NITROGEN FERTILIZATION

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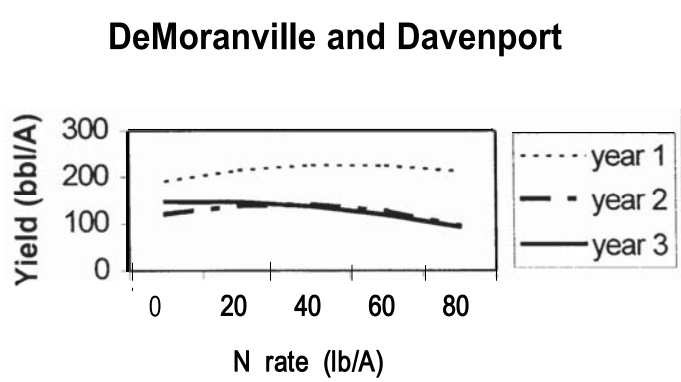
Nitrogen is the most important fertilizer element in cranberry production determining vegetative growth and productivity. Your choice of N rates and timing can make the difference between adequate growth and high yields and excessive growth with poor cropping. Choice of N form can be important in maximizing the efficiency of fertilizer use and in protecting environmental quality. These factors will be discussed and factors affecting N fertilizer use will be explored.

Nitrogen rates.

N rates have been studied in several growing areas and on various cultivars. A common result in these studies was the observation that no treatment effect is apparent in the first year of the study. That is, plots receiving no fertilizer had similar yield to any of the N rate plots. This is evidence for the theory that fertilizer applied this season has little effect on this crop but rather is important for next year. By the third year of applications, however, separation among treatments is significant and certain trends are apparent. Almost universally, plots that receive no N for three years have poor yield. Regarding yield for the various N rates, two patterns were seen. Either yield increased to a maximum level and then declined with further increase in applied N *or* yield increased with each increase in N up to the highest rate in the study. The first pattern was the most common. The second pattern was seen with 'Stevens' when the highest rate in the study was 60 lb/A (Hart et al., 1994). However, in a study with rates up to 80 lb/A, yield decline in 'Stevens' was seen at high rates (figure below).



While high rates of N were not associated with high yield, they were associated with high levels of N in the leaf tissue. This may explain why as N rate increases, vegetative growth increases at the expense of yield. High N rates were also associated with decline in fruit quality as shown in the tables on the next page.

Results over all locations after 3 years of treatment (Davenport, 1996).

N rate (lb/A)	Yield (bbl/A)	Field rot (%)	30D rot (%)	60D rot (%)
0	114	3.8	5.4	8.2
20	148	5.5	6.7	9.7
40	130	7.7	10.2	14.2

Stevens in BC after 2 years(Davenport, unpublished).

N rate (lb/A)	Yield (bbl)	% rot	TAcy	%N	%K
0	214	4.05	23.2	0.88	0.61
25	222	4.74	20.3	0.99	0.61
50	247	5.64	16	1.09	0.66
75	67	8.42	8	1.26	0.77

At high N rates, field and storage rot increased and TAcy declined. It was interesting to note that as tissue N with increasing N rate, tissue K also increased. Similar effects on tissue K as well as a decline in tissue Ca were reported by Davenport and Provost (1994). Decline in Ca may be related to poor fruit quality.

Optimum N rates from studies in North America can be summarized:

Location	**Cultivar**	**Investigator**	**Optimum N rate (lb/A)**
All	All	Davenport	20
WI	Stevens	Davenport	40
MA	Early Black	DeMoranville	30
BC	Stevens	Davenport	50
MA	Stevens	DeMor./Davenp.	40-60
OR	Crowley	Hart et al.	40
OR	Stevens	Hart et al.	60

Nitrogen timing.

Optimum timing for N applications to cranberry has been studied in Oregon (Hart et al., 1994) and across North America (Davenport, 1994). Oregon studies with ^{15}N showed that uptake was most efficient early in the season. If N was applied after fruit set, less was taken up and most of that was stored in the roots. While early applications were more likely to move into new vegetation and fruit, high rates early in the season were associated with excessive vegetative growth. As a result of this research, a moderate N rate split into 4-5 applications was recommended for Oregon, with early applications limited unless tissue tests from the previous season showed N deficiency.

Davenport separated timing results by growing region since results varied by location. The timing recommendations from her research are shown in the table below.

State	Cultivar	Bud break	Bloom	Fruit set	Bud set	Pre-harv.
MA	Early Bl.	X	X	X	X	
NJ	Early Bl.		X	X	X	
WA	McFarlin	X	X	X	X	
WI	Stevens	X	X	X	X	X

Timing recommendations for other cultivars could not be made due to conflicting outcomes over the duration of the study.

Nitrogen forms.

Most crop plants assimilate N as nitrate (NO_3). However once taken up, the plants must then convert NO_3 to the metabolically useful ammonium (NH_4) form using the enzyme nitrate reductase. Evidence suggests that cranberry preferentially uses the ammonium form of nitrogen over the nitrate form. This phenomenon was first reported from the University of Wisconsin (Greidanus et al., 1972). In that study, cranberries grown with NH_4 grew well and accumulated N in their shoot tissue, while those grown on NO_3 showed little response. Further, no nitrate reductase activity was found in the cranberry leaves. However, a later study (Dirr, 1974) demonstrated nitrate reductase activity in cranberry roots.

In solution culture cranberries grew best in the presence of NH_4 but also showed adequate growth with a combination of the two N forms (Rosen et al., 1990). This result was confirmed by Smith (1994) in field and greenhouse experiments.

Cranberries evolved on acid soils. It has been shown for other crops and confirmed for cranberry soils that N remains in the NH_4 form in acid soils due to inhibition of the bacteria that mediate the transformation to NO_3. Cranberries may have lost the nitrate reductase enzyme during evolution since it was not critical to survival in an environment where much of the N was in the NH_4 form. Since NO_3 leaches readily in sandy soils and the cranberry can thrive with just NH_4, it is good management practice to avoid applying this NO_3 to cranberry beds.

Nitrogen availability.

Native nitrogen is released from cranberry soils due to mineralization - biological breakdown of organic nitrogen into ammonium. Mineralization was studied by Davenport and DeMoranville (unpublished). The amount of N released by this process depends on two major factors: 1) amount of organic matter present, and 2) soil temperature.

As organic matter increases in cranberry soil, release of ammonium increases. Increasing ammonium release followed the series: sand (pH 4.5) < layered < organic. However, in highly decomposed muck soil, the ammonium was rapidly converted to the less useful nitrate. Interestingly, clay content in the soil had a negative relationship with mineralization. While cranberry soils are normally low in clay, clay content should be taken into account when selecting a site for a new planting and when selecting material for sanding.

Mineralization rates were similar at temperatures from 55°F to 70°F. The rate increased dramatically when soil temperature rose to 75°F. Accumulated mineralized N also became available at low soil temperatures (50°F) as the soil drained to normal seasonal moisture levels (removal of winter floods).

Mineralized nitrogen (ammonium) is converted to nitrate by specific soil bacteria. This is an *undesirable* reaction on a cranberry bog. Populations of nitrifying bacteria and thus, the rate of this nitrification reaction, were influenced by two major factors: 1) soil type, and 2) soil pH.

Nitrification rate (nitrate release) was extremely high in muck soils. Nitrate release decreased by soil type as follows: muck > peat > layered > sand (average bog pH). Nitrification was lower in normal to acid cranberry sands (pH 4.5 or 3.0) than in high (6.5) pH sands. This confirms the results of Roper and Krueger.

Monitoring cranberry nitrogen status.

DeMoranville and Davenport surveyed N use, yield, plant growth, nitrogen content in the tissue, and leaf greenness to determine the least laborious and costly way to evaluate cranberry plant nitrogen nutrient status during the growing season. Testing for nitrogen content in the plants by chemical analysis is costly and the results are generally not available for days or weeks. In addition, nitrogen in the tissue is stable and susceptible to interpretation only late in the growing season. Many cranberry growers rely on a visual examination of upright length and color (greenness - indicative of the amount of chlorophyll present) as the basis of fertilizer decisions. Upright length can also be an objective criterion for decision-making if standardized. However, not all people perceive color in the same way, making color evaluation problematic. SPAD chlorophyll meters evaluated chlorophyll based on light transmittance, thus making the process objective.

Length of new growth in June was a good indicator of cranberry plant nutrient status. Stunted uprights are likely to be poor in nitrogen. SPAD readings could be used to estimate nitrogen status of cranberry plants throughout the summer. Readings could be made on old or new leaves during June and July but should be made on new leaves only in August.

Recommendations for cranberry growers.

Temperature:

- Applications of N should not be necessary early in the spring. From flood removal until soil temperatures exceed 55°F, adequate N should be available through biological processes.
- At soil temperatures from 55°F to 70°F, release of N from soil organic matter is only moderate. Fertilizer applications should be beneficial.
- During spells of hot weather, when soil temperatures exceed 70°F and air temperatures exceed 85°F, soil N release increases and crop development slows, so planned fertilizer N applications should be reduced, delayed, or eliminated.

Soil type and pH:

- Sandy bogs have less potential for natural N release. As organic matter in the soil increases, less fertilizer N should be used.
- As soil pH rises, biological conversion of cranberry-useable ammonium to less-desirable nitrate increases. Soil pH on cranberry bogs with soil organic matter content of 0-5% should be between pH 4.0 and 5.0, while soils with organic matter content greater than 5% should have a pH of 4.5 or less.

Nitrogen rates:

- Small-fruited cultivars such as Early Black and Howes require the addition of 20-30 lbs N per acre per season.
- Large-fruited cultivars such as Stevens may require more N, up to 60 lbs N per acre per season. Rates should be adjusted according to soil type and temperature. Rates

higher than 40 lbs/A should be used with caution as they may lead to vine overgrowth and reduction in fruit quality.

Monitoring vine nutrient status during the season:

- Length of new growth can be used to indicate nutrient status of cranberry plants up until early bloom. From hook stage through early bloom, ideal lengths are as follows:
  Early Black - 50 to 60 mm Howes - 45 to 55 mm
  Stevens - 60 to 70 mm Ben Lear - 55 to 65 mm
- SPAD Chlorophyll Meters may also be used to monitor leaf nitrogen status. Old or new leaves may be monitored in June or July, while only new leaves should be monitored in August. Meter reading vary by cultivar and year. Standard values are shown below.

	Roughneck to Hook		Bloom to Set		Pre-Harvest
	old	new	old	new	new
Early Black	40	25	35	35	35
Howes	45	30	40	40	40
Stevens	40	30	35	35	40
Ben Lear	40	25	35	35	40

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