



Effect of Soil-Test Phosphorus and Phosphorus Fertilization on the Severity of Soybean Sudden Death Syndrome

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SUDDEN DEATH SYNDROME (SDS) of soybean [*Glycine max* (L.) Merr.], caused by *Fusarium virguliforme*, can cause significant yield loss in soybean (Scherer et al., 1998) and has been associated with wet soils. Management practices to reduce yield losses have been to select tolerant varieties that are resistant to soybean cyst nematode (SCN), to alleviate soil compaction, and to delay planting to avoid wet soils. While these practices can reduce yield loss due to SDS, significant losses can still occur.

Since 1983, a long-term fertilizer application experiment has been conducted on a Eudora silt loam soil at the Kansas River Valley Experiment Field, near Topeka, KS as an annual corn-soybean rotation. Fertilizer treatments were applied biannually only before corn in a factorial complete block design with rates of N, P, and K in four replications. The total rainfall from April to September 2014 was 19.2 inches, and the study area received 6.7 inches of supplemental irrigation during the same period.

Asgrow 3833 soybeans were seeded 21 May 2014 at 140,000 seeds acre⁻¹. June rainfall (7.05 inches) was significantly more than the 30-yr average (3.81 inches). Foliar symptoms of SDS were observed in the study at the R5 growth stage. Foliar symptom severity and normalized difference vegetation index (NDVI) were recorded 28 Aug. 2014. Foliar symptom severity was rated as the percentage leaf area with symptoms. NDVI readings taken with a GreenSeeker meter model 505 handheld (Trimble Navigation) from the middle two rows of each plot. The uppermost trifoliate leaflets were collected at R6 and analyzed for total P. Soybean plant height was measured at maturity to the highest node having seed-bearing pods. Soil cores collected from each plot at the 0–12-inch sampling depth before planting were analyzed for soil-test P by the Mehlich-3 method. The two middle rows were combine-harvested. Grain weight and moisture were collected, and yield was expressed at 13% grain moisture. Population densities (expressed as colony-forming units, CFUs) of *F. virguliforme* were measured from

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Abbreviations: CFU, colony-forming unit; NDVI, normalized difference vegetation index; SCN, soybean cyst nematode; SDS, sudden death syndrome.

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Table 1. ANOVA from long-term macronutrient study at Kansas River Valley Experiment Field, 2014.

Variable	Yield	NDVI†	SDS	Height	<i>F. virguliforme</i>
			Pr > F		
N	0.547	0.692	0.701	0.909	0.337
P	<0.001	0.000	0.000	<0.001	0.304
K	0.163	0.847	0.580	0.512	0.592
N*P	0.504	0.493	0.540	0.438	0.999
N*K	0.459	0.396	0.801	0.017	0.572
P*K	0.586	0.262	0.401	0.765	0.121
N*P*K	0.887	0.781	0.902	0.293	0.846

†Normalized difference vegetation index (NDVI) measured with a GreenSeeker meter (Trimble Navigation) collected 28 Aug. 2014 at growth stage R5.

post-harvest soil samples (Cho et al., 2001) and confirmed from DNA extracted from soil isolates (O'Donnell and Cigelnik, 1997).

ANOVA analysis was completed to evaluate the effect of N, P, and K on the variables measured (Table 1). SDS severity, NDVI, height, and yield were significantly affected by the rates of P fertilizer application (Tables 1 and 2). Neither N or K or any of the interactions were significant (Table 1). Previous work has shown some relationship between soil nutrient levels and SDS (Schermer et al., 1998), primarily for K. Rupe et al. (1993) showed that the severity of SDS was greater at higher concentrations of soil-test K that included higher concentrations of soil-test P. Our results agree with the findings of Schermer et al. (1998) for P; however, K application rates showed no relation to SDS in this study. This could be due to generally high soil-test K in our study (194 ppm K average at 0–12 inches). The results from this study do not agree with those of Rupe et al. (1993), and it is possible that different levels of soil-test P show a different relation to SDS expression. The onset of SDS was probably brought on by the above-normal rainfall in June (Leandro et al., 2013). There is no record of SDS in this long-term experiment before 2014. The historic average yield increase with the highest P rate is approximately 6 bu acre⁻¹, compared with an 18.9 bu acre⁻¹ yield increase in 2014 (Table 2).

As the P rate increased, the severity of SDS decreased. At the 60 lb acre⁻¹ rate, less than half of the

leaf area showed SDS symptoms, compared with the area showing SDS at the control rate, 0 lb acre⁻¹ (Table 2). Soil-test P and leaf P showed the greatest difference between the 60 lb acre⁻¹ application and the 30 and 0 lb acre⁻¹ treatments. The largest differences for NDVI, height, and yield were between plots with 60 lb acre⁻¹ P applied and the control, with no P applied (Table 2). The CFUs for *F. virguliforme* did not differ significantly among P treatments, although the trend was for fewer CFUs with increasing P.

There were correlations between the severity of SDS foliar symptoms, NDVI, and yield (Pr > F = 0.05; Fig. 1 and 2). SDS symptoms were negatively correlated with NDVI, and NDVI was positively correlated with yield. The severity of SDS was also negatively correlated with soil-test P and leaf P (Fig. 3 A and B).

Previous studies suggest that essential plant nutrients can affect resistance or tolerance to pathogens. This relationship is not well understood and is often contradictory; however, optimum levels of P are generally associated with healthier plants. It is possible that the improved nutrient status of the soybean plants increased their tolerance to SDS, and possibly other pathogens, during this study. The development of the disease in 2014 might have been counteracted by the addition of P. With this long-term study and the application time of fertilizer P, these results could be primarily due to levels of soil-test P levels that accumulated over time (Table 2). This possibility would suggest that maintaining optimum agronomic levels of soil-test P may maintain overall plant health. Additional studies would be required to evaluate the effect of fertilizer P application to the soybean crop and the severity of SDS. This could offer producers another tool to help manage the disease and increase productivity.

Acknowledgment

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Table 2. Effect of phosphorus applied to corn on sudden death syndrome (SDS) and yield of soybean, Kansas River Valley Experiment Field, 2014.

P applied to corn	Soil-test P†	Leaf P	SDS severity	<i>F. virguliforme</i>	NDVI‡	Height§	Yield
lb P ₂ O ₅ acre ⁻¹	ppm	%	% foliage affected	CFUs g ⁻¹ soil¶		inches	bu acre ⁻¹
0	6.5	0.15	58	70.8	0.758	29.8	34.0
30	14.9	0.18	43	62.5	0.777	36.0	44.8
60	45.6	0.26	23	41.7	0.799	37.0	52.9
LSD (0.05)	4.4	0.01	16	NS	0.018	2.2	4.3

†Phosphorus in top 12 inches of soil.

‡Normalized difference vegetation index (NDVI) measured with a GreenSeeker meter (Trimble Navigation) collected 28 Aug. 2014 at growth stage R5.

§Measured from soil to top node with seed-bearing pods.

¶CFUs, colony-forming units.

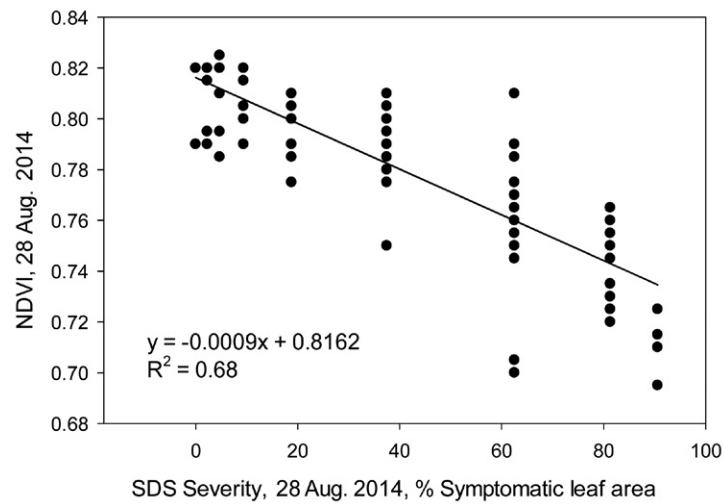


Figure 1. Relationship between visual ratings for severity of foliar symptoms of sudden death syndrome (SDS) and normalized difference vegetation index (NDVI) measurements with a GreenSeeker meter in a long-term macronutrient fertility study at the Kansas River Valley Experiment Field, 2014.

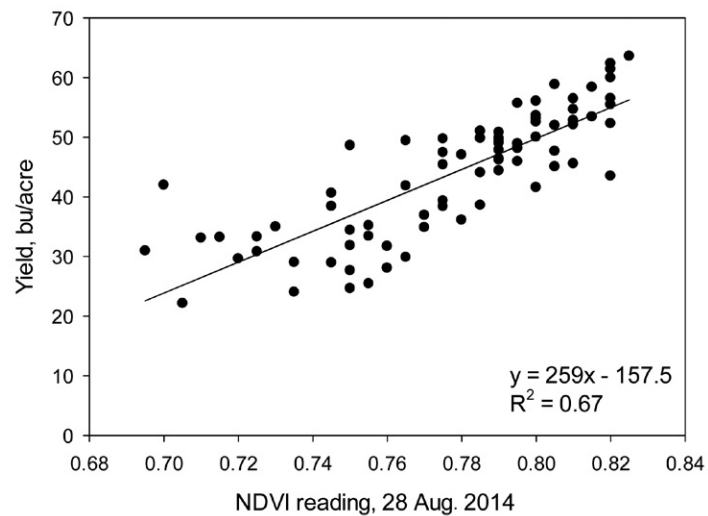


Figure 2. Relationship between normalized difference vegetation index (NDVI) and yield of soybean in macronutrient fertility study at the Kansas River Valley Experiment Field, 2014.

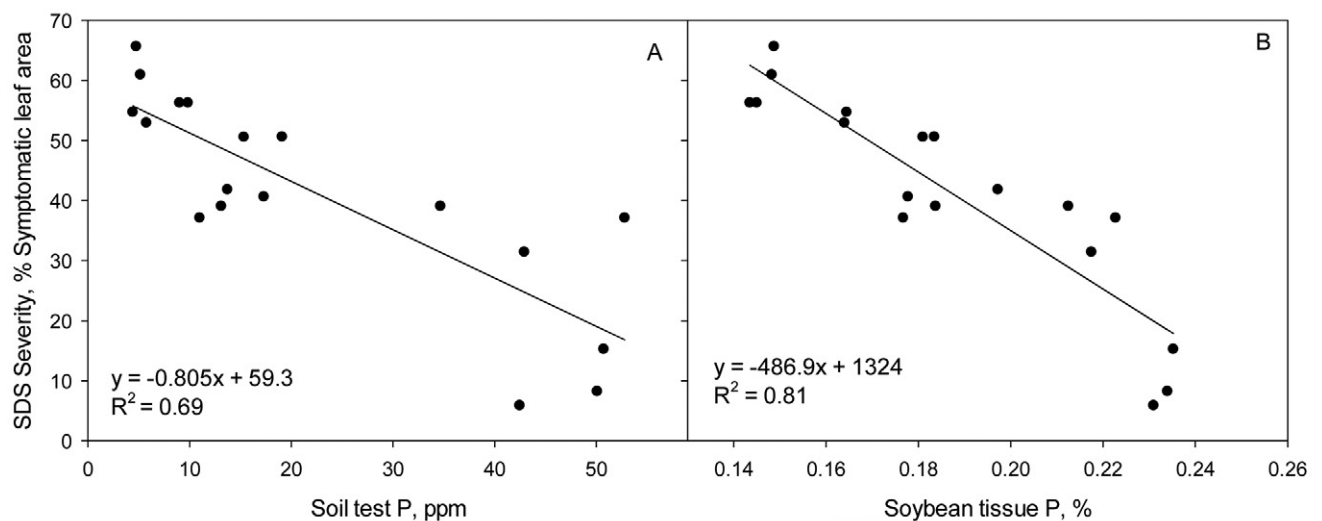


Figure 3. Foliar symptoms of sudden death syndrome (SDS) relationship with (A) soil-test P and (B) soybean tissue P. Averages are from the macronutrient fertility study at the Kansas River Valley Experiment Field, 2014.

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