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FIG FRUIT GROWTH AND QUALITY DEVELOPMENT AS AFFECTED BY PHLOEM STRESS

A. B. M. S. HOSSAIN* and A. N. BOYCE
Institute of Biological Sciences, Faculty of Science, University of Malaya, Kuala Lumpur 50603, Malaysia

Abstract

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Fig fruit set, growth and yield, weight and maturity index as influenced by phloem stress (represented by partial bark ring) were studied. The treatments were namely control (unringed), I-shape partial ring (I-SPR), X-shape partial ring (X-SPR) and S-shape partial ring (S-SPR) at pre harvest stage. Phloem stress was represented by partial bark ringing. The percent flower bud and fruit set were greater in S-SPR treated than in other treated branches. However, the result showed that all three treated branches had significantly higher percentage of flower bud and fruit set than that of the control one. Fruit length and diameter were higher in I-SPR, S-SPR, X-SPR treated branches than in control (un-ringed). Fruit number per bunch was lower in treated branches than in control branches. On the contrary, bunch weight, per fruit weight, soluble solids content and maturity index were greater in I-SPR, S-SPR, X-SPR treated branches than in control (un-ringed) branches. The result showed that phloem stress represented by partial ringing as dwarfing component was a useful practice for fig fruit growth and quality development.

Key words: dwarfing, fruit quality, peach, summer pruning

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).

Dwarfing fruit trees plays an important role in fruit growth, development and quality. Partial ringing (phloem stress) can be used to make tree dwarfed. Ringing tends to increase the size and sugar content of fruit and cause the fruit mature a few days to a week earlier (Tukey, 1964). Sitton (1949) reported that the increase of trunk growth above the girdling might be caused by swelling of the trunk with accumulation of carbohydrates.

Arakawa et al. (1997) stated that flowering in the

E-mail: sharif@um.edu.my; sharifhort@yahoo.com

following spring of apple trees was significantly increased by girdling. 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. Hossain et al. (2006) found that soluble solids content was higher and acid content was lower in partially ringed peach trees than in control trees. Onguso et al. (2004) reported that maturity index was higher in partially ringed peach trees than in control trees. They also suggested that flower bud formation and early flowering in the following year of peach trees were significantly increased by partial bark ringing. In addition, they stated that partial bark ringing (girdling) blocked the translocation of sucrose from leaves to the root zone through phloem bundles and found higher sucrose and starch content in partial bark ringing than in unringed trees. There is no literature yet on bark ringing (phloem stress) applied to the fig trees. The aim of this research was to investigate the influence of different types of bark ringing (phloem stress) on flower bud and fruit formation, fruit bunch weight, per fruit weight, total soluble solids, titratable acidity and maturity index.

Materials and Methods

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

Plant material: A 10-year-old fig tree (*Ficus carica* L.) was used in the experiment. The tree was 3.0 m of height and canopy size was 6.0 m. The tree consisted of 6 main branches and 12 sub-branches. Branch spacing was 0.5 m approximately.

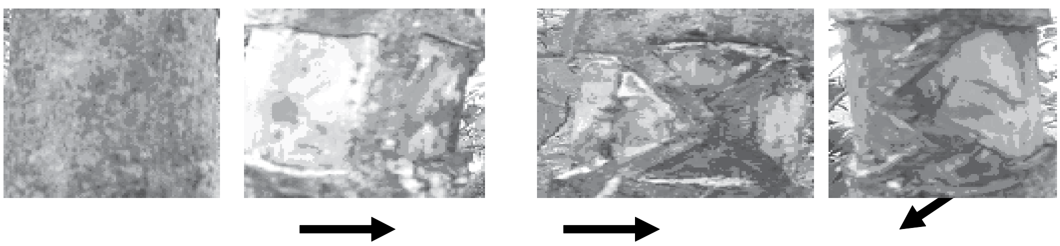
***Intercultural operations**:* Weeding, irrigation and pesticide were done as needed. The soil was fertile and loamy.

Treatment setting: The treatments were control (unringed), I-shape partial ring (I SPR), X-shape partial ring (X SPR) and S-shape partial ring (S SPR). Phloemic stress was represented by different types of partial ringing. A partial ring was made by using a knife (thin razor blade type) on 20 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).

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.

Data collection in first season (April- June 2007): Percent flower bud and fruit set were measured once. Fruit length and diameter were measured every week (0-5th week). .

Fruit harvesting weekly (0-5th week): Fruit harvested 0-5th week to determine the TSS and TA every week. Three fruit per branches were randomly selected and used to determine Total soluble solids



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

(TSS) and titratable acidity (TA) in mid May 2007. Total Soluble solids were measured with a refractometer (Atago PR-1) and TA was determined by titration with 0.1N NaOH using phenolphthalein as an indicator.

Final fruit harvesting: Fruit were harvested and recorded immediately after harvest on 7th June 2007. Data were measured on number of fruit per bunch, per bunch weight, per fruit weight and maturity index on 7th June 2007.

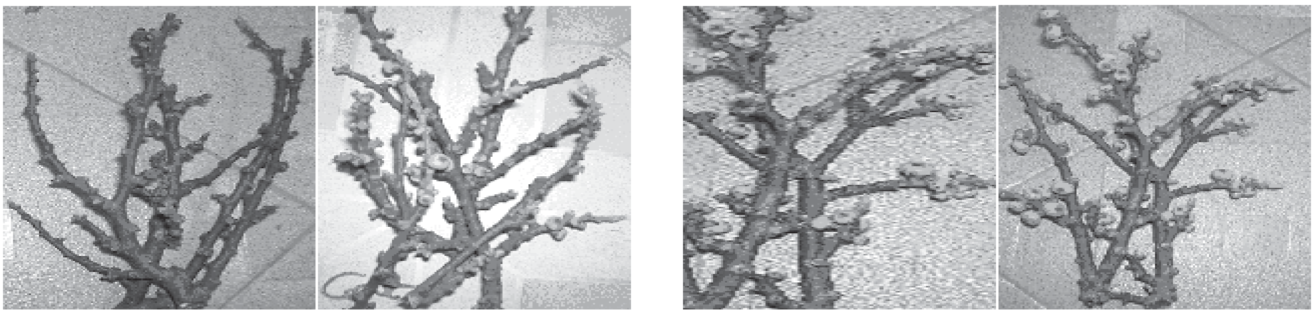
Maturity index: Maturity index was determined in mid May 2007 and the following season in mid September 2007 by scoring 1 – 5. Green fruit were scored 1 and full ripen fruit were scored 5.

Total soluble solids (TSS) and titratable acidity (TA): Five fruit per tree were randomly selected and used to determine soluble solids content (TSS) and titratable acidity (TA) in mid May 2007. Soluble solids content was measured with a refractometer (Atago PR-1) and TA was determined by titration with 0.1N NaOH using phenolphthalein as an indicator.

Fruit harvesting in second season (Sep. - Nov. 2007): The experiment was continued until the 2nd season (Sep. - Nov. 2007). Fruit were harvested in mid November 2007 and data were measured according to the 1st season to compare in different treatments and seasons. At post harvest stage, harvested fruit were stored at 28, 15, 8 and -2^{0}C with or without 70% ethanol application immediately after measurement.

Results

Figure 1 showed the ringing structures namely control (un-ringed), I shape partial ring (I SPR), X shape partial ring (X SPR) and S shape partial ring (S SPR). The percent flower bud and fruit set were greater in S-SPR treated trees than in other treated and control



Control I SPR X SPR S SPR

Fig. 2. Photos show flower bud and fruit set were difference at different treatments

branches (Figure 2). However, several days earlier flower bloom was initiated in all ringed branches than in un-ringed branches (Figure 2). The result showed that all treated branches had significantly higher percentage of flower bud and fruit set than in control branch (Figure 3). Fruit length and diameter gradually increased over the weeks from 0- 5 in both ringed and un-ringed branches (Figure 4). The highest fruit length and diameter was found in S SPR. From 0-5th weeks, TSS gradually increased weekly and TA gradually declined in case of all treatments (Figure 5). Figure 6 photos showed the early maturity and bigger fruit development in phloemic stress (I SPR, X SPR

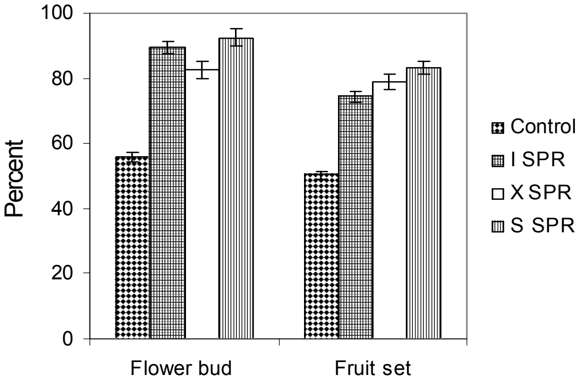


Fig. 3. Flower bud and fruit set were measured at different treatments. Vertical bars represent SE (n = 3)

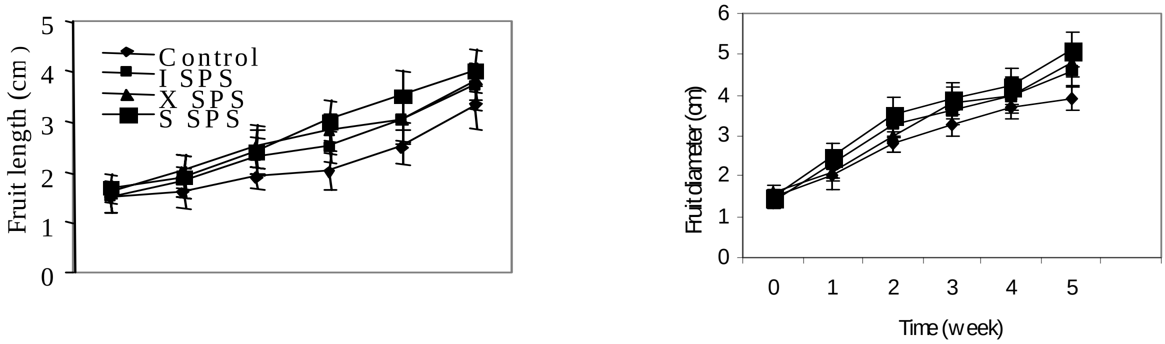


Fig. 4. Fruit length and diameter were recorded over the weeks from 0- 5 in both ringed and un-ringed branches. Vertical bars represent SE (n = 3)

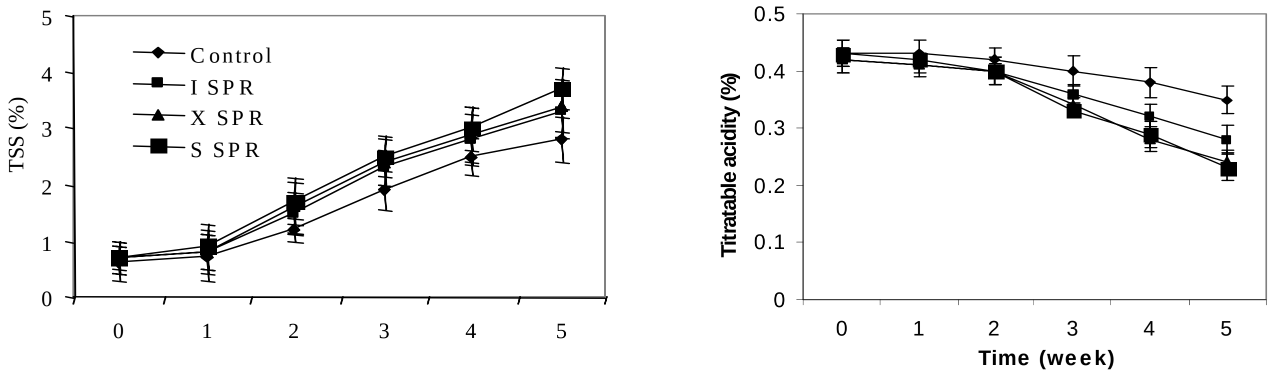


Fig. 5. Total soluble solids and Titratable acidity were recorded over the weeks from 0-5 in both ringed and un-ringed branches. Vertical bars represent SE (n = 3)

and S SPR) than in control branches. TSS was higher in ringed branches than in un-ringed branches. Whereas TA was lower in ringed branches than in un-ringed branches. In 6th week harvested fruit were counted (Table 1). Fruit number/branch was less in ringed branches than in control branch. However, mean fruit weight, bunch weight, maturity index and TSS were higher in ringed branches than in un-ringed branch. The maximum per fruit weight, bunch weight, maturity index and TSS were found in S SPR (Table 1) in both 1st and 2nd seasons. TA was lower in ringed branches than in unringed branch. Similar trends were also observed in second season (Table 1). This indicated that phloemic stress promoted fruit maturation earlier in the following years. Total storage day (TSD) TSS and TA were measured in different temperatures having 70% ethanol or without 70% ethanol by wrap white plastic (Table 2). The shelf life was higher in low temperatures with 70% ethanol or without (8^0C + Et +C, 8^0C +C, -2^0C+C and -2^0C + Et +C) than in high temperatures 28^0C +C, 28^0C+ Et +C, 15^0C+C and 15^0C + Et +C) in case of all treatments. The maximum TSS was observed in 8^0C + Et +C in case of S SPR and the minimum was in -2^0C +C in case of control treatment (Table 2). The lowest TA was found in 8^0C + Et +C in S SPR treated branches.

Discussion

The results represented that phlomeic stress followed by partial ringing was useful for sweetness 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

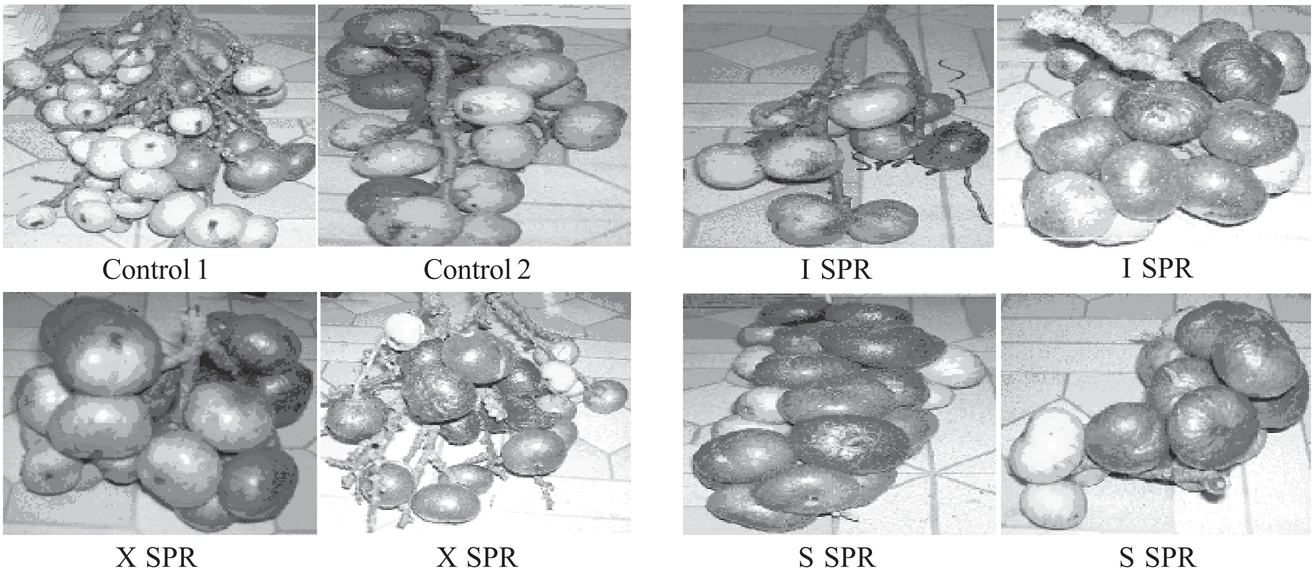


Fig. 6. Photos show the early maturity and better fruit development (bigger) in phloemic stress (by bark reducing) treatments than control in different brunches of fig fruit trees

Table 1
Fruit yield and quality were measured after harvesting in 6th week during 1st season (April 07-June 07) and season (Sep 07-Nov 07). Mean±SE (N = 3)

1st season (April 07-June 07)						
Treatment	Fruit no./ bunch	Bunch weight, g	Fruit weight, g	Maturity index	TSS(%) in week	TA(%) in 6th week
Control	20.8±2.0	465.0±11.0	22.3±1.5	3.2±0.50	2.9±0.30	0.31±0.04
I SPR	19.2±1.5	563.1±11.5	29.3±2.5	3.8±0.55	3.8±0.35	0.29±0.03
X SPR	19.0±1.0	533.2±12.0	27.3±2.3	4.0±0.56	3.5±0.25	0.30±0.03
S SPR	18.6±0.9	630.0±12.5	34.0±2.5	4.5±0.45	4.4±0.30	0.30±0.02
2nd season (Sep 07-Nov 07)						
Treatment	Fruit no./ bunch	Bunch weight, g	Fruit weight, g	Maturity index	TSS(%) in week	TA(%) in 6th week
Control	21.5±2.1	475.0±10.0	22.9±1.2	3.4±0.5	3.0±0.2	0.30±0.05
I SPR	20.0±2.0	590.2±9.0	29.5±2.0	4.0±0.3	3.9±0.3	0.28±0.03
X SPR	20.1±2.0	567.3±10.5	28.2±2.0	4.5±0.4	3.7±0.2	0.26±0.02
S SPR	19.7±1.7	660.5±12.0	34.7±2.1	4.8±0.4	4.1±0.3	0.26±0.02

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. Hossain et al. (2006) found the similar results to the

Table 2
Record of total storage day (TSD), total soluble solids (TSS), titratable acidity (TA) after harvesting of fig fruit at different temperatures until skin red color disappeared. Mean±SE (N = 3).Et. = Ethanol, C = Plastic covering

Total storage day (TSD)/shelf life								
Treatment	28ºC+C	28ºC+Et+C	15ºC+C	15º+Et+C	8ºC+C	8ºC+Et+C	–2ºC+C	–2ºC+Et+C
Control	2.0±0	2.5±0	4.0±0.5	5.0±1	6.0±0.5	7.0±1	10.0±1.5	13.0±0.5
I-PR	2.0±0	2.5±0	4.5±0	5.0±1	7.0±1.5	8.5±1	12.0±1.0	14.0±0.5
X-PR	2.0±0	2.5±0	4.5±0	5.5±1	7.5±1.0	8.0±1	12.0±1.5	15.5±1.0
S-PR	2.0±0	3.0±0	5.0±0.5	6.0±1	7.0±1.5	9.0±1	13.0±1.5	16.0±0.5
Total soluble solids (TSS)								
Treatment	28ºC+C	28ºC+Et+C	15ºC+C	15º+Et+C	8ºC+C	8ºC+Et+C	–2ºC+C	–2ºC+Et+C
Control	3.7±0.4	3.9±0.3	4.5±0.2	5.0±0.3	3.0±0.35	3.5±0.2	3.0±0.2	3.5±0.3
I-PR	3.5±0.3	4.5±0.2	5.0±0.2	5.5±0.3	3.1±0.25	4.0±0.2	3.0±0.2	3.5±0.1
X-PR	3.8±0.3	4.2±0.1	5.5±0.2	6.5±0.3	3.5±0.25	4.5±0.2	3.0±0.2	4.5±0.1
S-PR	4.0±0.2	5.5±0.4	5.5±0.3	8.0±0.35	4.0±0.35	4.5±0.3	3.5±0.2	4.0±0.2
Titratable acidity (TA)								
Treatment	28ºC+C	28ºC+Et+C	15ºC+C	15º+Et+C	8ºC+C	8ºC+Et+C	–2ºC+C	–2ºC+Et+C
Control	0.26±0.04	0.24±0.01	0.23±0.02	0.12±0.01	0.30±0.02	0.27±0.02	0.30±0.02	0.28±1
I-PR	0.26±0.02	0.25±0.0	0.22±0.03	0.07±0	0.30±0.02	0.27±0.02	0.29±0.01	0.27±0
X-PR	0.24±0.03	0.15±0.01	0.20±0.02	0.06±0	0.30±0.02	0.28±0.01	0.30±0.01	0.27±0
S-PR	0.25±0.02	0.15±0.0	0.20±0.01	0.05±0	0.28±0.03	0.26±0.02	0.29±0.01	0.26±0

present result in peach trees.

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. In the experiment, it was found that total soluble solids and maturity index were higher and acid content was lower in I SPR, X SPr and S SPR than in control. Hossain et al. (2006) found that total soluble solids and maturity index were higher and acid content was lower in partially ringed peach trees than in control trees. This might be due to the adequate carbohydrates and nutrients accumulated in upper ringing than lower ringing. 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.

Phloemic stress represented by partial bark ringing applied to the fig trees was capable of impeding growth and fruit quality development of the fig trees. Nevertheless, partial ringing of 5 mm bark-bridge (97% ringing) confirmed surviving trees with a good dwarfing effect. 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 be-cause it may be implemented in all woody fruit tree species.

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