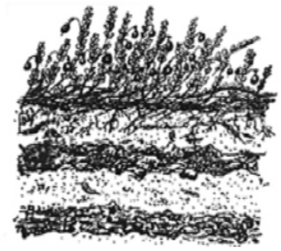

BEST MANAGEMENT PRACTICES GUIDE FOR MASSACHUSETTS CRANBERRY PRODUCTION

Nutrient Management in Cranberry Production

Nutrient elements are required by cranberry plants for the production of vegetation (new leaves and stems), roots, and fruit (crop). Cranberry plants get these nutrients from the soil, from water, or from fertilizers added to the bog. While cranberries require the same nutrients as other plants, they are unique in that the *amounts* required are much smaller than for most crop plants. The reason for this is that cranberries have adapted through evolution for growth on acidic, sandy or organic soils. These soils have little nutrient content, and the plants in the family Ericaceae such as cranberries and blueberries that evolved on them have correspondingly low nutrient needs. Further, cranberries are perennial plants with the capacity to store and reuse nutrients in old leaves, wood, and roots. A unique and important feature of cranberries is that they maintain their leaves over the winter. These leaves also serve as a nutrient source when the plants resume growth in the spring.

Commercially, cranberries are grown in either organic soils modified by surface application of sand, or in mineral soils. On most Massachusetts cranberry bogs, the rooting zone typically contains about 95% sand -- the average organic matter in the surface horizon is less than 3.5% and silt and clay make up less than 3% of the soil. Therefore, the root zone of a cranberry bog has low cation exchange capacity: little ability to hold positively charged nutrients such as ammonium, potassium, magnesium, and calcium. This can present horticultural and environmental challenges. On the horticultural side, it is important to retain nutrients in the root zone where they can be taken up by the plants. On the environmental side, the layered structure of cranberry soils attenuates the downward leaching of nutrients. Layers of sand are added to the bogs every 2-5 years leading to alternating sandy and organic layers. The organic layers, comprised of decaying roots and leaves, have the capacity to hold nutrients. Leaching is further minimized if the subsoil is highly organic, as in a peat-based bog. These characteristics protect the ground water, but growers must still guard against movement of nutrients into surface water.

Why cranberries need fertilizer: Each season nutrients are removed from the bog during harvest and detrashing (removal of fallen leaves and debris from the bog floor). During harvest, the elements removed in the largest quantities are nitrogen (N), potassium (K), and calcium: >20 lb/acre (N) or >15 lb/A (K and calcium) in an average (150 bbl/acre) crop. The amount of nutrient removal increases with larger crops and is less when crops are small. Phosphorus (P) removal is 4-5 lb/acre in an average crop. Cranberry growers add fertilizer to their bogs to compensate for the nutrient removal. Most fertilizer added to producing cranberry bogs contains nitrogen, phosphorus, and potassium in various ratios (N-P-K fertilizer). While P removal is low, some P is included in the mixture to maintain nutrient supply and because much of the P in cranberry bog soils binds with iron or aluminum and is not available to the plants at crucial growth stages such as bloom. The exact fertilizer composition is chosen based on soil type, time of year (plant stage), and plant requirements, including information supplied in tissue testing and knowledge of the amount of nutrient that will be removed in crop and used in new growth during the season. Fertilizer is applied to cranberry bogs using ground rigs (spreaders and seeders), helicopters (aerial application), and the sprinkler system (fertigation).

Properly managing the amount of fertilizer used on cranberry bogs can have both environmental and financial benefits for growers. Financial benefits (cost savings) may be achieved by not applying more fertilizer than necessary, using split applications to increase efficiency (and reduce amount applied), and limiting N applications to avoid a shift from fruit production to production of vegetation. While it is important to consider financial benefits when choosing nutrient management practices, always consider the potential impact to water quality and requirements for meeting water quality standards when formulating your management plan.

Nutrient and water management go hand-in-hand in cranberry production. Many recommendations for nutrient management BMPs relate to water management. Also review the Water Management BMPs as you design your nutrient management plan.

Recommended Practices - General

Review the Cranberry Chart Book regularly and attend educational programs.

The BMP Guide is revised periodically but the Chart Book Nutrient Management section is reviewed and updated annually. As research results and grower experiences increase our knowledge, the newest information will appear first in the Chart Book and at annual update meetings held during the winter.

Formulate a nutrient management plan for each management unit and review it regularly.

A good nutrient management plan should be part of your whole farm planning efforts and is included in a conservation farm plan. Technical assistance for planning is available through the USDA Natural Resource Conservation Service (NRCS) and the Conservation Districts. Financial assistance for plan implementation may also be available from NRCS.

Base fertilizer use on the properties of your bog – be site-specific.

Nitrogen (N) applications are important in cranberry nutrient management. But the average recommended seasonal rate of N can vary from 10 to 60 lb/acre depending on the characteristics of the soil, the cultivar being grown, the weather that season, the general appearance (length and color of uprights) of the plants, and the amount of crop produced. Some of these factors are fixed on a given bog, but others vary each season. Seasonal phosphorus (P) rate should be adjusted based on cultivar and tissue test results. Additional guidance on choosing a fertilizer rate is provided in the Chart Book and in the Nitrogen for Bearing Cranberries bulletin.

To accomplish site-specific management, it is important to keep good records of past applications and responses, to be aware of the weather including rainfall and soil temperature, and to observe the bogs frequently to assess vine response and crop potential.

Keep detailed records of fertilizer use, water management, and crop response.

This is the single most important practice you can do when it comes to managing cranberry bog nutrition. Every bog responds differently depending on soil factors, organic matter content, depth of underlying peat, location (spring temperatures), and previous cultural practices. Learn how yield and plant tissue mineral content on your bog respond to fertilizer and plan accordingly. This information will allow you to refine your nutrient management plan each season. Information that you gain in this process can also be shared with fellow growers and extension professionals in order to advance industry knowledge.

Weather records, including rainfall and soil temperature, are also helpful. Record fertilizer applications (rate and date of application) for each management unit. Also record flood practices (e.g. late water), sanding, pruning, and any other practices that can interact with nutrient management.

Test soil for organic matter and pH every 2-4 years. Soil tests can be taken in the spring or in the late summer with the tissue test. Test plant tissue for mineral content every 1-4 years depending on previous results and variability in your fertilizer applications. For example, more frequent testing is called for if you have been changing your management. Collect the samples between Aug. 15 and Sept. 15. Tissue tests are important 'report cards' for how well your nutrient management is supporting the plant needs.

Observe your bog often. Do not be afraid to modify your fertilizer plan as conditions warrant.

Make a plan for the season in the early spring based on your records and expectations, then monitor response as the season progresses. The amount of fertilizer to be applied may need to be adjusted depending on spring temperatures, stress from diseases or insects, or plant response (or lack thereof). However, remember that all fertilizers are not fast-acting and cold temperatures can slow response. Do not add more until you are SURE that it is warranted.

Do not starve the plants before bloom then make a heavy fertilizer application.

Aside from water, the most important constituents of the fruit are carbohydrates (acids and sugars) that the plants make in the green leaves and transfer to the fruit. Plants that are starved for mineral nutrients in the spring will not make enough new green leaf surface to produce the carbohydrates necessary to support a large crop. Adding large amounts of fertilizer to stunted plants will not set a large crop of fruit. By that time, fertilizer is no longer the limiting factor *if* nutrition was inadequate earlier.

Wait for soil temperature to rise to 55º F before applying spring fertilizers.

Cranberry plants have little ability to take up nutrients when the soil is cold. Fertilizers applied too early in the spring may volatilize, wash out of the root zone or become tightly bound to the soil (and not available for uptake) before the soil warms enough for uptake into the plants.

Good drainage and adequate irrigation are essential for best response to fertilizer.

Moisture and aeration in the soil can determine nutrient availability. Plants take up nutrients dissolved in the soil water. If soil is too dry, minerals cannot dissolve and move to the roots and uptake cannot occur. Conversely, if soil is waterlogged, oxygen the plant needs for root respiration to drive active uptake will be limited. In fact, an irrigation study showed that when the bog is too wet, fruit set declines. High manganese levels on a tissue test may indicate poor drainage.

Proper soil drainage improves fertilizer efficiency so that less fertilizer is required. Check soil moisture at least twice a week; soil should be moist but not saturated in the top 6 inches. The use of water-level floats, sensors, and/or tensiometers is highly recommended.

Calibrate fertilizer application equipment.

Proper calibration of application equipment including the irrigation system, ground rigs, and aircraft will ensure that the desired dose of fertilizer is applied. Calibrate ground application equipment as recommended by the manufacturer and cross check by observing that the amount applied per desired area is achieved. Directions for irrigation system timing are in the Chemigation section.

Recommended Practices - Protection of water quality

Fertilizer N and P can be environmental pollutants. N is of particular concern in estuarine waters, while P is primarily associated with degradation of water quality in inland, freshwater systems. When excess P is provided in such systems, algal blooms (eutrophication) can result. Some of these algal blooms are comprised of bluegreen algae (cyanobacteria) and may contain natural toxins which can harm humans, domestic animals and wildlife. As the algal population peaks and the algae die, oxygen in the water is depleted, which may ultimately result in fish kills. While leaching is of minimal concern in cranberry fertilizer management, the potential for movement of N and P in surface water should be taken into account in management decisions.

It is always the best practice to limit the off-site movement of N and P in surface water so as to prevent environmental degradation. It is critically important to use all practices available to limit movement of N and P in surface water that will ultimately drain to an impaired body of water. The water quality in many estuaries and ponds has degraded to such critical levels as to warrant being listed by the Commonwealth on the Federal Clean Water Act's 303(d) list, also known as the Integrated List of Waters. In order to comply with the Federal Clean Water Act the State is required to establish federally enforceable limits to pollutants, from all sources, to ensure that water quality is restored. This limit, known as a Total Maximum Daily Load ("TMDL"), is a regulatory limit that defines the greatest amount of a pollutant that a waterbody can accept and still meet water quality standards for protecting public health and maintaining the use of those waters for drinking, swimming, recreation and fishing. You should be aware of whether your bog discharges to an impaired or sensitive receiving water. If a TMDL for nutrients is in place for the water body receiving discharge from your bog, you must modify your discharge load to comply with the specific reduction in nutrients required by that TMDL.

To ensure protection of aquatic life, maintain water visibility, prevent algal blooms (especially toxic bluegreen blooms) and other environmental considerations, growers need to be aware of the amount of total P in the discharge flow when releasing water directly or indirectly to any impaired water bodies. This may involve testing of the water prior to and/or during the release. Test results can then be compared to accepted impaired water body standards. If the water test results show that standards are not being met, management changes may be required, including full implementation of recommended BMPs.

To determine if a bog directly or indirectly discharges to an impaired water, and for further information on fresh-water TMDLs, consult the Massachusetts Integrated List of Waters Found at http://www.mass.gov/dep/water/resources/tmdls.htm or contact the CCCGA office or your local Conservation District. For information on water testing procedures and analysis, please contact the UMass Cranberry Station.

Avoid large quantities of fertilizer applied at one time.

The root zone of cranberry soils is quite sandy and has little capacity to hold added nutrients. Fertilizer application rates in excess of the amount that can be taken into the plants within a reasonable period of time (generally about 2 weeks) will result in some of the nutrients moving out of the plant root zone during rainfall and irrigation events. These nutrients are potential sources of off-site contamination.

Apply fertilizers to respond to crop demand.

The timing of nitrogen and phosphorus applications is an important factor affecting the potential for nutrient loss to the environment. The greater the time between application and plant uptake, the greater the chance for loss to ground or surface water. It is best to time fertilizer applications based on the stage of plant growth. Applications should be delayed when spring temperatures are cold. Cranberry plants respond to nutritional support during initial leaf expansion in the spring, during bloom, during fruit set, and during bud development for the following season. The greatest demand occurs during vigorous shoot growth, bloom, and early fruit development (set). In most years, this period occurs between mid-June and mid-July. Fertilizer requirements at the other growth stages (early spring and late summer) are less.

Exercise particular caution in applying fertilizer to bogs that are sandy or drain excessively.

Both of these conditions increase the risk of leaching and may be characteristic of new or renovated plantings. Consider the use of organic or slow-release fertilizers and avoid large amounts of soluble materials applied all at once. Sand contributes minimal nutrients so fertilizer requirements may be larger than those of organic-based bogs. This requirement may be best satisfied by frequent small applications of fertilizer or slow-acting, low-leaching materials. Mineral soil bogs may also require occasional minor element supplementation, but the use of these materials should be based on tissue test results.

If some is good, more is not necessarily better.

Over the past 30 years, a body of research has shown that the predominant limitation to cranberry yield is photosynthesis, the process in which green plants harness the energy of the sun in carbohydrates that are then used in the structure of vines and berries. While a nutrient *deficiency* can limit yield, once nutrients are within the required range, adding more will not overcome other limitations to yield. An excellent resource summarizing this body of research is "The Physiology of Cranberry Yield".

Supplying enough N to ensure adequate leaf area and green pigment is important to support carbohydrate production but if you add excess N, you will begin to see plants that are producing leaves and stems at the expense of fruit. Adding more than 20 lb/acre P in the absence of a tissue deficiency has never been shown to increase yield in any research study or in any study of commercial plantings in Massachusetts or Wisconsin. In fact, there is good evidence that less than 20 lb/acre is adequate for native cultivars or beds with high tissue P.

Excess fertilizer N and P can have adverse impacts on the environment. If the plant cannot use the fertilizer and does not take it up, the potential exists for movement into ground or surface waters. The unused nutrients also represent money and energy wasted.

Prevent direct input of fertilizers into surface water.

Preventing direct application of fertilizers to streams and ditch water is the single most important step in reducing the potential for off-site movement of nutrients. Use of part-circle sprinklers or sprinkler guards can be effective in minimizing direct application to water. Persons applying fertilizers with ground rigs should be cautious about keeping fertilizer out of ditch water. It is difficult to control non-target application of aerially applied fertilizer, so consider other methods in environmentally sensitive areas. Avoid heavy irrigation immediately following fertilizer applications to minimize surface runoff and do not apply fertilizers when heavy rain is predicted.

Reduce the level of water in ditches as much as possible prior to application of fertilizer.

Lowering the water level in ditches before a fertilizer application will allow for adsorption of nutrients onto sediment and vegetation in the ditches and increases the water holding time in the system. Research has shown that cranberry bogs have a great capacity to filter nutrients, especially N, from water. Slowing the water movement through the system maximizes this process.

Use of fall fertilizer is not recommended.

Fertilizer applied in the fall has the greatest potential for leaching loss, especially on mineral soil bogs. Fall fertilizer may be moved below the root zone by the weight of the winter flood and any added phosphorus may dissolve into the flood. It is preferable to apply supplemental fertilizer in the following spring, particularly if harvest occurred later in the fall.

Occasionally, fall fertilizer applications may provide cultural benefits on bogs showing symptoms of stress, where the late summer tissue tests show deficiency, or where crops have been especially heavy. Answer the questions in the box to decide if a conservative application of fall fertilizer use is indicated.

Should I Use Fall Fertilizer?

Question	Answer	Fall fertilizer?
Are your vines lush or long?	Yes	No
Did you have a big crop?	No	No
Have you already applied more than 30 lb N (50 lb for hybrids)?	Yes	Probably not
Does the bog have deep organic soil with normally little need for early spring fertilizer?	Yes	Probably not
Did the late summer tissue test show deficiency?	Yes	Maybe

If you still think that fall fertilizer is needed, follow the recommendations below.

- Apply only when necessary (see the box)
- Apply no later than mid-November
- Apply only when soil temperature is >50º F
- Apply no more than 5 lb/acre N
- Choose a product with little or no P but high K

P is not needed in the fall (natural release from the soil is occurring), but added K may enhance hardiness. N and K are the two elements that are removed in the greatest quantity in harvested fruit; P is at much lower concentrations in the berries.

If fall fertilizer is applied too soon after an early harvest, cold tolerance may be reduced. For late harvest, fertilizer should be applied soon after the harvest flood is removed to maximize the time between fertilizer application and the winter flood and minimize nutrient leaching. Applications when soil temperature is below 50º F are not likely to be taken up into the plant.

Limit water discharge during seasonal fertilizer application periods.

Limit the flow out of the bog system during the seasonal period when fertilizers are applied. This may be accomplished by impoundment, dropping ditches prior to fertilizer applications, diverting flow through by-pass canals, or capturing outflow using tailwater recovery channels and ponds. Also be aware of forecasted rain events.

N concentration in discharge water can be attenuated as the water flows through open streams, wetlands, and ponds. This natural attenuation involves the conversion of dissolved N in the water to gaseous forms that dissipate into the air. Additional small amounts of N may be taken up by wetland plants along the pathway. When water must flow out of the bogs, take steps to maximize natural N attenuation as the water moves towards coastal waters. This can be accomplished by installing by-pass canals, tailwater channels and ponds, or by increasing the length of the pathway the water travels, increasing the residence time of the water prior to ultimate discharge to coastal waters. If a tailwater system is employed, water conservation is also accomplished.

If recommended P fertilizer rates are followed, the data suggest that commercial cranberry bogs can achieve relatively low seasonal discharges of P. If the bog discharges to sensitive waters, lakes or downstream impoundments, additional lowering of export rates may be necessary. This could be achieved by the diversion of some or all discharge water within your water management system for reuse or storage, recycling the water to the greatest extent possible.

Manage harvest and winter floods to minimize P mobilization and discharge.

Cranberry soil chemistry, particularly the high iron and aluminum associated with acidic soils, leads to extensive binding of P as iron and aluminum phosphates in the soil. That P can be released from such compounds when flooded soils become anaerobic (depleted of oxygen). In the absence of oxygen, iron and aluminum change chemical state and no longer strongly bind P. This presents a risk during long floods used in cranberry management.

When fertilized bogs are flooded, P is released from the soil into flood water. As the oxygen depletes from the soil (~10 days), additional, and often substantial, P release occurs. The magnitude of both release events appears to increase when fertilizer P applications exceed 20 lb/acre.

Data from laboratory and field studies indicated that native cranberry wetland soils can act as sinks for P under aerobic (oxygenated) conditions. Under commercial management with P fertilizer applications, cranberry soils no longer removed P from water and when fertilizer P applications exceeded 20 lb/acre, P moved from the bog soil into flood water even under aerobic conditions. As beds were held in flooded conditions the soil became anaerobic after ~10 days and P was released into the water regardless of bog management. However, the magnitude to P release from the soil was proportional to previous fertilizer P additions.

Recommendations to limit P discharge from bogs:

- Do not exceed 20 lb/A P (~45 lb/acre P_2O_5) per season to minimize the risk of P moving into floods.
- Reduce P to less than 20 lb/acre P per season if tissue test P is >0.16% and on native cultivars with adequate tissue P.
- Hold harvest floods for about 3 days to allow settling, then complete discharge by Day 10 to avoid mobilizing bound P as oxygen depletes in the flooded soil.
- Once winter flood freezes, remove the water from beneath the ice to minimize soil saturation and P mobilization. Exact timing should be based on sanding plans and ability to re-flood if the ice is lost.

Recommended Practices -- Nitrogen

The single most important nutrient element in cranberry production is nitrogen. N is required by cranberry plants for the production of vegetation (new leaves and stems), roots, and fruit (crop). N is an important part of proteins, including the most important plant protein, chlorophyll.

Understand the nitrogen cycle in the cranberry bog.

Approximately 95-99% of the N in soil that becomes available to the plant during the growing season comes from the decomposition of soil organic matter. While cranberry soil is relatively low in organic matter, cranberries obtain some N from that source either directly through the mediation of mycorrhizal fungi that live in a symbiotic relationship with the plant roots or through the process of *mineralization*.

Nitrogen mineralization is a process in which bacteria convert organic N into ammonium-N. This reaction is dependent on soil moisture and temperature. As a result the process provides most N early in the season as the soil dries after the winter flood and in late summer when the soil temperature approaches 70ºF – those are times when added fertilizer is least needed.

Ammonium-N from the organic matter or from fertilizer can be converted to nitrate-N by the process of *nitrification*, mediated by nitrifying bacteria. Cranberries use nitrate poorly and nitrate can leach in the soil or be converted to gaseous forms. Conversion of ammonium to nitrate can be minimized by managing soil pH to limit the population of nitrifying bacteria. In sandy or layered cranberry soils (organic matter 0-5%), this is accomplished by maintaining pH between 4.0 and 5.0. If the soil is highly organic (>5%), a pH below 4.5 is recommended.

Each season nitrogen is lost from the bog system in the harvested crop and when the bog is detrashed (removal of fallen leaves from the bog floor). During harvest, more than 20 lbs N/acre is removed in an average (150 bbl/acre) crop.

Apply nitrogen in the ammonium-N form (NH_4).

Field and greenhouse experiments have demonstrated that cranberries preferentially use ammonium nitrogen rather than nitrate nitrogen. Cranberries can use nitrate-N if ammonium-N was also present, but did poorly if supplied with nitrate-N alone. Do not use fertilizers in which all of the nitrogen comes from the nitrate form.

Fertilizers containing all N in the ammonium form (ammoniated or blends with N from ammonium sulfate, ammonium phosphate, or urea) should remain your first choice. Fertilizers containing both ammonium and nitrate may be used - both N types will be taken up by the plants. However, the best practice is to keep nitrate content to a minimum. Nitrate leaches readily in coarse sandy soils, but ammonium does not. By choosing ammonium forms, the potential for leaching nitrate to the surrounding environment is minimized as long as the soil pH is <5.5. At higher pH, ammonium may be converted to nitrate. Organic forms and urea convert to ammonium-N in the soil.

Timing: Plan N fertilizer applications based on phenology, soil type, and temperature.

N must be available in the soil during periods of plant demand – vegetative growth, fruit production, root renewal, and bud set. These periods coincide with the stages of roughneck (1/2 to 1 inch new growth), bloom, fruit set, and early August bud set. Seasonal N application rate should be divided into three to four applications corresponding to those periods: 20-25% at roughneck stage, 30-35% at bloom, 30-35% at fruit set (about 2-3 weeks after bloom), and ~20% at bud development/fruit sizing (early August). Split application timing allows for in-season rate adjustment as conditions warrant.

On sandy soils with little organic matter, nitrogen fertilizer must be used to meet these demands. If organic matter is present, then temperature plays a role in deciding when to apply N fertilizer. For typical cranberry bogs (~3% organic matter), applications of N should not be necessary early in the spring. From flood removal until soil temperatures exceed 55ºF, adequate N should be available through biological processes.

As soil temperatures increase from 55ºF to 70ºF, release of N from soil organic matter is only moderate. Fertilizer applications should be beneficial during this period for all soil types. This corresponds to the period from roughneck stage through bloom/fruit set.

During spells of hot weather, when soil temperatures exceed 70ºF and air temperatures exceed 85ºF, soil N release increases and crop development slows, so planned fertilizer N applications should be reduced, delayed, or eliminated.

Rates: Apply nitrogen fertilizer based on cultivar, plant condition, and response.

Small-fruited cultivars such as Early Black and Howes generally 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 then also be adjusted according to soil type. Rates higher than 40 lbs per acre should be used with caution as they may lead to vine overgrowth and reduction in fruit quality.

Consistency in management is important for achieving predictable yields. Research has shown that N application rate in the year before a crop may be a more important predictor of yield than N rate in the current season. Further, timing of N application may be even more important than rate.

Excess N leads to over-vegetative plants with long uprights, many runners, and few fruit. Excess vegetative growth may increase susceptibility to disease, spring frost, or insect feeding. High N rates may also lead to poor fruit quality and delay color development in the fruit and can have adverse carry-over effects in following years as stored excess N is remobilized.

Additional nitrogen fertilizer should be added if the cranberry plants show signs of nitrogen deficiency - poor growth, loss of leaf greenness, and/or low nitrogen content in the leaf tissue. Reduce use if vines growth is excessive, crop potential is reduced (for example, by frost damage), or tissue test levels are excessive.

After sanding or a late water flood, reduce the amount of nitrogen applied.

Spring fertilizer application may be eliminated on late water bogs (apply first fertilizer at bloom). Overall rate reduction should be 20-30%. Sanded bogs tend to be warmer due to the sunlight being absorbed by the sand. Warm soils release more native N (increased mineralization) so less should be added as fertilizer.

Monitor cranberry plant nitrogen status.

Observe growth and flowering. Adjust fertilizer based on the appearance of the plants and the potential for cropping. Pay particular attention to upright length and growth above the fruit. Length of new growth can be used to indicate nutrient status of cranberry plants until early bloom. Less than sufficient length indicates the need for N fertilizer. From hook stage through early bloom, sufficient-range lengths are as follows:

Early Black – 2.0 to 2.4 inches	Howes -- 1.8 to 2.2 inches
Stevens -- 2.4 to 2.8 inches	Ben Lear -- 2.2 to 2.6 inches

Healthy cranberry plants with adequate N are deep, bright green. If the leaves are light green, fading to yellow, N may be insufficient.

Tissue testing for %N is used to determine nutrient status of cranberry plants. The standard value for all cultivars in August (recommended testing time) is 0.9-1.1%, with up to 1.3% acceptable for high-yielding hybrids. Earlier in the season, higher values (up to 1.5%) are normal. As growth dilutes the nitrogen in the plants, N concentration declines to approximately 1%. Values below normal may indicate the need for added N fertilizer.

Recommended Practices – Phosphorus

Phosphorus plays many roles in plant metabolism. P is involved in energy transfer in plants and is a primary constituent of genetic material (DNA). P plays a regulatory role in photosynthesis and starch synthesis, active transport of materials across membranes, root growth and function, and hormonal balance. This last function is critical to initiation of flowers. While only modest amounts of P are removed from cranberry beds in fallen leaves and fruit, it is essential that soil P be available to the cranberry plants to support seasonal growth and flowering.

P use should not exceed 20 lb/acre per season. Lower rates are often indicated.

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 any more than 20 lb/acre 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/acre P, with no improvement at higher rates.

The only exceptions to the not to exceed 20 pound recommendation are beds with documented deficiencies (tissue P <0.1%) or new beds with fresh sand planting medium (use up to 20 lb/acre at planting and no more than *a total* of 30 lb/acre for the season on those beds).

Twenty pounds of actual P is the amount in ~45 lb/acre P_2O_5 as expressed on the fertilizer bag, 15 lbs actual is ~35 lb/acre P_2O_5.

> Fertilizer bags show P (the middle number) as phosphate. To convert phosphate to actual P multiply by 0.44. For example, 100 lb of 13-13-13 has 13 lb phosphate (100 x 0.13) but only 5.7 lb of P (13 x 0.44). The Chart Book provides additional calculation examples.

If tissue test P is >0.12%, especially on native cultivars, reduction of annual P rates to 10-15 lb/acre is recommended. Reduce to even lower rates if tissue P remains >0.16%. The Chart Book provides guidance for tissue testing protocols to use in conjunction with P reduction.

Apply P in N-P-K fertilizer with high N:P ratios.

Since most growers apply P as part of N-P-K fertilizer and choose the rates for those materials based on N requirements, it is important to choose the correct ratio materials to avoid over application of P. The best materials have a 1:1 or 2:1 ratio of N:P. Popular examples that fit these ratios are 15-15-15 or 18-8-18. Even higher N:P ratios are acceptable for beds that have high N requirements and/or high tissue P.

The P in slow release N-P-K materials performed as well as soluble triple super phosphate in field plots, but sometimes at a higher material cost.

Do not apply P to wet soils; they are releasing P.

Classic cranberry bog soils have different soil P retention and release patterns depending upon how saturated the soil is. As the soil goes from the fully saturated conditions after the winter flood, through the wet conditions of spring and the frost protection season, to finally the relatively dry conditions of summer, the soil's retention of P increases and its ability to release this P decreases. For this reason, applying phosphorus to cranberries on traditional soils prior to roughneck stage is not a recommended practice. In the early season, the soil is already releasing phosphorus. Once the soil reaches seasonal dryness (late spring), P is only released if a certain threshold amount is present in the soil, indicating the need for fertilizer applications under those conditions. These recommendations mean that P can be applied with the same timing as N, in convenient N-P-K materials.

Sandy soils readily release P that had been previously applied and bound to the soil. However, the total P holding (and releasing) capacity of these soils is poor, indicating a need for low rate applications at frequent intervals. Uptake and release in sandy soils is not particularly dependent on flooding cycles (aerobic status). This likely explains the response to higher P rates on newly planted cranberry beds.

Monitor cranberry plant phosphorus status.

Use tissue testing to determine if the plants are getting sufficient P. Collect samples between August 15 and September 15. The sufficient range for P is 0.1 to 0.2%. If values are >0.12%, and you are applying 20 lbs/acre, plan to reduce P rates. If you have reduced P and tissue P remains >0.16%, further reduction (with continued testing) is recommended.

No commercially available soil test for P provides useful information for cranberry management. The most common test (Bray) tends to overestimate P availability since it dissolves bound P that is probably not soluble in native soil. When soil iron is >200 ppm, common in Massachusetts bogs, interference completely eliminates any predictive value of a soil test for P.

Recommended practices - other nutrients

Avoid excessive use of potassium (K).

K fertilizer is used to restore turgor (hydration of the vines) in the spring or at other times when vines are brittle and dry. K used for this purpose is often applied in combination with magnesium. Otherwise, K is applied in the N-P-K fertilizer growers use to support plant growth and crop production. To assure adequate K supply, common cranberry fertilizers include K in a 1:1 ratio with N. Seasonal rates of K applied to cranberry beds are in the range of 40-100 lb per acre. Field plot research did not show any measurable benefit to the addition of higher K rates. The sulfate form of K is preferable since research has shown that when K is applied as KCl, chloride may accumulate in the cranberry tissue.

Avoid unnecessary use of minor elements.

While cranberries require many other mineral elements beyond N, P, and K, typically these are in sufficient supply in the soil to satisfy plant needs. When testing shows that these other elements are lacking in the plants or in the soil, they are applied as needed. Calcium is applied as gypsum (calcium sulfate) since the addition of lime can raise the soil pH beyond the range suitable for cranberry production. Magnesium is added as Epsom salts (magnesium sulfate) or in combination with K (KMag, SulPoMag). Sulfur (as sulfate) is supplied as a component in N-P-K fertilizers (ammonium and potassium sulfates are common ingredients). Therefore, sulfur in the elemental form is not used as a fertilizer in cranberry production but may be used to lower soil pH if necessary.

Micronutrients (iron, manganese, zinc, copper) are very available in acidic soils. For this reason, cranberries seldom suffer micronutrient deficiencies, nor do they require micronutrient fertilizers in general. One exception is the use of micronutrient supplements in fertilizer blends during the first season of a newly planted mineral soil bog. Another exception is the use of calcium-boron supplements at bloom. For bogs with poor yield histories, such calcium-boron supplements may increase fruit set. On established beds, apply micronutrients based on tissue test results.

Recommended practices - New and Renovated Bogs

Nutrient management for establishment of new plantings is focused on the development of a good root system and on rapid growth of runners. Rapid plant establishment is key to limiting problems with weed infestations in the first two years after planting. However, extreme N rates may lead to problems with leaf diseases and with fruit rot diseases as the beds transition into production.

Plants need roots to take up fertilizer - time applications accordingly.

If you plant cuttings, they will not take up fertilizer until roots form. This usually takes 2-3 weeks. The only fertilizer that should be applied prior to rooting are slow-releases materials (these can go on about 1 week after planting) and P applied just prior to or at the time of planting to encourage rooting (limit to no more that 20 lb/acre). Be aware that some fertilizers can burn new roots.

If you plant rooted cuttings, applications may begin immediately. However, be aware that plug plants may experience transplant shock and appear dormant for up to 3 weeks after planting. With this in mind, applications other than slow release materials may be most effective if applied 2-3 weeks post-planting.

Choose slow-release fertilizer for part of the Year 1 requirement.

Slow-release N applied at the time of planting provides a sustained growth stimulation during stand establishment and may supply all fertilizer requirements for the year. In addition to a slow release application, additional N fertilizer added regularly throughout the first season can encourage rapid and even vining-in over the soil surface. However, remember that the planting sand does not hold fertilizer well. Slow-release materials overcome the tendency for nutrients to wash below the root zone. Other fertilizers, if used, should be applied at low rates every 10-20 days to avoid wash-through.

Limit use of 'complete' fertilizers on new beds.

It is a good practice to integrate some N-P-K fertilizer with N-only materials in Years 1 and 2. However, N-P-K choices should have no more than a 1:1 N:P ratio, higher P ratios are not necessary. Total P application in the first season should not exceed 30 lb/acre. Periodically including K is a good practice as K tends to move through the sand during the frequent irrigations required on new plantings.

Limit use of P to no more than 30 lb/acre in Year one, then transition to lower rates.

While P is important in rooting, after Year 1 the P requirement is substantially decreased. By Year 3, rates should be not exceed 20 lb/acre per season, similar to any producing bed.

Do not apply fertilizer after mid-August.

N applied late in the summer may lead to vine growth that is too sensitive to cold damage in the fall. Cease fertilizer applications no later than mid-August.

Reduce N use once vine cover is adequate to transition to fruit production.

By the end of the first year, runners should be about a foot long. The plants will have a good root system and will begin to tolerate drier conditions. Late water may help to encourage vining-in if used in the second season.

By the end of Year 2, the fertilizer applications should begin to transition towards those in a plan for established beds. By Year 3, the bog should be well established and should have received a light sanding. An established-bed fertilizer schedule should be used.

For further information:

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