Bulgarian Journal of Agricultural Science, 16 (No 5) 2010, 547-552
Agricultural Academy

CHLOROPHYLL FLUORESCENCE INTENSITY, PHOTOSYNTHETIC YIELD AND FLOWERING IN FIG FRUIT TREES AS AFFECTED BY PHLOEM STRESS

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Abstract

HOSSAIN, A. B. M. S., A. SALLEH, M. A. MEKHLED and A. M. Al-SAIF, 2010. Chlorophyll fluorescence intensity, photosynthetic yield and flowering in fig fruit trees as affected by phloem stress. *Bulg. J. Agric. Sci.,* 16: 547-552

Chlorophyll fluorescence intensity, photosynthetic yield in leaves and flowering of fig trees (*Ficus carica* L.) as affected by phloemic stress (represented by partial bark ring) were studied. The treatments were un-ringed, I-shape partial ring (I-SPR), X-shape partial ring (X-SPR) and S-shape partial ring (S-SPR). The greater bark thickness (width) was found in I SPR treated branch than other treated branches. Branch circumference of all three types of treatment showed higher value in upper ring than in lower ring. The maximum SPAD value was observed in control branch earlier after treatment whereas the maximum value was found in S-SPR treated branch later. Besides, the percent flower bud and fruit set were greater in S-SPR treated trees than other treated branches. The flower bud and fruit set were higher in treated branches than in control. Chlorophyll fluorescence intensity was found similar upward trends with some fluctuations in case of all treatments. The intensity was higher in control and I-SPR treated branches than in other treatments. Fo (lower fluorescence), Fm (higher fluorescence), Fp (Intermediate fluorescence) were highest in leaves of control, I-SPR and X-SPR treated branches. However, X-SPR treatment represented the maximum optimum quantum yield [(Photosynthetic yield (Fv/Fm)]. Resulting, the study represents that phloemic stress (I-SPR, X- SPR & S-SPR), can be applied for the dwarfing physiological growth and early flowering of fig tree and the most effective one was S-SPR.

*Key words***:** Fig fruit, ringing, fluorescence, flowering, fruit set

Introduction

The fig fruit is a highly perishable climacteric fruit and oldest species of the fruit tree having been cultivated by humans for over 5000 years (Owino et. al., 2006). The common fig (*Ficus carica* L.) is a tree indigenous to southwest Asia and the eastern Mediterranean region; belong to family Moracea (Duenas et. al., 2008). Figs (*Ficus carica* L.) are usually cultivated especially in warm, dry climates. The world production of figs is about one million tons (Veberic et. al., 2008). This fruit is an important crop worldwide for dry and fresh consumption (Duenas et. al., 2008).

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Dwarfing fruit trees plays an important role in fruit growth, development and quality. Large vigorous fruit trees are a problem to the fruit growers, because ladders have to be used during fruit thinning, bagging and harvesting. If trees are small sized, then it is easy to pick fruit from the ground. Small, compact, dwarf or size controlled fruit trees provide for easier pruning, thinning, spraying and harvesting and could lead to production of high-grade fruit at lower production cost (Tukey, 1964). Partial ringing can be used to make tree dwarfed. Ringing tends to increase the size and sugar content of fruit and to cause the fruit to mature a few days to a week earlier (Tukey, 1964). Trunk girdling of apple trees reduces chlorophyll concentration in leaves and is significantly lower in girdled tree than control (Arakawa et al., 1997). Sitton (1949) reported that the increase of trunk girth above the girdling might be caused by swelling of the trunk with accumulation of carbohydrates.

Arakawa et al. (1997) stated that flowering in the following spring of apple trees was significantly increased by girdling and also peach Hossain et al. (2007) found the similar results to the present result in peach trees (Hossain et al., 2007; Onguso et al., 2004; Onguso et al., 2005a; Onguso et al., 2005 b). Schneider (1969) stated that girdling blocks the translocation of sucrose from leaves to the root zone through phloem bundles. The block decreases starch content in root system and accumulation of sucrose in the leaves (Plaut and Reinhold, 1967). Rose and Smith (2001) stated that complete girdling of stems killed the plants and partial girdling made weakening the plant. There is not available literature on bark ringing applied to the fig trees. The aim of this research was to investigate the influence of different types of bark ringing on bark thickness, trunk circumference, flower bud and fruit formation, leaf chlorophyll.

Materials and Methods

Site

The experiment was conducted in the University of Malaya fruit orchard, located in Kuala Lumpur, Malaysia.

Plant material

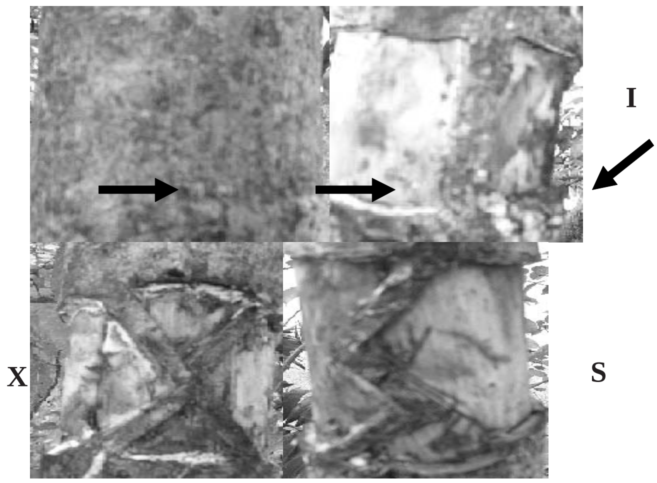
10-year-old fig tree (*Ficus carica* L.) was used in the experiment. The tree was 4.0 m of height and canopy size was 5.0 m. The tree consisted of 6 main branches and 12 sub-branches. Branch spacing was 0.5m approximately.

Intercultural operations

Weeding, irrigation and pesticide were done as needed. Fertilizers were applied in the 1st year when tree was planted at the rate of N, P and K (10%, 10% and 10%) 20 g respectively. The soil was fertile and loamy.

Treatment setting

Phloemic stress was represented by different types of partial ringing. The treatments were control (unringed/no phloemic stress), I-shape partial ring (I SPR), X-shape partial ring (X SPR) and S-shape partial ring (S SPR). A partial ring was made by using a knife (thin razor blade type) on 20th April 2007. The partial ringing was consisted of removing a 5 cm length (vertically) bark (from trunk) leaving a 5 mm width (horizontal thickness) connecting bark band (strip) in the trunk, 10 cm above from the base of branches (Figure 1).



Control (no stress) | I shape Partial ringing (phloemic stress) | X shape Partial ringing (phloemic stress) | S shape Partial ringing (phloemic stress)

Fig. 1. Photos show the ringing structures control (un-ringed), I shape partial ring (I SPR), X shape partial ring (X SPR) and S shape partial ring (S SPR)

Data collection

Regenerated bark growth and branch circumference were measured at 7 days intervals starting from the following week of treatment setting. Regenerated bark growth was measured horizontally with vernier caliper. The percentage of flower bud and initial fruit set were measured.

Chlorophyll fluorescence intensity and optimum quantum yield measurement

Chlorophyll fluorescence intensity/yield was measured by Hansatech Plant Efficiency Analyzer. Leaf was attached to the leaf clip and kept for 2 h to maintain dark adaptation. Afterward, the leaf clip was oriented with the side containing shutter plate. When light shine was applied on to the leaf, the fluorescence signal was continued for 3 second and observed fluorescence yield or photosynthetic yield. It was represented by Fo, Fm, Fv and Fv/Fm (Photosynthetic yield or optimum quantum yield). Where, Fo = Lower fluorescence, Fm = Higher fluorescence, Fv = Relative variable fluorescence (Fm - Fo). Temperature = 28^0C. Time range = 10µs-3 sec.

Chlorophyll content (SPAD unit) measurement

Chlorophyll content (SPAD unit) was measured by Chlorophyll meter SPAD-502, Minolta Co. Japan which represented by SPAD value. The leaf was inserted into the meter and measured SPAD value 3 times from upper, medium and lower parts of a single leaf.

Design of Experiment

The experimental design was completely randomized design. There were 3 replications and 4 treatments (including control) used in the experiment. Treatments were set randomly. A total of 12 branches used in the experiment. Standard errors were calculated.

Results

Figure 1 showed the ringing structures namely control (unringed), I shape partial ring (I SPR), X shape partial ring (X SPR) and S shape partial ring (S SPR). Despite insignificant differences, the greater bark thickness (width) was found in I SPR treated branch than in other treated branches (Figure 2). From Figure 2 it was also observed that within 7 week time duration the bark regeneration was just less than 5 mm in all treatments. However, there was nearly similar trend in X-SPR and S-SPR treated branches.

Branch circumference of control and treated fig trees are compiled in Table 1. All ringed treatments showed higher value in upper ring than in lower ring.

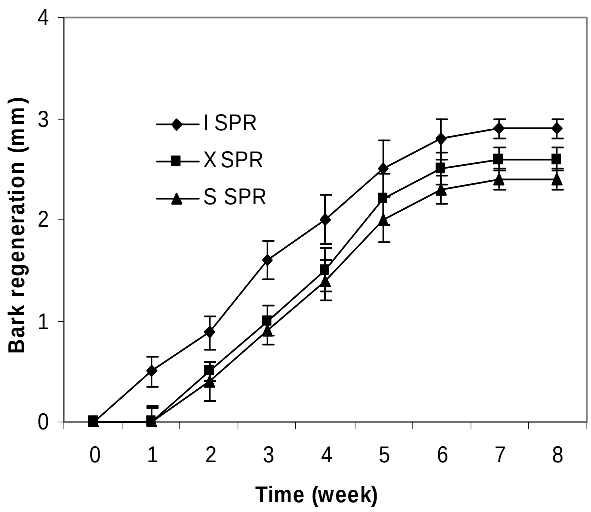


Fig. 2. Bark regeneration (thickness) was measured in treated and control branches. Vertical bars represent SE (n = 3)

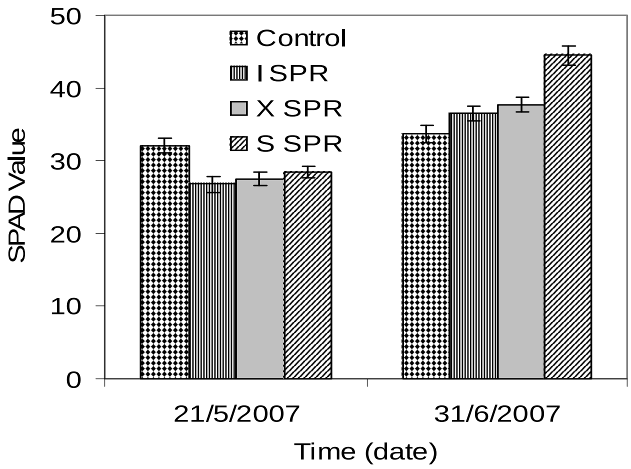


Fig. 3. SPAD value (chlorophyll content) was measured in treated and control branches in May, 2007 and June 2007 .Vertical bars represent SE (n = 3)

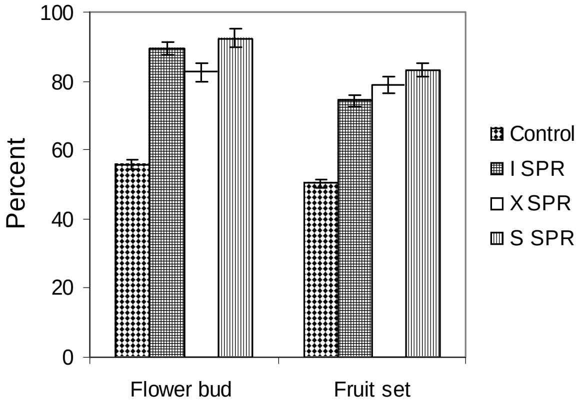


Fig. 4. Flower bud and fruit set were measured at different treatments. Vertical bars represent SE (n = 3)

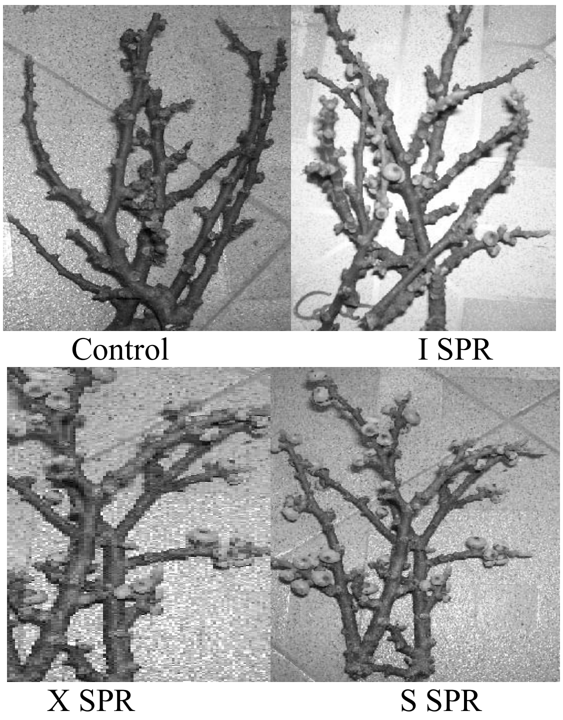


Fig. 5. Photos show flower bud and fruit set with difference at different treatments

The Upper ring/Lower ring ratio was observed highest in S-SPR treated branch (1.04). Conversely, U/L ratio was similar (1.02) in both I-SPR and X-SPR treated branches.

The maximum SPAD value was observed in control branch in May where as the maximum SPAD value was in S-SPR treated branch in June (Figure 3). Besides, the percent flower bud and fruit set were greater in S-SPR treated trees than in other treated and control branches (Figure 4). However, the result showed that all treated branches had significantly higher percentage of flower bud and fruit set than in control branch (Figure 4). Photos showed that flower bud and fruit set were difference at different treatments in Figure 5.

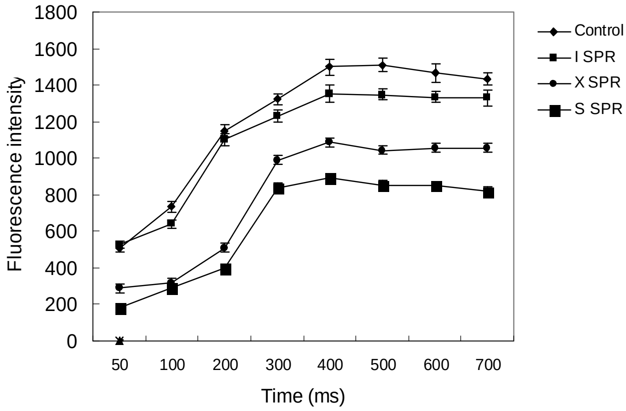


Fig. 6. Chlorophyll fluorescence intensity followed by time (ms) as affected by different treatments. Vertical bars represent SE (n = 3)

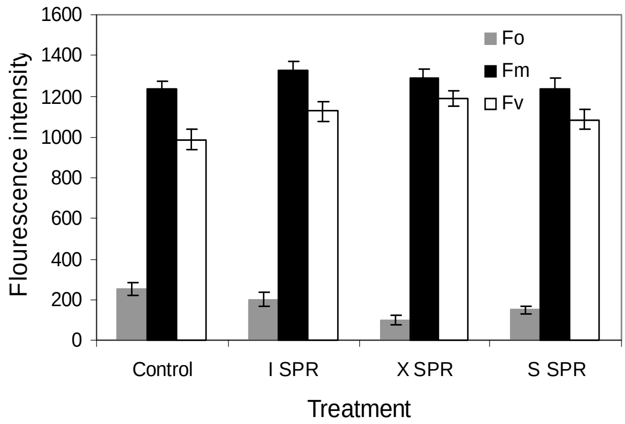


Fig. 7. Fo (Flower fluorescence), Fm (higher fluorescence), Fp (intermediate fluorescence) were measured at different treatments. Vertical bars represent SE (n = 3)

Chlorophyll fluorescence intensity followed by time was represented in Figure 6. Chlorophyll fluorescence intensity was found similar upward trends with some fluctuations in case of all treatments. The intensity was higher in control and I-SPR treated branches than in

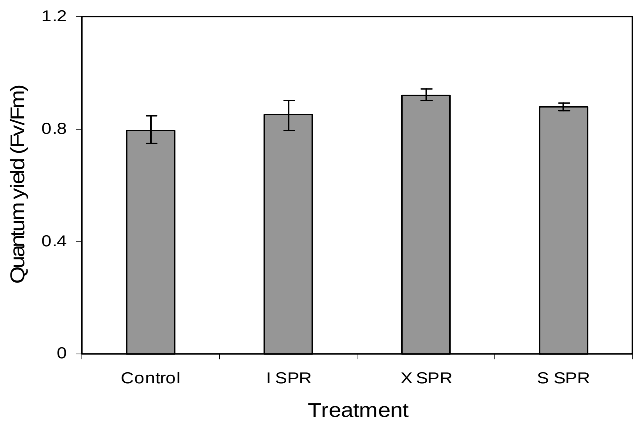


Fig. 8. Optimum quantum yield (Fv/Fm) was measured at different treatments. Vertical bars represent SE (n = 3)

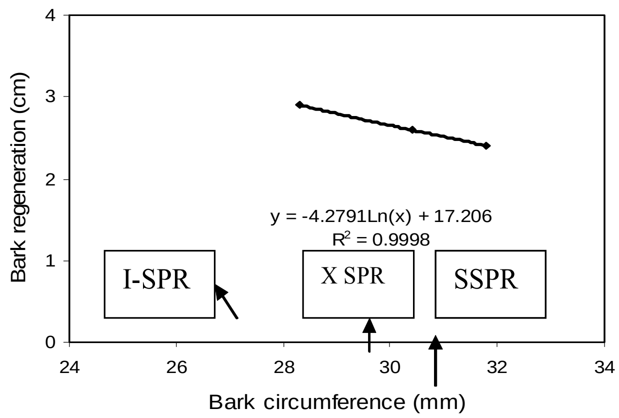


Fig. 9. Correlation was determined between branch (bark) circumferences and bark regeneration at different treatments

Table 1

Stem circumference of fig branches as affected by different treatments Mean±SE (n = 3)

Treatments	Initial	Circumference, cm		
		Lower ring (L)	Upper ring (U)	Ratio (U/L)
Control (unringed)	28.5± 1.20	28.7±1.00	28.6±0.98	0.99±0.02
I-PR	27.5± 1.00	27.6±1.10	28.3±0.97	1.02±0.01
X-PR	29.4± 0.96	29.6±1.20	30.4±0.95	1.02±0.02
S-PR	30.0± 1.00	30.5±0.85	31.8±0.97	1.04±0.02

other treatments. F_o (lower fluorescence), Fm (higher fluorescence), Fp (intermediate fluorescence) were highest in leaves of control, I-SPR and X-SPR treated branches, consecutively (Figure 7). However, X-SPR treatment represented the maximum optimum quantum yield (Fv/Fm) (Figure 8). There was a positive linear correlation was found between branch (bark) circumference and bark regeneration at different treatments shown in Figure 9.

Discussion

The results represented that phlomeic stress followed by partial ringing was useful for dwarfing of fig fruit trees and early flowering. The possible reason is less suppression of nutrients movement between shoot and root by phloemic stress using partial bark ringing. In addition, partial ringing decreased phloem of bark which consequently restrained carbohydrate transport. Among treatments, maximum bark regeneration was in I-SPR treated branch. It might be as a result of readily vertical circulation of nutrients in I-SPR than in other two types of ringing where nutrients must be circulated laterally. Tukey (1964) stated that nutrient sap may circulate laterally or vertically if normal phloem transport was checked by ringing.

Branch circumference was higher in upper ring than in lower ring in all treatments. The increase of stem girth above the girdling might be caused by swelling of the trunk with accumulation of carbohydrates (Sitton 1949). The highest U/L ratio was obtained in S-SPR treated branch. The most possible reason was the entrapment of carbohydrate was more frequent due to difficulty of circulation of carbohydrate in lateral way of S-SPR treatment.

In the present study, chlorophyll (SPAD) was lower in May and June in treated branches than in control branch. Because of the treated branches were affected by phloem stress. Hossain et al. (2007) found the similar results to the present result in peach trees (Onguso et al., 2004; Onguso et al., 2005a; Onguso et al., 2005b) and also stated in big fruit (Hossain and Boyce, 2009). The high percentage of flower bud and fruit set was in all treated branches than in control one. Arakawa et al. (1997) found similar finding that flowering in the following spring of apple trees was significantly increased by girdling. This might be due to entrapment of adequate carbohydrates and nutrients in upper ringing. Among all ringed treatments, percentage of flower bud and fruit set was higher in S-SPR than in other treatments. As discussed above, the possible reason was frequent entrapment of carbohydrate in upper ringing due to hindrance of circulation of carbohydrate in lateral way of S-SPR treatment.

The chlorophyll fluorescence intensity was higher in control and I-SPR treated branches than in other treatments. Arakawa et al. (1997) reported that trunk girdling of apple trees reduced chlorophyll concentration in leaves and was significantly lower in girdled trees than in control trees. Hossain et al. (2006) found the similar results to the present result in peach trees. Quantum yield (Fv/Fm) was higher in X-SPR than in other treatments.

Conclusion

Phloemic stress represented by partial bark ringing applied to the fig trees was capable of impeding growth of the fig trees. Nevertheless, partial ringing of 5 mm Bark Bridge (97% ringing) confirmed surviving trees with a good dwarfing effects. Moreover, the lateral partial ringing was more effective than the vertical ringing.

The study also represented that within two types of lateral partial ringing (X SPR & S SPR), the most effective one was S SPR. In addition, this method is significant because it may be implemented in all woody fruit tree species.

Acknowledgements

The authors are grateful to Institute of Postgraduate Studies, University of Malaya, Kuala Lumpur, Malaysia for providing fund in this research.

References

Arakawa, O., K. Kanno, A. Kanetsuka and Y. Shiozaki, 1997. Effect of girdling and bark inversion on tree growth and fruit quality of apple. *Acta Horticulturae (ISHS),* **451**: 579586.

Duenas, M., J. J. Pé rez-Alonsoa, C. Santos-Buelgaa and T. Escribano-Bailona, 2008. Anthocyanin composition in fig (*Ficus carica* L.) *J. Food Compos. Ana.,* **21**:107-115.

Hossain, A. B. M. S. and A. N. Boyce, 2009. Fig fruit growth and quality development as affected by phloem stress. *Bulgarian Journal of Agricultural Science*, **15** (3):189-195.

Hossain, A. B. M. S., F. Mizutani, J. M. Onguso, A. R. El-Shereif and H. Yamadah, 2007. Inhibiting peach trees growth with abscisic acid, hinokitiol and tropollone applied to the partially ringed bark strips. *J. Hort. Sci. Biotech.,* **82**: 175-178.

Hossain, A. B. M. S., F. Mizutani, J. M. Onguso, Ali. R. Shereif and H. Yamada, 2006b. Dwarfing peach trees by bark ringing. *Scientia Horticulture*, **110:** 38-43.

Hossain, A. B. M. S., F. Mizutani, J. M. Onguso and A. R.El-Shereif, 2006. Dwarfing peach trees and development of fruit quality by maintaining partially ringed bark strips as an innovative process in dwarfing technology. *Botanical Studies*, **47:** 251-257.

Onguso, J. M., F. Mizutani, A. B. M. S. Hossain and A.L. El-Sherief, 2005a. Effect of electric vibration on the shoot growth and fruit quality of peach trees. *Scientia Horticultura* , **108**: 359-363.

Onguso, J. M., F. Mizutani, A. B. M. S. Hossain and A.L. El-Sherief, 2005b. Effect of electric vibration on the shoot growth and fruit quality of peach trees. *Scientia Horticulturae*, **108:** 359-363.

Onguso, J. M., F. Mizutani and A. B. M. S. Hossain, 2004. Effect of partial ringing and heating of trunk shoot growth and fruit quality of peach trees. *Botanical Bulletin of Academia Sinica*, **45:** 301-306.

Owino, W. O., Y. Manabe, F. M. Mathooko, Y. Kubo and A. Inaba, 2006. Regulatory mechanisms of ethylene biosynthesis in response to various stimuli during maturation and ripening in fig fruit (*Ficus carica* L.) *Plant Physiol. Biochem.,* **44:** 335-342.

Plaut, Z., and L. Reinhold, 1967. The effect of water stress on the movement of 14 Csucrose tritiated water within the supply of leaves of young bean plants. *Aust. J. Biol. Sci.,* **20:** 297307.

Rose, M. A. and E. Smith, 2001. Overwintering plants in the landscapes. In: Horticulture and Crop Science, Ohio State University Extension, Columbus. USA. p. 1.

Sitton, B. G., 1949. The effect of different methods of girdling bearing and defruited tung branches. *Proc. Am. Soc. Hort. Sci.,* **53:** 119124.

Schneider, H., 1969. Effect of trunk girdling on phloem of trunk of sweet orange trees on sour orange rootstocks. *Hilgardia,* **22**: 593 601.

Tukey, H. B., 1964. Tree structure, physiology and dwarfing.Dwarf FruitTrees, *Cornell University Press*, UK. P.562.

Veberic, R., M. Colarica and F. Stampara, 2008. Phenolic acids and flavonoids of fig fruit (*Ficus carica* L.) in the northern Mediterranean region. *Food Chemistry,* **106**:153-157.

Received January, 12, 2010; accepted for printing August, 18, 2010.