VARIABILITY OF SOIL TEST POTASSIUM IN SPACE AND TIME

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Soil test K is variable in space and time. Soil test K is variable in space over time. Soil test K is inherently spatially variable due to differences in the K released from the soil over time. When crops are grown, the removal of K with grain, forage and residue removal also results in spatially variable K due to differences in crop growth across the landscape. Examples of spatial variability of K are available at nearly any retail fertilizer store that offers site-specific nutrient management services that include K soil testing. A more rigorous example is displayed in Figure 1, from Franzen, 2007, with the 40-acre field sampled at regular 80-foot intervals.

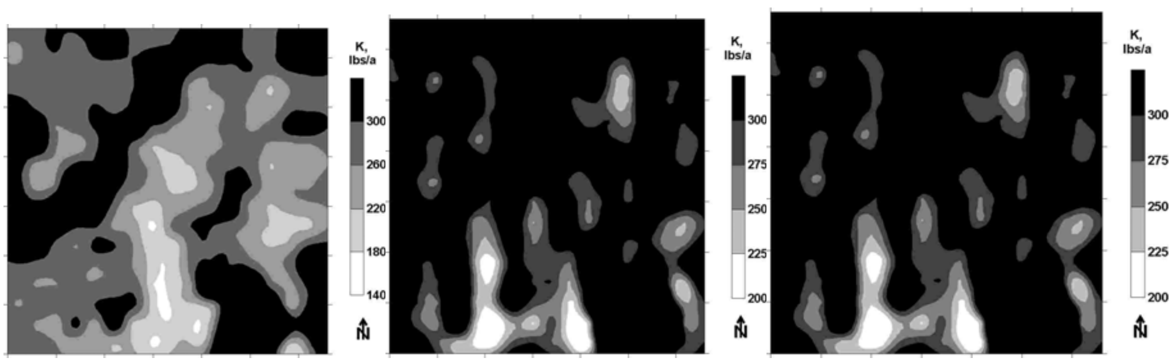


Figure 1. Soil test K from an 80 foot sampling grid sampled prior to cropping of a 40-acre field near Thomasboro, IL after a long fallow period in 1982 (left), again in 1988 after heavy broadcast K applications (center), and again in 1992 after 5 growing seasons without K application (right).

Another example of variability of K is shown in Figure 2. In both Fig. 1 and Fig. 2, the initial soil testing followed low if any K applications, so the soil test patterns reflected more or less ‘natural’ differences in the soil ability to supply K and differences caused by crop removal during the previous 60-80 years following natural prairie break-out. The 1988 sampling at both locations illustrated the masking of natural variability due to heavy fertilizer applications. At Thomasboro between 1982 and 1988, a total of 790 lb K_2O/acre was applied and an estimated 212 lb K_2O per acre was removed for a total addition of 578 lb K_2O per acre. At Mansfield, a total of 2550 lb K_2O was applied between 1961 and 1988, and an estimated 1250 lb K_2O per acre removed due to grain yield, resulting in a total addition of 1300 lb K_2O. In both fields, as K was removed from 1988-1992 without K fertilization, soil test patterns tended to move towards the original boundaries.

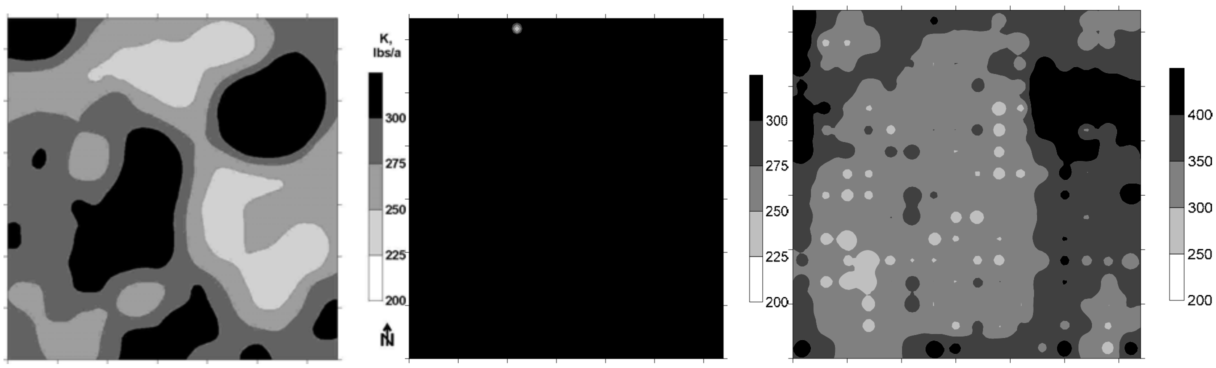


Figure 2. Soil test K from an 80 foot sampling grid sampled prior to cropping of a 40-acre field near Mansfield, IL prior to heavy fertilization with K (left), again in 1988 after heavy broadcast K applications (center), and again in 1992 after 5 growing seasons without K application (right).

In North Dakota, K fertilization, while becoming more common with greater acres of soybean and corn, is still low in traditional spring wheat and sunflower growing areas. High K areas usually have a higher clay content and may also be found in depressions in the landscape. The two factors are not always found together due to the highly variable glacial till landscape or residual parent materials found outside the Red River Valley.

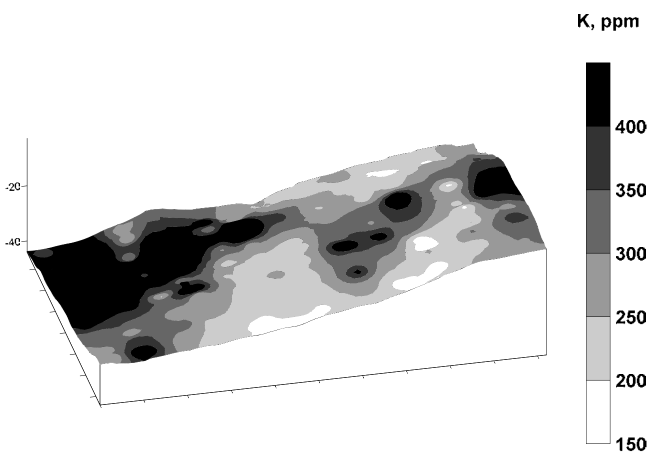


Figure 3. Topography and parent material variability of K in a 40-acre field near Valley City, ND. High K areas are located in depressions and higher clay content soils. Lower K is located on sandy ridges.

Source of variability appears to make a difference in soil sampling for site-specific K. At Mansfield in 1992, the 330 foot grid was poorly correlated with the original 80 foot grid due to the man-made high K levels and resulting man-made variability. At Thomasboro, a 330 foot grid was as highly correlated as the 220 foot grid at Mansfield, probably because the heavy P and K fertilization at Thomasboro was conducted for a shorter period of time with about half the K addition compared to Mansfield. The K drawdown from 1988 to 1992 was sufficient to move the K tests back towards more natural patterns for the field.

Table 1. Mansfield and Thomasboro 1992
P and K correlation between 80 foot grid and two less sampling-intensive grids.

Location	Soil test	Sampling grid, feet	
		330	220
		Correlation r	
Mansfield	P	0.16	0.42
	K	0.17	0.41
Thomasboro	P	0.46	0.53
	K	0.41	0.59

At Valley City, a 440 foot grid, 330 foot grid and a 220 foot grid had correlation with the original 110 foot grid of 0.25, 0.24 and 0.27 respectively, while the topography-based sampling correlation was 0.39. In an Iowa study of 8 field sites, Mallarino and Wittrey (2004) concluded that zone-based sampling was better than grid sampling for K and organic matter, grid sampling tended to be better for P.

One of the spatial problems with K and perhaps other fertilizer nutrients is man-made variability. In Illinois at Thomasboro, several individual grid points varied from sampling to sampling despite multiple cores taken to represent each grid point. At several of these grid points, an 8 foot grid pattern around the central grid point was taken from a 144 foot by 144 foot area. An example of the P patterns within the sites is shown in Figure 4. The north-south areas of high P are about 50 feet apart, which is the spread pattern for the fertilizer applicator used in the field. Areas of low P are similarly about 50 feet apart. This sort of variability is one reason why multiple soil cores are needed to represent an area, and why even with GPS sometimes P, K and other nutrient values from specific areas of the field seem to 'bounce around' between samplings.

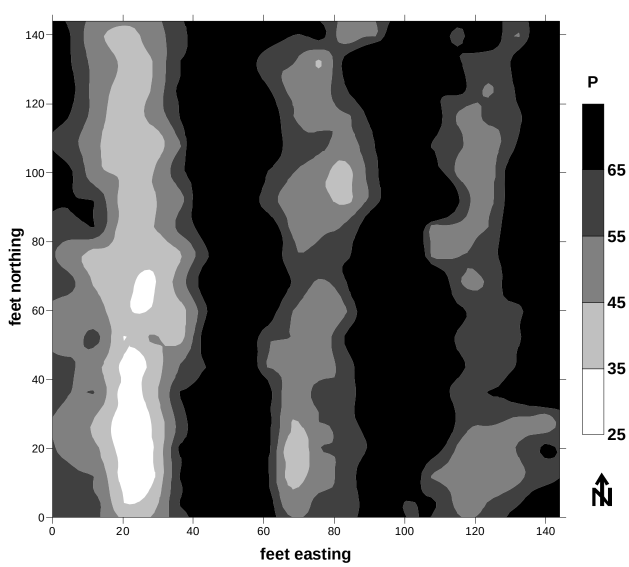


Figure 4. Bray P, lb/acre from a 144 foot by 144 foot area within the Thomasboro field.

Banded fertilizer at planting has been a problem for representing soil P and K levels for many years. Recently, fertilizing strategies for strip-till have increased the acres that have banded fertilizer P and K regularly applied. After examining patterns from banded fertilizer, Kitchen et al., 1990, suggested that each soil sample consist of about 20 soil cores. They also recommended sampling in a transect perpendicular to the planting row.

There also seems to be concern regarding P and K stratification vertically from surface-applied, or nearly surface-applied fertilizer. Some sources suggest sampling the 1-inch or 2-inch depth to determine the extent of stratification. Most sources do not recommend what the elevated levels might mean for crop production, or suggest that the stratification is actually hurting grower profitability or crop production. If there are no recommendations that suggest some rate change or management change from the presence of stratification, why do some recommendations even suggest separately sampling the surface?

A perplexing problem in potassium soil testing is the tendency for sampled areas to vary over time in a manner not related to crop uptake. Potassium soil tests tend to be higher in dry soil than wet soil. With air-drying of samples, there may be a tendency to think that moving all the soil to a dry state would alleviate the problem of K variability with moisture, however, this is not the case. Peck and Sullivan (1995) summarized some of their work that sampling the same areas of soil every 2 weeks over a number of years, depending on the plot. Unfortunately, the original data has been lost, and only 9 years of data were summarized. Taking the graphs available in Peck and Sullivan (2005), the original data was estimated and compiled for use in the following discussion. One of the conclusions that the authors reached was that P and pH were much more stable than K, and probably could be sampled any time of year and provide similar levels (Figure 5, Figure 6).

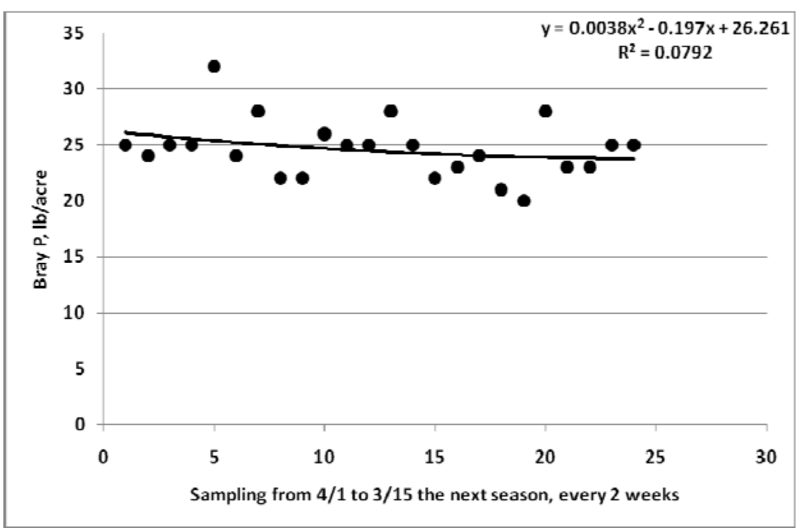


Figure 5. Every 2 week sampling for P from April 1 to March 15 the next season in a single experimental plot. No fertilizer added, but crop was grown (From Peck and Sullivan, 1995).

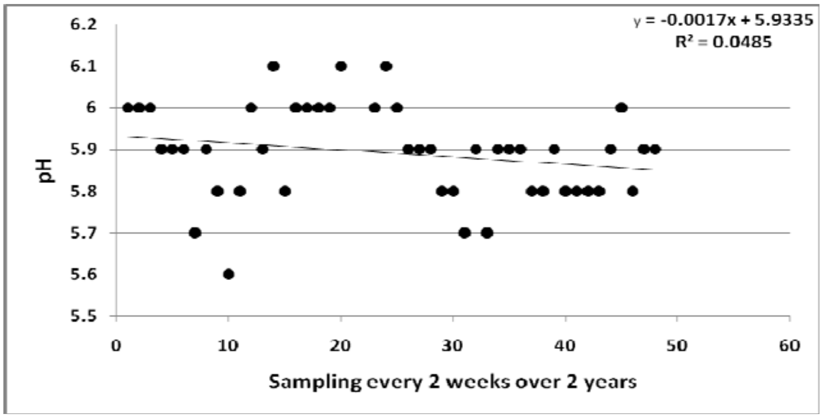


Figure 6. Every 2 week sampling for pH from April 1 to March 15 for 2 seasons in a single experimental plot. No lime was added. The reduction in pH from sampling 4 to14 and 27 to 34 was probably caused by fertilizer ammonia nitrification and resulting acidity produced from the transformation. (From Peck and Sullivan, 1995).

In contrast, there was considerably more variability between sampling dates for K over 9 years (Figure 7). There was some smaller variability between consecutive sampling, but the large variation was caused by seasonal moisture characteristics. Soil test K was highest in the winter and early spring when soil moisture levels were high. During the growing season, soil test K decreased and was lowest usually in the fall when the soil was driest. During wet season, the K variability was not as pronounced.

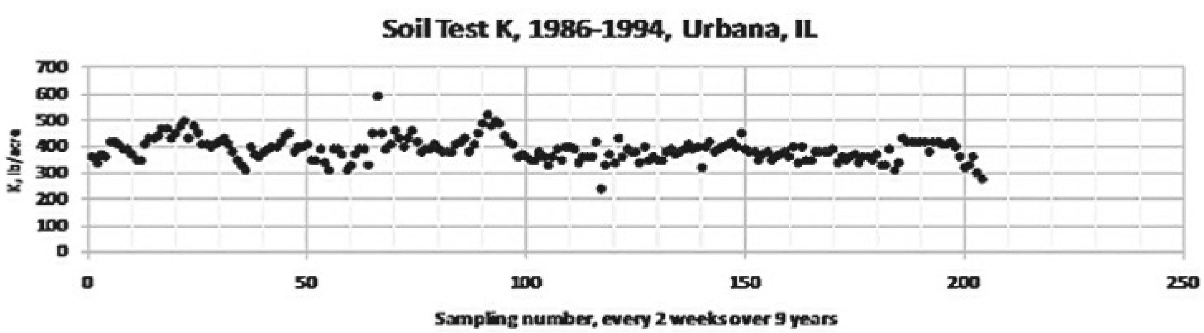


Figure 7. Soil test K in one experimental plot sampled every 2 weeks for 9 years (from Peck and Sullivan, 1995). The first sampling date is April 1.

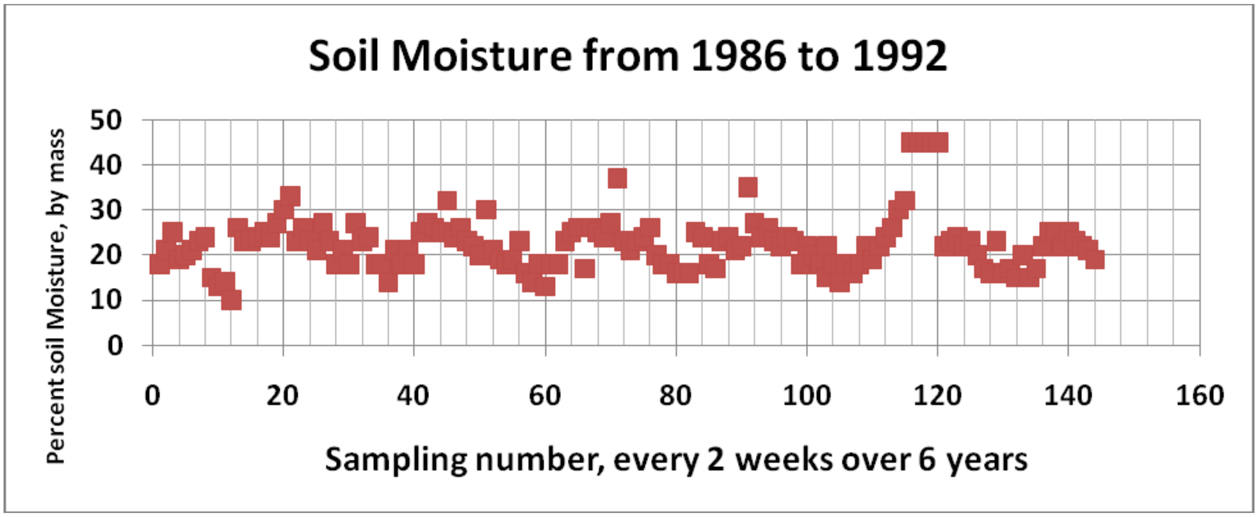
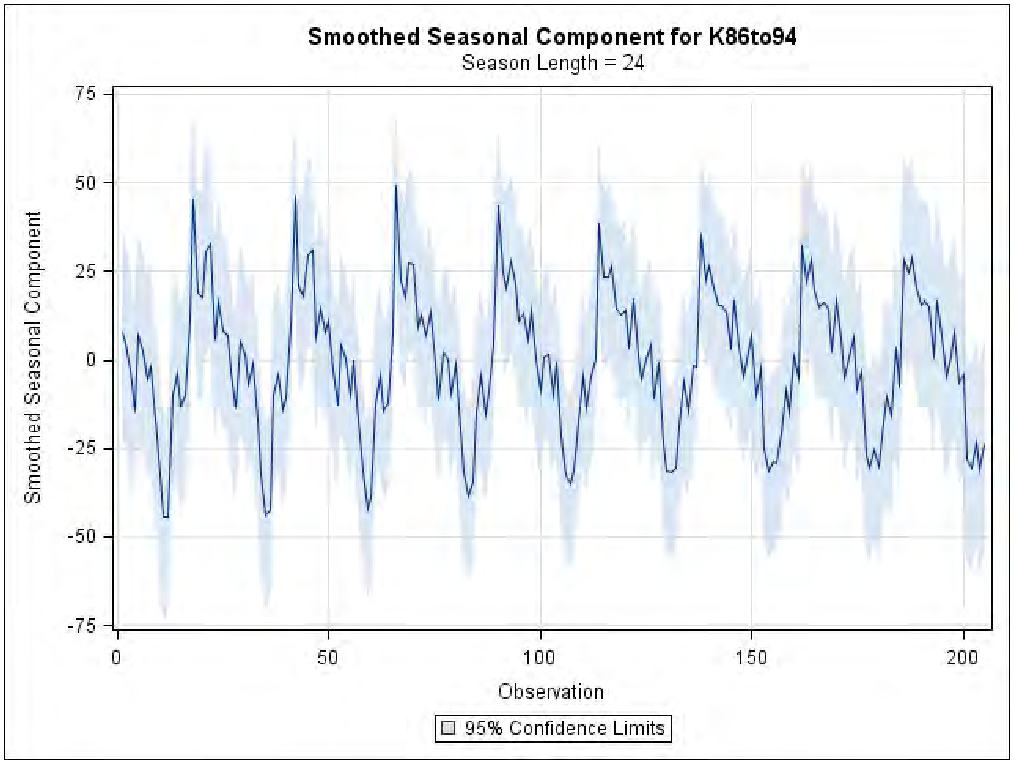


Figure 8. Soil moisture from K sampled plot every 2 weeks for 6 years. The first sampling date is April 1.

It is difficult to always recognize the seasonal variability of the K levels and to be convinced that they are seasonally and moisture related. To evaluate the periodicity of the K levels and moisture from the soil samplings, PROC UCM within SAS was used. The results shown in Figure 8 clearly point to related periodicity on an annual basis related to soil moisture periodicity.

The method of sample preparation did not seem to affect the periodicity of the K test. In Figure 9, field moist and air-dried preparations of the same soil samples appeared to follow similar trends, although the field moist sample was nearly always lower in value compared to air-dry. As long as the calibration of the two preparations was good, the method of preparation did not seem to be an issue in variability. The differences between field moist and air-dried sampling decreased as the K test increased. In addition, Mallarino demonstrated that the method of drying soil samples also influences K analysis (Mallarino et al., 2002). Air-dried samples at room temperature had lower K analysis than samples dried at 40^{o}C, which had lower K levels than the same samples dried at 50^{o}C. Not only is consistency in drying method important, but use of the same laboratory that uses consistent drying methods, with drying spaces designed to provide a uniform drying temperature during the process is also important.



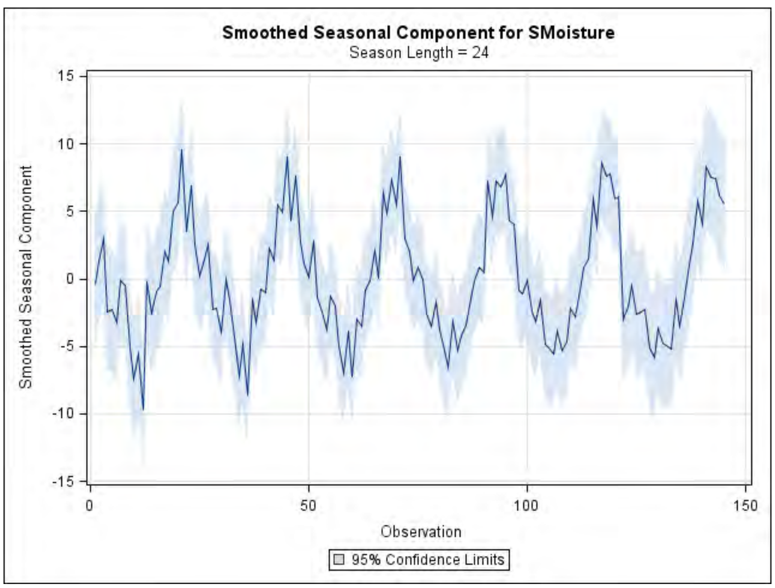


Figure 9. Smoothed periodicity of soil K levels (top) over 9 years and soil moisture levels (bottom) over the first 6 years. Between weeks 0 and 150, there are 6 peaks of K and soil moisture. The periodicity of the two factors are very similar (data from Peck and Sullivan, 1995).

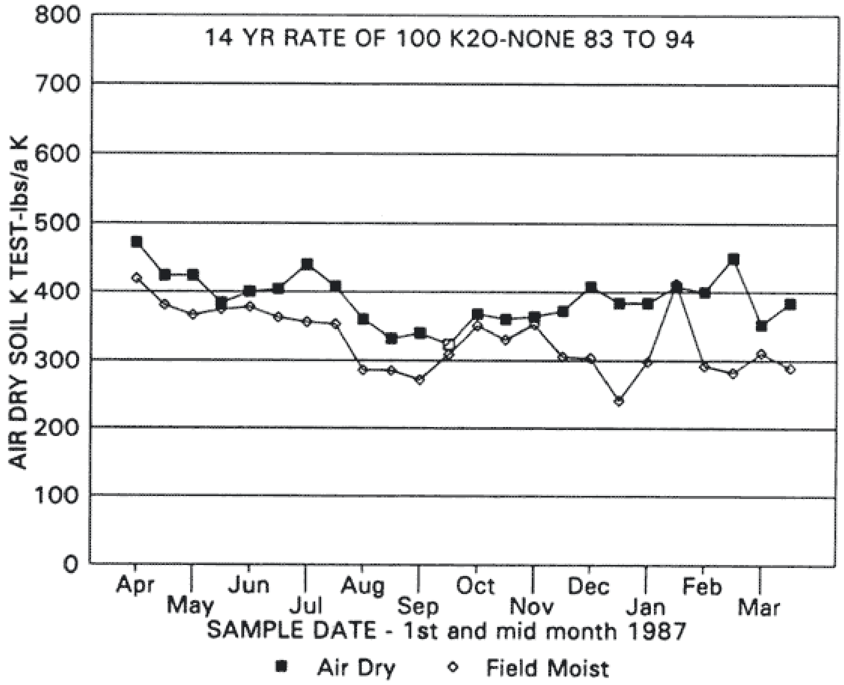


Figure 10. Comparison of the field-moist versus air-dry soil sample preparation on K test for 24 sampling periods. (From Peck and Sullivan, 1995).

SUMMARY

Potassium soil test may be highly variable within fields. In the western part of the North Central Region, where the history of K fertilization is marked by low rates of K fertilizer and fields where K has never been applied, natural variability of K is governed by clay content and landscape position. In areas where K fertilization has been high, man-made variability is more common. Man-made variability may be experienced as differences in historic rates within fields merged over years of ownership and rental agreements, inaccurate fertilizer/manure applications, or fertilizer banding. Temporal differences in K levels at individual sample locations are common due to the relationship of moisture and K release from soil clays. Higher moisture tends to increase soil test and lower moisture tends to decrease soil test. The seasonal periodicity of soil test K suggests that fields should be sampled at similar periods to observe real trends in K buildup-drawdown. Field moist K analysis was generally lower than air-dried analysis. Analysis method should be consistent to observe real soil test K trends.

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