CORRELATIONS OF FERTILITY WITH YIELD

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Cranberry growers want to ensure that fertility is not a limiting factor for achieving the highest possible yields. In the fall of 2005 about fifteen Wisconsin cranberry growers shared some of their data from Stevens beds with the University of Wisconsin-Madison. These data were assembled into a single file and statistical correlations were made between yield and various measures of fertility. Data collected included the county where the marsh was located, data year, year planted, percent organic matter in the soil, estimated cation exchange capacity, years since last sanding, soil pH, soil test P, soil test K, tissue N, tissue P, tissue K, pounds of N applied, pounds of P_2O_5 applied, pounds of K_2O applied, and the number of applications of N, P, and K. A summary of the data is shown in Table 1.

Table 1. Summary statistics for grower data from 'Stevens' beds in Wisconsin. Mean is the average value. Median is the middle number with an equal number of observation above and below. R2 values describe the variation in yield described by variation in the parameter measured. P values describe the strength of the correlation. Small p values suggest strong correlations. $198 < n < 311$.

Variable	Min	Max	Mean	Median	r^2	p value
Year planted	1965	2001	1992			
Percent organic matter	0.1	10	1.73	1.1	0.043	0.0047
Cation exchange capacity	0.5	17	4	2.5	0.057	0.0012
Years since sanded	0	8	1.2	1	0.013	0.0612
Soil pH	4.1	6.8	5.1	5.0	0.024	0.034
Soil test P	6	476	165	122	0.011	0.159
Soil test K	0.2	361	87.6	74.4	0.043	0.0043
Tissue N	0.93	1.88	1.26	1.25	0.025	0.03
Tissue P	0.09	0.24	0.15	0.15	0.002	0.04
Tissue K	0.07	0.71	0.55	0.55	0.008	0.234
Pounds N applied	11	69	35.1	35.1	0.159	0.0001
Number of N applications	2	9	5	5	0.136	0.0001
Pounds P_2O_5 applied	26	154	73.5	75	0.051	0.0001
Number of P_2O_5 applications	1	9	4.7	5	0.03	0.0056
Pounds of K_2O applied	28.5	347	162	168	0.149	0.0001
Number of K_2O applications	1	11	6.9	7	0.104	0.0001
Yield	17	439	233	233		

The data shown in Table 1 document that there is great variation in grower practice in the application of fertilizer and there is great variation in the results. Correlations between yield and factors that should, to some extent, determine yield

produced interesting results. Strong correlations do not necessarily mean cause and effect relationships. Further, the fertilizer correlations are not independent because most growers apply complete N-P-K fertilizers so increases in one element are not independent of increases in others.

This article will go through the macronutrients: Nitrogen, Phosphorus, and Potassium and describe the correlations that exist between them and yield and will provide some interpretive comments.

Nitrogen

Nitrogen is perhaps the most important element provided to cranberry vines as fertilizer. While there is a positive relationship between tissue N and yield and between pounds of N applied and yield, the r^2 values are still quite low (0.025 and 0.159, respectively). The p value for tissue N was barely significant. The data suggest that while increases in N do lead to increases in yield, the potential increases are modest. Increasing N applied led to increases in tissue N. However, only about 12% of the variation in tissue N was related to the pounds of N applied suggesting that other factors are also important.

These data for 'Stevens' vines do show that virtually all growers have tissue N in excess of 1.1%. This suggests that 'Stevens' vines can at least tolerate if not benefit from increased tissue N concentration. Therefore, we are increasing our tissue N guidelines for 'Stevens' vines so the sufficient range would be 0.9 to 1.3%. This does not change our guidelines for non-hybrids such as 'Searles' and 'Ben Lear'. Also, this increase in the guidelines reduces the margin for error in managing nitrogen. If one overshoots the target by just a little bit the opportunity for vine overgrowth leading to reduced yields is substantial.

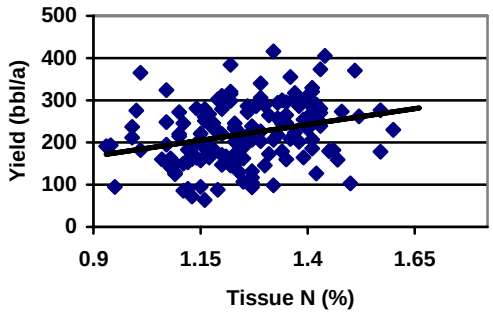

Figure 1. The relationship between tissue N and yield for Stevens cranberries in Wisconsin.

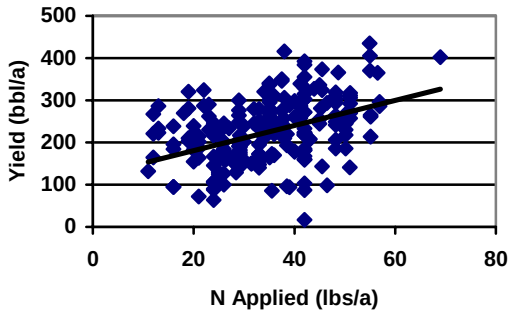

Figure 2. The relationship between pounds of N fertilizer applied and yield in Stevens cranberries in Wisconsin.

Phosphorus

Phosphorus is an important mineral element, but it is also an important pollutant of fresh water ecosystems. Anything that growers can do to reduce the potential of phosphorus leaving their marsh in water will reduce the threat of pollution to associated fresh water bodies.

Tissue P is not a strong predictor of yield in cranberries. While there was a positive relationship the slope is very shallow and the p value is large. There was no relationship between soil test P and yield in this data set. However, because we did not know which lab did the analytical work reported we don't know what soil test method was used. This is at least one reason for the bimodal distribution in Figure 4. The lower soil test P values are likely Bray and the higher values are likely Mehlich. Figure 5 shows the relationship between Bray soil test P and tissue P. In these data soil test P is still not a strong predictor of tissue P. Pounds of P_2O_5 applied was a stronger predictor of yield than tissue or soil test P. However pounds of P fertilizer is not independent of applied N and K. There is not strong evidence that increasing applications of P will lead to higher yields. Virtually all of the samples represented by the data in Figures 3 and 5 show tissue sufficiency in P. Similar results were found in an analysis of samples submitted to the UW Soil and Plant Analysis Lab (Fig. 5). High rates of application of P_2O_5 have not led to high tissue P suggesting other factors are involved.

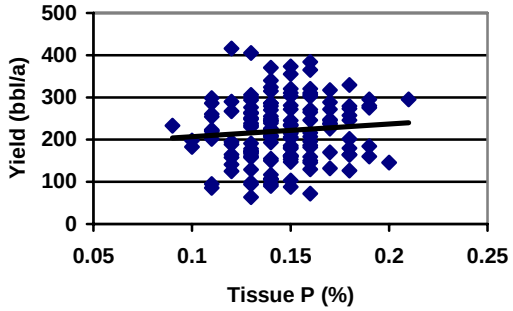

Figure 3. The relationship between tissue P and yield in 'Stevens' cranberries in Wisconsin.

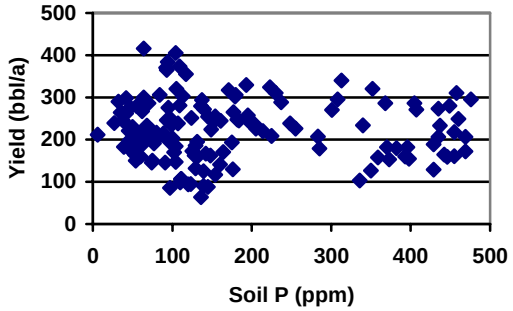

Figure 4. The relationship between soil test P and yield in 'Stevens' cranberries in Wisconsin. This is not a statistically significant relationship.

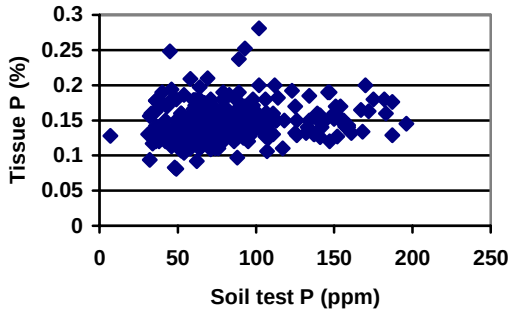

Figure 5. The relationship between soil test P (Bray 1) and tissue P in 200 cranberry samples submitted to the UW Soil and Plant Analysis Lab, 2002-2004.

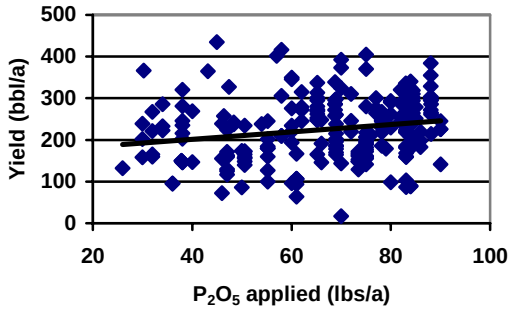

Figure 6. The relationship between applied P_2O_5 and yield in 'Stevens' cranberries in Wisconsin.

Potassium

Potassium is an important mineral element for all fruit crops. However, growers may be overemphasizing the importance of potassium. In a 400 bbl/a crop only 35 pounds of potassium are removed in the crop. [40,000 lbs x 12.5% dry matter= 5,000 lbs dry matter x 0.7% potassium in fruit = 35 lbs K/a].

Both tissue K and soil test K had a negative relationship with yield, particularly soil test K. This may be the results of too much K in the soil, but it may also be related to chloride injury if the chloride form of potassium is used or it may simply be a salt effect. This may also reflect the effect of other soil parameters that also influence the ability of a soil to retain K such as K content and organic matter content. There was a positive correlation between K fertilizer applied and yield, however since most fertilizer is applied as a complete N-P-K this may simply be residual effects from N and P. It is impossible to segregate these effects in this dataset.

There was not a significant relationship between soil test K and tissue test K. Thus, increasing soil K did not lead to higher tissue levels. Virtually all samples in this dataset were within the guidelines of 0.4 to 0.7%.

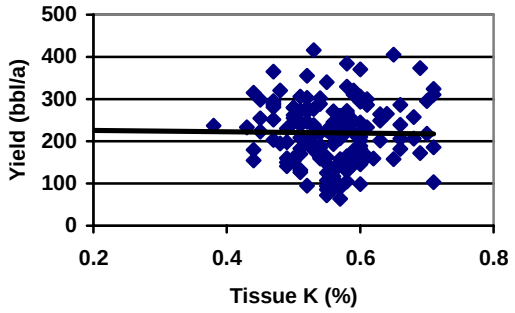

Figure 7. Relationship between tissue K and yield in 'Stevens' cranberries grown in Wisconsin.

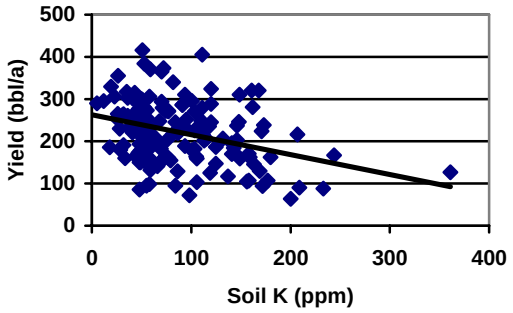

Figure 8. The relationship between soil test K and yield in 'Stevens' cranberries grown in Wisconsin.

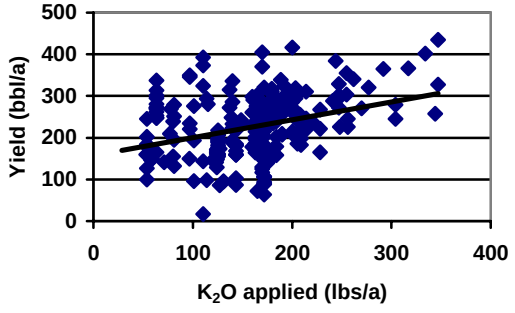

Figure 9. The relationship between the amount of K_2O fertilizer applied and yield in 'Stevens' cranberries in Wisconsin.

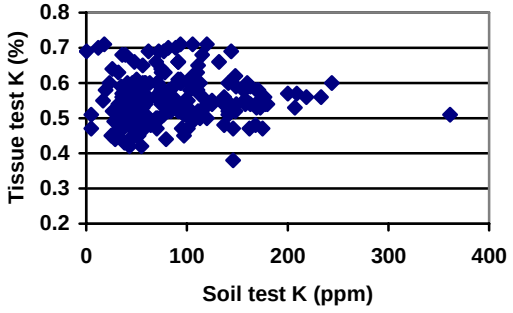

Figure 10. The relationship between soil test K and tissue test K for 'Stevens' cranberries grown in Wisconsin.

If yield is negatively related to increasing soil potassium, perhaps it is useful to consider what affects soil potassium. The amount of potassium fertilizer applied had a positive relationship with soil test potassium, but this was not a strong correlation (Figure 11). The best correlation with soil test potassium was cation exchange capacity (Figure 12). This is not surprising since potassium is a positively charged ion (cation). The other soil factor that correlated well with potassium was percent organic matter in the soil (Figure 13). This suggests very strongly that a large fraction of the ability of soil to retain and exchange cations resides in the organic fraction of cranberry soils (Figure 14).

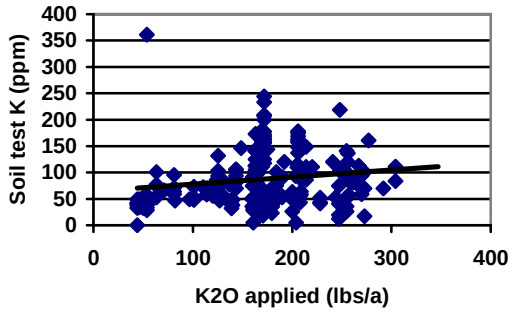

Figure 11. The relationship between applied potassium fertilizer and soil test K for 'Stevens' cranberries grown in Wisconsin.

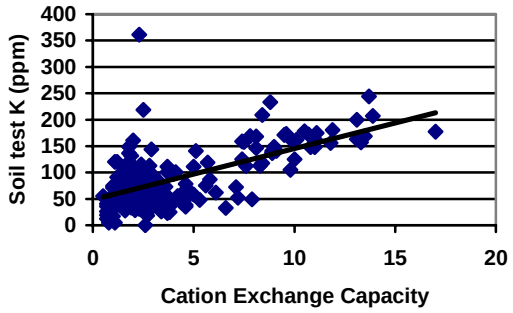

Figure 12. The relationship between estimated cation exchange capacity and soil test potassium in Wisconsin cranberry soils.

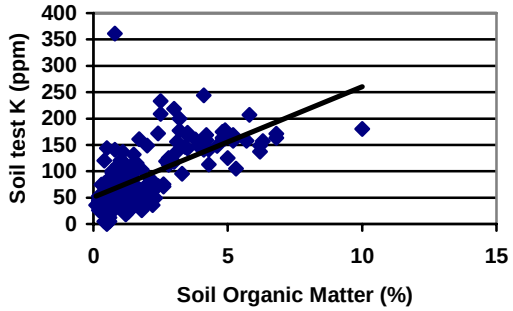

Figure 13. The relationship between soil organic matter and soil test potassium in Wisconsin cranberry soils.

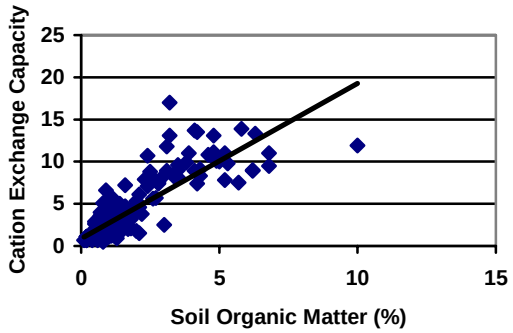

Figure 14. The relationship between soil organic matter content and estimated cation exchange capacity in Wisconsin cranberry soils

Summary.

In summary there were generally positive correlations between the amount of fertilizer applied and yield, but not between tissue test levels and yields for N-P-K examined in this study. Drawing conclusions from the fertilizer application data is

troublesome because the data for individual elements are not independent from the other two elements since most growers apply complete products containing N-P-K.

One important weakness of the data included in this analysis is that there was no control. None of the data represented beds that had received no fertilizer. Further, virtually all of the samples included in this study were in the sufficient range for N, P, and K. Because all samples were in the sufficient range increases in yield resulting from additional applications of fertilizer are negligible. Figure 15 shows a normalized response curve for crops to either increasing fertilizer application or increasing tissue concentration of a critical element.

These data do not justify growers being able to apply N-P-K fertilizers at amounts substantially higher than those rates in guidelines published by the University of Wisconsin-Extension.

Figure 15. A generalized yield response curve for application of fertilizer or mineral nutrition status of crop plants. The aim in designing fertility programs is to achieve and maintain tissue sufficiency. Once in the sufficient zone adding more fertilizer does not lead to significant increases in yield.