Evaluation of N Fertilizer Rate and Timing on Wheat Yield

Researchers

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Abstract

This project sought to evaluate the effects of N rate and timing on yield and grain protein content in irrigated winter wheat grown in central Oregon. Currently, many wheat producers in the area apply N fertilizer in the fall, rather than in the spring, due to logistical concerns of weather, soil moisture, and workload. By evaluating the effect of fall and spring applications of N, we aim to provide guidance for growers on when to apply N fertilization in an effort to maximize grain yield. Large-scale plots were used to assess N rate and timing effects on grain yield, test weight and protein percentage. To trace the fate of fertilizer N, ^{15}N labeled urea was applied to micro-plots in fall and spring, and soil and biomass samples were collected and analyzed to track recovery of the ^{15}N labeled urea. Winter wheat grain yield for 2013-14 and 2014-15 where soil test N was high was largely unresponsive to N fertilization. The labeled ^{15}N urea was recovered primarily from the top six inches of soil and losses ranged from 0 to 30% in 2013-14. Winter wheat response to N fertilization in central Oregon is highly variable likely due to variation in soil depths and textures as well as soil N supply related to crop rotation.

Introduction

The 4R concept of nutrient management means using the:

- Right fertilizer rate at the
- Right time with the
- Right fertilizer source in the
- Right place.

The researchers at COARC in Madras wanted to address the first two R's (rate and timing) for winter wheat in central Oregon. In addition to measuring N fertilizer rate and timing effects on grain yield and protein, we also measured the fate of applied N applied using ^{15}N labeled urea. Conventional wisdom states that applying all of the nitrogen required for winter wheat in the fall is not the best management practice because the N could be immobilized in the soil, leach below the root zone, or be lost as volatilized NH_3 where urea is topdressed on high pH soils.

However, there are many factors that play into management decisions and can take priority over what research suggests as best management practices. Factors such as spring rainfall and field conditions can prevent timely spring application of nitrogen to winter wheat. Some growers choose to apply all of the crop's nitrogen in the fall when field conditions are good which may limit the effectiveness of applied N fertilizer rather than risk not being able to apply nitrogen in

the spring. To determine the impacts of nitrogen rate and timing, as well as the fate of N applied, large plots (70 ft by 300 ft) were placed in three commercial fields for the 2013-14 and the 2014-15 crop years.

Materials and Methods

N Rate and Timing

Three locations were used for the 2013-14 crop year: Madras (previous crop wheat), Culver (previous crop potatoes), and Lower Bridge (previous crop garbanzo beans). Soil tests at the three locations were performed prior to nitrogen fertilizer application. Soil test nitrate (NO_3) values were 58 (Madras), 114 (Culver), and 60 (Lower Bridge) lb NO_3/a. Nitrogen rates used were 0, 60, 120, and 180 lb N/a for either fall or spring application.

Three locations were used for the 2014-15 crop year: Madras (previous crop carrot seed), Culver (previous crop wheat), and Lower Bridge (previous crop garbanzo beans). Soil tests at the three locations were performed prior to application of fertilizer nitrogen. Soil test NO_3 values were 159, 19, and 54 lb NO_3/a at Madras, Culver, and Lower Bridge, respectively. Plots were then fertilized in either the fall or spring at nitrogen rates from 0 lb/a to 280 lb/a in 70 lb increments (Table 1.).

^{15}N Fate and Recovery

To measure trace the fate of applied in fall or spring, we applied 150 lb N/a of ^{15}N labeled urea to micro-plots within the check plot. These micro-plots with the ^{15}N labeled fertilizer were used to determine the fate of fall and spring applied N fertilizer by quantifying the amount of applied N taken up by the wheat crop, the amount of applied N remaining in the soil as organic N, and residual inorganic N in soil. The results allow us to determine the percentage of applied N that can be accounted for in the wheat crop and in the soil, as well as the percentage of applied N lost to NH_3 volatilization, NO_3 leaching, and/or denitrification. The entire wheat plant was harvested from the micro-plots when wheat was at milky to mealy ripe growth stage (Feekes 11.1-11.2). Samples were dried, weighed, and ground and were analyzed at the Stable Isotope Research Unit at Oregon State University. After the plants were removed soil cores were collected to a depth of up to 36 inches to determine where in the soil profile the ^{15}N labeled N was at the end of the season.

Results and Discussion

^{15}N Fate (2013-2014)

Data from this year (2014-15) is currently being analyzed therefore the results discussed are from the previous year's project (2013-14). The soil distribution of the ^{15}N labeled urea at all locations found the majority of the recovered ^{15}N in the surface six inches (Table 2). Table 3 shows the amount of the labeled urea found in the plant and in the soil and what percentage of the labeled urea was recovered. If less than 100% was recovered that indicates that there was a net loss of the labeled urea from the system. Looking at the soil distribution of the labeled urea recovered, leaching of N with fall application on sandy soils could be problematic during wet years.

Overall, N loss for the 2013-14 crop year ranged from no loss to almost 30%. The Culver site in the first year started with a high soil nitrate concentration (114 lb N/a) and the low recovery of the labeled urea could be due to dilution in both the soil and plant. In general, spring N application resulted in more N left in the soil than fall application, meaning that less N made it into the wheat and lowering the efficiency of the N applied.

Yield 2013-14

At the Madras location, fall applied N yielded better than spring applications. The grower application of 225 lb N/a in the fall outperformed all treatments prompting us to increase N rates for the second year of the trial. The Culver location (following potatoes) was unresponsive to N fertilizer due to high soil N availability prior to N applications. Lower Bridge saw higher yields from spring N applications than fall N.

Yield 2014-15

Yield results varied by location. At the Madras location where soil test nitrate was high before application of the nitrogen fertilizer and the previous crop was carrot seed, there was no response to the fertilizer (Figure 1). At the Madras location, significant lodging was observed in the high nitrogen rates (>140 lb/a) for both fall and spring application. Additionally, N application >70 lb/a reduced yields, particularly in the spring. Both Culver and Lower Bridge were responsive to N fertilization. Spring application of N at the Culver location was more effective than the fall application of N. It is likely that the residue carryover from the previous year's wheat immobilized the fall applied N, particularly at lower application rates resulting in poor crop uptake. At Lower Bridge yields with fall or spring applied N were comparable up to a rate of 140 lb N/a. At N rates above 140 lb N/a spring N reduced yield; a common response observed when the N supplied to plants is excessive. The field at Lower Bridge came out of garbanzo beans and N release from the garbanzo residue

The yield data from the 2013-14 crop year at Lower Bridge indicated that spring application of N performed better than fall application. The difference between the two years lies in the winter conditions for the fields. The winter of 2013-14 was colder with more winter precipitation, whereas the winter of 2014-15 was warm with little to no precipitation. The soil at Lower Bridge is a sandy loam so the increased winter precipitation in 2013-14 potentially leached as much as 10% of the N applied in the fall resulting in depressed yields in the fall N application plots.

Grain Protein and Test Weight

The results from this year's (2014-15) grain protein and test weight analysis are not yet available.

Conclusions

The yield results of this trial indicate a strong influence of crop rotation on the effect of spring or fall N application. Response to N fertilizer can range from a negative response from over application of N fertilizer (2015 Madras >140 lb/a & Lower Bridge Spring N) to highly significant responses (2015 Culver). We can gain some guidance from the results of the two years of data. This data clearly highlights how critical preplant soil tests can be when determining fertilizer application rates. Failure to account for soil N supply capacity before making fertilizer N rate/timing decisions increases the probability of making unprofitable N

fertilizer applications. The data from the Culver location in 2013-14 (following potatoes) and the Madras location in 2014-15 (following carrot seed) showed no response to N fertilization with soil test N at 137 lb N/a and 159 lb N/a, respectively. These locations followed low residue crops, which prevented immobilization of N in the soil and thus needed no additional N fertilization.

The Lower Bridge results (following garbanzo beans) from 2013-14 indicated that spring application of N performed better than the fall applications. This is likely due to a cold, wet winter where the fall applied N on a LaFollette sandy loam had more opportunity to be leached below the root zone. However, the 2014-15 data showed the reverse; fall application of N out yielded the spring applications.

The wheat after wheat rotations showed similar results to the Lower Bridge, where the first year indicated fall applications were more effective but the second year indicated spring applications. This is likely the result of the growing conditions for the two years. Again, 2013-14 was a cold, wet winter and 2014-15 was a warm, dry winter. The cold, wet winter prevented the wheat residue from the previous year's crop from breaking down rapidly leading to prolonged immobilization of N in the residue. The capacity of the soil to supply N to the crop was so low that without fall N the yield potential could not be met by spring N alone. The warm, dry winter in 2014-15 allowed for more rapid breakdown of the wheat residue and thus making the N in the soil more available to the crop in the fall so that the spring application of N went to the growing wheat rather than being tied up in the residue.

Data from 2013-14 and 2014-15 indicate that spring N application is superior to, or at least as good as, fall N application with respect to getting applied N into the plant rather than having it immobilized in the soil or lost from the soil/plant system. This is confirmed by the ^{15}N data from 2013-14 and yield response data in 2013-14 and 2014-15. The apparent exception was the yield response at Madras in 2013-14, which was the result of insufficient soil N in the fall, which limited yield potential.

Table 1. Distribution of ^{15}N labeled urea in soil at each location (2013-14 crop year).

	Madras		Culver		L. Bridge	
Soil depth inches	Fall	Spring	Fall	Spring	Fall	Spring
	lb N/a	lb N/a	lb N/a	lb N/a	lb N/a	lb N/a
0 to 6	31.2	42.5	42.8	37.7	47.9	51.9
6 to 12	2.8	5.1	5.9	12.2	6.2	12.6
12 - 24	-*	2.2	4.0	10.9	14.7	10.9
24 to 36	-	1.9	4.3	-	8.6	6.8

*Missing values for soil depths indicate that samples were unable to be collected at that depth.

Table 2. Recovery of 150 lb N/a as ^{15}N-labeled urea from plant and soil at each location for 2013-14.

Location	Time	Plant		Soil		Total		
		lb N/a		lb N/a		lb N/a		%
Madras	Fall	87	a*	34	d	121	b	80
	Spring	85	a	51	cd	136	ab	89
Culver	Fall	51	b	57	bcd	108	b	72
	Spring	54	b	61	abc	114	b	76
L. Bridge	Fall	57	b	77	ab	134	ab	90
	Spring	81	a	82	a	163	a	109

*Means followed by different letters indicates significant differences.

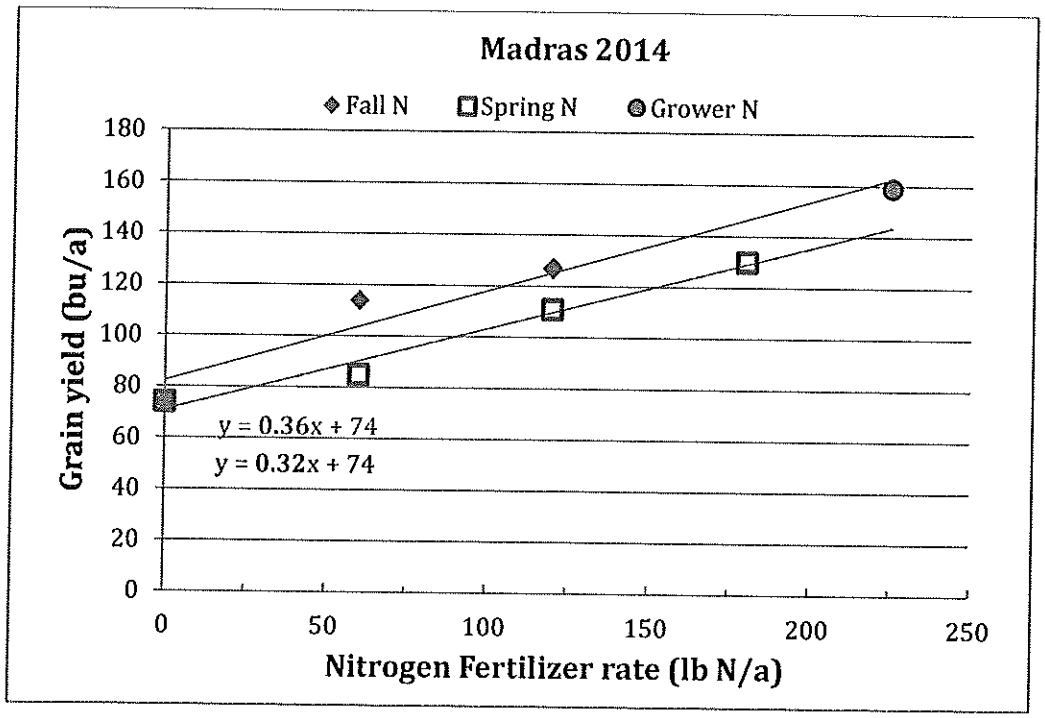

Figure 1. Response to N rate and application time (spring or fall) at the Madras location for 2013-14.

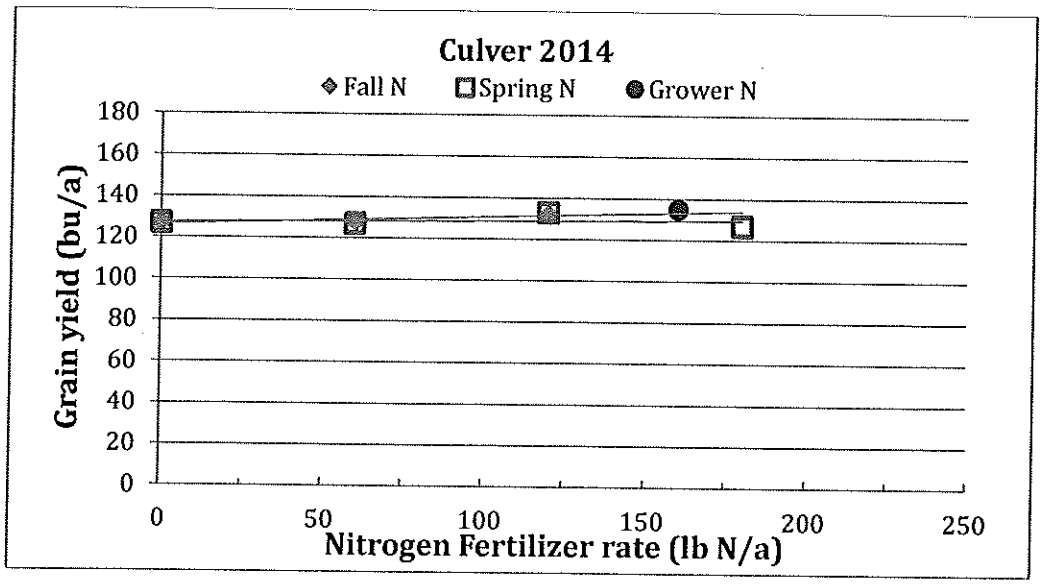

Figure 2. Response to N rate and application time (spring or fall) at the Culver location for 2013-14.

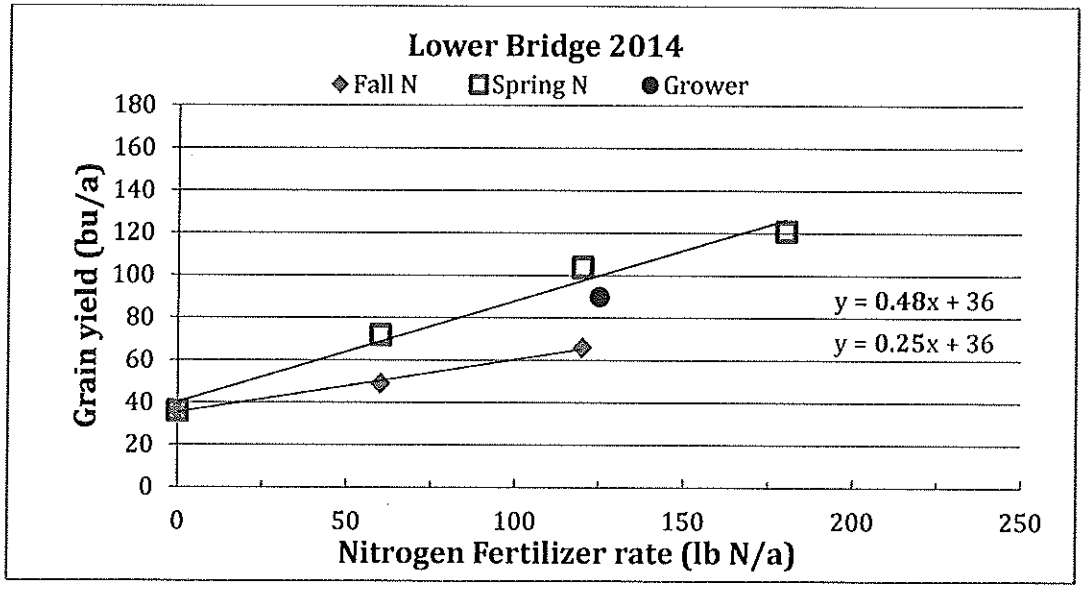

Figure 3. Response to N rate and application time (spring or fall) at the Lower Bridge location for 2013-14.

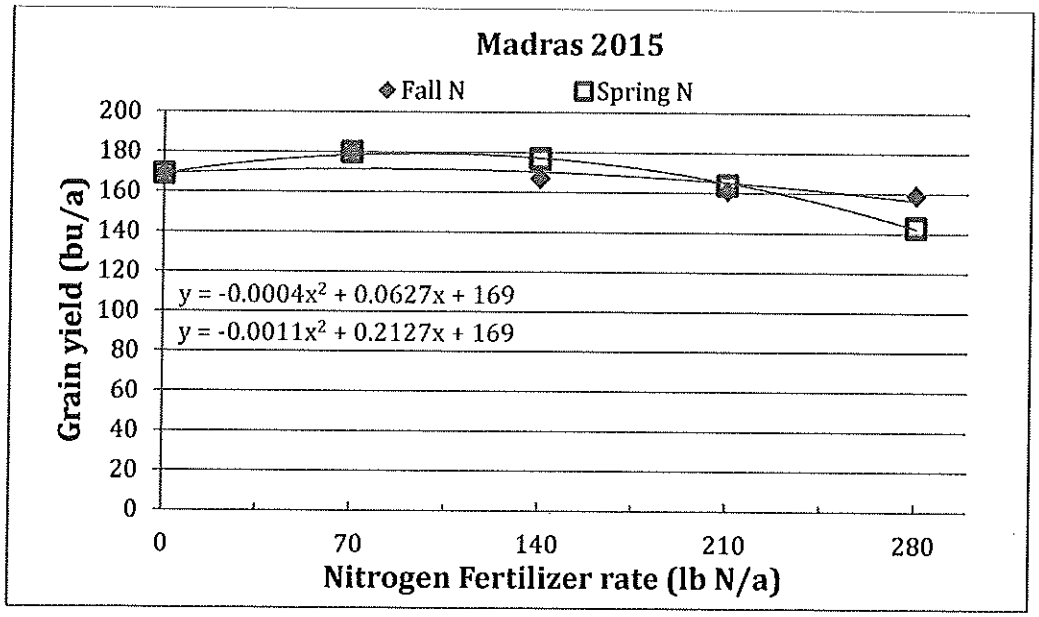

Figure 4. Response to N rate and application time (spring or fall) at the Madras location for 2014-15.

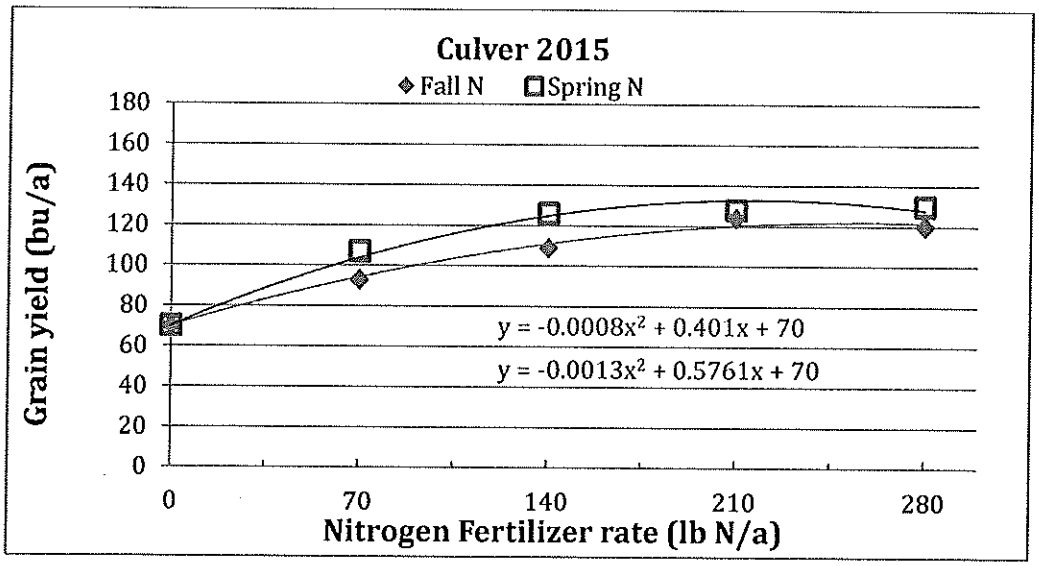

Figure 5. Response to N rate and application time (spring or fall) at the Culver location for 2014-15.

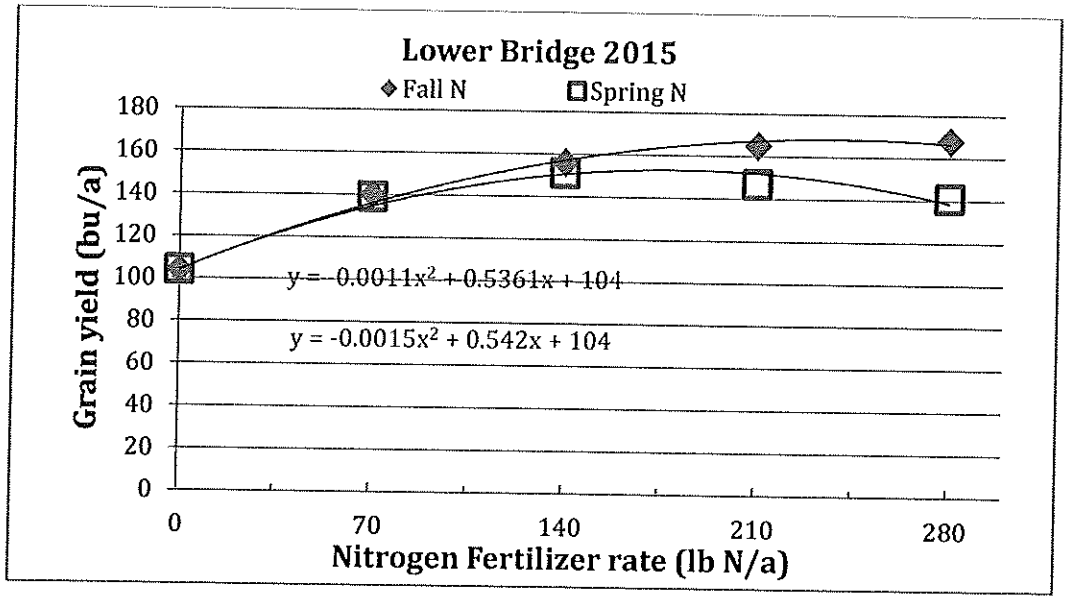

Figure 6. Response to N rate and application time (spring or fall) at the Lower Bridge location for 2014-15.