Nutrient Management of Berry Crops in Oregon

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This summary is intended as a brief overview and as a supplement to the nutrient management guides available online at Oregon State University (http://extension.oregonstate.edu/catalog/): *Nutrient Management for Blueberries in Oregon*, EM 8918; *Caneberries: Nutrient Management Guide*, EM 8903-E; and *Strawberries. Fertilizer Guide*, FG 14). I encourage everyone working with commercial berry crops to access these and other publications on soil sampling, modifying soil pH etc.

Key questions that need to be answered with regard to any nutrient management program are: How much nutrient should be applied? When is the best time to apply the nutrient? What source of the nutrient or what material is best to apply? And what method of application is best?

How much nutrient should be applied is often estimated using soil and plant tissue testing, experience, observations of plant growth, and information on the amount of nutrient generally required for good growth and production. Nutrient availability and plant nutrient status are assessed by soil and tissue testing. I will focus most on this aspect of developing and adjusting a nutrient management program.

Soil testing

Soil testing is commonly the only method used to adjust nutrient management programs in annual crops – in these crops there is not enough time to adjust fertilizer programs based on tissue analysis.

In perennial crops, soil testing is important to adjust soil nutrient status prior to planting. This not only gets plants off to a good start, but is the only way to effectively increase soil pH. Pre-plant incorporation of nutrients that are immobile or do not move readily into the rooting zone with a surface application (e.g. phosphorus, potassium) is very effective.

Prior to planting get a representative sample of the field/block. Taking soil samples to the tillage depth (where any pre-plant application of nutrients would be incorporated) is recommended. You may also choose to take a tillage depth sample (e.g. to 6 inches deep) but also a deeper one (from 6 inches to 1.0 or 1.5 ft) to get an idea of stratification of soil pH and nutrients. Take soil samples well in advance of planting so that pH can be adjusted (e.g. sample in early fall for spring planting of caneberries or strawberries or a year in advance for blueberries) – it takes time for incorporated lime or sulfur to react and change soil pH.

Base nutrients to be incorporated prior to planting on target or recommended soil levels (Table 1). In blueberry, be conservative on addition of sulfur to acidify the soil, as raising the pH to the target range if too much sulfur (S) was incorporated is difficult. Be aware that standard fertilization programs lead to acidification of the soil in the row – the pH will thus decrease over time in all perennial berry crops. **Generally, for every 100 lb N/acre/year applied (as urea), soil pH will decrease 0.1 unit per year in our soil.** For these reasons the target pH for newly planted berry crops should be at the top of the recommended range (Table 1).

Annual soil sampling is not needed in perennial berry crops unless you are correcting a problem. We recommend soil samples be collected every two to three years to monitor changes in soil nutrient status. In established fields, sample at the same time of year (e.g. late winter or fall) so that years can be more easily compared. Collect soil samples in the plant row (where the fertilizer is applied) and, in drip irrigated fields, sample at a similar distance from the emitter and plant in all sub-sample locations. The irrigation wetting front, fertigation, and band applications of fertilizer affect soil sample results. Do not collect soil samples in spring right after fertilization has occurred. If mulch is present, remove the mulch layer before taking the soil sample. How deep should the soil sample be? You can take soil samples so that the depth reflects where the most active berry crop roots are: soil surface to 0.5-1 ft deep in strawberries and 1.5-2 ft deep in caneberries and blueberries. However, nutrients and soil pH are often stratified – fertilization over time leads to varying soil pH and nutrient content with soil depth. If you take a sample from the soil surface to 1.5 ft deep, the reduced soil P and K and the higher soil pH at the lower depths will reduce the average soil P and K and increase the soil pH relative to what is found in the fertilizer "zone" nearer the soil surface. This should be kept in mind when interpreting soil analysis results and planning nutrient management programs. You can take soil samples at two depths (e.g. 0 to 3 in. and 3 in. to 1 ft) to better understand the level of stratification occurring in your farm.

Testing soil to predict nitrogen (N) application rates in berry crops is not advised. Note that high soil N concentration in late summer/fall can be an indicator of excessive N fertilization.

Table 1. Suggested critical levels for **soil** nutrient content (adapted from OSU nutrient management guides listed in first paragraph)

Nutrient	Unit	Blueberry	Caneberry	Strawberry
pH (2:1; in water)	target:	4.5 to 5.5	5.6 to 6.5	5.4 to 6.5
	Deficient at less than:			
Phosphorus (P; Bray)	ppm	25 to 40	20 to 40	45
Phosphorus (Olsen)	ppm	10 to 20	10 to 20	20
Potassium (K)	ppm	100 to 150	150 to 350	75 to 175
Calcium (Ca)	ppm	1000	1000	1000
Magnesium (Mg)	ppm	60	120	120
Manganese (Mn)	ppm	20 to 60	20 to 60	20 to 60
Boron (B)	ppm	0.5 to 1.0	0.5 to 1.0	1.0
EC	dS/m	2	2	2

Note. Recommended levels may change in the future from local research findings.

Keep soil pH in the range considered ideal for the berry crop (Table 1). In blueberry, if soil pH is too low then we see problems with manganese (Mn) and aluminum (Al) toxicity to plants. When soil pH is too high we can see problems with less iron (Fe) and zinc (Zn) being available. **If pH is below or above recommended levels, plant symptoms of nutrient deficiencies or toxicities often occur;** in such situations the problem is best fixed by correcting soil pH.

Soil pH affects nitrification – or the rate an ammonium-N fertilizer is nitrified to nitrate-N. At a soil pH of 6.0, fertilizers containing ammonium-N (e.g. urea, ammonium sulfate) are rapidly nitrified to nitrate-N (80% converted in 6 weeks). In contrast, at a pH of 5.5, nitrification is much slower (30 to 40% in 6 weeks) (see figure 4 in caneberry nutrient management guide for data). **Caneberries and strawberries take up the nitrate form of N** – keeping soil pH closer to 6.0 allows for use of less expensive fertilizers containing ammonium as they would be rapidly nitrified allowing for efficient plant uptake. **Blueberry plants take up ammonium-N**; keeping soil pH at 4.5 to 5.5 delays nitrification, keeping the ammonium fertilizer in a form that can be taken up by the plants.

Tissue testing

Leaf tissue analysis provides information on the nutrient content of the plant – sometimes even when soil nutrient content is adequate, the plant is not able to take up the nutrients required (e.g. soil pH is incorrect; dry or saturated soil; weather; cultural issues such as overcropping, irrigation, etc.).

Tissue standards have been developed using results from research experiments and estimated from large databases that relate tissue nutrient levels to good yielding fields for each crop (OSU). Well-designed research experiments are needed in many berry crops to improve tissue standards.

In all berry crops, **tissue nutrient concentration changes throughout the season**; for example, leaf N concentration (%N) is always highest in the early season and lowest before leaf fall in autumn. The recommended time of sampling leaves for tissue analysis is related to a period of time when the leaf nutrient concentration is most stable.

Tissue nutrient levels will also change with location or age of the leaf and what type of leaf it is. For example, in caneberries results from floricane leaves will be different than primocane leaves; in strawberry, results from leaves during fruiting will be different than leaves after renovation; in blueberry, leaves from whips will have different nutrient levels than those from lateral shoots. **Always sample the recommended tissue at the recommended time** (Table 2).

Table 2. Recommended tissue and time of sampling for berry crops.

Crop	Sample time	Tissue to sample	Comments
Strawberry	After renovation (~ mid- to late-Aug.)	Most recent fully-expanded leaves	Soil sampling best for short-term field plantings
Floricane-fruiting blackberry & raspberry	late-July to early-August	Primocane leaves approx. 1 ft from tip	Standards are based on Marion and Meeker
Primocane-fruiting raspberry & blackberry	late-July (rasp) from bloom - early red fruit (blackberry)	Most recent fully expanded primocane leaf	Standards for primocane raspberry need modifying Standards are being developed
Blueberry	late-July to early-August	Most recent fully-expanded leaves	Avoid whips (sample from laterals) Standards developed from Bluecrop

Note. Recommendations may change in the future from local research findings.

When collecting tissue samples:

- Sample at the correct time for the crop; published **tissue standards are NOT correct if sampled at any other time of the season.**
- If you are seeing problem plants at any time of the year, collect leaves from affected and "normal" looking plants and compare tissue analysis results for clues as to the cause.
- **Collect the right tissue**; for example, there are no standards for fruiting lateral leaves in caneberries.
- Do not wash leaves as some nutrients can be leached with washing. Note that any micronutrients in fungicide applications, foliar nutrient applications, and dust on leaves can lead to "higher" than typical nutrient results (keep records).
- Sample cultivars separately. While there is little data on cultivar specific standards, we do know that cultivars differ – one reason may be fruiting season. Research is underway to try to address this.
- Keep excellent records on crops and blocks sampled, time of year sampled and any associated yield or fruiting season information. It will be important to look for trends over time.
- In perennial crops, tissue analysis and observations of plant growth are best used to plan for and adjust nutrient management programs for the following year.
- Do not use just tissue N concentration to adjust N fertilizer programs. Use recommended fertilizer application rates as a starting point and adjust programs based on observations of plant growth and tissue N.
- Be aware that tissue nutrient concentrations that are below or above the recommended levels (Table 3) may indicate a soil problem (e.g. high tissue Mn may mean soil pH is too low).

Nutrients in the plant move in either the xylem (with water – this tissue is dead) or the phloem (with "food" – this tissue is alive). Nutrients that move in the xylem are not mobile within the plant as they simply move with water to the leaves (not from leaves to the fruit or from old leaves to new leaves, for example). Nutrients that move in the phloem are mobile within the plant. The nutrients that are mobile in the plant are: N, P, K, Mg, and Cl. The ones that are immobile are: S, Fe, Mn, Cu, Zn, Ca, and B.

Table 3. Recommended **tissue** sufficiency levels for berry crops, Oregon.
Refer to Table 2 for correct time of sampling and tissue to sample.

Nutrient	Blueberry	Caneberry	Strawberry
Nitrogen (%N)	1.76 to 2.0	2.3 to 3.0	2.5 to 3.0
Phosphorus (%P)	0.11 to 0.4	0.19 to 0.45	0.15 to 0.3
Potassium (%K)	0.41 to 0.7	1.3 to 2.0	1.0 to 2.0
Calcium (%Ca)	0.41 to 0.8	0.6 to 2.0	1.0 to 2.0
Magnesium (%Mg)	0.13 to 0.25	0.3 to 0.6	0.2 to 0.5
Sulfur (%S)	0.11 to 0.16	0.1 to 0.2	0.11 to 0.4
Manganese (ppm Mn)	30 to 350	50 to 300	50 to 650
Boron (ppm B)	30 to 80	30 to 70	25 to 45
Iron (ppm Fe)	60 to 200	60 to 250	60 to 200
Zinc (ppm Zn)	8 to 30	15 to 50	20 to 50
Copper (ppm Cu)	5 to 15	6 to 20	6 to 20

Note. Recommended levels may change in the future from local research findings.

Fertilizer applications

Berry crops require adequate amounts all nutrients to grow and produce fruit. This will vary by plant age and perhaps by type or cultivar – particularly as yields and vigor differ.

Nutrients that are removed in harvested fruit and prunings, depending on the crop, in addition to the nutrients needed for plant growth need to be considered when planning nutrient management programs. Our research has shown that nutrient removal in fruit harvest varies with berry crop and yield (Table 4). For example, an estimated 15 lb N/acre is removed in a 5 ton blackberry crop (Table 4). In raspberry and blackberry, flailing the prunings (from caning out) between the rows returns these nutrients to soil making them available to the plant roots. However in blueberry, nutrients from flailed prunings are not returned to the plant over time because there are no blueberry roots in the row middles. The estimated nutrient content removed (per acre) when pruning mature blueberry plants is shown in Table 4.

Table 4. Amount of nutrient removed **per ton** of fresh fruit harvested per berry crop and nutrient removed per acre when pruning mature blueberry (adapted from research done by Strik)

	Macronutrients (lb/ton)					
Crop	N	P	K	Ca	Mg	S
Fruit						
Red raspberry	3.5	0.5	3.0	0.3	0.4	0.2
Trailing blackberry	2.9	0.5	3.0	0.3	0.5	0.2
Blueberry	1.4 - 2.0	0.1 - 0.3	0.8 - 2.9	0.1 - 0.2	0.1	0.1
Prunings (per acre)						
Blueberry	14.0	1.5	6.5	3.0	0.9	1.0

	Micronutrients (oz/ton)			
Fruit	B	Cu	Mn	Zn
Red raspberry	0.1	0.0	0.1	0.1
Traling blackberry	0.1	0.0	0.2	0.2
Blueberry	0.01 - 0.06	0.01 - 0.02	0.04 - 0.3	0.01 - 0.04
Prunings (per acre)				
Blueberry	0.2	1.0	12.0	0.5

Note: Red raspberry cultivar was 'Meeker'; blackberry was 'Marion' and 'Black Diamond' (no cultivar effect); blueberry range is for 'Elliott' (lower values) and 'Bluecrop'. Pruning data are for mature 'Elliott'. No data for strawberry in Oregon.
Results will likely be adjusted as research on crop removal is underway.

Efficiency of plant uptake of a fertilizer is affected by plant age (depth and width of root zone), presence of a surface mulch, amount of coverage of the in-row area (plants that fill the row space have a greater efficiency of uptake than those that do not), method of application (efficiency varies with granular, liquid, or foliar applications), and the amount and timing of fertilizer applied. Recommended rates thus may vary among application methods, not to mention plant age (Table 5). Applying higher than recommended rates of fertilizer can have adverse effects on plant productivity, fruit quality and the environment.

Table 5. Recommended nitrogen fertilizer rates for berry crops (adapted from OSU nutrient management guides referenced above)

Crop	Planting year (lb N/acre)	Mature (lb N/acre)	Comments
June-bearing strawberry	30 to 60 (soon after planting) + 20 to 30 (late July/early Aug)	50	Apply at renovation; spring N not recommended unless planting weak
Floricane-fruiting blackberry & raspberry	30 to 50 (soon after planting) (split applications)	50 to 80	Split applications starting at just before primocane emergence (or fertigate)
Primocane-fruiting raspberry & blackberry	30 to 50 (soon after planting) + 20 at bloom	50 to 80 (soon after planting) + 20 at bloom	Split applications starting at just before primocane emergence (or fertigate)
Blueberry	0.8 oz/plant hand fertilization of granular recommended Adjust for inefficiency if broadcast band or fertigated	N rate increases as planting ages 100 to 165 from year 5 to 8+	Split applications starting at bloom emergence (or fertigate) Add 25 lb N/a in year fresh sawdust added

Research is underway to determine optimum collection sample times for various blackberry, raspberry, and blueberry cultivars and whether standards should differ among cultivars. In addition, we are learning more about nutrient uptake (all nutrients) to provide better recommendations on time and rate of nutrient application. Finally, we are measuring the nutrient removal from pruning in blueberry and caneberries to learn more about nutrient budgets. All of this information should be very useful to help growers better manage their berry crop nutrient programs.

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