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Nutrient Ratios, Sufficiency Levels, or Both?

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Introduction

A use of soil analysis is predicting fertilizer response Two approaches widely used in North America for predicting fertilizer response of crops are sufficiency levels (SL), and basic cation saturation ratios (BCSR).

The SL approach assumes that are certain levels of plant nutrients in soil that can be defined as optimum. Below the SL (the soil test value corresponding to 80% to 90% of maximum yield, crops will respond to nutrient application and above the crops will not respond nutrient addition. The BCSR approach is based on the concept that maximum yields can only be achieved by creating an ideal ratio of calcium, magnesium and potassium in the soils system (Rehm, 1999).

What is the basis of each approach, and how has each faired when tested?

Bases of SLs and BCSR Approches.

SLs are developed through fertilizer rate trials conducted on soils to establish a range of soil test values. Yields plotted against soil test values are used to determine if responsiveness is correlated with soil test value, and to estimate the SL.

Bear and others first proposed BCSRs. Based on greenhouse trials, Bear et al. (1945) suggested that in the ideal soil, Ca, Mg, K, and H should occupy 65%, 10%, 5%, and 20%, of the cation exchange capacity, respectively. Graham (1959), supported this, indicating that the optimum balance is 75% Ca, 10% Mg and 2.5 to 5% K, but that ranges could be 65 to 85% for Ca, 6 to 12% Mg, and 2 to 5% K.

Research Comparing SLs with BCSR

In Ohio, McLean, et al. (1983) adjusted BCSRs.

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INTEGRATING FERTILIZER AND MANURE NITROGEN SOURCES

By Amber Moore – University of Idaho, Twin Falls Research and Extension Center, Twin Falls, ID

To successfully integrate nitrogen fertilizers into a manure application program, we recommend following four key steps:

STEP 1. GET A MANURE/COMPOST TEST DONE.

Manure varies widely from one pile to the next due to factors that include feedstock, age of manure, cattle type, bedding type, number of turns, pile temperature, and dairy management practices. For example, in a recent compost application study soil test K levels in two separate locations varied significantly, despite the fact that dairy compost from the same composting facility was applied at the same rate and time (Table 1). After closer inspection, we noticed that the field that responded strongly in terms of soil

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Table 1. Soil test K (ppm) differences, as affected by compost K content and rate (four replications and RCBD design at both locations) (*unpublished data: Falen, Hunter, Kinder, and Moore*)

Compost Rate (tons/acre	Blaine (compost had 40 lbs K_2O/ton	Camas (compost had 28 lbs K_2O/ton
0	82	121
5	121	144
10	151	148

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Over four years yields were not related to BCSRs. They concluded that, "The results strongly suggest that for maximum crop yield, emphasis should be placed on providing sufficient, but not excessive levels of each basic cation rather than attempting to attain a favorable BCSR which evidently does not exist."

In Nebraska, fertilizer recommendations using BCSRs were compared with those from SLs. Over a nine year period, BCSR based fertilizer recommendations did not produce yields significantly different from SLs but the cost of implementing BCSR based recommendations was much higher than those based on SLs. (Olson et al., 1982). They concluded that "cation balance in soil is not an essential consideration in estimating crop nutrient needs..." and "the nutrient sufficiency approach to soil testing, when adequately calibrated, promises the surest method of achieving most economic yields while conserving non-renewable resources and preserving environmental integrity."

At about the same time, Liebhardt (1981), working on Delaware soils applied four K. Wide ranges of ratios of Ca and Mg did not influence yield as long as soil pH was in a satisfactory range. No responses to K fertilization were obtained.

Simson et al. (1979) conducted trials in Wisconsin adding gypsum or Epsom salts to two soils. Both soils contained sufficient Ca and Mg based on SLs, Ca:Mg ratios ranging from 2.28 to 8.3 had no impact on alfalfa or corn yields. Similarly, Sautoy (2007), using high yield South African corn data, found no correlation between yield and Ca:Mg ratios. And McGahan et al. (2009) found that extractable Ca was a better predictor of Ca availability than were Ca:Mg ratios in serpentinite California soils.

Rehm and Sorensen (1985) reported that adjusting K:Mg ratios did not affect corn yields in Nebraska. Johnston and Karamanos (2005) reported that in six trials in the northern Great Plains on soils with sufficient K concentrations, but low K saturation percentages, no significant barley or wheat yield increases resulted from adding K.

Stevens et al. (2005) studied the effect of calcite, dolomite, gypsum and Epsom salt on cotton yields and found that yields increased in response to pH adjustment, but that there was no effect of changing BCSRs. They stated, "Under the soil and environmental conditions tested in this research the BCSR concept did not show any merit for managing cotton fertility on well drained Delta soils."

Conclusion

Research comparing the BCSR and SL approaches are clear; plants are much more sensitive to actual cation levels (ultimately to soil solution chemical activities) and not the ratio in which cations are present. Sufficiency levels are superior to basic cation saturation ratios for predicting economic fertilizer responses.

Thanks to James Walworth, PhD, Professor of Soil Science, Department of Soil, Water and Environmental Science, University of Arizona for assistance with editing.

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Integrating Fertilizer and Manure Nitrogen Sources, cont. from pg 1

test K had almost twice the concentration of K in the compost compared to the compost applied to the other field. This finding served as a clear reminder of the importance of testing manure for nutrient content.

STEP 2. UNDERSTANDING THE AVAILABILITY OF NITROGEN IN MANURE

To understand how to integrate manures and fertilizers, it is imperative to first understand the nutrient value of manure as a nutrient source. One factor that has a major influence on N availability from manures is the chemical form of organic N (Table 2). Manures containing primarily unstable and readily mineralizable N compounds (amino acids, urea, NH_4^+, uric acid), such as poultry litter and swine manure, will release plant available N forms (ammonium and nitrate) rather quickly. Alternatively, 44-49% of the N in manure from ruminant animals (beef and dairy cattle), is in stable organic N forms which can take several years to decompose. Cattle manure also contains significantly more lignin than chicken or pig manure (Table 3). Lignin is an extremely stable organic compound and very difficult to decompose, contributing the lower plant availability of N from cattle manure.

Table 2. Composition of organic N compounds in manures from various animal species. (Havlin et al., 2005)

Animal species	Amino acid	Urea	NH_4^+	Uric acid	Other (stable organic N)
Poultry	27	4	8	61	1
Beef	20	35	0.5	0	44
Dairy	23	28	0.5	0	49
Swine	27	51	0.5	0	22

Table 3. Comparison of typical lignin contents of various manures and wheat straw. http://compost.css.cornell.edu/calc/lignin.html#txt14

Substrate	Lignin (%)
Wheat straw	8.9
Cow manure	8.1
Chicken manure	3.4
Pig manure	2.2

A useful tool for estimating N availability from solid manures and composts is the Oregon State University (OSU) Organic Fertilizer Calculator (available at http://smallfarms.oregonstate.edu/calculator/. The OSU organic fertilizer calculator allows Oregon growers to predict N availability from manure, compost, and other amendments based on N and dry matter content. Another tool is the calculator imbedded in the extension article "Estimating Plant Available Nitrogen from Manure" (http://extension.oregonstate.edu/catalog/pdf/em/em8954-e.pdf). The Nitrogen availability calculator takes into account ammonium content of the manure, incorporation timing after manure application, and release of N from manure application 1-9 years prior. This calculator can be of great use on field with a history of manure applications, and can provide a good estimate of N release from manures and composts.

STEP 3. PSNT SOIL SAMPLE

Finally, if N content information is not available to the grower, or for those looking for an alternative to the calculator, we recommend conducting a second soil sampling for ammonium and nitrate at the time that potatoes are just beginning to flower in your area, or when corn plants are between 6 and 12 inches tall. This is often referred to as the PSNT (Pre-Sidedress Nitrate Test). The idea behind this is that warmer temperatures from April to June will trigger N mineralization in the soil, which releases plant available N from the organic N compounds in the soil. While N mineralization continues into the warmest months of the growing season, plant N absorption rates will also most rapid, and plants will take up every bit of nitrate in the soil, so you will no longer be able to 'see' the mineralized N in a soil test. The early season PSNT soil test can help you to determine how to manage in-season applications of N.

STEP 4. DETERMINE EXACTLY HOW MUCH SUPPLEMENTAL FERTILIZER IS NEEDED

When applying fertilizer to manured fields, it is important to determine exactly how much fertilizer is needed, otherwise it is likely that the fertilizer will be under- or over-applied. While this can be calculated by hand, online tools like the Minnesota Manure Calculator (http://www1.extension.umn.edu/agriculture/manure-management-and-air-quality/manure-application/calculator/) can help growers to quickly and easily estimate how much fertilizer is needed to supplement a manure application. To insure the most accurate estimate of fertilizer amount, *be sure to use your own NPK values and estimates for N availability*. Estimates suggested in the calculator may be drastically different from the manure that you are working with, and can cause you to under- or over-apply fertilizer.

Leaf Sampling and Interpretation, and Nutrient Budgeting for Almond

By Patrick Brown, Sebastian Saa, Saiful Muhammad, and Blake Sanden – Department of Plant Sciences, UC Davis; University of California Cooperative Extension, Kern County, Bakersfield, CA

INTRODUCTION

Optimizing fertilizer nitrogen efficiency requires viable methods to monitor field nitrogen status and an understanding of tree demand. Historically, almond nutrient status has been monitored by comparing leaf samples collected in July with established standards. Collection of leaves earlier in the season would more be useful, however, for making current year management decisions.

Efficient and profitable nitrogen application demands that nitrogen be applied at the right rate, the right time, and in the right location. To achieve these goals knowledge of the timing of crop nutrient demand, and the relationship between yield potential and demand must be established.

Our goals were to develop early season sampling strategies to guide current season nitrogen management and to derive annual and long-term patterns of almond nutrient demand and uptake and the relationship to fertilizer application and tree yield.

MATERIALS AND METHODS

In one study, four field sites in 8 to 10 year old 'Nonpareil' almond orchards of good to excellent productivity were sampled for 3 years. Leaf and nut samples were collected five times annually, from full leaf expansion to harvest. Data were used to develop models to predict leaf tissue change over the season.

Another experiment consisted of four rates of nitrogen (125, 200, 275 and 350 lb/ac), supplied as UAN 32 and CAN 17, with 20%, 30%, 30% and 20% of the nitrogen applied in February, April, June and October, respectively. Leaf and nut samples were collected monthly and analyzed for N, P, K, Ca, S, Mg, B, Zn, Cu, Mn and Fe.

RESULTS AND DISCUSSION

The results of our studies indicate that early season leaf analysis can be used for nutrient management purposes. Figure 1 shows the pattern of leaf nitrogen change throughout the season. We developed and validated a model (UCD-ESP) that utilizes nutrient ratio analysis and crop phenology to predict expected nutrient status in

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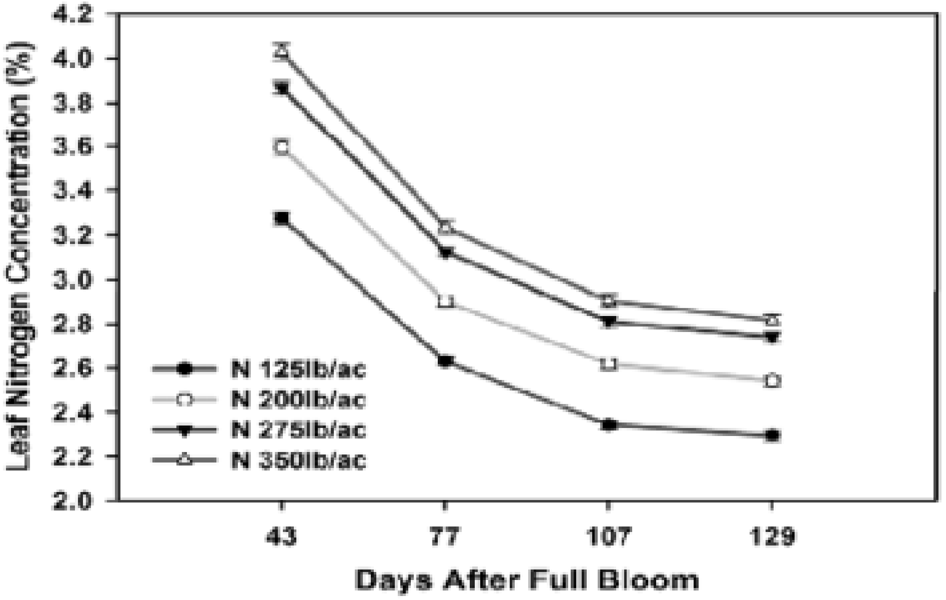

Figure 1. Changes in leaf N sampled at 4 dates from full leaf out to harvest.

Leaf Sampling and Interpretation, and Nutrient Budgeting for Almond, continued from pg 4

July based on early season leaf samples (available at http://ucanr.edu/sites/scri/Crop_Nutrient_Status_and_Demand__Patrick_Brown/). This Excel model 'adjusts' April sampling so that results can be interpreted with July sampling period standards.

We have derived a standard protocol to effectively evaluate orchard nutrient status. This minimum protocol assumes that one annual sample is collected per orchard (improved management can be attained by taking additional samples, especially in areas of lower productivity).

- Collect leaf samples 6 weeks after full bloom for April sampling, or at standard late July sampling time.
- Collect one sample if your orchard is uniform in terms of yield. Avoid trees with obvious problems (i.e. sick trees).
- Collect multiple samples (separately) if zones of varied productivity are present.
- Collect leaves from 18 to 28 trees, each at least 30 yards apart.
- Collect leaves from all sides of each tree from at least 6 to 8 well-exposed spurs 5-7 feet from the ground.
- *Send* samples to the lab and ask for a UCD-ESP analysis (for California labs)

Nitrogen accumulation in the fruit increased from fruit formation in early March through harvest and was 80% complete at shell hardening (mid-June). The amount of N removed in fruit increased as N applied increased from 125 to 275 lbs N per acre, however neither yield nor N removal increased significantly when higher rates of N were applied. On average Nonpareil removed 68 lbs N, 80 lbs K, and 8 lbs P, whereas Monterrey removed 65 lbs N, 76 lbs K, and 7 lbs P per 1000 lb of kernel yield equivalent. Note: these nutrient removal rates are calculated on the basis of the nutrient present in all fruit parts (hull, shell, kernel) required for 1000 lb kernel yield.

SUMMARY

Our research suggests that almond N management can be optimized by conducting an early season leaf analysis to determine current and predicted status, estimating current yield, and applying N according to demand and timing of nutrient accumulation in fruit. The following strategy is recommended:

Base fertilization rate on realistic, orchard-specific yield, accounting for all N inputs and adjusting in response to spring nutrient and yield estimates.

- Make a preseason fertilizer plan based on expected yield, less the N in irrigation and other inputs. 1000 lb kernel removes approximately 65 – 70 lb N.
- Conduct an early leaf analysis.
- In May, review leaf analysis results, update your yield estimate, then adjust fertilization for remainder of season.
- Time application to match demand in as many split applications as feasible
    - Apply 20% of seasonal demand after leaf out
    - 80% N uptake occurs from full leaf out to kernel fill
      Apply up to 20% hull split to immediately post-harvest, if trees are healthy and if harvested yield indicates an unmet demand.

Note that no orchard is 100% efficient in use of applied fertilizers, therefore fertilizer N rates must be adjusted accordingly. In a well-managed orchard a fertilizer efficiency of 70% is possible, thus calculated N application rates should be multiplied by 1.4 to derive actual fertilizer N requirements.

NITROGEN MANAGEMENT FOR HIGHBUSH BLUEBERRY

By David Bryla and Oscar Vargas – USDA ARS Corvallis and Oregon State University

Field trials at Oregon State University evaluated nitrogen fertilizer practices for highbush blueberry to identify the optimum fertilizer source, rate, placement, and timing for drip fertigation. Malabon silty clay loam was acidified to pH 5.5 using elemental sulfur, and Douglas fir sawdust (3 - 3.5 in.) was incorporated 8 in. deep prior to planting. Plants were planted 2.5 x 10 ft. apart on 3 to 4-ft. wide raised beds, and mulched with 2 in. of sawdust.

Trial 1

'Bluecrop' blueberries were fertilized with four application methods (split fertigation, weekly fertigation, and two non-fertigated treatments), and four rates (0, 45, 90, 135 lbs N/ac per year). Liquid urea (20-0-0) was injected three times from April to June for split fertigations or injected weekly from leaf emergence in mid-April to beginning of fruit production in late-July. Non-fertigated treatments were fertilized with granular ammonium sulfate and irrigated by drip or microsprinklers.

Weekly urea fertigation produced more growth in years 1 and 2 than split fertigation or non-fertigated granular ammonium sulfate. Fertigated plants required more nitrogen (> 135 lbs N/ac) to reach maximum canopy cover or plant size because much of the injected NH_4-N wound up between the young plants where it was unavailable for root uptake, unlike granular fertilizer which was applied near the base of the plants. Granular fertilizer produced higher leaf and soil nitrogen concentrations but also high levels of plants salt stress.

Trial 2

'Earliblue', 'Duke', 'Bluecrop', 'Draper', 'Elliott', and 'Aurora' blueberries were fertigated weekly (mid-April to mid-July) with two drip tubing laterals, each 8 in. from plants on opposite sides of the row, or a single lateral of KISSS (Kapillary Irrigation Subsurface System) tape (KISSS America Inc., Longmont, CO) near the base of the plants. KISSS tape is constructed with a geotextile fabric to distribute water more evenly than conventional drip. Irrigation lines, on top of beds, were covered with sawdust mulch. Liquid urea was drip-applied at 90 or 180 lbs N/ac, KISSS at 180 lbs N/ac, annually.

A single lateral of KISSS tape produced the same or higher leaf nitrogen levels than two drip lines in year 1, resulting in larger plants in 'Earliblue, 'Bluecrop', 'Elliott', and 'Aurora', likely due to the position of the drip lines. With KISSS, nitrogen was applied closer to the plants than it was with drip. By year 2, however, drip produced higher leaf nitrogen levels than KISSS, when 180 lbs N/ac was applied, and resulted in little difference in plant size or pruning weight. Pruning weights were also similar between low and high nitrogen drip treatments by year 2.

Trial 3

'Draper' blueberries were planted with 12 fertilizer treatments. Granular ammonium sulfate (90 lbs N/ac) was mixed into the soil with sawdust prior to planting, except in the no 'pre-plant N' treatment.

Liquid urea (90 lbs N/ac annually) applied weekly from mid-April to late-July in treatments 1-4 through

1) one drip line placed near the base of the plants
2) two drip lines, fixed 8 in. on either side of the plants
3) two drip lines placed near the base of plants initially but moved 8 in. from the plants in year 3
4) KISSS tape

Other fertilizer treatments were:

5) Fertigation with urea sulfuric acid (90 lbs N/ac)
6) Two split-applications of granular urea (10 lb N/a each) in April and May, then weekly liquid urea injections (total 90 lb N/a)
7) One application of controlled-release polymer coated urea (54 lbs N/ac)
8) One application of controlled-released urea followed by weekly liquid urea injections in June and July (54+36 lbs N/ac)
9) Weekly injections of 10-23-0.1 with organic acids (90 lbs N/ac)
10) Weekly injections of 10-23-0.1 but without organic acids
11) Identical to #3 but with no pre-plant N
12) Identical to #3 but with fertigation extended to mid-September

Drip lines were placed away from the plants in treatments fertilized with granular or controlled-release urea and near the plants in treatments fertigated with urea sulfuric acid or organic acids.

After year 1, plant dry weight was greatest in plants fertigated with organic acids or urea

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Nitrogen Management for Highbush Blueberry, continued from pg 6

sulfuric acid and lowest (regardless of fertilizer source) in plants with two drip lines fixed away from the plants. Pre-plant nitrogen fertilizer or late-season nitrogen had no effect. After year 2, organic acids produced the largest plants, primarily due production of more roots (Fig. 1). Yield was lowest in plants fertigated with urea sulfuric acid or fertilized with controlled-release fertilizer followed by fertigation.

We recommend:

- Two drip lines per row: locate lines near the base of the plants during first year or two after planting, then moving them away from the plant.
- Use nitrogen fertigation rather than granular nitrogen fertilizers.
- Use urea sulfuric acid or organic acids in high pH and/or poor quality soils.
- Do not use pre-plant nitrogen on fertigated blueberries.
- Do not extend nitrogen fertigation late in the season.

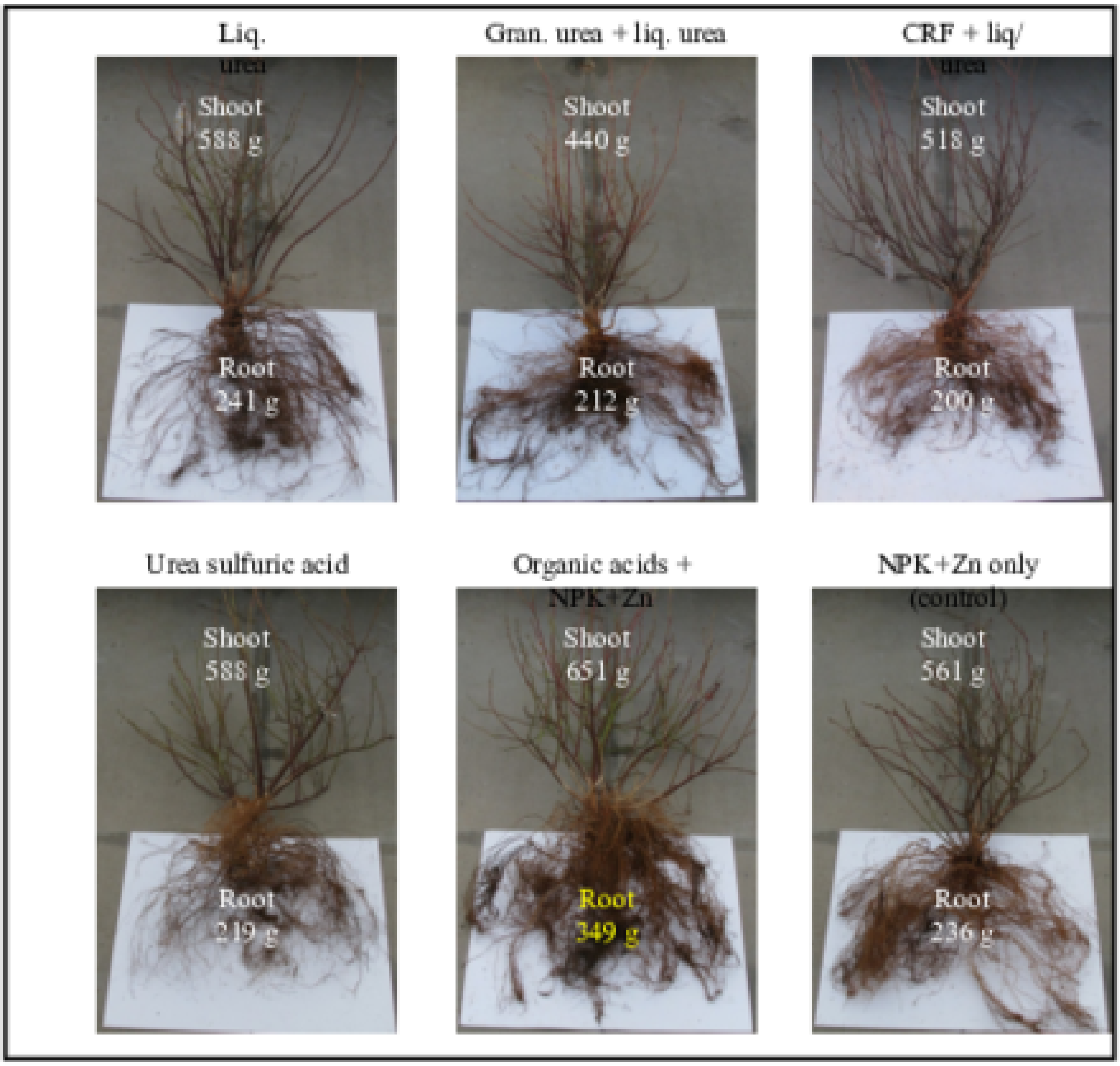

Figure 1. Effects of different fertilizers on shoot and root growth in 'Draper' blueberry.

Can Late Season Nitrogen Increase Yeast Assimilable Nitrogen (YAN) in Wine Grapes?

By Joan R. Davenport and Margaret McCoy – Washington State University, Prosser, WA

Wine grape berries in Washington State are historically low in nitrogen (N; Spayd and Anderson-Bagge, 1996; Hagen et al., 2008). This can affect the wine making process. YAN (yeast assimilable nitrogen) is the N in a wine must that the yeast rely on to complete the fermentation process. When there is not enough N in the must, the fermentation can become "stuck" and this can result in undesirable wild yeast colonizing the must causing undesirable aromas and flavors.

Nitrogen can be added to a wine must during fermentation to enrich the N supply. Interestingly, one of the most commonly used materials is DAP (diammonium phosphate), which can also be used as a fertilizer. For wine, only food grade DAP is used. However, when wine grapes are grown and fermented using organic practices, the limited N supply in the berries and the must is more difficult to adjust due to the limitations of organically approved nutrient additives.

Our interest was twofold. The first was to see if late-season N fertilizer applications could increase N in the fruit without encouraging excess plant canopy growth. The second was to see if there is a difference in the flavors of wines produced with higher N from field vs N added during fermentation. Since part of our interest is in flavors, we chose to work with the aromatic 'Riesling' grape.

Over 2 growing seasons (2011 and 2012) we applied either conventional or organic N fertilizers to foliage or soil to an established Riesling vineyard. Treatments (Table 1) were replicated 4 times, in a randomized block arrangement, with vineyard rows serving as blocks and each treatment applied to 10 vines per row separated by 2 border plants.

For soil application, material was applied twice during the season, at early veraison (ripening) and two weeks later. It was applied during a drip irrigation event by pipetting a measured amount of fertilizer at each drip emitter in the plot. For foliar application, material was applied at 5 weekly intervals, starting at early version, by hand using Solo backpack sprayers. For the control, water was applied without fertilizer.

Vines were monitored throughout the 2011 and 2012 growing seasons to evaluate the impact of the treatments on vine vigor by measuring shoot length

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Table 1. Soil and foliar N fertilizer supplements to Riesling grapes.

Treatment Name	Treatment Code	Material Used	Rate Applied (lbs/ac N)	Number of Applications
Soil Control	SX	Water	0	2
Soil Organic Low Rate	SO15	Nitrex	15	2
Soil Organic High Rate	SO30	Nitrex	30	2
Soil Conventional Low Rate	SC15	UAN32	15	2
Soil Conventional High Rate	SC30	UAN32	30	2
Foliar Control	FX	Water	0	5
Foliar Organic Low Rate	FO15	Nitrex	15	5
Foliar Organic High Rate	FO30	Nitrex	30	5
Foliar Conventional Low Rate	FC15	UAN32	15	5
Foliar Conventional High Rate	FC30	UAN32	30	5

Can Late Season Nitrogen Increase Yeast Assimilable Nitrogen in Wine Grapes?, continued from page 8

over the entire growing season. Whole leaf tissue samples were collected at veraison (prior to N fertilizer applications) in both years and at bloom in the second year (2012) to evaluate plant N status. No more than 5 days prior to commercial harvest, fruit from the center two vines in each plot was harvested by hand, the clusters counted, and the fruit weighed to determine yield.

A subsample of fruit was separated for later analysis for quality factors. In the second year, fruit was collected from within each plot for winemaking. During the winemaking process, the length of time to complete fermentation was monitored.

In winter, when the plants were dormant, vines were pruned back to 15 2-bud spurs on each vine. Prunings were collected and weighed for each plant to determine pruning weights as another measure of plant vigor.

In the first year the only soil treatment that increased YAN was the organic N (Nitrex) at 30 lbs/ac (Fig. 1). All foliar applications increased YAN. The increase with the conventional fertilizer (UAN 32) was greater as the N rate increased.

Impact of treatments on the length of time to complete fermentation is shown in Figure 2. In 2012, the high rate foliar treatments and the soil applied Nitrex at 30 lbs/ac N fermented more rapidly than any other soil treatments. This supports the 2011 YAN results indicating increased berry YAN with these treatments.

Leaf tissue N was lower than the 2.50% leaf tissue N minimum for wine grape leaves at veraison (Davenport and Horneck, 2011) throughout the entire experiment. The range of tissue N at veraison in 2011 was 1.37 - 2.27% with an average of 1.74%. Nitrogen increased at bloom (average was 2.27; range was 1.99 - 2.57%) and veraison (average was 2.42%; range 2.08-2.67%) in 2012. Despite regular grower fertilization with N and the use of our supplements, leaf N status remained low.

Measurements if both shoot length and pruning weight showed that the late season N fertilizer application did not increase vine vigor (data not shown), indicating that it is possible to increase grape berry YAN without increasing vine vigor. The wine is still in the bottle awaiting sensory analysis, so to date, no conclusions on the impact of our treatments on flavor and aroma are available.

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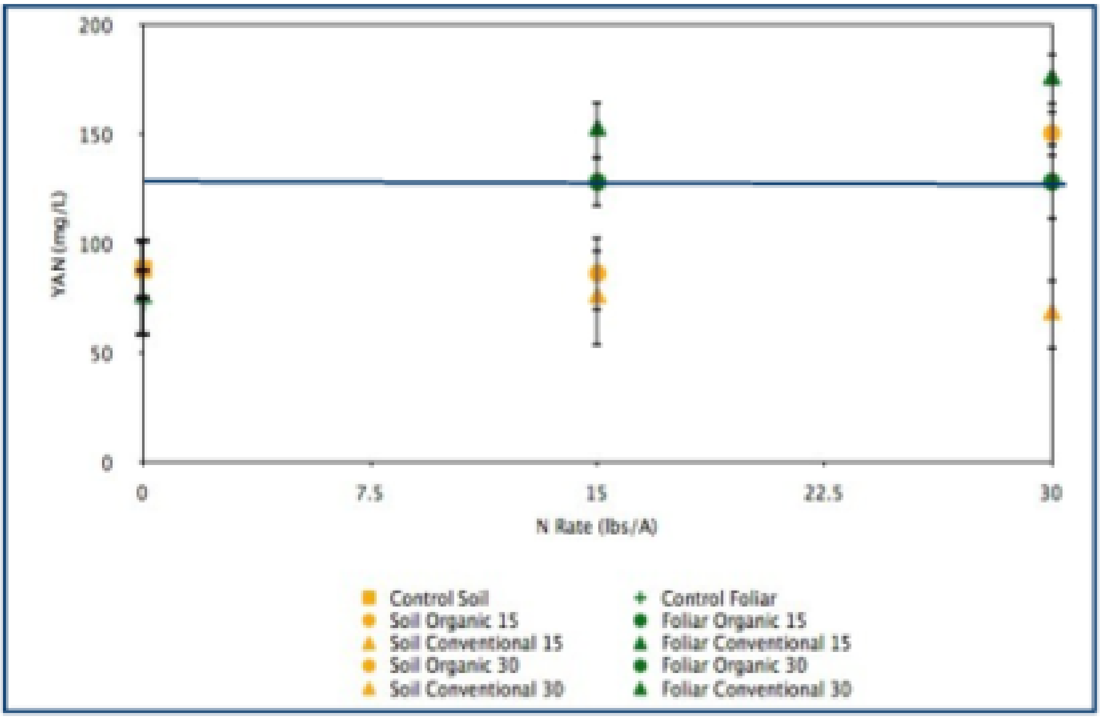
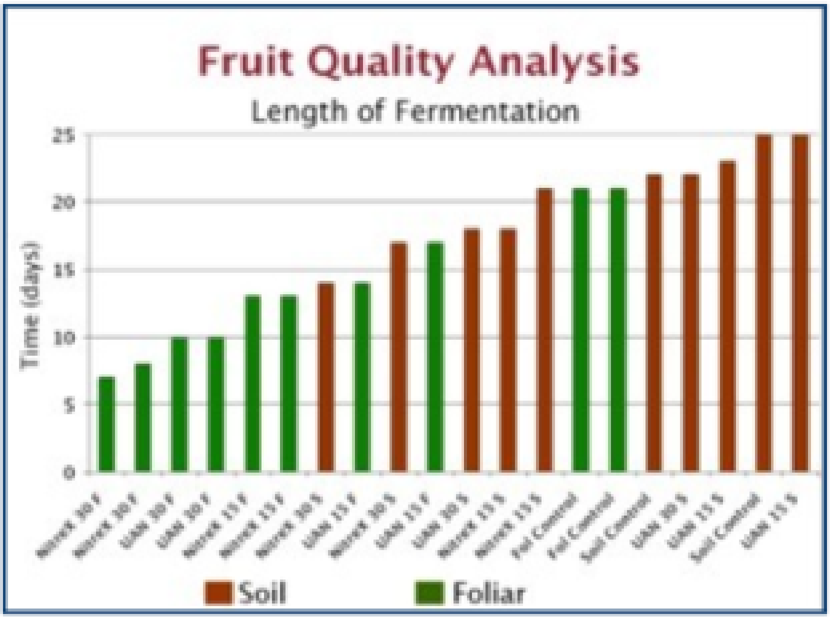


Figure 1. Average Yeast Assimilable Nitrogen (YAN) in Riesling grapes with or without soil or foliar supplemental N. The dotted line represents the YAN level that is considered necessary for a complete (non-stuck) fermentation.

Can Late Season Nitrogen Increase Yeast Assimilable Nitrogen in Wine Grapes?, continued from page 9

Figure 2. Number of days to complete fermentation in duplicate lots of Riesling must in relationship to late season supplemental N fertilizers.



Pressing Riesling grapes in a small bladder press for research wine.

Riesling vineyard in central Washington state with the Horse Heaven Hills in the background.

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