DEFINING OPTIMUM NITROGEN FERTILIZATION PRACTICES FOR PERENNIAL RYEGRASS AND TALL FESCUE SEED PRODUCTION SYSTEMS IN THE WILLAMETTE VALLEY

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Introduction

Oregon grass seed growers typically do not monitor crop or soil nitrogen (N) levels during the growing season and often apply fertilizer N in excess of recommended rates. Excessive fertilizer N use may result in leaching losses. This study has three objectives: 1) Determine the level of spring applied nitrogen fertilizer needed for optimizing both crop and economic returns; 2) Update OSU Extension Service Fertilizer Guidelines; and 3) Develop educational programs to reduce excessive N fertilization.

Large scale on-farm plots were established in three perennial ryegrass and three tall fescue fields. The fields were selected to represent soil types typically used for seed production in the Willamette Valley. Spring fertilizer treatments of 0, 45, 90, 135, 180, 225, and 270 lb N/a were split-applied (50/50) using precision application equipment. Normal grower equipment was used to swath and combine plots. Yields were measured using a weigh-wagon. Crop and soil samples were obtained for N uptake, soil N levels, and yield components. Results from the first-year crop indicated N levels above 135-180 lb N/a for perennial ryegrass and 90-135 lb N/a for tall fescue did not statistically increase seed yield. Perennial ryegrass was able to take up more N in above-ground biomass than tall fescue. Levels of soil NO_3-N were increased by the highest N rate (270 lb N/a) but were below 10 ppm. Based on sampling in the fall, the potential for leaching losses of N from normal application rates of N fertilizer does not appear to be a problem. These results are from the first year of a multi-year study.

Procedure

Large scale on-farm plots averaging 4.2 acres per site were established at 6 locations (3 perennial ryegrass, 3 tall fescue) prior to fertilizer applications. One North Valley and two South Valley sites for each species were established, encompassing soils in poorly drained to moderately well drained conditions (e.g., Concord-Amity and Woodburn soil types). All sites were in their first crop year and specific information for each site is shown in Table 1.

Table 1. Site information for the perennial ryegrass and tall fescue locations.

Location	County	Variety	Planted	Soil type
Perennial ryegrass				
J Bar V Farms	Marion	Cutter	Fall 97	Woodburn silt loam
L3 Farms	Linn	DLF-1	Fall 97	Concord and Amity silt loam
Venell Farms	Benton	SR 4200	Fall 97	Dayton silt loam
Tall fescue				
Malpass Farms	Linn	Kittyhawk SST	Fall 96	Bashaw silty clay
Nixon Farms	Lane	Duster	Spring 97	Malabon silty clay loam
Roselawn Farms	Marion	Tomahawk	Fall 98	Woodburn silt loam

Plots were approximately 22 ft wide by 300 ft long (depending on fit in the field and grower equipment size). Spring fertilizer treatment rates of 0, 45, 90, 135, 180, 225, and 270 lb N/a were used. The seven treatments were replicated three times in a randomized complete block. Experimental data was analyzed using appropriate statistical analyses (e.g., ANOVA, Regression).

All sites were fertilized between February 26 and April 13 at the pre-determined rates using a split application (50/50) about four weeks apart. Applications were done between approximately 400 and 800 growing degree days (GDD) as is generally recommended. The 400 GDD and 800 GDD points were March 1 and April 18, 1998, respectively. Accumulated GDD using the T_{sum} method was calculated by summing the daily degree day values obtained by adding the maximum and minimum temperatures for the day, dividing by two and subtracting the base temperature, which for temperate grass is 0°C. Accumulated GDD was calculated beginning January 1. Additional details regarding calendar dates of N application and harvest at each site are shown in Table 2. Fertilizer was applied using a Gandy Orbit-air spreader pulled by a four-wheeler or small Kubota tractor. In addition to fertilizer N treatments , each site also fertilized with 275 lb/a of 0-15-20-10 at the same time as the first N application to ensure there were no other nutrient limitations. The plots were managed the same as the rest of the field for all other cultural management practices (weed control, fall fertilizers, disease control, etc.) by the grower-cooperator.

Table 2. Dates of fertilization, windrowing, and combining for optimum N study, 1998.

Location	Variety	Fertilizer application 1st date	Fertilizer application 2nd date	Windrow	Combine
Perennial ryegrass					
J Bar V Farms	Cutter	3/6	4/9	7/15	8/4
L3 Farms	DLF-1	3/19	4/13	7/17	7/30
Venell Farms	SR 4200	3/11	4/13	7/21	8/5
Tall fescue					
Malpass Farms	Kittyhawk SST	3/5	4/8	7/7	7/17
Nixon Farms	Duster	2/26	4/8	7/8	7/18
Roselawn Farms	Tomahawk	2/27	4/9	7/11	7/18

Plant samples were taken approximately 2 weeks following the first N application, at heading (May 12-15), and at maturity (June 26-30). Yield components samples were obtained at or following pollination during June. Plots were swathed into windrows between July 7 and July 21 and combined between July 17 and August 5 using grower equipment (Table 2). Seed yield from each plot was measured using a Brent YieldCart and adjusted for clean seed yield following an assessment of percent cleanout from sub-samples taken at harvest. Sub-samples taken at harvest were also used to determine seed size and are currently at the OSU Seed Testing Laboratory for purity and germination analysis.

Results and Discussion

Crop yield and response

*Perennial ryegrass***:** Seed yield in perennial ryegrass increased as fertilizer rates increased up to the 135 lb N/a rate. Yield at rates higher than 135 lb/a was not significantly different (Table 3) at L3 Farms and Venell Farms. However, the highest seed yield at J Bar V Farms was obtained at 180 lb N/a. Regression analysis of these data (Table 4) resulted in the response curves (not shown) which will be used for economic analysis at the completion of this study. Higher spring N application rates resulted in more biomass and increased N uptake by the crop as shown at the Venell site (Table 6). With harvest index remaining constant (Table 7), increased biomass generally increased seed yield.

Table 3. Seed yield (lb/a) of perennial ryegrass following varied rates of spring applied N, 1998.

Spring N rate (lb/a)	L3 Farms		Venell Farms		J Bar V Farms		3-site average
0	1526	c*	1163	d	1542	e	1410
45	1803	b	1690	c	1796	d	1763
90	1969	ab	1860	bc	1835	cd	1888
135	1998	ab	2078	abc	1914	bcd	1996
180	2087	a	2080	ab	1986	ab	2051
225	2193	a	2265	a	2041	a	2166
270	2165	a	2238	ab	1947	abc	2117
LSD 0.05	275		388		121		--

*Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values (p=0.05).

Table 4. Seed yield statistical summary for perennial ryegrass and tall fescue, 1998.

Location (variety)	ANOVA	Regression analysis Linear (r^2)	Quadratic (r^2)
Perennial ryegrass			
L3 Farms	((	(((0.66)	(((0.74)
Venell Farms	((	(((0.69)	(((0.80)
J Bar V Farms	((	(((0.54)	(((0.68)
Tall fescue			
Malpass Farms	(	NS	NS
Nixon Farms	NS	NS	((0.29)
Roselawn Farms	((	(((0.68)	(((0.83)

NS = not significant P value
* = P value < 0.05
((= P value <0.01

Tall fescue: Seed yield in tall fescue was not as responsive to increased N fertilization rates as was observed in perennial ryegrass. Seed yield at two of the tall fescue sites (Malpass and Nixon Farms) showed little or no response to increasing fertilizer rates (Table 5). Regression analysis of these data (Table 4) resulted in response curves (not shown) which will be used for economic analysis at the completion of this study. At the Malpass site, one of the plots harvested at the 180 lb N/a rate was much lower in seed yield than the other two plots, hence the decrease in yield at that rate and subsequent affect on these statistics. The Malpass site is located in the poorly drained soil site and some of the stand was thin or missing. At the Nixon site there was no statistical difference in seed yield due to fertilizer rates. In contrast to these two locations, seed yield at the Roselawn site responded to N applications up to 135 lb N/a. Rates above 135 lb N/a did not increase seed yield. Harvest biomass at the Roselawn site increased as the N rates increased (P-value < 0.10). The Roselawn site was the only tall fescue site responsive to higher N fertilization rates.

Table 5. Seed yield (lb/a) of tall fescue following varied rates of spring applied N, 1998.

Spring N rate (lb/a)	Malpass Farms		Nixon Farms	Roselawn Farms		3-site average
0	1648	bc	1536	1313	d	1499
45	1709	abc	1724	1657	c	1697
90	1886	a	1771	1886	bc	1847
135	1796	ab	1708	2164	ab	1890
180	1556	c	1818	2166	ab	1847
225	1678	bc	1775	2335	a	1929
270	1796	ab	1673	2177	ab	1882
LSD 0.05	184		NS	304		--

Crop nitrogen uptake

Tissue nitrogen levels and uptake in above-ground biomass at harvest were very different between perennial ryegrass and tall fescue. Perennial ryegrass tissue N increased as the level of applied N increased (Table 8) and leveled off at the higher rates. In contrast, the tall fescue tissue N levels were not affected by the rates of N applied. Perennial ryegrass had a wider range of tissue N values (0.7 to 2.3% N) than tall fescue (0.8 to 1.7% N) and took up more total nitrogen in above ground biomass (Table 9). In addition, perennial ryegrass at all three locations took up significantly more N than was applied up to the highest applied N rates (Figure 1), while tall fescue N uptake did not increase significantly with higher applied N rates. When all three sites for tall fescue are averaged, N uptake peaked at about 90 lb N/a (Figure 2) and took up less N in above ground biomass than was applied at treatments above 135 lb N/a. As can be seen in Table 9, the soil provided a large amount of mineralized N even at the 0 N rate. Uptake in the 0 N/a applied treatment averaged 78 lb N/a in the perennial ryegrass stands and 104 lb N/a in the tall fescue sites, indicating a considerable amount of soil N mineralization.

Soil NO_3-N

Soil samples were taken prior to fertilizing in February (0-1ft depth only) and following crop harvest in late September. Samples taken post-harvest were obtained from three treatments: 0, 135, 270 lb N/a and at three depths: 0-1, 1-2, 2-3 ft. Results are detailed in Tables 10-13. At all perennial ryegrass and tall fescue sites, the highest fertilizer rate (270 lb N/a) generally increased the levels of NO_3-N in the top 12 inches of soil (see Tables 12 and 13). In the 1-2 ft and 2-3 ft profiles there were no differences in the levels of soil NO_3-N except at L3 Farms (Table 10). Soil NO_3-N concentrations taken after harvest, when compared with February samples, decreased slightly at the 0 N rate, were about the same at the 135 N rate, and increased slightly at the 270 N rate. Even though there were greater NO_3-N concentrations in the high applied N rate, concentrations were almost all below 10 PPM. Efficient soluble nitrogen removal by the fibrous root systems of these perennial grass seed crops during crop growth and development for seed production results in low NO_3-N concentrations in the soil following harvest. Use of recommended N rates will result in little potential for leachable N being available in the soil after harvest.

Table 10. Soil NO_3-N concentrations (ppm) at three soil depths of perennial ryegrass following varied rates of spring applied N, 1998.

Spring N rate (lb N/a)	pre-fert. 0-12 in.	Post harvest samples 0-12 in.	13-24 in.	25-36 in.	Soil NO_3-N changes (top 12 inches)
L3 Farms.					
0	1.3	1.9	1.0	1.1	0.6
135	--	3.7	1.6	1.2	2.4
270	--	7.7	4.4	3.5	6.4
LSD 0.05		NS	1.9	1.7	--
Venell Farms.					
0	1.1	1.5	1.2	1.2	0.5
135	--	2.6	1.3	1.3	1.5
270	--	4.7	1.7	2.5	3.6
LSD (0.10)		(2.0)	NS	NS	--
J Bar V Farms					
0	2.8	0.7	0.8	0.7	-2.1
135	--	2.4	1.1	0.9	-0.4
270	--	3.1	1.0	1.0	0.3
LSD 0.05		1.4	NS	NS	
3 site average					
0	1.7	1.4	1.0	1.0	-0.4
135	--	2.9	1.3	1.1	1.2
270	--	5.2	2.4	2.3	3.4

Table 11. Soil NO_3-N concentrations (ppm) at three soil depths of tall fescue following varied rates of spring applied N, 1998.

Spring N rate (lb N/a)	pre-fert. 0-12 in.	Post harvest samples 0-12 in.	13-24 in.	25-36 in.	Soil NO_3-N changes (top 12 inches)
Malpass Farms					
0	3.3	5.4	2.3	2.1	2.2
135	--	7.8	4.0	3.3	4.6
270	--	12.6	3.8	2.9	9.3
LSD 0.05		NS	NS	NS	--
Nixon Farms					
0	2.1	1.4	1.4	1.3	-0.7
135	--	2.2	1.3	1.7	0.1
270	--	4.7	1.9	2.0	2.6
LSD (0.10)		(2.3)	NS	NS	--
Roselawn Farms					
0	3.5	1.9	1.3	1.1	-1.5
135	--	3.2	1.3	1.3	-0.3
270	--	9.0	2.8	5.3	5.5
LSD 0.05		NS	NS	NS	
3 site average					
0	2.9	2.9	1.6	1.5	-0.0
135	--	4.4	2.2	2.1	1.5
270	--	8.7	2.9	3.4	5.8

Table 12. Soil NO_3-N concentrations (in ppm) from spring N fertilizer rate and depth of sampling of perennial ryegrass, 1998.

Treatment	L3 Farms	Venell Farms	J Bar V Farms	3-site average
Spring N rate (lb N/a)				
0	1.3	1.3	0.7	1.1
135	2.2	1.7	1.4	1.8
270	5.2	2.9	1.7	3.3
LSD 0.05	NS	*1	*1	--
Soil sample depth				
0-1 ft	4.4	2.9	2.0	3.1
1-2 ft	2.3	1.4	0.9	1.6
2-3 ft	1.9	1.7	0.9	1.5
LSD P-value	(1.9) 0.080	*1	*1	--

*1 Interaction of rate x depth significant at P#0.05 (see table m)

Table 13. Soil NO_3-N concentrations (in ppm) from spring N fertilizer rate and depth of sampling of tall fescue, 1998.

Treatment	Malpass Farms	Nixon Farms	Roselawn Farms	3-site average
Spring N rate (lb N/a)				
0	3.3	1.4	1.4	2.0
135	5.1	1.7	1.9	2.9
270	6.4	2.8	5.7	5.0
LSD 0.05	*1	*1	2.5	--
Soil sample depth				
0-1 ft	8.6	2.7	4.7	5.4
1-2 ft	3.4	1.5	1.8	2.2
2-3 ft	2.8	1.6	2.6	2.3
LSD 0.05	*1	*1	NS	--

*1 Interaction of rate x depth significant at P#0.05 (see table n)

Summary

Optimum levels of spring applied N for seed production were 135-180 lb N/a in the perennial ryegrass and 90-135 lb N/a in the tall fescue as shown by combining all three sites for each species. Applying more than the optimum rates did not ensure increased yield. It must be noted that these results are from first-year seed crops, and only by continuing these trials for 2-3 years will we be able to provide data over the life of these stands. Seed yields for all locations, as indicated in Tables 3 and 5, were well above Willamette Valley average yields of 1372 lb/a for perennial ryegrass and 1332 lb/a for tall fescue in the 1995-97 period. Soil test results show efficient use of applied N and potential for leaching losses reported appear low for recommended use rates. These sites are being continued for a second year (and possibly a third year) to determine the long-term economic and agronomic effects of these treatments.

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Table 6. Total biomass (ton/a) at maturity of perennial ryegrass and tall fescue following varied rates of spring applied N, 1998.

Spring N rate (lb/a)	PERENNIAL RYEGRASS				TALL FESCUE			
	L3 Farms	Vennel Farms	J Bar V Farms	3-site average	Malpass Farms	Nixon Farms	Roselawn Farms	3-site average
0	5.6	2.6	6.2	4.8	5.7	7.0	5.3	6.0
45	5.1	5.4	6.2	5.6	4.9	8.1	6.3	6.4
90	5.6	5.7	7.5	6.3	6.0	7.1	6.0	6.4
135	6.3	7.7	7.1	7.0	6.3	7.5	6.6	6.8
180	7.0	6.2	6.8	6.7	6.7	9.0	7.3	7.6
225	7.6	5.9	5.8	6.4	7.4	8.0	8.6	8.0
270	6.2	6.2	7.3	6.5	6.2	6.6	7.5	6.8
LSD 0.05(0.10)	NS	2.0	NS	--	NS	NS	(1.67)	--

Table 7. Harvest index (%) of perennial ryegrass and tall fescue following varied rates of spring applied N, 1998. (%=seed yield / total biomass * 100)

Spring N rate (lb/a)	PERENNIAL RYEGRASS				TALL FESCUE			
	L3 Farms	Vennel Farms	J Bar V Farms	3-site average	Malpass Farms	Nixon Farms	Roselawn Farms	3-site average
0	12	19	13	15	13	10	11	12
45	15	14	13	14	15	10	12	12
90	15	14	11	13	14	11	14	13
135	14	12	12	13	13	11	14	12
180	13	15	13	14	10	10	13	11
225	13	16	15	15	10	10	12	11
270	15	16	12	14	13	12	13	12
LSD 0.05	NS	NS	NS		NS	NS	NS	

Table 8. Tissue N concentration (%) in above ground biomass at maturity of perennial ryegrass and tall fescue following varied rates of spring applied N, 1998.

Spring N rate (lb/a)	PERENNIAL RYEGRASS				TALL FESCUE			
	L3 Farms	Vennel Farms	J Bar V Farms	3-site average	Malpass Farms	Nixon Farms	Roselawn Farms	3-site average
0	0.7	0.8	0.9	0.8	1.0	0.9	0.8	0.9
45	0.9	1.0	1.1	1.0	1.6	1.2	1.3	1.4
90	1.2	1.1	1.3	1.2	1.3	1.3	1.4	1.3
135	1.5	1.1	1.6	1.4	1.3	1.3	1.2	1.2
180	1.2	1.7	1.9	1.6	1.4	0.8	1.0	1.1
225	1.6	1.5	2.4	1.8	1.2	1.1	1.3	1.2
270	1.6	2.0	2.2	1.9	1.6	1.0	1.3	1.3
LSD 0.05	0.4	0.6	0.8	--	NS	NS	NS	--

Table 9. N uptake (lb/a) at maturity in above ground biomass of perennial ryegrass and tall fescue following varied rates of spring applied N, 1998.

Spring N rate (lb/a)	PERENNIAL RYEGRASS				TALL FESCUE			
	L3 Farms	Vennel Farms	J Bar V Farms	3-site average	Malpass Farms	Nixon Farms	Roselawn Farms	3-site average
0	77	39	120	78	109	121	83	104
45	91	107	139	112	159	197	159	172
90	138	124	193	152	152	181	161	165
135	191	170	236	199	162	175	148	162
180	160	210	239	203	187	153	144	161
225	251	178	270	233	179	173	220	190
270	199	241	316	252	202	137	198	179
LSD 0.05	66	64	120	--	NS	NS	NS	--

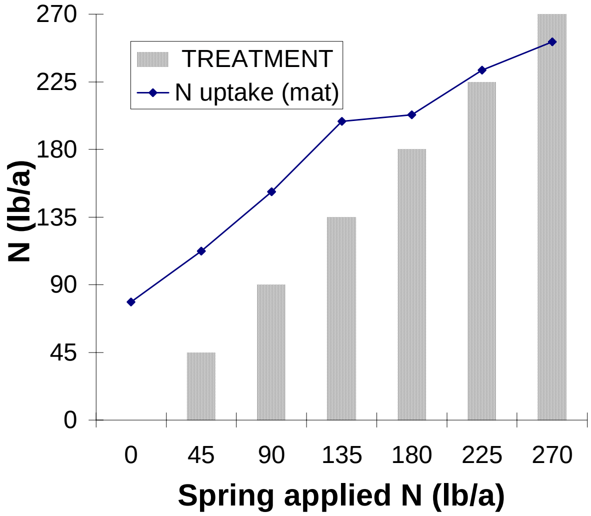

Figure 1. Perennial ryegrass crop nitrogen uptake across fertilizer nitrogen treatments, 1998

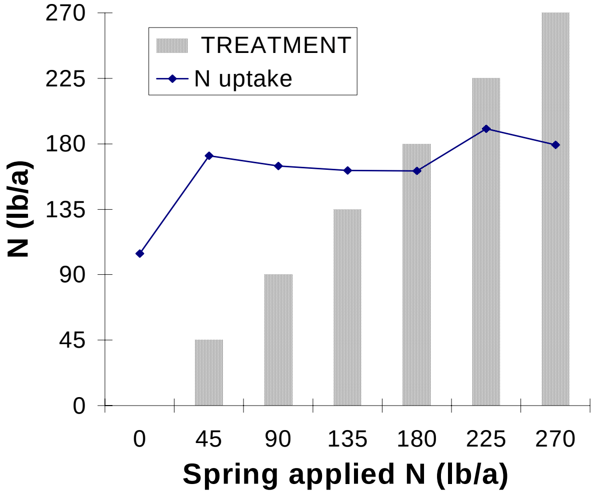

Figure 2. Tall Fescue crop nitrogen uptake across fertilizer nitrogen treatments, 1998