BIOLOGIA PLANTARUM 41 (4): 623-627, 1998

BRIEF COMMUNICATION

Effects of local source-sink manipulations on fruits and leaves of young pear trees

P.I. GARRIZ, G.M. COLAVITA and H.L. ALVAREZ

Facultad de Ciencias Agrarias, Universidad Nacional del Comahue, 8303 Cinco Saltos, RN, Argentina

Abstract

The effects of modifying local source-sink relations on fruit and leaf characteristics of young pear trees were evaluated during the 1997 - 1998 growing season. The following treatments were applied: early spur ringing (ESR) from 27 days after full bloom (DAFB), late spur ringing (LSR) from 97 DAFB, early 15 % spur leaf area removal (ELAR) and late 15 % spur leaf area removal (LLAR). ESR and LSR significantly inhibited fruit growth, suggesting that the fruiting spurs were not fully autonomous in their carbon economy. ELAR and LLAR had little effect on fruit size; sink strength was demonstrated here, since the presence of the fruit caused an efficient transfer of photoassimilates. ESR treatment decreased specific leaf mass (SLM) by 23.84 % when measured 94 DAFB. ELAR did not significantly influence SLM. Treatments had no marked influence on fruit quality.

Additional key words: growth, leaf area removal, fruiting spur, *Pyrus communis*, ringing.

Source-sink interactions play an important role in determining both crop yield and the distribution of individual fruit sizes (Minchin *et al.* 1997). Under natural conditions, fruit trees are subjected to direct loss of leaf area due to physical damage, including insect feeding, invasion by fungi, bacteria and viruses, pesticide

---

Received 22 June 1998, *accepted* 20 September 1998.

Abbreviations: DAFB - days after full bloom; ELAR - early 15 % spur leaf area removal; ESR - early spur ringing; LLAR - late 15 % spur leaf area removal; LSR - late spur ringing; SLM - specific leaf mass; SSC - soluble solid concentration.

Acknowledgements: Research supported by project A-038, Comahue National University. We thank Angel J. Alvarez for technical assistance, Claudia Herczeg for manuscript review and *Los Alamos de Rosauer S.A.* nursery for providing the plants.

Fax: (+54) 99 982200, e-mail: cabilder@uncoma.edu.ar

phytotoxicity, wind action, hail or air pollution. Leaf damage decreases the source-sink ratio (Flore and Lane 1996); carbon assimilation potential is influenced by the extent and timing of the injury. Studies carried out by Masseron and Dalle (1988) showed that pear fruit size was affected by the age of the fruiting branches (younger branches having the largest fruits), the degree and time of fruit thinning and harvesting date. In Japanese pears cv. 'Kosui', the fruit-leaf area ratio was negatively correlated with the mean fruit mass (Kishimoto *et al.* 1994).

In general, shoot expansion of most cropping pears is at its maximum 40 to 60 d after full bloom (DAFB) and its control at this time is important for fruit set and improved light penetration (Chalmers *et al.* 1984); then, it declines as the fruits begin to grow rapidly (Garriz *et al.* 1996). Furthermore, red colour development in pear is influenced by cultural and environmental factors, like temperature and light (Dussi *et al.* 1997). Manipulating the vegetative growth-fruiting relationships may be considered as the goal of tree management (Forshley *et al.* 1992). The most appropriate training system (including pruning and bending) could be optimised provided that the natural growth and fruiting habits of the trees are known (Lespinasse and Lauri 1997).

The aim of the present study was to evaluate the effects of modifying source-sink relations by spur ringing and partial leaf area removal during two developmental stages on fruits and leaves of pear trees.

Five-year-old pear (*Pyrus communis* L.) cv. 'Sensation Red Bartlett' trees trained to palmette leader and growing at the experimental farm, Comahue National University (lat. 38°56'S long. 67°59'W) were studied on a sandy loam soil. The trees were spaced 4.0 × 2.3 m with north-south row orientation. The orchard was located in an arid region, with average annual rainfall of 250 mm; it was irrigated by surface flooding and received management according to the integrated fruit production programme for pears. Fruit load was 0.21 fruits cm^{-2} trunk cross-section area.

The following treatments were applied: early spur ringing (ESR), late spur ringing (LSR), early 15 % spur leaf area removal (ELAR), and late 15 % spur leaf area removal (LLAR). Early and late treatments were applied on 20 October 1996 (27 DAFB) and on 29 December 1997 (97 DAFB), respectively. The total number of experimental trees was 20; two comparable branches on each of five uniform trees were selected for good exposure and uniformity of size. On each branch, four fruiting spurs were tagged and thinned, leaving one fruit per spur. One branch of each pair was chosen at random and subjected to the specific treatment; the other branch was left as control. Ringing, the removal of a strip of bark down to the cambium to prevent movement of assimilates, was made at the base of the spur. Leaf area was reduced by excising disks with a cork borer (0.38 cm^2); the leaf margin and midrib were not disturbed.

Leaf area was measured with an area meter (*CI-202, Cid*, Vancouver, USA). The maximum diameter from ESR and ELAR was measured at two-weekly intervals with a *Vernier caliper* (model *30-410-5, General Supply Corporation*, Jackson, USA) (n = 20 per treatment and date). The fully expanded spur leaf which was closest to each tagged fruit was collected 94 DAFB. Samples were oven-dried at 80 °C for 48 h to obtain specific leaf dry mass (SLM).

Fruits from all treatments were picked on 12 February 1997 and fruit diameter measured. Soluble solids concentration (SSC) was determined with a hand-held refractometer (*Erma*, Tokyo, Japan), and fruit firmness was measured by a penetrometer (model *FT 327, R. Bryce*, Alfonsine, Italy) with an 8.0 mm plunger. Data was analysed using the *Statistical Analysis System* (*SAS Institute*, Cary, USA). Significance of differences between the mean values was detected by Student's *t*-test.

Fruit diameter of young pear fruitlets that were subjected to ESR fell behind the control fruits soon after treatment application (Fig. 1*A*); significant ($P \leq 0.05$) differences were detected from 94 DAFB until harvest, suggesting decreased movement of metabolites to the fruit. ESR reduced final fruit size by 18.2 %, as compared with control (Fig. 1*A*).

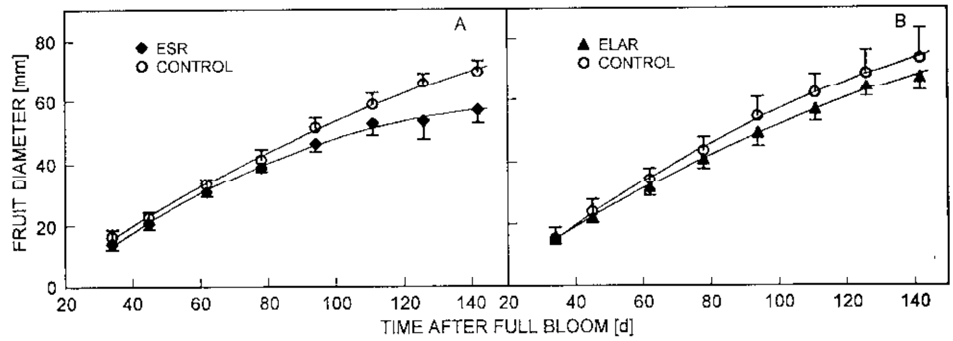

Fig. 1. Effect of early spur ringing (ESR) (*A*) and early spur leaf area removal (ELAR) (*B*) on pear fruit diameter during season 1997 - 1998. The *vertical bars* denote SE ($n = 20$).

Availability of photosynthates was also critical for fruit growth during the later stages of fruit development, since a significant ($P \leq 0.05$) decline in fruit diameter was detected in LSR relative to control (Fig. 2*A*).

After ELAR, fruits never recovered to the same size as controls, but there was no significant reduction in final diameter (Fig. 1*B*). Similarly, no marked influence on final fruit size was detected for the late season treatment (Fig. 2*B*), which could be attributed to a mechanism of growth adjustment acting to maintain favourable resource import. The results also reflected the sink strength, since the presence of the fruit caused an efficient transfer of photoassimilates. Hormone concentrations are usually higher in the fruits than in the shoot, giving a hormone-directed transport advantage to the fruit (Seeley 1990).

Marini and Sowers (1994) reported that peach fruit size at harvest was related not only to fruit position on the fruiting shoot, but also to the presence/absence of lateral shoots at the same node. They also found that fruit mass was influenced by the interaction of fruit number per shoot with fruit trunk cross-sectional area, thus demonstrating the dependence of fruit growth on carbon fixed locally as well as in more distant parts of the tree.

Softening of the flesh and juice soluble solid concentration (SSC) were not significantly affected by both early (data not shown) and late application of treatments (Fig. 2*A,B*). In previous studies, no changes were detected in SSC of

'Bartlett' fruits which were exposed to full solar radiation, compared with a shade treatment imposed during a prolonged period, whereas flesh firmness was decreased by 8.07 % (Garriz *et al.* 1997). The ripening process involves a wide array of physiological and biochemical changes in pears; firmness is the most common method used to determine maturity and in relation to the percentage of SSC, pears must contain levels of 10 % or more if they are to be harvested (Westwood 1993).

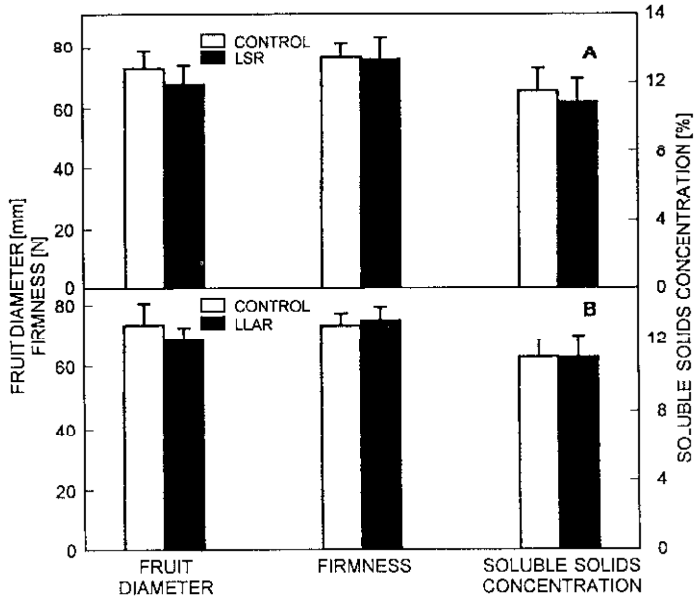

Fig. 2. Fruit diameter, firmness and soluble solids concentration as affected by late spur ringing (LSR) (*A*) and late spur leaf area removal (LLAR) (*B*) during the season 1997 - 1998. The *vertical bars* denote SE ($n = 20$).

ESR led to a significant reduction of specific leaf dry mass (SLM) ($P \leq 0.05$) of fully expanded leaves, as compared to control (17.38 ± 7.77 *vs.* 22.82 ± 4.57 mg cm^{-2}) when measured 94 DAFB; this effect was possibly the result of a decline in spur leaf net photosynthetic rate (P_N) imposed by the phloem flux restriction. Barden (1978) reported that SLM might be used as a tool to determine photosynthetic potential. Ringing has been shown to reduce P_N of apple leaves by 50 % (Mika and Antoszewski 1973).

ELAR did not significantly diminish SLM relative to control (23.80 ± 5.62 *vs.* 22.08 ± 5.35 mg cm^{-2}), suggesting a photosynthetic compensation effect (Table 1). Layne and Flore (1992) reduced the leaf area of 1-year-old sour cherry trees; less than 30 % LAR was compensated for by higher estimated carboxylation efficiency and ribulose-1,5-biphosphate regeneration capacity. Ferree *et al.* (1986) found that 15 % of the total apple leaf area might be lost before the capacity of the remaining leaf area was impaired.

The studies reported here provide a basis for evaluating the efficiency of some orchard cultural practices like pruning and pest control in the future.

References

Barden, J.A.: Apple leaves, their morphology and photosynthetic potential. - HortScience **13**: 644-646, 1978.

Chalmers, D.J., Mitchell, P.D., Jeric, P.H.: Break the rules and boost orchard dollars. - Aust. Country **4**: 54-56, 1984.

Dussi, M.C., Sugar, D., Azarenko, A.N., Righetti, T.L.: Effects of cooling by over-tree sprinkler irrigation on fruit color and firmness. - HortTechnology 7(1): 55-57, 1997.

Ferree, D.C., Hall, F.R., Ellis, M.A.: Influence of mites and diseases on net photosynthesis of apple leaves. - In: Lakso, A.N., Lenz, F. (ed.): The Regulation of Photosynthesis in Fruit Trees. Pp. 56-62. NY State Agr. Exp. Sta., Geneva 1986.

Flore, J.A., Layne, D.R.: *Prunus*. - In: Zamski, E., Schaffer, A.A. (ed.): Photoassimilate Distribution in Plants and Crops. Pp. 825-849. Marcel Dekker, New York 1996.

Forshey, C.G., Elfving, D.C., Stebbings, R.L.: Training and Pruning of Apple and Pear Trees. - Amer. Soc. hort. Sci., Alexandria 1992.

Garriz, P.I., Alvarez, H.L., Alvarez, A.J.: Influence of altered irradiance on fruits and leaves of mature pear trees. - Biol. Plant. **39**: 229-234, 1997.

Garriz, P.I., Alvarez, H.L., Colavita, G. M.: A regression model of the growth pattern of 'Bartlett' pear fruits. - Adv. hort. Sci. **10**: 191-194, 1996.

Kishimoto, O., Tomomatsu, A., Fukamachi, H., Sugar, D.: Effects of unpruning on fruit productivity and shoot growth in Japanese pears. - Acta Hort. **367**: 232-238, 1994.

Layne, D.R., Flore, J.A.: Photosynthetic compensation to partial leaf area reduction in sour cherry. - J. amer. Soc. hort. Sci. **117**: 279-286, 1992.

Lespinasse, J.M., Lauri, P.E.: Influence of fruiting habit on the pruning and training of fruit trees. - Compact Fruit Tree **29**: 75-82, 1997.

Marini, R.P., Sowers, D. L.: Peach fruit weight is influenced by crop density and fruiting shoot length but not position on the shoot. - J. amer. Soc. hort. Sci. **119**: 180-184, 1994.

Masseron, A., Dalle, E.: Le nashi. Aspects particuliers de condvite et the taille du verger. - Infos **43**: 4-8, 1988.

Mika, A., Antoszewski, R.: Photosynthesis and distribution of photosynthates in apple shoots treated by pinching and bark ringing. - Biol. Plant. **15**: 202-207, 1973.

Minchin, P.E.H., Thorpe, M.R., Wünsche, J.N., Palmer, J.W., Picton, R.F.: Carbon partitioning between apple fruits: short- and long-term response to availability of photosynthate. - J. exp. Bot. **48**: 1401-1406, 1997.

Seeley, S.: Hormonal transduction of environmental stresses. - HortScience **25**: 1369-1376, 1990.

Westwood, M.N.: Temperate Zone Pomology. - Freeman, San Francisco 1993.