Max Clover

Influence of phosphorus and nitrogen on celery

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Added phosphorus and nitrogen maintained yields and increased size

Transplanted celery is known for its shallow, fibrous root system, which results in the intensive use of water and nutrients, especially nitrogen and phosphorus. A two-year field study begun in 1984 at the University of California South Coast Field Station in southern Orange County evaluated applications of nitrogen, phosphorus, and potassium to determine the effects of a constant rate of fertilizer on celery yield and size under trickle/drip irrigation. Because potassium applications had no effect on celery yield or quality during this period, this article deals exclusively with the influence of phosphorus and nitrogen on celery yield and size and on soil phosphorus levels.

Field study

Celery was transplanted into a 1-acre block in the spring of both 1984 and 1985; one-half of the block also received transplants during the fall of 1984. Half of the area thus produced two crops, while the other half produced three. Randomized complete block designs (factorial) were used on each half with three replications and eight treatments (plots) per replicate. Each plot consisted of six 40-inch double-row beds, 60 feet long.

Fertilizer rates for each growing season consisted of two levels each of nitrogen, phosphorus, and potassium. Nitrogen, as calcium nitrate, was applied preplant at 100 or 200 pounds of actual nitrogen per acre, 2 inches below and to the side of the plant row. An additional 300 or 600 pounds actual nitrogen per acre was applied weekly, in graduated increments (during the latter third of the irrigation set) through the drip line. The phosphorus treatments consisted of 0 or 60 pounds per acre of banded treble superphosphate. Potassium was banded at 0 or 150 pounds per acre of muriate of potash. No additional phosphorus or potassium was applied during the rest of the season.

The crop was sprinkle-irrigated for the first two weeks after transplanting. Then the irrigation pipe was removed, and water was applied through the drip system for the remainder of the growing season. The trickle/drip tubing was low flow (0.3 gallon per minute per 100 feet), installed approximately 5 inches below the soil surface in the center of each bed. Irrigation frequency was based on three tensiometers placed in different parts of the field 8 inches deep beneath the plant row. The crop was irrigated when any of the tensiometers registered −0.2 bar (20 centibars), which occurred two to three times a week during the summer. Approximately 2 to 3 acre-inches of water were applied through the sprinklers and 14 to 15 acre-inches through the drip system in each of the three growing seasons.

Yield was determined from the four center beds of each plot with 5-foot buffers at either end. A commercial harvesting crew picked the celery, which was classified as either 24, 30, 36, or 48 stalks per carton, and the size and weight per box recorded.

After each harvest, the beds were rototilled, parallel to the bed, to minimize soil movement between plots. Beds were then shaped before preplant fertilizer application and transplanting. No other cultural practices were performed.

Each plot was sampled for soil phosphorus and potassium before the 1984 spring planting and again one year later. Before the experiment, two plots at either end of the study site were intensively sampled to determine the number of observations necessary to estimate soil phosphorus to within 2 ppm at the 95 percent confidence interval. This procedure indicated that two auger buckets per plot, 3 inches in diameter and 12 inches long, were sufficient to estimate soil phosphorus under the test conditions. Initial average phosphorus levels for the sandy loam soil were 10 to 13 ppm (Olsen sodium bicarbonate test).

Results

Preplant application of phosphorus strongly affected total celery yield in the three successive crops (table 1). Yield declined over this period in plots without a phosphorus application, but no significant decrease in yield occurred with the additional phosphorus (60 pounds) between the 1984 and the 1985 spring-planted crops. The high level of nitrogen offset the lack of additional phosphorus in nonphosphorus plots during the first growing season, but not in the fall 1984 or spring 1985 crop. High nitrogen rates thus may compensate for low phosphorus levels for only short periods of time, such as one season.

Significant differences occurred in production of the 24-stalk size in the two spring crops, but not in the fall crop (table 2). Adding phosphorus resulted in over 83 percent in the combined classes 24 and 30 at all three harvests.

Available soil phosphorus declined in all treatments over the harvests (table 3). The decline in plots that received no additional phosphorus averaged 4.3 to 4.8 ppm, compared with 1.1 to 3.2 ppm in plots with applied phosphorus.

There was a significant interaction between available soil phosphorus ($P \leq 0.05$) and phosphorus treatment in plots that

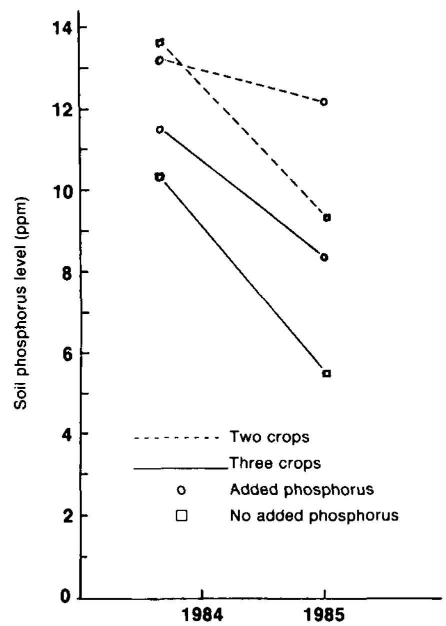

Fig. 1. Change in soil phosphorus over two or three crops from 1984 to 1985 with and without added phosphorus fertilizer.

produced two crops (fig. 1). The plots that produced three crops did not show any significant interaction; soil phosphorus decreased proportionately regardless of phosphorus treatment. There are three possible reasons for the lack of response in the second case: First, the additional unharvested crop, which was rototilled into the soil following the fall harvest in the three-crop plots, would have returned soil phosphorus, accumulated by the plant, back to the soil. Second, the warmer soil temperatures and moisture from irrigation may have promoted the additional release of fixed soil phosphorus. Last, the number of samples per plot used to determine soil phosphorus levels may not have been adequate, even though an estimation of sample size was made for this experiment.

Soil phosphorus levels in plots that were cropped twice and received no phosphorus declined significantly, while those with added phosphorus showed no significant decline (table 3). Irrespective of treatment, there was no significant decline in soil phosphorus for plots cropped three times. When soil levels between the two years were averaged over treatment, there was a significant decline for both cropping frequencies. This decline between years regardless of cropping frequency seems to indicate that the level of preplant phosphorus was inadequate to maintain soil levels over the period of this trial.

TABLE 1. Effect of nitrogen and phosphorus applications on total packout yield of celery in three growing seasons

Season	Fertilizer treatments*			
	N1PO	N2PO	N1P1	N2P1
	metric tons/hectare†			
Spring 1984	63.49 d	74.99 bc	75.18 bc	73.27 bc
Fall 1984	76.45 bc	74.92 bc	85.82 a	80.29 ab
Spring 1985	54.79 e	55.09 e	67.99 cd	75.59 bc

NOTE: Means followed by different letters across a row and/or column are significantly different by Duncan's multiple range test (DMRT) at the 5% level.
*N1PO, N2PO = nitrogen at 100 or 200 pounds per acre, respectively; no phosphorus applied. N1, P1, N2P1 = nitrogen at 100 or 200 pounds; phosphorus at 60 pounds per acre.
†To convert metric tons/hectare to pounds/acre, divide by 0.00112.

TABLE 2. Influence of phosphorus application on percentage of celery in various sizes (stalks/carton)

Stalk size	Growing season and treatment*					
	Spring 1984		Fall 1984		Spring 1985	
	PO	P1	PO	P1	PO	P1
	%					
24	46 c	62 ab	58 b	62 ab	45 c	73 a
30	28 a	21 b	22 ab	22 ab	25 ab	14 c
36	15 b	11 bc	13 bc	10 bc	20 a	10 c
48	11 a	6 a	7 a	6 a	9 a	3 a
24 + 30	74	83	80	84	70	87

NOTE: Percentages, for each planting date, followed by different letters within a row are significantly different (DMRT, 1% level).
*PO = no phosphorus. P1 = phosphorus at 60 pounds per acre.

TABLE 3. Soil phosphorus levels (ppm) without (PO) and with 60 pounds/acre phosphorus (P1) applied

Cropping frequency	Soil phosphorus		
	Phosphorus treatment		
	PO	P1	Average
TWO CROPS	ppm		
Spring 1984	13.6 a	13.2 a	13.4*
Spring 1985	9.3 b	12.1 a	10.7
Average	11.5 (ns)	12.7	
% change	31.6	8.3	
THREE CROPS			
Spring 1984	10.3 a	11.5 a	10.9**
Spring 1985	5.5 a	8.3 a	6.9
Average	7.9*	9.9	
% change	46.3	27.8	

NOTE: Phosphorus levels followed by different letters within a row or column for a particular cropping frequency are significantly different (DMRT, 5% level).
*,** Indicates difference for average soil phosphorus levels between phosphorus treatments or between years at .05 and .01 level of significance, respectively.

Conclusions

Preplant application of phosphorus signficantly influenced celery yield. The banded, preplant application of 60 pounds per acre of phosphate phosphorus per crop was sufficient to maintain celery yield over three growing seasons. In plots that did not receive this application, the high level of nitrogen apparently compensated for the lack of additional phosphorus during the first growing season, but not during the last two seasons. The high rate of nitrogen and additional phosphorus did not increase celery yield between the two spring crops, a surprising result considering the difference in the levels of nitrogen applied.

Phosphorus also strongly influenced celery size. The addition of 60 pounds per acre increased the packout of the larger 24 stalks per carton class during the spring but not the fall season. The combined class of 24 and 30 stalks per carton represented 83 percent or more of total yield during each of the three growing seasons at this level of applied phosphorus. Celery growers consider 75 percent or better to be a good packout of these two classes. Phosphorus is known to promote root development and maturation. In the case of celery, earlier maturation is indicated by larger head size. The additional phosphorus was probably the cause of the earlier and larger stalks.

Preplant phosphorus influenced celery quality more during the spring than during the fall growing season. The poorer fall response may have been caused by higher soil temperatures and moisture during the summer enhancing the availability of soil phosphorus. This result implies a need for different management schemes when fertilizing celery in the spring than in the fall.

Over the two-year period, soil phosphorus levels declined regardless of cropping frequency. The decline in soil phosphorus was signficant for the two-crop plots as compared with the three-crop plots. This difference was probably due to the additional phosphorus returned to the soil by the extra celery crop in the three-crop plots. Soil phosphorus for plots that received 60 pounds of phosphorus fell below 10 ppm with no significant influence on celery size or yield. The continuous decline in soil phosphorus indicated that the phosphorus level may have been inadequate to maintain soil levels over extended periods.

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