Weed Control and Fertility in Organic Blueberry Production Systems

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Oregon is a leading production region in the U.S. for blueberry and blackberry. While the amount of organic production of these crops on organic farms in the U.S. was relatively small (3%) when last surveyed in 2008, the Pacific Northwest accounted for 40% to 50% of the total area planted to these crops. Our positive research results from long-term certified organic production systems trials (5-year and 9-year trials in blackberry and blueberry, respectively) have had some impact on organic production in our region. In blueberry, certified organic area has increased from an estimated 2% of total planted acreage in 2006 to about 20% in 2015.

Our blueberry trial was designed with input from an advisory committee and included treatments to evaluate the impact of planting method, cultivar, mulch, and fertilizer source and rate. The one-acre research trial was planted in October 2006 and was "transitional" in the establishment years, but was certified organic in the first cropping year (2008) – a typical pattern for commercial growers. The planting was considered mature in the eighth growing season (2014). There were 48 treatment combinations of planting method (raised beds of ~ 1 ft high or flat ground), fertilizer rate and source (a "low" and a "high" rate of either feather meal or fish emulsion), mulch type (sawdust alone; compost topped with sawdust, or weed mat), and cultivar (Duke or Liberty). Plants were spaced 30 inches apart in the row with 10 ft between rows. A grass was grown between rows. The plants were irrigated by drip, and irrigation rate was adjusted to maintain soil water content at similar values across treatments.

The granular feather meal (ranging from 11% to 13% N, depending on product or batch) or fish emulsion (4% to 5% N) fertilizers were applied initially at "low" and "high" rates of 25 and 50 lb N/acre, respectively, during the first few years of establishment (2007–2009) and then increased incrementally as the planting matured to 65 and 125 lb N/acre, respectively, by 2013. In 2007−14, feather meal was broadcast on top of the organic mulches or under the weed mat (around plants from 2007–2010 and opened for application to the in row area from 2011–2014) with half of the total nitrogen (N) applied in March and the other half in May. Fish emulsion was diluted with 10 parts water (v/v) and was applied by hand as a drench around the base of the plants in 2007–2009, side-dressed with a sprayer on each side of the row in 2010, and injected through the drip system (fertigated) in 2011–14 in seven equal applications every 2 weeks from mid-April to early July.

Mulch treatments were: a) Douglas fir sawdust (3" deep to the in-row area); b) yard debris compost (1.5" deep) topped with sawdust (2" deep) ("compost + sawdust"); and c) "weed mat" [black, woven polyethylene ground cover] with sawdust mulch (5 cm) in the 8-inch diameter planting hole. The intent of the compost + sawdust treatment was to have the sawdust mulch act as a barrier to weed seed germination in the more nutrient rich compost layer. The two organic mulches were initially applied just after planting and were then replenished (Jan. 2011 and 2013), as needed, to maintain mulch depth. The solid 1.5-m-wide piece of weed mat, centered over the row, was installed just prior to planting and was replaced with "zippered" weed mat in winter 2010–2011 allowing the weed mat to be opened and granular fertilizers to be applied underneath. Weeds were removed by hand-weeding from plots mulched with sawdust and weed mat (i.e., the planting hole area) and were controlled using OMRI-approved lemon

grass oil (Avenger®, Cutting Edge Formulations, Inc., Buford, GA), 20% acetic acid (vinegar) or propane flaming/heat, depending on the year, in addition to hand-weeding in plots mulched with compost + sawdust. Labor and product costs were recorded.

Ripe fruit were harvested by hand approximately every 7 days. In 2011–2014, the planting was sprayed weekly with a spinosad insecticide ("Entrust® SC"; Dow Agro Science, Indianapolis, IN) or a pyrethrin ("PyGanic"®), from when the 'Liberty' fruit first turned blue through harvest, to help control Spotted Wing Drosophila [*Drosophila suzukii*]; applications to the early-season 'Duke' were not required as insect populations were very low. In 2013–2014, *Bacillus subtilis* ("Serenade® MAX"; AgraQuest, Davis, CA)] was applied in spring for control of botrytis, per label rate and recommendations. No other pesticides were required during the study period. Scare alarms (Bird Gard LLC, Sisters, OR) were used for bird control. To determine the returns per treatment, fruit were sold to a commercial organic berry packer (fresh and processed markets).

While mechanical methods of weed control may be possible in flat ground planting systems, plants grown on raised beds averaged 28% more yield than on flat ground. We only recommend planting on raised beds now. In our long-term study, there has been no effect of mulch type on yield or fruit quality – this is good news for growers.

The between-row, grass cover crop was maintained by mowing and the edges by using vinegar (when planting was young) or a string-trimmer (presently). Drip irrigation (only in the row) reduced grass growth in our dry summers. Weed "pressure" in the row increased as the planting aged. Weeds were fewest in the weed mat mulch (only around "planting hole" area) and greatest in the compost topped with sawdust mulch. Weeds were hand-pulled in all treatments. While Avenger Ag® and vinegar were used as contact herbicides, these products were only effective when weeds were quite small and application was followed by hot, sunny days. Propane heat/flaming was not effective or safe. Hand pulling of weeds was thus needed frequently in the compost + sawdust mulch treatment greatly increasing the weed management costs in this mulch type. While weed mat offered the most economical way to control weeds, plants grown with weed mat required 30 to 50% more irrigation – likely a result of a change in plant architecture and an increase in soil temperature in this treatment. Addition of compost to the mulch layer did provide a source of nutrients to the field (Table 1) and the high pH of the yard debris compost used helped mitigate the decline in soil pH that occurs with fertilization over the planting life. We are continuing to evaluate the impact of these mulches on soil and plant nutrient levels.

We analyzed all of the organic fertilizers used for nutrient content (Table 1). While we applied the products to "hit" a target rate of N based on the percentage of N as stated on the product labels, there was less N in the product and thus lower rates of N were applied. In addition to N, these organic fertilizers also contained high amounts of K (fish emulsion) and Ca (feather meal). The addition of these other nutrients when using organic fertilizer materials or products, even when they are not required by the plants, must be considered in these organic production systems. Available fertilizer sources differ in cost of application and in cost per pound of N. For example, feather meal was applied as a granular product on top of the organic mulch or under weed mat, whereas fish emulsion was successfully fertigated. Costs averaged $4.50/lb of N for the feather meal and $8.15/lb of N for the fish.

We observed cultivar differences in plant growth and yield response to fertilizer source and rate during establishment and maturation. When plants were establishing, fish emulsion increased growth compared to feather meal, likely because N in the fish was more available to

plants when needed. In the later years of the study, when the first application of feather meal was done earlier to improve N availability, there was little effect of fertilizer source and rate in 'Liberty', on average, whereas 'Duke' had greater yield when fertilized with feather meal than with fish emulsion.

When we began our research, the most common production system used in organic fields was growing blueberry on raised beds, mulching with sawdust and fertilizing with fish emulsion. When we compare cumulative yield in our study to this industry standard, 'Liberty' had a greater yield when fertilized with feather meal than with fish when sawdust mulch was used, whereas fertilizer source had little impact when compost + sawdust or weed mat mulch were used. In contrast, fertilizer source had a large impact on yield of 'Duke' with little effect of mulch. In 'Duke', fertilization with the low rate of fish emulsion led to greater yield than with the high rate of fish.

We have also evaluated the adaptation of eight other cultivars to organic production systems over 9 years. Some varieties have been less adapted to the organic systems trialed, indicating growers need to choose wisely to get good production and returns. We have also tested various additional types of organic fertilizers and can now offer growers specific recommendations, including some others that may be applied through the drip irrigation system. Since our research began, weed mat has become very common in organic as well as conventional blueberry fields in the Pacific Northwest thus reducing costs of herbicides and hand weeding.

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Table 1. Nutrients applied to mature blueberry (since 2013) using organic fertilizer sources and mulches.

			Nutrients applied based on actual fertilizer content (as analyzed in a lab)										
Fertilizer	Treatment	Target rate	Macronutrients (lb/acre)						Micronutrients (oz/acre)				
source	name	(lb N/acre)	N	P	K	Ca	Mg	Na	B	Fe	Mn	Cu	Zn
Feather meal	"low"	65	58	1.5	2.7	3.6	0.3	0.5	0	7	1	0	5
	"high"	125	112	2.9	5.2	7.0	0.5	1.0	0	14	1	1	10
Fish	"low"	65	60	13	18	0.2	5	45	1	5	2	0	6
	"high"	125	115	25	35	0.4	9	87	2	10	4	0	11
Mulch[z]	sawdust	2-3" deep	62	5	20	27	5	-	32	-	16	-	0
	compost	1.5" deep	545	86	305	546	127	-	32	-	385	-	96

[z]Nutrients applied in volume of sawdust alone and the yard debris compost portion of the compost + sawdust mulch treatment. Mulch was replenished over the study; only one application is provided here.

Bernadine Strik evaluating blueberry growth in the certified organic blueberry research planting at Oregon State University's NWREC, Aurora, OR, 2013