Effect of Reflective Fabric on Yield of Mature ‘d’Anjou’ Pear Trees

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Abstract. Reflective fabric was installed before bloom in 2009 and 2010 in alleyways of a mature, low-density ‘Anjou’ pear orchard (269 trees/ha). Four treatments were applied to study intracanopy light environments on fruit growth rate and size, cropload, yield, and fruit quality: 1) no fabric (NF); 2) partial-season fabric applied before full bloom (FB) and removed 75 days after full bloom (dafb) (PSF); 3) full-season fabric applied before FB and removed at harvest (FSF); and 4) shadecloth (60%) applied 60 dafb through harvest (SC). FSF and PSF improved yield by 12% and 18%, respectively, over the two-year period relative to NF. The high yields of fabric treatments were attributed to fruit number in the lower (less than 2.4 m) interior, mid-, and exterior zones of the canopy. Photosynthetic active radiation (PAR) was increased by fabric 28%, 95%, and 30% in the lower exterior, mid-, and interior canopy, respectively. Photosynthesis:light response curves indicated improved carbon assimilation of pear leaves developing in the elevated PAR environment of the lower canopy. Fruit growth rate and final size were unaffected by fabric treatments. FSF fruit size was similar to NF despite higher fruit density. Compared with NF, FSF had a small, non-significant effect on fruit maturity (increased softening) at harvest. Yield and fruit size of SC fruit were significantly reduced. The number of fruit in SC trees did not differ from NF in 2009, but the effect of shade reduced fruit number in 2010. Fabric did not affect fruit quality attributes after three and six months of regular atmosphere cold storage. Pears from SC trees did not attain ripening capacity after three months of cold storage and a 7-day ripening period and had lower sugar content compared with other treatments. The cumulative yield advantages associated with FSF support its use in mature pear orchards.

In the United States, ‘Anjou’ (Pyrus communis L. ‘Anjou’) winter pear production occurs solely in the Pacific northwestern states of Oregon and Washington. The annual North American production of ‘Anjou’ pear is 11.3 million boxes (20 kg/box) equating to 248,600 tons (Ing, 2002). ‘Anjou’ pear trees are inherently vigorous and non-precocious but have a long productive life; consequently, a large percentage of ‘Anjou’ acreage has not undergone renovation and exists at low tree densities (less than 300 trees/ha). Average ‘Anjou’ pear yields throughout Oregon’s Hood River Valley are 39 tons/ha (OAIN, 2010; U.S. Department of Agriculture, National Agricultural Statistics Service, 2006). Depending on prices, and given increased costs of production, economic models indicate that these levels are insufficient to sustain grower profitability (Seavert et al., 2007).

Low-density pear orchards are characterized by multiple leader trees with a relatively large proportion of the canopy consisting of non-productive, structural wood. Large pear trees are associated with high production costs (Seavert et al., 2007), but commercially viable, size-controlling rootstocks are not currently available in the United States to renovate old orchards and improve production efficiencies (Elkins et al., 2012). The reliance on heading cuts during dormancy to control tree size encourages excessive early and midseason vegetative growth, which, in turn, limits intracanopy light distribution (Einhorn, personal observation). ‘Bartlett’ fruit set and fruit retention decreased under 80% shadecloth applied between 14 dafb and harvest (Garriz et al., 1998). Application of shade (0%, 30%, 50%, 65%, and 82.5%) 50 dafb was negatively, linearly related with ‘Bartlett’ fruit size, soluble solids content (SS), and leaf weight per area (Kappel, 1989).

Materials and Methods

Plant material and experimental design. Reflective fabric (Extenday™, Auckland, New Zealand) was installed Spring 2009 before bloom in a mature (greater than 70 years old), low-density ‘Anjou’ pear orchard (6.1 m × 6.1 m; 269 trees/ha) located in the lower Hood River Valley, OR (lat. 45.7° N, long. 121.5° W). Soil was a Van Horn series, fine sandy loam. A randomized complete block design was applied to four replications of four treatments: 1) [NF] No Fabric, 2) [PSF] Partial-Season Fabric applied prior to full bloom (FB) and removed 75 days after full bloom (dafb), 3) [FSF] Full-Season Fabric applied prior to FB and removed at harvest, and 4) [SC] 60% shade-cloth applied 60 dafb through harvest. The term Fabric is used to describe effects associated with both of the fabric treatments. Full bloom occurred on 24 Apr. 2009 and 13 Apr. 2010. Each replication of NF and fabric treatments consisted of 12-tree plots. Three equal lengths of fabric were installed in adjacent rows for each plot, and the four center trees were used for data collection (Fig. 1). Completion of the ‘Anjou’ June drop (≥70 dafb) and the cell division stage of fruit growth (≥60 dafb; Westwood, 1993) were the principal factors for selecting 75 dafb for removal of fabric from PSF trees. At 60 dafb, shade structures were erected to enclose two trees per replication in 60% shade-cloth but ended 2 m from the ground to enable commercial applications of insecticides through an airblast sprayer. Otherwise, the experimental trees were managed commercially. The experiment was repeated on the same trees in 2010.

Light measurement. Photosynthetic active radiation (PAR) was measured with a ceilometer (AccuPAR LP-80; Decagon Devices, Inc., Pullman, WA) in each of the four experimental trees per replicate plot. PAR measurements were taken at midday (1200 to 1400 HR) on several dates in 2009 beginning 50 dafb. Light conditions were similar.
on all dates; clear sky readings exceeded 1500 μmol·m⁻²·s⁻¹. The ceptometer was positioned horizontally at a height of 1.5 m at each of the four cardinal directions, and PAR was recorded at three canopy depths beginning at the perimeter of the canopy and working toward the center: 0 to 1 m, 1 to 2 m, and 2 to 3 m (n = 16 per replication). Tree spacing was 6.1 m within the tree row, so 3 m ended at the center of the canopy. Reflected PAR was measured by inverting the ceptometer at each of the canopy positions and depths described previously.

**Fruit size and yield.** In 2009 and 2010, 20 fruit per replication were randomly selected on limbs of similar cropload and canopy position and fruit diameter was measured weekly (Cranston Fruit Gauge; Cranston Machinery Co., Oak Grove, OR). Three of the four experimental trees per replication were harvested at commercial timing; 14 Sept. 2009 (143 dafb) and 20 Sept. 2010 (160 dafb). Individual tree yields were pooled for replicate means. One hundred fruit were randomly selected from each tree’s yield (i.e., 300 fruit per replication) and weighed to derive average fruit weight. The fourth tree per replicate plot (one per treatment) was harvested before the commercial harvest. For these trees a polyvinyl chloride (PVC) scaffolding system was built to divide tree canopies into six distinct zones. Two 6.1-m PVC lengths were placed on the orchard floor in a perpendicular orientation and centered at the tree trunk. Each length was plumbed with PVC tees (spaced at 1-m intervals with one tee at each end; six tees for each of the two horizontal PVC lengths). Inserted into each tee was a 4.8-m PVC vertical pipe (roughly equivalent to the height of the trees). Verticals were marked with colored laboratory tape 2.4 m from the ground. Vertical lengths were tied to limbs within the canopy to maintain a 90° orientation in both directions. Tree flagging was used to connect the outer four upright PVC verticals at the 2.4-m marks. Canopy limbs and ladders were used to create a uniform circle around the exterior of the canopy. Because the circle was developed around a center point, tree canopies did not always fit perfectly within the perimeter of the circle; however, trees filled their space allotment and canopies did not vary greater than ± 30 cm from the outer circle. This pattern was repeated for the next two sets of PVC uprights inward so that three concentric zones were established within canopies. Fruit were harvested in the 1-m zone between the outer circle of flagging and the next circle inward, termed the exterior canopy; between the second circle and third circle inward, termed the midcanopy; and within the remaining interior circle, termed the interior canopy. For each of these three canopy zones, fruit were separately harvested below and above 2.4 m, thereby creating six distinct zones. Given the time requirements for assembly and removal of scaffolding, and the detailed harvests, only one complete replication could be harvested per day (four total trees); thus, 4 d were required to complete these harvests. The remaining experimental trees per treatment replication were harvested on the fifth day (i.e., commercial harvest timing).

**Fruit quality.** At harvest, fruit firmness (FF) was measured on 20 fruit per tree (80 fruit per replication) with a Fruit Texture Analyzer (Güts Manufacturing, Strand, South Africa) using an 8-mm diameter probe. Sections of skin, ±2 cm in diameter, were removed at the widest point of the fruit on opposite sides. An additional 40 fruit per tree were immediately placed in regular atmosphere cold storage (−1 °C) after harvest and analyzed at three and six months from harvest. At each sampling period, fruit were ripened for 7 d in 20 °C before determination of fruit quality attributes. FF was measured on 20 fruit per tree (80 per replicate) as described previously. After FF measurements, a composite sample comprised of 10 fruit per replication was juiced (Juice Extractor 6001C; Waring Products, New Hartford, CT), and 0.5 mL of juice was pipetted onto a digital refractometer (Palatte series, PR-101α; Atago USA, Inc., Kirkland, WA) to determine SS. Analysis of total acids (TA), as malic acid equivalents, was determined using 10 mL of juice + 10 mL of deionized water and titrated with 0.1 N sodium hydroxide to an endpoint pH of 8.1 using a titrator fitted with an automated sampler (DL15 and Rondolino; Mettler-Toledo Inc., Zurich, Switzerland). Juice from 100 mg of fresh fruit (~10-g slice taken from each of 10 fruits) was transferred to a graduated cylinder for determination of extractable juice (EJ). As pears ripen, the volume of EJ decreases (Chen et al., 1983); thus, EJ is a good ripening indicator.

**Accumulated heat units.** Accumulated heat units (AHUs) were calculated each year from FB to 60 dafb using temperature data generated by an IFPNet meteorological station (Wy’East RC&D, 2009) located within 100 m from the experimental orchard. AHUs were derived by dividing the sum of the daily minimum and maximum temperatures by 2 and subtracting the low temperature thresholds (7.2 °C).

**Light response curves.** Photosynthesis (Pₚ) light response curves were generated in situ with a PP systems Ciras-2 gas analyzer (PP Systems, Amesbury, MA) using a cuvette fitted with a light-emitting diode light source (PP Systems). Measurements were taken on the first fully mature leaves of extension shoots, between 1200 and 1400 μmol·m⁻²·s⁻¹. Leaves were acclimated to the dark, then provided light in a stepwise manner (0, 50, 100, 200, 400, 600, 800, 1000, 1250, 1500, 1750, 2000 μmol·m⁻²·s⁻¹). Pₚ was observed to stabilize before the next light level. Each curve took ≥25 min to complete. A total of six replicate leaves was used to estimate the response of shaded and exposed leaf populations; six curves were generated on each of 2 successive days (three for shade leaves and three for exposed leaves). Clear sky PAR exceeded 1500 μmol·m⁻²·s⁻¹ on both dates.

**Statistical analysis.** Statistical analyses were performed using the SAS system software (SAS 9.2; SAS Institute, Cary, NC). Treatment means were compared using analysis of variance with PROC GLM and significance was tested at P ≤ 0.05. Mean separation was determined by Fisher’s protected least significant difference test. Regression analysis for fruit growth was performed by PROC REG.

**Results and Discussion**

**Fruit size, maturity, and yield of whole trees.** Cumulative fruit growth of exposed ‘Anjou’ was unaffected by fabric in either year (Fig. 2A–B) compared with NF. SC fruit growth was limited by 97 dafb and 128 dafb (46 d and 32 d before harvest) in 2009 and 2010, respectively (Fig. 2A–B). These results agree with earlier work showing a linear, negative relationship between ‘Bartlett’ fruit size and percent shade when applied between 50 dafb and harvest (Kappel, 1989). Reduced ‘Bartlett’ fruit growth was also observed when branches were covered with 80% shade from 76 dafb to harvest (Garriz et al., 1998). Fruit size of all treatments was markedly larger in 2009 than 2010 by 60 dafb (Fig. 2C). AHUs calculated between full bloom and 60 dafb were 480 and 317 for 2009 and 2010, respectively. As a result of the linear growth pattern of pear fruit between 60 dafb and harvest, the smaller fruit in 2010 required an additional 17 d to attain similar fruit size as in 2009 (Fig. 2C) based on the regression equation. In 2009, total tree yields were 20% and 26% greater for PSF and FSF relative to NF, a projected yield increase of 20 to 25 tons/ha, respectively (Table 1). Compared with NF, the higher yields of fabric trees were attributed to greater fruit number but not fruit size (Table 1). In contrast, the number of fruit on

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**Fig. 1.** Fabric and tree dimensions of a single replicate fabric plot. Xs represent trees. The center four trees per plot were used for data collection and are denoted by a circled x.
SC and NF trees did not statistically differ, but significantly lower yields of SC fruit were associated with smaller fruit size (Table 1; Fig. 2A–B). In a separate commercial ‘Anjou’ field trial, we have recently observed a 25% yield improvement for reflective fabric plots (four ≈1-ha replications with or without fabric) in the first year (2010) relative to the untreated control (Dunley and Einhorn, unpublished data). In that study, fabric was removed 60 dafb. The increase in yield was a function of higher fruit set (similar to the Year 1 results of the present study); no differences in fruit size were detected.

Despite a ≈17% yield increase for NF trees in 2010 (an additional 385 fruit per tree), FSF and PSF yields were numerically, but not significantly, higher. NF yields exceeded the average Oregon, Hood River County, yields by ≈2.5- to 3-fold. The site has deep, fertile soil and trees are productive. Interestingly, yields of individual fabric trees did not fluctuate between years (Table 1), indicating the potential for consistently high annual yields. Additional years of research will be required to confirm these observations and determine whether NF trees display some degree of biennial bearing. Aside from possessing a genetic disposition for biennial bearing, for which ‘Anjou’ has not been characterized, biennial, or alternate, bearing of fruit trees can be influenced by several environmental factors (Monselise and Goldschmidt, 1982). ‘Anjou’ pear trees are subject to carbohydrate limitations from year to year depending on environmental, pathological, or cropload conditions, all of which may affect consistent bearing (Monselise and Goldschmidt, 1982), especially the latter given that ‘Anjou’ trees are not thinned commercially. SC yield, fruit size, and number were all significantly reduced in 2010 (Table 1). Over the two-year study, PSF and FSF increased yield by 12% and 18% relative to NF (24 and 38 additional tons/ha at the density of the experimental orchard), but only the cumulative yield of FSF was significantly higher than NF (Table 1). Although tree yields of FSF were numerically higher than PSF, a significant difference between the two fabric treatments was not detected (Table 1). Bertelsen (2005) reported yield improvement of pear from reflective fabric treatments, although results were inconsistent and varied depending on cultivar (‘Clara Frijs’ and ‘Comice’) and tree density (1250 or 2050 trees/ha); fruit size was slightly larger in fabric treatments, but not significantly. The authors are unaware of any additional published reports of reflective fabric use in pear orchards.

FSF and PSF fruit were not statistically, physiologically more advanced at harvest relative to NF; determined by FF (Table 1). Late-season application of reflective materials has been used to enhance skin color or advance maturity in peach (Layne et al., 2001) and apple (Andris et al., 1998; Doud and Ferree, 1980; Iglesias and Alegre, 2009; Miller and Greene, 2003). In 2010, the significantly smaller SC fruit were firmer than all other treatment fruit at harvest (Table 1), as similarly observed with shade-treated ‘Bartlett’ (Kapel, 1989).

**Fruit quality.** In 2009, SC fruit were significantly firmer than NF fruit after three months of cold storage and ripening [23.1 newtons (N) vs. 15.9 N, respectively] despite having similar FF as other treatments at harvest (Table 1). At six months, SC fruit were capable of softening to levels attained by other treatment fruit (data not shown). SC fruit attained ripening capacity after three months of cold storage in 2010, perhaps because fruit were harvested at a lower flesh pressure in 2010 compared with 2009 (Table 1). In both years, flesh pressures at harvest were well within the acceptable commercial range for ‘Anjou’ (58 to 67 N). ‘Anjou’ requires a minimum of 60 d cold storage when harvested at pressures greater than 60 N to develop ripening capacity and soften to acceptable FF (less than 17.5 N) for consumption (Chen and Mellenthin, 1981). Inability for 90 d cold storage to induce full ripening capacity would indicate insufficient maturity at harvest. EJ and TA did not differ among treatments after storage durations in either year. SS was significantly reduced for SC fruit in both years compared with NF (11.6% and 11.7% for SC compared with 12.8% and 12.2% for NF in 2009 and 2010, respectively), as similarly observed in ‘Bartlett’ (Kapel, 1989).

**Fruit size, yield, and photosynthetically active radiation within canopy zones.** Individual FSF tree canopies, divided into six zones, had significantly higher yields (total fruit weight and number of fruit) in the lower (0 to 2.4 m tree height) midcanopy compared with NF trees in both years and in the interior canopy in 2009 (Table 2). In 2009, PSF yield

**Fig. 2.** Effect of groundcover treatment on cumulative fruit growth of ‘Anjou’ pears in 2009 (A), and 2010 (B), respectively. NF = no fabric; PSF = partial-season fabric applied before full bloom (FB) and removed 75 d after full bloom (dafb); FSF = full-season fabric applied before FB and removed at harvest; SC = 60% shadecloth applied 60 dafb through harvest. Fruit diameter of fabric treatments 60 dafb through harvest in 2009 and 2010 (C). Accumulated heat units from full bloom through 60 dafb were 480 and 317 for 2009 and 2010, respectively. Vertical dashed lines in A and B signify removal of fabric from PSF plots; bold lines at bottom of A and B represent application of shade. Asterisks at top of A and B signify significance at P < 0.05. Symbols in A and B are the means of four replicate trees (n = 20). Fruit size of all treatments was larger in 2010, but only fruit of fabric treatments were plotted in C to remove the effect of cropload on fruit size given the nearly identical yields of fabric treatments in 2009 and 2010 (see Table 1).
Table 1. Fruit firmness, average fruit size, number of fruit per tree at harvest, tree yield, and projected per-hectare production of mature, low-density ‘Anjou’ trees treated with ground application of reflective fabric or overcanopy shade relative to a no-fabric control.

| Treatment | 2009 Yield (kg/tree) | 2010 Yield (kg/tree) | Projected production* (tons/ha) |
|-----------|----------------------|----------------------|-------------------------------|
| NF        | 68                   | 61.1                 | 95                            |
| PSF       | 65.6                 | 60.4                 | 115                           |
| FSF       | 64.8                 | 60 b                 | 120                           |
| SC        | 65.4                 | 65.9 a               | 71                            |
| P > F     | 0.32 b               | <0.0001              | 51                            |

*Projected production based on the measured tree yields at a planting density of 269 trees/ha.

Table 2. Yield, number of fruit, average fruit size, and fruit firmness at harvest in 2009 and 2010 for six different zones of mature, low-density ‘Anjou’ canopies treated with ground application of reflective fabric or overcanopy shade relative to a no-fabric control.

| Treatment | Exterior canopy (< 2.4 m) | Exterior canopy (> 2.4 m) | Midcanopy (< 2.4 m) | Midcanopy (> 2.4 m) | Interior canopy (< 2.4 m) | Interior canopy (> 2.4 m) |
|-----------|---------------------------|---------------------------|---------------------|---------------------|---------------------------|---------------------------|
| Yield (kg) | 2009 | 2010 | 2009 | 2010 | 2009 | 2010 | 2009 | 2010 | 2009 | 2010 |
| NF | 70.9 ab | 89.5 | 189.8 | 202.7 | 10.5 c | 19.9 b | 83.8 | 77.2 a | 2.3 c | 5.7 | 12.9 | 8.5 |
| PSF | 80.5 ab | 79.8 ab | 148.6 | 163.2 | 24.6 b | 21.6 b | 92.8 | 90.6 a | 8.2 ab | 9.8 | 16 | 9.5 |
| FSF | 107.2 a | 111.1 a | 153.1 | 165.6 | 37.2 a | 38.8 a | 96.6 | 91.5 a | 10.6 a | 9.1 | 14.7 | 7.6 |
| SC | 52.6 b | 49.5 b | 126.7 | 92.9 | 14.9 bc | 16.8 b | 64.8 | 41.3 b | 2.8 a | 4.5 | 11.7 | 4.6 |
| P > F | 0.045 b | 0.035 a | 0.238 | 0.133 | <0.0001 | <0.0001 | 0.294 | 0.014 | 0.019 | 0.199 | 0.789 | 0.511 |

Weight and number of fruit was intermediate between NF and PSF in the less than 2.4 m zone (Table 2). In 2010, PSF yield did not significantly differ from NF or FSF irrespective of the zone (Table 2). *PAR* was significantly increased in the exterior and midcanopy of fabric trees relative to NF trees by 28% and 95%, respectively (Table 3). In fact, relative to NF, *PAR* for PSF was ~10-fold and 5-fold higher in these canopy zones for fabric treatments. *PAR* interception tended to be higher in the interior canopy of fabric trees, but not significantly (Table 3). Improved yield in lower FSF canopies was a direct consequence of higher *PAR* as similarly observed in apple (Miller and Greene, 2003). Other investigators have demonstrated fruit quality improvements in the lower canopy above reflective films for apple (Glenn and Puterka, 2007; Iglesias and Alegre, 2009; Meinhold et al., 2011; Miller and Greene, 2003) and peach (Layne et al., 2001). Roughly 2% of full sunlight was reflected from NF sod alleyways compared with 14% from the fabric in the exterior canopy (Table 3). Comparable reflectance values from white fabrics have been previously documented (Atkinson et al., 2006; Blanke, 2008; Miller and Greene, 2003; Sandler et al., 2009).

The higher intercepted *PAR* in lower fabric canopies (614 μmol·m⁻²·s⁻¹ relative to NF) would confer small, but positive gains in pear leaf Pn (Fig. 3). Light-saturated gross Pn for exposed leaves (12 μmol·m⁻²·s⁻¹) was observed at ~50% of full *PAR* (Fig. 3). Pₗ light response of pear leaves was similar to that reported for apple (Laksø, 1994). These additional photoassimilates were likely necessary to size FSF fruit given their relatively high croploads (Table 2). Little is known, however, of the relative sink strength of fruit of European pear. As the season progressed, the sink strength of Japanese pear (*Pyrus pyrifolia* Nakai) fruit increased from ~40% (60 dBa) to greater than 80% beginning three months from harvest relative to the total amount of ¹³C recovered in leaves, current-season bourse shoots, two-year-old spur wood, and fruit (Zhang et al., 2005).

In 2009, the number of fruit in different zones of SC canopies was similar to NF, but yield was negatively and significantly affected by fruit size (Table 2). *PAR* was limited to the...
Table 3. Light (PAR) interception and reflectance at three depths of mature ‘Anjou’ pear canopies as affected by reflective fabric applied to the orchard floor or overcanopy shadecloth (SC) relative to a no-fabric control (NF).*

| Treatment | Exterior canopy* | Reflectance* | Midcanopy | Reflectance | Interior canopy | Reflectance |
|-----------|------------------|--------------|-----------|-------------|----------------|------------|
| NF        | 481 b' (31')     | 26 b (2)     | 136 b (8) | 21 b (1)    | 78 ab (5)      | 18 b (1)   |
| Fabric    | 614 a (38)       | 229 a (14)   | 265 a (17)| 137 a (9)   | 101 a (6)      | 85 a (5)   |
| SC        | 93 c (6)         | 26 b (2)     | 79 bc (5) | 13 b (1)    | 39 b (2)       | 11 b (1)   |

*Data are means of four replications; n = 16.


d2 Light interception and reflectance were determined for both Fabric treatments (PSF and FSF), but data are not provided for each because PSF and FSF had equivalent PAR interception and reflectance values. PAR = photosynthetically active radiation; PSF = partial-season fabric applied before full bloom and removed 75 d after full bloom; FSF = full-season fabric applied before full bloom and removed at harvest.

In conclusion, our data support the use of full-season reflective fabric in mature ‘Anjou’ pear orchards given its positive effect on light environment and yield and maintenance of fruit quality. Although the interior, 2-m-diameter column of our experimental trees only comprised 3.5% to 6% of the total tree yield, significant yield improvements in the lower, midcanopy had a marked impact on total tree yield of FSF (Table 2). Yield of PSF did not significantly differ from FSF or NF. A sustained evaluation of white reflective fabric applied full- or partial-season is ongoing to determine if the incremental yield improvements observed among NF, PSF, and FSF herein change in magnitude with time. In the short term, several methods are available to improve light use in low-density, mature pear plantings including summer pruning; application of reflective fabrics or particle films (Glenn and Puterka, 2007); and possibly through judicial use of water (Behboudian et al., 2011; Mitchell and Sweet, 1972) and specifically ‘Anjou’ pears. Light interception and reflectance were determined for both Fabric treatments (PSF and FSF), but data are not provided for each because PSF and FSF had equivalent PAR interception and reflectance values. PAR = photosynthetically active radiation; PSF = partial-season fabric applied before full bloom and removed 75 d after full bloom; FSF = full-season fabric applied before full bloom and removed at harvest.

Fig. 3. Light response curves for exposed (solid symbols) and shaded (open symbols) ‘Anjou’ leaves within canopies. PP = net photosynthesis; PPF = photosynthetic photon flux. Data are means of six leaves. Measurements were taken in the field at solar noon.

The present study. Intracanopy PAR was also not measured in that study, thus limiting comparisons between their results and ours relative to the role of light on floral bud development.

Projected production (per ha) of FSF from cumulative average tree yields (Table 1) would have returned an additional $13,818 per ha based on the average returns per unit for 2009 and 2010 ($200 per 0.55 ton bin) compared with NF. Labor costs to harvest the additional fruit would have been $1311 per ha based on a $19 per bin harvest rate. Fabric installation and removal costs were not estimated in our study given the relatively small experimental plot sizes, but estimates from commercial tree-fruit use range from $1.36 to $618 per ha (V. Burgers, personal communication). After deducting all labor costs (assuming the highest installation costs) and the costs of the fabric (Meinhold et al., 2011), a net profit of $3985 per ha would have been realized relative to NF. In this scenario, the seven-year projected life of the fabric would have been paid off after the first two years of use.

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Khemira et al. (1993) proposed that greater than 30% of full sunlight is necessary for floral initiation in pear and other temperate-zone tree fruit species. This value greatly exceeds the average PAR interception in the midcanopy of fabric and NF trees (Table 3), yet roughly 32% and 25% of the total fruit per tree resided in these zones, respectively. Clara Frises’ pear trees treated with reflective fabric had nearly 2-fold the floral buds of control trees in the third year (Bertelsen, 2005); however, despite the high tree densities, trees were relatively small (12 years old, slender spindles), which starkly contrast the
