Nitrogen stabilization in the Pajaro Valley in lettuce, celery, and strawberries

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If nitrapyrin becomes available, considerable savings in costs for fertilizing may be realized.

Frequent irrigations of vegetable crops in California's central coast area leach some of the applied nitrogen fertilizer below the plant root zone. Growers, therefore, apply nitrogen several times during the season to insure its availability during critical plant-growth periods. In experiments this leaching was reduced by using nitrification inhibitors, and single preplant nitrogen applications with nitrapyrin proved possibly more effective than split applications of nitrogen alone. (Nitrification inhibitors are not registered for use on vegetable crops.)

The ammonium form of nitrogen (NH_4+) is relatively immobile in most soils (except in soils with a very low exchange capacity) because it is positively charged and binds the negatively-charged clay particles. Soil bacteria, which use the NH_4+ as an energy source, can break this bond. They convert the ion to the nitrite and then the nitrate forms, both of which are negatively charged. The released anions then can move freely whenever the soil becomes wet.

Growers recognize that on all soil types some applied fertilizer is lost below the crop root zone. Therefore, they sidedress two or three times in lettuce, and more often in celery. Strawberries, a long-term crop requiring 3 to 5 acre-feet of water per year, may be fertilized five to eight times per year to help maintain adequate soil nitrogen levels for the crop.

Various coated or chemically-bound nitrogen fertilizers are available, but they are relatively expensive and do not always provide enough available nitrogen during rapid plant growth. This is particularly true where the nitrogen demands of lettuce and celery are not constant over the entire growing cycle.

The experiments

These experiments tested the use of 0.5 pounds per acre active ingredient of nitrapyrin (N-Serve), a nitrification inhibitor in lettuce, celery, and strawberries. On strawberry fields, the coated fertilizer Osmocote was compared with nitrogen alone. The primary function of nitrapyrin is to slow down the bacterial conversion of ammonium N to the nitrate form by temporarily inhibiting the nitrosomonas bacteria. This helps to retain nitrogen in the ammonium form and prevent its leaching too deeply into the soil. This could result in considerable savings by reducing both the total amount of nitrogen applied and the number of sidedress operations.

TABLE 1. Calmar Lettuce Yields Obtained in Nitrogen Stabilization Experiments.

Treatments			Yield
Total lb. N/Acre*	Timing of application	Nitrapyrin 0.5 lb AI/Acre	Carton/Acre 2-doz. size
0	Control	0.0	54.5a†
60	30 preplant + 30 sidedress	0.0	239.6b
60	Preplant	0.5	457.0c
120	60 preplant + 60 sidedress	0.0	468.3c
120	Preplant	0.5	752.0e
180	90 preplant + 90 sidedress	0.0	631.6d
240	120 preplant + 120 sidedress	0.0	805.0e

*$(NH_4)_2SO_4$ used as source of N.
†Significant at 5 percent level.

TABLE 2. Celery Yields Obtained in Nitrogen Stabilization Experiments.

Treatments			Yield
Total #N/Acre*	Timing of application	Nitrapyrin 0.5 lb AI/Acre	Crates/Acre
0	Control	0.0	405†
50	Post transplant	0.5	798c
100	50 post transplant + 50 midseason	0.0	703b
100	Post transplant	0.5	900d
150	Post transplant	0.5	993e
200	100 post transplant + 100 midseason	0.0	884d
200	Post transplant	0.5	1067f
300	150 post transplant + 150 midseason	0.0	1082f
400	200 post transplant + 200 midseason	0.0	1110f

*$(NH_4)_2SO_4$ used as source of N and applied as band application.
†Significant at 5 percent level.

The lettuce experiment was conducted on Watsonville loam soil with low (6 to 8 ppm) nitrate-nitrogen residue. The beds were listed on 40-inch centers. Nitrogen rates used were 0, 60, 120, 180, and 240 pounds of N per acre, with and without nitrapyrin. Those without were treated in split applications: half the ammonium sulfate was applied as a preplant sidedressing, and the other half was sidedressed after thinning. Plots with nitrapyrin received their total nitrogen in a preplant band application.

Ammonium fertilizer without nitrapyrin was applied in a split application to provide comparison with grower practices and to keep the number of plots at a manageable level. Previous experiments in several areas of California and Arizona have demonstrated that split applications of N are at least equal to a single application and, in some cases, have resulted in significant yield increases.

Lettuce and celery absorb 70 percent of their nutrients during the last 30 percent of their growing season. High soil fertility levels, therefore, are needed close to harvest. Any practice that would reduce loss of nitrogen because of denitrification or leaching through the entire growing season would be beneficial.

Results

The lettuce field experiment was seeded to the Calmar variety and farmed by the grower as part of his normal operation. Lettuce seedlings were thinned to 10- to 12-inch spacings for a near-perfect stand. The second sidedress of nitrogen on plots without the nitrification inhibitor was made about two weeks after thinning. A commercial crew harvested the entire experiment. The packed cartons in each plot, which contained two dozen heads, were weighed.

The addition of nitrapyrin to nitrogen fertilizer resulted in a higher yield of marketable lettuce heads per equivalent amount of nitrogen applied (table 1). Application of 120 pounds of nitrogen per acre with nitrapyrin yielded significantly more lettuce than did the nitrogen-only plots at the 180-pound rate and almost as much as nitrogen-only plots treated with 240 pounds per acre.

The celery experiment was conducted on a Watsonville clay loam soil. Seedlings were transplanted, and three sprinkler irrigations using a total of 5 inches of water were applied to establish the stand. Fertilizer treatments were applied about three weeks after transplanting. All nitrogen plus nitrapyrin treatments were applied as a single sidedressing. At the same time, in non-nitrapyrin plots half of the nitrogen for the crop was applied and the second half was sidedressed about one month later. The field was sprinkler-irrigated during the first 30 days, then furrow-irrigated.

Approximately 3 acre-feet of water were applied per acre. Nitrogen deficiencies became apparent early in the season in non-fertilized control plots in which plants were chlorotic and stunted. Color differences were not observed in other treatments, although some growth differences were observed. Again, nitrapyrin-treated plots outyielded those without nitrapyrin for comparable rate of nitrogen (table 2). Plots with 200 pounds N plus nitrapyrin or 300 to 400 pounds N plus nitrapyrin per acre produced the maximum yield. This gave a 30 percent savings in nitrogen and a 50 percent savings in sidedressing costs.

Strawberry trials included summer and fall plants. Fall-planted Tioga strawberries were slot-fertilized just before planting. All fertilizer was placed about one inch below root level to prevent root burn. N was used at 75, 150, and 225 pounds per acre, half with and half without nitrapyrin. One plot used 75 pounds of Osmocote. Control plots had no applied nitrogen. The experiment was harvested over two years. A significant yield increase occurred during the first year of harvest at all rates, compared with 0 nitrogen. Furthermore, addition of nitrapyrin resulted in significant yield increases over ammonium sulfate alone at both the 75- and 150-pound N rates. However, no yield differences were observed between the two treatments at the 225-pound rate, which stunted the strawberry plants. There were no significant differences among any of the fertilizer rates for the second year of harvest.

The 75-pound Osmocote treatment yielded about the same as the 75-pound N plus nitrapyrin treatment.

Summer-planted Tioga plots received 0-, 35- and 70-pound N applications and 35 pounds of Osmocote. Nonfertilized plots yielded significantly less than did all other treatments. The 35-pound-N-per-acre rate without nitrapyrin resulted in a yield increase over the unfertilized plots, but was surpassed by 35-pound N plots with nitrapyrin. Neither of the 70-pound N treatments was significantly different in yield from the 35-pound rate with nitrapyrin nor the 35-pound N rate of Osmocote.

Conclusion

Nitrapyrin appeared effective in delaying oxidation of NH_4+ to the leachable nitrate form. Apparently, nitrapyrin helped increase availability of nitrogen to plant roots by reducing the leaching of nitrates beyond the effective rooting depth. This stabilization of ammonium in a single application lasted long enough to grow crops of lettuce, celery, and first-year strawberries. If nitrapyrin becomes registered and available to vegetable and strawberry growers, considerable savings in costs might be realized by reducing nitrogen application rates and the number of sidedressings. Denitrification could be reduced and possible nitrate pollution to underground water would be lessened with use of a nitrogen stabilizer.

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TABLE 3. Strawberry Yields Obtained in Nitrogen Stabilization Experiments.

Winter-planted Tioga

Treatment		Yield	
Total #N/Acre*	Nitrapyrin 0.5 lb AI/Acre	Tons/Acre 1st year	Tons/Acre 2nd year
0	0.0	14.0a†	19.3
75	0.0	14.9b	19.5
75	0.5	16.4c	19.7
150	0.0	14.9b	19.4
150	0.5	17.1d	20.1
225	0.0	14.8b	20.5
225	0.5	15.2b	20.7
Osmocote 75	0.0	16.1c	19.8

Summer-planted Tioga

Treatment		Yield
Total #N/Acre*	Nitrapyrin lb AI/Acre	Tons/Acre
0	0.0	34.2a†
35	0.0	35.4b
35	0.5	36.8c
70	0.0	36.9c
70	0.5	36.4c
Osmocote 35	0.0	36.7c

*$(NH_4)_2SO_4$ used as source of N.
†Significant at 5 percent level.