PROJECT DESCRIPTION:	**Corn and Soybean Yield and Soil Test Calibration as Affected by Potassium Fertilization**
PROJECT NUMBER:	**R2018-1 MN DEPT OF AGRICULTURE**
ANNUAL REPORT DUE DATE:	**On or before April 30, 2019**
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ORGANIZATION:	**University of Minnesota**

Introduction

Research on potassium (K) fertilization of corn and soybean in Minnesota has not received a great deal of attention in recent years. Generally, resources have focused on nitrogen and phosphorus, because of greater potential economic return and environmental concerns related to these nutrients. During the last 10 years agriculture has experienced tremendous volatility of input and commodity prices, including fertilizer K (potash 0-0-60). Price volatility of inputs and commodities increases financial risk for growers. These financial risks include the risk of yield loss from inadequate fertilizer K application and risk of applying expensive fertilizer that may not be needed, especially on short-term rental farmland. These experiences have raised questions about K fertilization of agronomic crops.

A long-term research study established in 2011 continued in 2018 at two locations (Waseca and Rochester) to address K fertilization questions. The objectives of this study were: 1) determine the effects of STK level and K fertilizer rate on crop yield, profitability, and K removal in corn and soybean; 2) to measure STK incline/decline rates as affected by K fertilization rate and document temporal STK variability as affected by crop removal and K fertilization; and 3) to evaluate the field moist soil test as a predictor of crop response to STK levels and fertilizer K additions.

Materials and Methods

Experimental sites were established in April of 2011 on different soils (parent materials) at three locations in Minnesota. Sites at the Southern Research and Outreach Center in Waseca (Nicollet–Webster clay loam, glacial till) and the Sand Plain Research Farm in Becker (Hubbard loamy sand, outwash) had been mined to low levels of STK, with little or no fertilizer K application for several years. The Rochester site (Mt Carroll silt loam, loess) had received reduced “starter” rates of K fertilizer and infrequent beef manure. In March of 2018, the Becker location was terminated due to Excel Energy selling the land used for this site. All sites were cropped to a three-year corn-corn-soybean rotation [corn in 2017 and 2018 and soybean in 2016]. Twelve individual plots [20 ft wide by 55 ft in length (40 ft at Rochester)] were replicated 4 times for a total of 48 plots per site. Plots were arranged in a split-plot design with the main plot being three rates (0, 60, and 120 lb K_2O/ac) of K as potash (0-0-60) broadcast-applied in the fall annually during the initial “build” phase of the study (2011 through 2015, last application made in October of 2014). At Rochester, where initial soil test K values were greater, fertilizer K rates of 0, 40, and 80 lb K_2O/ac were used during this period. These initial rates created three distinctly different soil test levels within each of these main plots during this “build phase” of this study. In the “calibration phase” of the study, main plots were split into sub-plots and these sub-plots received four rates (0, 60, 120 and 180 lb K_2O/ac) annually. These sub-plot treatments were applied for the first time in October of 2015 for the 2016 growing season. Experimental procedures and dates for which procedures were performed are found in Table 1.

Soil samples were taken in June at 0- to 6- 6- to 12- and 12- to 24-inch depths and again in October at a 0- to 6-inch depth. Ten 0.75-inch diameter soil cores per plot were taken from each of the 48 plots. The 0- to 6-inch depth samples were kept cool and moist after collection and later delivered to Solum Lab (Ames, Iowa) where they were mixed and analyzed using their field moist procedure (Mehlich III extractant). The remaining sample was dried on a paper plate at 100° F for 12-14 hours in a forced air oven, returned to the paper bags and left at room temperature until they were ground, and sent to the University of Minnesota (RAL) soil testing lab for ammonium acetate K extraction and analysis. These samples were analyzed using techniques described in Recommended Chemical Soil Test Procedures for the North Central Region (2015).

Nitrogen, P, and S fertilizers were applied to meet crop needs at all sites (Table 1). Corn was planted at 35,500 seed/ac after preplant tillage (field cultivator). Weeds were controlled with a combination of pre and post emergence herbicide applications. Grain yield and moisture content were determined with a research plot combine by harvesting center two or three (Waseca) rows of each of the 48 plots. Yields were calculated and are reported at 15.5% moisture. Grain samples were collected and ground prior to measuring K concentration and calculating K removal in grain. Grain tissue samples were analyzed by Brookside Lab using a wet ash extraction with nitric acid and hydrogen peroxide in a closed Teflon vessel in a CEM microwave. Each sample (extractant) was analyzed on a Thermo 6500 Duo ICP.

The data were analyzed as a split-plot experiment with main-plots (STK levels), sub-plots (K fertilizer rates), and interaction term (main plot × sub plot) as fixed effects and block and interactions with block as random effects. All data were statistically analyzed using SAS® (SAS 9.4, SAS Institute Inc., 2012. Cary, North Carolina). A 0.10 level of significance is used unless otherwise stated.

Results and Discussion

Waseca

Weather data characterizing the 2018 growing season at Waseca are presented in Table 2. Abundant rainfall and large temperature deviations from normal describe the weather during the first few months of the 2018 growing season. April had near normal precipitation but much of it came as snow due to air temperatures which averaged 13 degrees F. less than normal. The months of May and Jun had greater than normal precipitation and both were warmer than normal. July and Aug were near normal for both precipitation and temperature. September had 215% of normal precipitation and was warmer than normal. Growing season (May-September) rainfall totaled 30.77 inches or 9.31 inches more than normal. Most of the excess precipitation occurred on 4 and 5 Sep as corn neared physiological maturity. Growing degree units (GDUs) for the season were greater than normal (data not shown). High winds in late August and again in early September resulted in lodged corn and affected grain harvest.

Corn grain yields were affected by the main effects (STK level and K fertilizer rate) and interaction between main effects (Table 3). Yields increased with increasing STK level and were greater with K fertilizer application at 60, 120, and 180 lb K_2O/ac than with the controls (0 lb K_2O/ac). Grain yields ranged from 151 to 222 bu/ac among K treatments. The significant interaction between STK level and K fertilizer rate (sub-plot rate) is explained by the magnitude of the yield response to K fertilizer at various STK levels. At the Low STK level, 60 lb K_2O/ac increased yields 64 bu/ac; whereas, at the High STK level 60 lb K_2O/ac increased yields only 12 bu/ac (Figure 1a). This interaction effect is what would be expected as STK in the Low STK control (treatment # 1) was only 72 ppm in June (dry test); whereas, STK in the High STK control (treatment # 9) was 102 ppm. Grain moisture was considerably drier in the control treatments at each STK level. Severe K deficiency in some of these treatments resulted in pre-mature death of corn plants.

The significant interaction between STK level and K fertilizer rate (sub-plot rate) showed concentration of K in grain was numerically least with the Low STK level at 60 lb K_2O/ac (treatment # 2) and greatest with the Medium STK level at 120 lb K_2O/ac (Table 3). Grain K removal was greater with Medium and High STK levels than with Low STK, when averaged across the main effect of K fertilizer rate. Grain K removal increased with increasing K fertilizer rate up to 120 lb K_2O/ac, when averaged across STK levels. The significant STK level × K rate interaction for grain K removal was like the interaction for grain yield. Greatest response in grain K removal between fertilized and nonfertilized control treatments occurred with Low STK levels and no or only small differences were found in K removal at High STK levels.

The various soil test levels (Low, Medium and High) in the main plots were created during the build phase of this study (2012 through 2015); therefore, it's expected that STK would be different among these main plots (Table 3). When averaged across the main plots (STK Levels), STK for all sampling times increased as fertilizer K rate (sub-plot K rate) increased. In June, mean STK across all treatments ranged from 72 to 164 ppm with the dry test (ammonium acetate extractant) and from 68 to 181 ppm with the Solum moist test (Mehlich III extractant). In October (2018), mean STK across treatments ranged from 116 to 206 ppm with the dry test and from 48 to 141 ppm with the moist test. On this Des Moines Lobe glacial till soil at Waseca, STK with the moist test was considerably less than the dry test for October sampling. These findings are like those observed at this site in 2016 and by Mallarino (personal contact) on similar soils in Iowa. Due to AFREC not funding this study in 2017, the October 2017 samples were not analyzed with the moist procedure.

Economic return to fertilizer K was calculated from treatment means by comparing fertilized treatments to the control (0 lb K_2O/ac) treatment within a STK level (Low, Medium, and High). The value of corn was set at $4.00 per bushel and fertilizer K was $0.30 per lb K_2O. Large economic returns were found at the Low STK level (>$200/ac) and Medium STK level (>$73/ac); however, at the High STK level economic return ranged from –$10 to $27 per acre (Table 3). At all STK levels, most of the return from K fertilizer application was obtained with 60 lb K_2O/ac. This finding has important implications for challenging economic times in agriculture. If farmers are looking to reduce input costs by reducing K fertilizer rates, they should not apply less than 60 lb K_2O/ac/year on Low and Medium testing glacial till soils as these data showed a large return on investment with this rate.

The relationship between relative yield (soybean in 2016 and corn in 2017 and 2018) and STK as affected by fertilizer K rate and STK method (dry vs moist) is shown in Figure 2. The charts on the left show the relative yield response of control plots (zero K fertilizer) as affected by STK. These data show a greater yield response on a percentage basis for corn than soybean and a wider STK range of response in corn in 2017 than in 2018. When the fertilized plots are added (charts on right), it's clear the moist test has a lower STK critical value than the dry test and the data appear to fit a more defined plateau response function. These data suggest the moist test better describes the yield response function than does the traditional dry (ammonium acetate) test. More response curve fitting will be conducted with these data in coming months.

The effects of K fertilizer rate on STK incline and decline rates as affected by soil sampling time at Waseca are presented in Figure 4. For the June sampling, STK declined at 3.4 ppm/year in the control and inclined (increased) at 0.8 and 7.3 ppm/year with 60 and 120 lb K_2O/ac, respectively. With October sampling, STK increased 1.2, 2.6 and 6.6 ppm/year with 0, 60 and 120 lb K_2O/ac rates, respectively. These data imply October sampling with the standard dry soil extraction is less precise than June sampling. This observation assumes STK should decline over time when no fertilizer K is applied for seven years.

Rochester

Growing season temperatures at Rochester (data not shown) were similar to Waseca. Growing season (May-September) precipitation totaled 29.19 inches or 8.34 inches more than normal (Table 2). The months of May, June and September all had at least 66% greater than normal rainfall. Although the growing season had considerably greater than normal rainfall, the warmer than normal May and June conditions were generally favorable for corn growth. High winds during a late August thunderstorm did result in lodged corn.

Corn grain yields were affected by treatment main effects and the interaction between main effects at Rochester (Table 4). Yields were greater with the High STK level than with the Low STK level, when averaged across K rates. Moreover, yields were greater with K fertilizer (60, 120, and 180 lb K_2O/ac) than with the control (0 lb K_2O/ac). Grain yields ranged from 176 to 221 bu/ac among K treatments. Like Waseca, the significant interaction between STK level and K fertilizer rate was explained by the magnitude of the yield response to K fertilizer at various STK levels (Figure 1b). The yield response was large (37 to 45 bu/ac) at the Low STK level, modest (about 17 bu/ac) at the Medium STK level, and nonexistent at the High STK level. Grain moisture was drier in the control treatments at each STK level, especially at the Low STK level.

Potassium concentration in corn grain was not significantly affected by treatments at Rochester (Table 4). Generally, grain K removal increased with increasing K fertilizer rate up to 120 lb K_2O/ac, when averaged across STK levels. The significant STK level × K rate interaction for corn grain K removal was like the interaction for grain yield. A large response in grain K removal occurred at the Low STK level, modest response at the Medium STK level, and no response was found at the High STK level.

At Rochester, like Waseca, different soil test levels (Low, Medium and High) were created in the main plots during the build phase of this study (2012 through 2015) and when averaged across these STK Levels, STK for all samplings increased as fertilizer K rate (sub-plot K rate) increased (Table 4). In June, mean STK across all treatments ranged from 70 to 190 ppm with the dry test and from 75 to 233 ppm with the moist test. In October (2018), mean STK across treatments ranged from 95 to 188 ppm with the dry test and from 73 to 190 ppm with the moist test. On this silt loam (Loess) soil, STK with the moist test was slightly less than the dry test for October sampling. This finding is unlike Waseca, where large differences between the June and October samplings were observed with using the dry test.

Economic returns to fertilizer K application (sub-plot rates) were greater at the Low STK level ($128 to $142/ac) than at the Medium STK level ($11 to $51/ac, Table 4). Negative economic returns were observed at the High STK level. At the Low STK level, economic return was maximized with 120 lb K_2O/ac; whereas, at the Medium STK level, economic return was maximized with 60 lb K_2O/ac.

The relationship between relative yield (soybean in 2016 and corn in 2017 and 2018) and STK as affected by fertilizer K rate and STK method (dry vs moist) at Rochester is shown in Figure 3. The following observations from Waseca also apply to these Rochester data: 1) corn had a greater yield response on a percentage basis than soybean; 2) 2017 corn had a wider STK range of response than did corn in 2018; 3) the moist test had a lower STK critical value than the dry test; and 4) the moist test better described the yield response function than the dry test.

The effects of K fertilizer rate on STK incline and decline rates at different soil sampling times are presented in Figure 5. It's important to note during the build phase (2012 through 2015), 0, 40 and 80 lb K_2O/ac were applied annually at Rochester followed by 0, 60 and 120 lb K_2O/ac during the calibration phase (2016 through 2018). For June sampling, STK declined at 6.6 and 4.8 ppm/year with 0 and 40/60 lb K_2O/ac, respectively and inclined at 2.4 ppm/year with 80/120 lb K_2O/ac. For October sampling, STK increased 2.9 ppm/year with 80/120 lb K_2O/ac rate and decreased 4.5 and 1.8 ppm/year with 0 and 40/60 lb K_2O/ac, respectively. These data showed October sampling performed better at Rochester (Loess soil) than at Waseca (glacial till soil) as it did not overestimate STK.

Summary

Potassium fertilization research continued at two locations (Waseca and Rochester) in 2018. This study measured the effects of fertilizer K rate at different STK levels on crop yield, K removal in grain and economic return to K fertilizer application. These data are currently being used to modify K fertilizer guidelines for corn and soybean. New guidelines are planned to be released this spring or early summer in electronic form via the nutrient management website (also on Twitter and Facebook pages).

Outreach and Extension for the period from 1 April 2018 to March 31, 2019

These research data were presented by the PI or Co-PI at SROC Agronomy Tour (June), North Central Extension-Industry Soil Fertility Conference (Poster session, November), McCleod County Corn and Soybean Day (December), AFREC Winter Research Update (December), and SROC Winter Crops Day (January 2019). The PI has had requests from agricultural professionals to use the Winter Crops Day presentation for employee training purposes.

Acknowledgement

Funding for this project in 2018 was provided by Minnesota's Agriculture Fertilizer Research and Education Council (AFREC). Prior to 2015 this project was funded by the Minnesota Corn Research and Promotion Council (MCR&PC). The authors greatly appreciate the support of these organizations.

References

Gavlak, R., D. Horneck, and R.O. Miller. 2005. Soil, Plant, and Water Reference Methods for the Western Region. Western Region Extension Publication 125 (3rd edition).

Kaiser, D.E., J.A. Lamb and R. Eliason. 2011. Fertilizer guidelines for agronomic crops in Minnesota. Ext. Publ. 06240-S Univ. of Minnesota.

SAS Institute Inc. 2008. SAS 9.2 Users guide. SAS Institute Inc., Cary, North Carolina

Warncke, D. and J.R. Brown. 2015. Potassium and Other Basic Cations. In: M. Nathan and R Gelderman, editors. Recommended chemical soil test procedures for the North Central Region. North Central Region Publication No. 221 (Revised). SB 1001. Missouri Agri. Exp. Stn. Columbia, MO. p. 36-44.

Table 1. Experimental procedure details for each site in 2018.

Procedure	Units	Experimental site/location	
		Waseca	Rochester
Previous crop		Corn	Corn
Preplant N application		8 May	1 May
N rate and source	lb N/ac	140, urea	140, urea
S application		8 May	1 May
S rate and source	lb S/ac	15, AMS	15, AMS
Spring P application		---	---
Spring P rate, source	lb P_2O_5/ac	---	---
Preplant tillage		30 Apr	17 May
Planting date		1 May	18 May
Hybrid brand		NuTech 5L-702	NuTech 5L-702
Pre-emerge herbicide timing		19 May	25 May
June soil sampling		15 Jun	25 Jun
Sidedress N application		6 Jun	14 Jun
N rate and source	lb N/ac	40, urea w/NBPT	40, urea w/NBPT
Post herbicide timing		---	7 Jun
Plot notes		13 Jul	3 Jul
Combine harvest		30 Oct	19 Oct
Fall soil sampling		30 Oct	29 Oct
Fall K application		---	---
Fall P application		---	---
P rate, source	lb P_2O_5/ac	---	---
Fall tillage type		Disk chisel	---
Fall tillage date		2 Nov	---

Table 2. Growing Season Precipitation at Waseca and Rochester.

		Precipitation			
		Waseca		Rochester	
Month	Year	Precip.	Normal†	Precip.	Normal
		----- inches -----		----- inches -----	
May	2018	5.28	3.93	6.96	3.66
Jun	2018	5.78	4.69	7.22	4.34
Jul	2018	4.38	4.42	3.06	4.53
Aug.	2018	4.79	4.75	4.07	4.66
Sep.	2018	10.54	3.67	7.88	3.66
May-Sep.	Total	30.77	21.46	29.19	20.85

† 30-Yr normal, 1981-2010.

Table 3. Corn yield, K concentration and removal in corn grain, plant population and soil test K as affected by fertilizer K rate at Waseca in 2018.

Trt	Main Plot Level	Fertilizer K Rate: Main Plot	Fertilizer K Rate: Sub Plot	Grain Yield	Relative Grain Yield	Grain H_2O	Grain [K]	Grain K Removal	Final Plant Pop.	Soil test K (0- to 6-inch depth): 2017 Oct	2017 Moist O	2018 Jun	2018 Moist J	2018 Oct	2018 Moist O	Econ.‡ Return
#		-- lb K_2O/ac --		bu/ac	%	%	%	lb K/ac	pl*10^3/ac	ppm						$/ac
1	Low	0	0	151 f†	67.9 f	15.6 e	0.35 abc	24.9 f	32.9	112	no	72	68	116 g	48	
2	Low	0	60	215 abcd	96.7 abcd	17.5 bc	0.31 d	31.5 de	32.6	117	data	86	91	123 g	60	238
3	Low	0	120	213 bcd	96.0 bcd	17.8 ab	0.34 bcd	34.3 bcd	32.6	131		95	107	156 def	81	214
4	Low	0	180	221 ab	99.5 ab	18.0 a	0.33 bcd	34.6 bcd	32.7	137		120	144	167 bcd	107	227
5	Med.	60	0	185 e	83.4 e	16.1 d	0.32 cd	28.1 ef	32.8	121		80	75	122 g	51	
6	Med.	60	60	212 cd	95.6 cd	17.8 ab	0.33 bcd	33.2 cd	32.6	134		96	105	144 ef	67	90
7	Med.	60	120	222 a	100.0 a	18.0 a	0.37 a	39.2 a	32.9	144		113	128	176 bc	87	111
8	Med.	60	180	217 abc	97.7 abc	17.9 ab	0.36 ab	36.8 ab	32.5	154		123	156	171 bcd	109	73
9	High	120	0	208 d	93.8 d	17.2 c	0.36 ab	35.3 bc	32.5	132		102	92	143 f	68	
10	High	120	60	220 abc	98.9 abc	17.8 ab	0.35 abc	36.4 abc	32.7	153		122	142	160 cde	86	27
11	High	120	120	219 abc	98.8 abc	18.0 ab	0.33 bcd	34.5 bcd	32.9	157		141	167	178 b	119	8
12	High	120	180	219 abc	98.8 abc	18.1 a	0.36 ab	37.4 ab	32.9	170		164	181	206 a	141	-10
Stats for the main effects of an RCB design with a split-plot arrangement																
Main plot STK level (K rate)																
Low (0 lb K2O/a)				200 C	90.1 C	17.2 B	0.33	31.3 B	32.7	124 C		93 B	102 C	141 B	74 B	
Medium (60 lb)				209 B	94.2 B	17.5 AB	0.35	34.3 A	32.7	138 B		103 B	116 B	153 B	79 B	
High (120 lb)				217 A	97.6 A	17.7 A	0.35	35.9 A	32.7	153 A		132 A	146 A	172 A	103 A	
P > *F*:				0.002	0.002	0.069	0.235	0.011	0.440	0.002		0.002	<0.001	0.031	0.051	
Average LSD (0.10):				5	2.2	0.3	NS	2.0	NS	8		12	11	17	19	
Sub plot K rate																
0 lb K2O/ac				182 B	81.7 B	16.3 C	0.34	29.4 C	32.7	122 D		84 D	79 D	127 D	56 D	
60				216 A	97.1 A	17.7 B	0.33	33.7 B	32.6	135 C		102 C	113 C	142 C	71 C	
120				218 A	98.3 A	17.9 A	0.35	36.0 A	32.8	144 B		117 B	134 B	170 B	96 B	
180				219 A	98.7 A	18.0 A	0.35	36.2 A	32.7	154 A		136 A	160 A	181 A	119 A	
P > *F*:				<0.001	<0.001	<0.001	0.281	<0.001	0.178	<0.001		<0.001	<0.001	<0.001	<0.001	
Average LSD (0.10):				5	2.2	0.2	NS	2.0	NS	7		8	9	7	9	
Interactions																
Main plot × sub plot (P > *F*):				<0.001	<0.001	<0.001	0.065	0.009	0.530	0.765		0.582	0.263	0.090	0.786	
Average LSD (0.10):				9	3.8	0.4	0.03	3.5	NS	NS		NS	NS	17	NS	

† Values within a column followed by same letter are not different at P<0.10 (lower case letters signify interaction effects, upper case letters main effects).

‡ Economic returns compare fertilized to the control within a main plot STK level (calculated at $4.00 per bu. corn and $0.30 per lb K2O).

Table 4. Corn yield, K concentration and removal in corn grain, plant population and soil test K as affected by fertilizer K rate at Rochester in 2018.

Trt	Main Plot Level	Fertilizer K Rate Main Plot	Fertilizer K Rate Sub Plot	Grain Yield	Relative Grain Yield	Grain H_2O	Grain [K]	Grain K Removal	Final Plant Pop.	Soil test K (0- to 6-inch depth) 2017 Oct	2017 Moist O	2018 Jun	2018 Moist J	2018 Oct	2018 Moist O	Econ.‡ Return
#		-- lb K_2O/ac --		bu/ac	%	%	%	lb K/ac	pl*10^3/ac	ppm						$/ac
1	Low	0	0	176 c	79.5 c	15.0 e	0.39	32.0 d	34.9	98 g	no	70	75	95	73	
2	Low	0	60	213 a	96.2 a	18.3 bc	0.37	37.1 bc	34.5	109 fg	data	96	112	107	85	130
3	Low	0	120	220 a	99.6 a	18.8 abc	0.39	41.0 a	34.6	119 ef		130	156	139	125	142
4	Low	0	180	221 a	100.0 a	19.0 ab	0.36	37.9 abc	34.6	151 c		164	192	161	161	128
5	Med.	40	0	201 b	90.9 b	16.5 d	0.38	36.2 c	34.7	104 fg		79	101	103	80	
6	Med.	40	60	219 a	98.7 a	18.2 bc	0.39	39.8 ab	34.4	108 fg		88	112	116	86	51
7	Med.	40	120	218 a	98.7 a	19.1 a	0.39	40.0 ab	34.1	145 cd		151	190	149	138	33
8	Med.	40	180	218 a	98.3 a	19.4 a	0.39	39.6 ab	34.3	157 bc		169	212	186	181	11
9	High	80	0	217 a	97.9 a	18.0 c	0.37	37.9 abc	34.2	110 fg		94	111	120	96	
10	High	80	60	218 a	98.3 a	18.6 abc	0.34	35.0 cd	33.9	129 de		124	150	135	114	-14
11	High	80	120	221 a	99.7 a	19.0 ab	0.38	40.3 ab	33.8	177 a		192	212	185	188	-20
12	High	80	180	218 a	98.4 a	19.2 a	0.37	38.1 abc	33.9	170 ab		190	233	188	190	-49

<u>Stats for the main effects of an RCB design with a split-plot arrangement</u>

	Grain Yield	Relative Grain Yield	Grain H_2O	Grain [K]	Grain K Removal	Final Plant Pop.	2017 Oct	2017 Moist O	2018 Jun	2018 Moist J	2018 Oct	2018 Moist O	Econ. Return
Main plot STK level (K rate)													
Low (0 lb K2O/a)	208 B	93.8 B	17.7 B	0.38	37.0	34.7 A	119 B		115 B	134 B	125 B	111 B	
Medium (40 lb)	214 AB	96.7 AB	18.3 A	0.38	38.9	34.4 AB	128 B		122 B	154 AB	139 A	121 B	
High (80 lb)	218 A	98.6 A	18.7 A	0.37	37.8	34.0 B	147 A		150 A	177 A	157 A	147 A	
P > *F*:	0.054	0.054	0.020	0.140	0.223	0.069	0.027		0.012	0.044	0.021	0.029	
Average LSD (0.10):	7	6.5	0.5	NS	NS	0.5	15		16	25	15	20	
Sub plot K rate													
0 lb K2O/ac	198 B	89.4 B	16.5 C	0.38	35.4 C	34.6	104 D		81 D	96 D	106 D	83 C	
60	216 A	97.8 A	18.4 B	0.36	37.3 B	34.2	115 C		103 C	125 C	119 C	95 C	
120	220 A	99.3 A	19.0 A	0.39	40.4 A	34.2	147 B		158 B	186 B	158 B	150 B	
180	219 A	98.9 A	19.2 A	0.37	38.6 AB	34.3	159 A		174 A	212 A	178 A	177 A	
P > *F*:	<0.001	<0.001	<0.001	0.105	0.001	0.341	<0.001		<0.001	<0.001	<0.001	<0.001	
Average LSD (0.10):	6	5.8	0.5	NS	1.9	NS	9.0		13	16	11	13	
Interactions													
Main plot × sub plot (P > *F*):	<0.001	<0.001	0.002	0.465	0.076	0.996	0.032		0.289	0.760	0.478	0.295	
Average LSD (0.10):	10	10.4	0.8	NS	3.4	NS	18		NS	NS	NS	NS	

† Values within a column followed by same letter are not different at P<0.10 (lower case letters signify interaction effects, upper case letters main effects).

‡ Economic returns compare fertilized to the control within a main plot STK level (calculated at $4.00 per bu. corn and $0.30 per lb K2O).

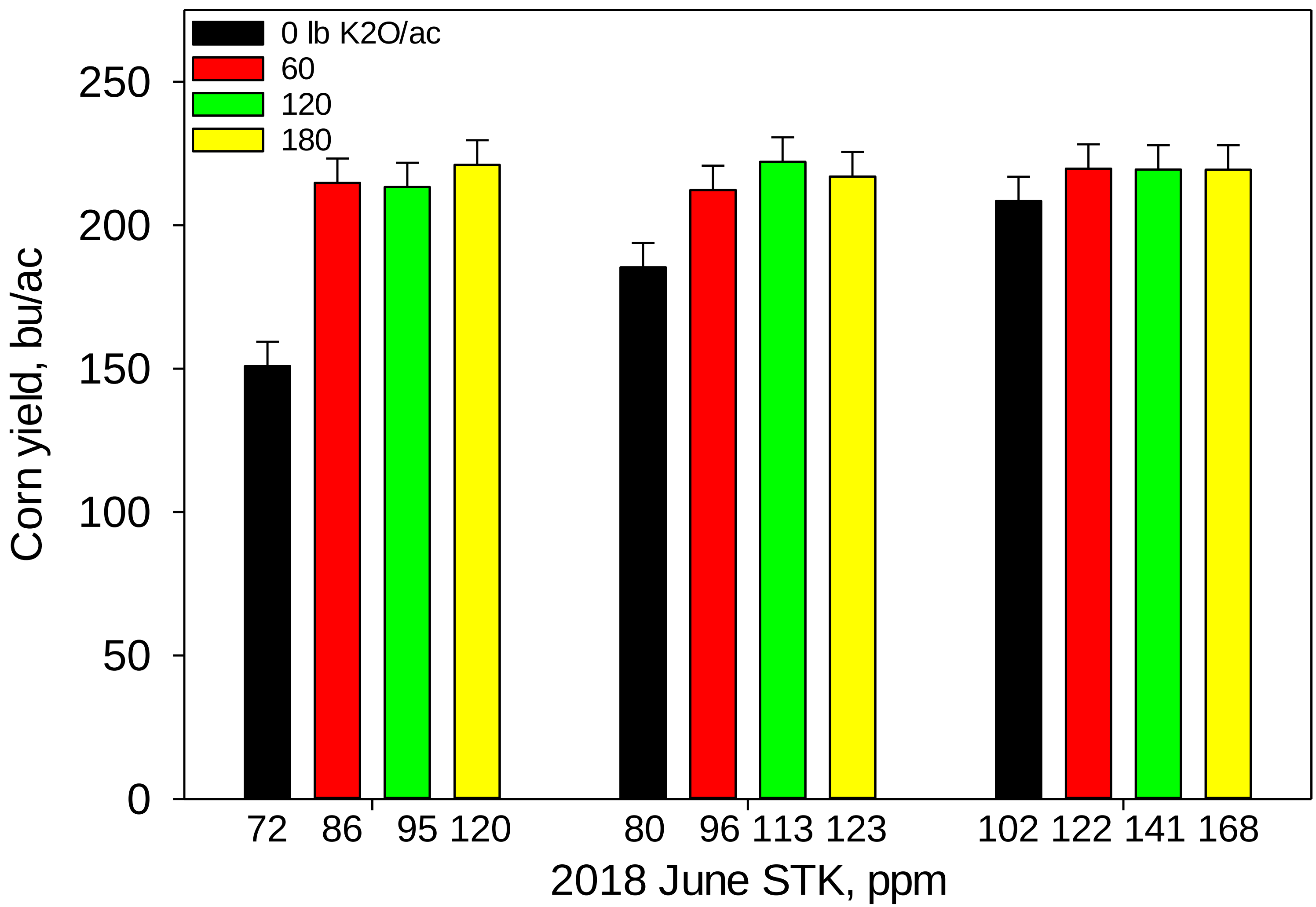

Figure 1a. Corn yield as affected by K fertilizer rate and soil test K (dry test) in 2018 at Waseca.

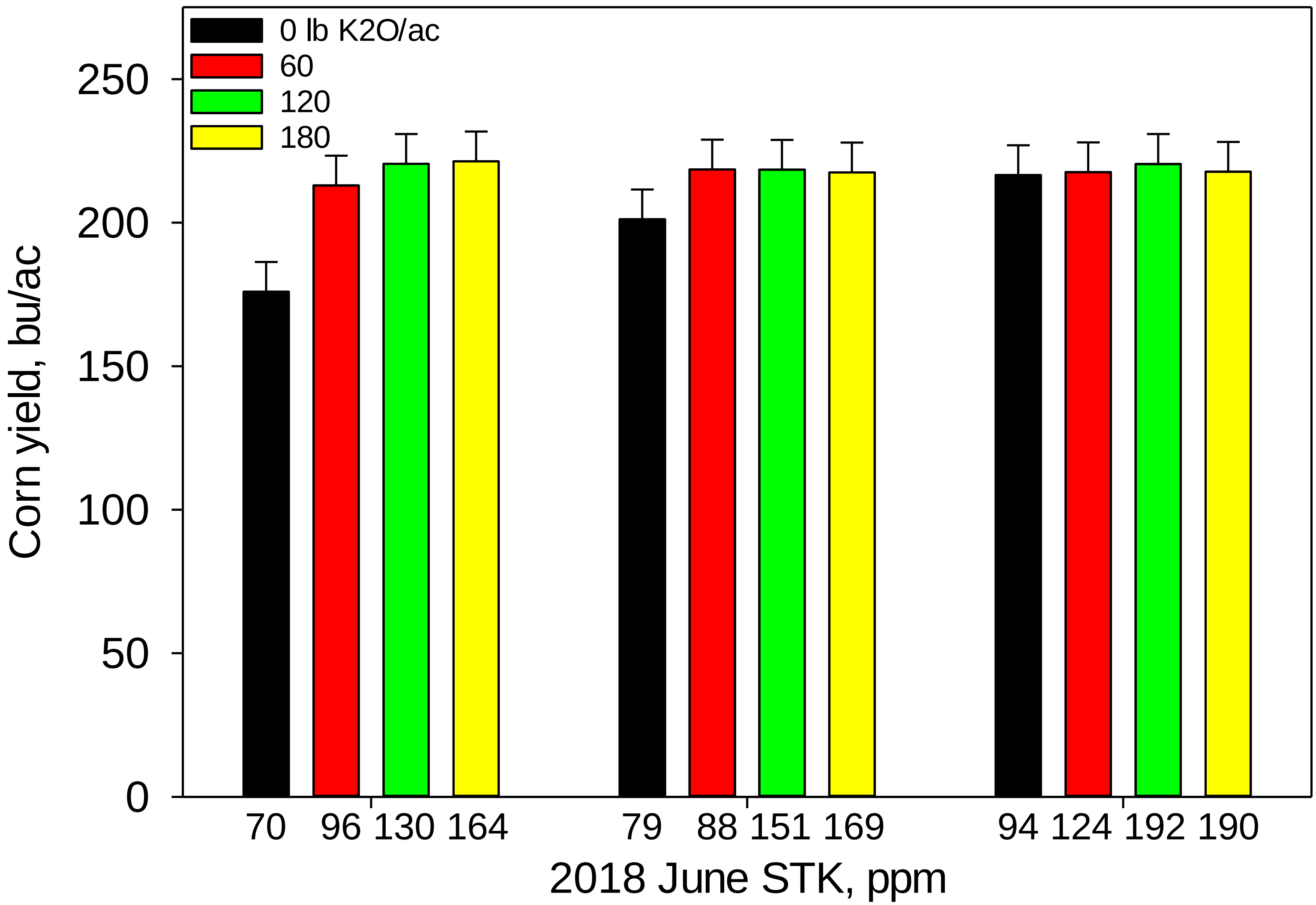

Figure 1b. Corn yield as affected by K fertilizer rate and soil test K (dry test) in 2018 at Rochester.

Relative yield as affected by STK (dry vs moist) at Waseca.

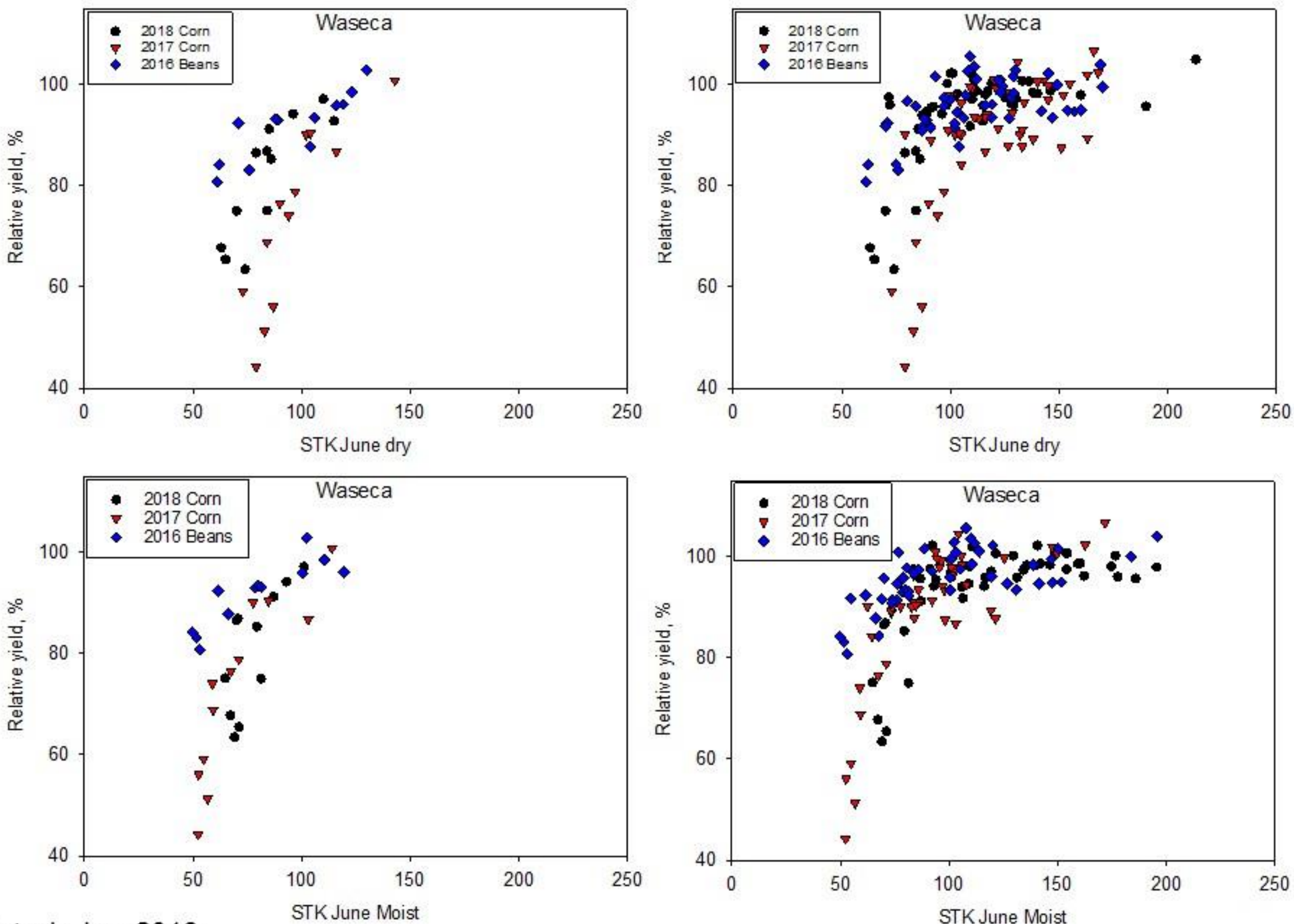

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Figure 2. Relationship between relative yield and soil test K (June) at Waseca [control plots only (left), all plots (right)] .

Relative yield as affected by STK (dry vs moist) at Rochester.

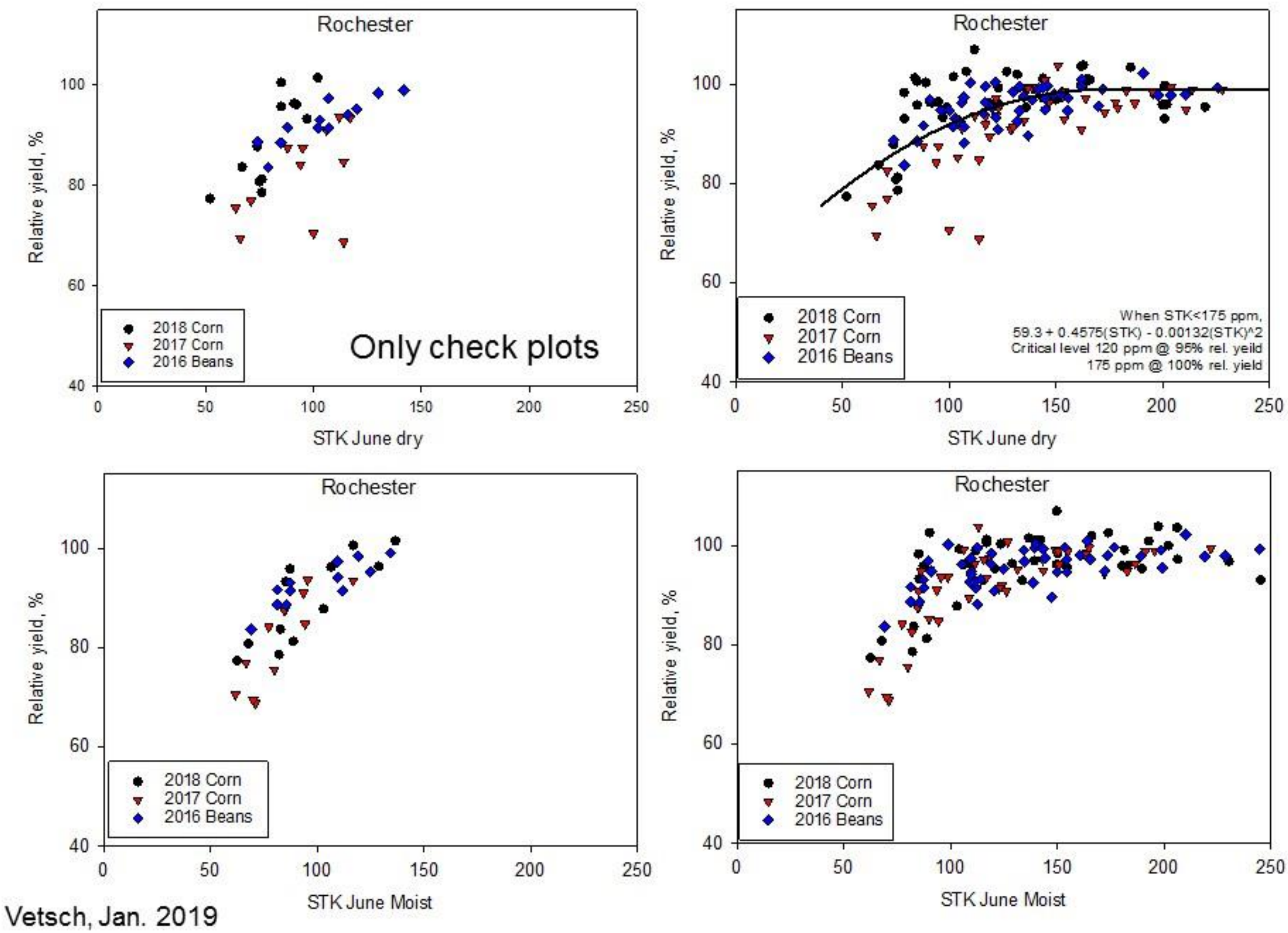
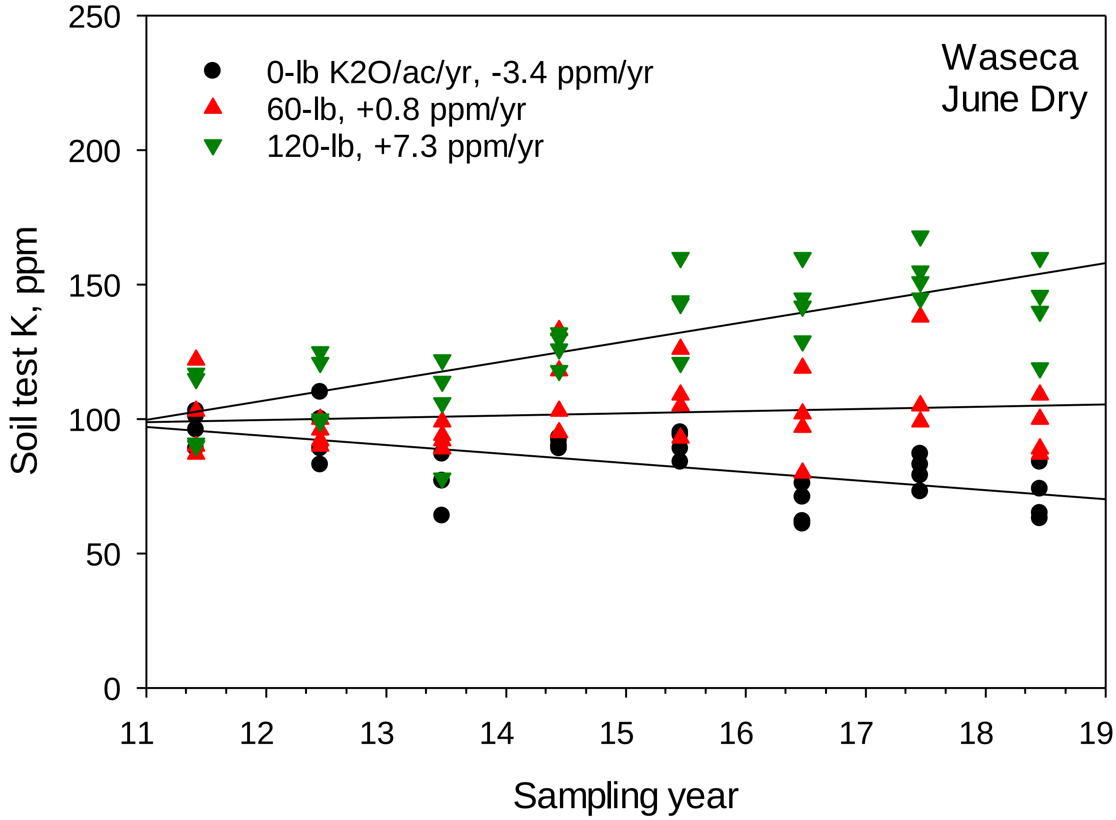


Figure 3. Relationship between relative yield and soil test K (June) at Rochester [control plots only (left), all plots (right)] .



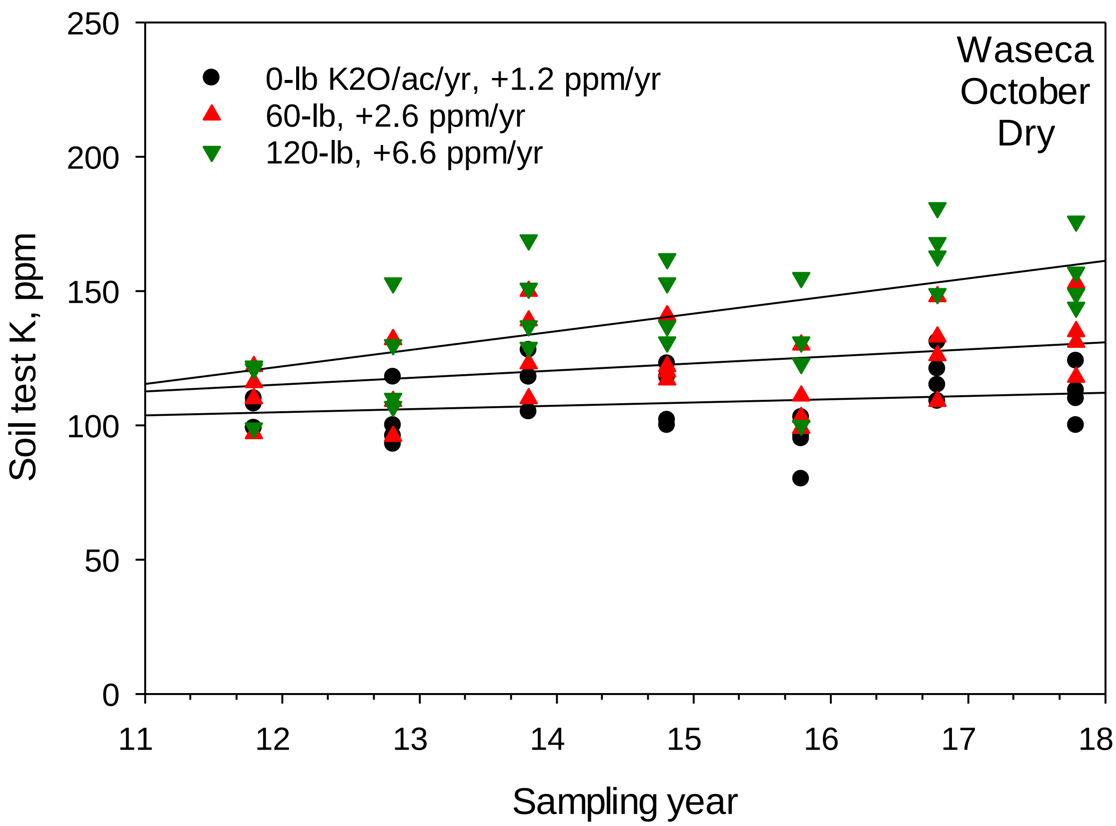


Figure 4. Soil test K incline and decline across years as affected by sampling time and K rate at Waseca.

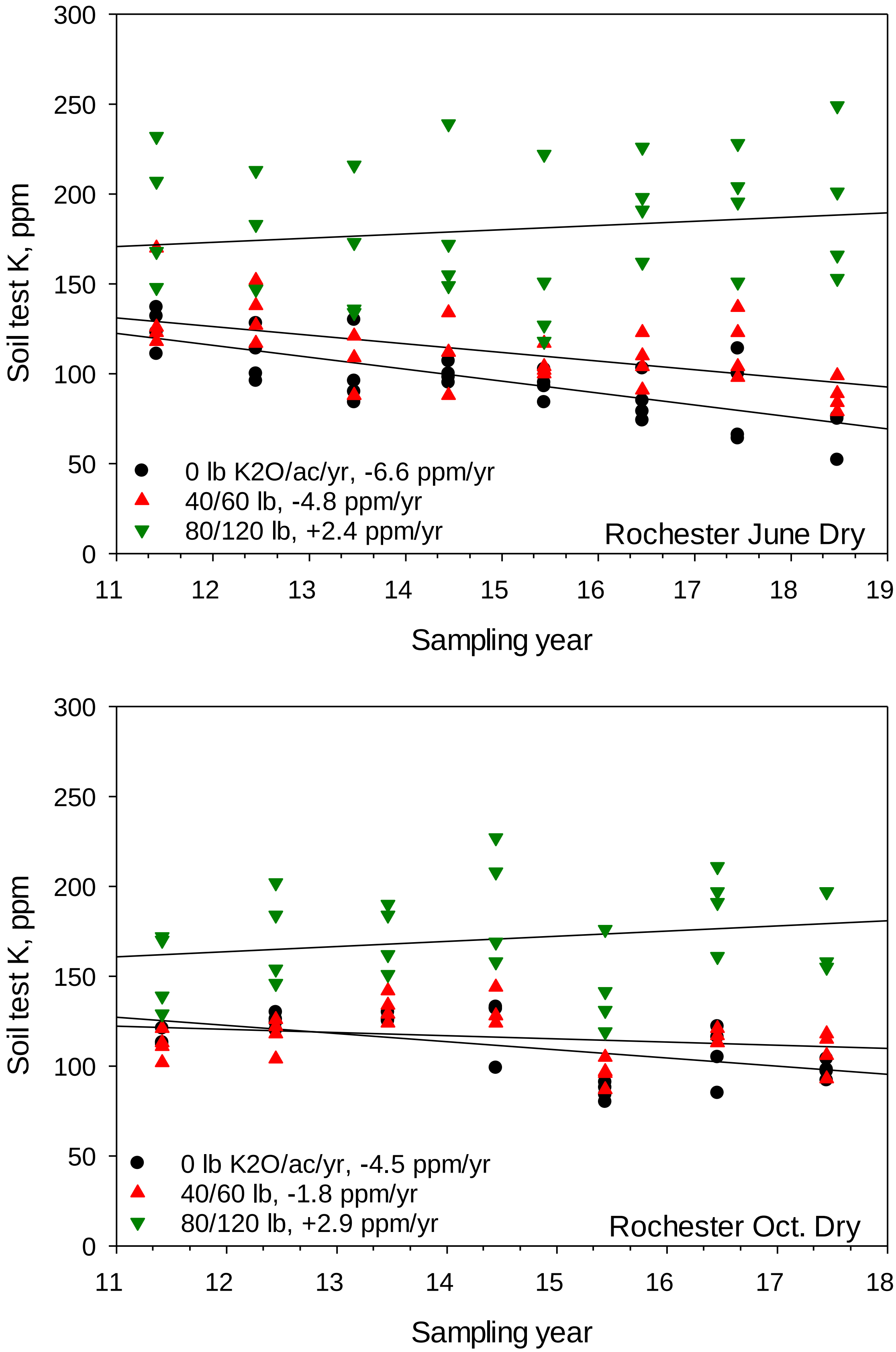


Figure 5. Soil test K incline and decline across years as affected by sampling time and K rate at Rochester.