Soil Mineralogy and Possible Influence on Potassium Fertilizer Response in North Dakota

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ABSTRACT

When fields in eastern North Dakota were first cultivated in the late 1800's to early 1900's, native available K levels were very high. A recent change in rotation from a wheat-based rotation with little K export in grain to a corn-soybean rotation with greatly increased K export has resulted in a dramatic decrease in soil test K in some fields. The critical K soil test level for corn production is currently 150 mg kg^{-1} using the 1 N ammonium acetate extraction on low temperature oven dried soils. However, investigation of the validity of the current critical soil test level has only recently been seriously researched. Findings in 2014 and 2015 indicate that potassium feldspar content of the soil mineral fraction and the smectite and illite content of the clay fraction plays a role in whether corn requires K. The results indicate that growers either need to identify the mineral content of their soil, or a different soil test method needs to be identified to predict K requirement for corn in North Dakota.

INTRODUCTION

Initial soil available K levels in newly plowed prairie soils of North Dakota were very high, and have remained so until recently despite serious topsoil erosion and limited K fertilizer application. The recent change from a wheat-based low K removal rotation to a corn-soybean and in some fields continuous soybeans has led to a dramatic decrease in soil test K in eastern North Dakota while the acreage of corn grown rivals that of smaller Corn Belt states. The current critical soil test K level for corn is 150 mg kg. The level was adopted from that of neighboring states and it has never been serious researched in North Dakota.

OBJECTIVE

Determine the critical level of soil test K in North Dakota.

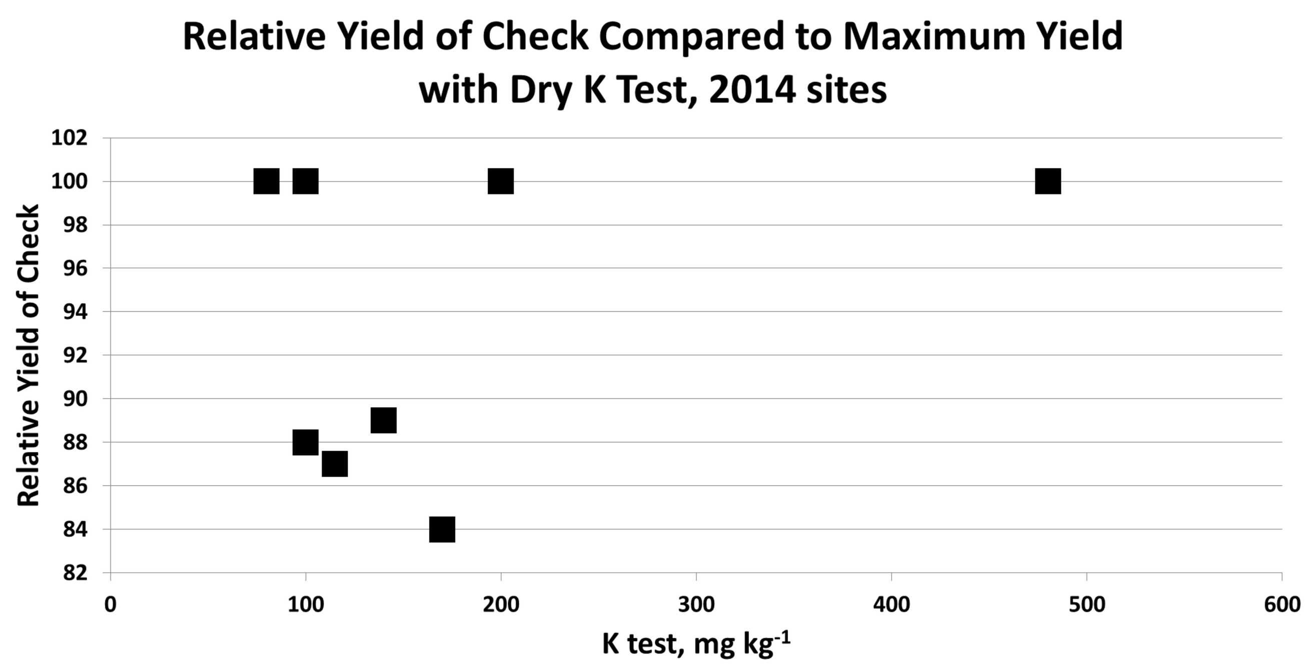
MATERIALS AND METHODS

In eastern North Dakota, 10 K rate experiments were established in 2014 and 13 in 2015. At each site, preplant soil cores from the experimental area were composited from the 0-15 cm depth and analyzed for available K after air drying and grinding using the 1 N ammonium acetate extraction method recommended by the NCERA-13 committee on soil testing and plant analysis. The experimental design for the K rate experiments was a randomized complete block, with 6 K treatments and four replications. The size of each experimental unit was 3.3 meters wide by 9.8 meters long. Potassium fertilizer treatments as commercial fertilizer grade KCl (0-0-60) were applied prior to planting and spring field tillage at the rates of 0 (check), 30, 60, 90, 120, and 150 kg ha-1. Most of the sites were conventional till, and the K treatments were incorporated by a shallow (5-8 cm deep) tillage tool into the soil before planting. One site in 2014 and one site in 2015 were surface applied on long-term (> 20 years) before planting. One row was harvested (9.8 m) after physiological maturity and shelled using an Almaco corn sheller (Almaco, Nevada, IA, USA) and measured moisture for yield determination using a Dickey-John GAC 500 XT moisture tester (Dickey-John Corporation, Auburn, IL). Mineral speciation was conducted by ACT Laboratories in Ancaster, ON, CA.

RESULTS

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

At 10 of 23 sites, the critical level of 150 mg kg^{-1} did not predict whether or not a yield increase would result from K application. Moist soil samples from each site was sent to ACT labs in Ontario, Canada for mineral speciation. Potassium feldspar content of the whole soil, and the smectite and illite content of the clay fraction appeared to be influencing the results of K fertilization. Greater K-feldspar and illite content tended to decrease the likelihood of yield increase from K fertilizer, and higher smectite with lower K-feldspar appeared to increase the likelihood of yield increase when K test was at or above 150 mg kg^{-1}. A principle component analysis of the role of K-feldspar, illite, smectite and K test was conducted using SAS 9.4 for Windows (SAS, Cary, NC).



Factor	K test	K-feldspar	Illite	Smectite
K test	1.0			
K-feldspar	0.17	1.0		
Illite	-0.03	-0.32	1.0	
Smectite	0.05	0.33	-0.99	1.0
Relative yield	0.29	-0.0002	0.32	-0.25

Principle component analysis indicates that relative yield in the experiments were related positively with K test and illite. As smectite increased, relative yield decreased.

SUMMARY

Ten of 23 site K responses were incorrectly predicted by soil test K. Relative yield was also related to clay smectite speciation and potassium feldspar content of soil minerals. The results indicate that either growers need to know the mineral speciation of the soil to better predict yield response to K, or there needs to be an improved K availability soil test to improve prediction.

ACKNOWLEDGEMENTS

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