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BEST MANAGEMENT PRACTICES (BMPs) TO MINIMIZE NITRATE LEACHING FOR IRRIGATED POTATOES

By

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Managing Fertilizer Applications for Minimizing NO3-N Leaching

Introduction:

Nitrate nitrogen (NO3-N) leaching is becoming an alarming threat to ground water in many areas in the U.S. In one study in North Carolina, over 9000 domestic wells were sampled for nitrate. Over 3 percent (288 wells) contained NO3-N at levels exceeding the Environmental Protection Agency (EPA) safe drinking water standard of 10 mg/L (Jennings, et al., 1991). Ground water quality concerns in central Nebraska surfaced in the mid 1950s when scientists observed increasing NO3-N concentrations in the ground water of some river valleys (Olson et al., 1962). In Utah also, excessive NO3-N contamination has been found in private wells. This is a concern because ground water is the major rural source of domestic water in Utah.

Crop producers sometimes fear that in order to prevent groundwater contamination, they will have to reduce fertilization so much that crop yields will be reduced. This fact sheet illustrates that one can frequently reduce NO3-N leaching without reducing potato crop yield. The results presented here are preliminary and are based primarily on computer simulation studies. Improved guidance will no doubt be presented by those involved in field studies, once more results of such studies become available. This fact sheet does demonstrate the need for appropriate soil testing and fertilization.

The approach here is to use a computer simulation model to predict nitrate leaching for a range of ammonium nitrate fertilization levels. First, we discuss the representative site and climatic data and management practices used in these simulations.

Representative Data and Practices:

We assume a low-yielding variety potato planted on May 25, 1990, on a sandy loam soil, in southwestern Utah. The crop is irrigated by a well-managed sprinkler irrigation system. Irrigations are properly scheduled by carefully monitoring soil moisture status using a neutron probe. Since each irrigation is applied according to crop water requirements, deep percolation (below the root zone) is not excessive.

Soil testing before fertilization and planting reveals 211 lbs/ac of residual NO3-N in the first 4 ft of soil profile (potato root zone depth). The organic material in the soil can also provide up to 67 lbs/ac of N via mineralization. Ammonium nitrate fertilizer (300 lbs/ac) is applied in one application by mixing in the top soil layer (incorporation) before planting. Ammonium nitrate fertilizer is 35% nitrogen by weight. Therefore, 300 lbs/ac of ammonium nitrate fertilizer contain 105 lbs/ac of N available to the crop (300 X 0.35 = 105). The potato crop, harvested on October 16, yields 15.3 tons/ac.

Simulation Overview:

Computer simulations are performed using NLEAP, Nitrogen Leaching & Economic Analysis Package, (Shaffer et al., 1990). This model has proved to be very practical for predicting N leaching in Colorado and elsewhere.

As is mentioned later, some simulations are merely preliminary. However, simulation results are also

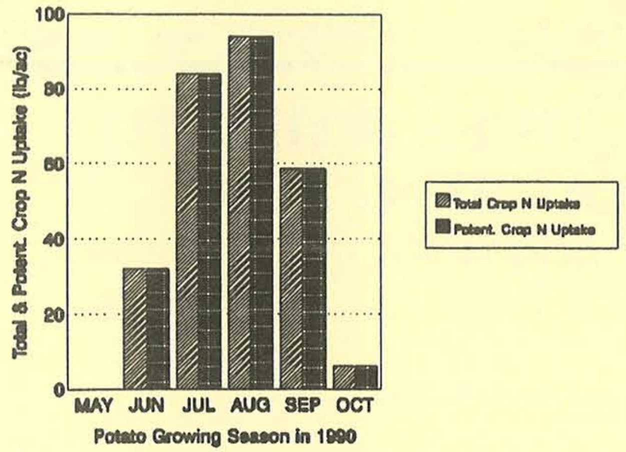

Figure 1. Simulated total and potential crop N uptake (lbs/ac) for Scenario I (300 lbs/ac ammonium nitrate, incorporated).

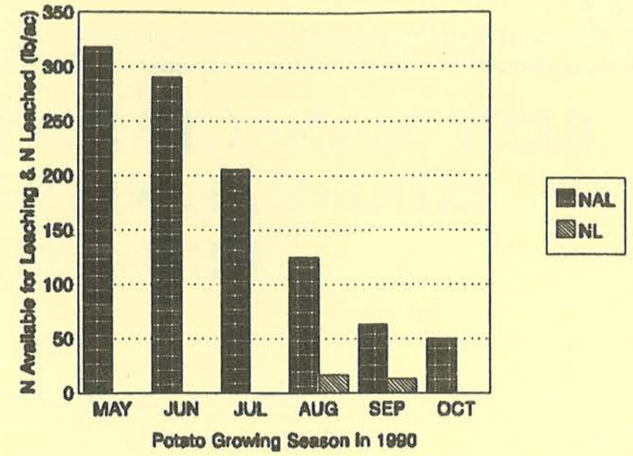

Figure 2. Simulated N available for leaching (NAL) and N leached (NL) below potato root zone for Scenario I (300 lbs/ac ammonium nitrate, incorporated).

presented for each of three scenarios. The scenarios differ in the amount of ammonium nitrate fertilizer applied and/or the application method. In overview, the first scenario simulates the control field experiment. The second uses the same application method (soil incorporation), but a greatly reduced fertilization amount. The third scenario uses the fertilizer applied using chemigation (applying fertilizer by mixing in the irrigation water).

All three simulated scenarios are designed to achieve the same potato yield. The goal of scenarios II and III is to apply the minimum amount of fertilizer needed to achieve maximum yield for two particular application methods.

Adequacy of soil moisture, without over-irrigation, and all other factors affecting yield is assumed.

Scenario I - Simulation of Field Plot Experiment (Soil Incorporation):

Reiterating, the assumed yield for this variety of early potato yield is 15.3 tons/ac. This is obtained by providing adequate water and 300 lbs/ac of ammonium nitrate. NLEAP indicates that there is no unsatisfied nitrate need--total and potential crop N uptake rates are equal (Figure 1) throughout the assumed growing season.

According to NLEAP, total available N (residual + applied fertilizer + mineralized organic) exceeds seasonal crop N uptake needs. NLEAP predicts 275 lbs/ac of total or potential seasonal crop N uptake. Total N available is about 383 lbs/ac (211 + 105 + 67 = 383). Thus, available N exceeds crop needs by about 108 lbs/ac.

NLEAP computes a residual N uptake efficiency. This is the percentage of the total residual N that is utilized by a crop during the growing season. For example, the 63% efficiency (Table 1) indicates that only 133 of the 211 lbs/ac of residual soil NO3-N are utilized by the crop. Only 78 lb/ac (74% of 105 lb/ac) of applied fertilizer N is used. Also utilized is 64 lb/ac of N derived from mineralization of organics. The sum of these three uses equals the plant need (275 lb/ac).

Figure 2 shows monthly N available for leaching (NAL) and N leached (NL) for this first scenario. At the end of the growing season, the total predicted NAL in the 4 ft root zone is 80 lbs/ac and the total predicted NL below the root zone depth is 28 lbs/ac (Table 1). This equals the 108 lb/ac of excess N.

NLEAP computes a Movement Risk Index (MRI). For the utilized irrigation practice the MRI is low, 0.19 (Table 1). MRI indicates the status of water movement below the crop root zone. Its value can vary between 0 and 1. MRI values between 0 and 0.3 are considered low. These indicate irrigation management practices which are well balanced with precipitation and crop water use requirements. The MRI of 0.19 shows that little water is expected to percolate below the potato root zone.

The Annual Leaching Risk Potential (ALRP) computed by NLEAP for this scenario is low (Table 1). A qualitative index, the ALRP combines leaching of NO3-N with potential impacts on underlying aquifers. It is indexed as low, moderate or high. A moderate or high ALRP indicates that the ground water aquifer is threatened with possible NO3-N contamination. In such a case, changes in farm N management practices and/or

Table I. Simulated effects of ammonium nitrate fertilization rates and methods on NO3-N leaching and on net income from properly irrigated potatoes.

Scenario	Amount of N (and fertilizer) applied or simulated	Method of application	Residual soil NO3-N	Residual NO3-N uptake effic.	Applied fertilizer N uptake efficiency	NO3-N available for leaching (NAL)	NO3-N leached (NL)	Movement risk index (MRI)	Annual leaching risk potential (ALRP)	Crop yield	Net income
	lb/ac	--	lb/ac	%	%	lb/ac	lb/ac	--	--	ton/ac	$/ac
I	105 (300)	Soil incorporation	211	63	74	80	28	0.19	Low	15.3*	820.00
II	25 (71)	Soil incorporation	211	90	88	14	14	0.19	Low	15.3*	858.93
III	24 (68)	Chemigation	211	90	91	14	14	0.19	Low	15.3*	859.44

*Assumed, because NLEAP predicts that N available equals N needed and the assumed maximum yield is 15.3 ton/ac.

irrigation practices might be needed. Here however, since sprinkler irrigations are properly scheduled and managed (low MRI), a low ALRP indicates that there is no immediate threat to ground water aquifer from NO3-N contamination. This is because at this study site, the water table is far beneath the ground surface (169 ft). If the water table were close to the ground surface, the ALRP would be much greater.

NLEAP computes a net income of $820/ac (1990 market prices) from the crop, after deducting all input expenses (for seed, tillage, sprinkler irrigation, labor, pesticide, and fertilizer). This net income/ac is later compared with those obtained for scenarios II and III.

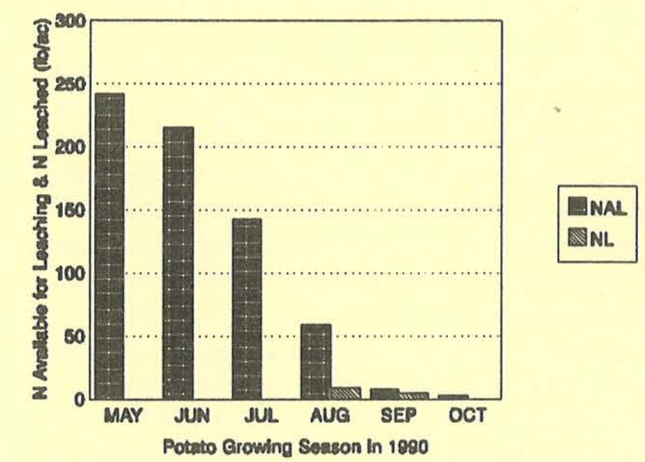

Figure 3. Simulated N available for leaching (NAL) and N leached (NL) below potato root zone for Scenario II (71 lbs/ac) ammonium nitrate, incorporated).

Scenario II - Simulation of Minimal Fertilizer Application for Maximum Yield (Soil Incorporation):

As mentioned above, NLEAP indicates that the actual field applied fertilizer exceeded crop needs. Thus, different lesser applications of fertilizer are also simulated. The intent is to determine, through repeated simulations, how little fertilizer can be applied without reducing potato yield. These simulations differ from that of scenario I only in how much fertilizer is incorporated in the soil. Through these repetetive trial and error simulations, it is found that as little as 71 lbs/ac of fertilizer (24% of that actually applied) can be applied without reducing yield. This results because, again, total crop N uptake equals potential crop N uptake throughout the potato growing season.

As shown in Figure 3 and Table 1, NAL and NL amounts (lbs/ac) are much less than those of scenario I (Figure 2). Overall, predicted NAL at the end of potato growing season is only 14 lbs/ac (83% less) and predicted NL below potato root zone depth is also 14 lbs/ac (50% less). Crop N uptake efficiency for residual soil NO3-N is greatly improved (90%). Applied fertilizer N uptake efficiency improves to 88%. The MRI is unchanged since water management does not change. ALRP is also low, indicating that farm N management practices are adequate to avoid threatening ground water quality. Because less fertilizer is applied, net income increases $38.93/ac.

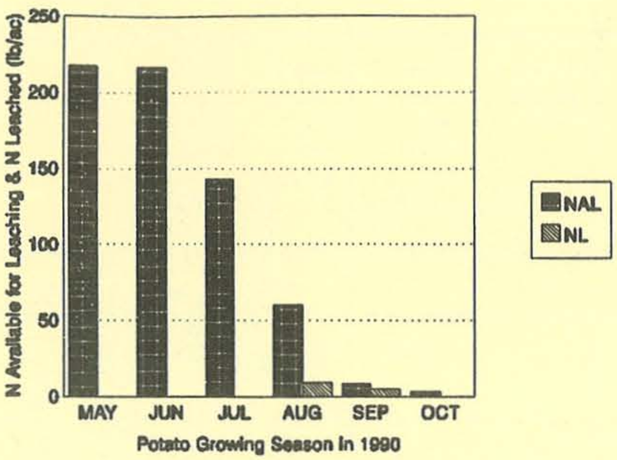

Figure 4. Simulated N available for leaching (NAL) and N leached (NL) below potato root zone for Scenario III (68 lbs/ac ammonium nitrate, chemigation).

Scenario III - Simulation of Minimal Fertilizer Application for Maximum Yield (Chemigation):

Numerous preliminary simulations are again performed to determine the smallest fertilizer amount, applied through sprinkler irrigations (chemigation), that should still yield 15.3 tons of potatoes per acre. Applying only 68 lbs/ac of ammonium nitrate fertilizer in the first irrigation on June 28, should be sufficient. Again, total crop N uptake equals potential crop N uptake throughout the growing season.

Except for the net income and applied fertilizer N uptake efficiency, all the other results computed by NLEAP (Figure 4 and Table 1) are very similar to results of scenario II. Applied fertilizer N uptake efficiency is the highest (91%) in this case. As a result, only 68 lbs/ac of ammonium nitrate fertilizer need be applied to achieve the same potato yield. Since the amount of fertilizer is 3 lbs/ac less than that of scenario II, the net income is the greatest of all scenarios (Table 1).

CONCLUSIONS

Soil testing should be used to determine residual soil NO3-N for the entire root zone depth of a crop before planting. The results should guide subsequent fertilization. Care should be taken to apply as little fertilizer as necessary to achieve the target yield. The amount of fertilizer applied, plus all other N sources (such as residual soil NO3-N, crop residue, manure, organic waste), should not exceed crop N uptake needs.

Avoiding excessive fertilization will help reduce nitrate leaching and will help protect ground-water quality. It will also improve net economic return. Avoiding excessive or inefficient irrigation can also help reduce leaching of nitrates.

Applying fertilizer through irrigation (chemigation) can cause less NO3-N leaching than soil incorporation. However, applying the proper fertilizer amount is probably more important than the application method, in preventing groundwater contamination.

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