Impact of Nitrogen Fertilization Treatments on Residual Soil Nitrate Accumulation Patterns in California Wheat - *Partial 2013 sampling results and 2014 sampling done*

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Abstract / Summary
Research was conducted in wheat grown for grain with 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 primary projects in 2013 were operated and will be reported on by the Co-PI's at the Intermountain REC location (Steve Orloff, UCCE Siskiyou County, PI) and San Joaquin Valley locations (Steve Wright, UCCE Tulare and Kings Counties, PI), with this affiliated project set up to monitor soil nitrate N levels as affected by the different nitrogen management treatments. In addition, in 2014 Mark Lundy was added as an additional Co-PI with trial locations added in the lower Sacramento Valley (Yolo County).

The overall goal of the joint projects was to evaluate impacts of N application treatments and growth stage timing on yield, grain protein, and potential for significant nitrate N movement within the active crop root zones and at greater depths. This project is a continuing effort to focus on deep soil sampling as part of the overall N management field trials. 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 plants.

Introduction, Background and Objectives
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.

Co-Principal Investigators Steve Orloff and Steve Wright have been conducting wheat N management trials since 2011 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 the prior three years 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. 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 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 - 2013 Studies

The basic nitrogen management treatments were imposed at three locations (Siskiyou County and two sites in the San Joaquin Valley) in 2013. The basic treatments for these studies were as shown in the tables below for West Side REC and Kearney REC site data:

Table 1 Average post harvest timing soil nitrate-N values as a function of N treatments identified and depth in the soil profile at the UC West Side REC trial site in 2013.

Values shown are average soil NO3-N (ppm) in each zone of the soil profile																
Variety shown is Summit – Columns shown are treatment # as identified in Table 1.																
Depth in soil profile (ft)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
0-1	5.73	4.96	9.41	6.02	5.39	5.2	4.36	3.53	3.92	5.11	6.02	6.48	3.66	3.45	4.86	
1-2	3.36	2.54	2.61	5.19	8.23	3.34	2.66	3.22	1.97	3.89	3.08	4.3	3.01	2.96	4.08	
2-3	1.44	2.76	1.56	5.65	4.62	1.43	2.04	1.38	1.18	3.81	5.34	3.41	2.61	5.48	2.35	
3-4	1.15	2.23	1.93	3.13	2.86	1.14	1.16	0.86	1.34	3.91	3.4	6.1	2.82	4.84	3.55	
4-6	1.56	2.91	2.06	3.88	2.27	1.6	3.08	1.38	1.56	2.55	3.23	5.51	2.37	3.31	3.34	
6-8	1.11	2.82	1.72	2.8	4.81	1.22	1.57	1.11	0.99	2.41	2.26	4.21	2.22	2.19	3.13	
TOTAL in 8 foot profile	**62.7**	**88.3**	**85.1**	**122.9**	**130**	**61.8**	**72**	**51.5**	**49.9**	**98.2**	**106.3**	**146.5**	**78.5**	**102.2**	**102.4**	
N Applied amounts per treatment (lbs N/ac)																
Preplant	**80**	**130**	**80**	**80**	**280**	**80**	**80**	**80**	**80**	**130**	**130**	**130**	**200**	**200**	**130**	
Tillering		**50**	**50**	**50**		**50**			**50**	**50**	**50**	**50**	**50**	**50**	**50**	
Jointing		**50**		**50**			**50**					**50**		**50**		
Boot				**50**			**50**	**50**	**50**	**50**		**50**	**50**		**50**	
flowering		**50**	**50**	**50**			**50**	**50**			**50**	**50**			**50**	
TOTAL	**80**	**280**	**180**	**280**	**280**	**130**	**230**	**180**	**180**	**230**	**230**	**330**	**300**	**300**	**280**	

Table 2. Average post harvest timing soil nitrate-N values as a function of N treatments identified and depth in the soil profile at the UC Kearney REC trial site in 2013.

Values shown are average soil NO3-N (ppm) in each zone of the soil profile																
Variety shown is Summit – Columns shown are treatment # as identified in Table 1.																
Depth in soil profile (ft)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0-1	3.17	14.23		9.84		6.4		4.44		11.22			15.06	11.89		
1-2	1.89	7.41		8.35		2.86		3.65		5.1			12.17	14.57		
2-3	3.05	9.56		8.37		5.92		5.64		8.32			12.87	14.14		
3-4	3.14	7.12		5.95		3.48		3.63		6.57			6.57	6.47		
4-6	5.5	7.13		6.35		4.24		3.0		5.23			6.99	5.15		
6-8	6.5	6.52		4.37		3.04		3.6		4.72			4.66	5.01		
TOTAL in 8 foot profile	**133.9**	**249.1**		**204.8**		**126.1**		**116.1**		**194.0**			**265.6**	**255.8**		
N Applied amounts per treatment (lbs N/ac)																
Preplant	**80**	**130**	**80**	**80**	**280**	**80**	**80**	**80**	**80**	**130**	**130**	**130**	**200**	**200**	**130**	
Tillering		**50**	**50**	**50**		**50**			**50**	**50**	**50**	**50**	**50**	**50**	**50**	
Jointing		**50**		**50**			**50**					**50**		**50**		
Boot				**50**			**50**	**50**	**50**	**50**		**50**	**50**		**50**	
Flowering		**50**	**50**	**50**			**50**	**50**			**50**	**50**			**50**	
TOTAL	**80**	**280**	**180**	**280**	**280**	**130**	**230**	**180**	**180**	**230**	**230**	**330**	**300**	**300**	**280**	

- Data is not shown for treatments #3, 5, 7, 9, 11, and 12 since the PI for the site indicated that there were stand issues with the wheat crop in replications of those specific treatments.

Similar data was collected at the Intermountain REC site in 2013 but will be analyzed and presented separately by the PI for that research site. The soil samples at the sites evaluated in these studies were collected prior to significant post-harvest rains, and were targeted to occur within approximately 4 to 8 weeks after harvest if possible. 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. Siskiyou County trials were sampled post-harvest, for a total of over 600 samples 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. Similar sample numbers were obtained from West Side REC and Kearney REC sites in the San Joaquin Valley. The primary trial samples were analyzed, and results will be interpreted by the primary project PI's in relation to the yield responses of the included wheat cultivars.

In 2014, soil samples were collected pre-plant and post-harvest at the West Side REC site (clay loam soil) in Fresno County in July and early August. Similar soil sampling was done at the Yolo County site in June and July of 2014. Post harvest soil samples are to be collected to a depth of 8 feet at the Intermountain REC site in October, 2013 (not yet done at the time of this report in late September). Soil samples have been 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 each year have to be air dried, ground, run through a 2 mm sieve, subsampled and prepared for analyses for nitrate N. The analyses are completed for 2013 trial work, and for the 2014 soil samples collected at the Yolo County field site. The samples have been prepared but not yet submitted for analyses from the UC West Side REC site as of the date of preparation of this report, but plans are to submit them to the UC Davis Analytic Lab during the month of October. Additional analyses need to be done to determine treatment effects on accumulated soil nitrate-N in different parts of the soil profile, but it was evident that some of the later application timings and higher rates of soil applied N resulted in higher ending soil nitrate-N levels in the upper 4 to 6 feet of the soil profile. Similar evaluations will be done on the soil samples collected from 2013 trial site at Intermountain REC and at 2014 trial sites.

Discussion:
The data analyzed generally indicates 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 different test sites that may be related to irrigation amount and method differences, as well as differences in soil water holding capacity and other characteristics that could impact nitrate and nitrate movement in the soil. Data summaries evaluated in general show only small differences or no significant differences 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.

Total number of soil samples collected or remaining to be collected from 2014 trials: The number of soil samples to be collected during post-harvest sampling in 2014 is estimated to be about 800 samples (West Side REC site), about 570 samples (Yolo County site), and the number for the sampling at the Intermountain REC site is not known at this time, but in the past has been between 600-700. With this number of samples, we expect to utilize our full 2013-2014 budget plus carryover funds to pay for the analyses.

Budget and Expenditures:
Funds from the 2013-2014 project allocations ($10,000) are being spent primarily on soil sample preparation and analyses done through the UC Davis Analytical Laboratory (most of the funds), with some additional expenditures on staff time (sample preparation and grinding), limited supplies (sample containers, repair parts for soil sampler) and limited travel (mostly to field site at Intermountain REC).

Cooperative Support –
Additional Proposal submitted to CDFA-FREP progam, funded starting in January, 2014

The project investigators 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) earlier in 2013, and we received notification in August that we would be receiving $75,000 in funding for the project in 2014, 2015, and 2016. The FREP proposal budget we submitted indicated that we would continue to apply for funds for this ongoing project from the California Wheat Commission, so we hope to expand the project some in terms of test sites and some data collection if both funding sources are available. With FREP program funds from the submitted proposal for 2014-2016 funding, then the likely changes in our plans would include one additional test site in each of the areas (northern CA and southern SJV), addition of Mark Lundy (UCCE Colusa County) as a new cooperator on the project in Sacramento Valley, plus more detailed plant sampling 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.