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SUDDEN DEATH SYNDROME OF SOYBEAN

In a previous blog posted on this website, a link to a Nov. 2015 PMN article entitled "First Report of Sudden Death Syndrome [SDS] of Soybean Caused by *Fusarium virguliforme* in Louisiana" was provided. In this article, Louisiana State University scientists and specialists provide a detailed account of their confirmation of the first-reported presence of SDS in Louisiana soybeans.

SDS has been increasing in Midsouth soybeans in recent years, and was a major yield-limiting disease in Missouri and Tennessee in 2014-2016 and Missouri in 2017 and 2018. Its now-confirmed presence in Louisiana indicates that this disease may become a major soybean pest in the more southern Midsouth states in coming years.

Details about this disease, pictures of soybean foliage and roots that show infection symptoms, and management practices for its avoidance and/or control can be found in the below linked articles. If/when this disease becomes a major pest in the Midsouth states, information in this White Paper and in the below articles should be consulted and used as a guide for its management.
Sudden Death Syndrome of Soybean, by Westphal, Abney, Xing, and Shaner [APS]
Sudden Death Syndrome of Soybeans, [Pioneer Crop Insights]
Sudden Death Syndrome in Soybean, by Kelly [UTcrops News Blog]
Sudden Death Syndrome, by Westphal, Xing, Abney, and Shaner [Purdue Extension]
Sudden Death Syndrome, [SRII].
A compilation of the major points in the above resources follows.

- SDS is a fungal disease that also occurs in a disease complex with soybean cyst nematode [SCN]. When SDS occurs in the presence of SCN, disease symptoms occur earlier and are more severe. In fact, a soybean variety susceptible to both pathogens will be damaged more than by either pathogen alone. Thus, if both SCN and SDS pathogens are present in a field, a management strategy to control both pests is imperative.
- SDS is caused by the soil-borne fungus *Fusarium virguliforme*.
- The SDS pathogen survives between soybean crops as spores in crop residue and in the soil.
- SDS begins as a root disease that limits root development and causes root and nodule deterioration.
- The pathogen likely infects roots of soybean seedlings soon after planting, but SDS symptoms are not usually detectable on plant foliage until after beginning of flowering.
- SDS often appears first in low-lying field areas that are poorly drained.
- The fungus produces toxins in the roots that are translocated to the leaves.
- Plants with advanced foliar symptoms of SDS will also display root symptoms since SDS causes root rot.
- SDS is diagnosed by symptoms on both leaves and roots of soybean.
- High soil moisture increases the severity of the disease. The disease tends to be most severe on well-managed soybeans with a high yield potential as a result of irrigation.
- Fields that develop SDS likely will have the disease during subsequent years.
- No crop rotation appears to significantly reduce SDS. In particular, the common corn-soybean biennial rotation does not reduce the incidence and severity of SDS.
- The extent of yield loss due to SDS depends on the severity and timing of the disease expression. When the disease develops early in the season, flowers and young pods will abort. When the disease develops later, soybean plants will have fewer seeds per pod or smaller seeds.
- Varieties that are less susceptible to SDS are available. Thus, it is critical that producers with SDS-infested fields determine the SDS-susceptibility level of chosen varieties to ensure that the most resistant varieties are grown on those fields. Click here to access an article that contains links to seed company sites where SDS ratings for their varieties can be found.
- Foliar fungicides do not control the disease since the fungus itself does not spread to the leaves–e.g. it only colonizes the roots and lower stem. Rather, the toxins produced by the fungus are transported to the leaves and produce the characteristic foliar symptoms of the disease.
- Variety selection is the main management tool against SDS effect since there are now varieties that have a high tolerance rating.

Bayer CropScience [ILeVO–active ingredient fluopyram, Group 7] and Syngenta [Saltro–active ingredient pydiflumetofen, Group 7] have developed fungicide seed treatments that should minimize root infection by *F. virguliforme* after planting in the spring when soil and environmental conditions may favor its development on soybean plants. Both of these seed treatment products are rated Very Good against the *F. Virguliforme* pathogen by the Crop Protection Network.

When variety resistance to SDS doesn't provide adequate control of the disease, these fungicide seed treatments can be part of an IPM strategy for managing the disease. According to information in a FarmProgress article titled "How to manage soybean sudden death syndrome" by Zaworski and Mueller, results from a study conducted by the North Central Soybean Research Program showed that soybean seed treated with either Saltro or ILeVo alone or in combination with other seed treatments protected yield from reductions caused by SDS. The authors cautioned that, like variety resistance, these products will not likely eliminate all of the effects that can result from a confirmed presence of the disease-causing pathogen.

Results from research conducted by Kansas State University scientists in 2013 and 2014 in fields with a long history of SDS show that using ILeVO seed treatment can alleviate the effects of SDS. To better understand and interpret the below results, realize that the ILeVO label states that the application rate for SDS control is 0.15–0.25 mg/seed, while the application rate for control of soilborne nematodes is 0.075–0.25 mg/seed.
Data in Table 1 indicate the following.

- ILeVO applied to seed at 0.075 mg/seed [lowest labeled rate for nematode control] along with Poncho/VOTiVO [insecticide/nematicide seed treatment] resulted in a yield that was greater than that from the treatment that received only Pancho/VOTiVO. Thus, a lower-than-labeled rate of ILeVO added to Poncho/VOTiVO increased yield.
- ILeVO applied to seed at 0.075 mg/seed along with Poncho/VOTiVO resulted in a yield that was similar to that from applying ILeVO at the 0.15 mg/seed [lowest labeled rate for SDS control].
- SDS severity symptoms in response to ILeVO followed the same pattern as yield response.

Data in Table 2 indicate the following.

- Adding ILeVO at the lowest [0.15 mg/seed] and highest [0.25 mg/seed] labeled rates for SDS control resulted in significant yield increases in soybean varieties with three levels of SDS resistance/susceptibility. However, using the highest vs. lowest rate of the fungicide increased yield significantly only in the susceptible variety.
- SDS severity in response to ILeVO in the varieties with the three levels of resistance/susceptibility followed the same pattern as yield response.

Research conducted by Kandel et al. and Gaspar et al. in midwestern U.S. states provide the following results.

- ILeVO seed treatment combined with proper variety selection can reduce SDS severity and provide economical protection against yield reductions caused by SDS.
- Yield response to ILeVO seed treatment was greatest in fields with a history of SDS or visible SDS symptoms.
- The economically optimum seeding rate was lower when ILeVO seed treatment was used.
- ILeVO seed treatment suppressed SDS more consistently in years where conditions [such as high soil moisture] were more conducive to SDS development. This point is especially important for Midsouth producers who irrigate.

Kandel et al. reported results from a 3-year (2013-2015) study conducted at seven locations [18 total field experiments] in 4 midwestern U.S. states and Ontario, Canada. In the study, five soybean cultivars with differing levels of SCN resistance and differing SCN resistance sources were evaluated with and without ILeVO seed treatment. Experiments were conducted in fields with a history of both SCN and SDS; SCN was present in all experimental fields. Major results follow.

- Average yield from the treatment that had base fungicide/insecticide/nematicide + ILeVO-treated seed was 3 bu/acre [6%] greater than yield from the treatment that had only the base seed treatment.
- SCN resistance source influenced SDS development across a broad geographical area, and cultivars with no SCN resistance source had greater SDS disease severity symptoms. The authors surmised that conditions that favor SCN may also favor infection by the SDS pathogen and associated yield losses attributed to SDS.
- The authors concluded that although proper SCN management can reduce SDS disease severity, producers should not rely on SCN resistance for SDS management.

It is likely that not all instances of using ILeVO will result in the magnitude of yield increases seen in the above studies. Therefore, it is recommended that soybean producers accurately calculate their SDS risk and potential yield losses because adding this seed treatment component will add an additional cost.

Results from another Kansas study suggest that maintaining an optimum level of soil phosphorus is a tool that may decrease the effect of SDS in the Midsouth. Click here for a summary of those results and here for the journal article.

Results from research studies that evaluated ILeVO seed treatment in Nebraska and Michigan confirm the following.

- There are no clear guidelines to determine at what point a field will see enough response to ILeVO to justify its use and expense.
- In fields with a history of exhibiting significant above-ground SDS symptoms, ILeVO added to a complete seed treatment increased yields significantly in 1/3 of the cases in the Nebraska studies [1 year–3 sites] and in about 1/4 of the cases across 2 years in the Michigan studies [11 trials].

- In the Michigan studies, 2-year average yield increase across all site-years was 2.4 bu/acre.
- Yield increases were only marginally profitable in most of the cases.

Table 1. Influence of ILeVO seed treatment for SDS on yield of SDS-resistant soybean variety Stine 43RE02 [MG 4.3] at the Kansas River Valley Expt. Field–Rossville, 2014.

Seed treatment*	Yield	SDS severity
	bu/acre	*% leaf area at R6*
Poncho/VOTiVO check	47.4	52
ILeVO (0.15 mg/seed) + Poncho/VOTiVO	59.6	16
ILeVO (0.075 mg/seed) + Poncho/VOTiVO	57.0	31
Gaucho 600 check	54.0	25
ILeVO (0.15 mg/seed) + Gaucho 600	57.2	16
ILeVO (0.075 mg/seed) + Gaucho 600	57.1	7
LSD (0.05)	3.7	22.9

*ILeVO: 0.15 mg/seed is lowest label rate for SDS; 0.075 mg/seed is lowest label rate for soilborne nematodes.
*Poncho [clothianidin]/VOTiVO (*Bacillus firmus*–a biological seed treatment that provides early-season protection against certain nematode species) is a combination insecticide/nematicide seed treatment.
*Gaucho 600 [imidacloprid] is an insecticide seed treatment.
Click here for source by Adee, Jardine, Schapaugh, and Todd.

Table 2. Influence of soybean variety and seed treatment on SDS at the Kansas River Valley Expt. Field–Rossville, 2013.

	Soybean varieties					
Seed treatment*	Most resistant	Moderately resistant	Susceptible	Most resistant	Moderately resistant	Susceptible
	-----------*Yield (bu/acre)*-----------			*SDS severity (% leaf area at R6)*		
None	28.6	29.2	21.3	18	44	63
ILeVO (0.25 mg/seed)	41.6	39.7	37.4	4	28	45
ILeVO (0.15 mg/seed)	42.9	41.0	26.2	5	28	72
LSD (0.05)	-------------------8.3------------------			------------------17.4-----------------		

*ILeVO rates: 0.15 - 0.25 mg/seed label rate for SDS.
Click here for source by Adee, Jardine, Schapaugh, and Todd.

Iowa State University researchers conducted studies to identify genes and marker-assisted selection approaches that can be used by breeders to develop soybean lines with resistance to SDS. The end result of this endeavor is to provide plant breeders the tools to identify the genetic basis for host plant resistance to SDS in soybean so that resistant varieties can be developed and released. Details of this research are published in an article titled "Genome-wide association and epistasis studies unravel the genetic architecture of sudden death syndrome resistance in soybean".

Additional studies conducted at ISU by Dr. Madan Bhattacharyya are testing the hypothesis that incorporating a combination of genes from the plant Arabidopsis could confer or build a high level of resistance to SDS in soybeans. He uses transgenic techniques to insert these genes into the soybean genome. Soybean plants with one of these genes called PSS1 have shown enhanced SDS resistance in two years of field trials. It is expected that incorporation of additional PSS genes together with natural SDS-resistance genes will provide soybeans with durable resistance to the pathogen that causes this disease.

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