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Nutrition Management For Producing Bogs

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NUTRITION MANAGEMENT FOR PRODUCING BOGS 2008

Prepared by Carolyn J. DeMoranville

CONSIDER IMPLEMENTING A PHOSPHORUS REDUCTION PLAN IN 2008 !!

PLANT APPEARANCE

Decisions regarding nitrogen rate for a cranberry bog should be based in part on the length and density of uprights. By mid-June (hook stage), the minimum total growth on the new uprights should be 2.25 inches for 'Early Black' and 'Howes', and 2.5 inches for 'Ben Lear' and 'Stevens'. Flowers on uprights longer than 4 inches may be poorly pollinated and fruit poorly colored. Flowering uprights should have 1.5 to 2 inches of leafy length above the flowers and fruit. Presence of adequate foliage (length) by mid-June is significantly correlated with yield later that season. Small, stunted uprights early in the season are associated with poor crops. The average upright density for a productive bog should be about 600 uprights/sq. ft. for 'Early Black' and 400 uprights/sq. ft. for 'Howes', 'Ben Lear', and 'Stevens'. Ideally, 200 or more of these uprights should be the flowering type. An adequate stand of vegetative uprights is also important, as about 80% of these 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.

Leaf greenness is related to the pigment, chlorophyll, which 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. As an alternative, SPAD Chlorophyll Meters may be used. Measurements should be taken on 25-30 detached leaves/A, using only healthy, clean leaves (no feeding damage or residue on surface). Old or new leaves may be monitored in June or July, while only new leaves should be monitored in August. Meter readings vary by cultivar and year. Values below standard indicate the need for N fertilizer. Standard minimum SPAD values are as follows:

		Roughneck to hook stage (June)		Bloom to fruit set (July)	Pre-harvest (August)
Cultivar	Leaves:	old	new	old or new	new only
Early Black		40	25	35	35
Howes		45	30	40	40
Stevens		40	30	35	40
Ben Lear		40	25	35	40

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

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. YV usually appears as temperature and water stress increase during high summer and may be more severe if Casoron has been used.

SOIL AND TISSUE TESTS

Soil and tissue tests are tools which 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 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. Tissue tests are more useful for setting target fertilizer ranges. We recommend sampling every 3-5 years for soil, every 2-4 years for tissue. 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. Use periodic soil testing to monitor any change in soil pH. For further information regarding tissue testing, refer to “Cranberry tissue testing for producing beds in North America” fact sheet (available at the Cranberry Station or at http://www.hort.wisc.edu/cran/mgt_articles/articles_nutr_mgt/a3642.pdf).

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, for example the diagnosis of a disease. Soil can be collected into 1 qt zipper plastic bags, 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 area as instructed below. A management area may vary in size but will be all one 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. 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 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%.* Call the Cranberry Station for interpretation of other elements.

Tissue samples should 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, one from nearby 'normal' vines.

Samples collected after mid-September give lower analysis values than those collected earlier. This is especially true for nitrogen that is also 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	Minor Element	Concentration in dried tissue
	percent		*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/bog. 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. The resulting sample will weigh less and cost less to mail. 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 Bray test for soil P is the most commonly used in the eastern United States. However, this test, like all common P soil tests, is of limited value in cranberry soils. 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 spring.

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

CONVERSIONS FOR SOIL TEST RESULTS

lb/A K, Ca, Mg or P	divide by 2.27 to get ppm
lb/A K_2O	divide by 2.75 to get ppm K
lb/A P_2O_5	divide by 5.2 to get ppm P

CONSIDER IMPLEMENTING A PHOSPHORUS REDUCTION PLAN IN 2008 !!

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.

MAJOR ELEMENTS

NITROGEN, PHOSPHORUS, AND POTASSIUM (NPK):
Most often these elements are added together in 'complete' NPK fertilizer. The amount to apply depends on the desired N rate. When low N rate is required (generally pre-bloom), low N materials (3-13-26 or 5-15-30) or no N materials (0-25-25) may be used. However, a study of P fertilizer has indicated that high P rates do not increase yield compared to that with moderate P rates and that excess P in the soil may be associated with lower yield. If tissue P is in the sufficient range, we do not recommend exceeding a 1:2 ratio of N to P. 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 try reduced P ratio fertilizer on their bogs, especially if high N applications are planned.** N rate is chosen based on vine appearance, tissue test, soil type, previous response, and weather (spring temperature). Based on bog history - use the lowest N rate that gives adequate vegetative growth and maintains productivity. A nitrogen rate of 20-25 lb/A (higher for Ben Lear, Stevens, and other hybrids) for the season is a reasonable starting point if you are unsure about rate.

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 high Ca use. Lime can have adverse effects by changing soil pH. Use of materials high in chloride (Cl) may lead to decline in production. Avoid use of high rates of 0-0-60.

CONSIDER IMPLEMENTING A PHOSPHORUS REDUCTION PLAN IN 2008. P FERTILIZER REDUCTION CAN RESULT IN SUBSTANTIAL IMPROVEMENTS IN WATER QUALITY.

MINOR ELEMENTS

- Minor element deficiencies are rare in cranberries due to low requirements and high availability on 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 State average crops. 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 aircraft is more effective than sprinkler application. This is a foliar feed - apply accordingly.

  CAUTIONS : 1. Manganese containing fertilizers or fungicides (Maneb or Mancozeb) may cancel 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, you should eliminate the FIRST application.

Plant/soil condition	Recommended fertilizer rate
Nitrogen (N)	
Yellow, short, or low N vines	40-60 lb/A
Normal vines	10-40 lb/A
Rank vines or excessive N	0-20 lb/A (none pre-bloom)
High yielding 'Stevens'	20-60 lb/A
Phosphorus (P)	
Tissue tests normal	supplied in NPK, no more than 1:2 ratio **NO MORE than 20 lb/A P recommended (45 lb/A P_2O_5)**
Soil and tissue tests low	use NPK with higher P (1:3 or 4 ratio)
Soil P normal, tissue P low	2-4 lb/A foliar P (pre-bloom)
P excessive in soil	avoid NPK with high P
Potassium (K)	
Soil and tissue tests normal	supplied in NPK, 40-120 lb/A recommended
Soil and tissue tests low	120 lb/A as 0-0-22-11 (best), or 0-0-50
K excess	use no supplements
Calcium (Ca)	
Soil or tissue deficient	20-30 lb/A (actual Ca) as gypsum AVOID LIME
Magnesium (Mg)	
Soil or tissue deficient	10-30 lb/A as 0-0-22-11 or magnesium sulfate (Epsom salts)

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.
- FISH FERTILIZER is a liquid fertilizer. It should be washed in.

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- Make sure ground application equipment is properly calibrated.

CALCULATING FERTILIZER N AND P RATES -- IMPORTANT FOR P REDUCTION PLANS

Basic information - How to calculate rates from the N-P-K on the bag

- Pounds of N = pounds of fertilizer multiplied by the first number as a decimal
  - example: 150 lb 12-24-12 = 18 lb N (150 x 0.12)
- Pounds of actual P = pounds of fertilizer multiplied by the middle number as decimal multiplied by 0.44 to convert to actual P (the bag number is P_2O_5)
  - example: 175 lb 15-15-15 = 11.55 lb P (175 x 0.15 x 0.44)
- Pounds of K = pounds of fertilizer multiplied by the last number as a decimal multiplied by 0.83 to convert K_2O to actual K
  - example: 200 pounds of SulPoMag (0-0-22) = 36.5 lb K (200 x 0.22 x 0.83)

Example #1

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

My bog requires 35 lb N/acre; 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 = 291.7 pounds of fertilizer
- to calculate P - multiply pounds of fertilizer by middle number as decimal and then by 0.44 (to convert to actual P)
  - 291.7 x 0.24 x 0.44 = 30.8 pounds of P applied

That's more P than I expected. What if I switch to 15-15-15?

- Figure out how much 15-15-15 to get 35 lb N
  - 35 divided by 0.15 = 233 pounds fertilizer
- Now calculate the P
  - 233 pounds fertilizer x 0.15 x 0.44 = 15.4 pounds of P applied

Example #2

I always use 400 lb/A 12-24-12. How much N and P am I applying?

- For N - multiply the pounds of fertilizer by 0.12 (the percent N in 12-24-12)
  - 400 x 0.12 = 48 pounds of N
- For actual P - multiply the pounds of fertilizer by 0.24 (the percent P_2O_5 in 12-24-12) and then multiply by 0.44 to convert to actual P
  - 400 x 0.24 x 0.44 = 42.2 pounds of actual P

WOW -- maybe I want to try that 18-8-18 I am hearing about - how much should I use?

- To get 48 pounds of N with 18-8-18, divide 48 by 0.18 to get pounds of fertilizer
  - 48 / 0.18 = 267 pounds of 18-8-18
- So - how much P is that? Multiply fertilizer by 0.08 to get pounds of P_2O_5 then convert to P by multiplying by 0.44
  - 267 x 0.08 x 0.44 = 9.4 pounds of actual P

FERTILIZER SOURCES FOR CRANBERRY PRODUCTION

Nitrogen (N): Nitrogen is most often added with phosphorus and potassium in NPK fertilizers. To determine rate of N in granular fertilizers, multiply the percent N (first number on the bag) by the amount of fertilizer to be used. For liquid formulations, the calculation must include a correction for the weight of the liquid.

For example: 9-18-9 liquid contains 9% N by weight	Multiply 9% by the weight of a gallon to determine the pounds of N in a gallon

Other N fertilizers:

Ammonium sulfate	21-0-0	this material may also be used to control moss (4 lb/15x15 ft)
Monommonium phosphate	11-49-0	
or diammonium phosphate	18-47-0	found in 'complete' NPK fertilizers
Urea	46-0-0	(urea breaks down to form 2 ammonium molecules)
Fish fertilizer	2-4-2	most common - 10 gal provides 2.5 lb N, 2 lb P, 2 lb K
Slow release fertilizers		IBDU, methylene urea, sulfur coats, resin coats
Organic fertilizers		Composted chicken manure, fish fertilizer, feather meal
Other organic N forms		Seaweed and humate compounds have not given a positive response in cranberry research plots. **Avoid sludge based products (e.g. Miloganite) as they are high in heavy metals which become very plant-available in acid soils.**

Phosphorus (P): Research showed that P applied at 20, 40, or 60 lb/A gives increased yield compared to using no P fertilizer. However, there were no differences in yield among the three rates. 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, bone meal, or rock phosphate can supply the P needs of cranberry bogs as well. *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 actual P per season if tissue test is normal. See calculations page.**

Potassium (K): Potassium is generally added with nitrogen and phosphorus (NPK) or 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. To determine pounds of K in 100 pounds of fertilizer, multiply 0.83 by the third number on the fertilizer label.

General information:

- The best available evidence indicates that cranberries respond poorly to nitrate N; the AMMONIUM FORM is recommended, monoammonium phosphate is an excellent source. Light rates of urea 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. Non-uniform blends will sort during application, giving poor results.

- FISH HYDROLYSATE FERTILIZER is available commercially 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 as a replacement for fall fertilizer (see timing for fish-granular NPK program).

- 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 S for weed suppression. Advice from experts prior to S application is recommended. 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

- CALIBRATION AND EVEN APPLICATION of granular materials becomes more difficult when the rate falls below 75-100 lb/A. When you plan to apply low N rates, a higher rate of a low assay fertilizer may be a better choice than a low rate of a more concentrated material. Example: 100 lb/A 5-15-30 compared to 42 lb/A 12-24-12 to apply 5 lb N/A. However, avoid excessive P applications when using high P ratio fertilizers. See Major Elements section.

TIMING - WHEN TO APPLY FERTILIZERS TO CRANBERRIES

NPK fertilizer may be added in several forms (see previous section). The form chosen will determine the time schedule for applications. Information is presented below for sample programs based on various NPK forms. 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. At soil temperatures 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.

It is best to time fertilizer applications by the growth stage of the plants. This is especially true when weather has been unusual and plant development is off-schedule. For a cold spring, delay soil amendment applications. Fertilizer applications will be less effective if soil temperature is below 50°F because roots will not take up nutrients effectively in cold soil. Dates listed are only approximate, based on an average weather year. See major element section for information regarding rates.

Abbreviation:	Stage:	Timing (avg. weather year):
ES	Early spring	mid-April to mid-May
BB	Bud break	mid-May
RN	Roughneck (1" new growth)	late May
HK	Hook	early June
E-BL	Early (10%) bloom	2nd week June
BL	Mid-Bloom	late June
ST	Fruit Set (pea size)	2-3 wks. after BL
BD	Bud development	early August
EF	Early Fall	late August to September
PH	Post harvest	mid-October through November

Programs

Stage	NPK granular	Slow release NPK	Slow/fast NPK	NPK granular/Fish	Fish (2 alternatives)	
BB		100% total N		10-20 gal/A fish	50%	25%
RN	20-25% total N		40% total N			
HK						25%
BL	25-30% total N		60% total N	30-35% total N as granular		
ST	25-30% total N			30-35% total N as granular	50%	25%
BD	20-25% total N					
EF				10-20 gal/A fish		25%

Optional for any program

ES	Soil amendments	Correct K, Ca, Mg deficiencies
	Soil conditioners	0-0-22-11 or similar at 100-300 lb/A (100-150 recommended)
BB to HK	Minor element supplements	Foliar sprays for deficiencies only
E-BL *and* BL	CaB	2 qt/A
EF	Fish as fall fertilizer	5-10 gal/A
PH	Fall fertilizer	no more than 5 lb N/A; high K materials best if any used AVOID high P materials

IMPORTANT CONSIDERATIONS FOR CRANBERRY FERTILIZING

- CAREFULLY EXAMINE your P fertilizer use. Consider implementation of a reduction plan. Use no more than 20 lb/A of actual P (45 lb/A P_2O_5).
- REVIEW the Nutrient Management BMP in the Best Management Practices Guide for Massachusetts Cranberry Production available from the Cranberry Station. Excellent information and decision trees for planning N and P management are available as well: http://www.hort.wisc.edu/cran/ (select Nutrient Management then Nitrogen or Phosphorus for Bearing Cranberries articles).
- 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 fact sheet 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.

- SANDY BOGS CANNOT HOLD NUTRIENTS WELL - apply lower fertilizer rates more frequently. Slow-release fertilizers are also recommended for bogs planted on mineral soils.
- Cranberry bog soil has little capacity to HOLD cations, i.e., 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.
- AVOID LARGE 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 overvegetative 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 often unnecessary, 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.

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 50°F before application of fertilizer to ensure response. If long-lasting or organic forms were used, reapplication may not be necessary -- response may only be delayed.
- IF FLOWER BUDS ARE DAMAGED BY SPRING FROST, heavy N fertilization can lead to overgrowth. Use lighter rates.

EFFECTS OF PESTS AND CULTURAL PRACTICES

- Decreasing pre-bloom N may impact TIPWORM populations by limiting lush growth for insect feeding.
- 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. A light rate 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.

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