Increasing planting speed using off-the-shelf precision planting technology, Project # 11-2022
Final Report
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Background and Objectives

Mechanical planters are the most commonly used equipment for planting soybean in Mississippi. However, optimal planting speed with mechanical planters is generally around 5-6 mph, though faster ground speeds are often used. During the planting season, producers face pressure to get as much land planted as quickly as possible during tight calendar and weather windows. New metering and seed delivery technology claims to enable planting at faster speeds without sacrificing singulation or stand establishment (Kinze Manufacturing, 2020). Still, these tools require testing and validation under Mississippi conditions. Recent research using corn in Georgia found "a hard threshold after 8 mph resulted in penalties for both emergence and final yield without the addition of an advanced seed delivery system. Speeds marginally slower than 8 mph, despite having an average full emergence, exhibited high variability in the seed singulation which was noted by numerous multiples and skips along the rows. This trend occurred in the first two planters [mechanical and electrical metering], with only a slight advantage for using the electric control seed metering and hydraulic system, while the addition of the Speed Tubes drastically improved singulation at higher speeds which eventually resulted in a general yield increase" (Russell et al., 2021). Corn seed, however, is planted at a much lower rate than soybean seed, so it seems likely that results using high seeding rates (such as with soybean) will generate greater differences at high speeds than those observed using corn, although it should be noted that crop plasticity is greater in soybean than corn. It may be expected that the performance of precision seed delivery systems may differ by soil type and soil conditions, so testing at multiple locations is important.

If producers can increase planting speed without sacrificing stand, yield and quality, this should result in fewer labor hours and more time to manage early-season fertility and weed control, as well as reduce the risk of getting caught by untimely rainfall during the planting season.

Objectives

Objective 1: To quantify soybean response at different planting speeds with various seed metering/delivery systems.
Objective 2: To determine the return on investment for seed metering/delivery systems that enable faster planting.

Report of Progress/Activity

Objective 1:

Trials were planted at 5 locations instead of 3 as proposed: Starkville, Brooksville, Verona, and two locations in Stoneville (a clay soil and a silt loam soil). The target speeds tested were 5.5, 7.5, 9.5, and 11.2 mph. The highest speed attained in all locations was 9.6 mph, except at Starkville where the highest speed was 9.7 mph. Future work will ensure that the proposed speeds are met. The target seeding rate used was 123,333 seed/ac with LS4795XS; more careful calibration is needed in future work to ensure that planters

are dispensing seed at the same rate under field conditions. The tractor was a Case IH Maxxum 125, which provided excellent operator comfort even at high speeds. The mechanical planter was a John Deere MaxEmerge; the electronic planter was equipped with downforce, electronic metering, and high-speed seed delivery. We were unable to acquire electronic metering without high-speed seed delivery, so the treatment was excluded from the experimental design. Data were collected on emergence rate, plant stand, and spacing. Plant spacing variability and yield were estimated. Seed quality analysis was performed by the State Seed Testing Laboratory.

Preliminary results indicate no differences in plant stand, yield, and seed qualities (oil and protein) between planters at a given speed, or between speeds with a given planter (Table 1). Increased planting speed generally reduced plant stand (Figure 1). In-row plant spacing variability increases with speed but is lower using the electronic planter compared to the mechanical planter (Figure 2). The lack of differences in yield in the combined analysis was also observed for yield at individual locations except for Stoneville silt loam (Figure 3). The lack of differences among planters should be interpreted with caution, as planting large acreage with a mechanical planter at high speeds is likely to result in mechanical failure and costly field repairs. We do not know the 'breaking point' for the electronic planter yet, but as there are few moving parts, we anticipate that it should be able to handle high speeds for a longer time than a mechanical planter. (Future work may include running the electronic planter to failure in order to identify weak points in the system, so that those can be communicated to growers.)

Objective 2:

Planter technology return on investment (ROI) preliminary data were analyzed by comparing net returns, revenue minus associated costs, of a mechanical planter to a precision planter with downforce and to a precision planter without downforce. Per acre planter costs were calculated using standards from the American Society of Agricultural and Biological Engineers. The parameters for planter cost calculations were:

- Precision planting with downforce (as was used during the trials)
- Precision planting without downforce (this assumes yield would have been the same as with downforce)
- List price of a John Deere 1725 12-row planter was $105,758
- List price of SureSpeed on a 12-row unit was an additional $37,800
- List price of SureSpeed plus SureForce was $50,950 for a 12-row unit
- Additional InCommand 1200 display list price of $6750
- Purchase price was 90% of the list price
- Expected useful life was 8 years
- Salvage value of 44% of list price
- Depreciation based on 2000 acre farm size and an annual tractor use of 500 hours
- Planter annual use varied given the amount of time it would take to plant 2000 acres at a given speed
- Interest rate of 4%
- Fuel price of $4.35/gallon
- Labor wage rate of $15.27/hr
- Fuel (diesel) use was 0.044 gallons/hp-hour with a 250 hp tractor
- Lubrication and filters were 15% of fuel cost
- Labor hours were 1.2 times machinery hours
- Taxes, insurance and housing were 1.5% of the average value

- Delta sites planted 40-inch rows
- Hills sites planted 38-inch rows

Equipment costs for various planting configurations are shown in Table 2.

Revenue was calculated by multiplying soybean price by plot yield. Soybean prices were determined using 5-year price histories (2017-2021). Analyses used the average price ($10.10/bu), maximum price ($13.30/bu), and minimum price ($8.48/bu) to assess if there was any variability in results across prices.

ANOVA showed that there were no differences in ROI between planters (mechanical, precision with downforce, or precision without downforce), planting speed, location x planter, planter x speed, or location x planter x speed interactions at all locations ($p \geq 0.38$) except at the Stoneville silt loam location. Location was the only significant factor for economic results ($p < 0.0001$), primarily due to yield differences at each location. Net returns of mechanical planters compared to planters equipped with SureSpeed and SureForce were modeled using three soybean price scenarios: the 5-year average soybean price (Table 3), the 5-year low soybean price (Table 4), and the 5-year high soybean price (Table 5). It is important to note that net returns for almost all locations were not significantly different between planters or speeds. Therefore, the net returns shown within location are generally only numerical differences and not significant differences. However, economic analyses do not include potential yield increases due to more acreage planted on time.

Impacts and Benefits to Mississippi Soybean Producers

During the planting season, MS soybean producers are under pressure to plant as much acreage as possible quickly due to calendar and weather constraints. Many farmers, especially those targeting early production systems, fail to plant at the critical window, realizing a negative effect on potential yield. Preliminary results show that we can plant faster without a yield penalty. We expect that planting more acreage within the critical planting window will increase whole-farm yield. Speed also reduces labor hours and allows for more time spent on other management responsibilities.

End Products–Completed or Forthcoming

Completed

1. What's New in Planter Technologies? 2023. Science for Success Webinar, March 24, 2023. 113 attendees. https://soybeans.ces.ncsu.edu/2023/03/planter-technologies-webinar-recording-available/ (passcode Wwf%Xf6!).
2. Mulvaney, M.J., Lowe, W., Bryant, C.J., Chesser, D., Mills, B., Bheemanahalli, R., Dulaney, P., & Harper, N. (2022). Increasing Planting Speed Using Off-the-Shelf Precision Planting Technology [Abstract]. ASA, CSSA, SSSA International Annual Meeting, Baltimore, MD. https://scisoc.confex.com/scisoc/2022am/meetingapp.cgi/Paper/142070.
3. Mulvaney, M.J., Lowe, W., Bryant, C.J., Chesser, D., Mills, B., Harper, N, Dulaney, P., &. Bheemanahalli, R. (2023). How Fast Can We Plant Soybean? ASA Southern Branch Meeting, February 4-6, 2023. Oklahoma City, USA.
4. O.E. Olomitutu, M.J. Mulvaney, J.W. Lowe, C.J. Bryant, B. Mills, P. Dulaney, N. Harper, D. Chesser. (2023). How fast can we plant soybean in Mississippi? North Mississippi Research & Extension Center Producer Advisory Council. Poster. Feb. 16, 2023.
5. O.E. Olomitutu, M.J. Mulvaney, J.W. Lowe, C.J. Bryant, B. Mills, P. Dulaney (g), N. Harper, D. Chesser. (2023). How fast can we plant soybean in Mississippi? Mid-South Farm & Gin Show, Memphis, TN. Poster. Feb. 24-25, 2023.

Forthcoming
The following products are anticipated:

1. MS Thesis, Noah Harper (Dr. Wes Lowe, major professor).
2. Peer reviewed publication, Agronomy Journal.
3. MS State Extension publication.

The trial will be validated during future research, both on-farm and on-station. We do not recommend farmers to plant with a mechanical planter at speeds higher than 6 mph. Hence, future research will test the precision planter at speeds greater than 6 mph while the mechanical planter will be run only at 6 mph to serve as a check. Future research questions that may be addressed in the future include:

1. What are the mechanical limitations of the precision planter?
2. Can faster speeds make growers more resilient to climate change?
3. If we can get more even stands, can we reduce seed rates?
4. Variable downforce: Is it more important at high planting speeds? Is variable rate downforce important at all for soybean production?
5. Which components of advanced planting technology are necessary for soybean production, and which are unnecessary?

A graduate student is being trained on this, and findings from this project will be presented in extension talks, bulletins, posters, presentations, and peer-reviewed publications.

Graphics/Tables

Table 1. ANOVA of soybean response to planter type and planting speed. Data were averaged over all locations and emergence timings.

Response	Effect	DF	FValue	ProbF
Plants/ac	planter	1	1.93	0.2588
Plants/ac	speed	4	1.63	0.2305
Plants/ac	planter*speed	4	0.22	0.9243
Plant spacing	planter	1	11.78	0.0415
Plant spacing	speed	4	3.05	0.0599
Plant spacing	planter*speed	4	0.85	0.5217
Std. Dev. of plant spacing	planter	1	7.19	0.075
Std. Dev. of plant spacing	speed	4	3.33	0.0472
Std. Dev. of plant spacing	planter*speed	4	0.8	0.5468
Yield	planter	1	0.14	0.7057
Yield	speed	3	0.26	0.9028
Yield	planter*speed	3	0.19	0.9404
Oil	planter	1	3.34	0.0703
Oil	speed	3	0.41	0.7432
Oil	planter*speed	3	0.15	0.9301
Protein	planter	1	0.66	0.4197
Protein	speed	3	0.2	0.8977
Protein	planter*speed	3	0.11	0.9527

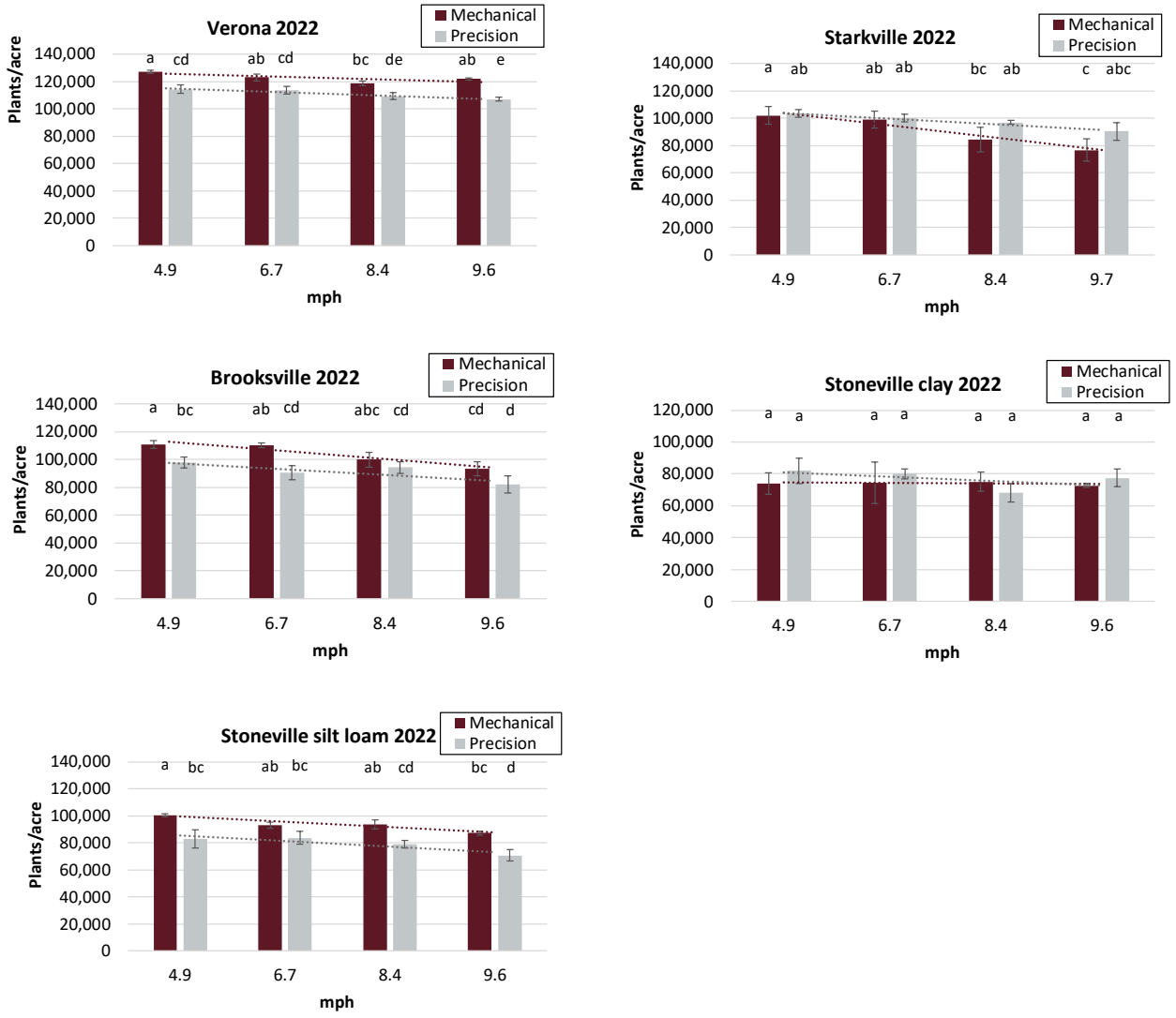

Figure 1. Soybean stand using mechanical vs. electronic planters at various planting speeds at various locations in MS during 2022. Although there were generally no significant differences among treatments (LSD p<0.05), a trend toward decreasing plant stands at higher speeds was observed.

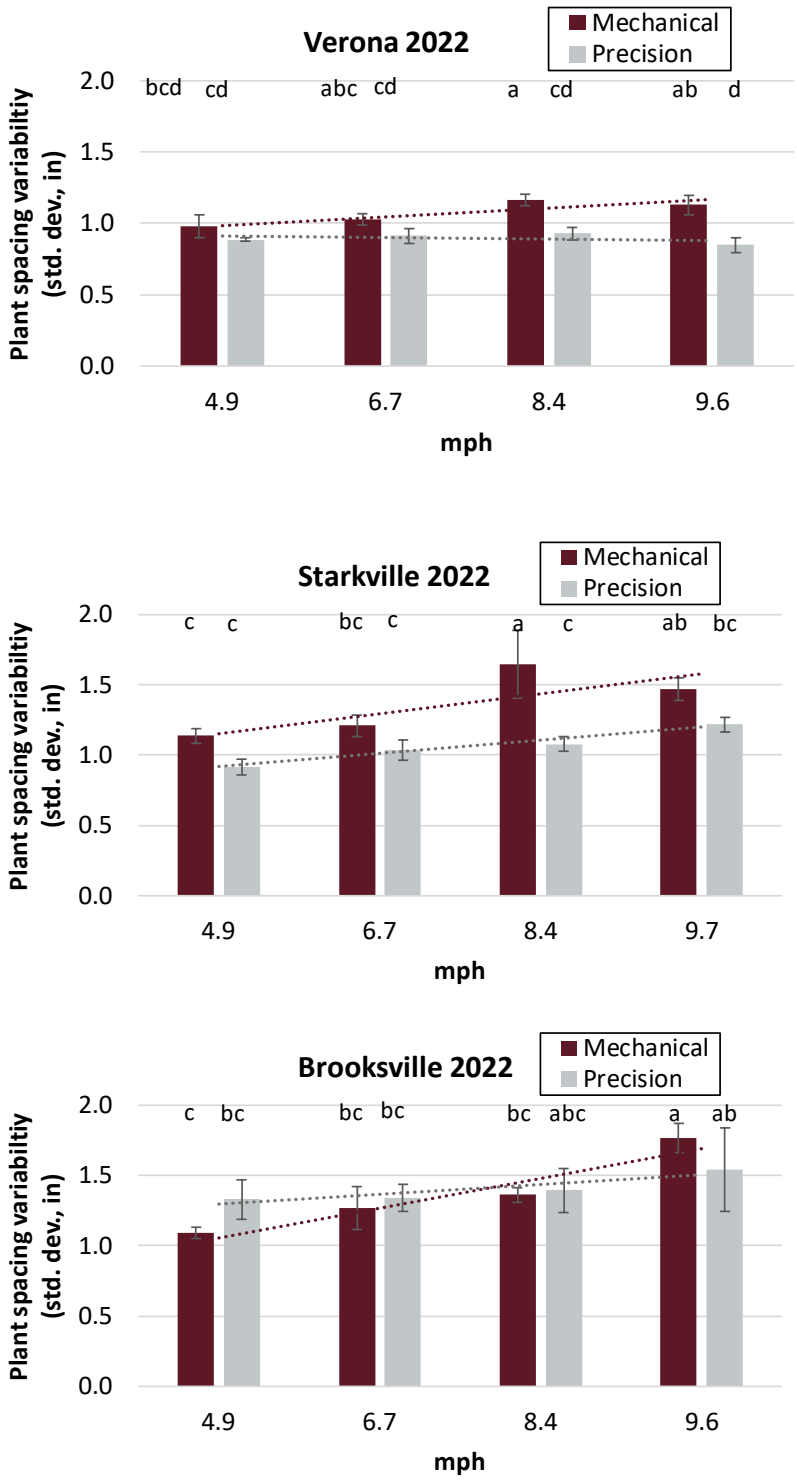

Figure 2. In-row plant spacing standard deviation at three locations in MS during 2022. Variability increases with planting speed, but the increase is lower with the precision planter than with the mechanical planter. Different letters above means indicate significantly different response (LSD p<0.05).

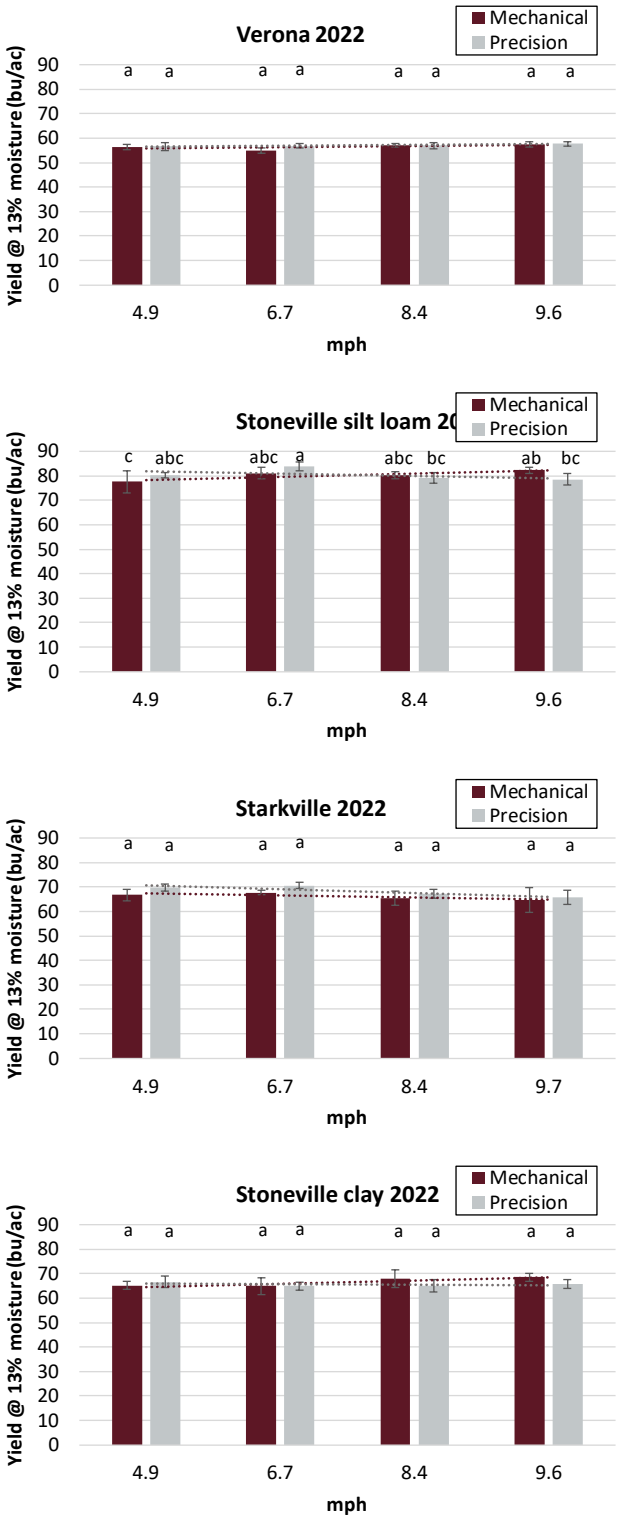

Figure 3. Soybean yield using mechanical vs. electronic planters at various planting speeds at various locations in MS during 2022. Although there were generally no significant differences among treatments (LSD p<0.05).

Table 2. Equipment costs ($/ac) for a John Deere 1725 12-row planter with or without precision planting components when used at different planting speeds ($/ac). Scenarios without downforce assume that yield would be the same as with downforce.

Planting speed	4.9 mph	6.7 mph	8.4 mph	9.7 mph
Mechanical, 38" rows	$19.43	$15.57	$13.41	$12.33
Precision w/ downforce, 38"	$24.11	$19.73	$17.27	$16.05
Precision w/o downforce, 38"	$23.04	$18.78	$16.39	$15.20
Mechanical, 40" rows	$18.70	$15.05	$12.98	$12.00
Precision w/ downforce, 40"	$23.29	$19.13	$16.79	$15.67
Precision w/o downforce, 40"	$22.24	$18.20	$15.92	$14.84

Table 5. Net returns using a JD 1725 with or without precision planters equipped with downforce. Returns are based on the 5-year average soybean price (2017-21). Only at the Stoneville silt loam location were net returns significantly different by planting speed (similar letters represent similar net returns). All other locations had similar net returns over planting speed (p<0.05, LSD).

	---------- Starkville ----------			
Planting speed	4.9 mph	6.7 mph	8.4 mph	9.7 mph
Mechanical	$654.24	$667.70	$647.13	$640.38
Precision	$680.62	$693.84	$661.96	$648.28

Planting speed	4.9 mph	6.7 mph	8.4 mph	9.6 mph
	---------- Verona ----------			
Mechanical	$549.71	$539.43	$563.81	$567.36
Precision	$547.80	$554.71	$558.43	$566.17
	---------- Stoneville clay ----------			
Mechanical	$639.82	$640.44	$674.58	$680.36
Precision	$649.37	$637.12	$640.72	$649.42
	---------- Stoneville silt loam ----------			
Mechanical	$765.82 c	$804.57 abc	$798.05 abc	$819.48 ab
Precision	$785.97 abc	$826.49 a	$783.13 abc	$778.44 bc

Table 6. Net returns using a JD 1725 with or without precision planters equipped with downforce. Returns are based on the 5-year low soybean price (2017-21). Only at the Stoneville silt loam location were net returns significantly different by planting speed (similar letters represent similar net returns). All other locations had similar net returns over planting speed (p<0.05, LSD).

	---------- Starkville ----------			
Planting speed	4.9 mph	6.7 mph	8.4 mph	9.7 mph
Mechanical	$552.19	$564.19	$547.07	$541.51
Precision	$573.87	$585.74	$559.06	$547.65
Planting speed	4.9 mph	6.7 mph	8.4 mph	9.6 mph
	---------- Verona ----------			
Mechanical	$463.49	$455.35	$476.37	$479.54
Precision	$461.17	$467.69	$471.22	$477.96
	---------- Stoneville clay ----------			
Mechanical	$540.06	$541.15	$570.42	$575.47
Precision	$547.48	$537.71	$541.12	$548.66
	---------- Stoneville silt loam ----------			
Mechanical	$646.97 c	$680.41 abc	$675.19 abc	$693.53 ab
Precision	$663.38 abc	$698.4 a	$661.96 abc	$658.14 bc

Table 7. Net returns using a JD 1725 with or without precision planters equipped with downforce. Returns are based on the 5-year high soybean price (2017-21). Only at the Stoneville silt loam location were net returns significantly different by planting speed (similar letters represent similar net returns). All other locations had similar net returns over planting speed (p<0.05, LSD).

	---------- Starkville ----------			
Planting speed	4.9 mph	6.7 mph	8.4 mph	9.7 mph
Mechanical	$867.68	$884.18	$856.41	$847.18
Precision	$903.90	$919.92	$877.16	$858.76
Planting speed	4.9 mph	6.7 mph	8.4 mph	9.6 mph
	---------- Verona ----------			
Mechanical	$730.03	$715.27	$746.69	$751.04
Precision	$729.00	$736.71	$740.83	$750.65
	---------- Stoneville clay ----------			
Mechanical	$848.46	$848.12	$892.42	$899.72
Precision	$862.49	$845.04	$849.04	$860.14
	---------- Stoneville silt loam ----------			
Mechanical	$1014.38 c	$1064.25 abc	$1055.01 abc	$1082.92 ab
Precision	$1042.37 abc	$1094.41 a	$1036.57 abc	$1030.04 bc