The Economics of Establishing Blueberries for Organic Production in Oregon – a Comparison of Weed Management Systems

Bernadine Strik
Department of Horticulture
Oregon State University
4017 ALS
Corvallis, OR 97331, USA

Gil Buller
NWREC
15210 NE Miley Rd
Aurora, OR 97002, USA

Handell Larco
Department of Horticulture
Oregon State University
4017 ALS
Corvallis, OR 97331, USA

James Julian
NWREC
15210 NE Miley Rd
Aurora, OR 97002, USA

Keywords: *Vaccinium corymbosum*, weed mat, landscape fabric, weed control, raised beds, sawdust, mulch, cost of production

Abstract

The objectives of this study were to determine the cost of establishing a highbush blueberry field for organic production in western Oregon. The research plot, at the North Willamette Research and Extension Center (NWREC), Aurora, Ore., had a Willamette Silt Loam soil with an organic matter content of 3.7% and pH of 4.9 prior to planting on 9 Oct. 2006. The treatments compared for cost of production in "year 0" (2006; planting preparation) and "year 1" (2007; first growing season) were: i) planting into raised beds or on "flat ground"; ii) the cultivars Duke and Liberty; iii) the weed management treatments a) Douglas fir (*Pseudotsuga menziesii*) sawdust mulch and weed management by hand, b) compost plus sawdust mulch with weed management using acetic acid and hand control as needed; and c) landscape fabric with sawdust mulch in the planting hole; and iv) method and rate of fertilization: feather meal or liquid fish fertilizer at 25 or 50 kg N/ha. The total costs of land preparation, planting establishment, and maintenance after year 1 ranged from US$30,311 to $35,534 per hectare depending on treatment. Raised beds increased costs $1,263, on average, compared to planting on flat ground. Adding compost to the mulch increased costs $976 in flat ground and $1,156 in raised beds for materials and labor to apply, but also increased weed management costs by $1,519 due to higher weed pressure and use of acetic acid. Cost differences between weed management and fertilizer treatments may change as the planting matures, weed pressure changes, and we learn more about fertilizer requirements and best timing/frequency of application in this organic system.

INTRODUCTION

Blueberries are long-lived perennials, requiring 7 or more years to reach full production. Establishment costs can surpass $37,500 per ha to establish an 8 ha planting of highbush blueberries grown in a conventional system in Oregon (Eleveld et al., 2005). First year establishment costs of conventional, southern highbush blueberries in Georgia are over $24,345 per hectare (Fonsah et al., 2007).

Blueberries grow best on well-drained soils, high in organic matter, and with a pH of 4.2 to 5.5 (Strik et al., 1993). In most production regions, blueberry plants are grown on raised beds of about 0.3 m high to improve soil drainage in the root zone, and an organic mulch is used (Strik, 2007). Plantings are established in autumn or spring, usually with 2-year-old container-grown plants. An organic material, commonly sawdust, is often incorporated prior to planting with the goal of improving soil drainage. However, White (2006) reported that use of sawdust as a pre-plant amendment in raised beds reduced highbush blueberry plant growth; amended soils required more irrigation and plants were more likely to be water stressed.

Blueberries are shallow-rooted and thus readily susceptible to drought injury (Bryla and Strik, 2006); however, blueberries are also susceptible to over-irrigation, which often leads to problems with root rot (Bryla and Linderman, 2007). A uniform and adequate supply of moisture is essential for optimum plant growth. Soil moisture level was the greatest factor affecting blueberry root growth in southern highbush, and high irrigation and low bed height significantly improved the growth of rabbiteye blueberry (Spiers, 1998; 2000).

Weed management in blueberries is critical for economic production (Pritts and Hancock, 1992; Strik et al., 1993). Pre-emergent and contact herbicides are commonly used in conventional production systems. Sawdust is also commonly applied as mulch on the soil surface in the row after planting, not only to improve organic matter content, but also for annual weed control. The mulch layer is maintained for the life of the planting. In some production regions, a weed barrier permeable to water or black plastic may be used in the blueberry row; whether these materials are cost effective is not clear (Pritts and Hancock, 1992). However, there are many successful plantings in which no mulch or weed barrier has been used. Acetic acid (vinegar) at a concentration of 9% was effective at controlling at least 79% of weeds present; a second application at 1% did not control re-growth (Young, 2004). A 20% acetic acid application provided at least 79% control of liverwort (*Marchantia polymorpha*), but only 35 to 65% control of silver thread moss (*Bryum argenteum*; Fausy, 2003). In red raspberry, Weed Pharm (20% acetic acid) applied in May controlled 30% to 78% of white clover and dandelion, post-emergence (Miller and Libbey, 2007). Most fields have a permanent grass cover in the aisles between rows to facilitate winter management and weed control (Strik, 2007).

Surface mulches generally improve growth in blueberry (Clark, 1991; Clark and Moore, 1991; Lareau, 1989; Moore, 1979; White, 2006). Douglas fir bark is commonly used in conventional and organic blueberry production systems in the Pacific Northwest, USA. However, this has become an expensive input and mulches like sawdust, with a high carbon (C) to nitrogen (N) ratio, make fertilizer management much more difficult. Sawdust mulch, for example, immobilizes N applied from conventional fertilizers (White, 2006). It is often more difficult and more expensive to compensate for N immobilization with organic fertilizer products.

In Oregon, un-mulched young plantings of ‘Bluecrop’ grew best with a fertilization rate of 50 $kg\cdot ha^{-1}$ N, the lowest rate applied. However, plants recovered only 53%, or 26.5

$kg \cdot ha^{-1}$ N, of the ^{15}N-fertilizer. At this rate of fertilization, 58% of the nitrogen present in these plants at the end of the planting year came from the fertilizer. Thus, young blueberry plants do not need much fertilizer N (Bañados, 2006; Bañados et al., 2006; Hart et al., 2006). In mulched, young 'Elliott' blueberry plants, fertilizer recovery was 10 to 20% and fertilizer N was immobilized in the mulch (White, 2006).

Well-composted organic materials (low decomposition rates in soil) released < 10% of their total N during the first year in the field (Gale et al., 2006). In contrast, specialty fertilizers (fish meal, feather meal, or seed meals) decomposed rapidly (>50% decomposition in one month) and released plant-available N rapidly. High rate applications of organic materials can build soil N mineralization rates for 7+ years after application, suggesting that soils in Oregon may mineralize sufficient N for blueberry production if they receive periodic, high-rate compost applications (Cogger et al., 2001; Sullivan et al., 2003).

There is minimal information available or known on organic production systems in northern highbush blueberry. The long-term goal of this study is to develop organic production systems for highbush blueberry that maximize plant growth, yield, and fruit quality; facilitate weed, water, and nutrient management; and provide an economic benefit to growers. The objective presented here is an economic assessment of year 0 and year 1 organic blueberry establishment costs as affected by production method including raised bed or flat ground production, weed management, cultivar, and fertilization rate and method.

METHODS AND MATERIALS

The research trial was established 9 Oct. 2006 on a site in transition to organic production at the North Willamette Research and Extension Center (NWREC), Aurora, Ore., USA. Prior to planting, the site was in wheat and then seeded with buckwheat (*Fagopyrun esculentum*) on 30 May, 2006 which was incorporated prior to seed head formation. The soil was a Willamette Silt Loam (fine-silty mixed superactive mesic Pachic Ultic Argixeroll) with an organic matter content of 3.7% and pH of 4.9 prior to planting. Pre-plant establishment included sub-soiling and power spading for deep tillage, roto-tilling, and bed shaping (if needed). Other than the buckwheat, no organic material was added to the soil before planting.

The treatments compared for cost of production in "year 0" (2006; planting preparation) and "year 1" (2007; first growing season) were: i) planting into raised beds (0.3 m high, 0.38 m wide at the top, and 1.5 m wide at the base) or on "flat ground"; ii) the cultivars Duke and Liberty; iii) the weed management treatments a) Douglas fir (*Pseudotsuga menziesii*) sawdust mulch (9 cm deep) and weed management by hand pulling, b) compost (yard debris; 4 cm) with sawdust (5 cm) mulch on top and weed management using vinegar (20% acetic acid; OMRI approved) and hand pulling as needed; and c) landscape fabric (weed mat) with sawdust mulch (5 cm) in the 20 cm diameter planting hole; and iv) method and rate of fertilization: feather meal (Nature Safe; pH 5.7; EC 1.7 mS cm^{-1}; 13% N: 0% P2O5: 0% K2O: 2% Ca: 1.3% S) was applied in a split application on 3 Apr. and 16 May 2007, and the fish fertilizer ("Fish Agra"; pH 3.7; EC 20.4 mS cm^{-1}; 4% N: 1% P2O5: 1% K2O: 0.8% Ca: 1.7% S: 800 ppm Mg: 29 ppm Zn: 76 ppm Al: 54 ppm Cu: 327 ppm Fe; 5 ppm Mn; 2.5 ppm B) was applied every 2 weeks from 16 Apr. to 9 July; the fertilizer rate was 25 or 50 $kg \cdot ha^{-1}$ N.

The experimental design was a split-split plot with 5 replicates. The raised and flat beds were randomly assigned to single rows as main plots; and within them, fertilizer treatments were randomly assigned as subplots, and cultivar and weed management practices were randomly assigned as sub-subplots. Plots were 4.6 m long with 6 plants each. Plant spacing was 0.76 m by 3 m with two-year-old container grown (4 L) plants established.

Plants were irrigated by a single lateral of drip tubing, with 2 $L \cdot h^{-1}$ in-line emitters spaced every 0.3 m. The system was designed so that raised and flat beds could be irrigated independently to adjust for differences in water use if needed. A second lateral was also installed in the weed mat plots to increase water application during high temperatures if needed. Grass was planted between the rows. The research planting was certified as organic in May 2008 by Oregon Tilth (OTCO; Salem, Ore.).

All costs (materials and labor) were recorded in year 0 and 1 with data presented by treatment extrapolated to a per hectare basis.

RESULTS AND DISCUSSION

Assumptions for economic analysis

This analysis assumes the grower owns a typical complement of farm equipment for an 8 ha organic blueberry farm: a 35 hp tractor, flail mower, harrow, manure spreader, roto-tiller, side-dresser, air-blast sprayer, pickup truck, and wagon (Eleveld et al., 2005). In addition, a custom sprayer was developed for application of vinegar and fish emulsion (high density polyethylene with stainless steel or plastic fittings and nozzles, wand for spot spraying, and boom with 2 nozzles: $1200). Land is leased on a long-term basis at $988 per ha, cash-rent. A single drip irrigation line plus overhead irrigation system for cooling and frost protection was installed at a cost of $5,683 per ha. Irrigation water was applied to maintain consistent, adequate soil moisture across all treatments; pumping costs were $4.50 per ha-cm. Land was seeded with a cover crop in year 0 which was incorporated during land preparation. The custom sprayer and irrigation system were amortized over 10 years. All labor costs were $15 per hour. These aforementioned establishment costs in "year 0" are included in the total cost of production figures presented (Table 1), but are not further outlined below; only costs affected by the treatments used in this study are described here.

No organic matter or fertilizer were used prior to planting, as it was deemed un-necessary; based on a recent economic analysis (Eleveld et al., 2005), this saved over $5,000 per ha in establishment year 0.

Planting establishment, year 0

The cost of planting establishment varied with cultivar. 'Duke', a non-patented cultivar cost $3.15 per plant compared to $3.45 for 'Liberty', assuming a grower was to purchase a large volume of plants. With a planting density of 4,305 plants/ha, it would cost $1,292 more per ha to establish 'Liberty'. In this paper we will only present economic data for 'Duke'.

Establishing a planting on raised beds was more expensive than on flat ground. The equipment and labor to make the raised beds cost $741 per ha (Table 1). The weed management treatments of sawdust mulch, sawdust + compost mulch, and weed mat applied in year 0 cost $3830, $4806, and $3064 per ha on flat ground, respectively, including materials and labor (Table 1). It was more expensive to establish mulches on raised beds as the in-row area was larger. For the purposes of this study, the weed mat material cost $2,965 per ha and was amortized over 5 years. The cost reported for the weed mat mulching treatment (Table 1) includes the amortized cost ($593 per ha), installation, cutting holes prior to planting, and addition of sawdust mulch after planting. It cost $0.70 per piece to plant through weed mat, compared to $0.40 per plant for treatments without weed mat.

The economic significance of the added cost of production on raised beds will depend on future plant growth, yield, and any economic differences in planting maintenance resulting from raised beds vs. flat ground production.

Weed management, year 1

There was no significant difference between raised beds and flat ground systems for weed pressure, measured as percent coverage in 2007. There was not a lot of weed pressure in any treatment, averaging less than 20% weeds on any date. Weed management treatment, however, significantly affected weed pressure. The weed mat plots had significantly fewer weeds than the other treatments (data not shown); the weeds that did occur were in the "planting hole" and required hand pulling. The sawdust + compost treatment had the most weeds and vinegar was used to control them. Vinegar was generally applied every three weeks throughout the warm, dry growing season when it was most effective. When weeds escaped control, they were hand pulled and labor recorded. Only hand weeding was done in the sawdust mulched plots, as required.

In 2007, the sawdust mulched plots (hand weeded only) required 18.2 hours of labor per ha to pull weeds. Vinegar was quite effective for controlling weeds during the hot summer months in the sawdust + compost treatment, but required 61 hours of equipment operator labor per ha (5 applications per season; 2 people required for each application) and $250 product per ha for in-the-row weed management. In addition, 7.4 hours of labor was required to hand weed when the vinegar treatment was ineffective (generally at cooler times of the season). In contrast, the weed mat plots required the least labor -- 6.8 hours of hand weeding per ha. The sawdust + compost treatments thus cost the most to maintain weed-free in year 1 (Table 1). Commercial growers may have more cost effective ways to apply organically approved chemicals such as vinegar for weed control.

Treatment effects on irrigation, year 1

In general, there was lower soil moisture through the season on raised bed plantings than on flat ground plantings, especially in weed mat plots (data not shown). Soil temperature (at 5 cm) was 1 to 5 °C warmer during the day (7am to 7pm) on most dates in 2007 in weed mat plots than in sawdust plots (data not shown). Differences were more pronounced in raised bed plots than in flat ground plots. To avoid plant water stress, raised beds with a weed mat cover required 370 L more water per plant, 131% more water, than did plants mulched with sawdust on raised beds in year 1. At $4.50 per ha-cm in irrigation pumping costs, raised beds with weed mat cost $69 per ha more to irrigate than raised beds with sawdust or sawdust + compost mulch and were the most costly to irrigate of all treatments. When compared with flat ground, raised beds required an additional $38, $6, and $6 per ha in pumping costs for weed mat, sawdust, and sawdust + compost mulch treatments, respectively. In general, irrigation costs in year 1 were about $1,000 per ha, including equipment (amortized portion for year 1), installation, and pumping charges (Table 1).

Organic fertilization rate and method, year 1

In this paper we are not including the effects of fertilizer rate, 25 or 50 $kg \cdot ha^{-1}$ N, on plant growth. We are thus presenting only the costs for fertilization with feather or fish emulsion at the 50 $kg \cdot ha^{-1}$ N rate. Plants fertilized with feather meal were not as vigorous in mid-season as those fertilized with fish emulsion, perhaps because the feather meal was not readily available in this drip irrigated field (minimal rainfall in summer; data not shown). We thus applied a low rate of fish emulsion to the feather meal treatment -- 3.9 $kg \cdot ha^{-1}$ N was applied on each of 28 June and 5 July as a liquid soil drench above the root zone to try to prevent plant loss; this was successful. Costs presented here include this added treatment.

At the 50 $kg \cdot ha^{-1}$ N rate, the cost of fertilizing with fish emulsion was $1,347 for product plus $1,338 for equipment and labor costs per ha (7 applications per season each requiring a tractor driver/applicator) compared to $721 and $830 for the feather meal treatment, respectively (Table 1). It should be noted that we applied all of the fish emulsion by hand to these young plants. Our fertilizer applications were performed as part of a comprehensive study and not a commercial operation. Therefore, the costs we present here are estimates based upon grower feedback. Further research may show that fewer applications are required, thus reducing costs. Also, earlier applications of feather meal may have eliminated need for additional applications of fish emulsion.

CONCLUSIONS

The total costs of land preparation, planting establishment, and maintenance of an organic highbush blueberry planting after year 1 ranged from US$30,311 to $35,534 per hectare depending on production system. In the organic production systems we are studying, raised beds increased costs $741, $667, and $847 for bed construction and mulching with sawdust or sawdust + compost, respectively, compared to planting in flat ground. Adding compost to the mulch increased costs $976 in flat ground and $1,156 in raised beds for materials and labor to apply, but also increased weed management costs by $1,519 per ha due to higher weed pressure and the application of vinegar for weed control in this treatment. It is not known at this time whether compost provides any benefit to plant growth. Cost differences between weed management and fertilizer treatments may change as the planting matures, weed pressure changes, and we learn more about fertilizer requirements and best timing/frequency of application in this organic system.

ACKNOWLEDGEMENTS

The authors appreciate research funding support provided by the Oregon Blueberry Commission and the Northwest Center for Small Fruits Research.

Literature cited:

Bañados, M.P. 2006. Dry weight and 15N-nitrogen and partitioning, growth, and development of young and mature blueberry plants. Ph.D. thesis, Oregon State University, 172 pp.

Bañados, M.P., B.C Strik and T.R. Righetti. 2006. The Uptake and Use of ^{15}N-Nitrogen in Young and Mature Field-Grown Highbush Blueberries. Acta Hort. 715:65-71.

Bryla, D.R. and R.G. Linderman. 2007. Implications of irrigation method and amount of water application on *Phytophthora* and *Pythium* infection and severity of root rot in highbush blueberry. HortScience 42:1463-1467.

Bryla, D.R. and B.C. Strik. 2006. Variation in plant and soil water relations among irrigated blueberry cultivars planted at two distinct in-row spacings. Acta Hort. 715:295-300.

Clark, J. 1991. Rabbiteye and Southern Highbush Blueberry Response to Sawdust mulch. Arkansas Farm Research. Jan.-Feb:3.

Clark, J.R. and J.N. Moore. 1991. Southern highbush blueberry response to mulch. HortTech. 1:52-54.

Cogger, C.G., A.I. Bary, S.C. Fransen and D.M. Sullivan. 2001. Seven years of biosolids vs. inorganic nitrogen applications to tall fescue. J. Environ. Qual 30: 2188-2194.

Eleveld, B., B. Strik, K. DeVries, and W. Yang. 2005. Blueberry economics. The costs of establishing and producing blueberries in the Willamette Valley. EM 8526. 41 pp. http://eesc.oregonstate.edu/.

Fausey, J.C. 2003. Controlling liverwort and moss now and in the future. HortTech. 13:35-38.

Fonsah, E.G., G. Krewer, K. Harrison, and M. Bruorton. 2007. Risk-rated economic return analysis for southern highbush blueberries in soil in Georgia. HortTech. 17:571-579.

Gale,E.S., D.M. Sullivan, D. Hemphill, C.G. Cogger, A.I. Bary and E.A. Myhre. 2006. Estimating Plant-Available Nitrogen Release from Manures, Composts, and Specialty Products J. Environ. Qual. 35:2321-2332.

Hart, J., B. Strik, L. White, and W. Yang. 2006. Nutrient management for blueberries in Oregon. EM 8918, 14 pp.

Lareau, M. 1989. Growth and Productivity of Highbush Blueberries as Affected by Soil Amendments, Nitrogen Fertilization and Irrigation. Acta Horticulturae. 241:126-131.

Miller, T. and C. Libbey. 2007. Weed control in small fruits. Research progress in 2006. Proc. Western Wash. Hort. Assoc. (http://wwha.wsu.edu/). Date accessed: 6-26-08.

Moore, J.N. 1979. Highbush Blueberry Culture in the Upper South. 4th Natl. Blueberry Res. Workers Conf. 4:84-86.

Pritts, M.P. and J.F. Hancock. 1992. Highbush blueberry production guide. NRAES-55, Ithaca, NY, 200pp.

Spiers, J. 1998. Establishment and Early Growth and Yield of 'Gulfcoast' Southern Highbush Blueberry. HortScience. 33(7):1138-1140.

Spiers, J.M. 2000. Influences of cultural practices on root distribution of 'Gulfcoast' blueberry. Acta Hort. 513: 247-252

Strik, B.C. 2007. Horticultural practices of growing highbush blueberries in the ever-expanding U.S. and global scene. J. Amer. Pom. Soc. 61(3, Aug):148-150.

Strik, B., C. Brun, M. Ahmedullah, A. Antonelli, L. Askham, D. Barney, P. Bristow, G. Fisher, J. Hart, D. Havens, R. Ingham, D. Kaufman, R. Penhallegon, J. Pscheidt, B. Scheer, C. Shanks, and R. William. 1993. Highbush blueberry production. Ore. State Univ. Ext. Serv. Publ. PNW 215.

Sullivan, D.M., A.I. Bary, T.J. Nartea, E.A. Myrhe, C.G. Cogger, and S.C. Fransen. 2003. Nitrogen availability seven years after a high-rate food waste compost application. Compost Sci. Util. 11(3): 265-275.

White, L.D. 2006. The effect of pre-plant incorporation with sawdust, sawdust mulch, and nitrogen fertilizer rate on soil properties and nitrogen uptake and growth of ‘Elliott’ highbush blueberry. M.S. thesis, Oregon State University, 63 pp.

Young, S.L. 2004. Natural product herbicides for control of annual vegetation along roadsides. Weed Tech. 18:580-587.

Table

Table 1. Costs for establishment of an organic 'Duke' blueberry field as affected by treatment in year 0 (establishment) and year 1 (first growing season, 2007). "S + C" = Sawdust + Compost mulch

Planting sys.	Mulch type	Fertilizer type 50 kg N/ha	Cost of production (US$ per hectare)						
			Year 0			Year 1			(year 0+1)
			Raised bed	Planting	Mulch	Weed mngm't	Fertilizer	Irrigation	TOTAL
Flat	Sawdust	feather meal	$0	$1,722	$3,830	$273	$1,551	$986	$30,311
Flat	S + C	feather meal	$0	$1,722	$4,806	$1,792	$1,551	$986	$32,807
Flat	Weed mat	feather meal	$0	$3,013	$3,064	$102	$1,551	$1,024	$30,704
Flat	Sawdust	fish emulsion	$0	$1,722	$3,830	$273	$2,685	$986	$31,444
Flat	S + C	fish emulsion	$0	$1,722	$4,806	$1,792	$2,685	$986	$33,940
Flat	Weed mat	fish emulsion	$0	$3,013	$3,064	$102	$2,685	$1,024	$31,837
Raised	Sawdust	feather meal	$741	$1,722	$4,497	$273	$1,551	$992	$31,726
Raised	S + C	feather meal	$741	$1,722	$5,653	$1,792	$1,551	$992	$34,401
Raised	Weed mat	feather meal	$741	$3,013	$3,064	$102	$1,551	$1,061	$31,483
Raised	Sawdust	fish emulsion	$741	$1,722	$4,497	$273	$2,685	$992	$32,859
Raised	S + C	fish emulsion	$741	$1,722	$5,653	$1,792	$2,685	$992	$35,534
Raised	Weed mat	fish emulsion	$741	$3,013	$3,064	$102	$2,685	$1,061	$32,616