

Impact of Nitrogen Fertilization Treatments on Residual Soil Nitrate Accumulation Patterns in California Wheat

Project Leader

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Abstract / Summary

Research was conducted to monitor soil nitrate N levels as affected by a range of nitrogen management strategies that differed in the total amount of applied N and in the timing of split N fertilizer applications. The overall goal of the joint projects was to evaluate impacts of split fertilizer application treatments and growth stage timing of N applications on yield, grain protein, and potential for significant nitrate N movement below the crop root zones. This project is a continuing effort to focus on deep soil sampling as a complementary joint project working as part of nitrogen (N) management wheat trials being conducted in Siskiyou County by Steve Orloff of UCCE and in the San Joaquin Valley by Steve Wright of UCCE. Funding for this project provides for extensive deep soil sampling post-harvest in multiple nitrogen management treatments, plus some limited pre-plant soil sampling. This research should be helpful in providing insight on how to maximize nitrogen efficiency and to determine the fate of nitrogen that is not taken up by the grain plants.

Introduction, Background and Objectives

Proper nitrogen management is essential in wheat production for achieving acceptable levels of both yields and protein content. As yields continue to increase with wheat and other agronomic crops, it is often considered that higher nitrogen rates are required to keep pace with crop demand. Nitrogen management in wheat can be somewhat complicated due to the effect of application timing on nitrogen partitioning within the plants. N applications made prior planting or in the early developmental stages are used primarily to encourage acceptable root and shoot growth, and in many studies over a range of locations nationwide, N availability during early growth stages had a profound impact on yield. However, early-season applications usually do not result in significant nitrogen concentrations in the grain head. Late-season N applications are often required to obtain adequate nitrogen concentrations and, thus, higher protein levels in the wheat head. However, these late-season nitrogen applications alone typically do not improve yields.

Sometimes growers over-apply N in attempts to achieve both yield and protein goals with fewer fertilizer applications. Over-fertilizing can lead to inefficient fertilizer use, reduced profitability and have unwanted environmental consequences such as potential for nitrate leaching below effective crop root zones. There is concern and untested assumptions regarding the fate of applied nitrogen in the soil. Leaching in semi-arid areas such as the southern San Joaquin Valley is generally thought to be less of an issue because of low rainfall as long as irrigations are relatively uniform and efficient. Data from actual field trials in wheat production areas would assist in identifying practical approaches in N management that might help improve crop responses to applied N while reducing potential N losses.

The Co-Principal Investigators for this trial have been conducting wheat N management trials the past two years at locations in Siskiyou County and the San Joaquin Valley, focusing on optimum nitrogen application timing and rate needed to achieve high yield, and resulting N management impacts on seed protein. Initial efforts this past year focused on adding deep soil sampling for residual nitrate-N post harvest in order to better understand some aspects of N uptake and zones of accumulation or use of soil nitrate-N across treatments after crop harvest. A basic reason for adding these evaluations to the N studies is concern over soil nitrate levels following fertilization and crop production, and the possibility of nitrate leaching below the active root zone. There is potential in California for increasing scrutiny and perhaps even regulation over nitrogen use in crop production.

The objectives for this component of the nitrogen management studies are to:

1. Quantify the level of residual nitrate-N in the soil profile following a wheat crop fertilized according to treatments designed to apply a wide range of total applied N
2. Determine the impacts of specific N fertilization treatments that apply fertilizer N at different crop growth stages on soil nitrate-N accumulation patterns with depth in the soil profile at each test site

Materials and Methods / Procedures - 2012 Studies

The basic nitrogen management treatments were imposed at two locations (Siskiyou County and southern San Joaquin Valley) in 2012. The basic treatments for the 2012 studies were as follows:

1. Control – **(unfertilized)**
2. 120 Pre-plant **(Total N 120 lbs)**
3. 120 Pre-plant + 30 lbs Flowering **(Total N 150 lbs)**
4. 120 Pre-plant + 50 lbs Tillering **(Total N 170 lbs)**
5. 120 Pre-plant + 50 lbs Tillering + 30 lbs Boot **(Total N 200 lbs)**
6. 120 Pre-plant + 50 lbs Tillering + 30 lbs Flowering **(Total N 200 lbs)**
7. 120 Pre-plant + 50 lbs Tillering + 30 lbs Boot + 30 lbs Flowering **(Total N 230 lbs)**

The treatments were applied across four grain varieties at a location in the Intermountain Region and three grain varieties and one location in the San Joaquin Valley. In addition, there was an additional nitrogen study done at Intermountain REC with 18 application rate and timing applications that match the seven treatments shown above (plus additional ones), and select treatments of that study were also sampled for the 2012 study. The samples were collected prior to significant post-harvest rains, and were targeted to occur within approximately 2 to 4 weeks after harvest. At the sampled test locations, in order to reduce the costs associated with laboratory analysis we sampled only three of the four replications. However, this is still a significant number of samples (three replications x 7 fertilizer treatments x 4 varieties). This research objective required support from the California Wheat Commission due to the high number of soil analyses required and the significant costs of nitrate analyses.

Samples were collected in one foot increments between the surface and four feet depth, and then in two foot increments from four to eight feet depths. Both of the Siskiyou County trials were sampled post-harvest, for a total of about 670 samples total at post harvest timing plus a limited additional number of soil samples collected at pre-planting or early post-planting timing to characterize initial soil nitrate profile conditions. Since the West Side REC trial was not judged to have adequate plant populations, and there were some replication losses associated with intrusion into the plots from an outside farm contractor, a decision was made to not collect and analyze deep soil samples post-harvest at the 2012 West Side REC site. The Principal Investigator at that location's trial (Steve Wright) made the determination that these issues made the test results unreliable and not necessarily representative of the expected treatment effects. Even with the decision that the West Side REC location in 2012 was not suitable for field nitrate sampling due to stand problems and harvest problems, we added an additional trial to the sampling in Siskiyou County for soil sampling, and the total number of samples to be analyzed totals about 700, which will utilize the majority of the budgeted soil analysis funds for this project year.

Originally this residual nitrate-N project was also to include sampling at a test location in Imperial Valley in cooperation with Dr. Khaled Bali on a Wheat Commission supported trial there. However, this effort was not coordinated by the Principal Investigator or Dr. Bali, and did not take place in 2012. The trial funds available and time required for sampling at the Imperial Valley location were one of the limitations, and coordination of timing to do the work was another issue to be resolved. If the Principal Investigator and Dr. Bali can set up a workable schedule to handle all of the soil sample collection needed for his trial in one trip from the San Joaquin Valley to Imperial Valley, we will consider again adding the Imperial Valley site if supplemental funding from sources such as FREP can assist in covering the additional soil testing, soil sample supplies and travel costs. We are not sure this is possible within the time and funding constraints for the current supported project, and will reduce the budget somewhat to reflect the lack of time and funds to cover the Imperial Valley efforts.

Soil samples were collected: (a) pre-plant or soon after planting in three to four locations within the trial site initially to characterize the initial soil nitrate-N status; and (b) in extensive sampling to a depth of eight feet after grain harvest. Trials were conducted at the West Side Research and Extension Center (WSREC) and at two field sites in Siskiyou County, CA at the Intermountain Research and Extension Center. Soil samples were collected using a trailer-mounted powered Giddings soil sampler, with samples collected at the following depths as separate samples for analysis purposes: 0-1 foot, 1-2 foot, 2-3 foot, 3 to 4 foot, 4-6 feet, and 6-8 feet. Soil samples from the 2012 trials in Siskiyou County were just collected in late September, 2012. Samples will be dried, ground and prepared for analyses for nitrate N, but the analyses will not be completed likely until late in 2012 at the UC ANR testing laboratory. With this sample timing in mind, there is not much in the way of 2012 data to discuss in terms of trial results other than to indicate that samples were collected in all treatments as planned, to a depth of eight feet in three replications of each of the treatments. However, to give an indication of the type of work done with this data, similar field trials were conducted in 2011 (through the funded projects of Wright and Orloff), although this investigator (Hutmacher) did not receive funding for work done on those projects in 2011.

TABLE 1. Post Harvest average soil nitrate-N (lbs nitrate-N/acre) in 2011 field trial locations contained in parts of the soil profile as a function of site and N treatment (values shown are averaged across all varieties). PRELIMINARY SUMMARY
- Subject to changes as evaluations continue.

Treatment (lbs N applied at growth stage)	Scott Valley Siskiyou County			Intermountain REC SiskiyouCo.			West Side REC Fresno County		
	Average lbs N as nitrate-N in lbs/ac for depth range shown			Average lbs N as nitrate-N in lbs/ac for depth range shown			Average lbs N as nitrate-N in lbs/ac for depth range shown		
	0 to 4 ft	4 to 6 ft	6 to 8ft	0 to 4 ft	4 to 6 ft	6 to 8ft	0 to 4 ft	4 to 6 ft	6 to 8ft
Untreated control	27.8	14.8	40.1	50.7	21.7	20.2	23.1	35.6	17.9
120 lbs preplant	31.7	14.1	45.2	62.4	31.0	25.8	75.3	34.2	13.2
120 preplant + 50 tillering	30.4	25.2	37.2	61.6	27.0	19.6	55.9	37.7	16.7
120 preplant, 30 flowering	35.6	21.2	42.3	90.7	37.5	19.4	53.8	33.1	17.3
120 preplant, 50 tiller, 30 boot	49.5	21.1	49.7	86.9	38.7	19.4	42.5	44.5	18.1
120 preplant, 50tiller,30flow	42.4	15.4	41.1	95.7	48.7	18.6	- no trt this site	-	-
120 preplant, 50 tiller, 30 boot, 30 flower	63.1	20.7	45.4	107.3	35.8	20.5	52.9	46.3	20.9

Table 1 shows some preliminary summary information on soil nitrate accumulation patterns seen at post harvest timing in the 2011 study (as mentioned, 2012 study results will not be available for some months). We are still working on this data set, and many of the details are not shown since the values shown are averaged across 3 or 4 different varieties, which differ in some growth characteristics and yield to some extent. The data to this point shows higher soil nitrate-N values at the post harvest sample timing in the surface 4 feet of the higher N application treatments, indicating some residual effects of these treatments when compared with untreated control plots. There also are some differences across the three different test sites shown for the 2011 data that we will have to analyze to consider differences in soil water holding capacity and other characteristics that could impact nitrate in the soil. In all three sites, data summaries show little difference in deep (6 to 8 foot depth) soil nitrate-N between control plots and most treatments, suggesting little movement of nitrate from upper profile into that zone. There are some suggestions that soil nitrate levels were higher in some of the higher N application treatments than in control /untreated plots at the 4 to 6 foot depth at two of the three sites. Additional efforts will be made in this and the 2012 data sets to evaluate varietal differences in the patterns seen, and how that might relate to yield differences or responses to N management practices.

Budget (planned expenditures during calendar year 2012 with CA Wheat Commission Funding)

- *Note that this project required that the Siskiyou County N project headed up by Steve Orloff and the San Joaquin Valley project headed up by Steve Wright were funded and carried out, since those projects set up the N application treatments needed to conduct this part of the study.*
- *While the budget was originally \$16,000, the Imperial County work was not conducted in 2012, and some of the expenses at other sites were higher than expected, resulting in different expected expenditures.*

Category	Amount (\$)
Soil analyses (Univ. CA ANR Testing Laboratory) – nitrate analyses, plus some other baseline soil nutrient tests at each site	7,700
Soil sampling supplies, repairs to soil grinders and supplies	800
Repairs and supplies related to Giddings soil sampling equipment, trailer mounted	1,500
Part-time Research Asst. time, casual labor for soil preparation, grinding soils, analyses	1,900
Travel – to research sites	1,700
TOTAL	\$13,600

Cooperative Support – Additional Proposal submitted:

The project investigators recently (August, 2012) applied for additional funds for an expanded version of this project to the CA Dept of Food and Agriculture's Fertilizer Research and Education Program (FREP). If FREP program funds are also acquired from the submitted proposal for 2013-2015 funding, then the likely changes in our plans would include one additional test site in each of the areas (northern CA and southern SJV) and more detailed plant and soil sampling within season at each test site. We also could consider addition of more varieties in the soil sampling to be conducted in efforts as part of the project plan.

Recommendations and Future Plans

Plans are to request continuing funds to conduct additional studies of N management options and resulting plant responses and soil nitrate responses to changes in N fertilizer application amounts and timing.