SOYBEAN RESPONSE TO ROW SPACING AND STARTER NITROGEN AND SULFUR IN SOUTHERN ILLINOIS

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ABSTRACT

Narrow row spacing is widely adopted in soybean [*Glycine max* (L.) Merr.] production to improve canopy closure; however, its interaction with starter nitrogen (N) and sulfur (S) fertilization under southern Illinois conditions is poorly understood. We evaluated no-till soybean response to row spacing and starter fertility at Carbondale, IL, in 2024 and 2025. The experiment followed corn in a split-plot randomized complete block design with four replications, with row spacing (15 and 30 inches) as main plots and fertility as subplots: no fertilizer, 15 lb N ac^{-1} as urea ammonium nitrate (UAN), and 15 lb N ac^{-1} plus 10 lb S ac^{-1} as UAN plus ammonium thiosulfate. Biological yield at R8, grain yield, and harvest index were analyzed by year because treatment effects differed between years. In 2024, row spacing and fertility interacted for biological and grain yield; 15-inch rows receiving N+S produced 5.47 tons ac^{-1} of biomass and 90.1 bu ac^{-1} of grain, exceeding the 15-inch no-fertilizer and N-only treatments by 34 to 39% and 56 to 62%, respectively, and all three 30-inch treatments by 58 to 78% and 55 to 76%, respectively, whereas fertility had no effect in 30-inch rows. Harvest index was greater in 30-inch than in 15-inch rows (50.1 vs. 44.3%). In 2025, fertility had no effect, and 30-inch rows increased biological and grain yield compared to the 15-inch row spacing by 46 and 44%, respectively, with no difference in harvest index. The benefits of narrow rows and starter N+S were inconsistent across years, and yield differences mainly reflected biomass accumulation rather than partitioning to grain. Additional site-years are needed to determine when narrow rows and starter N+S increase soybean yield in this environment.

INTRODUCTION

Atmospheric sulfur (S) deposition in Illinois has declined sharply over the past two decades, largely because of coal scrubbing and the shift to natural gas (David et al., 2016; Bruulsema & Olson, 2024), and is now well below the roughly 30 lb S ac^{-1} removed over a corn-soybean rotation. Across 52 U.S. sites, however, soybean yield responded to nitrogen (N) or S additions at only 12 sites, and S limited crop growth at only 3 (Brooks et al., 2023). Soybean responses to S are more likely on soils with low organic matter and tend to disappear when soil organic matter exceeds about 3.2 to 3.4% (Kaiser & Kim, 2013; Borja Reis et al., 2021).

In no-till soybean following corn, surface residue keeps soils cooler and wetter in spring, which slows mineralization of N and S from organic matter. Starter N and S placed near the row may bridge this early-season gap, particularly on the low-organic-matter soils of southern Illinois. Yet soybean yield responses to N fertilizer are inconsistent, because biological N fixation and soil mineralization usually supply most of the crop's N demand (Salvagiotti et al., 2008).

Narrow rows close the canopy earlier, increase radiation interception during seed set, and often increase soybean yield relative to 30-inch rows (Andrade et al., 2002; De Bruin & Pedersen, 2008). Greater biomass potential in narrow rows may also raise crop N and S demand, so the response to starter N and S may depend on row spacing. The objectives of this study were to: i) evaluate the effects of row spacing (15 vs. 30 inches) and starter N and N+S on soybean biological yield, grain yield, and harvest index, and ii) determine whether row spacing changes the soybean response to starter N and S. We hypothesized that the response to starter N+S would be greater in 15-inch rows.

MATERIALS AND METHODS

Site Description

Field experiments were conducted in 2024 and 2025 at the Southern Illinois University Agronomy Research Center, Carbondale, IL. The soil was a Stoy silt loam (fine-silty, mixed, superactive, mesic Fragiaquic Hapludalfs), a soil common in southern Illinois soybean production. Pre-plant soil samples (0-7 inches) had 2.3% organic matter, pH 6.0 (1:1 water), 18 ppm Bray P-1, 110 ppm K, and 6.8 ppm SO_4-S. Daily weather was obtained from the Illinois Climate Network (ICN) Carbondale station of the Illinois State Water Survey WARM program.

Experimental Design and Treatments

The experiment was arranged as a split-plot randomized complete block design with four replications. Row spacing (15 and 30 inches) was the main plot, and starter fertility was the subplot with three levels: unfertilized check (None); 15 lb N ac^{-1} as UAN (28-0-0; N); and 15 lb N ac^{-1} plus 10 lb S ac^{-1} as UAN plus ammonium thiosulfate (ATS; 12-0-0-26; N+S). Starter fertilizer was applied at planting 2 × 2 inches below and beside the seed furrow.

Crop Management and Measurements

Soybean (AG39XF3) was no-till planted into corn residue in early May 2024 and late April 2025 at 160,000 seeds ac^{-1} and harvested in October. At full maturity (R8), aboveground biomass, including grain, was hand-harvested from two 1-m row segments per plot, one from each of the two center rows. Samples were oven-dried at 60 °C to constant weight and weighed to determine biological yield, which was converted to tons ac^{-1}. Grain yield was determined by threshing the R8 biomass samples and was adjusted to 13% moisture. Harvest index (HI) was calculated following Orlowski et al. (2016) as the ratio of grain yield to total aboveground biological yield (stems, leaves, pods, and grain), with grain yield converted to tons ac^{-1} to match biological yield, and is reported as a percentage:

HI (%) = (Grain yield ÷ Biological yield) × 100

Statistical Analysis

Data were analyzed with PROC GLIMMIX in SAS 9.4 (SAS Institute, 2017). Row spacing, fertility, and their interaction were fixed effects; block and block × row spacing were random effects. Because year × treatment interactions were significant, each year was analyzed separately. Residual normality and homogeneity of variance were checked before analysis. Means were separated with Tukey's HSD at $P \leq 0.05$;

interaction means were separated when the row spacing × fertility interaction was significant, and main-effect means otherwise.

RESULTS AND DISCUSSION

Growing-Season Weather

The two seasons differed mainly in rainfall distribution, not temperature. Mean air temperature from planting to harvest was 72.0 °F (May-October) in 2024 and 71.8 °F (April-October) in 2025. In 2024, total rainfall was 18.4 inches; August was dry (0.6 inches) during seed fill and was followed by a very wet September (7.8 inches). In 2025, total rainfall was 23.9 inches, and May-June received 10.1 inches compared with 7.4 inches in 2024.

Biological Yield

In 2024, row spacing and fertility interacted for biological yield (Table 1). Soybean in 15-inch rows receiving N+S produced 5.47 tons ac^{-1}, which was 34 to 39% greater than the 15-inch None and N treatments and 58 to 78% greater than all three 30-inch treatments. Fertility had no effect in 30-inch rows, and N alone did not increase biomass in either row spacing. In 2025, only row spacing affected biological yield: 30-inch rows produced 3.60 tons ac^{-1} compared with 2.47 tons ac^{-1} in 15-inch rows, a 46% increase.

Grain Yield

Grain yield followed the same pattern as biological yield in both years (Table 1). In 2024, 15-inch rows with N+S yielded 90.1 bu ac^{-1}, which was 56 to 62% more than the 15-inch None and N treatments and 55 to 76% more than the 30-inch treatments (51.3 to 58.1 bu ac^{-1}). In 2025, fertility had no effect, and 30-inch rows outyielded 15-inch rows by 44% (54.0 vs. 37.5 bu ac^{-1}).

The 2024 response supports our hypothesis that narrow rows increase the response to starter N+S. Because N alone had no effect, the gain can be attributed to S or to the combined N+S supply. The site had low soil organic matter (2.3%) and low SO_4-S (6.8 ppm), conditions under which soybean S responses are most likely (Kaiser & Kim, 2013; Borja Reis et al., 2021). The lack of response in 30-inch rows is consistent with the infrequent responses reported across U.S. environments (Brooks et al., 2023). The magnitude of the 2024 response was large for a single site-year and was not repeated in 2025.

The reversal of the row-spacing effect in 2025 was associated with poor stand establishment in narrow rows. At R8, 15-inch rows had 38% fewer plants than 30-inch rows. Narrow rows increase yield mainly through earlier canopy closure and greater light interception (Andrade et al., 2002), a benefit that depends on an adequate stand.

Harvest Index

In 2024, HI was greater in 30-inch than in 15-inch rows (50.1 vs. 44.3%), with no fertility or row spacing × fertility interaction effect (Table 1). Larger narrow-row canopies may have partitioned less dry matter to grain under the dry August of 2024. In 2025, HI was not affected by row spacing, fertility, or their interaction (Table 1). Across both years, grain yield differences tracked biological yield more closely than HI, indicating

that treatments affected yield mainly through biomass accumulation rather than partitioning to grain.

Table 1. Biological yield at R8, grain yield, and harvest index of no-till soybean as affected by row spacing and starter fertility at Carbondale, IL, in 2024 and 2025.

Row spacing	Fertility	Biological yield (tons ac^{-1})		Grain yield (bu ac^{-1})		Harvest index (%)	
		2024	2025	2024	2025	2024	2025
15 in	None	4.07 b	2.74	57.7 b	40.7	41.1	45.4
	N	3.93 b	2.37	55.6 b	36.9	42.7	46.8
	N+S	5.47 a	2.28	90.1 a	34.9	49.2	45.7
30 in	None	3.48 b	3.52	58.1 b	52.2	50.4	44.4
	N	3.35 b	3.71	56.2 b	56.7	50.1	45.7
	N+S	3.08 b	3.58	51.3 b	52.9	49.8	44.4
Row spacing means							
15 in		4.49	2.47 b	67.8	37.5 b	44.3 b	46.0
30 in		3.31	3.60 a	55.2	54.0 a	50.1 a	44.8

Within a column, means followed by different letters differ (Tukey's HSD, $P \leq 0.05$). Letters are shown for treatment means when the row spacing × fertility interaction was significant; otherwise for row spacing means. None, unfertilized check; N, 15 lb N ac^{-1} as UAN; N+S, 15 lb N ac^{-1} plus 10 lb S ac^{-1} as UAN plus ATS. Grain yield adjusted to 13% moisture. To calculate harvest index, grain yield was converted to tons ac^{-1}, the same unit as biological yield.

CONCLUSIONS

On a low-organic-matter soil in southern Illinois, starter N+S increased soybean biological and grain yield only in 15-inch rows and only in 2024; starter N alone had no effect in either year. Narrow rows did not provide a consistent yield advantage: they were superior with N+S in 2024, but 30-inch rows yielded 44% more than 15-inch rows in 2025, when stand establishment in narrow rows was poor. In both years, yield differences reflected biomass accumulation more than partitioning to grain. Narrow rows should be paired with practices that secure an adequate stand, and additional site-years are needed before starter N+S can be recommended for narrow-row soybean in this environment.

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