EFFICIENT PHOSPHORUS MANAGEMENT IN COASTAL VEGETABLE PRODUCTION

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Introduction

Decades of heavy phosphorus fertilizer application to vegetable fields in the Salinas and Pajaro Valleys have resulted in substantially increased soil P concentration. Soil test P levels frequently exceed the threshold for expected crop response to continued P fertilization; however, many growers continue to apply P to such fields. While this generally does not cause agronomic problems, it may be a significant contributor to the undesirably high P concentration found in the Salinas and Pajaro River systems. Parts of both watersheds have been listed by the California EPA as 'impaired' for soluble nutrients, based on the prevailing Federal water quality standards. This project was undertaken to reevaluate the current P management recommendations for lettuce production in light of this potentially serious environmental problem.

Objectives

1) Develop efficient P fertilizer guidelines for coastal lettuce production
2) Document the relationship between soil characteristics, soil test P levels, and potential loss of P through in runoff.

Methods

To determine the current P status of agricultural land in the Salinas and Pajaro Valleys, soil from 30 fields, most in long-term vegetable rotations, was collected in spring, 2002 (Table 1). The fields, located in Monterey, San Benito, Santa Clara and Santa Cruz Counties, represented both conventionally farmed and organically managed land. These soils will be used in a study designed to correlate the soluble and total P concentration of runoff water (from rain or irrigation) with the soil test P value and soil hydraulic properties. The intent is to provide a simple system by which growers can rank their fields for P runoff potential, so that remedial actions can be targeted where they would do the most good.

Six trials were conducted in commercial lettuce fields in the Salinas Valley in 2002 evaluating whether P fertilization in fields with moderate or high soil test P levels actually affected crop productivity. The fields chosen varied from 54 – 171 PPM bicarbonate P (top 6 inches of soil, Table 2). Existing recommendations rank these field as moderate (fields 1 and 3) or high P availability (fields 2,4,5 and 6). A strong crop response to preplant P fertilization would not be expected, based on prior research with cool-season vegetables. In fields 3 and 5 the grower did not apply P fertilizer; we established 4 plots within each of these fields which received a preplant fertilization with 130 lb P_2O_5 / acre. In all other fields the growers applied P, and we established 4 plots per field in which this P application was skipped. The experimental design was randomized complete block, with each plot being 4 beds wide and 200 feet long. All data were collected in the middle 100 feet of each plot, from the middle two beds.

Plant P status was monitored by biweekly sampling through the crop season, including at harvest. Plots with and without P fertilization were photographed on a biweekly basis with a digital infrared camera; these images allowed calculation of the percent of ground covered by the plant canopy, an objective, non-destructive measure of plant vigor. Prior to commercial harvest, 30-40 whole plants per plot were selected at random and weighed to compared total plant biomass between treatments. Where practical, data on marketable yield and head size distribution was collected by working with the commercial harvest crew. Where that was not possible, selected plants were trimmed to simulate commercial harvest, and the marketable yield of the treatments were compared.

Results

The soils collected in the field survey ranged from 14 – 196 PPM bicarbonate extractable phosphorus, averaging 78 PPM (Table 1). To put these numbers into context, soils from the Sacramento Valley that have been farmed for an equivalent period of time typically range from 10-25 PPM bicarbonate P. The difference reflects the higher application rates, and more frequent application, of P fertilizers in the coastal valleys. Despite these high soil test P values, many coastal vegetable growers continue to apply P before each crop, and a substantial number also apply P in sidedressings.

In the first trial, planted in early April, significant response to preplant P was observed (Table 3). This was somewhat surprising, since the soil bicarbonate P level was 54 PPM, above the response threshold cited in most references. Early planting (cold soil temperature) was undoubtedly a factor, since P bioavailability is reduced at lower soil temperature. Field 2 was planted only a week later, but had substantially higher soil test P (124 PPM). As expected, production in plots in which preplant P was skipped was equivalent to the grower's standard P application. Fields 3 and 4 had intermediate soil test P levels, and neither showed significant crop response to P fertilization. Fields 5 and 6 also showed no crop response to P fertilization; not only did both fields have high soil test P, they were planted during the warmest part of the season.

In the first trial (the only responsive field) there was a consistent trend toward slightly smaller plants in the 0 P plots, based on the infrared camera images. These differences were apparent at thinning, and were maintained throughout the growing season (Fig. 1). Preplant P apparently functioned mostly to maximize early seedling growth; once a substantial root system was established, the field soils had sufficient P availability to maximize crop growth, and all plots grew at a similar rate. This implies that a low rate, at-planting P fertilizer application (a phosphoric acid overspray, for example) might provide the same crop response as a heavier preplant application. This would be environmentally desirable, since it would minimize further P loading in these soils.

P application had minimal impact on tissue P concentration in any field at any time in the cropping cycle (Table 4). Leaf P concentration was well above current sufficiency standards in both P treatments in all fields. This reinforces the conclusion that heavy preplant P application is not an efficient practice in soils with moderate to high soil test P levels. In several non-responsive fields, mid-season midrib PO_4-P concentration in plots with and without P was below commonly cited sufficiency levels (usually considered to be 2,000 – 3,000 PPM), suggesting that these standards need to be reevaluated.

In summary, soil P levels in the coastal vegetable production areas are high enough to potentially contribute to surface water quality problems. Continued P fertilization of high P soil is an inefficient practice, particularly for fields planted when soils are warm. Even for spring planted fields there may be a more environmentally benign, and more cost effective, approach than the conventional preplant application.

Table 1. Soil test bicarbonate P content (PPM) of survey fields.

Field	Location	Management type	Bicarbonate P (PPM)[z]
1	King City	conventional	14
2	King City	conventional	18
3	King City	conventional	30
4	Hollister	organic	33
5	Santa Cruz	organic	34
6	Salinas	conventional	36
7	Morgan Hill	conventional	40
8	San Juan Bautista	organic	41
9	Gilroy	conventional	42
10	San Martin	conventional	42
11	Gonzales	conventional	47
12	King City	conventional	54
13	King City	conventional	58
14	Salinas/Buena Vista	conventional	65
15	Gilroy	conventional	65
16	Greenfield	conventional	77
17	Salinas	conventional	78
18	Chualar	conventional	79
19	Greenfield	conventional	80
20	Salinas/Buena Vista	conventional	85
21	Morgan Hill	conventional	87
22	Hollister	organic	92
23	Gilroy	conventional	93
24	Soledad	conventional	95
25	Watsonville	conventional	124
26	Castroville	conventional	126
27	Chualar	conventional	149
28	Salinas	conventional	185
29	Santa Cruz	organic	188
30	Santa Cruz	organic	196

[z] top 6 inches

Table 2. Characteristics of the 2002 field trial sites.

Field	Location	Bicarbonate extractable soil P (PPM)[z]	Lettuce type	P application rate (lb P_2O_5 / acre)	Planting date[y]
1	Salinas	54	Head	59	April 3
2	Salinas	124	Head	60	April 11
3	Soledad	55	Romaine	130	May 11
4	Chualar	72	Head	42	June 12
5	Chualar	171	Head	130	July 15
6	Chualar	78	Romaine	72	July 26

[x] top six inches of soil
[y] date of first water

Table 3. Lettuce response to P fertilization.

Field	P treatment (lb P_2O_5 / acre)	% of plants marketable	Whole plant wt (lb)	Marketable plant wt (lb)	Boxes 24s / acre
1	0	81[z]	2.15[z]	1.46 [z]	847 [z]
	59	87	2.29	1.56	751
2	0	93	2.42	1.58	1020
	60	95	2.52	1.57	1018
3	0		1.55	1.07	
	130		1.65	1.08	
4	0	84	2.56	1.66	
	42	83	2.64	1.70	
5	0	75	1.55	1.06	
	130	77	1.56	1.08	
6	0		1.21	0.90	
	72		1.17	0.88	

[z] significantly different from the applied P treatment

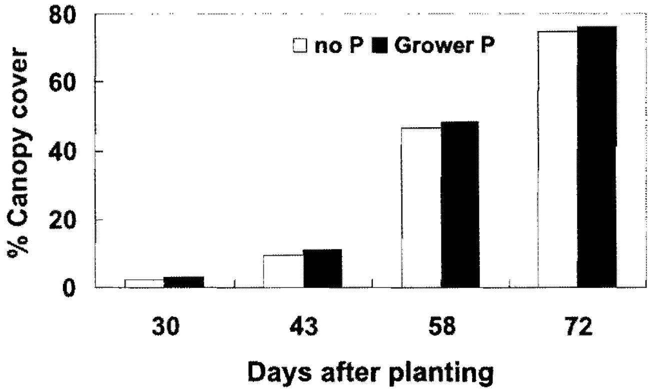

Fig. 1. Canopy cover development in field 1.

Table 4. Effect of P fertilization on lettuce tissue P concentration.

Field	P treatment (lb P2O5 / acre)	At thinning % leaf P	At heading % leaf P	At heading PPM midrib PO_4-P	At harvest % leaf P
1	0	0.42	0.43	1370	0.64
	59	0.42	0.43	1250	0.66
2	0	0.35	0.48	1620	0.68
	60	0.35	0.51	1600	0.71
3	0	0.39	0.37	840	0.38
	130	0.41	0.40	830	0.42
4	0	0.50	0.51	3480	0.78
	42	0.50	0.53	3440	0.81
5	0	0.54	0.44	2480	0.55
	130	0.59	0.49	2760	0.59
6	0	0.54	0.56	1430	0.56
	72	0.52	0.56	1490	0.56