Fall Applications of Nitrogen and Potassium and their Effect on Winter Hardiness on Annual Bluegrass

Progress Report to:

Canadian Turfgrass Research Foundation

Research Team:

Katie Dodson

James B. Ross

Mark Anderson

Darrell Tompkins

Jason Pick

Prairie Turfgrass Research Centre
Olds College

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Objectives of this Study

The overall objectives are:

- to determine the effects of fall applied nitrogen and potassium on cold hardiness,
- to determine the relationship between plant cold hardiness, soil nutrient status, and plant tissue content,
- to determine if soil nutrient deficiencies or excesses have an impact on plant cold hardiness,
- to develop recommendations based on soil nutrient and plant tissue status with regard to fall fertilization in order to ensure maximum cold hardiness.

Plot Establishment and Treatments List

This trial was established on a USGA specification putting green located at Olds College. This green was established in the summer and fall of 2012 with annual bluegrass seed cv. Two Putt. Baseline fertility levels were established in year one with the intent of having all nutrients in the sufficiency range at the commencement of the trial in mid-August. Soil extractable nutrient status and plant tissue testing were used to determine deficient, sufficient and excessive levels. The plots were laid out in a randomized complete block design (RCBD) with four replications and two treatment levels (nitrogen and potassium rates) (Table 1).

Table 1 - List of Treatments

Treatments	Nutrient Source & Rate	
	Ammonium Sulphate 21-0-0	Potash Sulphate 0-0-52
Nitrogen 0x Rate + Potash 0x Rate	0.0 kg N/100m^2	0.0 kg K/100m^2
Nitrogen 0x Rate + Potash ¼x Rate	0.0 kg N/100m^2	0.125 kg K/100m^2
Nitrogen 0x Rate + Potash ½x Rate	0.0 kg N/100m^2	0.25 kg K/100m^2
Nitrogen 0x Rate + Potash 1x Rate	0.0 kg N/100m^2	0.5 kg K/100m^2
Nitrogen ¼x Rate + Potash 0x Rate	0.125 kg N/100m^2	0.0 kg K/100m^2
Nitrogen ¼x Rate + Potash ¼x Rate	0.125 kg N/100m^2	0.125 kg K/100m^2
Nitrogen ¼x Rate + Potash ½x Rate	0.125 kg N/100m^2	0.25 kg K/100m^2
Nitrogen ¼x Rate + Potash 1x Rate	0.125 kg N/100m^2	0.5 kg K/100m^2
Nitrogen ½x Rate + Potash 0x Rate	0.25 kg N/100m^2	0.0 kg K/100m^2
Nitrogen ½x Rate + Potash ¼x Rate	0.25 kg N/100m^2	0.125 kg K/100m^2
Nitrogen ½x Rate + Potash ½x Rate	0.25 kg N/100m^2	0.25 kg K/100m^2
Nitrogen ½x Rate + Potash 1x Rate	0.25 kg N/100m^2	0.5 kg K/100m^2
Nitrogen 1x Rate + Potash 0x Rate	0.5 kg N/100m^2	0.0 kg K/100m^2
Nitrogen 1x Rate + Potash ¼x Rate	0.5 kg N/100m^2	0.125 kg K/100m^2
Nitrogen 1x Rate + Potash ½x Rate	0.5 kg N/100m^2	0.25 kg K/100m^2
Nitrogen 1x Rate + Potash 1x Rate	0.5 kg N/100m^2	0.5 kg K/100m^2

Research Initiated Since Last Report

- Representative tissue and soil samples were collected in July 2014 and sent to the lab for the determination of baseline levels for the initiation of the study in mid-August 2014. The results of this testing showed that the deficiencies found in the spring sampling were addressed by our spring and summer fertilizer applications. This ensured that the fertilizer treatments applied this fall should be measureable.

- Fertilizer treatments commenced after an initial soil and tissue sampling on Aug. 15th 2014. A total of 4 applications were put down on a biweekly basis through to the first of October.
- Soil and tissue samples were collected on Sept. 15th and Oct. 15th to look at the effects of the fertilizer treatments on both the plant tissue and rhizosphere.
- Randomized plot sampling with a soil probe was performed on Oct. 6, Oct. 20, Nov. 3 and Nov. 24. Originally the plan was for 3 samplings, however the weather did not cool off significantly until mid Nov. so a fourth sampling occurred on Nov. 24th and the plants are currently in the regrowth stage in the greenhouse for the LT_{50} tests.
- Percent moisture of the crowns was determined for each sampling date mentioned above. Twenty-five crowns were isolated from a probe core and the top 5mm and bottom 3mm from the base of the crown were used to determine the percent moisture content of each plot.

Progress to Date

- The 2014 fall treatments were all successfully applied and samples taken. All results from Brookside labs have been entered into a table for further analysis.
- All LT_{50} data has been collected, had statistical analysis and summarized with respect to fertility treatments.
- Percent crown moisture has been determined for the four sampling dates for all 64 plots.

Results Since Last Report

Tissue analysis

- As expected treatments that received 0 lbs of either N or K showed a depletion of N and K overtime with respect to each nutrient. (Table 2)
- There is an interaction between the N treatments and the K treatments. As the amount of N goes up more K is incorporated into the plant tissue. (Table 2) This is not too surprising as Zememchick and Albrecht (2002) found that K-limited environments reduce the nitrogen use efficiency (NUE) of plants. Plants require the presence of both macronutrients to ensure optimal growth.
- In the plots receiving no N, the data shows that the high rates of K are causing a decrease in cold tolerance. This suggests that there is an upper limit to how much K is added in the fall.

Soil analysis

- Nitrogen levels in the soil were estimated but a treatment difference was not specifically noted (Table 3)
- Potassium levels responded well to the various K levels added during the course of the experiment. As the application rate of K went up the soil K levels also went up. (Table 3)

LT_{50} test results:

- Very little difference between the first 3 sampling dates, most likely due to relatively warm fall (Fig. 3) (Table 4)
- Superficially it appears that the 0.25 and 0.5 rates of N slightly increased winter hardiness, while both the zero N rates and the high rate of N (1) lowered the winter hardiness rate. (Table 4)
- The fourth sampling (Nov. 24) resulted in the most cold tolerant plants. The best results were -15^{0}C and were all within the 0.5 and 0.25 lbsN/M rates and when K was also at the 0.5 and 0.25 lbsK/M rates.

Crown Moisture results:

- Crown moisture results ranged between 60 and 78% moisture. (Fig.1)
- Statistically N rates were significantly different, while K rates did not result in significant differences with respect to crown moisture. (Fig. 1)
- High N rates were associated with higher % moisture content (Fig.1)
- K rates are affected by N rates suggesting the importance of N in respect to K uptake by the plant. (Fig. 1)
- N rates correlated with crown moisture in the Nov. 24th sampling date. This supports the finding of Thompkins et al. (2001), which showed that higher N rates resulted in higher crown moisture rates. (Fig.2)

Plan for the next Period:

A spring sampling is scheduled for the end of April once the spring temperatures have arrived and snow cover is lost, with the expectations of examining the plant's health and overall cold tolerance after the winter. Spring green-up will be evaluated both visually and with digital pixel analysis. The overall plot will be treated uniformly throughout the spring and summer to ensure a uniform test plot for round two of the trail commencing Aug. 15th 2015. The focus will be on supplying the plots with sufficient levels of NPK in the spring to help with recovery from our destructive sampling of the plots and to help raise the P levels back into the sufficiency levels. After a second year of data is collected, the ultimate goal is to be able to correlate tissue analysis with both crown moisture and relative cold tolerance. Year One's data suggests that there is a need to fine tune the N and K applications into a finer range from 0.1-0.75 lbs/M in a future study. It will also be beneficial to repeat the study with a foliar program to see if the results from a foliar program are similar to the granular program currently being implemented. This will be important because the general trend is that more and more superintendents are switching to a primarily foliar-based program.

Treatment	N (lbs)	K (lbs)	Aug. 15 N (%)	Aug. 15th P (%)	Aug. 15 th K (%)	Sept. 15 N (%)	Sept 15 P (%)	Sept. 15 K (%)	Oct 15 N (%)	Oct 15 P (%)	Oct 15 K (%)
1	0	0	2.195	0.26375	1.8725	2.085	0.28125	2.1475	1.86	0.2025	2.0625
2	0	0.25	2.1225	0.271	1.885	2.43	0.302	2.51	2.135	0.21325	3.14
3	0	0.5	2.335	0.277	2.1325	2.235	0.299	2.6575	1.5125	0.15425	2.945
4	0	1	2.305	0.29475	2.145	2.2	0.27925	2.9375	1.705	0.162	3.8875
5	0.25	0	2.455	0.32075	2.1425	2.935	0.32325	2.395	3.53	0.29625	2.045
6	0.25	0.25	2.465	0.2865	2.1	2.8	0.3075	2.585	2.855	0.2345	2.5025
7	0.25	0.5	2.3075	0.282	2.1025	2.815	0.3105	2.735	2.96	0.24075	3.3025
8	0.25	1	2.1975	0.251	1.95	2.7975	0.286	2.8125	2.2875	0.184	3.2175
9	0.5	0	2.4175	0.26	2.0475	3.285	0.303	2.32	3.3325	0.28675	1.9475
10	0.5	0.25	2.4575	0.2615	2.1	3.3075	0.29225	2.635	3.0125	0.26425	2.83
11	0.5	0.5	2.565	0.29575	2.2	3.065	0.29025	2.8375	3.085	0.24	3.2775
12	0.5	1	2.4225	0.294	2.175	2.7075	0.29775	3.04	2.975	0.22525	3.9575
13	1	0	2.625	0.282	2.0175	4.105	0.33525	2.345	3.9525	0.276	1.71
14	1	0.25	2.72	0.28525	2.0675	4.1925	0.3275	2.79	3.955	0.28025	2.885
15	1	0.5	2.47	0.27225	2.0425	4.28	0.32125	2.9475	4.29	0.287	4.1675
16	1	1	2.4675	0.27375	2.0125	4.0425	0.33	3.1325	3.19	0.23125	4.0225

Table 2: Summary of Tissue analyses from Aug, Sept and Oct. 2014 with respect to N,P,K. Phosphorus remained at a relatively steady state throughout the experiment, while N and K varied with respect to the rates of N and K applied during the experiment. The highest levels of K in the tissue correlated with N applications, suggesting that applying K alone may not help with getting more K into the plant.

Treatment	Nitrogen (lbs)	Potassium (lbs)	Aug. 15 N (ppm)	Aug. 15 P* (mg/kg)	Aug 15 K* (mg/kg)	Sept. 15 N (ppm)	Sept 15 P* (mg/kg)	Sept 15 K* (mg/kg)	Oct. 15 N (ppm)	Oct 15 P* (mg/kg)	Oct 15 K* (mg/kg)
1	0	0	18.63636	22.75	108.75	19.09091	18	108.25	19.88636	14.75	119
2	0	0.25	18.06818	20	97.75	21.13636	18.5	187.5	19.20455	20	331.5
3	0	0.5	19.09091	16.5	126	18.29545	17.5	278.25	18.52273	13.5	653.25
4	0	1	19.09091	20.5	113.25	17.95455	14.75	479.5	19.09091	14	1050.5
5	0.25	0	17.72727	16.25	121.25	17.04545	10.75	93.5	19.54545	15	105
6	0.25	0.25	19.09091	18.25	127	18.52273	17	168	18.86364	14.75	371
7	0.25	0.5	18.86364	21	127	19.31818	17.5	304.5	18.97727	17.5	579.5
8	0.25	1	19.88636	20.25	116.5	18.06818	15.75	477	18.63636	15.5	1047.5
9	0.5	0	19.09091	13	118.75	19.54545	10.75	104.25	19.54545	12	93.25
10	0.5	0.25	18.63636	17	113.5	20.11364	14.25	166.25	19.09091	13.25	364
11	0.5	0.5	18.06818	16.75	122.75	18.40909	14.25	301	18.52273	12.5	694.25
12	0.5	1	18.86364	18	117.5	19.31818	13.25	498.75	19.77273	14.5	945.5
13	1	0	18.29545	17.25	93	20.90909	10.75	73.75	21.25	12.25	70.5
14	1	0.25	17.72727	16	90	18.63636	12.75	162.25	19.77273	12.75	279.25
15	1	0.5	18.97727	14.75	97	18.63636	9.5	239.75	19.31818	12.25	539.75
16	1	1	18.40909	16.75	102	17.84091	16	554	19.20455	13	1083.75

Table 3: Summary of Soil analyses from Aug, Sept and Oct. 2014 with respect to N,P,K. Nitrogen levels did not change with respect to treatment, but that was expected as soil N levels are variable and do not reflect plant uptake. Potassium soil levels responded well to K treatments.

Treatment	Nitrogen (lbs/M)	Potassium (lbs/M)	LT_{50} Mean Oct 6	LT_{50} Mean Oct 20	LT_{50} Mean Nov 3	LT_{50} Mean Nov 24
1	0	0	-9.5	-9	-11	-11.75
2	0	0.25	-8.75	-9.375	-11	-11.5
3	0	0.5	-7.8125	-8	-10.375	-11.25
4	0	1	-8.5	-7	-8.875	-10.875
5	0.25	0	-7.125	-8.5	-9.625	-11.75
6	0.25	0.25	-7.375	-8.875	-10.75	-12.25
7	0.25	0.5	-8.375	-7.375	-10	-11.5
8	0.25	1	-8.8125	-8.25	-8.125	-11.75
9	0.5	0	-8.5	-8.5	-10.5	-13.5
10	0.5	0.25	-9.375	-7.75	-10.125	-12
11	0.5	0.5	-8.75	-8	-9.5	-12.25
12	0.5	1	-8	-8.625	-9.75	-12
13	1	0	-7.25	-7.75	-8.25	-11.5
14	1	0.25	-7.625	-8	-7.625	-11.75
15	1	0.5	-7	-8	-9.25	-11.25
16	1	1	-7.25	-8	-7.75	-11.625

Table 4. Summary of Fall 2014 LT_{50} results. The mild fall weather required us to sample 4 times in order to see the effects of the fertilizer treatments on cold tolerance. The best LT_{50} readings were reliably when both the N and K were at the 0.25 lbs and 0.5 lbs rates.

Fig.1: Percent Crown Moisture with relation to fertility treatments. Nitrogen appears to play a more important role than potassium in respect to crown moisture content.

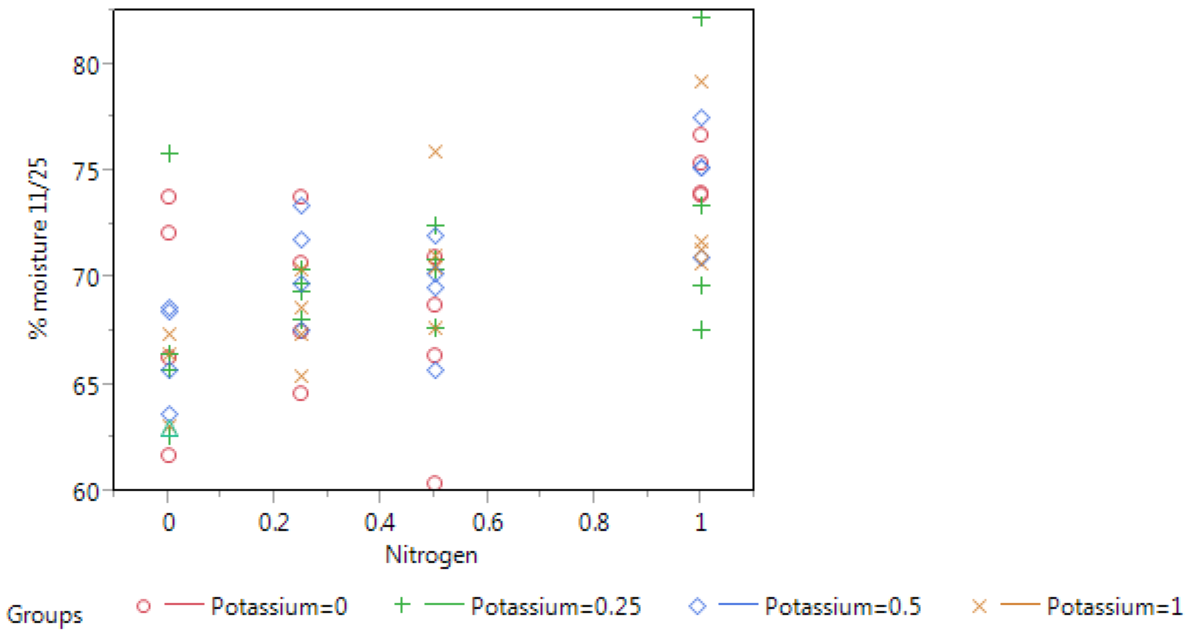
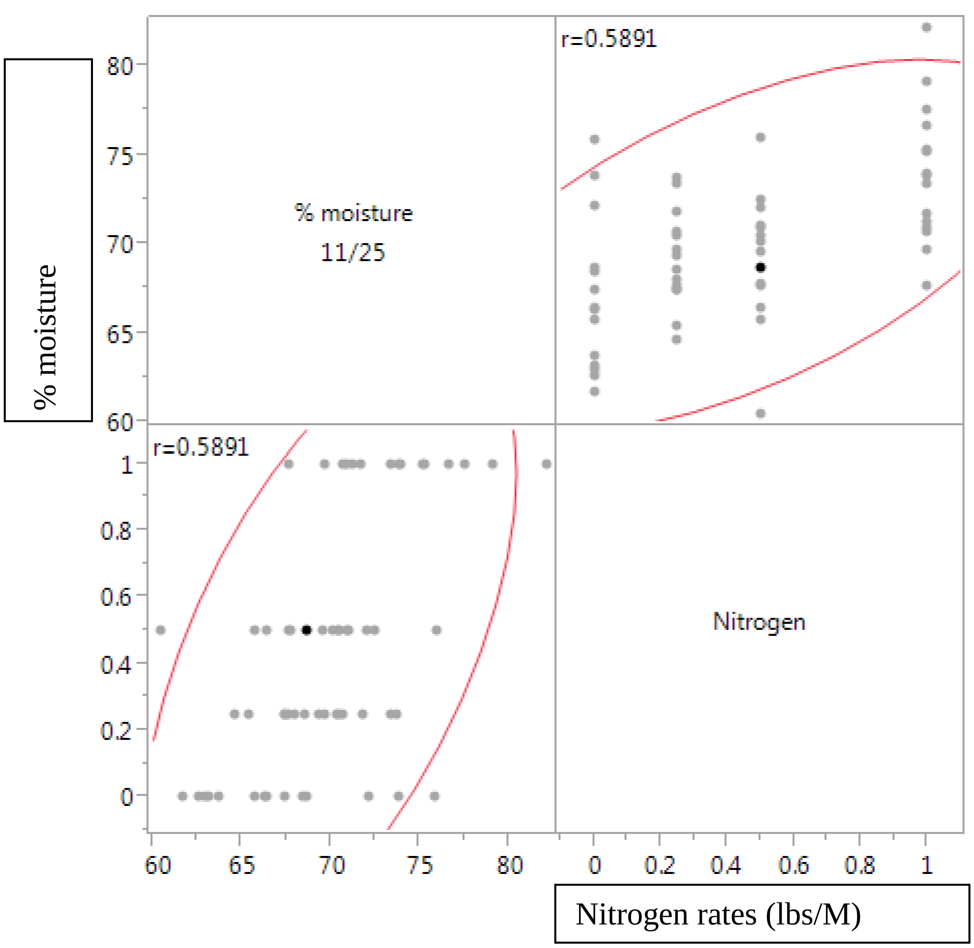


Figure 2: Percent crown moisture correlates with nitrogen rates. Nitrogen and % crown moisture are positively correlated with each other (r=0.59).



Weather Data:

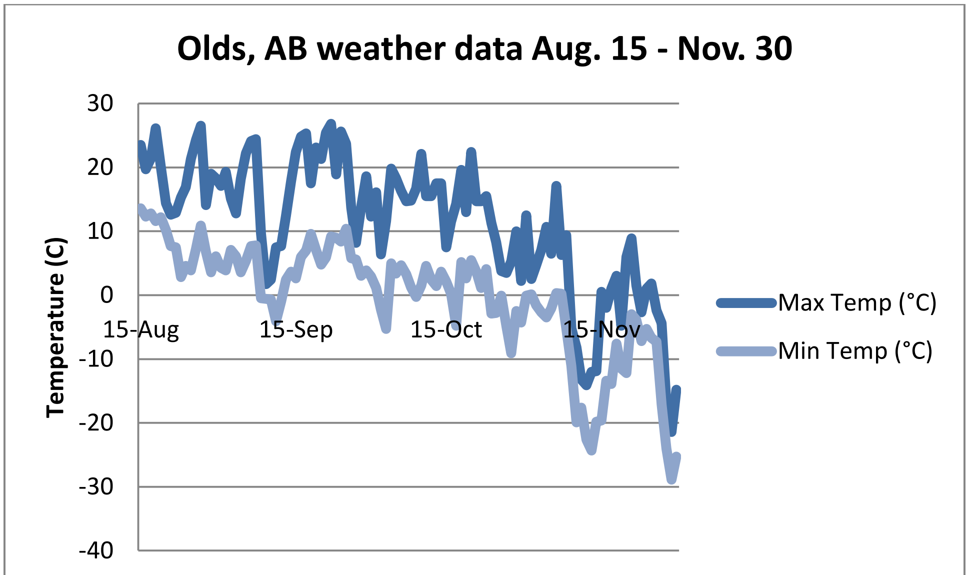


Figure 3. High and low temperatures for Olds, Ab. from Aug. 15th through Nov. 30th 2014. Note the temperatures were not sustained cold temperatures until Nov. 9th, this is why a fourth sampling in an attempt to measure the plants after they reached their maximum cold hardiness.