2009 Elba Muck Soil Nutrient Survey Results Summary, Part II of III: Phosphorus, Potassium and Nitrogen

Christy Hoepting, Cornell Cooperative Extension Vegetable Program

Introduction

This is the second part of a three-part newsletter article that describes the general nutrient status of the Elba muck land, based on a survey conducted in spring of 2009. In response to a finding that the Elba muck land was a major source of pollution into its water shed, the Oak Orchard, delivering excessive amounts of phosphorus and nitrogen, free soil nutrient tests were conducted for Elba muck land growers in hopes that they would apply nutrients according to the needs of their soils. In total, soil samples were taken from 21 "fields" or "blocks" which were approximately 10, 25, 50 or 100 acres in size, and often consisted of several fields. Two to 20 sub-samples were taken per "field/block" for a total of 160 sub-samples. Samples were analyzed by the Cornell Nutrient Analysis Laboratory (CNAL).

All of these soil test results were summarized by Christy Hoepting, Onion Specialist, Cornell Cooperative Extension Vegetable Program (CCE-VP). In addition to phosphorus and nitrogen, all information from the soil tests including organic matter, pH, potassium and micronutrients, were reviewed and opportunities for improved nutrient management for onion production suggested. It is hoped that this will mark the beginning of collaborative efforts among onion growers, CCE-VP, SWCDs and EPA to reduce nutrient loading into the Oak Orchard and other water sheds, but also to improve onion yield and profitability by optimizing nutrient management.

In Part I of this article, opportunities for improved nutrient management were identified:

1) 13% of the soil sub-samples had less than 20% OM with the lowest reading being 2.4%. As OM decreased, pH increased. Some of this ground is being used to grow onions and should be managed more like mineral soil with respect to fertility and certain pesticide applications.
2) A shift towards higher pH has occurred in the Elba muck land: 65% of the fields/blocks had pH higher than the optimum. Above pH 5.8 to 6.0, manganese (Mn), zinc (Zn), boron (B) and phosphorus (P) are tied up and can become deficient.
3) It is not possible to reduce soil pH by applications of sulfur on the calcareous/marly muck soils of the Elba muck land. Instead, pH, Mn and P need to be managed by using acidifying fertilizers applied in a band and foliar sprays.

25% of fields had excessive levels of phosphorus - growers can cut P fertilizer for 3 years!

Phosphorus is an essential plant nutrient and occurs at very low levels in virgin muck. At one time, muck soils required judicious amounts of P fertilizer to produce healthy onions. Today, that is no longer the case. Research studies at Cornell on muck soil showed that the critical level of P, above which onion response to additional P would be unlikely, is 160 lbs per acre. According to the 2009 soil survey in Elba, 28.6% of the fields/blocks had available P that was higher than 160 lbs per acre (Figure 1). Since Cornell recommendations are conservative, the addition of 50 lbs per acre is recommended when soil P is 161 to 220 lbs per acre; in the Elba muck land soil survey only 5% of the fields/blocks fell into this category. However, 24% of the fields/blocks had more than 220 lbs of P with the highest recording of a sub-sample being 513

lbs per acre! In another Cornel study, a single 450 cwt onion crop grown in the Elba muck land removed only 22 lbs of P! When muck soils test very high (>220 lbs per acre), there may not be a crop response for at least 3 years. In these situations, a low rate of 20 lbs per acre of P in the band at planting is still recommended, as is continued soil testing on a yearly basis to accurately monitor soil nutrients.

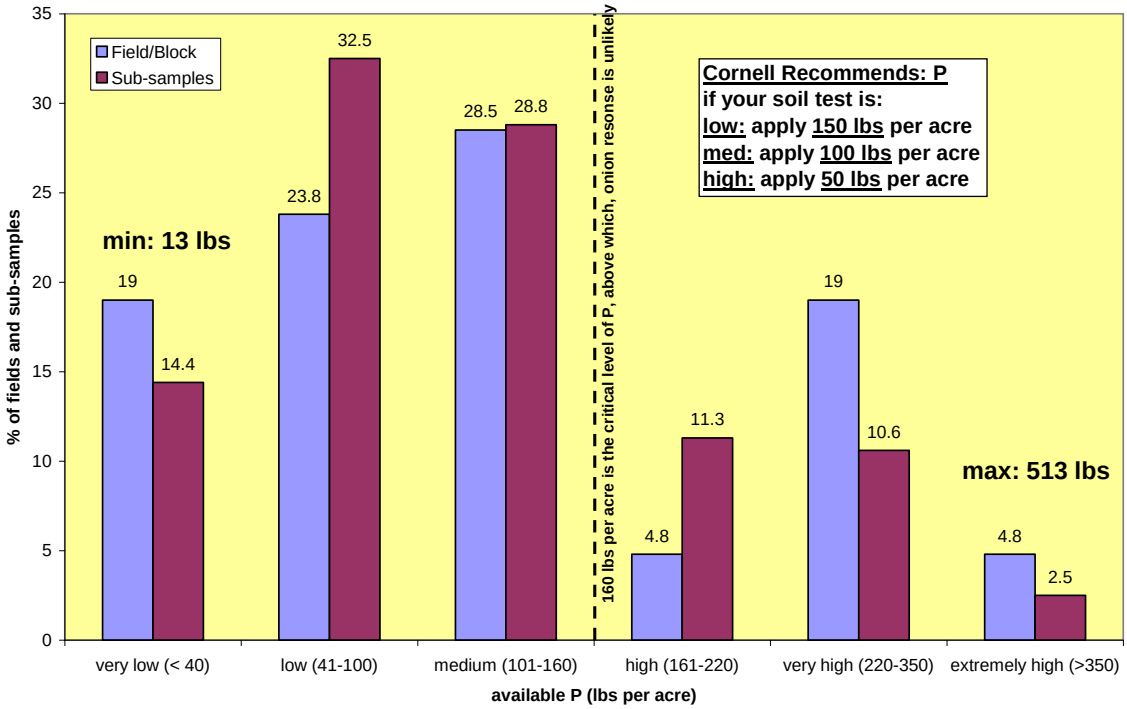

Figure 1. Soil survey, Elba muck, Spring 2009: Available phosphorus of 21 fields/blocks and 160 sub-samples.

Interestingly, the distribution of soil P levels in the Elba muck land in 2009 was similar to a survey of muck soils throughout New York State that was conducted in 1953 and 1954. In this study, 12% of the 573 samples had very low levels of P (compare to 19% in Elba 2009), 75% had low to medium levels (compare to 52% in Elba 2009) and 25% more than 179 lbs per acre (compare to 29% in Elba 2009). In 3% of the samples (compare to 4.8% in Elba 2009), available P was greater than 360 lbs per acre! In this study, 72% of the onion growers applied higher rates of P than were recommended. This begs the question whether onion growers are still applying higher than recommended rates of P 55 years later?

Very high soil phosphorus can also induce a zinc (Zn) deficiency, which has reportedly occurred in other muck lands. In the Elba muck land, however, the soil survey showed that the levels of Zn were generally very high, irregardless of P or pH. Details on Zn will be reported in Part III in next month's issue of *Veg Edge*.

Excess phosphorus pollutes waterways

When excess phosphorus is applied to muck soil, it is either absorbed by the soil or lost through leaching. Phosphorus may also find its way to waterways when it is attached to soil particles that are eroded by wind and water. The water monitoring project conducted by the Soil and Water Conservation District of Orleans County and SUNY Brockport in 2008-2009 reported

elevated levels of total phosphorus (eg. 5 to 12 mg/L) and soluble reactive phosphorus (eg. 1 to 2 mg P/L) from the Elba muck land. Too much phosphorus in the water encourages growth of green algae, which causes eutrophication of lakes. In turn, when bacteria eat the algae, they use up dissolved oxygen, suffocating fish and other aquatic life. Water that has more than 0.1 mg/L of total phosphorus is considered highly eutrophic. The windstorm of May 2009 in the Elba muck land, although undocumented, very likely resulted in a spike of P levels in the Oak Orchard water shed.

There is an obvious opportunity to reduce P fertilizer inputs by having soils tested regularly and only applying what the crop needs; in some cases, no P may be needed at all for several years. Also, keeping the soil in the fields by using wind breaks and cover crops whenever possible should be a high priority. Growing onions in a minimum tillage system may also be a viable option in some cases (look forward to an article on this in an upcoming issue of *Veg Edge*).

Watch out for phosphorus being tied up at low and high soil pH

Availability of P can be reduced below pH 5.0, as it binds to iron, and when pH is alkaline, bound by calcium. Phosphorus deficiency results in slow growth, delayed maturity, and a higher-than-normal proportion of thick necks. Leaves may show brown, yellow and green mottling, and dead leaves become blackened. In the Elba muck land soil survey, out of the 21 sub-samples where P was very low (< 40 lbs per acre), 18 (86%) of them occurred where the pH was greater than 6.0 (Figure 2). Of the 11 sub-samples where the pH was greater than 7.0, 9 (82%) had very low available P. On higher pH marly muck soils, P needs to be managed by banding an acidifying fertilizer and foliar sprays (see Part I in last month's *Veg Edge* for more info). Soils with pH lower than 5.2 should be limed to remedy a P deficiency.

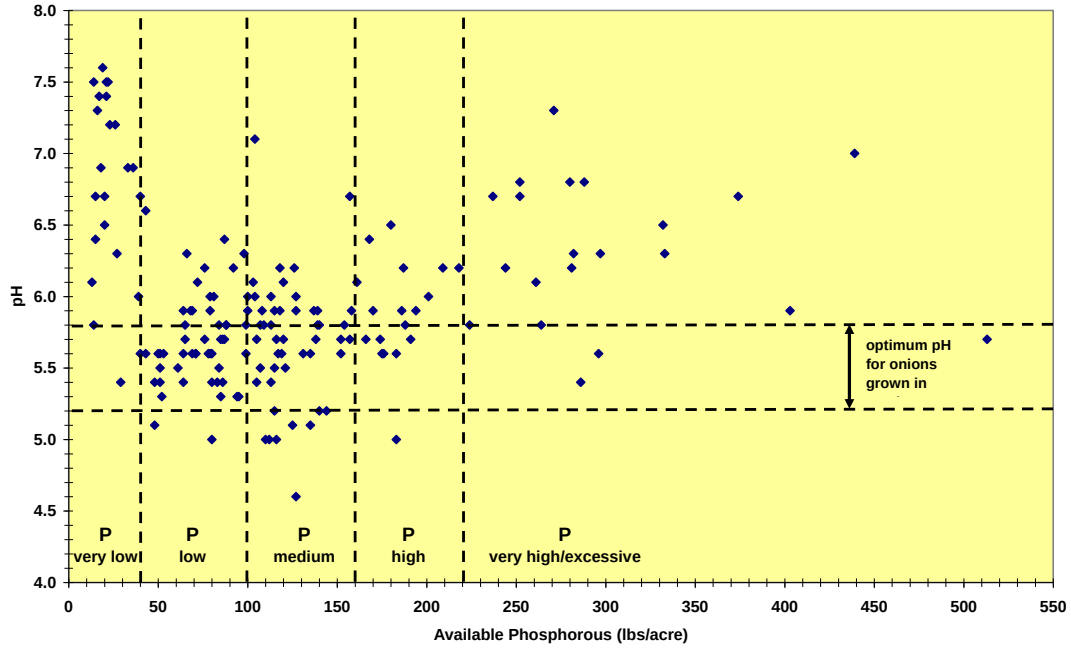

Figure 2. Soil survey, Elba muck, Spring 2009: Relationship between soil pH and available phosphorus for 160 individual sub-samples.

Soil levels of potassium are excessive – some fields won't need K inputs for a long time!

Potassium is an essential plant nutrient and occurs at very low levels in virgin muck. At one time, muck soils required judicious amounts of K fertilizer to produce healthy onions. Today, that is no longer the case. Research studies at Cornell showed that the critical level of K, above which onion response to added K would be unlikely, was 520 lbs per acre. According to the Elba soil survey, 81% of the fields/blocks exceeded this level of K (Figure 3). Since the Cornell recommendations are conservative, the addition of 50 lbs per acre is recommended when soil K is high (521 to 670 lbs per acre); in the Elba soil survey only 14% of the fields/blocks fell into this category. However, 43% of the fields/blocks had up to 1000 lbs of K, 19% had up to 2000 lbs of K and 5% had more than 2000 lbs of K with the highest recording of a sub-sample being 6790 lbs per acre!

In general, soil levels of K in the Elba muck land in 2009 were much higher than they were in a survey of muck soils throughout New York State that was conducted in 1953 and 1954. In this study, 41% of 572 samples had less than 500 lbs of K per acre (compare to 19% in Elba 2009), 44% had K levels between 500 and 1000 lbs per acre (compare to 57% in Elba in 2009), and 16% had more than 1000 lbs K per acre (compare to 24% in Elba in 2009). In 1953 and 1954, 54% of the growers reported using higher than recommended rates of K. Again, his begs the question whether onion growers are still applying higher than recommended rates of K 55 years later?

In another Cornell study, a single 450 cwt onion crop grown in the Elba muck land removed only 113 lbs of K! According to these figures, theoretically, it could take 10 to 60 years to use up all of the K available in some of the soils in Elba. Obviously, there is tremendous opportunity to save on input costs for onion growers in the Elba muck by reducing rates of K fertilizer, in some cases K fertilizer may not need to be applied for several years. Potassium levels can change more quickly than P, because it is more susceptible to leaching. Studies in Michigan have shown that 10 to 50% of available K can be lost by leaching from fall of one year through the following spring. Yearly soil testing is recommended to accurately determine the needs of the soil.

High levels of K may reduce Mg uptake due to competition for uptake sites on the plant roots. If the ratio of K: Mg is greater than 3, Mg could become deficient. In all of the 160 sub-samples, not one of them had a K: Mg ratio that was greater than 3 (data not shown). In fact, the majority of K: Mg ratios were less than 0.5, a result of very high soil levels of Mg in the Elba muck (see Part III in next month's issue of *Veg Edge* for more details on Mg).

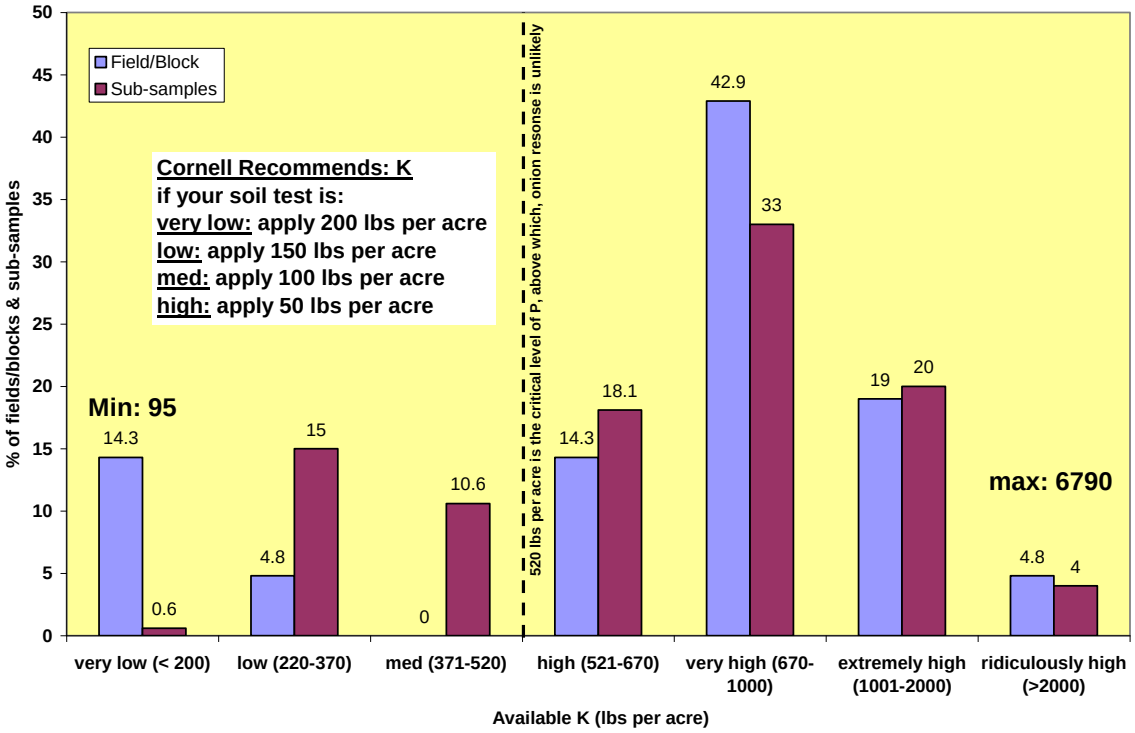

Figure 3. Soil survey, Elba muck, Spring 2009: Available potassium in 21 field/blocks and 160 sub-samples.

Much room for improving efficiency of nitrogen use in Elba muck land

Nitrogen is an essential plant nutrient. Ideally, one would hope to use just enough nitrogen (N) to ensure best quality and yield, but little extra. Nitrogen is soluble and very easily leached out of the soil into waterways, where it can serve as a pollutant. The water monitoring project conducted by SWCD of Orleans County and SUNY Brockport reported elevated levels of soluble nitrate (eg. 3 to 28 mg/L) and total nitrate (eg. as high as 37 mg N/L) from the Elba muck land. As a point of reference, the EPA maximum contaminant level of nitrate-N for drinking water is 10 mg/L. In 30 years of analyzing water samples, the scientists at SUNY Brockport had never seen nitrate levels so high! Such extremely high amounts of N detected in the waterways in the Elba muck land strongly suggest that excessive amounts of N are being applied to the crops.

In an early Cornell study, a single 450 cwt per acre onion crop grown in Elba removed 75 lbs of N. The Cornell recommendations are conservative, designed to meet the needs of 90% of the growers 90% of the time; 100 to 150 lbs per acre of N to be broadcast incorporated prior to planting. Extensive studies were conducted at Cornell that showed that 50 lbs per acre were sufficient on deep well-drained muck. In the spring of 2009, about 50% of the fields/blocks and sub-samples in the Elba muck land had less than 50 lbs of nitrate-N (Figure 4). Another 30% had 51 to 100 lbs of nitrate-N, from which an onion crop may or may not respond to additional N. Interestingly, 17.3% of the fields/block had greater than 150 lbs of nitrate-N with the highest recording of a sub-sample being 570 lbs! An oversupply of nitrogen early in the growing period may promote excessive top growth resulting in rapid bulb expansion and splitting. Late-season applications, which may promote excess top growth, delay maturity, and favor diseases such as Botrytis neck rot and bacterial bulb rot. Available N is such a moving target in the soil that

spring application of N fertilizer is not based on soil test results. However, it appears from this survey that there certainly is opportunity to reduce N inputs in the Elba muck land.

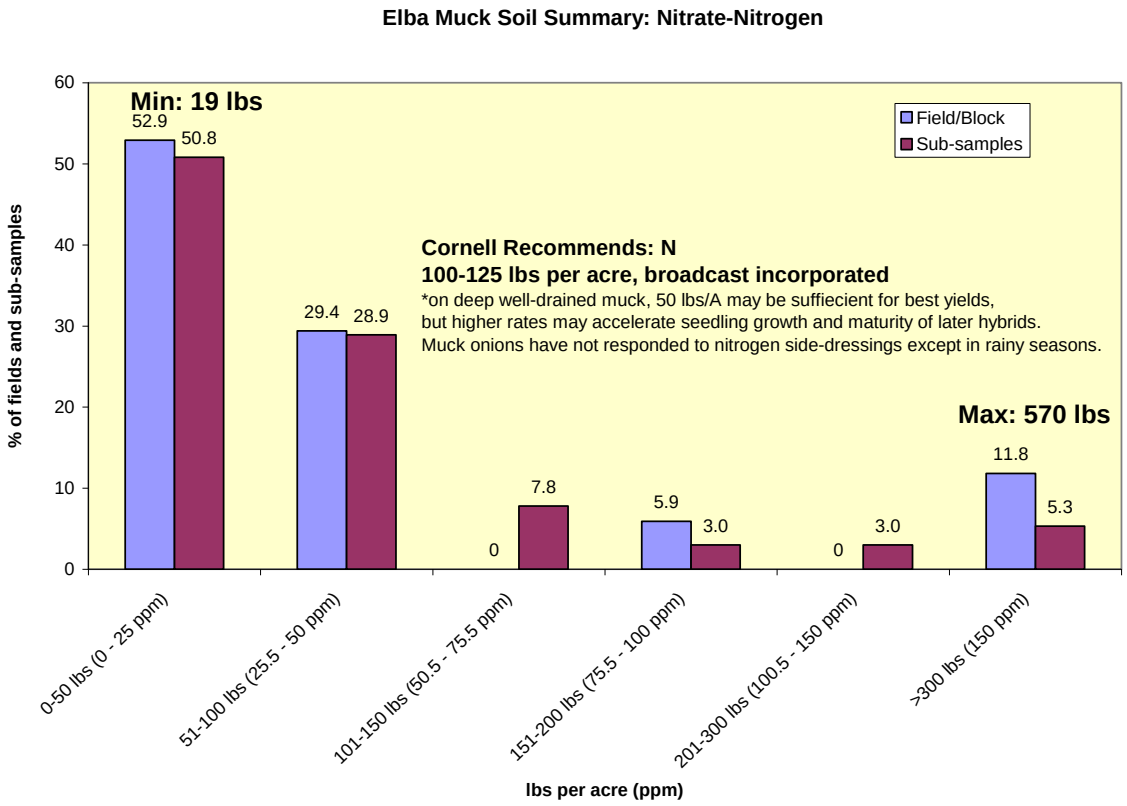

Figure 4. Soil survey, Elba muck, Spring 2009: Available nitrate-nitrogen of 21 fields/blocks and 160 sub-samples.

Cornell does not recommend side-dressing N for onions grown on muck, because N is released as organic matter decomposes during the summer months, a phenomenon that is limited in mineral soil, unless manure has been applied or legumes plowed down. The longer muck soils have been in production, the slower the decomposition of organic matter, and the less N that is available from the soil. Cornell studies also found that onions grown on muck seldom responded to nitrogen side-dressings, except during rainy seasons because of excessive leaching, and conversion to nitrous oxide when soils are saturated. Despite this, it is common practice for onion growers to side-dress nitrogen. In 2009, nitrate-N tests conducted at the time of N side-dressing on June 6 by Hoepting and Klotzbach in three fields in the Elba muck land showed 12.2, 37.5 and 135 ppm of available nitrate-N, which are equivalent to low, adequate and excessive levels of N, respectively. Such results demonstrate the potential of using pre-side-dress-nitrogen testing (PSNT) to optimize the efficiency of N inputs in onion production. In Michigan, PSNT testing has been very effective in onion production.

Other strategies to reduce loss of N include using split applications; apply 50 lbs per acre of N in the spring and side-dress more if PSNT deems it necessary. Experimenting with slow or controlled release fertilizers and nitrification inhibitors may also be worthwhile. A strategy to capture the nitrate-N that is left over in the soils after harvest is to plant a cover crop, such as

oats. The cover crop will take up the nitrate-N in the fall, and then release it back into the soil after it dies.

Summary:

- The Elba muck land has been identified as a major source of pollution into its local water shed, delivering excessive amounts of phosphorus and nitrogen.
- In response to these results, free soil nutrient tests were conducted for Elba muck growers in hopes that they would apply nutrients according to the needs of their soils. Together, the soil test results made an extensive database, the summary of which, is being presented in these three (Part I, II and III) newsletter articles.
- 25% of fields had excessive levels of phosphorus - growers could cut P fertilizer for 3 years!
- Phosphorous can become deficient where soil pH is greater than 7.0, which needs to be remedied by banding an acidified fertilizer and using foliar sprays.
- Soil levels of potassium were generally excessive with some fields not likely needing additional K inputs for several years.
- 17.3% of the fields/blocks had greater than 150 lbs of nitrate-N (recommended rate for broadcast incorporating in the spring is 100-125 lbs) available in early spring, with the highest recording of a sub-sample being 570 lbs!
- There is much opportunity to improve the efficiency of N use in onion production by using PSNT tests, experimenting with using less N fertilizer in the spring and adding more if necessary according to a PSNT, experimenting with controlled release fertilizers and nitrogen inhibitors, and planting cover crops in the fall to capture N that is not used up by the onion crop.

Word of caution about soil test results from different laboratories

Muck soil is unique compared to the more common mineral soils. There are several different tests that different soil testing laboratories use to measure the amounts of available nutrients to the same crop. Not surprisingly, different tests can give different results. In New York, fertility recommendations were derived by Cornell researchers based on studies conducted on muck soil in New York and soil test methods used by Cornell. Therefore, the recommendations and crop need match the soil test results. This summer, muck soil samples taken from the same field were sent to two different soil labs; one came back indicating available P was high and the other showed that it was low. This resulted from different analysis techniques; the accurate result was from the Cornell Nutrient Analysis Lab (CNAL), which is experienced in testing muck soils. As CNAL transitions to Dairy-One/Agro-One, extensive testing has been underway to calibrate the different testing techniques of each lab so that Cornell recommendations may be accurately applied to test results from Agro-One.

2009 Elba muck land soil survey results available

If there are any growers who would like copies of their soil test results, maps and recommendations, or for information on the database, contact Christy Hoepting (585-721-6953; cah59@cornell.edu). Look for "Part I: Organic Matter and pH" in last month's issue of Veg Edge and "Part III: Calcium, Magnesium and Micronutrients" in next month's issue of *Veg Edge*.