Nitrogen fertilizer management and groundwater quality regulation

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Protecting groundwater from pollution with nitrate coming from agricultural sources has been a focus of government regulatory interest for more than a decade. Although California's various Regional Water Quality Control Boards are taking somewhat different approaches to this issue, a common theme in their regulatory programs is evaluation of growers' nitrogen fertilization practices by comparing the amount of N applied to a crop with the amount of N assumed to be removed in harvested products. In theory, N applied but not removed at harvest is at risk of eventual loss to the environment through leaching, runoff or gaseous loss to the atmosphere. It is important to note that not all N applied but not removed in that year's harvest is lost to groundwater. In perennial crops a substantial amount of N can be sequestered in wood and roots. In crop rotations some N left in a field can be taken up by a subsequent crop. Nitrogen transformations in agricultural systems can be quite complex; N loss by volatilization and denitrification, or long-term sequestration in organic matter, can be substantial in certain cases. However, research projects in California and elsewhere support the general concept that as N applied (in fertilizer, organic amendments and irrigation water) increases above the harvest N removal, the *potential* for nitrate leaching to groundwater increases.

Crops vary widely in both the typical amount of N applied and in the amount of N removed with harvested products. Table 1 lists the estimated amount of N in a ton of marketable yield for some of California's major crops. These N removal values were developed through a survey of existing published data; research is currently underway to refine these values to ensure they are broadly representative of current California conditions. By comparing your clients' N application rates with the estimated N removed at their yield level you will see that the gap between N applied and N removed (A-R) can be quite different among crops.

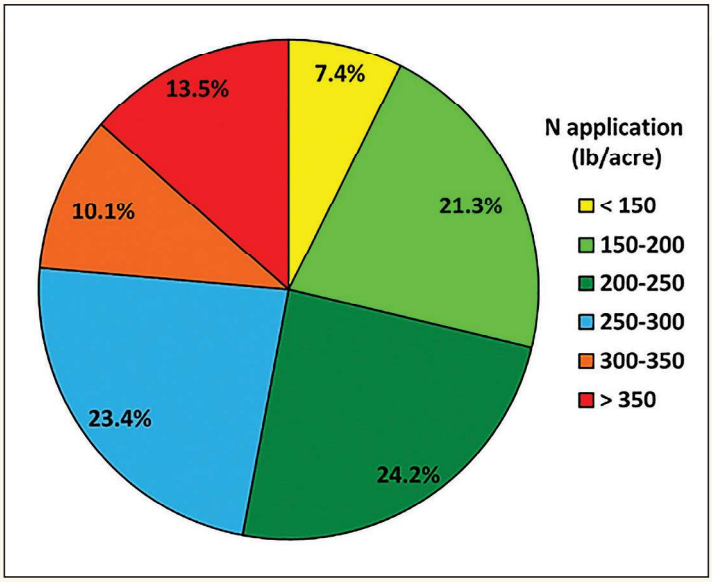
Growers in the Central Coast region, and in areas of the Central Valley designated as highly vulnerable to nitrate leaching, have been required to report annual crop-specific N application rates for several years; this requirement for N use reporting will undoubtedly expand in coming years. These reports provide data on the variability in N use rates among growers. Fig. 1 illustrates this variability for Central Coast celery production, but the same pattern is repeated across many crops, and both production areas. Depending on the crop, from 10-25% of fields report N rates far in excess of the industry average. While very high N rates may be justified in some fields by correspondingly high yields, available data suggests that N fertilization rate and yield are not highly correlated for most crops. Clearly, growers using N rates substantially greater than industry norms risk increased regulatory scrutiny.

Table 1. Estimated N content of harvested material. Data from Geisseler, 2016*.

Crop	N removal with yield
Perennials	
Almond	136 lbs/ton of kernels
Oranges	3 lbs/ton of fruit
Pistachio	56 lbs N/ton dry yield (CPC)
Walnut	32 lbs N/ton in-shell
Wine grapes	3 lbs/ton of grapes
Annuals	
Cotton	44 lbs N/ton lint & seed
Corn silage	8 lbs N/ton @ 70% moisture
Lettuce	3 lbs/ton of fresh weight
Processing tomato	3 lbs/ton of fresh weight
Wheat	43 lbs N/ton @ 12% moisture

** this reference contains N removal data for many other crops*

Fig. 1. Nitrogen application rate on celery, Central Coast region; 2017 grower-reported data. The graph depicts the percent of acres in each N application range.



In my experience growers have a variety of reasons for using high N rates. Among the most common is a recognition that their irrigation distribution uniformity may be suboptimal, and a high N application rate limits the chance of N deficiency in any part of the field. Mobile Lab programs in both the Central Coast and the Central Valley show that irrigation distribution uniformity below 80% remain common, even for low volume systems like drip or microsprinkler. In coming years compliance with the Sustainable Groundwater Management Act (SGMA) will provide an incentive to upgrade irrigation efficiency, and 'insurance' N application based on poor irrigation control should decline over time.

Some growers also believe that higher N rates may enhance product quality or postharvest life; this is particularly true for some leafy green vegetables. However, there is substantial evidence from California research that refutes this concept; in general, an N rate sufficient to maximize crop yield is sufficient to maximize product quality (Breschini and Hartz, 2002; Frischi et al., 2003). In fact, there is solid evidence that high N rates can be detrimental to crop production, primarily by increasing pest problems. Many studies have shown that high N rates increase insect populations (Godfrey and Hutmacher, 2001; Daane et al., 1995). This is intuitive, since plant material richer in N will better support insect growth and reproduction. Similarly, excess N can increase susceptibility to diseases such as hull rot of almond (Saa et al., 2016) and brown rot on peaches (Daane et al., 1995).

Whatever the rationale, using high N fertilization rates will become increasingly difficult to justify as regulatory pressure to protect groundwater quality increases. Consultants must play a significant role in helping their clients become more efficient with their nitrogen inputs. ■

For the vegetable industry UC has published a new reference manual "Efficient nutrient management in California vegetable production". This manual contains in-depth information about all aspects of fertility management, with chapters on soil testing, macro- and micronutrient management, efficient irrigation, organic production, and environmental protection. It can be ordered at https://anrcatalog.ucanr.edu/

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