ISRC Project Update

Title: Time of disease onset as an early indicator of soybean resistance to soybean sudden death syndrome (SDS)

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Project years: Oct 1, 2021 – Sept 30, 2023

Reporting period: Jan 1, 2022 – Feb 28, 2023

Total amount of funding: $60,000

Leveraged/Additional Funding:

Objectives: Determine if time of SDS onset is a reliable indicator of soybean resistance against SDS

Deliverables: New knowledge on the relationship between SDS severity/incidence and soybean yield loss; Information on reliability of disease onset for early and accurate identification of soybean resistance to SDS; Potential use in developing expedited and more accurate resistance screening assays; Potential use in assessing other SDS management tools

Benefit to Soybean Farmers: If time of SDS onset is shown to be a reliable indicator of soybean resistance to SDS, seed companies could use this parameter to improve selection of the most resistant genotypes and varieties for commercial use. In addition, time of onset could be used as a parameter to compare other management practices, such as seed treatments, for protecting soybean yield.

Progress Update

Field experiments

During the 2022 field season, 11 field trials were planted throughout Iowa (Table 1). Five of the trials were established at Iowa State University (ISU) research farms; two of those trials were artificially inoculated with the SDS pathogen, *Fusarium virguliforme*, one of which was irrigated and the other was not. The other six trials were established at commercial farms by collaborator Nathan Schmitz from GDM seeds who coordinated the planting, maintenance and harvesting of the field trials.

At each location, nine commercial soybean varieties were planted (Table 2). The varieties used were selected to represent three levels of resistance to SDS (susceptible, moderate and resistant) from each of three seed companies. The field plots were 20 ft. long and 10 ft. wide, with 30”spacing, and there were 4 to 6 replicate plots per treatment. Plots were monitored for the onset of SDS foliar symptoms on a regular basis. Once first symptoms were detected, the plots were rated for incidence (% plants per plot with symptoms) and severity (% leaf area with symptoms in the symptomatic plants). Plots were harvested at the end of the season.

Table 1 – Locations of SDS trials in 2022

Trial	Locations	Artificially Inoculated	Irrigated	ISU site or GDM seeds site
1	Hinds Farm, Ames	**Yes**	**Yes**	ISU
2	Hinds Farm, Ames	No	No	ISU
3	West Curtiss, Ames	No	No	ISU
4	West Curtiss, Ames	**Yes**	No	ISU
5	Northeast Farm, Nashua	No	No	ISU
6	Grinnell	No	No	GDM
7	Van Horne (Cedar Rapids)	No	No	GDM
8	Huxley (Elkhart)	No	No	GDM
9	Winterset	No	No	GDM
10	Atlantic	No	No	GDM
11	Story City (Ellsworth)	No	No	GDM

Table 2. Soybean varieties used in the 2022 field trials. Resistance based on SDS ratings provided by the companies.

Variety Code	Company	Variety	SDS resistance
V1	Pioneer	P25A54X	Susceptible
V2	Pioneer	P25A04X	Resistant
V3	Pioneer	P23A32X	Moderately resistant
V4	Syngenta	GH 2505	Susceptible
V5	Syngenta	GH 2442	Moderately resistant
V6	Syngenta	GH 1922	Highly tolerant
V7	Bayer	AG28XF2	Resistant
V8	Bayer	AG26XF2	Moderately Resistant
V9	Bayer	AG26XF1	Susceptible

Results:

Field experiments

The 2022 summer was dry and not very conducive to SDS development. SDS symptoms developed at three pf the ISU research farm locations but SDS incidence and severity were low throughout the season. Data for each of the three locations are shown in Tables 3-5. No SDS developed at the two other locations at Curtis Farm (data not shown).

SDS developed at five of the GDM locations. Ellsworth showed the most SDS with severity ranging from 17 to 40%, but with an average of 8 to 30 plants showing symptoms per plot, by the end of the season. SDS only developed at 1 to 4 plots in the Atlantic, Cedar Rapids, Grinnell, and Winterset locations (data not shown), so no comparisons between varieties could be done. No SDS developed in Elkhart.

Overall, in the 2022 field trials disease pressure was too low to reliably study the correlation between SDS index, time of SDS onset, and yield among varieties. However, we are consulting with a statistician for a more in depth analysis to look at those relationships within variety. We are also making plans for the 2023 field season.

Greenhouse experiments

During the reporting period, we also conducted four greenhouse experiments using the same nine commercial varieties that were used in the field trials. Soybeans were planted in pots, into soil infested by the SDS pathogen. After emergence, plants were assessed every two days for foliar SDS onset and disease severity using two approaches. First, visual ratings were made based on the percent leaf area showing yellow or brown discoloration. Then, plants were scanned using a multispectral plant phenotyping equipment (Phenospex-Planteye) that measures several plant parameters including plant height, leaf area, spectral reflectance. The goal was to compare the ability of the naked eye and a digital device to detect disease onset. At the end of 4 weeks, root rot, root dry weight and shoot dry weight were measured.

We observed that time of onset is very similar among the varieties, varying only by 2-3 days within an experiment (Figures 1-4). For example, in experiment 6 (Fig. 2), most soybean varieties, including susceptible check Spencer, started showing symptoms 23 to 26 days after planting, despite having different levels of resistance to SDS. The resistant check (MN1606) and a resistant commercial line (P25T09E) started symptoms at 33 and 27 dap, respectively, and showed overall less disease at the end of the experiment. In addition, the resistant check (MN1606) showed an 8-day delay compared with the susceptible check Spencer. Both these observations show that highly resistant varieties have a slower onset of SDS compared to very susceptible varieties. A similar contrast is present in Experiments 7 and 8 (Fig. 4).

However, time of onset does not appear to be correlated with SDS resistance in varieties in the moderately susceptible or moderately resistant range, as onset varied only by 2-3 days and there was too much variation among individual plants within variety to

Our data to date suggests that time of onset may not be a valuable indicator of resistance in soybean among moderately resistant varieties in greenhouse conditions. Field trials with higher disease pressure are needed to determine in SDS onset can be useful to separate resistance levels in field conditions.

Unfortunately, the Phenospex equipment developed a problem with the software and we have not been able to download the data for our experiments. The equipment is currently being serviced at the production site in Europe to determine if it is possible to recover the digital data.

Current and future work

Plans are underway to established field trials for the 2023 season. We will plant 4-5 trials at ISU research farms, using artificial inoculation and irrigation when possible. We are also in contact with Nathan Schmitz from GDM seeds, who has kindly agreed to plant field trials at multiple locations for this project again. We have purchased soybean seed and have prepared SDS inoculum for the field trials. In addition to the visual ratings of SDS, we plan to collaborate with a colleague at ISU to obtain drone images from the Ames locations to determine if digital imaging has the ability to detect SDS onset more reliably than visual ratings.

We will also conduct greenhouse trials to compare SDS resistance levels in the varieties used in the field trials and see if they correlate with field ratings.

Finally, we will consult with a statistician to discuss possible alternative analysis that can be done of the data from 2021-23 to explore correlations of onset time and SDS resistance in more depth. We will also conduct an analysis to determine the reliability of SDS onset as an indicator of SDS final disease severity within variety.

Supporting data: see below

2022 SDS Trial 1: Plots inoculated and irrigated

ISU, Hinds Memorial Irrigation Farm, Ames, IA

Treatment details	Var#	Stand count1/plot	Stand count2/plot	Stand count2/Ac	Vigor (1-9 scale)	SDS DX1	SDS DX2	SDS DX3	Defoli-ation%	Yield Bu/Ac	Yield Mt/Ha
P25A04X=RES.	**1**	579.25a	505.75ba	125889ba	7.75a	0.06b	0.12a	0.17c	35c	68.15a	4.58a
P23A32X=MOD RES.	**2**	402.50ba	512.75ba	127631ba	7.75a	1.84ba	15.96a	22.75bac	100a	59.35a	3.99a
P25A54X=SUSC.	**3**	419.50ba	561.75a	139828a	8.00a	4.38ba	29.24a	39.25a	86ba	61.86a	4.16a
GH1922=RES.	**4**	376.25ba	470.75ba	117177b	7.75a	1.57ba	11.24a	32.56ba	100a	62.85a	4.23a
GH2442=MOD RES.	**5**	343.00b	463.75b	115434b	8.00a	0.55b	4.12a	18.76bac	95ba	71.33a	**4.49a**
GHK2505=SUSC.	**6**	437.50ba	523.25ba	130245ba	8.00a	3.15ba	18.94a	34.83ba	98a	63.60a	4.28a
AG28XF2=RES.	**7**	397.25ba	504.00ba	125453ba	8.00a	0.24b	1.99a	9.92bc	36c	61.93a	4.16a
AG26XF2=MOD RES.	**8**	469.00ba	495.25ba	123275ba	7.75a	2.19ba	20.23a	27.06ba	68b	64.07a	4.31a
AG26XF1=SUSC.	**9**	388.50ba	518.00ba	128938ba	7.50a	6.65a	31.88a	36.46a	98a	64.02a	4.31a

Plot size: 10 ft wide x 17.5 ft long, row spacing: 30 inches. Results are average of four replications. Means within column followed by the same letter(s) are not significantly different from each other at 5% level of significance (*P*<0.05).

2022 SDS Trial 2: Plots Not inoculated and Not irrigated

ISU, Hinds Memorial Irrigation Farm, Ames, IA

Treatment details	Var#	Stand count1/plot	Stand count2/plot	Stand count2/Ac	Vigor (1-9 scale)	SDS DX1	SDS DX2	SDS DX3	Defoli-ation%	Yield Bu/Ac	Yield Mt/Ha
P25A04X=RES.	**1**	444.50a	495.25a	123275a	7.75a	0.063ba	0.084b	0.005b	25cd	73.56a	4.95a
P23A32X=MOD RES.	**2**	441.00a	526.75a	131116a	8a	0b	0b	0.010b	99a	69.87ba	4.69ba
P25A54X=SUSC.	**3**	442.75a	554.75a	138085a	7.75a	0b	0b	0.005b	35bcd	64.78bc	4.35bc
GH1922=RES.	**4**	341.25a	491.75a	122404a	7a	0b	0.006b	0.012b	100a	59.69c	4.01c
GH2442=MOD RES.	**5**	390.25a	488.25a	121532a	8a	0.011b	0.057b	0.097b	94a	69.55ba	4.67ba
GHK2505=SUSC.	**6**	416.50a	535.50a	133294a	8a	0b	0b	0.057b	94a	62.22bc	4.18bc
AG28XF2=RES.	**7**	346.50a	483.00a	120226a	7.5a	0b	0b	0b	14d	67.46ba	4.54ba
AG26XF2=MOD RES.	**8**	470.75a	514.50a	128066a	8a	0b	0b	0.005b	40bc	68.11ba	4.58ba
AG26XF1=SUSC.	**9**	451.50a	523.25a	130244a	8a	0.137a	0.205a	0.445a	60b	61.49bc	4.14bc

Plot size: 10 ft wide x 17.5 ft long, row spacing: 30 inches. Results are average of four replications. Means within column followed by the same letter(s) are not significantly different from each other at 5% level of significance (*P*<0.05).

2022 SDS Trial 5: non inoculated and non-irrigated

ISU, Northeast Research Farm, Nashua, IA

Treatment details	Var#	Stand count1/plot	Stand count2/plot	Vigor (1-9 scale)	SDS Inc%1	SDS DX1	SDS Inc%2	SDS DX2	Defoli-ation%	Yield Bu/Ac	Yield Mt/Ha
P25A04X=RES.	**1**	749.50bc	1761.83dc	8.33ba	0.04b	0.01b	1.12d	0.58c	21.67c	66.09ba	4.44ba
P23A32X=MOD RES.	**2**	836.83bc	2053.83bac	8.33ba	0.02b	0.004b	2.49dc	1.36c	50.00ba	63.63bac	4.2bac
P25A54X=SUSC.	**3**	944.17bc	2287.17ba	9a	0.21ba	0.10ba	6.15bc	3.84bc	38.33bc	62.28bc	4.18bc
GH1922=RES.	**4**	1017.00ba	2233.83ba	8.66ba	0.19ba	0.07b	10.73ba	6.35ba	63.33a	61.01c	4.10c
GH2442=MOD RES.	**5**	895.50bc	1863.83bdc	8.50bc	0.07b	0.04b	1.75dc	0.78c	18.33c	62.31bc	4.19bc
GHK2505=SUSC.	**6**	1299.33a	2389.67a	9a	0.41ba	0.19ba	12.80a	7.86a	31.67bc	67.18a	4.52a
AG28XF2=RES.	**7**	647.17c	1450.17d	9a	0.02b	0.01b	1.16d	0.59c	32.50bc	61.29c	4.12c
AG26XF2=MOD RES.	**8**	739.83bc	1883.50bdac	9a	0.04b	0.01b	2.59dc	1.17c	24.17c	62.32bc	4.19bc
AG26XF1=SUSC.	**9**	686.17bc	1883.50bdac	8.16c	0.61a	0.31a	8.75ba	5.51ba	32.50bc	61.87bc	4.15bc

Plot size: 15 ft wide x 73 ft long, row spacing: 30 inches. Results are average of six replications. Means within column followed by the same letter(s) are not significantly different from each other at 5% level of significance ($P<0.05$).

No white mold occurred in the plots.

2022 SDS Trial 6: non inoculated and non-irrigated

GDM, Story City (Ellsworth) , non-irrigated, non-inoculated

Treatment details	Var#	Stand count/plot (Jul 24)	Vigor (Jul 24)	SDS plants (Jul 24)	Sev% (Jul 24)	SDS plants (Aug 19)	Sev% (Aug 19)	SDS plants (Sep 13)	Sev% (Sep 13)
P25A04X=RES.	**1**	53.75	8.5	0	0	2	3.75	16.5	17.5
P23A32X=MOD RES.	**2**	43.25	7.375	0	0	0.25	1.25	8.5	27.5
P25A54X=SUSC.	**3**	57.5	8.25	0	0	0.5	1.25	10.75	27.5
GH1922=RES.	**4**	54.25	7.375	0	0	3.25	5	29.75	40
GH2442=MOD RES.	**5**	48	7	0	0	0.75	1.25	22	22.5
GHK2505=SUSC.	**6**	53.5	7.75	0	0	0.75	2.5	13.75	30
AG28XF2=RES.	**7**	59.75	8.5	0	0	3.5	2.5	11.5	17.5
AG26XF2=MOD RES.	**8**	61.75	8.5	0	0	5.5	5	16	27.5
AG26XF1=SUSC.	**9**	46.5	7.5	0	0	12.5	7.5	24.5	27.5

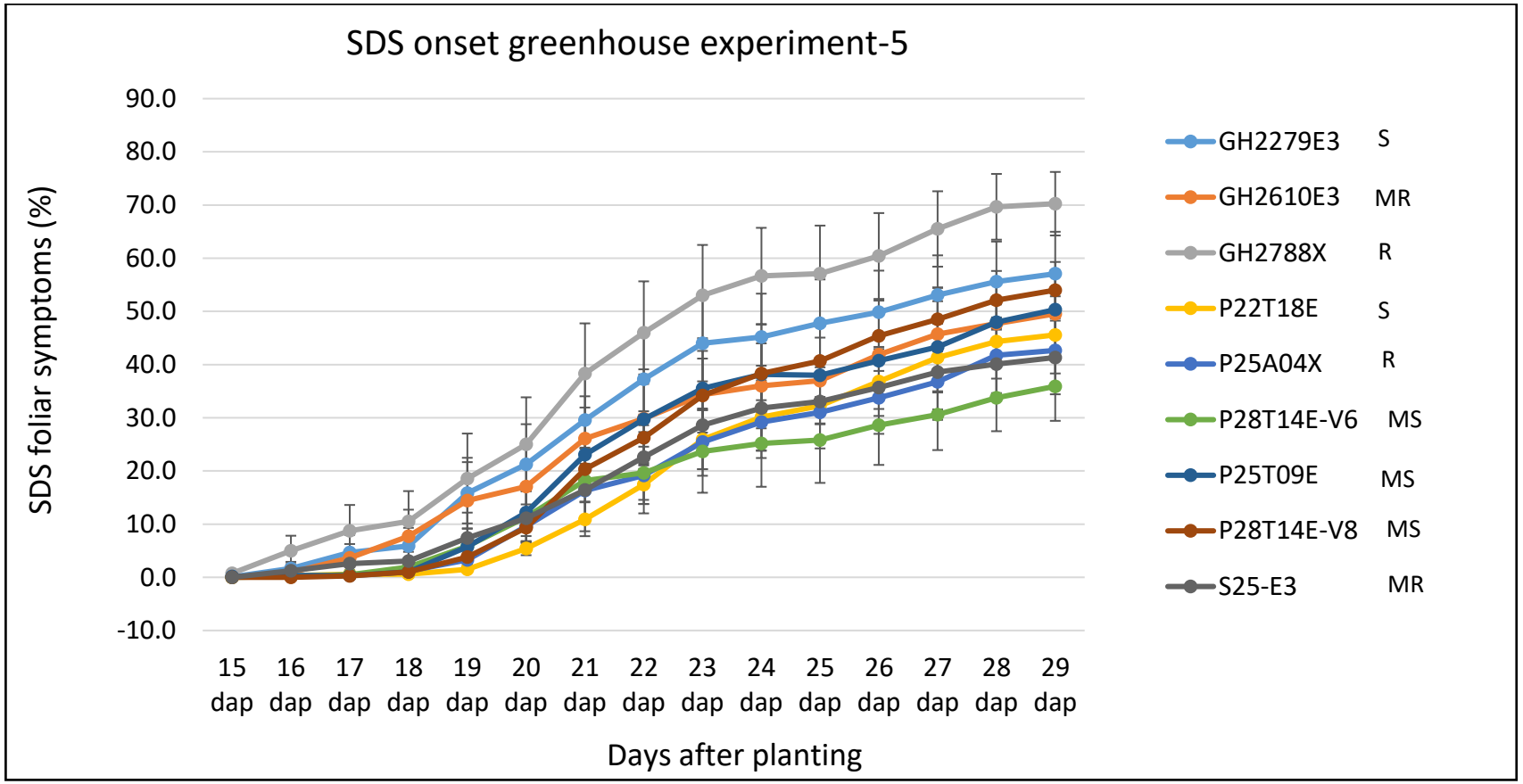

Figure 1. Progress of SDS foliar severity on 9 commercial soybean varieties used in the 2021 field trials. All soybean varieties started showing symptoms 16 to 19 days after planting, despite having different levels of resistance to SDS.

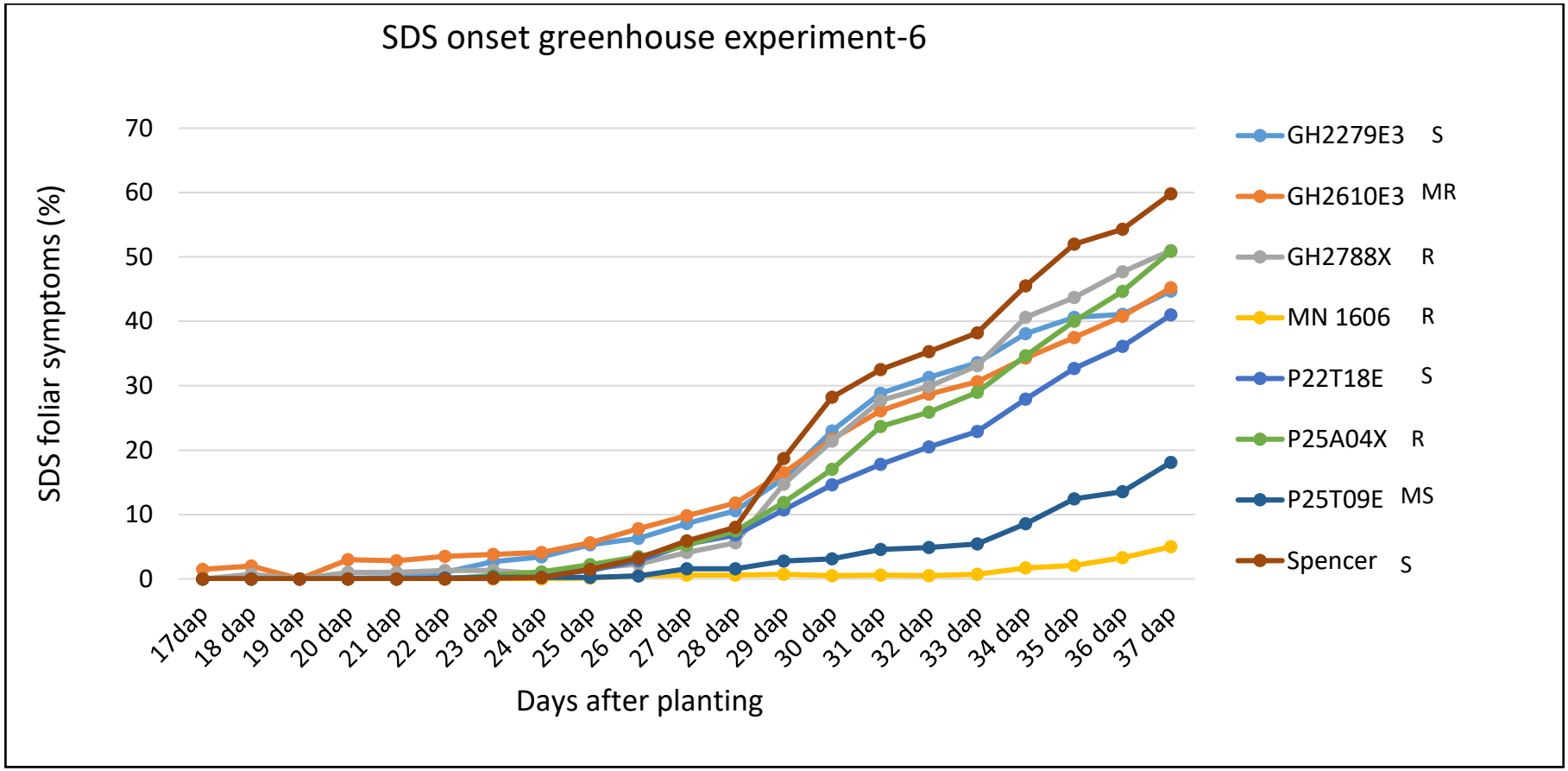

Figure 2. Progress of SDS foliar severity on 6 commercial soybean varieties used in 2021 field trials and 2 genotypes (Spencer – susceptible and MN1606 resistant) grown in greenhouse conditions. Most soybean varieties, including susceptible check Spencer, started showing symptoms 23 to 26 days after planting, despite having different levels of resistance to SDS. The resistant check (MN1606) and a resistant commercial line (P25T09E) started symptoms at 33 and 27 dap, respectively. The resistant check (MN1606) showed an 8-day delay compared with the susceptible check (Spencer).

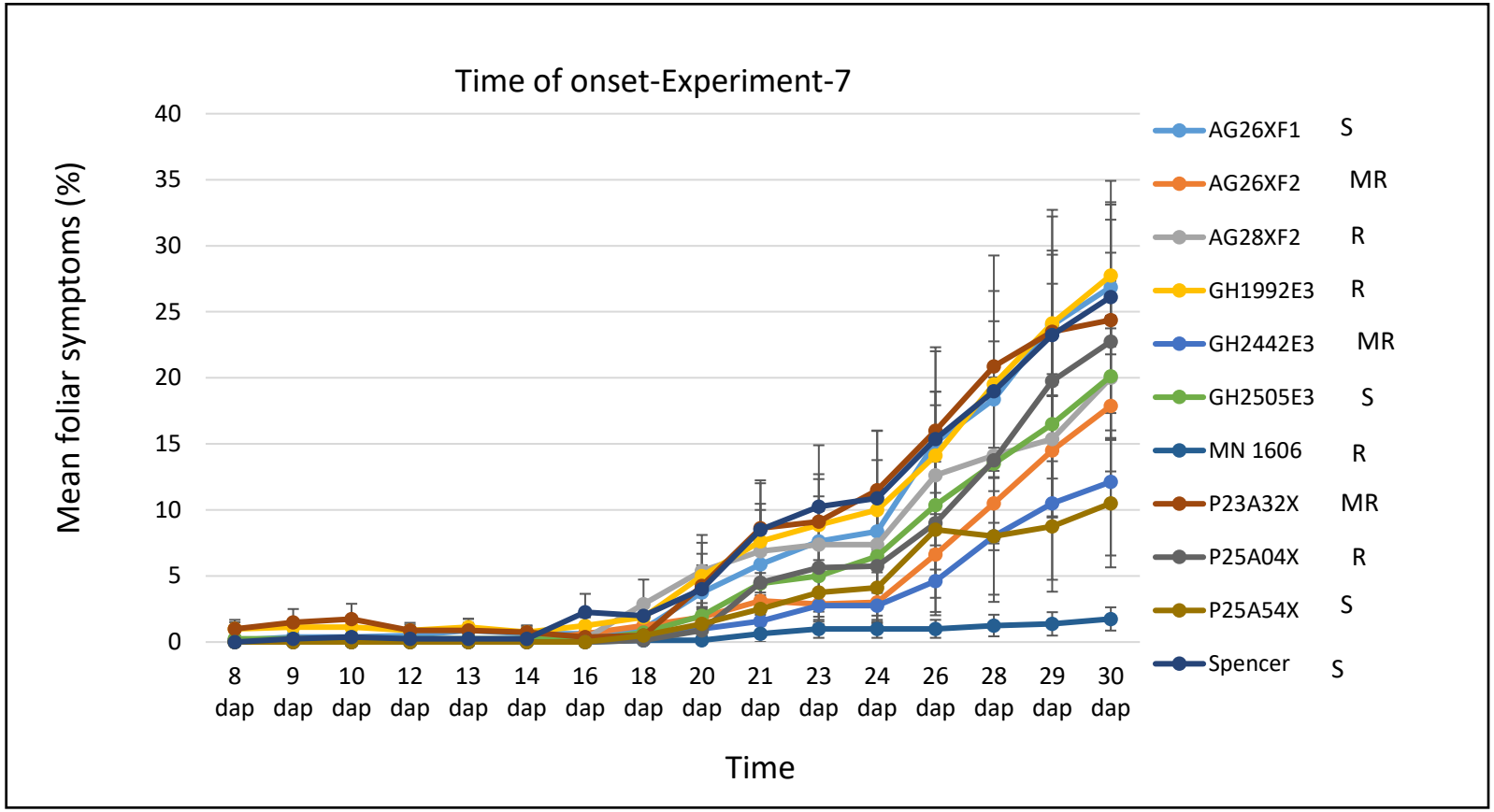

Figure 3. Progress of SDS foliar severity on 6 commercial soybean varieties used in 2022 field trials and 2 genotypes (Spencer – susceptible and MN1606 resistant) grown in greenhouse conditions. Most soybean varieties, including susceptible check Spencer, started showing symptoms 16-20 days after planting, despite having different levels of resistance to SDS. The resistant check (MN1606) started symptoms 21 dap, an 5-day delay compared with the susceptible check (Spencer).

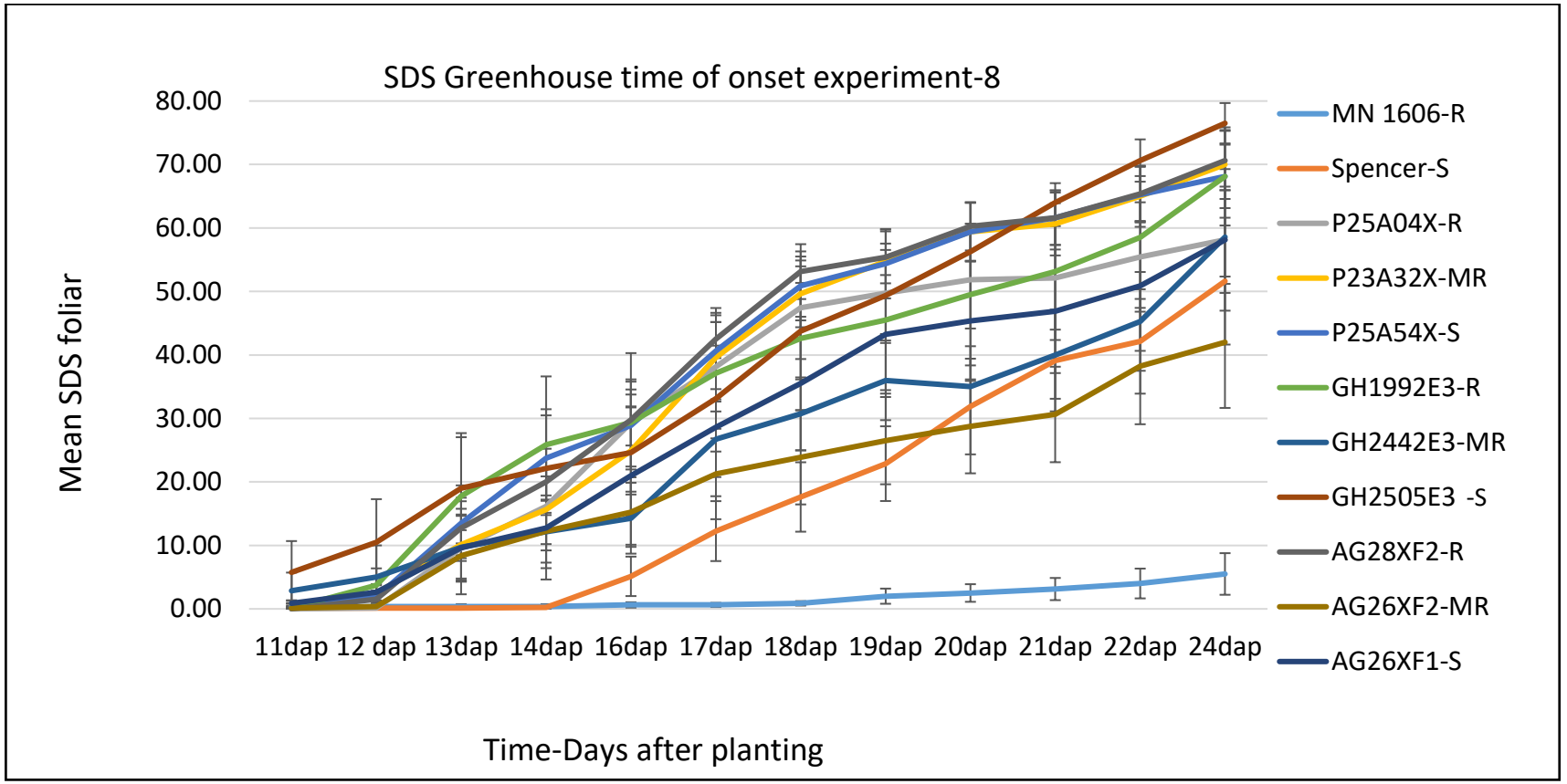

Figure 4. Progress of SDS foliar severity on 9 commercial soybean varieties used in 2022 field trials and 2 genotypes (Spencer – susceptible and MN1606 resistant) grown in greenhouse conditions. Most soybean varieties started showing symptoms 11 to 12 days after planting, despite having different levels of resistance to SDS. The resistant check (MN1606) and susceptible check (Spencer) started symptoms at 19 and 16 dap, respectively, with the resistant (MN1606) showing a 4-day delay in SDS onset.