

Organic Soybean Population Study

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This study was initiated to evaluate the impact of population density on soybean grain yield, seed quality and weed suppression. Four target populations (75,000, 150,000, 175,000 and 225,000 seeds/acre) were replicated 3 times. The highest and lowest populations were outside the range of populations commonly used in both conventional and organic production systems. Seed quality was an important aspect of this study because of the stricter quality standards required for food grade soybean markets.

Methods:

The experimental plots (4 rows x 960 ft) were planted in field 2B to a food grade soybean variety (Iowa 3001) on 6/27/98 using a Buffalo 4 row planter with 30" row spacing. The experimental site was located at the Allison Organic Research and Demonstration farm (Roseville, IL) and followed a three year crop rotation (corn-soybean-small grain/red clover). Mechanical weed control consisted of multiple shallow tillage passes prior to planting, 2 rotary hoeings and 3 row cultivations. Assessment of weed suppression consisted of counting the number of foxtail heads and broadleaves that emerged above the soybean canopy. Foxtail and broadleaves were sampled on 9/23/98 from 2 representative 1 row sections in each plot (80 total feet for foxtail and 360 total feet for broadleaves). The final stand count was performed on 10/8/98. Nine representative rows 5 feet in length were counted for each population treatment to arrive at the average population. The field was harvested on 11/17/98 with a Gleaner combine. Plot yields were determined using a weigh wagon and converted to yields per acre at 13% moisture. A representative sample of soybean seeds from each plot (20 g of seed isolated by 3 splits from 160 g) was visually separated into 6 quality categories and weights were determined for each category. Gross and net income (per acre) were both calculated using 1998 yield data and February 2008 grain and seed prices (Table 3).

Results:

Soybean yield increased with population increase (Graph1 and Table 1). The 2 highest soybean population treatments had a yield difference among each other of 1.7 bu/a, which was not statistically significantly different. However, both of these populations had yields that were significantly higher than the 2 other lower populations (Table 1).

Broadleaf weeds did decrease in numbers as soybean population increased, but not significantly even though the highest soybean population had less than half as many weeds as the lowest soybean population. Foxtail (predominately Giant) weeds also reduced in numbers as soybean plants increased. Significant differences of foxtail weeds among treatments were observed (Table 1).

The 2 higher populations produced significantly more excellent quality/unblemished seeds than the lowest soybean population (Table 2). Seed size did not vary significantly with population (data not presented).

Based on current seed and grain prices, the highest final population achieved in this study (166,900 plants/acre) was most profitable (Table 3).

Graph 1.

Yields in Various Soybean Populations

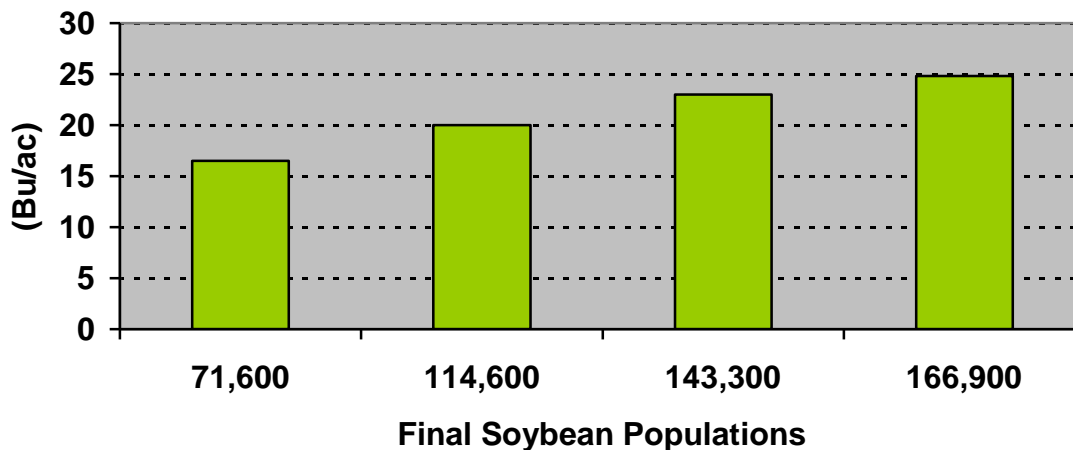


Table 1. Effect of Soybean Population on Grain Yield and Weed Counts

Intended Soybean Population	Final Soybean Population	Yield (bu/a)	% Yield increase relative to lowest population	Foxtail weeds/ac	% Foxtail reduction relative to lowest population	Broadleaf weeds/ac	% Broadleaf reduction relative to lowest population
75,000/ac	71,600/ac	16.5	N/A	131,018	N/A	1,293	N/A
150,000/ac	114,600/ac	20.0	21%	45,998	65%	1,019	21%
175,000/ac	143,300/ac	23.0	39%	29,648	77%	873	32%
225,000/ac	166,900/ac	24.8	50%	16,931	87%	631	52%
		LSD* = 2.96		LSD* = 25,599		LSD* = 727	

* $\alpha = 0.05$

Table 2. Effect of Soybean Population on Seed Quality

Intended Soybean Population	Final Soybean Population	% of soybean seeds Unblemished/ Excellent appearance	% of Soybean seeds with brown stain	% of Soybean seeds with purple stain	% of Soybean seeds with green stain	% of Soybean seeds with damage	% of Soybean seeds with splits
75,000/ac	71,600/ac	9.6	62.2	2.9	0.3	17.8	4.5
150,000/ac	114,600/ac	16.9	62.3	2.2	0.2	9.2	4.8
175,000/ac	143,300/ac	22.2	54.9	3.6	0.2	10.7	2.5
225,000/ac	166,900/ac	26.0	52.6	1.4	0.2	9.5	3.8
		LSD* = 7.58	LSD* = 15.5	LSD* = 2.0	LSD* = 0.7	LSD* = 6.2	LSD* = 5.4

* $\alpha = 0.05$

Table 3. Effect of Soybean Population on Production System Economics

Intended Soybean Population	Final Soybean Population	Yield (bu/a)	Gross income per acre at \$30/bu*	Intended Population Seed cost per acre at \$38.50 per bag**	Final Population Seed cost per acre at \$38.50 per bag**	Net income increase per acre over lowest population***
75,000/ac	71,600/ac	16.5	\$495	\$20.63	\$19.69	N/A
150,000/ac	114,600/ac	20.0	\$600	\$41.25	\$31.52	\$89
175,000/ac	143,300/ac	23.0	\$690	\$48.13	\$39.41	\$171
225,000/ac	166,900/ac	24.8	\$744	\$61.88	\$45.90	\$215

* Based on online report “USDA Livestock, Poultry, and Grain Market News” Feb, 2013.

** Based on the average full retail price of two food grade seed beans from Great Harvest Organics and Blue River Hybrids in 2012. Each bag contains 140,000 seeds.

*** This assumes there are no other differences in production or post harvest expenses. Seed expense figured into the net income was based on the average of intended and final population.

Summary of the Subsequent Year's Population Experiment:

A similar soybean population study was also performed in 1999 with higher yields, but less favorable results. This study was also planted to Iowa 3001 soybeans, but on 36" ridge-till rows and in field 1B. This experiment was planted 5/25/99, which was about one month earlier than the previous year's population experiment. Its methods of weed control included ridge-till planting, rotary hoeing 3x and row cultivating 3x. Weed populations were scored in the 1999 experiment instead of actual counts to save on time and due to no significant differences (table 4). Soybean quality was also evaluated, but there were no significant differences for any of the categories. Table 4 illustrates two of those for examples.

This 1999 experiment did show some significant yield differences among different populations. It also revealed a similar trend to the previous year with increasing yields as the population increased, with one exception. The highest population did drop in yield, but not significantly (table 4). It is important to note that a significant amount of rain (5.1") occurred between June 1st and June 13th. This led to shallow water standing in some parts of the field that may have impacted some of the reps yields. This may even be the reason for the highest population to break the pattern and drop in yield.

The amount of weeds in the 1999 experiment was fewer than in the 1998 experiment, even though it was planted a month earlier during a time when weed competition can be intense. This is most likely credited to planting under ridge-till management instead of using conventional tillage. Our experience with planting organic soybeans early (prior to the 2nd week in June) using conventional tillage is that the weeds are still very competitive with the crop. However, we have had good success with soybeans competing against weeds that were planted early under ridge-till management, such as the 1999 population experiment. While this experiment was not repeated exactly like the one in the previous year, it still revealed a pattern of increased yield with increased soybean population.

Table 4. Effect of Soybean Population on Grain Yield, Weed Counts, and Seed Quality in 1999 Study

Intended Soybean Population	Final Soybean Population	Yield (bu/a)	% Yield increase relative to lowest population	Foxtail Score**	Broadleaf Score**	% of Soybean seeds Unblemished/ Excellent appearance	% of Soybean seeds with damage
70,000/ac	61,600/ac	33.8	N/A	1.3	0.8	5.6	4.6
120,000/ac	97,800/ac	38.6	14%	1.2	1.0	6.1	3.0
160,000/ac	127,500/ac	40.2	19%	1.2	0.6	3.2	2.2
200,000/ac	161,300/ac	37.6	11%	1.4	0.4	6.8	2.9
		LSD* = 3.9		LSD* = 0.5	LSD* = 0.7	LSD* = 3.7	LSD* = 2.7

* $\alpha = 0.05$

** = Visual score of weed populations in an area of approximately 12'x20' using the following: 0 = none or insignificant, 1 = light, 2 = moderate, 3 = heavy

Discussion and Conclusions:

Our results suggest that there are multiple advantages to planting high populations of soybeans in organic production systems. In contrast, recent studies (e.g., Whigham (1998) and Nafziger (2003) indicate that conventional producers can increase profitability by planting at lower seeding rates than previously recommended.

Apparent differences in optimal soybean populations for organic and conventional production systems relate to differences in seed cost and role of competition in weed suppression. Weed suppression in organic soybean production relies heavily on rapid canopy closure while conventional soybean production relies heavily on herbicides to eliminate weeds. The cost of higher populations appears to be justified in organic production systems (table 3), at least up to the highest population in this study, due to accompanying benefits such as higher yields, better weed control, and higher quality beans. It is unclear why the higher soybean populations resulted in higher seed quality in 1998. It could be because the soybean plants in the higher population treatments had less competition from weeds, which may have resulted in less stress, insect pressure, and/or disease than treatments with more weeds.

These studies or similar ones will need to be repeated to draw stronger conclusions. We intended the final populations to be higher than was achieved. We are satisfied that our lowest population was low enough, but believe that the highest actual population in this type of study should be above 200,000/ac. Less tillage, higher top-end populations and an optimum planting date will be targeted if this type of study is pursued in the future.

Literature cited:

Whigham K. 1998. What is the best soybean seeding rate? Integrated Crop Management. Iowa State University Extension. <http://www.ipm.iastate.edu/ipm/icm/1998/4-27-1998/soyseed.html>

Nafziger E. 2003. Getting soybean planting right. Agronomy Day Field Tour Presentation. University of Illinois. http://agronomyday.cropsci.uiuc.edu/2003/soybean_planting/index.html