Nitrogen Management in Walnuts

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The following is a summary of a previous publication "Guide to Efficient Nitrogen Fertilizer Use in Walnut Orchards" written by Kathy Kelley Anderson, Joseph Grant, Steven A. Wienbaum and Stuart Pettygrove.

As the growing season approaches (and fertilizer prices rise), many walnut growers are asking the question, "How much nitrogen do I need to fertilize my orchard and when?" Although walnuts, a proteinaceous crop, need more nitrogen than some stone fruit, nitrate, being negatively charged, leaches easily in the soil. Compost, organic fertilizers, urea, and ammonium containing fertilizers are all eventually converted to nitrate by soil bacteria so regardless of form, leaching can occur at one point or another. Therefore, the right rate, time, place, and type become increasingly important as environmental concerns, regulatory restrictions and nitrogen prices increase. The best way to manage nitrogen applications is to first estimate orchard nitrogen requirements (based on your yield estimate), then determine your nitrogen need (yield estimate minus other sources of nitrogen), determine your applied nitrogen for the season (nitrogen needs divided by application efficiency) and determine the timing of nitrogen applications based on the phenology of the crop (during the growing season, nitrogen is taken up by the tree at a relatively even rate throughout fruit development, nothing needed after harvest, nothing needed during dormancy). This is referred to as nitrogen budgeting.

Let's first discuss the right rate. Nitrogen management plans require estimating the orchard nitrogen requirement based on yield estimates. It is suggested to determine this value by averaging the previous five years (while excluding very low yielding years). Nitrogen can be present in irrigation water, therefore, testing your water source is necessary for determining your application amount for the coming season. Nitrogen in irrigation water has been demonstrated to be taken up by trees, so we can incorporate this nitrogen value into our nitrogen budget, saving money and water resources. In rare cases, these resources have been found to contain as much as the equivalent of 100 to 200 lbs. of nitrogen in 3 acre-feet of water. More often some irrigation water sources are found to contain the equivalent of 20 to 40 lbs. of nitrogen in 3 acre-feet of water. Growers can send samples to a lab to determine the amount of nitrogen present in the water. This amount can then be calculated on an acre-feet basis and subtracted from the initial estimate of nitrogen needed which is based on the five-year average yield estimate. The resulting amount of nitrogen needed for the season is then divided into how many times you plan to apply nitrogen during the season. The number of times you choose to apply nitrogen should be partly determined based on the leaching capability of the soil (sandier soil is more likely to allow nitrogen to pass through it), and the form of nitrogen used (nitrate will leach more readily than ammonium). Furthermore, walnut trees take up nitrogen steadily through the growing season so applying smaller amounts more often is better for your crop. Unfortunately, even at our best attempts, not all the nitrogen applied and/or present is taken up by the plant. Research shows approximately 70% is taken up by the plant, so we also incorporate an efficiency factor of 0.70 into our budgeting estimates. Don't worry, we will circle back to this later.

Please see **Table 1** for ppm nitrate present in irrigation water and how that converts to lbs. of nitrogen applied per acre in volume of applied water per acre.

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Table 1. Amount of nitrogen applied in irrigation water as a function of nitrate-N (NO_3^-N), or nitrate (NO_3^-) concentration and the amount of irrigation water applied.

Nitrogen concentration in irrigation water		Pounds of nitrogen applied per acre in volume of applied water per acre	
ppm N as NO_3^--N	ppm NO_3^-	2 acre-feet	3 acre-feet
5	22.1	27	41
10	44.2	54	82
20	88.5	109	163
30	133	163	245

Note: Agricultural laboratories report results of water analysis as either ppm N (NO_3^-N) or ppm NO_3^-. Multiply ppm NO_3^-N in the water by 2.72 to calculate the pounds of nitrogen applied per acre foot of applied irrigation water. Multiply ppm of NO_3^- by 0.614 to obtain pounds of nitrogen.

Table extracted from Guide to Efficient Nitrogen Fertilizer Use in Walnut Orchards, UCANR publication #21623

So how much nitrogen is taken away from the field at harvest and how do we determine the right rate from that? Research shows that for every ton of nuts/hulls removed per acre, approximately 29 lbs. of nitrogen is removed, per acre. With an additional few pounds for limb and leaf growth, the CDFA assumes 40 lbs. of nitrogen is needed per one ton of walnuts removed, per acre (for current information please see their website: https://www.cdfa.ca.gov/is/ffldrs/frep/FertilizationGuidelines/).

We've covered quite a bit of ground here, let's run through an example. If my previous five-year yield average is three tons per acre from my orchard, I could assume I need to replenish this much nitrogen: 3 tons per acre multiplied by 40 lbs. nitrogen per ton equals 120 lbs. nitrogen per acre. Furthermore, if my water sample reflects approximately 40 lbs. of nitrogen per acre in my annual irrigation, I can remove 40 lbs. of nitrogen from that total, thus my application needed for the season becomes 80 lbs. of nitrogen per acre. Furthermore, I do not want to apply all that nitrogen at the same time because the trees need it throughout the fruit development process. Depending on my application method I could apply this amount of nitrogen across four to several applications until August, thereafter, walnut trees are no longer utilizing nitrogen for nut development. So, if I decide to apply four times during the season, my application rate would then become 20 lbs. of nitrogen per acre. Please see **Formula 1** for details:

Formula 1.

$$\frac{\left[\left(\frac{3\ tons\ of\ nuts\ per\ acre * 40\ lbs.of\ N\ per\ ton}{0.7\ efficiency\ factor}\right) - 40\ lbs.of\ N\ in\ irrigation\ water\right]}{4\ N\ applications}$$

$$= \mathbf{20\ lbs.of\ N\ per\ acre\ per\ application}$$

Right time: In general, trees can take up nitrogen when leaf out begins, but they don't need it until nut development begins to a greater extent. This is because early nitrogen needs are supplied by nitrogen remobilization in the tree. Therefore, applying nitrogen after harvest, during the winter, or even early spring, in the case of walnuts, is just a waste of money, resources, and can be an environmentally destructive action. That said, research has shown that walnuts take up nitrogen steadily during the fruit development period, therefore, "spoon-feeding" nitrogen gives you the best bang for your buck. Therefore, we suggest applying frequent small doses during the growing season. This will

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provide better nitrogen use efficiency. From the example above, **Formula 1**, applying 20 lbs. of nitrogen once a month from May to August is ok, but applying 10 lbs. of nitrogen every two weeks from May to August is better.

Right place: Depending on the application form, certain measures can be taken to reduce leaching even further. If fertigating, add the nitrogen during the last half or third portion of the irrigation set. This allows water to flush and move the nitrogen into the soil and rootzone. If fertigation occurs during the first four hours of a 24-hour set, much of the applied nitrogen will be carried too far into the soil depth, wasting money, and risking environmental detriment.

Knowing more about your soil and leaching capacity can help determine which forms of nitrogen you could use to reduce leaching, although all forms will convert to nitrate eventually so don't assume any form of nitrogen is "safer" than another. As a reminder, more frequent, smaller applications of nitrogen are more likely to keep the nitrogen in the rootzone where the roots can access it. One big nitrogen application in May and July reduces the available nitrogen for the crop in June and August when the crop still needs it for production (not to mention this practice increases leaching risk). Keeping nitrogen in the rootzone with more frequent applications at smaller application rates provides for a better crop in October (Ching!).

As we progress into the growing season (late June/July), we should start thinking about tissue samples. This helps determine how much nitrogen is needed based on the plant status and allows for rate adjustment in the following year. We collect samples in June and July because this is when leaf nitrogen content tends to stabilize. Collect 4 terminal leaflets per tree from spur leaves that are fully expanded at approximately 6 to 8 feet above the ground around the outside of the tree. To assess the entire orchard, make these collections from 29 randomly selected trees within the orchard. Submit the samples to a nutrient analysis laboratory. If leaf concentrations are below 2.3%, the trees are deficient and need additional nitrogen. If nitrogen leaf concentrations are between 2.3% and 2.7%, this orchard is adequate and needs no more nitrogen than previously assessed. If the concentrations are above 2.7%, this orchard is in excess of nitrogen, and savings can be taken advantage of by reducing or even eliminating nitrogen applications for a year or more depending on soil type (sandier soils are more prone to leaching). In other words, if your sampling numbers are above 2.7%, you can save money by not buying nitrogen when nitrogen is expensive and walnut prices are low. This is because of the stored nitrogen in the plant. If you go this route, be sure to follow your sampling next year to help determine the following year's application rates. This nitrogen savings is only good for about a year or two, and you don't want to short yourself in yield when the prices go back up. The current year's tissue samples will guide next year's nitrogen decisions and maybe save you some cash.

So, we've made it to August. By now we have a pretty good handle on our nitrogen budgeting. As a reminder, don't apply nitrogen after August, not only is this a waste of money and time since the tree is no longer using nitrogen for nut development, but this also makes trees more prone to freeze damage in the fall due to the unnecessary encouragement of new growth. September is best thought of as a slowdown month where we allow the trees to develop dormant buds and dormant tissues. Any nitrogen inputs during this time delay dormancy, furthering the risk of fall freeze damage. Take this moment to pat yourself on the back, farming is hard.

Now let's discuss the right type. Although we made it through the growing season, there is more to consider when it comes to nitrogen management in the orchard. For instance, certain forms of nitrogen and certain soils are more prone to nitrogen leaching. Ammonium is positively charged and held to clay soil particles, whereas nitrate is negatively charged and not held in place by clay soil particles. Sandier/siltier soils are at greater risk for nitrogen leaching and nitrate-based fertilizers are more prone to leaching. That said, ammonium will convert to nitrate at some point, so using only ammonium-based fertilizers does not put you in any "safe" zone, it just slows down the process a little bit. Additionally, since water moves nitrate through the soil profile, high rainfall and heavy irrigation are also situations more prone to leaching. Therefore, as stated previously, fertigation is recommended to be done at about halfway or one third of the way through an irrigation set as opposed to the beginning. This will keep your money spent on nitrogen in the root zone, and not below it.

Organic amendments such as manures, composts, blood meal, feather meal and fish waste do contain nitrogen, but

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the amount varies drastically based on the source and batch. Furthermore, some composts and manures contain potentially detrimental levels of other salts than what they may be worth for nitrogen content. Frequent chemical analyses of the compost sources are strongly encouraged before use. Compost and manures must be incorporated into the soil soon after application to avoid loss due to volatilization.

Cover crops can provide quite a bit of nitrogen depending on the current nitrogen content in the soil and species selection. Vetch, clover, and other legumes can provide as much as 150 lbs. of nitrogen per acre, but these species do not fix nitrogen when adequate levels of nitrogen are present for plant growth. If these cover crops are not fixing nitrogen, they are demanding it and in turn reduce available nitrogen for the trees. Thus, careful nitrogen management is necessary when growing cover crops for nitrogen production. To estimate the amount of nitrogen available in the cover crop, collect a small area, such as a square meter (3 feet by 3 feet) of mature cover crop and submit the sample to a laboratory for nitrogen analysis. After cutting, weigh the sample (fresh weight), place it in a plastic bag and immediately drop it off at the lab. Nitrogen budgeting assumes a 50% recovery if the cover crop is only mowed. Further information on cover crops in walnut orchards can be found in *Cover Crops for California Agriculture* (UC ANR publication 21471, 1989) and *Cover Cropping in Vineyards-A Grower's Handbook* (UC ANR Publication 3338, 1998).
Although we expect all forms of nitrogen to become nitrate (leachable) at some point, different forms of nitrogen have different levels of leaching risk and volatilization potential. Additionally, different formulations consist of different percentages of nitrogen. Please see **Table 2** for a quick digest of this information.

Fertilizer	Formulation	Nitrogen (%)	Equivalent acidity or basicity (lb. $CaCO_3$/100 lb. N)		Leaching Risk*	Volatilization potential
			Acid	Base		
ammonium nitrate	NH_4NO_3	33.5-34.0	62	--	M	L, M***
ammonium sulfate	$(NH_4)_2SO_4$	21.0	110	--	L	L, M***
calcium-ammonium nitrate solution	$Ca(NO_3)_2 \cdot NH_4NO_3$	17.0	9	--	M	L
calcium nitrate	$Ca(NO_3)_2$	15.5	--	20	H	L
urea	$CO(NH_2)_2$	45.0-46.0	71	--	L	M
UAN-32 solution** (urea-ammonium nitrate)	$NH_4NO_3 \cdot CO(NH_2)_2$	32	57	--	M	L

Table 2. Components of various nitrogen (N) fertilizers and their characteristics.

Notes: *L=Low, M=Medium, H=High. These terms are relative. All ammonium forms will leach after being converted to nitrate form. This takes place in 2 to 4 weeks in most soils Nitrate leaching can be severe on sandy soils and moderate on silt loams and clays.
**UAN is often inject through low volume irrigation.
***If not incorporated or banded below the soil surface, volatilization losses can be high on soils with a pH over 7.0.
Source: California Plant Health Association 2002, Cramer et. Al., 1986 and *Guide to Efficient Nitrogen Use in California Walnut Orchards* (UC ANR Publication 21623).

With rising prices related to nitrogen and increasing concerns related to nitrogen ground water contamination, I hope this article helps in deciphering your best nitrogen management practices. Young trees are different in their needs, if you have specific questions on young trees, please contact me or your local UCCE walnut advisor. For more information and guidance on nitrogen budgeting, please see the following resources:

https://www.cdfa.ca.gov/is/ffldrs/frep/FertilizationGuidelines/
https://www.growingthevalleypodcast.com/cures/2020/12/31/managing-nitrogen
https://anrcatalog.ucanr.edu/Details.aspx?itemNo=21623