

Nitrogen management and water quality protection

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Efficient management of nitrogen fertility is one of the most challenging aspects of horticultural crop production. Historically, a grower's primary concern was ensuring adequate N availability for maximum crop yield and quality. In recent years the environmental water quality aspects of agricultural N management have become a focus of governmental scrutiny. In a number of areas of California undesirably high levels of N have been found in both surface water and ground water. Through its Irrigated Lands Regulatory Program the State Water Resources Control Board is attempting to reduce agriculture's contribution to environmental nitrogen loading. Since that program affects thousands of agricultural operations statewide, growers and consultants need to understand how their irrigation and fertilization practices can affect water quality, and how those practices can be modified to reduce environmental impact.

There are two main environmental concerns regarding nitrogen in water. One relates to human health; a high level of nitrate-form nitrogen can induce methemoglobinemia in young children, a disorder in which the oxygen transport capacity of blood is reduced. The Federal limit for drinking water is 45 parts per million nitrate (NO_3^-), which is equivalent to 10 PPM nitrate-nitrogen ($\text{NO}_3\text{-N}$). This limit is universally applied to groundwater, because groundwater is so commonly used as a source of drinking water. The 10 PPM $\text{NO}_3\text{-N}$ limit also applies to many surface water bodies because they are designated for 'beneficial uses' for which that standard is used.

The other major concern with N in water relates to its ability to upset the ecological balance of aquatic ecosystems. Surface water in undisturbed ecosystems usually has very low soluble N concentration, often less than 2 PPM $\text{NO}_3\text{-N}$. When surface water is enriched with soluble N from any source (urban, industrial or agricultural) the growth of undesirable organisms like algae can be stimulated, kicking off a sequence of biological events that can severely stress aquatic ecosystems. Luckily, the immediate focus of the Irrigated Lands Program is on meeting the 10 PPM $\text{NO}_3\text{-N}$ drinking water standard, because even more stringent standards may be required to achieve environmental goals for surface water.

How tough is it to consistently meet a 10 PPM $\text{NO}_3\text{-N}$ standard for all water leaving an agricultural field? As a general rule, the $\text{NO}_3\text{-N}$ concentration of surface runoff tends to be only few parts per million higher than that of the irrigation water source; if you have low-nitrate irrigation water, runoff $\text{NO}_3\text{-N}$ concentration may be acceptable. That is not to say that low nitrate runoff poses no environmental problems; other constituents (sediment, pesticide residues, salinity) may be of environmental concern. From an environmental standpoint eliminating surface runoff, or at least limiting its volume, is always a good idea.

There are two situations in which preventing surface runoff is essential for water quality protection. If your irrigation water is high in nitrate, runoff containing that water will be correspondingly high; there is no practical, consistently effective way to remove nitrate from runoff water. Also, special care should be taken to prevent runoff during N fertigation; during fertigation $\text{NO}_3\text{-N}$ concentration may reach several hundred PPM.

Meeting a 10 PPM standard in water leaching from a production field is even more problematic. During a cropping season the soil water in an appropriately fertilized root zone of vegetable or orchard crops is commonly in the range of 20-50 PPM NO₃-N, sometimes higher; nitrate moves freely with the water, so any in-season leaching is likely to be out of tolerance. For these crops maintaining soil N fertility during the production season at a level that would allow leachate to consistently meet a 10 PPM NO₃-N standard would severely limit crop productivity.

However, this does not mean that crop production is incompatible with groundwater quality protection. The key to groundwater quality protection is minimizing the overall load of nitrogen released into a groundwater basin. Rather than worrying about the NO₃-N concentration of individual leaching events, it is more important to manage fields and orchards to limit the total pounds of N lost. Attention to the following points will limit overall NO₃-N leaching losses:

1) approach N fertilizer management on the basis of an N 'budget'

It is true that some fertilizer N is lost to the atmosphere through volatilization or denitrification, or tied up in soil organic matter; however, in most California production systems, the majority of fertilizer N not removed from the field in harvested product is eventually lost from the field in runoff or leaching. Aligning annual N application as close as possible to the amount of N removed with the harvested product limits the N pollution potential. For tree fruit and nut crops basing the N fertilization rate on the amount of N contained in the expected fruit or nut yield is an established practice; however, fertilization rates for vegetable crops are seldom thought of in this manner. While it is true that fertilization rates for individual vegetable crops may significantly exceed the crop N removal of that crop, considering the N 'balance' of each crop can help a grower identify where excess N may be entering his production system; careful consideration of rotational choices, and additional attention to non-fertilizer sources of N (residual soil NO₃-N, N mineralization potential of crop residue, N content of irrigation water, etc.) can help make the overall operation more nitrogen efficient.

2) control irrigation to limit in-season leaching

Irrigation efficiency and groundwater protection are inextricably linked; a large leaching volume almost inevitably will carry with it a significant N load. Drip and microsprinkler systems provide growers the ability to apply water uniformly, but appropriate management (irrigation frequency and volume, system maintenance, etc.) is required to achieve high irrigation efficiency; recent field surveys have shown large differences in irrigation efficiency among growers of horticultural crops. Where in-season leaching for salinity control is necessary, separating leaching events as far in time as practical from N fertigation can minimize N loss.

3) use winter cover crops

While not economically or logistically practical in all situations, growing winter cover crops can be a valuable tool in water quality protection. Significant levels of soil residual NO₃-N are common in the fall, particularly in vegetable fields; a fall-planted cover crop can 'trap' much of that N before winter rain can leach it out of reach. Studies in the Salinas Valley have documented that fall-planted non-legume cover crops can take

up in excess of 100 lb N/acre, nitrogen that otherwise could leach to groundwater. Cover crops can also provide significant surface water quality benefits by reducing runoff volume and sediment loss.

The bad news is that water quality regulation will increasingly impact horticultural crop growers in the coming years, and it is inevitable that some modification of current production practices will be required to meet environmental goals. The good news is that we have the tools and the knowledge to maintain economically-viable production while these goals are addressed.