Phosphorus Research: What we've learned so far

Teryl R. Roper
Dept. of Horticulture
University of Wisconsin-Madison

Phosphorus (P) is one of 13 mineral elements required for plants to grow, develop, and reproduce. It is involved in energy capture, transport, and utilization as well as in membranes, proteins, and genetic materials. Phosphorus is also potentially an environmental contaminant. It is often the limiting factor for algae growth and the growth of aquatic weeds. Balancing the agricultural requirement for phosphorus while protecting aquatic environments is the challenge for cranberry growers. This article will outline some reports from the literature, Wisconsin yield trials, and water sampling results.

The landmark research dealing with the phosphate needs of cranberry vines was done in Massachusetts by DeMoranville and Davenport (1997). They examined forms, rates, and timing for application of phosphorus containing fertilizers on cranberry yields. They conducted trials for three years at six properties before reporting the results. While their research was conducted in Massachusetts, I believe that the results apply equally well to Wisconsin conditions.

Forms. They looked at phosphorus in three different forms plus combinations including triple super phosphate (TSP), phosphoric acid, rock phosphate, inorganic 10-20-10, fish fertilizer, chicken manure, bone meal, 14-14-14, and Osmocote slow release fertilizer. TSP breaks down quickly into phosphate ions as does phosphoric acid. Rock phosphate is relatively insoluble and breaks down to phosphate slowly. The rate of release is likely related to soil pH and moisture. 10-20-10 and 14-14-14 contain phosphate as monoammonium phosphate and/or TSP and is readily soluble. Results of this research are shown in Tables 1 and 2.

Comparing the inorganic sources in Table 1, there were no differences among the products or combinations for yield. All had higher yields than the control. Tissue P was also similar among the products (data not shown). Subtle differences were noted between the inorganic, organic, and slow release products. However, all were better than no P. Rock phosphate and rock phosphate plus phosphoric acid were better than chicken manure or fish fertilizer. All other treatments were roughly equal in terms of yield or tissue P.

Rates. Phosphate as TSP was applied at four different rates: 0, 46, 92, or 137 pounds of P_2O_5 per acre. The fertilizer was applied in equally split amounts at roughneck, bloom, fruit set, and bud set. Yield was determined by harvesting rings with 2 x 2 meter plots. Plots receiving fertilizer had higher yields than unfertilized plots (Table 3). However, yield did not increase as fertilizer application increased above 46 lbs P_2O_5/a. This strongly suggests that 46 lbs P_2O_5/a is the optimal rate for P fertilization for cranberries. As P applications increased tissue P also increased, but yield did not increase along with P applications.

Timing. Plots received different rates of fertilizer at different timings. When the effect of fertilizer rate was factored out there was no effect of the timing of application on yield (data not shown).

Wisconsin Yield Trials

Over the past three years we have conducted a similar trial in Wisconsin. We wanted to pinpoint with more accuracy the optimal rate of P application for cranberries under Wisconsin conditions. We primarily used TSP, but we have also evaluated an inorganic slow release product. Rates of N and K were identical for all treatments. We have found no differences in yield as either fruit number or weight per 6" ring at either of two properties so far (Table 4). We did find some differences in tissue P at Marsh 1. However, note again that increasing tissue P with increasing fertilization did not lead to higher yields.

Water Sampling

Over the past three seasons we have monitored the phosphorus concentration in water in inlet and outlet water at two cranberry marshes in central Wisconsin. Marsh 1 is an older property with peat based beds. The inlet samples were taken in the reservoir while the outlet samples were taken in a major drainage ditch that exits the property. Marsh 2 is a newer property with sand based upland beds. The inlet samples were taken in a stream that supplies water to the property while the outlet samples were taken in a drainage pond or ditch. Samples were collected using autosamplers at each location. Water samples were pulled every 12 hours and then pooled across a week. Data are shown by week. Results are shown in Figures 1-3.

On only one sampling date across the three years did P in any sample exceed 1 ppm. This was also associated with having drawn algae into our sample bottles. We did find some P in outlet water for Marsh 1 on many dates, particularly later in the season during 2002 and 2003. Marsh 1 generally showed inlet and outlet water with less than 0.2 ppm P.

These data show that some P is leaving some properties in drainage water. While the concentrations are very low, when this is multiplied by a substantial amount of water moving through a property the total amount of P may be environmentally significant.

Conclusions

The data presented here strongly suggests that growers can reduce the amount of P fertilizer they apply while still maintaining high yields. There is no general relationship between tissue P and yield when fertilizer application exceeds 46 lbs P_2O_5/a and tissue P is above 0.1%. We urge growers to think carefully about the amount of P fertilizer they apply and to make every effort to reduce introducing phosphate into the environment.

Table 1. Comparison of soluble, insoluble and foliar P forms applied to field grown cranberries. Data collected after three successive years of treatments. All materials were applied each year at the rate of 40 lbs P_2O_5/a. Mean separation within columns by Tukey's HSD test.

Product	Yield (bbl/a)
Triple super phosphate	175 a
Phosphoric acid (foliar)	163 a
Phosphate rock	176 a
Rock + foliar	175 a
Rock + TSP	182 a
Control	124 b

Table 2. Comparison of inorganic, slow release, and organic forms of P applied to field grown cranberries. Data collected after three successive years of treatment. Mean separation within columns by Tukey's HSD test.

Product	Yield (bbl/a)	Shoot P (%)
Inorganic 10-20-10	173 ab	0.098
Fish (2-4-2 liquid)	137 bc	0.083
Phosphate rock	193 a	0.078
Osmocote	173 ab	0.071
Inorganic 14-14-14	163 ab	0.084
Chicken manure (3-4-3)	146 bc	0.085
Bone meal (4-12-0)	160 abc	0.081
Rock phosphate + foliar	190 a	0.078
Osmocote + foliar	162 ab	0.083
Control	124 c	--

Table 3. Comparison of four rates of phosphorus applied to field grown cranberries. Data collected after three successive years of treatment. Mean separation within columns by Tukey's HSD test.

Rate (lbs P_2O_5/a)	Yield (bbl/a)	Shoot P (%)
0	136 b	0.123 c
46	170 a	0.136 b
92	156 a	0.148 a
137	164 a	0.152 a

Table 4. Comparison of rates of triple super phosphate and polyon on two cranberry marshes in Wisconsin. Data were collected after 3 years of treatments. Mean separation within columns by Duncan's MRT following a significant F-test.

Treatment	Marsh 1			Marsh 2		
# P_2O_5/a	Fruit no.	Weight (g)	Tissue P (%)	Fruit no.	Weight (g)	Tissue P (%)
Control 0	144	218	0.140 a	53	74	0.125
5 TSP	146	230	0.146 ab	48	63	0.130
10 TSP	173	269	0.153 abc	60	84	0.134
15 TSP	144	222	0.159 bc	47	68	0.157
20 TSP	181	269	0.158 bc	47	63	0.142
30 TSP	139	217	0.156 bc	40	57	0.143
10 Polyon	158	239	0.155 bc	38	52	0.135
15 Polyon	152	239	0.160 bc	48	69	0.128
20 Polyon	134	207	0.163 cd	35	50	0.147
30 Polyon	146	228	0.175 d	36	46	0.158

Figure 1. Results of water sampling above and below two Wisconsin cranberry marshes during 2001. Samples were taken every 12 hours using an autosampler and were subsequently pooled across weeks.

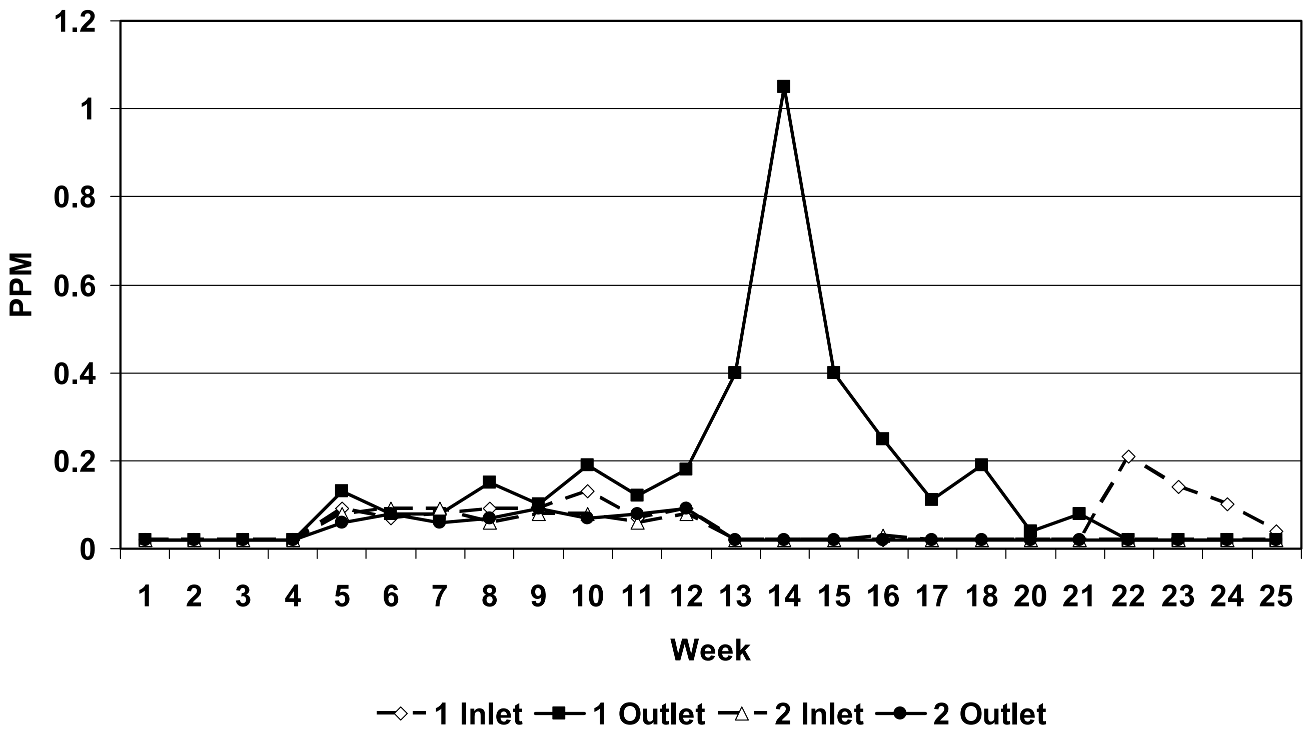

Figure 2. Results of water sampling above and below two Wisconsin cranberry marshes during 2002. Samples were taken every 12 hours using an autosampler and were subsequently pooled across weeks.

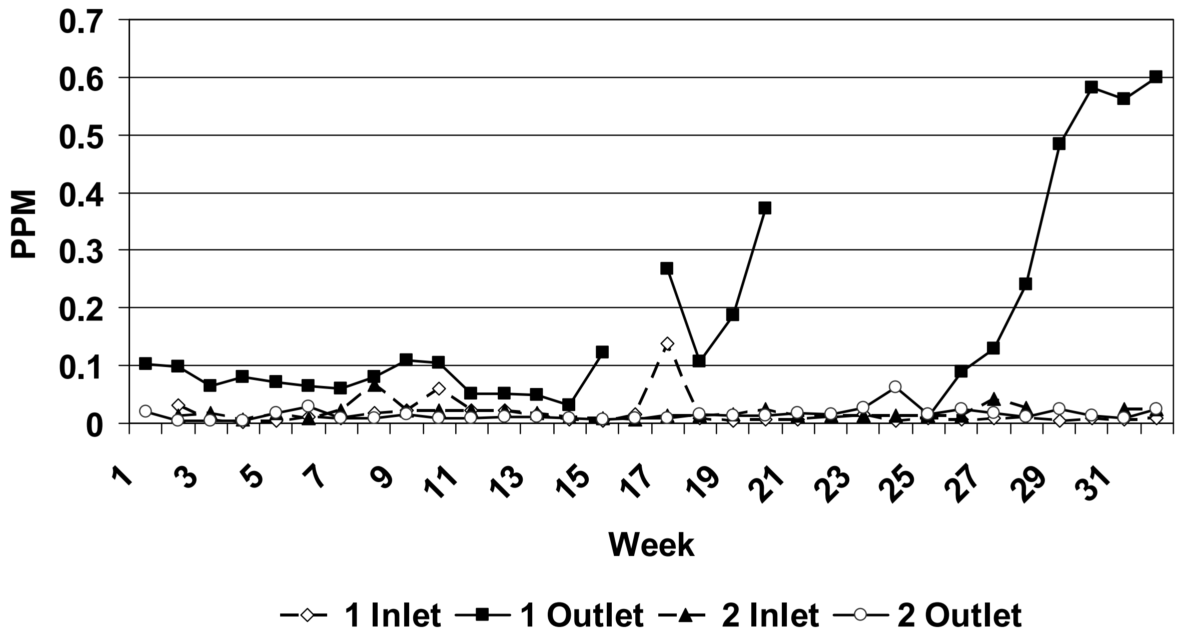

Figure 2. Results of water sampling above and below two Wisconsin cranberry marshes during 2002. Samples were taken every 12 hours using an autosampler and were subsequently pooled across weeks.