São Paulo: Editora Unesp, 2011. cap.4, p.77-91.

YAKUSHIJI, H.; MORITA, T.; JIKUMARU, S.; IKEGAMI, H.; AZUMA, A.; KOSHITA, Y. Interspecific hybridization of fig (*Ficus carica* L.) and *Ficus erecta* Thunb., a source of *Ceratocystis canker* resistance. **Euphytica**, Dordrecht, v.183, n.1, p.39-47, 2012.