Southern San Joaquin Valley (SSJV) Management Practices Evaluation Program (MPEP)

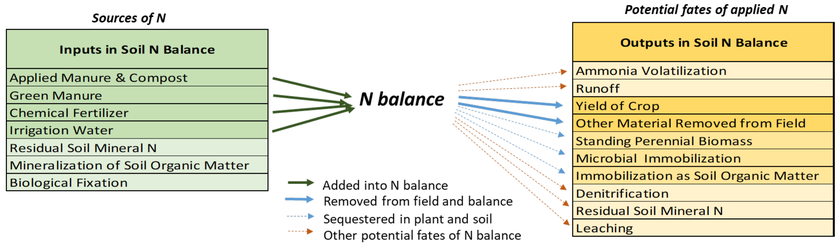
Nitrogen Balance as an Indicator of Nitrate Leaching Risk

Introduction

An expert panel convened by the State Water Resources Control Board in 2014 identified nitrogen (N) applied to fields ("A") and removed in crops ("R") as quantities that could be transformed into useful metrics to serve as indicators of large-scale trends in N fertilizer efficiency and risk of groundwater pollution. In Europe and New Zealand, the difference of A minus R ("N balance") has been adopted as an indicator of regional environmental risk of N losses from cropland. The Irrigated Lands Regulatory Program (ILRP) in the Central Valley now requires growers to develop N management plans (NMPs) from which N balance can be quickly calculated for the growers' reference. Understanding the N balance characteristics will help growers to interpret it.

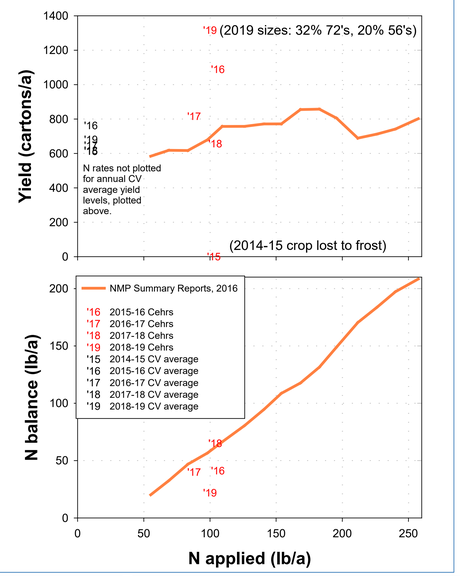
What is an N balance?

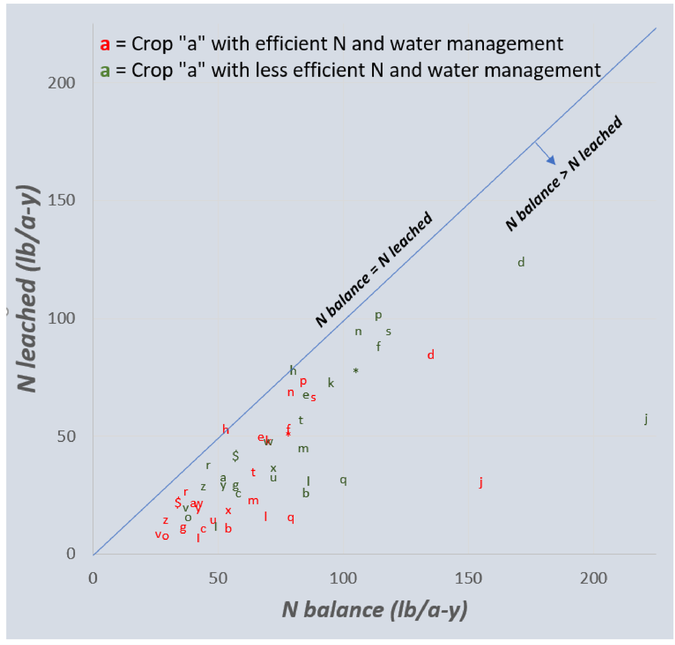
Figure 1. In this usage, the N balance = N applied (as organic or mineral fertilizers, green manure, or irrigation water) minus N removed from the field (crop yield and other material).



How is N balance related to management?

Figure 4. 2016 relationship of yield and N balance to N applied to oranges in the Central Valley (red lines), and one growers' yield and N balances from 2016-19 (plotted by year). This grower's 2018 shift in 3 crucial irrigation and fertigation practices resulted in a >60% decline in the 2019 N balance due to a nearly doubling of yield without applying more N.



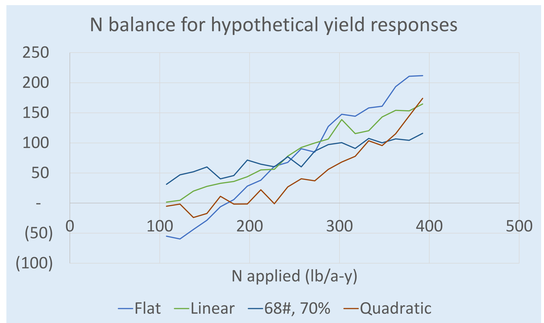


How is N balance affected by N application?

Since N balance is calculated from A, N balance and A are not independent quantities, and the balance tends to be higher when more N is applied. This holds true for all theoretical yield responses (Figure 2) and is observable in data from large numbers of actual fields (Figures 3 and 4). This tendency is for populations of fields. However, N balance for a given field or group of fields can be changed by management without changing A. For example, when a cooperator implemented more efficient N and water management on a block of navel oranges, more N was recovered into a much larger crop, shifting the N balance downward (Figure 4).

Figure 2. N balances for four hypothetical almond yield responses to N applied were calculated by randomly distributing yields around the assumed response pattern, then binning the results in 20 increments across the N applied range (as has been done with grower reports for the same parameters). Regardless of the type of yield response, N balance steadily increased with increasing N applied. The response types considered included the following:

Flat: Constant yield across all N rates
Linear: Linear yield response to N
68#, 70%: 68 lb N/1,000 lb of nuts, 70% NUE
Quadratic: Quadratic yield response to N



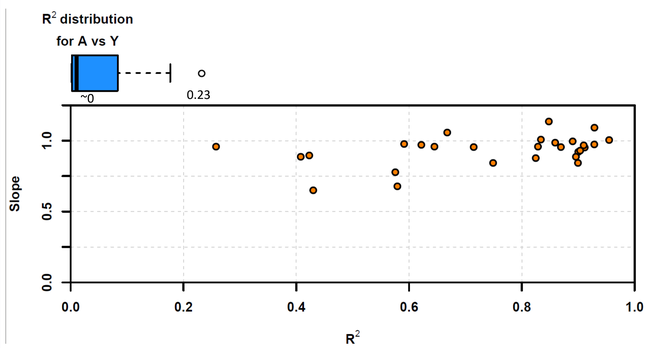


Figure 3. Yield and applied N reported by growers of 26 crops were analyzed. The upper plot of R^2 for prediction of yield by N applied shows a generally weak relationship, likely due to the many other independent factors affecting yield. On the lower plot, linear regression coefficients for prediction of N balance by N applied are plotted against R^2 (on the same horizontal scale as the upper plot) for the same crops. Crops' N balances steadily increase as more fertilizer is applied, as expected. Note that in this case, the statistical parameters simply align with the fact that N balance and N applied are not independently distributed.

How good an indicator of N leaching risk is the N balance?

Figure 5 (above). N leaching was modeled in SWAT for more and less efficient management of N and water. Leaching results are shown relative to N balance for 28 crops. In general and for each crop, a greater N balance tends to be related to higher rates of N leaching; however, N leached is nearly always less than the N balance. While the N balance is a useful indicator, *it nearly always exceeds N leached,* as one would expect due to the many other possible fates of applied N.

What does an N balance mean to a grower?

At https://agmpep.com/calc-y2r/, growers can quickly know a crop's N removed, then view the N balance in regional context. The goal is managing to minimize N balance and risk while growing a good crop. This can be achieved by applying less N, capturing more of the applied N in a larger yield, or both. A key to success is information that leads to changes in fertilizer or water management to enable these outcomes. Because the N balance (= risk) increases as more N is applied, N application rates need to be as informed, precise, and ***low*** as practicable. Lower N rates should be tried as more efficient practices are implemented, unless it is evident that N that is no longer being lost is contributing to a proportionally larger yield. Other possible benefits of eliminating over-fertilization are a) lower fertilizer bills, and b) avoiding production problems (weed and disease pressure, reductions in crop quality and value) that for many crops are associated with excessive N.

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SSJV MPEP Committee Coalitions

Buena Vista Coalition
Cawelo Water District Coalition
Kaweah Basin Water Quality Association
Kern River Watershed Coalition Authority
Kings River Watershed Coalition Authority
Tule Basin Water Quality Coalition
Westside Water Quality Coalition

USDA NRCS Conservation Innovation Grant

The SSJV MPEP Committee was awarded $2 million from the USDA NRCS Conservation Innovation Grant program to increase the use of management practices that reduce nitrate leaching. Growers and partners provided $7.6M of additional funds and in-kind.