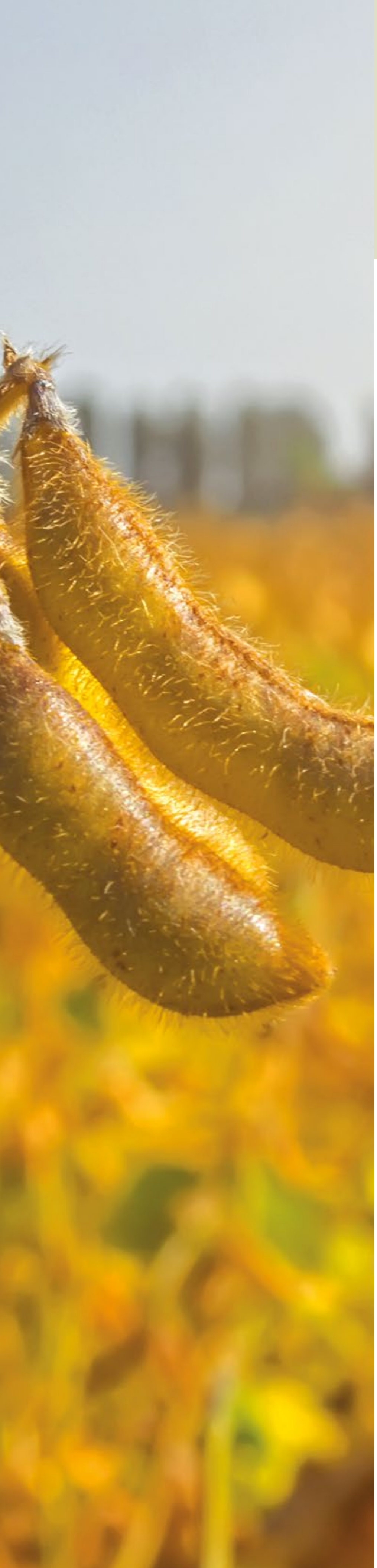

Effect of Nutrients and Fungicide Seed Treatments on Soybean Sudden Death Syndrome and Grain Yield

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Soybean is one of the most economically important crops due to its potential as an oilseed crop and major plant protein source used for livestock and human consumption. The top producers of soybean are Brazil (37% of the world's total), USA (31%), Argentina (14%), China (5%), Paraguay (3%), India (3%), and Canada (2%). According to BCC Research, the global seed treatment "fungicides market" was valued at $1.11 billion in 2016 and is projected to reach $2.44 billion by 2025, growing at a compound annual growth rate (CAGR) of 9.1% from 2017 to 2025.

Soilborne fungal pathogens cause root damage, potentially affecting nutrient uptake through hydrolytic enzymes or toxins. Some research suggests the use of micro and macronutrients and nanoparticles of micronutrients will provide resistance to root diseases and systemic defense against soilborne fungal pathogens. In a recent review, Navi and Harris have compiled a diversity of Fusarium spp. associated with sudden death syndrome (SDS) in different continents and within the United States. They also have provided comprehensive management options to minimize yield losses due to major soilborne pathogens of soybean, including Fusarium spp. The objective of this study was to find an alternative to the use of fungicides for potential seed treatments against SDS.

Materials and Methods

Experiment set up: In 2021, the trial with seven treatments was set up in a randomized complete block design with four replications, each with 10 ft. wide (four 30 in. rows) × 17.5 ft. long plots at the Hinds Research Farm, Ames, Iowa. The Curtiss Farm manager provided commercially untreated soybean seed of Pioneer P22T18E. The seed was treated with individual products (Table 1) at 5 ml/kg seed. The treated and untreated seeds were subsampled at 700 seeds in 8.5 cm × 20.3 cm envelopes per replication of 4-row plots. Also, Fusarium virguliforme (FV) inoculum increased on white milo was subsampled at 350 cc per envelope (8.5 cm × 20.3 cm) per 4-row plot at 5 cc/ linear foot. Seeds from each treatment and the inoculum subsampled separately in envelopes were placed into a 4-row cone plot planter and planted April 29 using an ALMACO 4-Row plot planter.

Plots were evaluated for stand counts (May 23 and 29), seedling stage SDS and Rhizoctonia root rot (May 30), vigor rating at V5 (June 21), and SDS ratings in reproductive stages (August 6 and 16; September 5 and October 19). Disease incidence percentage was calculated by the formula (infected plants × 100) divided by total plants in each plot, and SDS index was calculated by the formula (SDS incidence × SDS Severity)/9. The trial did require post-emergence herbicides, but was hand weeded through the cropping season due to irrigation laid out. The sprinklers were operated on non-rainy days from vegetative growth stage-4 (four unfolded trifoliate leaves) to reproductive growth stage-6 (full seed setting) to provide either irrigation water or rainfall a total of 2.5 cm/week. In the 2021 cropping season, pheromone traps (Spectracide Bag-A-Bug Japanese Beetle Trap) were used to protect the crop from Japanese beetles. Plots were harvested using a John Deere 4420 combined with Shivvers grain moisture meter and Avery-Weigh Tronix weigh scale indicator. Yields were adjusted to 13% grain moisture and measured in bushels/acre, and subsequently converted to metric ton/ha.

Yield advantage and economic change over untreated control: Yield advantages or change in yields of treated plots compared with untreated controls was calculated by the formula: Yields (t/ha) of individual treated plots – Yields (t/ha) of untreated control. Similarly, the economic advantage was calculated by the formula: Difference in Yield of treated plots over untreated control × World Bank soybean prices in USD per metric ton, as of November 30, 2021.

Data analysis: Stand counts, disease incidences, SDS disease index, and grain yields were analyzed using PROC ANOVA in SAS 9.4. (SAS, LLC). Fisher's least significant difference was used to detect the significant differences among the means (P = 0.05).

Results and Discussion

We observed Rhizoctonia root rot and seedling stage SDS in the seedling stage. The SDS also was observed in reproductive growth stages at this farm. Despite FV inoculations and running sprinklers to provide enough moisture for infection by FV, the SDS incidence and severities were low (Table 1). Also, no significant differences in SDS-DX were observed in six treated plots compared with untreated plots. The average soybean yield across treated plots was 3.32 t/ha compared with 3.13 t/ha in untreated plots. The highest yield of 3.48 t/ha was recorded in plots treated with Fulltec Ultra at 3 fl. oz., followed by Fulltec Plus at 3.5 fl. oz. (3.44 t/ha), Fulltec Ultra at 4 fl. oz./100 lb. (3.37 t/ha), ILeVo at 4 fl. oz./100 lb. (3.25 t/ha) and Fulltec Plus at 4 fl. oz./100 lb. (3.23 t/ha). Accordingly, the average yield advantage of treated plots was 0.19 t/ha (range varied from 0 t/ha in Fulltec Plus at 3 fl. oz./100 lb seed to 0.35 t/ha in Fulltec Ultra at 3 fl. oz./100 lb. seed) compared with untreated control (Table 1). Similarly, the average economic benefit of seed treatments across six treatments was $102.86/ha (range from $0 to $192.86/ha) compared with untreated control (Table 1). Economic benefit calculations were based on the World Bank's soybean prices as of November 30, 2021, at $551.04 per metric ton or $14.99/bushel. The net economic benefits of seed treatments with the individual product have not been calculated due to the lack of availability of seed treatments costs for 100 lb. soybean seed. However, change in yields and economic benefits over untreated control of other treatments are presented in Table 1.

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Table 1. Effect of nutrients and fungicide seed treatments on soybean sudden death syndrome (SDS) and grain yields of P22T18E in 2021, Hinds Research Farm (Fields 2 and 3), Ames, IA[1]

						Change over control		
Treatments and application rate (fl. oz./100 lb. seed)	Stand count	RS-Inc%	SS-SDS Inc%	Plant vigor	SDS-DX3	Yield t/ha	Yield t/ha	USD/ha*
Untreated control	519.75a	0.135a	0.180a	7.25b	0.04a	3.13a		
ILeVo[2] (4)	491.75a	0.108a	0.000a	7.75ba	0.00a	3.25a	0.12	66.12
Fulltec Plus[3] (3)	519.75a	0.050a	0.145a	8.50a	0.00a	3.13a	0.00	0.00
Fulltec Plus (3.5)	514.50a	0.175a	0.103a	8.25a	0.00a	3.44a	0.31	170.82
Fulltec Plus (4)	537.25a	0.000a	0.047a	8.00ba	0.15a	3.23a	0.10	55.10
Fulltec Ultra[4] (3)	544.25a	0.000a	0.050a	8.25a	0.08a	3.48a	0.35	192.86
Fulltec Ultra (4)	528.50a	0.055a	0.050a	8.50a	0.00a	3.37a	0.24	132.25

[1]Means within a column followed by the same letter(s) are not significantly different from each other at a 5% level of significance ($P < 0.05$).
[2]Active ingredients Fluopyram: N-[2-[3-chloro-5-(trifluoromethyl)-2-pyridinyl]ethyl]-2-(trifluoromethyl) benzamide* 48.4%, other ingredients 51.6%.
[3]Active ingredients (%) = N (6), P2O5 (17), B (1), Co (0.5), Mo (2), Zn (1.5).
[4]Active ingredients (%) = S (5), Mn (9), Co (0.10), Cu (0.30).
RS-Inc%= Rhizoctonia solani root rot incidence %, SS-SDS Inc%= Seedling stage SDS incidence %, Plant vigor= on 1-9 scale, where 1 is poor and 9 is excellent, DX is Disease index = (SDS disease incidence × SDS disease severity on 1-9 scale)/9. *Based on soybean prices as of November 30, 2021, at $551.04 per metric ton or $14.99/bushel