**Phosphorus Fertilizer Evaluations on Head Lettuce in the Salinas Valley**

University of California Cooperative Extension, Monterey County
Richard Smith, Tiffany Bensen, Husein Ajwa and Susanne Klose

**Background:** Concerns about soil phosphorus (P) levels came to the attention of the agricultural industry in the Salinas Valley about five years ago as the Regional Water Quality Control Boards began to discuss enforcement of Total Maximum Daily Load (TMDL) levels of waters coming from agricultural fields. Through careful fertilization of the crops in the Salinas Valley we have unwittingly built up phosphorus levels in valley soils (see Table 1). The common P levels found in Salinas Valley soils can lead to elevated levels of phosphorus in drainage waters, side creeks, and ultimately, the Salinas River. High P levels in these surface waters can stimulate excessive algal growth that can reduce oxygen levels in the water and impact water quality.

Phosphorus is a critical element for plant growth. It has complex soil chemistry and its availability is related to soil temperature, pH, sorption on clay and iron oxides, and interactions with secondary soil minerals such as calcium and iron phosphates. These factors generally keep phosphate in the soil solution at low levels. In general phosphorus is tightly bound in the soil, but if the secondary minerals become overloaded with phosphorus, it can leach deeper into the soil profile where it is captured by drain tiles. Phosphorus is also moved from agricultural fields on sediments in runoff.

Soil tests provide the best measure of available P for crop growth. Recommended soil levels for cool season vegetables were in the range of 35 to 40 ppm bicarbonate extractable P (Olsen test). Salinas Valley soils are often above this range (Table 2). In trials conducted in 2002-2003 on 12 Salinas Valley fields by Dr. Tim Hartz, Extension Vegetable Specialist only one site showed an increase in yield from P fertilization. Extractable P at this site was 54 ppm and the lettuce was produced in the early part of the production season when the soils were cold, a time when soil P is less available for crop growth. This study indicates that there may be a need for P fertilization on sites <55 ppm Olsen-extractable P in the winter, but that P fertilization of soils above this level, especially in the warm part of the season is not likely to improve lettuce yields.

Over the past two years we conducted four field trials on P fertilization of head lettuce. We examined P fertilizer types and application timing. This article summarizes the results of these studies.

**Summary of Results:** Four phosphorus fertilizer trials were conducted in 2004 to 2005 on sites that had varied soil P levels and planting date. No yield advantage was seen at three sites with initial soil P levels of 45, 47 and 68 ppm bicarbonate P. The site with 45 ppm P in the soil was planted on June 3 and indicates that this level of P is sufficient when the soils are warm. The sites with 47 and 68 ppm P were planted on January 20 and April 18 when the soils were cool, but no improvement in yield was observed at these sites. One test was conducted at a site with soil P levels of 30 ppm. This site probably had low soil P levels because it had just been reclaimed from the Salinas river bed. This trial provided significant insights into P fertilization. We observed a (marginally significant) yield response to P applied at low amounts (20 lb $P_2O_5$) at planting (Table 3). Actually this yield response was better than the higher rate of P (60 lbs $P_2O_5$) applied preplant. This observation is useful because it shows that we can

optimize yields in the situation where P fertilization is justified by applying rates of P at-planting that are similar to rates of P that are removed by the crop. For instance, an application of 20 ppm of $P_2O_5$ is equivalent to 9 lbs of P (actual P = $P_2O_5$ x 0.437). By applying rates of P that are close to what is being removed in the harvested portion of the crop (see Table 3 for estimates of P removed by the harvest portion of a crop), we can help to reduce further loading and loss of P in Salinas Valley soils. In many cases growers are already applying moderate rates of P in at-planting applications of phosphoric acid used as an anticrustant which these studies indicate are sufficient to maximize the yield of lettuce.

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**Recommendations:** Fertilization of head lettuce with P can be justified on sites with less than 55 ppm soil P in the winter. Once soils warm in the late spring, however, these sites do not respond to P fertilization. In situations where P fertilization is justified, low at-planting treatments applied in a band over the seedlines provides a useful technique to maximize yields. The low P fertilization rates will help reduce further loading of P in Salinas Valley soils.

**Background on the trial sites:** ***Trial No. 1:*** The trial was conducted on a Chualar loamy sand with 47 ppm soil P and 7.7 pH. Dry preplant materials were applied on December 9 with a small-plot experimental applicator and liquid preplant materials were applied with a commercial rig on December 11, 2003. The head lettuce variety Sniper was planted on January 20, 2004. The banded P treatment was applied on January 21 and the first germination water was applied on January 23. The field was sprinkler irrigated throughout the season, and the plots were harvested on April 30, 2004. ***Trial No. 2:*** The trial was conducted on Chualar loamy sand with 68 ppm soil P and 7.3 pH. 300 lbs of 0-0-50 was applied in the fall at listing. Preplant P applications were shanked into the beds on March 21, 2005 with a small-plot experimental applicator. The variety Sniper was seeded on April 18. All at-planting treatments applied as two 5-inch wide bands over each seedline immediately after planting. The field was switched to drip irrigation on May 30, and the plots were harvested on June 28. ***Trial No. 3:*** The trial was conducted on Metz loamy sand with 30 ppm soil P and 7.3 pH. The preplant treatment P of 400 lbs of 15-15-15 was applied at listing on April 25. All at-planting treatments were sprayed onto shaped beds prior to planting on April 29 on two 5-inch wide bands over the seedlines. The head-lettuce Sniper was sprinkler irrigated until thinning and then switched to drip irrigation in early June. The plots were harvested on July 6. Table 3 gives results for tissue analyses at mid-stage and harvest. ***Trial No. 4:*** The trial was conducted on Chualar loamy sand with 45 ppm soil P. Preplant P treatments were shanked into the beds on May 31 with a small-plot experimental applicator. The variety Sniper was seeded on June 2 and at-planting treatments were applied as two 5-inch wide bands over each seedline immediately after planting. The field was sprinkler irrigated until thinning and switched to drip irrigation on July 7. The field was harvested by a commercial crew on August 5.

Table 1. Comparison of soil P levels in adjacent fields on Chualar loam soil

| Site Background | Soil P ppm |
|---|---|
| Pasture (low intensity agriculture) | 37.3 |
| Low intensity vegetable production site (Research station) | 53.9 |
| High intensity vegetable production site (Typical of the Salinas Valley) | 92.6 |

Table 2. Phosphorus levels in Salinas Valley soils

| Soil Type | Number of sites | Range of soil P values | Mean Soil P Ppm |
|---|---|---|---|
| Sandy Loam | 6 | 62 - 139 | 93 |
| Loam | 6 | 36 - 133 | 90 |
| Clay Loam | 5 | 78 - 134 | 97 |

Table 3. Trial No. 3. Tissue and soil P analyses, nutrient uptake at harvest and yield data.

| Treatment | P/acre lbs | $P_2O_5$/acre lbs | Application | Mid Growth | | At Harvest | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Tissue Total P (%) | Soil P (ppm) | Soil P (ppm) | Crop P Uptake (Lbs/Acre) | Mean Head Wt. (Lbs) | Mean Wt./Acre (Tons) |
| Untreated | ---- | ---- | ---- | 0.313 | 35.5 | 34.17 | 11.3 | 1.09 | 29.57 |
| Actagro 7-21-0 | 9 | 20 | at planting[1] | 0.300 | 35.9 | 39.57 | 12.1 | 1.18 | 32.93 |
| Ortho Phos 12-58-0 | 9 | 20 | at planting[1] | 0.277 | 35.0 | 36.73 | 11.8 | 1.10 | 30.33 |
| 10-34-0 + 1% Avail | 9 | 20 | at planting[1] | 0.287 | 37.6 | 36.93 | 11.9 | 1.20 | 32.77 |
| 7-7-0-7[2] | 9 | 20 | at planting[1] | 0.297 | 35.5 | 34.37 | 11.9 | 1.17 | 32.20 |
| 15-15-15 | 27 | 60 | Preplant[2] | 0.277 | 36.1 | 34.03 | 10.7 | 1.04 | 28.90 |
| *LSD, α=0.10* | | | | *0.021* | *NS* | *2.68* | *NS* | *0.09* | *2.86* |

1 – Applied in two 5-inch wide bands over the seedline; 2 – Shanked into the beds at listing with a commercial applicator