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2017 Chart Book: Nutrition Management

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NUTRITION MANAGEMENT FOR PRODUCING BOGS 2017

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In late 2015, the Commonwealth of Massachusetts enacted regulations regarding nutrient management: 330 CMR 31.00 Plant Nutrient Application Requirements for Agricultural Land and Land Not Used for Agricultural Purposes. Those regulations underwent review and additional public comment in 2016 and the revised version will be released sometime in early 2017. Based on the previous version and the draft released for comments, record keeping of applications and soil and tissue test results will continue to be required. In addition, there is every indication that nutrient management plans for agricultural lands, including cranberry, will need to be based on plant needs (as determined by testing and research) and UMass Extension recommendations. This section of the Chart Book encompasses UMass Extension recommendations for cranberry nutrient management.

Last year, a section was added to the Cranberry Station website to provide information on how to develop a nutrient management plan that is based on Chart Book recommendations. To view these resources, follow the 'Nutrient Management for Cranberries' Quick Link on our home page (http://ag.umass.edu/cranberry). Resources include a plan template and Excel files with sample record keeping formats and nutrient calculators (determine fertilizer rates based on how much nutrient you want to apply). Growers may also choose to use the BOGS system, available from the Cape Cod Cranberry Growers Association. It is an online tool designed to plan and keep records that meet regulatory requirements for pesticide and nutrient applications.

Nutrient management decisions should be based on the needs of the plant. The plant is primarily made up of carbon compounds (the products of photosynthesis) and water. Mineral elements, the materials provided in fertilizer and the soil, are present in much smaller quantity, making up only about 10% of the plants' *dry* mass. The essential mineral elements are required for the plant to complete its growth and development and for the production of fruit. All three (carbohydrates, water and mineral nutrients) are needed. For maximum crop production, cranberry bed management must optimize photosynthesis by assuring adequate leaf area, provide adequate but not excess water, and provide the required mineral elements in the right amounts, in the right form and at the right time. Management must be flexible, adjusted for changing weather and observations of the plants. It should also be implemented in an environmentally sound way.

Cranberry is a perennial plant. As such, many of the mineral elements and carbon compounds are stored over the the winter in stems and roots, then remobilized to support new growth in the spring. In addition, decaying biomass (fallen leaves, decaying roots) in the soil, through the process of mineralization, can provide minerals, especially Nitrogen (N) and Phosphorus (P), back to the growing plants. In a mature cranberry bed, these processes account for about half of the plant's need for mineral nutrition. The rest is supplied in fertilizers. The plants in new sand-based cranberry plantings depend primarily on fertilizers for their nutrients.

Cranberry is a plant that evolved in acidic, sandy, nutrient-poor soils. Therefore, its requirements for nutrients are less than those for many other crops. Those requirements must be met to assure optimum growth and to achieve the yield potential possible for each cultivar. It should be remembered, however, that insufficient nutrition is only one potential cause of reduced yield. The plant must be healthy, with an adequate root system in order for it to take up the nutrients it needs. Overly saturated or dry soil or soil outside the pH range optimal for cranberries (4.0 to 5.5) can limit yield. Uniform irrigation is essential to maintain moist, *but not saturated* soil. Pest pressure, frost, or shading are other potential limiting factors. Additional fertilizer applications will not compensate for any of these problems.

The recommendations in the Chart Book are developed from a knowledge of how much mineral content is in a healthy productive plant. The recommendations focus largely on N, Potassium (K), and P. Added nutrients are required to replace those removed in the harvested crop and associated leaf trash. N is the element that is removed in the greatest quantity and that is found in the highest concentration of all of the nutrient elements when plant tissue is analyzed. Decades of research trials support the need for added N in cranberry production. Potassium is the mineral nutrient found in the highest concentration in cranberry fruit and as a result, K removal in crop harvest is similar to that of N. P removal in crop harvest is much less than that of N and K but research trials support the need for a modest annual addition of P to producing cranberry beds. The remaining mineral elements are seldom deficient in plant tissue tests and/or are found in substantial quantity in the bog soil. Therefore, their application is primarily recommended when a deficiency exists and not on a routine basis.

NITROGEN

Nitrogen rates.
For sustained yield, cranberries require annual additions of N fertilizer. The N fertilizer is not primarily used to produce fruit in the current year, rather it supports the building of the new growth that is the photosynthesis factory to support future production. In our research, current season N applications correlated to current season yield only 10-15% of the time, while in almost all cases applied N correlated significantly with production in the following two years.

With the implementation of newer cultivars, the base rate recommendations for N have been revised and split out by cultivar groups. These rates are based on analysis of the concentration of N in fruit tissue and in the biomass removed in harvest operations multiplied by the amount of biomass of fruit and leaves produced and then removed in harvest and detrashing operations. To replace the removed N, we need to apply fertilizer. The amount of N removed is then multiplied by a correction factor of 1.4 to account for the less than 100% efficiency of fertilizer uptake. The base rates calculated are then adjusted up or down based on seasonal conditions, observed plant growth, previous summer tissue tests, and historic bog responses.

The N *concentration* in fruit and new growth is similar among the cultivars but the amount of biomass (crop load) and leaf area produced and then lost in harvest operations differs among the groups. The tissue biomass calculations for Early Black are well researched and established. Each 100 bbl of fruit has 5.1 lb of N. Since N *concentration* in all cultivars is similar, as crop increases, for all of them, we can just scale up from the 5.1 lb/100 bbl to the numbers of bbl/A produced or expected. Early Black detrashing during harvest removes 13.4 lb N per acre in plant biomass above what is removed in the fruit. That amount is likely similar in Howes. But as we look at larger fruited cultivars, we observe that the plants and particularly the leaves are larger than those of the natives. For Ben Lear and first generation hybrids such as Stevens and Grygleski, we multiply the 13.4 lb N for plant biomass in Early Black by 1.5; for the newer Rutgers and University of Wisconsin hybrids, we multiply by 2. The base range reflects varying crop loads: up to 600 bbl/A for the newest hybrids and up to 300 bbl/A for the others. This does not mean that higher yields necessarily would require more N. In fact, for all but the newest cultivars, adding more N than required can result in yield *decline.*

Recommended base Nitrogen rates.

Cultivar group	Base N rate lb/A	Other considerations
Natives: Early Black and Howes	25-40	Reduce to 25-30 for crops less than 200 bbl/A
Older hybrids and large fruit: Ben Lear, Stevens, Grygleski, Pilgrim	35-50	Reduce to 35-40 for crops less than 200 bbl/A
Rutgers and University of Wisconsin cultivars: Crimson Queen, Demoranville, Mullica Queen, HyRed	50-80	Reduce to 50-60 for crops less than 300 bbl/A

With N fertilization, the aim is to provide enough N to produce a stand of uprights with optimal density and length that will support an optimal crop of good quality fruit. When the upright stand is too dense or too long, shading occurs, pollinators may be impeded, and conditions are perfect for fungal rot infections. A thin, stunted stand will not support a large crop since there will not be adequate leaf area, leading to a deficit in photosynthesis and a shortage of carbohydrates for making fruit.

Within the recommended rate ranges, previous observed outcomes, tissue test results (see page 68), and observations of the plants color and growth should be used to choose your rate. Some potential yearly adjustments to the recommendation based on growth and tissue test N:

- If vines are stunted or yellowed and tissue N is low - use more
- If vines are stunted or yellowed and tissue N is high - look for other limiting factors
- If vine growth is adequate (see below) and tissue test is in the normal range - continue with the chosen rate
- If vines are rank or leggy and tissue N is low - use less or change timing, vegetative growth is being favored over production
- If vines are rank or leggy and tissue N is high or adequate - use less
- If yield potential is limited by pest damage or frost - use less

Vine appearance.
Decisions regarding nitrogen (N) rate for a cranberry bog should be based in part on the length and density of uprights. The table below shows adequate stand density and upright length for four common cultivars assessed at hook stage (mid-June). Uprights generally should not be longer than 4 inches. An adequate stand of both flowering and vegetative uprights is important, as about 80% of this year's vegetative uprights will flower next year. Even and adequate vine cover is the key to good production: 200 flowering uprights/sq. ft., each producing an average of 1 berry, will give a crop of 200-300 bbl/A. To sample upright density: count all uprights in a circle 4 inches in diameter. Total upright density (approximate) for 'Early Black' should be 50/sample; density for 'Howes', 'Ben Lear', or 'Stevens' should be 35/sample.

Cultivar	Early Black	Howes	Ben Lear	Stevens
Upright density (per sq ft)	600	400	400	400
Minimum Upright total length (in)	>2.25	>2.25	>2.5	>2.5

Density of total uprights per sq ft, >40% should be flowering

Upright length above the fruit on a flowering upright should be 1.5 to 2 in.

Observations at hook stage (mid June).

Leaf greenness is related to the pigment chlorophyll that is involved in carbohydrate production through photosynthesis. Along with adequate growth (length) of the uprights, chlorophyll content is an important determinant of yield. Overall intensity and shade of leaf greenness (chlorophyll) is related to adequate N nutrition. With experience, growers can assess intensity of greenness by visual observation.

A bog with thin vine cover, pale leaves, or stunted vines may not be getting enough nitrogen. Remember also that vines that are too long and too dense are related to diversion of nutritional assets to vegetation (small berries), poor fruit color, increased fruit rot, and inability of bees to reach pollination sites.

Nitrogen timing.
Plan nitrogen fertilizer applications based on soil type and soil temperature. On sandy soils (<1% organic matter), nitrogen fertilizer may be applied throughout the season. On more organic cranberry soils and older beds, applications should be based on soil temperatures. For typical cranberry bogs (1-4% organic matter), 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 (mineralization). Nitrogen is slowly released from the soil early in the spring when the cranberry plants are dormant. This leads to a 'flush' of ammonium availability when the plants are breaking dormancy. As soil temperatures increase from 55°F to 70°F, release of N through mineralization is only moderate. Fertilizer applications should be beneficial. This corresponds to the period from roughneck stage through bloom. 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 especially on beds with high organic matter in the soil.

It is best to time N applications by the growth stage of the plants. Cranberries primarily use N during three stages; early season leaf production, fruit set, and bud set. When N is applied pre-bloom, it is rapidly taken into the plant and moved to the new leafy growth. While such applications can assure adequate upright length, adding too much N at this stage can lead to excessive growth. Fruit production is a very high demand period that extends from earliest set to about 3 weeks after the final fruit are set. Bud set is occurring during fruit set, so set applications also support this function.

Since the fruit set window is such a high N demand period, it is not unusual to see some loss of green color in the leaves above the fruit as the fruit are drawing N from both those leaves and the soil. Minor yellowing is normal, severe overall yellowing can indicate inadequate N fertilization. This should not be confused with Yellow Vine (see page 65), a patterned yellowing related to root stress and not improved by the addition of N.

Stage/formulation	% of total N for the season
Slow or controlled release	
Pre-roughneck (mid-May)	50-100%*
Fast-acting, soluble sources including soil-applied liquids	
All but the newest cultivars	
Roughneck to hook	up to 20%
75% in bloom (early set)	50-60%
75% out of bloom (late set)	30-40%
Fast-acting, soluble sources including soil-applied liquids	
Rutgers and U-WI cultivars	
Roughneck to hook	up to 20%
First fruit set	30-35%
7 days later	30-35%
7 days later	20-30%

*if less than 100%, apply remainder at set using fast-acting sources

Nitrogen sources.

Most cranberry growers in MA apply N in NPK fertilizer (aka 'complete fertilizers') primarily to reduce application costs when N, P, and K are all needed. In such fertilizers, the first number on the bag or jug is the percent N in the material. Since P requirements are substantially less than those for N and K, materials with high middle numbers (phosphate) should be avoided. This is especially true of materials with the middle number higher than the first. Note that when using liquid fertilizers, the percent on the jug is based on weight, so to calculate pounds per acre applied, one must correct for the liquid density (weight per gallon x gallons per acre x percent).

The best available evidence indicates that cranberries respond poorly to nitrate N especially in the absence of ammonium N; the AMMONIUM FORM is recommended. Monoammonium phosphate is an excellent source but can provide excess P (see the Phosphorus section below), ammonium sulfate is also an excellent source. Light rates of urea, a material that breaks down to ammonium, are suitable to correct N deficiencies quickly (when the urea is dissolved and used as a foliar feed). Use blended fertilizers with ammonium N and excellent uniformity of particle size or ammoniated materials. Non-uniform blends may sort during application, giving poor results. Liquid formulations designed to be applied to the soil and taken up through the roots can be substituted for granular materials.

FISH HYDROLYSATE FERTILIZER is available commercially, is useful for organic production, and has been shown to be a suitable substitute for granular, inorganic NPK. It may provide benefits in soil conditioning and reducing movement of nutrients out of the root zone. Fish fertilizer is a good choice where the bog holds water poorly and/or has a history of needing larger than normal fertilizer rates. The nitrogen in fish fertilizer is tied up in organic compounds. As these degrade in the soil, nitrogen is slowly released for use by the cranberry plants. Leaching losses of nitrogen are reduced. Therefore, 20% lower nitrogen rates provided as fish fertilizer should give the same result as a higher nitrogen rate provided in granular, inorganic fertilizer. This has been demonstrated on commercial bogs. Fish is especially useful in the spring and can be incorporated into a program that includes other inorganic fertilizers if organic production methods are not required.

PHOSPHORUS

PHOSPHORUS (P) RATES OF 10 LB/A (20 LB/A P_2O_5) OR LESS ARE STRONGLY RECOMMENDED UNLESS A DEFICIENCY IS DOCUMENTED.

Phosphorus is important for plant metabolism; it plays a key role in energy transfers, in transporting the sugars produced in photosynthesis, and is part of the DNA molecule. If P is deficient, growth and yield can be impacted. However, P does build up in the upper soil layers and some of that is available to the plants. This stratification often confounds P soil test results, making them difficult to interpret. Therefore, application recommendations are based on crop use and tissue testing. In addition, of the three main nutrients, P is required in the smallest amount (compared to N and K) with crop and harvest trash removal only accounting for about 5 lb/A in a 250 bbl/A crop.

Phosphorus rates.

IMPORTANT CONSIDERATIONS REGARDING P USE AND USE REDUCTION:

Research in Massachusetts and Wisconsin has shown that cranberries require additions of phosphorus fertilizer for sustained productivity. However, there is no evidence in *any* research plot work or commercial bed observations that more than 20 lb/A actual P is required for productive cranberries. In some studies on high P sand soils, there was no response to P fertilizer on beds with adequate tissue P. In other studies, on native cultivars, the greatest yields were on plots receiving 10-15 lb/A P, with no improvement at higher rates. In our most recent MA plot work, rates well below 10 lb/A gave the best yields if tissue P was in the sufficient range, while in deficient beds, 20 lb/A gave the best yield.

At several commercial sites, growers applying an average of 10 or less lb/A/yr P over a period of years have seen either no change or an *improvement* in their crops. Very little P is removed from the bog in the harvested crop; a yield of 250 bbl/A contains approximately 2 lb P and 500 lb of vine prunings contains about 1/2 lb P. Based on these data and observations, the P rate recommendations in this Chart Book were developed. The only exception to these recommendations are new beds with fresh sand planting medium (the recommendation for those is to use up to 20 lb/A at planting and no more than *a total* of 30 lb/A for the first season on new or renovated beds).

P can be an environmental pollutant. Adverse environmental impacts are reduced by using moderate P rates (no more than 20 lb/A per season) and by careful attention to harvest flood management. When bogs are flooded, especially when soil and water are warm, P from the soil can move into the flood water. The mechanism for this movement is under investigation. Possible explanations have been suggested: 1) dissolved P in the soil water moves into the flood, 2) P previously bound to iron in the soil is released as oxygen is depleted during flooding, and 3) loosely bound P forms in the soil are released. It is likely that the explanation will be a combination of all three. When the flood is released, the dissolved P then leaves the bog system.

To minimize P release in harvest floods: 1) Hold harvest floods for 2-4 days to allow settling of P-containing particles, then release gradually (to avoid flushing particles) so that discharge is completed within 10 days. Research has shown that holding floods beyond 10-12 days in the fall can result in oxygen depletion and release of P from iron in the soil. 2) Use no more than 20 lb/A P in fertilizer -- laboratory research showed that with higher P use, P movement into the flood begins immediately upon flooding and then accelerates as oxygen depletes. With low to moderate P use, P release into water is minimized.

Recommended Phosphorus rates.

Production system	Recommended P rate lb/A	as P_2O_5 lb/A	Notes
New plantings	up to 30	up to 68	Initial year only
Established beds, tissue test >0.16%	no more than 10	no more than 23	
Established beds, tissue test 0.11-0.15% and stable	no more than 15	no more than 34	Trying a lower rate (e.g. 10 lb/A) is encouraged
Established beds, tissue test <0.12% and trending down	up to 20	up to 45	15 lb/A P with testing should suffice
Established beds, tissue test <0.10%	20	45	

Based on production research, 10-15 lb/A P is sufficient to maintain productivity if tissue test P is in the sufficient range (0.1-0.2%). In fact, in plots and demonstration sites, production and fruit quality were maintained with an average of 10 lb/A and no significant relationship between P rate and yield was observed. As P fertilizer use was reduced, P output from the bog (in flood water) also decreased. Based on these studies, growers have reduced P applications well **below** the previously recommended maximum of 20 lb/A (5-year rolling average of ~10 lb/A) with no reduction in crop. When implementing a reduced P rate, it is important to collect August tissue tests and follow these recommendations: If P is <0.10% - increase the P rate and retest next season; if P is 0.10-0.11% - maintain the P rate and retest next season; if P is 0.12-0.15% - maintain the reduced P rate and retest in 2-3 years; if P is 0.16% or more - further P reduction should be considered.

Phosphorus timing and sources.
Phosphorus ties up in the soil quickly, binding to iron and aluminum. Therefore, P should only be applied when the plants are actively growing. Most growers apply P with N in NPK fertilizers; see N timing section.

When choosing fertilizers, remember that research indicates there is **no horticultural benefit** to high P rates (in excess of 20 lb/A actual P per season) and that high P applications can be associated with degradation in water quality. If tissue P is in the sufficient range, we do not recommend fertilizers with high P (middle bag number). In fact, excellent results have been seen in recent years with 1:1 or near 2:1 N:P ratios (for example, 18-8-18). **It is highly recommended that growers use reduced P ratio fertilizer on their bogs, especially if high N applications are planned.**

Phosphorus is generally added with nitrogen and potassium (NPK) or as super phosphate (0-25-0) or triple super phosphate (0-45-0). Research indicates that foliar P or soil-applied liquid fertilizer that contains P, bone meal, or rock phosphate can supply the P needs of cranberry bogs as well. The second number on the bag of NPK fertilizer is *phosphate* - P_2O_5.

To determine pounds of P in 100 pounds of fertilizer, multiply 0.44 by the second number on the fertilizer label.

Use no more than 20 lb/A actual P (~45 lb/A P_2O_5) per season except on new beds. See calculations on the last page of the Nutrition section.

POTASSIUM

The amount of K in cranberry leaves is second only to nitrogen among the mineral nutrients and K is the element in the greatest abundance in the fruit. Potassium is important in the movement of sugars in the plant, in maintaining plant hydration, and in many enzyme reactions in the plant. Cranberry sand soils are naturally low in K, leading an annual requirement for K additions.

Potassium rates.
K is often added with N in NPK fertilizers and is the third number on the bag. Fertilizer convention is such that the third number is actually percent potassium oxide (K_2O), so to calculate the actual K, that number is multiplied by 0.83. When tissue and soil tests are in the sufficient range, the K requirement is roughly similar to that for N, so choosing an NPK with similar first and third numbers works well.

Recommended Potassium rates.

	Recommended K rate lb/A	**Other considerations**
Soil and tissue tests normal	up to 100	Look for NPK with similar first and third numbers
Soil and tissue tests low	60-100	Consider a supplement like SulPoMag or KMag at 100-150 lb/A or a soil-applied liquid K supplement
Tissue test high	0-60	Use no supplements

Potassium timing and sources.
Supplemental K may be applied as soon as the soil warms in the spring, generally in early May. Otherwise, K is generally added with nitrogen and phosphorus (NPK).

Supplemental K is often added with magnesium (SulPoMag or similar product), but may be applied as a foliar spray (of little value in research trials) or as potassium sulfate (0-0-50). Muriate of potash (KCl, potassium chloride, 0-0-60) may be less desirable due to the adverse effects of chloride on cranberry vines when used at high rates over years. However, modest rates appear to have no adverse impact. While foliar applied K seems to have little utility in cranberry production, soil-applied liquid products containing K have been used with good results.

OTHER ELEMENTS

Calcium and Magnesium.
The other major elements, Calcium (Ca) and Magnesium (Mg) are seldom lacking in cranberries. However, Mg is often added with K in SulPoMag or KMag. On bogs with Yellow Vine (see below), Magnesium Sulfate (Epsom salts) may alleviate symptoms. Diagnosed deficiencies (using tissue tests) of Mg or Ca may be treated with 30 lb/A of the deficient element in granular form applied in the spring or with liquid supplements pre-bloom.

Soil balance of K, Mg, and Ca is important. Excessive use of any one can induce deficiency of the others. This is especially a risk with large soil applications of Ca. Lime can have adverse effects by changing soil pH and is not recommended for use in cranberry production. Products that supply Ca may improve fruit quality or firmness. Examples of Ca supplements suitable for cranberry include those that are gypsum based (gypsum and some formulations of Solu-Cal) and liquid supplements such as Full Measure CAL 30™ (this material increased Ca concentration in cranberry fruit in research trials).

Yellow vine (YV) manifests as an apparent nutrient deficiency. Beginning with older leaves, yellowing presents along leaf margins and between the veins on the leaf, leaving green only along the veins. Tissue tests of such leaves often show higher than standard potassium and low-normal magnesium. However, extensive investigation has shown that the nutrient imbalance is *secondary* to the primary problem – root insufficiency due to too much or too little moisture. Cranberry bogs with patches of YV were found to have soil water content (in the YV areas) that was either much higher or much lower than that in the surrounding green areas. Additionally, in greenhouse experiments, plants subjected to very shallow or very deep water table conditions developed YV. The consistent finding in the field has been that the rooting depth in YV areas is shallower than that in unaffected areas. In most cases, YV appears in areas that were too wet early in the season leading to poor rooting depth. Rooting depth can be improved by keeping the bed well drained early in the season. When the water table is closer than about 6 inches below the surface, root development and root function is impaired. Examine your drainage and irrigation practices if you see YV on your bog. Another symptom of poor drainage is high manganese (Mn) in the tissue test. YV usually appears as temperature and water stress increase during mid-summer and may be more severe if Casoron has been used since this herbicide can affect rooting and root function.

Minor elements.

- Minor element deficiencies are rare in cranberries due to low requirements and high availability in acid soils. Deficiencies may be brought on by soil mineral imbalances or stress conditions (drought, waterlogging).
- When deficiencies are suspected (visual symptoms), confirm with tissue testing. Once confirmed, deficiencies are best corrected with foliar sprays. Such sprays are applied between bud break and hook stage.
- CALCIUM-BORON (5% Ca, 0.5% B, no other minor elements) sprays were the only minor element supplements to give increased crops in our research on non-deficient bogs. Response was greatest on bogs yielding at or below 150 bbl/A. We found that 2 applications of 2 qt/A improved fruit set.

  TIMING: 10% bloom, mid-bloom. The second application seems most effective. Application by sprayer is more effective than sprinkler application. This is a foliar feed - apply accordingly; do not wash off the leaves.

  CAUTIONS : 1. Manganese-containing fertilizers or fungicides (Mancozeb group) may cancel any beneficial effect of CaB if applied with or around the same time as CaB.
  2. DO NOT use when leaf analysis is above 75 ppm B.
  3. If B levels are elevated, but below 75 ppm, eliminate the FIRST application.

APPLYING FERTILIZER TO CRANBERRY BOGS

- SPRINKLER SYSTEMS may be used to apply liquids, flowables, and foliar feeds. Make sure not to mix incompatible materials (jar test first). When using sprinkler systems to apply fertilizer - make sure that coverage is ADEQUATE AND UNIFORM. EVERY EFFORT SHOULD BE MADE TO PRESERVE WATER QUALITY - avoid application of fertilizer to water in ditches and canals.
- Foliar feeds should not be washed off the leaves. Liquid fertilizers should be washed onto the soil. Be sure that you know which you are applying. Liquid products that have recently been integrated into cranberry management in Massachusetts are primarily designed to be soil-applied and watered in.
- FISH FERTILIZER is a liquid fertilizer. It should be washed in.
- Make sure ground application equipment is properly calibrated.

SOIL pH

The optimal pH for cranberry soil is between 4.0 and 5.5. Use of sulfate containing fertilizers (SulPoMag, ammonium sulfate) does **not** affect soil pH. However, acid is released into the soil as the plants take up ammonium N. Otherwise, to substantially lower soil pH, elemental sulfur (S) application is used. Soil pH may influence the types of weeds that invade a bog. See the Weed Management section for information on the use of sulfur for weed suppression. Prior to making S applications, seek advice from Extension specialists or consultants. Apply no more than 500 lb/A/season in one or two applications. **Apply elemental S only to well drained soils and test soil pH prior to application.**

Use this table (courtesy of the Wisconsin Cranberry Crop Management Newsletter) to calculate the amount of S needed to lower soil pH based on desired amount of change and soil organic matter content from the soil test. This is a SLOW process depending on bacterial activity in the soil - pH change will occur over a period of months. Change will be fastest when soil is warm.

Desired pH change	Soil organic matter content (%)					
	0.5-2.0	2-4	4-6	6-8	8-10	>10
	----------------- Amount of sulfur needed (lb/A) ------------------					
0.25 units	250	750	1200	1700	2300	2800
0.5 units	500	1500	2500	3500	4600	5500
1 unit	1000	3000	5000	7000	9200	11000

SOIL AND TISSUE TESTS

Soil and tissue tests are tools that a cranberry grower can use for several purposes. These include:
(1) diagnosing deficiencies of mineral elements; (2) monitoring soil pH; and (3) aiding in the decision making process for choosing fertilizer (tissue tests). Soil and tissue tests are important for these reasons. However, there are no 'cookbook' type formulas for fertilizing a cranberry bog based on the test results. There are several reasons why such an approach will not work for cranberry production: (1) standard soil tests poorly predict availability of nutrients and poorly correlate with yield in cranberry; (2) as a perennial plant, cranberries store nutrients from the previous season(s) making it impossible to base fertilizer choices only on soil content and yield potential; (3) there is virtually no variability in soil test N values from bog to bog; (4) tissue test N concentration may vary depending on length of upright (N concentration in the tissue does not always correlate well with added N); (5) nutrient availability changes with soil pH and soil pH is not uniform from bog to bog; and (6) common soil test methods for P do not give results that correlate well with cranberry yields due to very acid soils in cranberry production – standard P tests are of no predictive value if soil iron is above 200 ppm.

With these warnings in mind, tissue and soil analyses can be beneficial as a long-term record of changes in your bog. Soil and tissue tests are particularly useful when compared to one another - a soil test alone is virtually useless in determining a fertilizer recommendation for cranberry. Use periodic soil testing to monitor any change in soil pH; we recommend testing soil every 3-5 years for this purpose.

Tissue tests are more useful for setting target fertilizer ranges. Regular tissue testing meets the mandate for testing in the Massachusetts Nutrient Management Regulations since this is the UMass recommended testing for cranberry. We recommend tissue sampling every 2-4 years (but see also P use and P reduction section above for protocols when adjusting P rates). Keep the results and use them in conjunction with your records of your bog management and performance (growth and cropping) to aid in making fertilizer decisions. For further information regarding tissue testing, refer to "Cranberry tissue testing for producing beds in North America" fact sheet (available at http://scholarworks.umass.edu/cranberry_factsheets/6/).

When and how to test

The results you receive from a soil or a tissue test are only as good as the sample you supply to the analytical lab. It is important to remember that the sample that you submit for testing for nutritional elements is not the same as the sample you would collect and submit for other purposes (e.g., the diagnosis of a disease). Soil can be collected into 1 qt zipper plastic bags (air dry the soil before sealing the bag); tissue should be collected into paper bags. Some analytical labs supply collection bags. Remember, a properly collected and handled sample of soil or tissue is essential to an accurate analysis. Collect one composite sample for each management unit as instructed below. A management unit may vary in size but will generally be a single variety that is treated uniformly, often under one sprinkler system.

Tissue samples**:** Samples for cranberry tissue analysis should NEVER contain roots, soil, runners, fruit, or trailing woody stems. In general all of these contaminants contain less nutrients than the upright tips. Including them will give a falsely low analysis. Tissue samples are best collected from **mid-August to mid-September**. Samples collected at that time should include **upright tips only** (do not strip off the leaves).

Collect no more than the **top 2 inches** of new growth (mix flowering and vegetative uprights). As you walk a transect across the bog, collect enough material to make about 1 cup (at least 50 upright tips). You may collect directly into marked bags as samples should not be washed. Collect samples when the plants are not wet. Do not mail samples in plastic bags. Moldy samples give poor results. **Always** request nitrogen determination. This increases the cost, but nitrogen levels in the tissue test are an important indicator of plant status and the success of fertilizer programs.

Sampling other than in August-September: Tissue samples may be collected at other times of the year if absolutely necessary. However, nutrient levels change more rapidly outside of the recommended time and make interpretation of the results more difficult. If sampling in the spring, samples should be collected in June and consist of **new upright tissue** only. Do not include last season's leaves - they will lead to a falsely low result. *In June samples, nitrogen should be 1.2-1.5%, phosphorus 0.15-0.19%, and potassium 0.7-0.9%.* Interpretations for other elements are challenging in June samples.

Tissue samples should also be collected when deficiency is suspected or diagnosis of a specific problem is needed. For problem diagnosis, collect 2 separate samples - one from the problem area, and one from nearby 'normal' vines.

Samples collected after mid-September give lower analysis values than those collected earlier. This is especially true for nitrogen (it is transported out of upright tips and stored in older tissue as dormancy approaches). Also, late in the season the uprights become more woody so that more of a tip sample is stem tissue. Stems have less nutrient content than do leaves so the overall result is a lower analytical value.

TISSUE STANDARDS (August 10 to September 15 collection)

These standards were developed in conjunction with researchers throughout the cranberry growing areas of the United States.

Major Element	Concentration in dried tissue (percent)	Minor Element	Concentration in dried tissue (ppm)
Nitrogen (N)	0.90-1.10 *	Boron (B)	15-60
Phosphorus (P)	0.10-0.20	Zinc (Zn)	15-30
Potassium (K)	0.40-0.75	Copper (Cu)	4-10
Calcium (Ca)	0.30-0.80	Iron (Fe)	problem if less than 20
Magnesium (Mg)	0.15-0.25	Manganese (Mn)	problem if less than 10, if greater than 500-600 check bog drainage
Sulfur (S)	0.08-0.25		

* = As high as 1.3 % has been seen for Stevens, but monitor growth closely if N is > 1.1 %.

***Soil samples*:** Samples for analysis of soil nutrients should NOT contain stems, leaves, or the surface duff layer (trash). These are all organic contaminants and will bias the organic matter (OM) determination for the sample. The inclusion of some roots is generally unavoidable. Use a soil probe with a 1-2 inch diameter to collect cores of 4-6 inch depth. Minimum requirements: 4 cores for up to 1 acre; and 1 core for each additional 2 acres up to a total of 10 cores/management unit. After the trash layer on the surface of each is discarded, these cores are combined to make a sample. Collect enough soil to fill a 1 qt plastic bag about ¾ full. At home, open the bags and dry the soil at room temperature for a day or two. Clearly mark each sample bag. OM determination (usually an additional charge) is often useful. Methods of analysis vary by lab - pick a lab and stick with it. The UMass Soils Lab uses the Morgan test. However, the Bray test for soil P is the most commonly used in other labs for samples from the eastern United States. The Bray test, like all common P soil tests, is of limited value in cranberry soils. Standard P ranges for both methods are provided on the next page. The best time to sample cranberry bogs is when the soil is not waterlogged. Wet soils give falsely high

P values. Soil samples may be collected with tissue samples in the late summer if no sanding is planned. Otherwise, sample soil in the spring.

UMass provides soil and tissue analysis services at the Amherst lab for a fee. Submission forms and soil boxes for this lab are available at the Cranberry Station. Also see their web site for downloadable forms and schedule of fees (http://soiltest.umass.edu/). Follow the links at the top of the page.

CONVERSIONS FOR SOIL TEST RESULTS

lb/A K, Ca, Mg or P	divide by 2.27 to get ppm
lb/A K2O	divide by 2.75 to get ppm K
lb/A P2O5	divide by 5.2 to get ppm P

SOIL STANDARDS (ppm)
Ammonium acetate extraction unless otherwise indicated.

Element	Deficient below	Normal	Excess above
Phosphorus (Bray)	20	20-60	80
Phosphorus (P)	4	4-9	10
Potassium (K)	10	10-40	50
Calcium (Ca)	20	20-80	90
Magnesium (Mg)	10	10-25	25
pH		4.0-5.0	

Base saturation: Ca should roughly equal the sum of K and Mg.
Base saturation is the *proportion* of the various positive cations in the soil. In acid soils 45-70% should consist of hydrogen ions (these replace much of the Ca that would be found in higher pH soils).

Cation Exchange Capacity (CEC): Measures ability of soil to hold positive ions (cations or bases). If CEC is low (<10), base saturation proportions are important. If CEC is high and all cations are in the normal range, the proportions in the base saturation are less critical.

If soil iron is above 200 ppm, soil P tests will not accurately reflect P availability.

IMPORTANT CONSIDERATIONS FOR CRANBERRY NUTRITION

- REVIEW the Nutrient Management BMP in the Best Management Practices Guide for Massachusetts Cranberry Production on our website (http://ag.umass.edu/cranberry/publications-resources/best-management-practices). Excellent information and decision trees for planning N and P management are available as well: visit (http://ag.umass.edu/cranberry/publications-resources/books-pamphlets) and select Nitrogen or Phosphorus for Bearing Cranberries articles. There is also a link on that page to the recently published Nutrient Management Guide for Oregon (em8672). It is also a good resource.

- The Cranberry Station website has an entire page devoted to Nutrient Management and planning (http://ag.umass.edu/cranberry/publications-resources/nutrient-management-for-cranberries). There are templates for writing a nutrient management plan and nutrient calculator tools that can be downloaded from that page.

- GOOD DRAINAGE AND ADEQUATE IRRIGATION are essential for best response to fertilizer. Monitor and maintain adequate soil moisture. Small, frequent irrigations may not be adequate to provide moisture to the root zone. For further information, refer to the Irrigation section and BMP.

- KEEP GOOD RECORDS. Comparison of rate/material and crop response over time will help to refine fertilizer practices tailored to YOUR bog. OBSERVE YOUR BOGS OFTEN -- fertilizer timing depends on growth stage/plant development. Rate can be refined as plants respond during the growing season. For growers managing 10 acres or more, records of nutrient applications are required under Massachusetts regulations.

- Cranberry bog soil has little capacity to HOLD cations (e.g., K, Mg, Ca). Much of the holding capacity is taken up by hydrogen ions. It is important to maintain a BALANCE among cations. Overuse of one can induce deficiency of the others. When you test bog soil for pH, check this balance as well.

- WHEN SYMPTOMS OCCUR - rule out water management issues, disease, and pest problems first. Then look at nutrition. Collect tissue for testing if necessary.

CAUTIONS:

- PRESERVE SURFACE WATER QUALITY - avoid applying fertilizer to water in ditches and canals. As possible, lower water levels in ditches prior to fertilizer application and impound water during and after fertilizer applications.

- AVOID HIGH RATES APPLIED AT ONE TIME, particularly on bogs constructed on mineral soils or very sandy bogs. Such applications may lead to lateral movement of fertilizer into water.

- EXCESSIVE NITROGEN FERTILIZATION leads to over vegetative plants. This may increase susceptibility to disease, spring frost or insect feeding. **High nitrogen rates are associated with poor fruit quality** and may delay color development in the fruit. High nitrogen rates can have adverse carry-over effects in following years -- excess applied nitrogen leads to high nitrogen concentrations in plant tissues such as stems and roots that can be remobilized in the plant and lead to excess vegetation, particularly when more nitrogen is added to the soil.

- FALL FERTILIZER (after harvest application) is not recommended, particularly if crop was small and no deficiencies have been noted. Late-season applications may not be properly taken up by the plants depending on soil temperature and state of dormancy. Generally, if uptake does not occur in the fall, the nutrients are no longer available the following spring. Organic types of fertilizers may be the exception. If you choose to use fall fertilizer, use low N and low or no P formulations.

EFFECTS OF WEATHER

- WINTER INJURY. If leaf drop occurs after withdrawal of winter flood, early spring fertilizer applications will aid in recovery by encouraging rapid, early production of new leaves. Do not skip spring fertilizer. SulPoMag (or similar material) at 100-200 lb/A may also aid recovery.
- COLD SOIL/AIR TEMPERATURES, particularly in the spring, will lessen or eliminate response of cranberry plants to fertilizer applications. If plants are already under stress, they may respond even less. If this occurs, care should be taken not to reapply before you are sure that the plants are not going to respond to the initial application. Soil temperatures should rise to 55°F before application of fertilizer to ensure response. If long-lasting, slow-release, controlled release, or organic forms were used, reapplication may not be necessary -- response may only be delayed.
- IF FLOWER BUDS ARE DAMAGED BY SPRING FROST, high N rates can lead to overgrowth. Use lower rates.

EFFECTS OF PESTS AND CULTURAL PRACTICES

- BOGS CONSTRUCTED ON MINERAL SOILS without a permeability restricting or confining layer have little ability to hold nutrients in the root zone. Use organic or slow-release N and avoid large rates applied all at once.
- DECREASE fertilizer rate if the bog has been SANDED. Sanding promotes production of new vegetative uprights from the runners. Sanding combined with high fertilizer rates can lead to overgrowth.
- DECREASE fertilizer rate if late water has been held. Spring fertilizer rate may be eliminated on late water bogs. Overall fertilizer rate may be decreased 30% or more. However, do not decrease fertilizer N by more than 40% at the risk of adverse impact on the following season crop.
- ELIMINATE fertilizer applications for the entire season if the bog has been subjected to a long SUMMER FLOOD (May-July, see Insect section) for grub control.
- If eliminating crop using a FLASH FLOOD, reduce fertilizer rate. Two low-rate applications, in the spring and mid-season, should suffice to support the plants.
- PRUNING stimulates growth - reduce spring fertilizer on heavily pruned bogs. However, if the bog has been mowed, fertilizer applications are required to encourage the production of new uprights.

CALCULATING FERTILIZER N AND P RATES -- IMPORTANT FOR PLANNING

<u>What's on the bag - What's on the bog</u>

Nitrogen (N)

First number on the bag is percent N
Multiply by weight of the bag and divide by 100 to get what will be applied on the bog

N example:

50 pound bag of 18-8-18
18 x 50 = 900 900/100 = 9
shortcut 1 - for a 50 pound bag, divide the first number by 2 to get pounds of N in the bag
**shortcut 2 - for a 100 pound application - the first number is pounds applied on the bog

What's on the bag - What's on the bog (*continued*)

Phosphorus (P)

Middle number on the bag is percent *phosphate* - P_2O_4
Convert the middle number to actual P - multiply by 0.44, then follow N instructions

P example:
50 pound bag of 12-24-12
24 x 0.44 = 10.56
10.56 x 50 = 528 528/100 = 5.28
shortcut 1 - for a 50 pound bag, divide the middle number by 2 and then multiply by 0.44 to get pounds of P in the bag
**shortcut 2 - for a 100 pound application - the middle number multiplied by 0.44 is the pounds applied on the bog
NOTE: if you want less than 20 pounds actual P on the bog, limit to no more than 45 pounds of *phosphate*

Potassium (K)

Last number on the bag is percent *potassium oxide* - K_2O
Convert the middle number to actual K - multiply by 0.83, then follow N instructions

K example:
50 pound bag of 0-0-22
22 x 0.83 = 18.26
18.26 x 50 = 913 913/100 = 9.13
shortcut 1 - for a 50 pound bag, divide the last number by 2 and then multiply by 0.83 to get pounds of K in the bag
**shortcut 2 - for a 100 pound application - the last number multiplied by 0.83 is the pounds applied on the bog

Nutrient Planning Example

Since we fertilize based on nitrogen -- decide how much N you need. Then choose a fertilizer and calculate how much N, P, and K you will apply.

My bog requires 35 lb N/A; I want to use 12-24-12

- To get 35 lb N -- how much 12-24-12?
  - divide amount of N needed by percent N (first number as decimal) in fertilizer
  - 35 divided by 0.12 = 292 pounds of fertilizer is needed
- to calculate P multiply pounds of fertilizer by middle number as decimal and then by 0.44 (to convert to actual P)
  - 292 x 0.24 x 0.44 = 30.8 pounds of P applied
- to calculate K multiply pounds of fertilizer by last number as decimal and then by 0.83 (to convert to actual K)
  - 292 x 0.12 x 0.83 = 29.1 pounds of K applied

That's more P than I expected. What if I switch to 18-8-18?

- Figure out how much 18-8-18 to get 35 lb N
  - 35 divided by 0.18 = 194 pounds fertilizer
- Now calculate the P
  - 194 pounds fertilizer x 0.08 x 0.44 = 6.8 pounds of P applied
- Now calculate the K
  - 194 pounds fertilizer x 0.18 x 0.83 = 29 pounds of K applied