EFFICIENT N MANAGEMENT FOR HIGH-YIELD VEGETABLE PRODUCTION

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Vegetable production is an N-intensive industry; rates of N fertilization can be very high, particularly where multiple crops per year are produced. In vegetable production areas across the country high nitrate-nitrogen (NO_3-N) concentration in surface water and groundwater is focusing regulatory scrutiny on fertilization practices. Furthermore, escalating energy prices mean higher N fertilizer costs, making efficient N management an economic as well as an environmental necessity. The basic principle of environmentally sound N management is that N applied but not removed from the field in the harvested product is at risk of loss to the environment. Vegetable crops differ widely in their N uptake, and in the percentage of that uptake removed from the field in the harvested product (Table 1). A grower must establish reasonable proportionality between N application and harvest removal. To maintain high crop productivity, this requires consideration of non-fertilizer sources of N, correct timing of fertilization, and efficient irrigation to limit leaching losses. The following discussion outlines steps toward efficient N management.

Determining an N fertilization template

Growers should have an N management template for each crop, based on crop N uptake requirements, and the pattern of uptake over the season. With few exceptions, a crop template should not plan a seasonal N application of more than the total crop N uptake; depending on soil type, crop rotation and irrigation management, an N template may call for a seasonal N application substantially lower than total crop N uptake. Timing of N application should match as closely as possible the pattern of N uptake by the crop, to minimize the opportunity for NO_3-N leaching. All annual vegetable crops have similar patterns of crop N uptake; the pattern for lettuce is given in Fig. 1. Whether the crop is seeded or transplanted, there are several weeks of crop establishment during which N uptake is minimal. That is followed by a phase of rapid growth during which between 3-6 lb N/acre/day is taken up; the higher end of that range represents cool growing conditions (fall through spring), while uptake > 4 lb N/acre/day is more common in summer. For crops harvested in a vegetative stage (lettuce or celery, for example), this rapid uptake phase lasts until harvest; for crops like processing tomato or potato, N uptake rate declines in the weeks before harvest as the crop senesces. Given this dependable N uptake pattern, it is easy to see that heavy preplant N application will be less efficient than in-season application, and that making multiple in-season applications (through fertigation, for example) will be maximally efficient.

Adjusting the template for field-specific conditions

The amount of non-fertilizer N available for crop uptake can vary enormously from field to field, and efficient fertilizer management requires maximum utilization of non-fertilizer N. Nitrate content of irrigation water can be a significant contributor to crop fertility. To determine the 'fertilizer credit' of the irrigation water, the calculation is:

PPM irrigation water NO_3-N x inches of crop transpiration x 0.23 = lb NO_3-N/acre

For example, if 10 PPM NO_3-N water is applied to lettuce with seasonal transpiration of 10 inches, the water would supply 23 lb N/acre. By making this calculation on the basis of crop transpiration, there is no need to adjust the estimate for irrigation efficiency.

Soils vary in the rate at which they mineralize (make plant-available) organic forms of N; while one cannot precisely predict how much mineralization will occur during a growing season, fields can be ranked on the basis of soil organic matter content. Fields with <1% organic matter will generally have limited in-season N mineralization, while soils >2% may contribute substantially to crop N supply. The characteristics of the prior crop residue also influences soil mineralization rate. Vegetable crop residue, which is often >3% N, will mineralize rapidly, while lower N residue (wheat straw, for example, which may be <2% N), may actually immobilize N for an extended period.

By far the most important field-specific factor to consider in adjusting an N fertilization template is the level of residual soil NO_3-N. In my experience, the amount of NO_3-N in the soil at the time a grower is ready to make a sidedress application can vary from less than 10 lb/acre to more than 200 lb/acre. Delaying or reducing N application to take advantage of this 'free' N can dramatically reduce potential N loss to the environment without compromising the crop. Averaged across dozens of demonstrations in California lettuce, celery and tomato fields, pre-sidedressing soil nitrate testing (PSNT) reduced seasonal N application by more than 30% with no loss of crop yield or quality.

Lastly, efficient irrigation is essential to efficient N management. At the typical range of soil NO_3-N concentrations maintained in vegetable fields, every inch of leachate will carry between 10-40 lb N/acre out of the root zone.

Table 1. Typical crop N uptake and harvest removal for selected vegetable crops.

	Pounds of N / acre	
Crop	typical crop uptake	removal with harvest
Processing tomato	240-280	160-180
Celery	190-220	120-150
Cantaloupe	150-180	70-90
Lettuce	110-140	60-80
Spinach	80-100	70-90

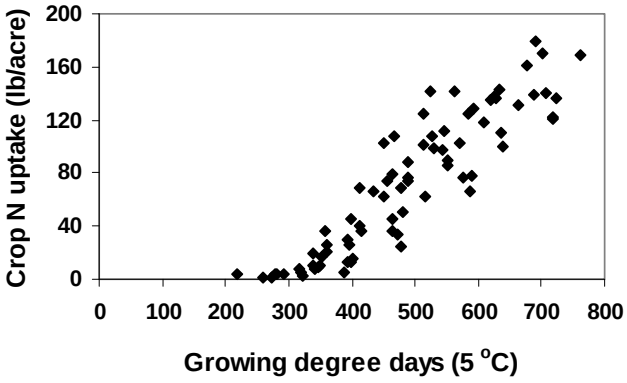

Fig. 1. Pattern of N uptake by lettuce; data from 20 coastal fields, 2009.

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