Effect of Pruning Severity and Branch Quality on Fruit Set and Fruit Dry Weight of 'Packham's Triumph' Pears *(Pyrus communis* L.)

L.P. Reynolds, G. Jacobs and K.I. Theron
Department of Horticultural Science University of Stellenbosch
Private Bag X1
7602, Matieland
South Africa

Abstract

The effect of dormant pruning and the quality of 2-year-old bearing units(BU) on fruit set and mean fruit dry weight of 'Packham's Triumph' pears wasdetermined during the 2002/03 season. Fruit set on short BU (28 cm long) was 20percent higher and mean fruit dry weight were 20 percent more than for long BUs(56 cm). On thick BU (14 mm basal diameter) 70 percent more fruit set than on thinBU (8 mm) and mean fruit dry weight was 20 percent more than on thick BU.

Keywords: sink strength, sink size

INTRODUCTION

The profitable commercial production of pears in South Africa has become increasingly difficult over the last decade. This is because the costs of production are increasing at a much faster rate than the compensatory increases in yield or market returns to the grower. To justify investments in pears it is essential to increase market returns by improving saleable yields. When pollination and fertilization are not limiting fruit set in pears have been increased by gibberellin spray treatments (Deckers and Schoofs, 2002) and by selective pruning cuts (Saunders et al., 1991).

The fruit size of pears is dependent on the sink strength of the fruit. Sink strength is the product of two components: sink activity, which is a measure of the potential flux of assimilate accumulation, and sink size, which is a measure of a potential volume for biomass gain (Patrick, 1988). Fruit thinning is practiced to increase fruit size. Increasing the leaf to fruit ratio and thus increasing the size of the source relative to the sink is offered as an explanation for the improved fruit size (Lakso, 1994; Wünsche and Lakso, 2000). In this paper we report on the effect of the length and thickness 2-year-old bearing units headed back in winter on fruit set and size of 'Packham's Triumph' pears.

MATERIALS AND METHODS Plant Material

'Packham's Triumph' pear trees on the farm Kromfontein, situated in the Koue Bokkeveld area of the Western Cape, South Africa were used. This area is characterized by a Mediterranean climate: cold wet winters and warm dry summers. The 'Packham's Triumph' trees, on BP2 rootstock, were planted in 1983 at a spacing of 4.5 m x 1.75 m in a North-South row orientation and trained to a central leader system.

Treatments

Two-year-old spurred units were selected in the winter of 2002. Units were headed back, during the last week of June, by pruning into the 2-year-old woods. To vary length; bearing units of comparable thickness were selected and headed back to leave units of either 28 cm or 56 cm long. To vary thickness bearing units with a basal of ca 8 or 14 mm were selected and headed back to leave units of 28 cm. On all units three distally situated spurs with large, well-developed terminal buds were retained while allother spurs were removed with thinning cuts. At anthesis, 3 October 2002, two flowers per inflorescence were hand pollinated with a glass rod. Viable pollen of the compatible pear cultivar Rosemarie was used. The remaining flowers in the spur cluster were removed.

To assess spur and bud quality spurs comparable to those left on the bearing units after pruning were collected in winter of 2002. Fresh weight of spurs was determined and bud composition in terms of

numbers of bract leaves, true and transitional leaves and flowers counted under a microscope.
At harvest, 10 February 2003, the entire BU with fruits was removed by pruning and brought to our laboratories. The following data were recorded: fruit set per BU; number aborted and mature seeds per fruit; dry weight of bourse plus bourse shoot per BU; and dry weight of fruit individually. Dry weight was determined by drying the fresh material at 70 °C in a convection oven until there was no change in the mass (5 days).

Statistical Analyses

Treatments were repeated 20 times in a completely randomized design. Data were analyzed by performing analyses of variance using General Linear Models Procedure of Statistical Analysis Systems (SAS Institute Inc., Cary, NC, USA).

RESULTS

In 'Packham's Triumph' dry weight of fruit was more on short BU and thick Bus compared to long BU and thin BU, respectively (Table 1). In both cases the increase was due to an increase in fruit set and an increased mean dry weight of fruit (Table 1). Dry weight of bourse and bourse shoot were small compared to dry weight of fruit. However, the 16.16 g allocated to the bourse and bourse shoot on thick BU was significantly more than the 2.76 g for thin BU (Table 1). The number of mature and aborted seed per fruit did not differ for short BU and long BU. Fruit on thick BU contained 5.2 mature seeds, which are significantly fewer than the 7.8 for thick BU (Table 2). The fresh weight of spurs was significantly greater on both thick BU and long BU, compared to thin BU and short BU, but this difference was not reflected in the composition of the reproductive buds borne terminally on the spurs (Table 3).

DISCUSSION

Fruit Set

Increased fruit set on both short BU and thick BU as compared to long BU and thin BU, respectively, cannot be explained by differences in flower quality. The greater fresh weight of spurs on long BU and thick BU were not reflected in the number of appendages (flowers, leaves and bracts) in the reproductive buds of 'Packham's Triumph' pears. The advantage of a better spur quality on long BU did not compensate for the apparent positional advantage of spurs borne on short BU in terms of fruit set. Since the increase in fruit set of short BU over long BU is only 20 percent compared to the 70 percent increase of thick BU over thin BU, it appears that spur quality is positively correlated with fruit set when positional effects are eliminated. Since number and dry weight of seed per fruit did not differ between short BU and long BU, reasons other than those related to pollination and fertilization should be considered for the increased fruit set on short BU.

Likewise the higher fruit set on thick BU despite a lower seed content implies that factors other than pollination and fertilization were responsible for the increased set. Pruning 'Packham's Triumph' at the intercalation between 1 and 2-year-old wood increased fruit set (Saunders et al., 1991). They concluded that set was affected more negatively by new developing shoots distal to the young fruitlets, than shoot:fruit competition for limited metabolites. Since the current BU were prepared by heading back into 2-year-old wood, shoot growth distal to the fruitlets as a factor affecting set was thus eliminated in all cases. The difference in fruit set between short BU and long BU or between thick BU and thin BU can thus not be ascribed to competition or correlative inhibition from distal growing shoots.

However, the possible role of the cytokinins and gibberellins in fruit set should be considered. Both gibberellins and cytokinins are implicated in fruit set of pears (Deckers and Schoofs, 2002; Fukui et al., 1985, cited by Bubán, 2000). Futher more the cytokinin and gibberellin content of apple xylem sap at bud swelling in spring was respectively 4 and 3 times higher in pruned trees than in non- pruned trees (Growchowska et al., 1984). The better fruit set on short BU and thick BU may be due to increased supply of xylem transported metabolites which increased sink strength of individual fruits.

Fruit Size

The reduction in fruit size with an increase in fruit numbers has, in most cases, been attributed to source limitation (Lakso, 1994; Wünsche and Lakso, 2000). However, in a recent study Marini (2003)

found that by reducing the number of fruiting shoots on peach trees, but keeping fruit numbers per tree constant, fruit size increases. This implies that the size of the source was not affected but sink strength of individual fruit was increased by the treatments that in turn improved fruit size. The increase in fruit size on short BU and thick BU, in spite of a 20 percent and 70 percent more fruit per bearing unit as compared to long BU and thin BU, respectively, could be due to an increase in the source or an increase in the sink strength of individual fruits, or both. The source was little affected by the pruning treatments, therefore an improved fruit: leaf relationship cannot explain the larger fruit. Palmer et al. (1997) reported that leaf assimilation is stimulated by crop productivity (increase in sink size) and that the leaf assimilation rate is curvilinear with crop load for 'Braeburn' apples, up to a maximum crop of 12 fruit m^{-2} leaf area.

In non-bearing trees the leaf assimilation rate was at times 64 percent lower rate than that of heavy cropping trees. With partial defoliation the photosynthetic rate of the remaining leaves was enhanced by 37 percent compared to the control (Zhou and Quebedeaux, 2003). Since we achieved larger fruit in spite of more fruit per BU it is unlikely that the photosynthetic source was limiting. Furthermore on thick BU there were 4.5 fruit per BU that contained only 5.2 seeds per fruit and yet mean dry weight per fruit was 20 percent more than for fruit on thin BU that contained 7.8 seeds per fruit and carried only 2.8 fruit per BU. Sink strength of fruit on thick BU thus far exceed that of fruit on thin BU. This increased sink strength in our view is possibly related to a better supply of xylem transported metabolites to fruit on thick BU and short BU.

Literature Cited

Bubán, T. 2000. The use of benzyladenine in orchard fruit growing: a mini review. Pl. Gr. Regul. 32: 381-390.

Deckers, T. and Schoofs, H. 2002. Improvement of fruit set on young pear trees cultivar 'Conference' with gibberellins. Acta Hort. 596(2): 735-744.

Fukui, H., Imakawa, S. and Tamura, T. 1985. Relation between early drop of apple fruit, cytokinin and gibberellin. J. Jap. Soc. Hort. Sci. 54: 287-292.

Grochowska, M.J., Karaszewska, A., Jankowska, B., Maksymiuk, J. and Williams, M.W. 1984. Dormant pruning influence on auxin, gibberellin, and cytokinin levels in apple trees. J. Amer. Soc. Hort. Sci. 109(3): 312-318.

Lakso, A.N. 1994. Apple, pp 3-43 In: B. Schaffer and P.C. Andersen (eds.). CRC Handbook of environmental physiology of fruit crops. vol. 1. Temperate Crops. CRC press, USA.

Marini, R.P. 2003. Peach fruit weight, yield, and crop value are affected by number of fruiting shoots per tree. Hort. Sci. 38(4): 512-514.

Palmer, J.W., Giuliani, R. and Adams, H.M. 1997. Effect of crop load on fruiting and leaf photosynthesis of 'Braeburn'/M.26 apple trees. Tree Phys. 17: 742-746.

Patrick, J.W. 1988. Assimilate partitioning in relation to crop productivity. Hort. Sci. 23(1): 33-40.

Saunders, R.C., Jacobs, G. and Strydom, D.K. 1991. Effect of fruit set and shoot growth of 'Packham's Triumph' pear trees. Sci. Hort. 47: 239-245.

Wünsche, J.N. and Lakso, A.N. 2000. The relationship between leaf area and light interception by spur and extension shoot leaves and apple orchard productivity. Hort. Sci. 35(7): 1200-1206.

Zhou, R. and Quebedeaux, B. 2003. Changes in photosynthesis and carbohydrate metabolism in mature apple leaves in response to whole plant source-sink manipulation. J. Amer. Soc. Hort. Sci. 128(1): 113-119.

Tables

Table 1. Effect of fruit bearing unit (BU) quality and dormant pruning on fruiting and bourse shoot growth of 'Packham's Triumph' pears.

	SBUs	LBUs	*Pr>F*	Thick BU[y]	Thin BU[z]	*Pr>F*
Fruit (dm in g)	124.30 [a]	85.20 [b]	*0.0109*	123.9 [b]	55.36 [a]	*< 0.0001*
Bourse and bourse shoots (dm in g)	7.35 [a]	7.98 [a]	*0.7215*	16.16 [b]	2.76 [a]	*< 0.0001*
Number of fruits	4.88 [a]	4.10 [b]	*0.0454*	4.53 [b]	2.65 [a]	*0.0016*
Average fruit dry weight (g)	25.7 [a]	20.32 [b]	*0.0197*	26.90 [b]	20.34 [a]	*0.0091*

SBU=Short BU (28 cm long); LBU= Long BU (56 cm long); [y] Basal diam. 14 mm [z] Basal diam. 8mm.

Table 2. Effect of BU quality and dormant pruning one seed content of 'Packham's Triumph' pears.

	SBUs	LBUs	*Pr>F*	Thick BU[y]	Thin BU[z]	*Pr>F*
Aborted seeds	3.417 [a]	3.066 [a]	*0.4932*	3.888 [b]	2.046 [a]	*0.0020*
Seeds	6.396 [a]	6.396 [a]	*0.7514*	5.249 [b]	7.821 [a]	*0.0030*

SBU=Short BU (28 cm long); LBU= Long BU (56 cm long); [y] Basal diam. 14 mm [z] Basal diam. 8mm.

Table 3. Effect of spur position on spur and flower bud of 'Packham's Triumph' pears.

	SBUs	LBUs	*Pr>F*	Thick BU[y]	Thin BU[z]	*Pr>F*
Sum of 3 spurs in June (fm in g)	0.5044 [a]	0.6565 [b]	*0.0210*	0.8272 [b]	0.4375 [a]	*0.0003*
Flower quality						
Bract leaves	7.2 [a]	7.0 [a]	*0.6938*	7.8 [a]	7.4 [a]	*0.2415*
Flowers	7.6 [a]	7.4 [a]	*0.7655*	7.0 [a]	7.0 [a]	*1.0000*
True leaves and transition leaves	2.6 [a]	1.8 [a]	*0.4468*	1.6 [a]	1.4 [a]	*0.8608*

SBU=Short BU (28 cm long); LBU= Long BU (56 cm long); [y] Basal diam. 14 mm [z] Basal diam. 8mm.