Scientia Horticulturae 214 (2017) 242–251

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

Establishing peach trees for organic production in Utah and the Intermountain West

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ARTICLE INFO

Article history:
Received 1 August 2016
Received in revised form
12 November 2016
Accepted 28 November 2016
Available online 5 December 2016

Keywords:
Organic stone-fruit establishment
Tree growth
Soil fertility

ABSTRACT

Adequate weed control and nutrient supply are critical for successful establishment of fruit trees. This is of particular concern in organic orchard establishment. In order to determine the best approach for establishing peach trees (*Prunus persica* L.) organically in climates characterized by hot dry summers and cold winters such as the North American Intermountain West, seven organic and three integrated and conventional treatment combinations were established in two first leaf orchards at the USU Kaysville Research Farm, Utah, in 2008 and 2009. Treatments consisted of different tree-row and alleyway mulch and fertilizer combinations. Compost or conventional fertilizer (16-16-16 and urea) were applied at a baseline rate of 4.9, 9.6, 19 g and 114 g of available nitrogen (N) per 1st, 2nd, 3rd and 4th leaf tree respectively and adjusted up or down on a plot basis based on tree growth. Compost was supplemented with a feather meal 13-0-0 fertilizer starting in year three to avoid over application of phosphorus (P) and potassium (K). Organic experiment tree growth was initially slowed by living and straw mulches present in the tree-row. By 2011, 3rd leaf trees were largest in treatments with Birdsfoot trefoil alleyways, despite considerable tree-row weed/living mulch pressure. In the integrated experiment, trees were larger in the compost plus conventional herbicide compared to conventional fertilizer and herbicide treatment. Paper mulch depressed tree growth in combination with both compost and conventional N sources, but more so in combination with compost and organic herbicide where weed control was moderate. Weed pressure not lack of N was determined to limit organic tree growth in this study. A trefoil alleyway may alleviate the need for intensive weed control when establishing organic peach orchards.

1. Introduction

The United States (US) market for organic produce continues to grow despite the recent economic downturn (Dimitri and Oberholtzer, 2009; Slattery et al., 2011). Growth in tree fruits and berries has been particularly strong with organic peach production increasing by 116 percent between 2008 and 2011 (Perez and Plattner, 2013). Organic production in the US has largely failed to keep pace, and meeting consumer demand continues to be a challenge (Dimitri and Oberholtzer, 2009). Utah and the Intermountain Western US are traditional producers of high quality tree fruit with high elevations, warm daytime temperatures and cool nights during the summer, resulting in fruit that is exceptionally sweet and flavorful. Overall fruit production has dwindled in recent years due to urbanization and changing markets, although the planted area of tart cherries and peaches has remained stable (Ernst et al., 2012; Utah Fruit and Berry Survey, 2006). The arid climate of the Intermountain West with relatively low disease pressure confers considerable advantages for organic production and growing urban centers provide access to markets. Currently, certified organic tree fruit in Utah is limited to a few very small producers, however. Challenges include a lack of local expertise, short growing seasons with cold winters and shallow alkaline soils low in organic matter. Strengthening an organic tree fruit industry in the region will require locally adapted best management strategies, something that is currently lacking.

A major challenge to establishing new organic orchards is the transition process. Successful organic production requires growers manage soil reserves of readily available nutrients as most organic fertilizers mineralize slowly in the short-term. Building

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http://dx.doi.org/10.1016/j.scienta.2016.11.040
0304-4238/

sufficient soil nutrient reserves can take time, especially in soils with very low native organic matter and high pH. Young fruit trees are particularly susceptible to competition from weeds which compete for water and nutrients and often provide a refuge for pests (Skroch and Shribbs, 1986; Hoagland et al., 2008, Tworkoski and Glenn, 2008). Bare soil or maintenance of an herbicide or tillage strip is generally preferred during the orchard establishment phase in both organic and conventional production (Welker and Glenn, 1991; Layne et al., 1994; Neilsen and Hogue, 2000; Tworkoski and Glenn, 2008). Tillage along with applications of compost is a commonly used organic orchard floor management system in the US (Hoagland et al., 2008). Adequate quantities of high quality compost can be difficult and expensive to obtain, however, while frequent tillage has been shown to disrupt surface roots and tree stability, and reduce soil quality over the long term (Skroch and Shribbs, 1986; Hoagland et al., 2008).

An alternative or complement to compost and other expensive organic inputs is to grow legumes in the orchard (Granatstein and Sánchez, 2009; Rowley et al., 2011). Legumes are capable of supplying significant N to fruit trees. Subterranean clover is used in coastal orchard regions in the US because of its low growth habit. In a California study, subterranean clover grown in the tree-row was found as effective as high 90 kg N ha^{-1} applications of compost + native vegetation for establishment of young peach trees at only a fraction of the cost of compost (Meyer et al., 2006). Many growers in Colorado and Utah plant orchards into established alfalfa and manage weeds by mowing. However, this practice has not been formally evaluated and has generally been discouraged in peach orchards due to the potential for problems with pests, particularly cat-facing insects (Killian and Meyer, 1982).

Legumes can also strongly inhibit tree growth through competition (Skroch and Shribbs, 1986; Hoagland et al., 2008; TerAvest et al., 2010). An Italian study showed that subterranean clover inhibited early growth of peach trees compared to a tillage control (Antonelli et al., 1997). Merwin and Stiles (1994) showed a similar competition problem with crown vetch planted in the tree- row of establishing apple trees. In tart cherry, Sánchez et al. (2003) showed that legumes incorporated into tree-row cover crop mixes did not increase yield relative to mixes with fewer or no legumes. Although fertigation + living mulches reduced yield discrepancies in this Michigan study. Stasiak and Rom (1991) indicated that competition effects may be short lived in establishing peach orchards, however. In addition, locating the legumes in the alleyway versus the tree-row may be critical to reducing competition and optimizing benefits (Granatstein and Sánchez, 2009; Mullinix and Granatstein, 2011).

There is also considerable interest in mulch, made from various organic and inorganic materials, for weed control in organic orchards (Granatstein and Mullinix, 2008; Tworkoski and Glenn, 2008; Cline et al., 2011; TerAvest et al., 2010). Hoagland et al. (2008) demonstrated good weed control with wood chip mulch, although tree nutritional problems were observed and soil quality was somewhat impaired. Use of woven fabric mulch was used successfully in sweet cherry establishment (Nunez-Elisea et al., 2005) although Neilsen and Hogue (1992) showed dramatic reductions in soil and leaf K in apple. Yield was highest in tart cherry systems receiving supplemental grass legume mulch combined with glyphosate as needed (Sánchez et al., 2003). And paper mulch significantly increased growth of apple (Hogue et al., 2010). Straw is effective for weed control during raspberry establishment (Bushway et al., 2008) and may sufficiently cool soil temperatures in the early spring to prevent premature bud break (Walsh et al., 1996; Wang et al., 2015), an increasing problem in a changing climate. Mulches may also hold additional benefits in terms of conserving soil moisture (Walsh et al., 1996; Wang et al., 2015). Increased rodent activity is of potential concern, however (Sullivan et al., 1998).

The goal of this study was to evaluate orchard floor management practices for establishing organic peach trees in environments characterized by hot dry summers, cold winters and shallow alkaline soils such as the Intermountain Western US. Two orchards were established in 2008 at the USU Kaysville Research Farm, Utah. A certified organic orchard was planted to test the effects of living and straw mulches as weed management strategies in the tree-row in combination with grass or legumes grown in the alleyway. These treatments were compared to common organic methods of maintaining weed free tree-rows, tillage and fabric mulch, with grass alleyways. A second orchard was established to investigate the interaction between nutrient availability from organic fertilizers and weed competition.

2. Materials and methods

2.1. Site history, experimental design and management

Two peach orchards (*Prunus persica* L.) were established in neighboring fields at the USU Horticulture Research Station in Kaysville, UT (41° 1′16.73″N, 111°55′43.37″W, 1336 m elevation). The fields were fallow prior to 2005 and were then planted to a succession of summer and winter cover crops to facilitate weed control. The soil type was a Kidman fine sandy loam. In April 2008, the two sites were clear cultivated and the orchards planted. The organic experiment was planted in twelve rows of 30 trees with 2.44 m in-row and 4.88 m between-row spacing, in a randomized complete block design with four blocks. The integrated experiment was planted in twelve rows of 25 trees with the same spacing and design described above. The blocking factor represented cultivar ('Starfire' and 'Coralstar' on 'Lovell' rootstock) and location within each orchard. Cultivars were planted in alternating blocks of three rows each resulting in plots of 3 × 5 trees in size with six (organic) or five (integrated) treatments per block. The three central trees in each 15 tree plot were designated as data trees; the surrounding trees served as guard trees to protect the data trees from edge effects. This layout resulted in two guard rows between data rows and two guard trees between data trees in a row.

Treatments were established in each experimental orchard in June of 2008. Organic experiment: straw mulch with a grass alleyway **(StGr)**, straw mulch and a Birdsfoot trefoil (*Lotus corniculatus*) alleyway **(StTr),** living mulch (low-growing shallow rooted allysum, *Lobularia maritima*) with grass alleyway **(LmGr)**, living mulch and legume alleyway **(LmTr)**, woven plastic mulch (5oz. Dewitt, Sikeston, MI) with a grass alleyway **(WfGr)** and tillage with grass alleyway **(TiGr)**. Treatments assigned to the integrated experiment were: conventional fertilizer plus herbicide **(CfH)**, compost as organic fertilizer plus herbicide **(OfH),** conventional fertilizer with paper mulch and reduced herbicide **(CfM)** and compost with paper mulch and organic herbicide **(OfM)**. All alleyways in the integrated experiment were planted to grass. Treatments **StGr**, **StTr, LmGr,** and **LmTr** were managed according to the sandwich system (Hoagland et al., 2008) with a narrow 0.3 m tilled strip maintained between the tree-row and alleyway using a tractor mounted rototiller. In the organic experiment a significant number of data trees failed to grow above the graft during the first season so all data-row trees were replanted in April 2009.

Chicken manure compost was applied to all treatments in the organic experiment and treatment **OfH** and **OfM** in the integrated experiment in 2008, and compost made of steer manure, steer stomach contents upon slaughter and wood chips was applied in 2009–2011. Compost was applied around the drip line of the tree within the tree-row in tillage, weed fabric, herbicide and paper mulch treatments, and to the tillage strips in the straw and living mulch treatments. Compost had a total N content of 1.89, 1.46, 2.25,