ACID SOIL ADAPTATION MANAGEMENT IN WESTERN NORTH DAKOTA WITH HARD RED SPRING WHEAT

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ABSTRACT

Hard Red Spring Wheat (HRSW) yields are decreasing due to acidic soils. No-till practices paired with heavy nitrogen (N) use have lowered the soil pH on many acres of the Northern Great Plains. Acid soil where the pH drops below 5.5 has an impact on nutrient availability, soil microbial activity, stunted roots from aluminum (Al) toxicity and other plant/soil interactions. These areas can be improved from surface liming; however, liming can be costly. For many producers facing this issue, especially those working rented land, there is a search for alternative options to reduce yield loss on acidic ground. Research has been conducted in western North Dakota on adaptive management strategies for mitigating the symptoms of aluminum toxicity and soil acidity including cultivar selection, in-furrow fertilizer application, and seed treatments. Cultivar selection showed a significant difference in yield. Interactions were found among cultivar, biochar application, and in-furrow phosphorus. It was observed that a susceptible cultivar of Hard Red Spring Wheat (SY Soren) had a yield response to in-furrow phosphorus (P), where a tolerant cultivar (Lanning) did not respond to in-furrow P. Calcium in-furrow did not have an impact on yield. Across HRSW cultivars a yield bump of 1.5 bushel was shown from seed placed P (0-45-0) applied at high rates (60 lb P2O5/ac). This mechanism doesn't appear to be as strong for HRSW as shown in similar durum trials. A yield reduction from biochar was identified with the control yielding 24 bushels/ac and a rate of 8 lbs/ac seed placed yielded 17.6 bushels/ac.

INTRODUCTION

North Dakota soils have historically been considered to be alkaline, however with increased implementation of no-till practices along with higher rates of N fertilizer, stratified soil acidity has formed. As the pH drops below 5.5 a variety of issues form including Aluminum toxicity, reduced nutrient availability, reduced microbial activity, and impacts on breakdown of certain herbicides. During the 2021 National Sunflower Association National Sunflower Survey a selection of fields were sampled at 0-3 inches at multiple sites within the field (Figure 1). The extent of fields with a pH below 5.5 was wider than many consultants and producers realized due to lack of precision soil sampling. In 2018 out of all samples sent to AGVISE laboratories, those with either grid or zone soil sampling were as low as 9-19% of samples in regions in western North Dakota (AGVISE, 2019).

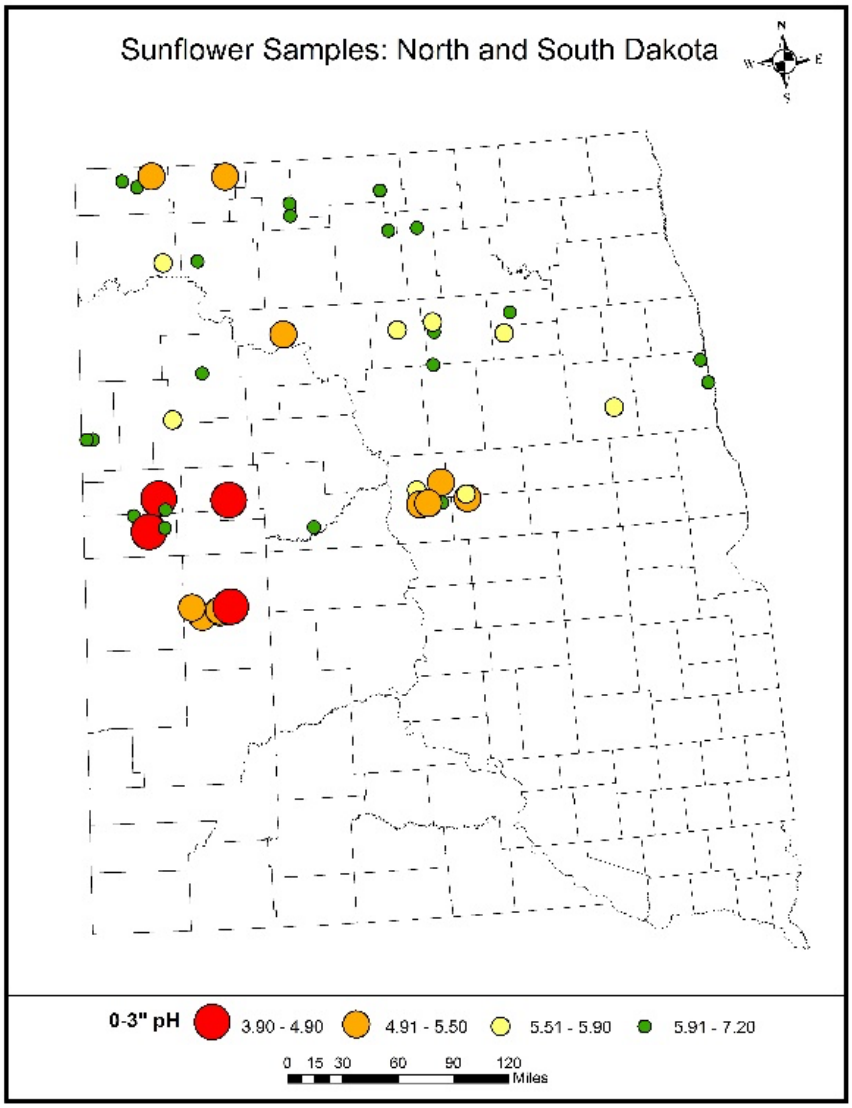

Figure 1. 0-3" soil samples taken in 2021.

Amending soils with agricultural lime is the most common and effective long- and short-term strategy to correct soil acidity. Other short-term strategies that can mitigate the impact of low soil pH on crop yield include planting aluminum-tolerant cultivars of wheat or aluminum-tolerant crops such as triticale (McFarland et al 2015). In the short term, high rates of phosphorus (P) fertilizer placed in seed furrows have been found to reduce the impact of Al toxicity in winter wheat in Oklahoma (Kaitibie et al., 2002) and durum wheat in Montana (Jones et al, 2019).

As producers in North Dakota are not familiar with the need to lime and infrastructure of lime sources and application equipment in the region are in the early stages and considered costly, many are searching for alternative short-term solutions. Even if lime is applied it may take time for the lime to react and often lime application does not have

a direct effect on yield (Godsey et al 2007). The objective of this study is to verify short-term strategy effectiveness for the western region of North Dakota.

MATERIALS AND METHODS

Three separate studies were conducted in 2021 in western North Dakota on acidic (pH<5.5) field sites. In all studies soil was sampled in the fall of 2020 and again in the spring of 2019 with a tubular probe at the stratified 0-3", 3-6" layers and at 0-6" to confirm that the trial areas were acidic. The pH was determined using 1:1 soil to deionized water ratio.

Wheat Cultivar Selection in Acidic Soils

In this study three locations were selected with sites near Minot, Dickinson, and Lefor, ND. At each site Hard Red Spring Wheat (HRSW) was planted and fertilized under best management practices into 5 by 30 ft plot units with 3 replications in Minot and Dickinson and 4 replications in Lefor. The cultivar treatments were arranged in a randomized complete block design (RCBD). Plot units were harvested with a small-plot combine at maturity. A total of 18 cultivars of HRSW were selected as treatments from company entries and public university released cultivars.

Data were analyzed with PROC Mixed with SAS (version 9.4, SAS Institute, Cary, NC). Field experiments were analyzed separately by location. Statistical analyses were performed with type 3 estimation with rep as random and cultivar as a fixed effect.

Biological Plant Growth Regulator Treatments HRS in Acidic Environments

In this study two locations were selected with sites near Dickinson and Lefor, ND. At each site HRSW was planted and fertilized under best management practices into 5 by 30 ft plot units with 3 replications in Dickinson and 4 replications in Lefor. The treatments were arranged in a RCBD. Plot units were harvested with a small-plot combine at maturity. A control, five seed treatments, and a foliar treatment were planted with the HRSW cultivar SY Soren (AgriPro, 2011). SY Soren was chosen as it has consistently shown susceptibility to aluminum toxicity and is otherwise, in neutral pH environments, considered a recommended cultivar for the region. Treatments included plant growth regulators (PGR) and mycorrhizal and bacterial products.

Data were analyzed with PROC Mixed with SAS (version 9.4, SAS Institute, Cary, NC). Field experiments were analyzed separately by location. Statistical analyses were performed with type 3 estimation with rep as random and applied treatment as a fixed effect.

In-Furrow Fertilizer Comparison for HRS in Acidic Soils

In this study one location was selected near Dickinson, ND. At this site HRSW was planted and fertilized under best management practices into 5 by 30 ft plot units with 3 replications. The experiment was a RCBD with a 2 x 2 x 2 x 3 factorial arrangement with two wheat cultivars, with and without 8 lbs/ac of biochar, with and without 60 lbs of P,

and three calcium treatments (untreated control, 60 lbs/ac of lime, and 200 lbs/ac of gypsum). Cultivars chosen were SY Soren (AgriPro, 2011) as a susceptible cultivar and Lanning (Montana Ag Exp Station, 2017) as a tolerant cultivar. Plot units were harvested with a small-plot combine at maturity. A control, five seed treatments, and a foliar treatment were planted with the HRSW cultivar SY Soren (AgriPro, 2011). SY Soren was chosen as it has consistently shown susceptibility to aluminum toxicity and is otherwise, in neutral pH environments, considered a recommended cultivar for the region. Treatments included plant growth regulators (PGR) and mycorrhizal and bacterial products.

Data were analyzed with PROC Mixed with SAS (version 9.4, SAS Institute, Cary, NC). Field experiments were analyzed separately by location. Statistical analyses were performed with type 3 estimation with rep as random and cultivar, biochar, P, and calcium as fixed effects.

RESULTS AND DISCUSSION

Wheat Cultivar Selection in Acidic Soils

Drought conditions in 2021 reduced yield potential greatly at the Minot and Dickinson locations. The Lefor location received above average rainfall for the season with 8 inches of precipitation from April through July recorded at the nearest weather station (Mayer Farm, Weatherlink) and the Dickinson location was in severe drought conditions with 6.7 inches recorded at the nearest weather station over the same period (Dickinson, NDAWN). Drought conditions in Minot created a large amount of variability causing a high covariance estimate. Due to high variability, data from Minot was not reported for 2021. Data (Table 1.) shows that some varieties yield significantly higher than others. Yields at Dickinson were highly suppressed due to drought conditions, but differences were still shown.

Table 1. Low pH HRSW variety trial yield results 2021.

Variety	Dickinson	Lefor
	bu/ac	
Bolles	18.0	57.3
CP3099A	**23.0**	-
CP3119A	**22.6**	**69.3**
CP3188	**21.8**	65.4
CP3530	**19.9**	-
CP3915	17.4	64.4
Dagmar	**22.6**	64.2
Duclair	**20.2**	61.5
Glenn	18.6	60.4
Lanning (tolerant check)	**20.5**	64.8
SY Soren (susceptible check)	**19.2**	61.9
TCG Heartland	15.8	62.3

TCG Spitfire	**20.8**	**72.6**
WB9479	12.7	61.8
WB9516	13.1	**68.4**
WB9590	13.2	66.8
WB9606	**21.4**	67.4
WB9719	11.2	**70.8**
LSD (0.05)	3.9	4.2

Average 0-3” soil pH was 4.9 at both the Dickinson and Lefor locations

Data from 2021 shows that multiple cultivars are available that show tolerance to low pH and aluminum toxicity. More data is required due to drought conditions to make specific recommendations as only 2 cultivars, TCG Spitfire and CP3119A were consistently listed as a top yielding cultivar at both locations.

Biological Plant Growth Regulator Treatments HRS in Acidic Environments

As seen in Table 2. no significant difference was found between any of the treatments and the control. At the Lefor, ND location we had above average rainfall conditions, and at the Dickinson, ND location we had extreme drought conditions. According to this data, these types of treatments are not effective at combatting the issue of Aluminum toxicity and yield losses associated with soil acidity.

Table 2. Spring wheat yields across treatments at 2 North Dakota locations in 2021.

	Lefor	Dickinson
Treatment	Yield	
Control	54.8	19.9
Ascend (seed trt PGR)	54.4	20.5
Kickstand (seed trt PGR)	55.6	18.9
Foliar PGR	55.2	20.9
Nutri-cycle (seed trt)	54.3	18.2
MycoApply (seed trt)	55.6	19.0
Humic Acid (granular)	56.4	19.7
LSD (0.1)	ns	ns

Average 0-3” soil pH was 4.9 at both the Dickinson and Lefor locations
Aluminum toxicity susceptible variety SY Soren was chosen.
All seed treatments applied at labeled rate.
Humic acid applied at 10lb/ac with seed at planting.
Drought was a major factor on yield at the Dickinson location however cv was still low.

In-Furrow Fertilizer Comparison for HRS in Acidic Soils

A significant difference in yield between the susceptible and tolerant varieties was found. We also found significant differences between treatments in biochar, phosphorus, and the interaction between variety, biochar, and phosphorus (Table 3). Biochar showed a negative yield response, this may be due to nutrient tie up or seed moisture loss with drought conditions.

Table 3. In-furrow fertilizer treatments in Dickinson 2021.

In-furrow treatment	Variety	
	Soren (susceptible)	Lanning (tolerant)
Control	21.4bc	25.7a
Control+biochar*	15.3e	18.1d
Phosphorus	25.1a	24.0ab
Phosphorus+biochar*	16.2de	21.0c
LSD (0.05)	2.6	

Phosphorus was seed placed at 60 lbs of P as TSP.
*biochar was placed in furrow at a rate of 8lbs/ac.

The data in the above table suggests that phosphorus (P) in-furrow is able to raise the yield of susceptible varieties, but has no impact on tolerant varieties. When ran across both varieties, however, P showed an overall significant positive impact on yield from the control (Table 4).

Table 4. P fertilizer across all other treatments, Dickinson 2021.

Treatment	Yield
Control	20.1b
60 lbs **additional** P	21.6a

We did not find any significant difference from the control for the various calcium sources, opposing current recommendations from consultants in the region. Due to possible impacts of drought this trial is planned to be repeated in 2022. Yields were compressed by drought conditions, and fortunately covariance estimates were low.

This data suggests that variety selection is an extremely important component of management in acidic soils -- however if a susceptible variety is used -- additonal P fertilizer may be an option, however the price of P fertilizer should be considered in that recommendation. It also shows that calcium products in-furrow do not appear to assist in management of soil acidity.

REFERENCES

AGVISE Laboratories, 2019. Precision soil testing doesn't cost, it pays. Agvise Winter 2019-2020 Newsletter, 2. https://www.agvise.com/wp-content/uploads/2019/11/1291-Winter-19-News_F.pdf

Godsey, C.B., G.M. Pierzynski, D.B. Mengel, and R.E. Lamond, 2007. Management of soil acidity in no-till production systems through surface application of lime. Agron. J., 99: 764-772. https://doi.org/10.2134/agronj2006.0078

Jones, C., R. Engel, K. and Olson-Rutz, 2019. Soil acidification in the semiarid regions of North America's Great Plains. Crops & Soils, 52: 28-56. https://doi.org/10.2134/cs2019.52.0211

Kaitibie, S., F.M. Epplin, E.G. Krenzer, Jr., and H. Zhang, 2002. Economics of lime and phosphorus application for dualpurpose winter wheat production on low-pH soils. Agron. J. 94:1139–1145. https://doi.org/10.2134/agronj2002.1139

McFarland, C.R., D.R. Huggins, and R.T. Koenig, 2015. Soil pH and implications for management: An introduction. FS170E. Washington State University Extension.