EFFECT OF SAMPLING TIME ON SOIL TEST POTASSIUM LEVELS

Lauren F. Vitko, Carrie A.M. Laboski, and Todd W. Andraski[1]

Introduction

Soil tests are an important tool to guide farmers in determining an appropriate fertilizer application rate. The interpretation of K soil test results are complicated by the fact that STK levels are known to fluctuate throughout the year (Blakemore, 1966; Childs and Jencks, 1967; Liebhardt and Teel, 1977). Therefore, the time of soil sampling may impact fertilizer recommendations. Fluctuations in soil test K (STK) have been attributed to clay mineralogy and environmental conditions, like soil moisture status, wetting and drying cycles, and freezing and thawing cycles (Childs and Jencks, 1967).

Soils high in 2:1 type clay minerals (micas and vermiculites) have the ability to fix K (i.e., trap K in the clay interlayer) or release potassium depending on the STK level and soil moisture status (Goulding, 1987). Soil tests only measure the solution and exchangeable forms of soil potassium, and do not measure the potassium that is 'fixed' in the interlayer of 2:1 clay minerals. Leubs et al. (1956) measured exchangeable K levels in the top ½ inch of two Iowa fields from June through August and found exchangeable K to be inversely related to soil moisture. In laboratory investigations, an increase in the number of wetting and drying or freezing and thawing cycles has been found to either increase or decrease the magnitude of fixation or release of potassium (Graham and Lopez, 1969; Zeng and Brown, 2000). However, the response of STK levels to environmental conditions differs widely among different soils; therefore it is important to evaluate how STK levels may fluctuate in the major soil groups of Wisconsin.

Currently, the University of Wisconsin does not specify what time of the year soil sampling should be done, but suggests that soil should be sampled consistently at the same time of the year (Laboski et al., 2006). If fluctuations in soil test K levels can be attributed to a particular time of the year or to particular weather/environmental conditions, then soil test interpretations could be fine-tuned. Of particular interest is whether soil test levels change significantly between the fall and the spring, since these are the times when soil is most likely to be sampled. Further, freezing and thawing and the return of K to the soil from plant residue over the winter may change soil test levels between the fall and the spring.

The change in STK with the addition of fertilizer and/or the removal of K is related to the potassium buffer capacity (KBC) of the soil. Currently, the University of Wisconsin assumes the mineral soils of Wisconsin to have a KBC of 6 or 7 lb K_2O/a per 1ppm soil test K, depending on soil group (Laboski et al., 2006). These approximations of KBC are used in the calculation of fertilizer application rates for low and very low testing soils. A better understanding of soil buffer capacity in the field will assist in improving fertilizer recommendations and in interpreting fluctuations in STK levels.

The objectives of this study were:

- Determine if STK levels fluctuate significantly throughout the three-year study.
- Determine if soil test levels change significantly between the fall and the spring.

[1] Graduate Research Assistant; Associate Professor; Researcher, Dept. of Soil Science, Univ. of Wisconsin-Madison, 1525 Observatory Dr., Madison, WI 53706.

- Evaluate if changes in STK affect soil test interpretation and fertilizer recommendations.
- Assess KBC at each location in terms of drawdown and buildup of STK.

Materials and Methods

Field plots were established in the spring of 2006 at Arlington, Hancock, Lancaster, and Marshfield Agricultural Research Stations, and a private farm in Fond du Lac County. These five locations represent five pedogenically unique mineral soils of Wisconsin (Laboski et al., 2006). The soil names, initial Bray-1 soil test K and P levels, organic matter content, pH, previous crop, and N fertilizer rates for each location are presented in Table 1.

The duration of the experiment was three growing seasons, 2006 through 2008. The experimental design was a split-plot with corn harvest management as the whole plot factor (grain and silage) and potassium fertilizer rate as the subplot factor with four replications. All locations received seven different K rates (0, 67, 134, 201, 268, 335, 401 lb K_2O/a) except Fond du Lac, which received only four rates (0, 67, 134, 201 lb K_2O/a). Potassium fertilizer (0-0-60) was preplant surface broadcast and incorporated in the spring of 2006 to a depth of 8 inches. No additional fertilizer was applied in 2007 or 2008.

The sites were cropped to corn in 2006, soybean in 2007, and corn again in 2008. Tillage was spring or fall chisel, except at Hancock which was moldboard plowed. Plot size was 10 ft in width (except at Hancock which was 12 ft in width) and 35 ft length. Best crop and pest management practices were followed at each location.

Table 1. Selected characteristics of soils and field sites.

		Initial soil test values†					N rate	
Location	Soil name	K	P	pH	OM	2005 crop	2006	2008
		— ppm —			%		— lb N/a —	
Arlington	Plano silt loam	123	33	6.7	4.0	Soybean	120	160
Hancock‡	Plainfield sand	40	97	6.6	0.8	New seeding red clover	200	215
Lancaster	Fayette silt loam	70	12	6.9	2.7	August alfalfa after oats	160	160
Marshfield	Withee silt loam	111	32	7.1	3.4	Soybean	120	110
Fond du Lac	Kewaunee clay loam	95	17	7.6	3.2	Soybean	120	120

†Bray-1 extracted K and P. K, P, pH, and OM determined for air-dried soils sampled in the spring of 2006, 0-20cm in depth.
‡ Irrigated.

For the corn grain harvest plots, soil samples were collected a total of 11 times at each location for the three-year duration of the experiment. Soil sampling occurred five times in 2006, four times in 2007, and twice in 2008. In 2006, soil was sampled late April or early May (prior to fertilizer application), June, July, September, and after harvest in October. In 2007, soil was sampled before planting in May, twice during the growing season in June and August, and after harvest in October.

In 2008, soil was sampled before planting in May and after harvest. The corn silage harvest plots were sampled prior to planting and after harvest each year. The different locations were not all sampled on the same day for each sampling event, but were all sampled within 1 to 14 days of each other.

Six soil cores, 0- to 8-inch depth, were collected from each plot and mixed to make a composite sample. Soil samples were homogenized, sieved to 0.08 inch, oven-dried at 95°F, and extracted with Bray-1. Extraction and analysis of potassium followed procedures outlined in Peters (2009). In 2006 and 2007 potassium was determined using atomic absorption flame spectroscopy, while ICP-OES was used in 2008.

The effect of sampling time on STK levels was determined for the 0 K rate and highest K rate silage and grain harvested plots at each location using a repeated measures ANOVA model in PROC MIXED of SAS (SAS Inst., Inc., Cary, NC). Contrasts were used to determine if soil test K levels differed significantly between the fall and spring of 2006-2007 or the fall and spring of 2007-2008.

Two different calculations of potassium buffer capacity (KBC) were made: a drawdown KBC and a buildup KBC. Drawdown KBC was calculated as the slope of the net K_2O removed (K_2O applied- cumulative K_2O removed) verses the change in STK (STK post-harvest 2008- STK before fertilizer application in spring 2006). Buildup KBC was calculated as the slope of the K_2O applied verses the change in STK (STK 6 weeks after fertilizer application in spring 2006- STK before fertilizer application in spring 2006). *T*-tests were used to compare KBC values from this study to KBC values assumed in Laboski et al. (2006).

Results and Discussion

Soil test potassium levels were found to be significantly (P<0.05) affected by time of soil sampling in the silage harvested plots at Arlington, Hancock, and Marshfield where no K was applied; at Arlington and Lancaster for the highest K rate; and in the grain harvested plots at Hancock, Marshfield, and Fond du Lac at both the highest K and no K applied rates (Fig. 1). For some treatments, fluctuations in STK were quite large but were not statistically significant because of variability between replicates.

Soil test K levels decreased in most of the unfertilized plots after three years of cropping; however, soil test K levels increased 8 and 10 ppm for the unfertilized grain harvested plots at Lancaster and Fond du Lac, respectively (Fig. 1). Soil test K levels remained greater at the end of three years compared to initial STK when 401 lb K_2O/a was applied at some locations but not at others. At Marshfield, for example, STK increased 31 ppm; while soil test K decreased 30 ppm at Arlington (grain harvested plots). After three years of cropping, STK decreased the most for the unfertilized grain and silage harvested plots at Arlington, compared to the unfertilized plots at the other locations; however, plant uptake of K was also greatest at this location.

Soil test K levels were significantly (P<0.05) greater in the spring than in the fall for the no K rate silage harvested plots at Hancock in 2006-2007, and the highest K rate silage harvested plots at Lancaster in 2007-2008 (Table 2). Soil test K levels were significantly (P<0.05) lower in the spring than in the fall of 2006-2007 for the highest K rate silage harvested plots at Arlington. Changes in soil test levels were relatively large for some treatments (a decrease in STK of 28 ppm in 2007-2008 at Marshfield in the silage harvested plots with the highest K rate, for example), but were not statistically significant because of the variability between replicates.

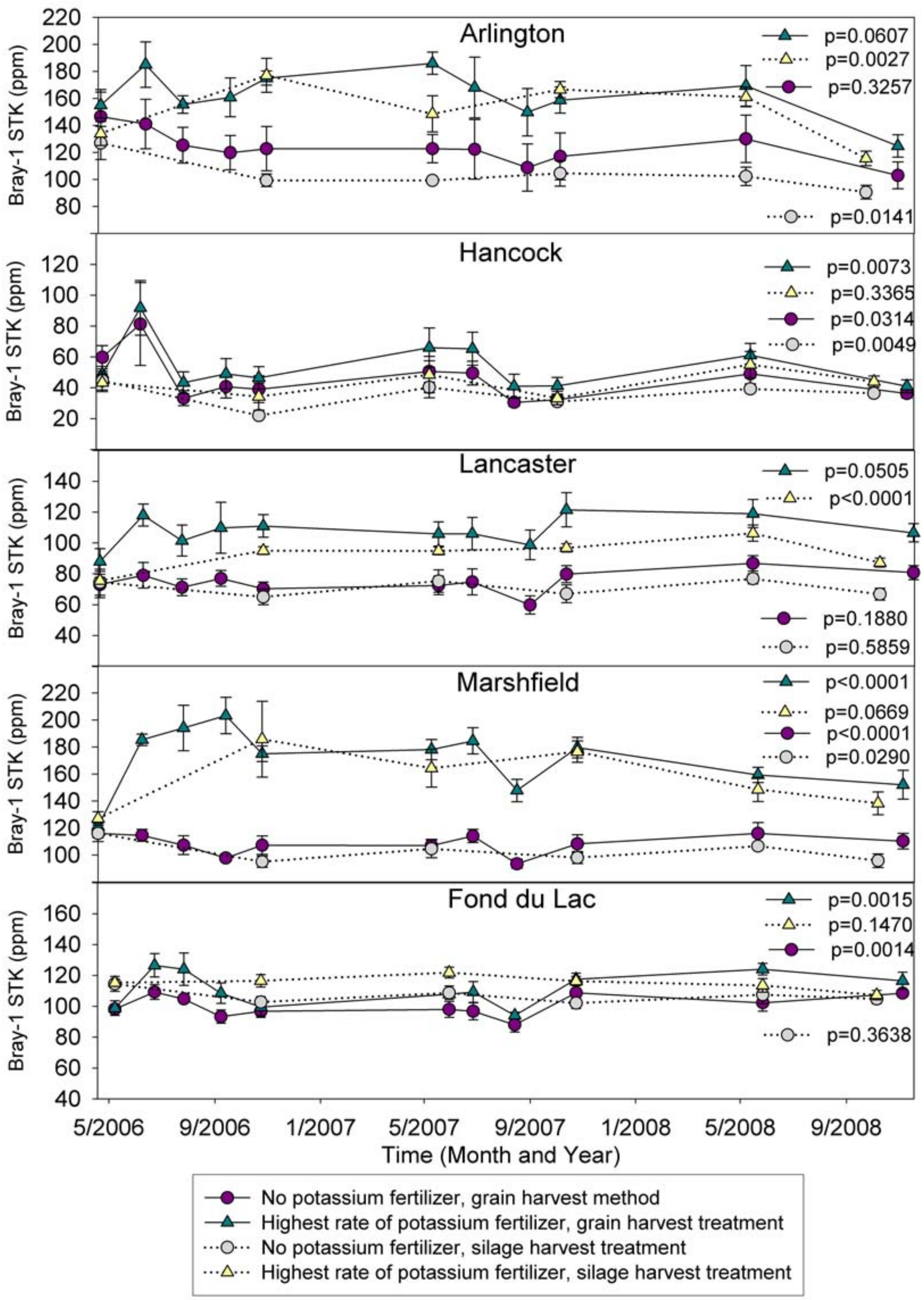

Figure 1. 2006-2008 oven-dried Bray-1 soil test potassium (STK) levels for fertilized (401 lb K_2O/a at all locations except Fond du Lac, which had 201 lb K_2O/a) and unfertilized plots harvested as grain or silage at five Wisconsin locations. P-values are given for the effect of time on Bray-1 STK.

Although fall verses spring sampling was not found to be statistically significant for many of the treatments, changes in STK between fall and spring were frequently large enough to affect soil test interpretation categories (Table 2) and subsequently the recommended rate of K fertilizer. STK interpretation categories were greater in the spring than the fall in 2006-2007 for the highest K rate corn silage and corn grain plots and no K rate corn grain plots at Hancock; the no K rate corn silage plots at Marshfield; and the highest K rate corn grain plots at Fond du Lac. In 2007-2008, STK interpretation categories were greater in the spring for the highest K rate corn silage and corn grain plots and the no K rate corn grain plots at Hancock; and for the highest K rate corn silage plots and no K rate corn grain plots at Lancaster. STK interpretation categories were lower in the spring than in the fall for the highest K rate corn silage plots at Arlington in 2006-2007; and for the highest K rate corn silage and corn grain plots and no K rate corn silage plots at Marshfield in 2007-2008.

Table 2. Changes in STK between fall and spring soil sampling, and its effect on soil test category.

Location	Harvest method	Rate	2006-2007			2007-2008		
			Change in STK†	Fall soil test category‡	Spring soil test category‡	Change in STK†	Fall soil test category‡	Spring soil test category‡
		lb K_2O/a	ppm			ppm		
Arlington	Silage	0	0	Opt	Opt	-2.25	Opt	Opt
		401	-28.5*	EH	H	-5.5	EH	EH
	Grain	0	0	H	H	13	H	H
		401	11	EH	EH	10.5	EH	EH
Hancock	Silage	0	18.25*	VL	VL	8.25	VL	VL
		401	14.25	VL	L	21.75	VL	L
	Grain	0	11.5	VL	L	16.75	VL	L
		401	19.5	L	Opt	19.75	VL	L
Lancaster	Silage	0	10.25	L	L	9.75	L	L
		401	-0.25	Opt	Opt	9.5*	Opt	H
	Grain	0	2.25	L	L	7	L	Opt
		401	-5.25	H	H	-2.5	H	H
Marshfield	Silage	0	9.5	L	Opt	8.5	L	Opt
		401	-21.5	EH	EH	-28	EH	H
	Grain	0	-0.25	Opt	Opt	7.75	Opt	Opt
		401	3	EH	EH	-20.25	EH	H
Fond du Lac	Silage	0	6	H	H	5.5	H	H
		201	5.25	Opt	Opt	-2.75	H	H
	Grain	0	1.25	Opt	H	6.25	H	H
		201	8.25	Opt	Opt	6.5	Opt	Opt

†Change in STK calculated as spring STK minus fall STK.
‡Soil test categories given in Laboski et al. (2006). Soil test categories include very low (VL), low (L), optimum (Opt), high (H), and excessively high (EH). For simplification, soil test categories are assumed for a corn grain crop.
*Indicates significantly different (P<0.05).

Potassium buffer capacity calculated as a drawdown (crop removal) resulted in greater values than KBC calculated as a buildup (Table 3). This may be caused in part to crops obtaining K from the subsoil. KBC drawdown values for Lancaster and Marshfield were significantly (P<0.05) greater than 7 and 6 lb K_2O/a per 1 ppm STK, respectively. KBC buildup values were not significantly different from either 6 or 7 lb K_2O/a per 1 ppm STK at any location. KBC could not be calculated for some of the locations/ harvest management systems because the slope of the regression was not significant (*P*>0.05).

Table 3. Potassium buffer capacity calculated as a drawdown and a buildup.

Location	Harvest management system	KBC drawdown	KBC buildup†
		lb K_2O/a per 1 ppm soil test K	lb K_2O/a per 1 ppm soil test K
Arlington	Grain	17.7	7.0
	Silage	12.5	
Hancock	Grain	20.9	9.3
	Silage	––§	
Lancaster	Both‡	16.1*	––§
Marshfield	Both‡	10.7*	4.9
Fond du Lac	Grain	––§	––§
	Silage	––§	

† KBC buildup was calculated for grain plots only.
‡ Data from grain and silage plots were combined.
§ The regression slope was not significant (*P*>0.05), therefore KBC could not be calculated.
*Indicates KBC is significantly different than the value of 6 or 7 lb K_2O/a per 1 ppm soil test (Laboski, 2006).

Conclusion

When interpreting the results of soil tests, it is important to consider that time of soil sampling may impact STK levels. Soil test K levels were found to be significantly affected by time of soil sampling during the 3-year period. Soil test K levels were significantly different between fall and spring soil sampling dates in 2006-2007 for the highest K rate silage harvested plots at Arlington and the no K rate silage harvested plots at Hancock, and in 2007-2008 for the highest K rate silage harvested plots at Lancaster. Although not statistically significant, differences in STK between fall and spring soil sampling dates were frequently large enough to change soil test categories, and thus impact fertilizer recommendations. The results of this study suggest that changes in STK levels between fall and spring sampling dates are not consistent from year to year, at a given location. Thus, the present recommendation to sample at the same time of year whenever possible is useful to reduce the variability in interpretation when soil is sampled at different times of the year.

Preliminary evaluation of KBC in the field revealed that buildup values were not significantly different than the values (6 or 7 lb K_2O/a per 1 ppm STK) currently used in determine nutrient application rates for low and very low K testing soils. However, KBC drawdown values were significantly greater than 6 and 7 lb K_2O/a per 1 ppm STK at Marshfield and Lancaster, respectively. Data from a laboratory investigation on KBC for these soils are currently be analyzed, and may help with interpretation of results from the field.

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