Potassium Recommendations for Corn in North Dakota: Influence of Clay Chemistry

NDSU SOIL SCIENCE

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ABSTRACT

Corn has recently become a top-five crop in area within the state of North Dakota. Potassium recommendations for corn were originally borrowed from central Corn Belt states, and were little researched within the state until recently. About 30 K-rate experiments were conducted in corn over the past 4 years with the goal to redefine the K soil test critical level. However, the research resulted in unexpected yield increases at high soil test levels at some sites and no yield response at low K soil test levels at other sites. Clay mineralogy and potassium feldspar content of the soils was determined all soils in the experiments. The results indicate that highly smectitic clay soils require a higher critical K soil test level compared with soils having more illitic clay content. A state map of smectite to illite clay ratio has been developed, directing farmers and their consultants to the recommendation system they should use in order to better fertilize their corn crop with K fertilizer.

INTRODUCTION

Potassium recommendations for corn in North Dakota were developed nearly forty years ago. Potassium (K) soil test levels were commonly above 400 ppm at this time, good corn yields were edging towards 100 bushels per acre and the primary rotations within the state were small-grain driven, with little K removed from the soil from harvested wheat, barley and sugar beet. Today, soil K levels are commonly around 150 ppm in the eastern part of the state where soybeans have been grown in some cases continuously for over twenty years. Corn yields commonly approach and lately have exceeded 200 bushels per acre field average. The demand for K is higher today for corn than it was when our previously published recommendations were last considered. Establishing modern K soil test levels and revisiting our soil sampling and testing procedures will enable North Dakota corn growers to be more profitable and efficient into the future

Objectives

-Build a modern K rate data base in corn to enable revision of our current K fertilizer recommendations and soil test critical levels.

-Investigate seasonality of soil test K for the purpose of better diagnosis of potential K fertilizer needs and to better track soil test K trends over time.

-Investigate alternative laboratory methods for determining soil test K- field moist vs dried soil.

METHODS

From 2014 through the 2016 growing seasons, 29 field studies were established and taken to yield in farmer fields in North Dakota. Experimental design was an RCB with 6 K rate treatments (0, 34, 68, 101, 132 and 165 kg ha^{-1} K_2O as 0-0-60 dry granular fertilizer) with 4 replications. Each experimental unit (plot) was 3.05 m wide and 9.15 m long. An application of S as 112 kg ha^{-1} gypsum was applied to all sites. If N and P were required, N and P were applied to the site as ammonium nitrate and mono-ammonium phosphate fertilizer. If zinc was required, it was applied as 34 kg ha^{-1} 36% zinc sulfate. One site had a soil pH of 4.8, so 1.9 tonne ha^{-1} fine limestone powder was applied to bring the pH up to at least 5.6. Potassium treatments were preweighed in plastic bags and hand applied. The farmers planted the sites when the rest of the field was planted, using their own variety selection. The cooperators also applied herbicides to the study areas when they applied herbicide to the rest of the field. Yield was obtained by removing all ears from an interior row of each experimental unit except the outer ear from each row end, shelling with an Almaco corn sheller, weighing and taking moisture and test weight using a Dickey John moisture-test weight instrument. The standard K soil test method is the 'dry' K soil test, using 1 gram of air-dry soil with 1-M ammonium acetate as an extractant, a specific shaking time at a specific number of cycles per minute, filtering, then analysis on an atomic absorption spectrophotometer. Iowa State uses a 'field-moist' K soil test, with a similar extraction and analysis procedure, but directly using the field-moist K soil sample rather than drying it prior to analysis. The sample weight is corrected for moisture content. Other soil test methods were investigated to try to capture release of K over time. These soil methods were the sodium tetraphenylboron extraction, a resin extractable K test with a resin bag manufactured by UNIBEST Inc., Walla Walla, WA, extracted over 168 hours, non-exchangeable K test over 5 minutes and 168 hours, and a cation exchange method using base saturation. The results were fit to models relating soil test method values with relative corn yield. Clay species and mineralogy related to potassium availability was conducted on check sample from each K rate study, and from a spring 2017 sampling of two to three major soil groups in each North Dakota county. A total of 167 samples were analyzed. Clay mineral species were determined with an XRD instrument using ACT Labs, Ontario, CA, with the Rietveld method.

RESULTS

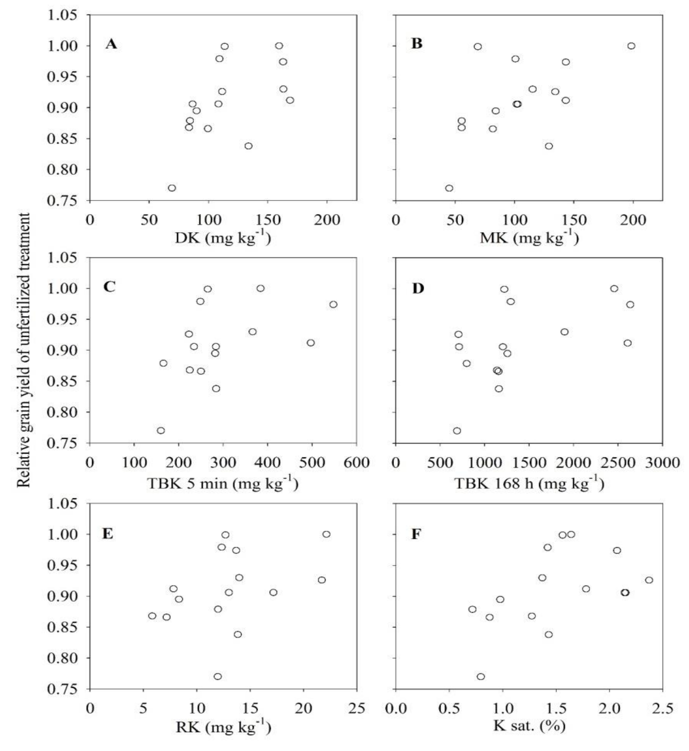

Figure 1. Relationship between relative yield of unfertilized corn and various soil test K methods:
(A) DK and (B) MK, NH_4OAc extractable K on
(B) air-dry and field-moist soil, respectively;
(C) TBK, tetraphenylboron extractable K for
(D) (C) 5 min and (D) 168 h; (E) RK, resin extractable K;
(E) and (F) K sat., K saturation.

Table 1. Data from 29 K rate studies in corn in North Dakota from 2014-16, with clay mineralogy of the clay fraction and potassium-feldspar content of the mineral portion of the soil are indicated. Beginning preplant soil test K (1 M ammonium acetate on dry soil) is also indicated along with expected yield increase compared to the yield increase experienced.
† Bold font denotes site where expected yield response or non-response was not recorded.

Site, Year	K test, mg kg^{-1}	Expected Yield Increase	Actual Yield Increase	Potassium-feldspar-%	Smectite%-Illite %
Buffalo, 2014	100	Y	N†	7.1	85-11
Walcott E, 2014	100	Y	Y	5.8	84-13
Wyndmere, 2014	100	Y	N	6.1	72-22
Milnor, 2014	100	Y	N	11.7	35-57
Gardner, 2014	115	Y	Y	5.3	76-20
Fairmount, 2014	140	Y	N	8.0	80-14
Walcott W, 2014	80	Y	N	7.3	52-40
Arthur, 2014	170	N	Y	1.7	85-11
Valley City, 2014	485	N	N	9.0	70-23
Page, 2014	200	N	N	5.7	74-20
Absaraka, 2015	113	Y	N	9.9	84-14
Arthur, 2015	125	Y	Y	9.5	85-12
Barney, 2015	170	N	N	6.3	79-16
Casino, 2015	120	Y	Y	6.4	85-12
Dwight, 2015	110	Y	N	6	82-15
Fairmount1, 2015	188	N	Y	5.6	87-10
Fairmount2, 2015	118	N	Y	7.4	79-12
Leonard N, 2015	380	N	N	6.9	70-25
Leonard S, 2015	190	N	N	5.5	52-41
Milnor, 2015	118	Y	Y	8.6	74-20
Prosper, 2015	205	N	N	9.2	83-14
Valley City, 2015	200	N	N	5.6	65-30
Walcott, 2015	109	Y	Y	6.2	47-48
Absaraka, 2016	160	N	Y	5.6	70-25
Valley City, 2016	226	N	Y	5.5	81-16
Gardner, 2016	60	Y	Y	6.1	77-19
Lisbon, 2016	78	Y	Y	5.0	72-22
Mooreton, 2016	70	Y	N	4.8	78-18
Colfax, 2016	54	Y	Y	5.3	77-16

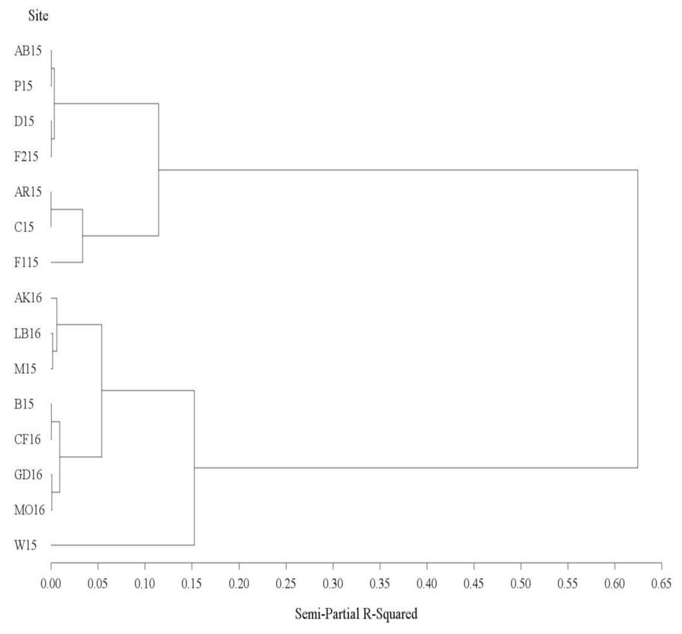

Figure 2. **Cluster tree of 2015 and 2016 K trials by smectite/illite ratio using Ward's minimum variance cluster analysis.**

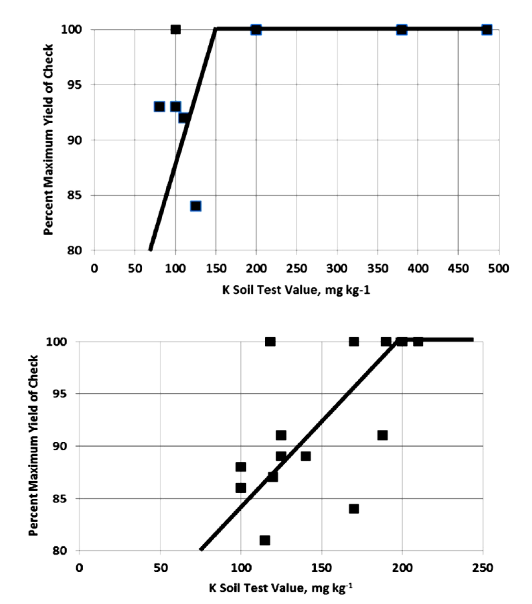

Figure 3. Percent maximum corn check yields in North Dakota K fertilizer rate studies at sites with smectite/illite ratio <3.5 (top) and smectite/illite ratio >3.5 (bottom).

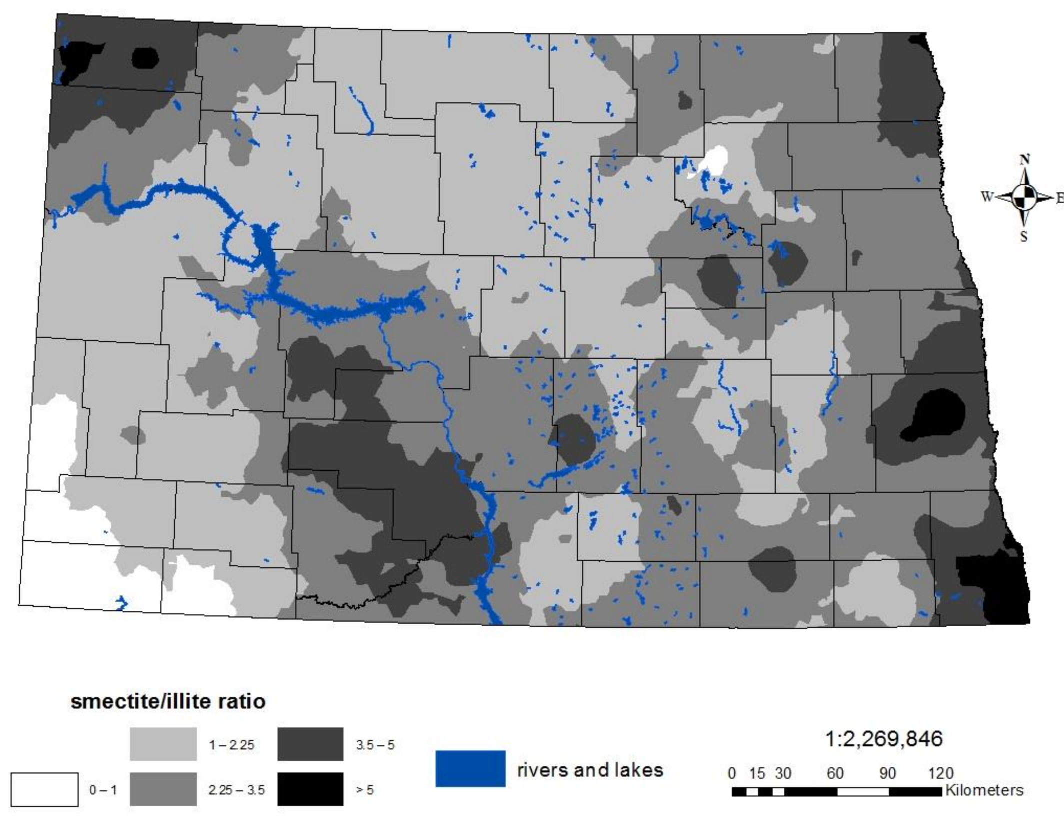

Figure 4. **Smectite/illite ratio of the clay portion of soils in North Dakota, from a soil sampling of two to three major soil groups in each North Dakota county, spring, 2017.**

RESULTS

Twenty-nine field K-rate studies were conducted over three growing seasons in North Dakota, however, only half of the sites responded as the old 150 ppm critical level would suggest (Table 1), using the dry soil test K 1-M ammonium acetate extractant. The other extractant procedures did not improve the predictability of K response (Figure 1). A Principle component analysis indicated that smectite and illite content of the clay fraction was related to K response. The Ward's minimum variance clustering technique separated sites at a smectite/illite ratio of 3.5 . Below 3.5, the critical level of 150 ppm K defined whether the corn responded to K fertilization, while above 3.5, the critical level of 200 ppm K defined corn response (Figure 3). The soil sampling of every county in North Dakota and subsequent clay species analysis resulted in a state map that is being used to direct K fertilizer recommendations (Figure 4).

SUMMARY

The K rate studies did not result in expected K critical levels. Alternative K extraction techniques were not superior to the 1-M ammonium acetate extraction used in North Dakota for 40 years. However, this extraction method without consideration of soil clay chemistry was only predictive at half of the experiment sites. If the sites were separated based on the smectite/illite ratio of 3.5, the predictability was greatly increased. A map of smectite/illite ratios to farmers is now available, along with a series of response-based and economic-based fertilizer K rate recommendations that will soon be available for a cell phone app for their use.

ACKNOWLEDGEMENTS

We are grateful to the North Dakota Corn Council for the majority of the funding used in this project. Significant funding also came from IPNI and BASF.