Soybean Seeding Rate and Nutrient Interactions on Growth and Yield in Michigan

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Introduction

- Seeding rate and nutrient inputs are two factors that producers can manipulate to alter the growing environment of individual soybean (*Glycine Max* (L.) Merr.) plants for improved plant production and economic return.
- Recent yield gains may be a result of increased dry matter production which can influence nutrient accumulation.
- Interplant competition is more prominent in greater soybean seeding rates and may contribute to yield plateaus.
- Decreased seeding rates may maximize the yield potential of individual plants while nutrient applications may support the additional biomass production found in modern soybean varieties.

Objective

Determine the soybean biomass accumulation, grain yield, and economic return responses to seeding rate and nutrient application interactions in Michigan.

Materials and Methods

- Field studies initiated in Richville, MI on 28 April 2017 on a Tappan-Londo loam and in Lansing, MI on 12 May 2017 on a Capac loam.
- Richville soil properties: 8.2 pH, 2.6% organic matter (OM), 23 ppm P, 155 ppm K, 7 ppm S, and 6.0 ppm Zn. Lansing soil properties: 6.6 pH, 2.1% OM, 30 ppm P, 134 ppm K, 8 ppm S, and 2.3 ppm Zn.
- Randomized complete block split-plot arrangement with four replications. Main plot factor was seeding rate and subplots were fertilizer treatments.
- **Seeding rates**: 50,000, 90,000, 130,000, and 170,000 seeds A^{-1}.
- **Fertilizer treatments**: non-fertilized control, K_2O pre-plant incorporated at 50 lbs K_2O A^{-1}, MESZ (12-40-0-10S-1Zn) applied in a 2x2 at 150 lbs MESZ A^{-1}, and K_2O plus MESZ at the previously listed rates.
- Biomass samples: 10 plants collected at V4, R2, R5, and R8. Netting assembled around 10 plants at R5 to collect senesced biomass.
- Cost estimates include: $37.00, $12.08, and $8.00 A^{-1} for MESZ, K_2O, and dry fertilizer application cost, respectively. An additional $82.50 was estimated for 140,000 seeds.
- Economic return calculated by subtracting treatment costs from gross profit estimates.
- Statistical analysis performed using PROC GLIMMIX in SAS.

Table 1. Mean monthly weather data for Richville and Lansing, 2017. Values in parenthesis are deviations from the 30-year average.

Location	Month				
	May	June	July	August	September
Richville					
T avg, ˚F	57 (-0.7)	69 (+1.5)	70 (-0.8)	67 (-2.1)	64 (-2.7)
Ppt., in	2.0 (-1.4)	4.8 (+1.9)	1.1 (-1.5)	2.3 (-1.0)	1.6 (-2.2)
Lansing					
T avg, ˚F	56 (-1.4)	68 (+0.2)	71 (-0.4)	67 (-3.0)	64 (-2.1)
Ppt., in	2.6 (-0.8)	3.3 (-0.2)	2.7 (-0.2)	1.4 (-1.9)	1.3 (-2.2)

Table 2. Soybean yield and economic return for Richville and Lansing, 2017. Yield is reported at 13.5% moisture.

Treatment	Location			
	Richville	Lansing	Richville	Lansing
	----------bu A^{-1}----------		----------US$ A^{-1}----------	
Seeding Rate				
50K	53.2 a†	46.3 b	$414 a	$353 a
90K	55.4 a	52.8 a	$410 a	$387 a
130K	55.6 a	51.6 a	$389 a	$353 a
170K	56.9 a	54.4 a	$376 a	$354 a
$P_r > F$	ns‡	< 0.01	ns	ns
Fertility				
None	53.5 a	50.7 bc	$410 a	$386 a
K_2O	54.0 a	48.7 c	$395 a	$345 b
MESZ	56.3 a	51.9 ab	$398 a	$359 b
K_2O + MESZ	57.3 a	53.8 a	$387 a	$356 b
$P_r > F$	ns	0.01	ns	0.03

† Values followed by the same lowercase letter are not significantly different at α=0.1
‡ ns, not significant.

Table 3. Total biomass accumulation per acre across sites, 2017. All values reported at 0% moisture.

Treatment	Total Biomass Accumulation			
	Richville		Lansing	
	V4	R5	V4	R5
	----------lbs A^{-1}----------			
Seeding Rate				
50K	246 b†	4999 a	148 b	4609 a
90K	277 b	4926 a	251 a	5005 a
130K	356 a	5257 a	279 a	5038 a
170K	339 a	5156 a	251 a	4741 a
$P_r > F$	0.02	ns‡	< 0.01	ns
Fertilizer				
None	211 b	4654 b	143 b	4275 b
K_2O	224 b	4735 b	139 b	4565 b
MESZ	395 a	5300 a	330 a	5297 a
K_2O + MESZ	388 a	5649 a	339 a	5257 a
$P_r > F$	< 0.01	< 0.01	< 0.01	< 0.01

† Values followed by the same lowercase letter are not significantly different at α=0.1
‡ ns, not significant.

Figure 1. Differences in R2 biomass accumulation. Plants pictured (left to right) are 50,000, 90,000, 130,000, and 170,000 seeds A^{-1} .

Table 4. Total V4 biomass accumulation per plant, Richville, 2017. All values are reported on a dry weight basis (0% moisture).

Fertility	Seeding Rate				$P_r > F$
	50,000	90,000	130,000	170,000	
	----------oz. $plant^{-1}$----------				
None	0.05 bA†	0.03 bB	0.03 bB	0.03 bB	< 0.01
K_2O	0.05 bA	0.04 bB	0.03 bB	0.03 bB	0.02
MESZ	0.09 aA	0.07 aB	0.06 aB	0.04 aC	< 0.01
K_2O + MESZ	0.09 aA	0.07 aB	0.06 aB	0.04 aC	< 0.01
$P_r > F$	< 0.01	< 0.01	< 0.01	< 0.01	

† Capital letters are specific to each row (fertility treatment) and lowercase letters are specific to each column (seeding rate). Values followed by the same lowercase or uppercase letter are not significantly different at α = 0.10.

Table 5. Total V4 biomass accumulation per plant, Lansing, 2017. All values are reported on a dry weight basis (0% moisture).

Fertility	Seeding Rate				$P_r > F$
	50,000	90,000	130,000	170,000	
	----------oz. $plant^{-1}$----------				
None	0.03 bA†	0.03 bA	0.02 bA	0.02 bA	ns‡
K_2O	0.03 bA	0.02 bA	0.02 bA	0.02 bA	ns
MESZ	0.08 aA	0.06 aB	0.05 aB	0.04 aC	< 0.01
K_2O + MESZ	0.08 aA	0.06 aB	0.05 aC	0.04 aD	< 0.01
$P_r > F$	< 0.01	< 0.01	< 0.01	< 0.01	

† Capital letters are specific to each row (fertility treatment) and lowercase letters are specific to each column (seeding rate). Values followed by the same lowercase or uppercase letter are not significantly different at α = 0.10.
‡ ns, not significant.

Preliminary Results and Discussion

- Total rainfall between 1 May and 30 September was 4.2 in. and 5.3 in. below normal for Richville and Lansing, respectively (Table 1).
- Seeding rate and fertilizer had no significant effects on yield in Richville. In Lansing, seeding rates between 90,000 and 170,000 seeds A^{-1} produced similar yield, while 50,000 seeds A^{-1} significantly decreased yield (Table 2). The potential may exist to reduce seeding rates without sacrificing yield. Total rainfall deficits from July – Sept. at both locations may have influenced pod development and grain fill.
- Seeding rate and fertilizer had no significant effect on economic return in Richville. Seeding rate had no significant effect on economic return but the unfertilized control plot significantly increased economic return in Lansing (Table 2).
- Seeding rate significantly affected biomass accumulation per acre at V4 at both locations. Total dry weight per acre plateaued at 130,000 seeds A^{-1}, suggesting interplant competition may not occur until soybeans are seeded above 130,000 seeds A^{-1}. At R5 total biomass accumulation was similar for all seeding rates at both locations (Table 3).
- Due to soybean ability to compensate at low seeding rates, biomass per plant decreased as seeding rate increased at V4. Seeding rate and fertilizer had a statistically significant interaction in Richville (P=0.02) and Lansing (P<.01). MESZ increased biomass per plant at lower seeding rates at both locations indicating greater response to MESZ at lower plant populations (Table 4; Table 5).

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