Potassium Sidedress on Soybeans

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Introduction and Objectives

There are three primary macronutrients, Nitrogen (N), Phosphorus (P), and Potassium (K). Of those three, K is relatively easy to manage, as it bonds to the soil cation exchange capacity (CEC) and is typically plant available (Bertsch and Thomas, 1985). On the Mid-Atlantic Coastal Plain, soil surface textures can range from loamy sand to silt loam, with sandier textures also imparting a lower CEC. Crop production requires that soils hold a suite of nutrients and lower CEC soils will have a limited ability to hold enough K to maintain greater yields. In particular, K will compete with Ca and Mg on the CEC, and K has a lower affinity (Bertsch and Thomas, 1985). As newer soybean genotypes produce greater yields, a subsequent higher use of K may be observed, requiring higher tissue concentrations (Stammer and Mallarino, 2018). In soils with lower CEC, maintaining greater K levels will be restricted, as K may leach below the root zone prior to plant uptake (Rosolem et al., 2010).

To overcome the potential loss of K prior to plant uptake, it is proposed that split applications like sidedressing N may be necessary. If applied during a more rapid uptake period for soybeans, the plant may have access to a greater portion of K fertilizer before it moves below the root zone. This has the potential to improve soybean yields, while also improving the efficient use of K fertilizer.

Methods

A sandy field at the University of Delaware Research Farm in Georgetown, DE was selected for the study. A composite soil sample was from the field was taken to determine soil K status. Three treatments included a 1) control (0 lbs/acre), 2) all pre-plant (60 lbs/acre), 3) split application (30 pre/30 split lbs/acre). The split application was applied at a later vegetative stage prior to flowering.

Each treatment included ten replications for a total of thirty plots. Plots were fifteen feet wide and 100 feet long and setup in a randomized complete block design (Figure 1). Soil samples were taken from each plot prior to sampling from the upper eight inches. Pre-plant K was applied for treatments 2 and 3 and soybeans were planted in 30 inch rows at 180,000 seeds per acre. Prior to reproductive stages, at V5-6, K was sidedressed with 0-0-62 granules using a Valmar spreader. The upper trifoliate leaves were collected from the plots prior to applying sidedress and a second time at R1/R2.

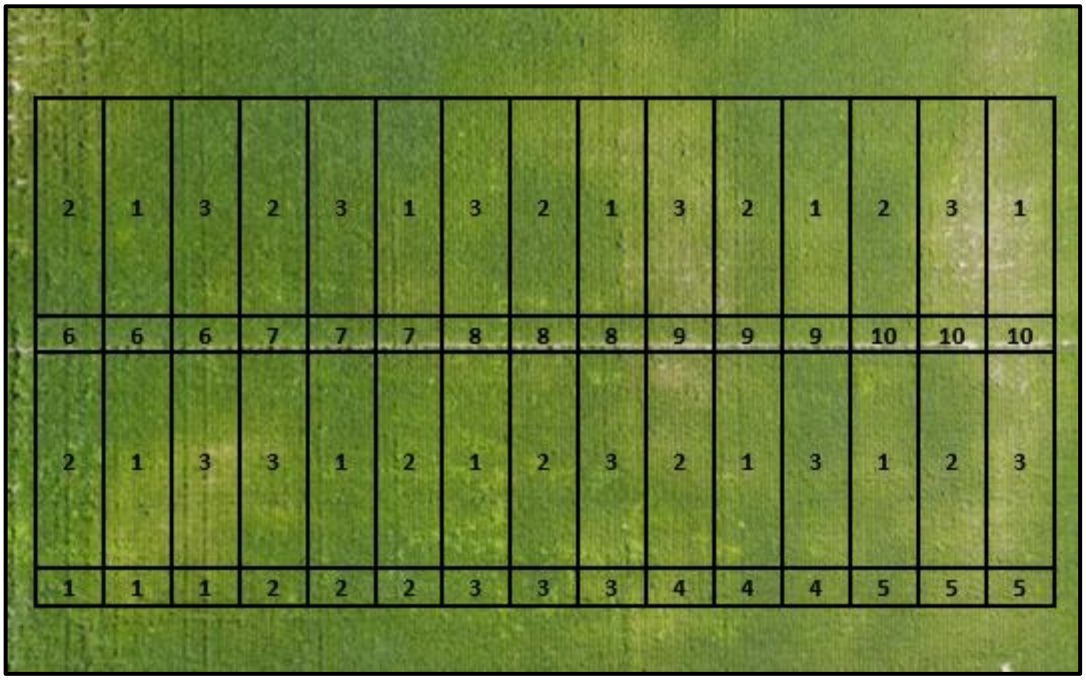

Figure 1: Field image with plot diagram including randomized treatment number (1-3) and block (1-10). Plots do not line up exactly under the borders, so visual symptoms do not correlate to plot yield.

Statistical Analyses

Each plot was harvested with a plot combine and yields were calculated based on the length and width of each plot. Results were analyzed in SAS as a randomized complete block design using PROC GLM. Correlations amongst continuous variables were analyzed in SAS using PROC CORR.

Reading Statistical Analyses in the Tables

For this statistical analyses, a p-value greater than 0.1 was determined to not provide significant differences between the treatments and is listed as NS in the tables. The smaller the p-value, there is greater likelihood that the K treatments are not the same (e.g 0.001 is more significant than 0.010) . If the relationship is significantly different, treatment values (Yield, Soil K, ect) will be followed by letters (a, b, ect). Any yield or soil K value with the same letter, whether separate or together (eg, a or ab) is considered similar in value.

Results and Discussion

Yield

There were no statistical differences in yield by K application, although split-applied K had the highest absolute yield (62.9 bu/acre). Most soils at the research farm have optimal K levels, which is why the UD recommended K rate was 60 lbs/acre (Table 1). A significant block effect was present, indicating field variability contributing to yields. This variability may have masked some differences in treatments, although it is accounted for in the statistical model. Yield correlated to the block numbers as well, with higher values on the right side of the field (Figure 1).

Both pre-plant and post-harvest soil test K significantly correlated to yield (Table 2), with post-harvest K having a higher correlation (r = 0.66 vs 0.58). Interestingly, soybean tissue tests prior to sidedress applications were not related to yield, but post-sidedress tissue samples were positively correlated (r = 0.45). While not a high correlation, it still indicates that yields and %K in the leaf tissue (post-sidedress) increased together.

Table 1: Average values for soil test K, plant tissue K, and yield by treatment. Treatments include no K applied, all pre-plant, and split-applied. Values followed by different letters are significantly different (a=0.1) within each column.

	Soil K (ppm)			Tissue K (%)		Yield
Treatment	**Pre-Plant**	**Harvest**	**Δ Pre-Harv**	**Pre-Split**	**Post-Split**	**(bu/acre)**
No K	149.9	121.3 b	28.6 a	2.61 b	2.06 b	61.2
Pre-Plant	142.5	139.9 a	2.6 b	2.74 a	2.11 b	60.2
Split-Applied	147.1	135.9 a	11.2 b	2.66 ab	2.21 a	62.9
Treatment p-value	NS	0.013	0.0038	0.0859	0.0518	NS
Block p-value	<0.0001	0.0117	NS	0.0739	NS	0.0061

Soil Test K

Pre-plant soil K levels ranged from 142.5 to 149.9 ppm and were not significantly different by treatment, but did vary across the treatment blocks. No differences in K by treatment would be expected, since no K had been applied at the time. The differences in K concentration across the blocks support the need to design projects to account for field variability.

Post-harvest K levels did see an effect by treatment, with those plots receiving no K having the lowest values (121.3 ppm). There was no difference in final soil K test levels between pre-plant (139.9 ppm) and split applied K (135.9 ppm). Additionally, when the final soil test level is subtracted from pre-plant, the largest loss in K (whether leaching or uptake) was also seen in plots with no fertilizer (Table 1). These results are expected, as plots receiving no K should have the final lowest value and the most uptake.

If an estimated 3.4 lbs K_2O is taken up per bushel soybean yield, similar amounts would have been taken up by no K (209 lbs K_2O/acre), pre-plant K (205 lbs K_2O/acre), and split applied K (215 lbs K_2O/acre) treatments. However, through a mass balance, those same treatment soils are only lacking 68, 76, and 97 lbs K_2O/acre, respectively, at the end of the season. This indicates an additional source of K to soybeans, whether from lower soil depths or fixed interlayer K (Bertsch and Thomas, 1985). The closest match to uptake was in the split applied plots, which may indicate more efficient uptake, but this study does not take leaching into account.

As mentioned above, post-harvest soil test K had a greater correlation to yield (Table 2). Both were also positively correlated to each other, although not very high (0.36). Since treatments received different amounts of K at different times, this result is not surprising. Pre-plant soil tests did not correlate to any of the tissue K amounts, but post-harvest soil tests correlated to soybean leaf tissue after sidedress applications (Table 2). This value was positive and higher than most other correlations (0.60), which may indicate that greater soil test levels and split applications did result in additional K uptake.

Table 2: Correlations and p-values of soil test K (pre-plant and harvest), leaf tissue K (pre and post sidedress) and yield. Example: Pre-Soil K and Yield have a significant (p=0.0008) positive correlation (0.58).

	Block	**Pre-Soil K**	**Harvest K**	**Leaf K Pre**	**Leaf K Post**	**Yield**
Block	1	**-0.61**	-0.12	**-0.38**	-0.18	**-0.33**
	.	**0.0004**	0.5356	**0.0403**	0.3496	**0.0780**
Pre-Soil K	.	1	**0.36**	0.16	0.27	**0.58**
	.	.	**0.0512**	0.4114	0.1541	**0.0008**
Harvest K	.	.	1	0.26	**0.60**	**0.66**
	.	.	.	0.1713	**0.0005**	**<.0001**
Leaf K Pre	.	.	.	1	0.05	0.14
	.	.	.	.	0.7893	0.4527
Leaf K Post	.	.	.	.	1	**0.45**
	.	.	.	.	.	**0.0116**

Plant Tissue K

Prior to the sidedress application, leaf tissue K was highest in the plots receiving all K pre-plant, but that treatment had similar amounts to the plots receiving a split application. While the plots receiving no additional K had the lowest tissue K levels, they were still similar to the side-dress K values. This means that greater K applications pre-plant resulted in more K uptake, regardless if soil test levels were considered adequate at planting. This did not result in higher yields though (Table 1).

Although overall tissue K levels were lower at R1/R2, the highest tissue K was found in the split applied plots (Table 1). Similar to pre-plant K, the addition of more K at sidedress resulted in higher K levels. These results are interesting, since the soils were not lacking K to begin with, the pre-plant K treatment added adequate amounts, and K uptake (based on yield) was greater than the overall loss soil test K (Table 1). This indicates that K uptake in soils is complex and based on many factors, including rooting depth, Ca and Mg concentrations, and soil minerals containing fixed K. It appears that even in soils with adequate K, additional uptake will occur with later K applications.

Correlations of leaf tissue K were more revealing, as tissue K prior to sidedress was correlated to block (field site location), but not post-sidedress (Table 2). This indicates that greater levels of K in several spots in the field also increased leaf tissue K, but side-dress applications evened out some of those effects. Pre-sidedress leaf tissue K was not correlated to any other factor, but post-sidedress tissue K correlated to both harvest soil K levels (r = 0.60) and yield (r = 0.45). While yield was not increased by sidedress K when compared across treatments (Table 1), the correlation of yield to higher tissue levels after sidedress applications still indicates the importance of K uptake for yield. That these tissue levels also correlated to post-harvest soil K test levels indicates that higher soil levels do increase K uptake later in the season, and could potentially be tied to higher yield. In this study adequate soil K levels and field variability may mask some of this effect.

Conclusions

Splitting K applications did not result in subsequent yield increases; however, this may have been masked by field variability, with greater soil K in certain parts of the field. Upon further inspection of soil test K and soybean tissue K, there are some trends in K uptake with split applications. Reproductive stage leaf tissue K was greater in plots where sidedress applications were made and correlated to both higher post-harvest soil test levels as well as yield. Where post-harvest K soil test levels were greater, they also correlated to higher yield, even though these soils were at optimum soil test K. While sandy soils don't appear to benefit from split applications, underlying relationships between plants and soil K levels still benefit yield and should be investigated further. This study will be repeated in 2020.

References

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