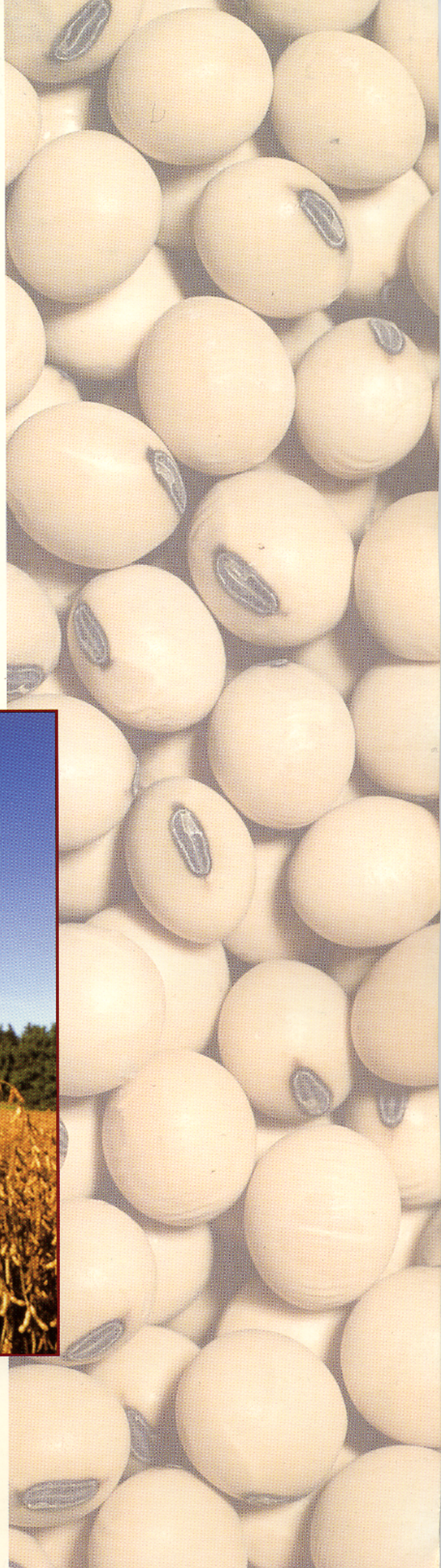
No-till soybean practices for the Midwest



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Contents

No-till soybean production has become increasingly popular in the Midwest within the last decade and for good reason: It's better for the environment, it's less labor intensive and less expensive than conventional tillage production, and it often provides better returns. This publication summarizes a collection of studies that examined production practices designed to help farmers realize a profit from their no-till soybean fields.

Improvements in soybean planting equipment, herbicides for weed control, and erosion concerns have all helped speed the adoption of reduced and no-till practices for soybean production in the Midwest. In the United States, no-till soybean acreage has increased from 6% in 1988 to 28% in 1998 (figure 1). Most midwestern states have shown a steady increase in no-till soybean acres during the past 5 years (figure 2). No-till is the predominate soybean planting system in Ohio and Indiana with more than 50% of the acres. More than a third of the soybean planted in Michigan, Illinois, and Missouri were planted no-till in 1998. The cost and time savings of no-till are a practical reality for many soybean growers.

Figure 1. Percent of soybean and all crops planted no-till in the United States, 1982–1998.

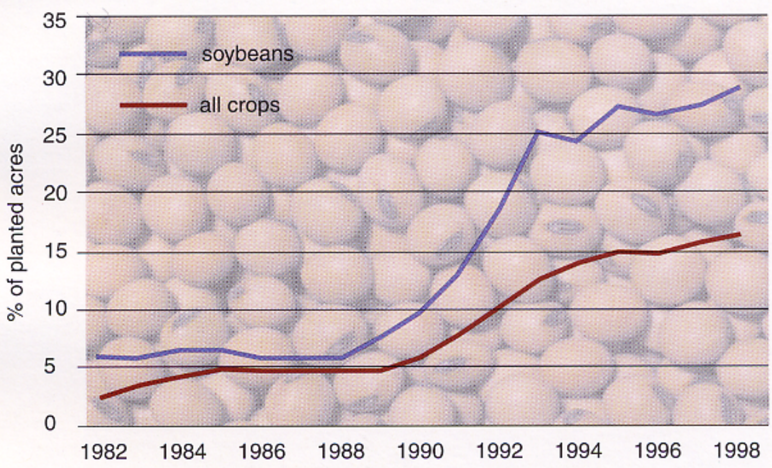
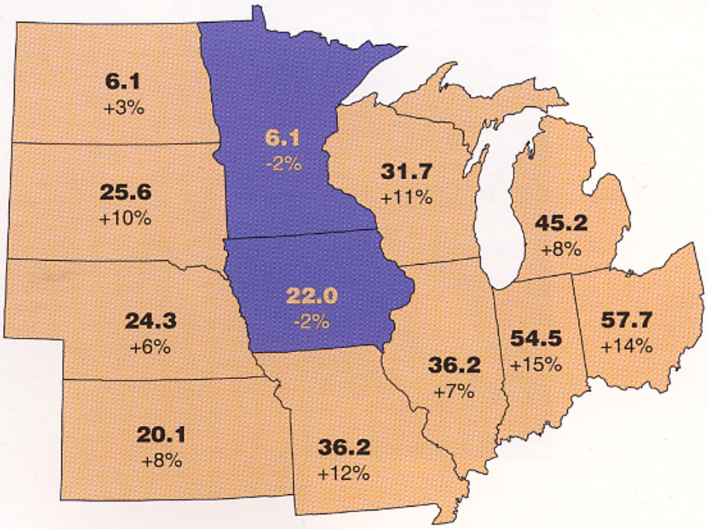


Figure 2. Percent of soybean planted using no-till in 1998 compared to 1994.



Researchers from eight Midwest states—Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, South Dakota, and Wisconsin—joined together to study no-till soybean management practices. From 1994 through 1996 they conducted trials with the following objectives:

- To enhance the adoption of no-till and reduced-till production practices by conducting on-farm trials to verify research recommendations. Figure 3 shows the location and distribution of these trials.
- To improve soybean variety selection by producers by conducting no-till variety tests and by developing a soybean variety performance database.
- To identify lower-cost herbicide treatments that could provide cost-effective weed control in no-till systems.

During this project information was distributed to growers through winter meetings, field tours, and individual state publications. This report summarizes the regional results with emphasis on yield and cost of production. Cost of production included all purchased inputs, land, machinery, and labor through harvest. The cost per bushel was determined by dividing total costs by the yield. Returns per acre were determined by multiplying yield by an average soybean price during each year of the study and subtracting production costs.

Tillage intensity

The primary purpose of this set of on-farm trials was to evaluate no-till (NT) soybean management practices against either conventional (CT) or reduced (RT) tillage practices. The diversity in tillage systems ranged from the use of the moldboard plow to a disk-plant system, and was compared in each case with no-till. Twenty-five replicated trials were conducted across six states during the 3-year study, however the majority of the comparisons were in 1994. No-till yields ranged from 33 to 72 bushels/acre while RT and CT had a range of 30 to 71 bushels/acre. In two trials, NT resulted in higher yields than RT or CT and in one trial the opposite occurred. In the other 22 trials yields did not differ due to tillage. When averaged across all trials (table 1), NT yields were the same as for RT and CT systems in spite of slightly lower plant stands. When production costs were included, the NT system returned $4 more per acre than RT or CT systems.

Figure 3. Locations of on-farm no-till soybean tests in the North Central Soybean Research Program Study, 1994–96.

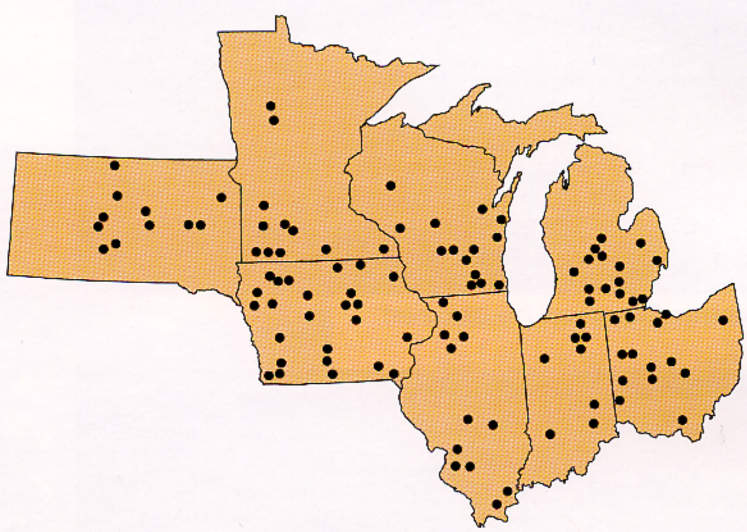


Table 1. Comparison of average soybean yields, population, costs, and returns between planted no-till (NT) and conventional tillage (CT) in the North-Central states.

Tillage system	Yield bushels/acre	Population plants/acre	Cost $/bushel	Return $/acre
No-till	48.4	161,000	$4.10	$116
Conventional/ reduced till	48.2	170,000	$4.18	$112

Wide rows (30–36 inches)

Intermediate rows (15–22 inches)

Narrow rows (7–10 inches)

Row spacing

The effect of row spacing on soybean yield has been a frequent question of growers for several years. Research results indicate maximum yields are produced when canopy closure occurs by the time the soybean plant begins flowering. Soybeans drilled in 7-inch rows generally require approximately 30 days to close the canopy when planted in mid-May. Generally, more days are needed for both earlier plantings and wider rows and when planting in the upper Midwest. Because of the slower, early growth of no-till soybeans, planting in narrow rows has generally been recommended. Row spacings were compared based on yield, cost, and returns. The following discussions summarize the findings.

Narrow vs. wide rows

In this study, 21 comparisons in five states were made between soybeans planted in narrow rows (7–10 inches) and wide rows (30–36 inches). In only six of the trials were yields significantly higher in the narrow row spacings, and in one case wide rows had higher yields than the narrow rows. However, with all trials combined (table 2), narrow row spacings had average yields that were 13% higher than wide row spacings. Production costs averaged nearly 50¢ less per bushel for narrow rows as compared to wide rows. And the average return from narrow rows was significantly higher—more than $30/acre—than for wide rows. Thus, while not all growers realized higher yields by using narrow row spacings, average yields were higher and returns per acre were greater for the narrow row system.

Narrow vs. intermediate rows

Nine growers in three states (Iowa, Ohio, and South Dakota) compared yield and production costs of narrow (7–10 inch) row and intermediate (15–22 inch) row spacings. There were no significant differences between these two systems (table 2). The data from these trials suggest that yields and profitability are nearly identical for soybeans planted in narrow or intermediate row spacings.

Although narrow-row yields were somewhat lower in this comparison than in the narrow vs. wide row comparison, the production costs in this study were lower and returns were about $50/acre more. This difference was primarily the result of good yield and lower land and other input costs for several comparisons made in South Dakota.

Table 2. Comparison of soybean yields, production costs, and returns in narrow rows, intermediate rows, and wide rows.

Row width	Yield bushels/acre	Cost $/bushel	Return $/acre
Comparison 1 (21 trials in five states)			
Narrow rows	47.5	$4.62	$89.30
Wide rows	42.1	$5.11	$58.52
Comparison 2 (9 trials in three states)			
Narrow rows	44.9	$3.45	$136.94
Intermediate rows	43.9	$3.52	$130.82
Comparison 3 (9 trials in two states)			
Intermediate rows	47.6	$3.97	$120.43
Wide rows	44.7	$4.25	$100.57

Intermediate vs. wide rows

Some growers are also interested in increasing yields with narrower row spacings but do not want to sacrifice the seed placement precision and/or residue clearing advantages afforded by most row planters. Nine growers in Iowa and Ohio compared soybean planted in the intermediate row spacings (15–22 inch) with conventional wide rows (30–36 inch). Soybean planted in intermediate rows averaged 6% higher yields, cost 28¢/bushel less to produce, and returned nearly $20/acre more than did soybean planted in wide rows (table 2). Therefore, it appears that producing soybean with intermediate row spacings in no-till is a viable option for producers in the Midwest.

Seeding rate

In most situations harvest stands are significantly lower than seeding rates, and the percent of plants that survive to harvest is generally lower with no-till than with conventional tillage systems. To maximize yields, plant populations must be optimum at harvest time. The final population size is a function of the seeding rate and growing conditions throughout the season. While producers can't control growing conditions, they can control the quality and quantity of the seed planted.

When determining seeding rate, it's critical to base calculations on the number of seeds per acre rather than pounds per acre since soybean seed size can vary from 2,000 to over 4,000 seeds/lb (table 3).

This set of studies examined the effect of seeding rate on soybean yields in 90 trials covering eight states. Nearly one-third of these trials (31) were conducted in Iowa over 25 counties.

Seeding rates ranged from a low of 74,000 to over 300,000 seeds/acre. Figure 4 shows the wide range of yields produced at each seeding rate. The average of the yields falls along the line drawn in the figure. When results from all seeding rates were compared, yields increased 2.04 bushels/acre for every increase of 50,000 seeds per acre; maximum yields occurred at seeding rates of approximately 225,000 seeds/acre. For each rate increase of 50,000 seeds, production costs were actually reduced by 50¢/bushel because of the yield increase. However, very little of the overall yield variation could be accounted for by variation in seeding rate.

Figure 4. Influence of seeding rate on no-till soybean yields.

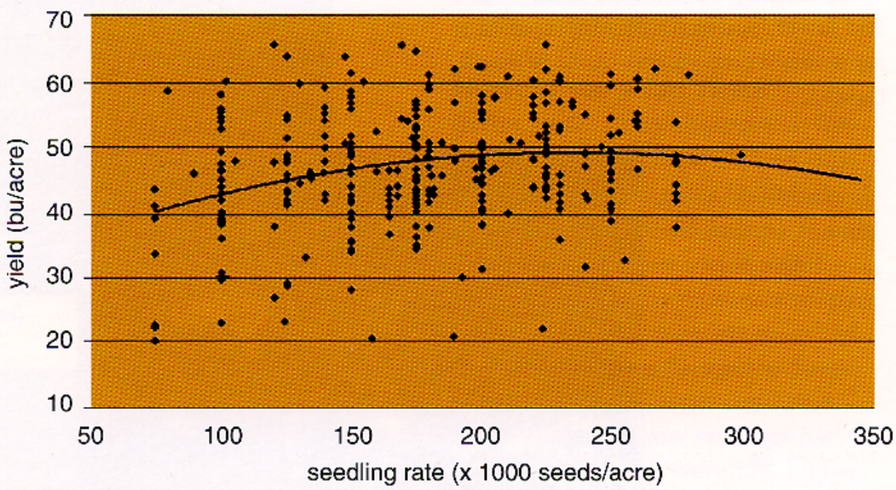


Table 3. Seed required for four seeding rates at different seed sizes.

Seed size (seeds/lb)	Seeds per 50 lb unit	Seeding rate per acre 150,000	175,000	200,000	225,000
		— pounds of seed per acre —			
2000	100,000	75	88	100	113
2250	112,500	67	78	89	100
2500	125,000	60	70	80	90
2750	137,500	55	64	73	82
3000	150,000	50	58	67	75
3250	162,500	46	54	62	69
3500	175,000	43	50	57	64
3750	187,500	40	47	53	60
4000	200,000	38	44	50	56

In other Wisconsin tillage studies, higher yields occurred with conventional tillage than with no-till at the same seeding rate. However, when harvest populations were similar, yields were nearly the same between the two tillage systems. Thus, under the cooler soil conditions of no-till production in the upper Midwest, increasing the seeding rate may increase profits.

The soybean plant adjusts to different stand densities by producing more branches and pods per plant if the population is low, and fewer if populations are high. With thin soybean stands, plants compete poorly against early weeds. When stands are too thick, lodging can reduce yields and diseases such as white mold may be more prevalent.

Another factor influencing seeding rate decisions is seed cost. As seed costs rise with new technologies, such as Roundup Ready, increasingly higher yields are needed to offset the added cost of increased seeding rates. For example, seed at $14/50 lb unit is equal to 28¢/lb; seed at $24/50 lb is equal to 48¢/lb. Also a rate increase of 50,000 seeds/acre (using 2,500 seeds/lb) costs $5.60/acre more if seed is $14/50 lb unit but would cost $9.60 more if seed is at $24/50 lb (table 4). Soybean producers will likely choose to reduce input costs by reducing seeding rates as seed prices increase.

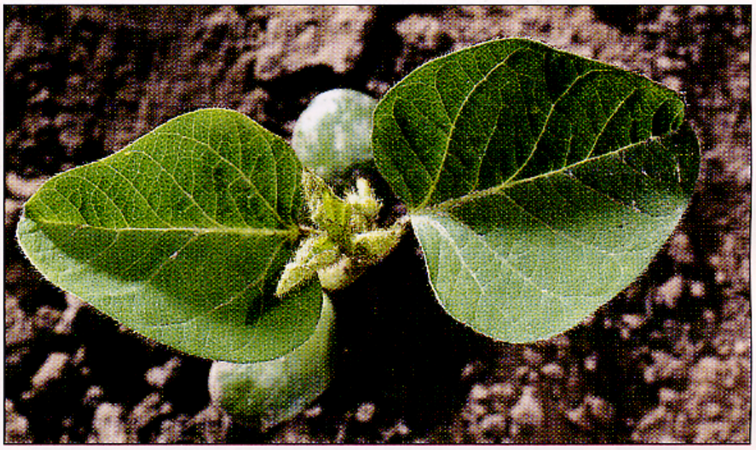


Table 4. Seed cost for 150,000 and 200,000 seeds/acre with different seed sizes.

Seed size	Price of a 50 lb unit of seed					
(seeds/lb)	$14	$16	$18	$20	$22	$24
	seed cost ($/acre) to plant 150,000 seeds/acre					
2000	21.00	24.00	27.00	30.00	33.00	36.00
2500	16.80	19.20	21.60	24.00	26.40	28.80
3000	14.00	16.00	18.00	20.00	22.00	24.00
3500	12.00	13.71	15.43	17.14	18.86	20.57
4000	10.50	12.00	13.50	15.00	16.50	18.00
	seed cost ($/acre) to plant 200,000 seeds/acre					
2000	28.00	32.00	36.00	40.00	44.00	48.00
2500	22.40	25.60	28.80	32.20	35.20	38.40
3000	18.67	21.33	24.00	26.67	29.33	32.00
3500	16.00	18.29	20.57	22.86	25.14	27.43
4000	14.00	16.00	18.00	20.00	22.00	24.00

Seed fungicide treatments

Cool, wet soil conditions are frequently associated with early planting dates and no-till production. These conditions slow seedling growth and are ideal for soil pathogens that may damage the soybean seed and reduce the stand. Using a fungicide seed treatment may improve seedling survival and lead to higher plant populations at harvest.

Fungicide seed treatments were evaluated in 50 on-farm trials over 3 years. The trials were performed in Illinois, Iowa, Michigan, Ohio, and Wisconsin. They compared harvest stand size, costs, and returns of soybeans treated with Rival, Rival + Apron, Agrosol-T, Vitavax 2000, or Thiram against the performance of untreated seed. Results were mixed: While the fungicide seed treatments increased harvest stands each year, yields were slightly higher (1 bushel/acre) only 2 out of 3 years (figures 5a and b). When the cost of the seed treatment was included in production costs, the cost per bushel ranged from 17¢ more to 15¢ less for treated seed (figure 5c). This resulted in returns ranging from $7.00/acre less to $11.00/acre more. Eight of these trials were conducted in Iowa. In five of the trials, there was no effect on yield due to seed treatment. Two trials resulted in higher yields when a seed treatment was used and one trial produced a higher yield without the fungicide. When averaged across all eight trials in Iowa, yields and cost per bushel were not different, but final harvest stands were increased 8,000 plants/acre with the fungicide seed treatment.

Figure 5a. Harvest population of no-till soybeans using fungicide treated and untreated seed.

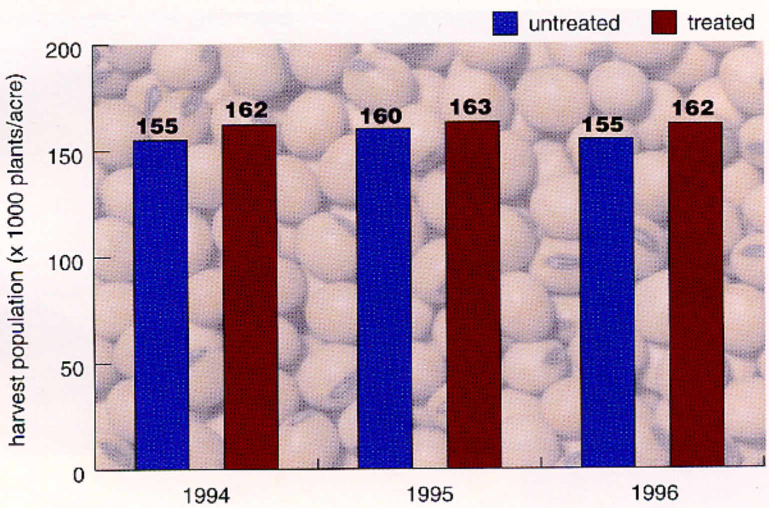
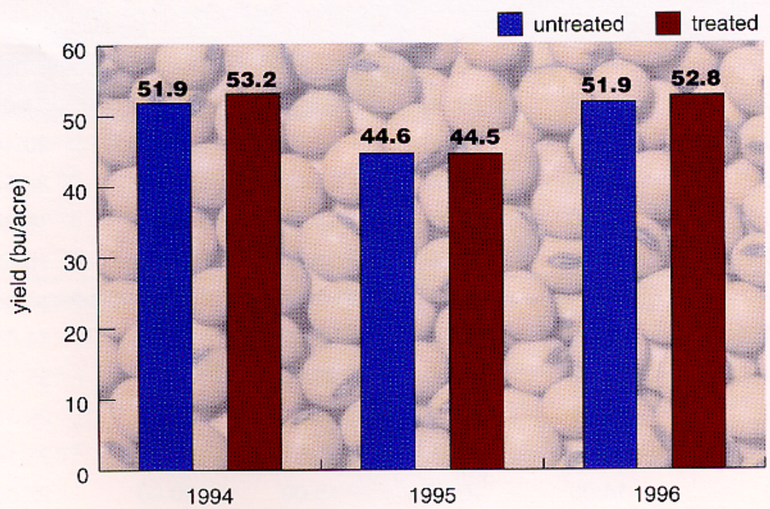


Figure 5b. Yield of no-till soybean using fungicide treated and untreated seed.



As a counterpoint to the multi-state findings, studies conducted over a 7-year period in Wisconsin found an average yield increase of 6.2 bushels/ acre (11%) and an initial plant stand increase of 21,500 plants/acre (19%). The results of these studies are illustrated in figures 6a and b. The differences are likely due to cooler soil temperatures and higher crop residue levels in the Wisconsin trials as compared to the multi-state trials. The Wisconsin studies were all planted at 225,000 viable seeds/acre using a no-till drill in 7.5-inch rows. The established plant stands were less than one-half the initial seeding rate and yet grain yields were always greater than 50 bushels/acre. Considering the final yield, replanting to increase plant stands would not have been a profitable recommendation. However, the use of fungicide-treated seed was profitable in this situation.

Figure 6a. Yield of no-till soybeans using treated (Rival) and untreated seed in Wisconsin.

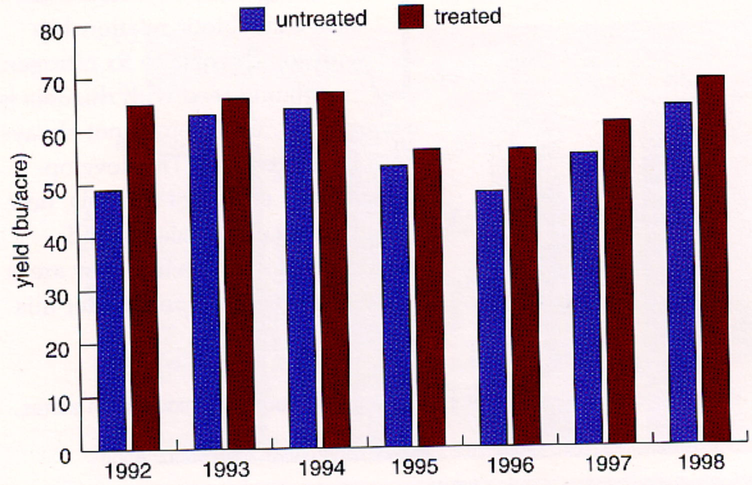


Figure 6b. Established plant stands of no-till soybeans using treated (Rival) and untreated seed in Wisconsin.

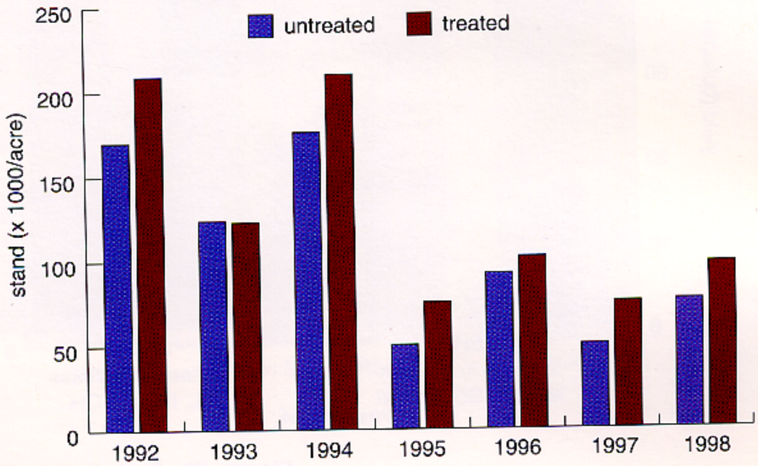
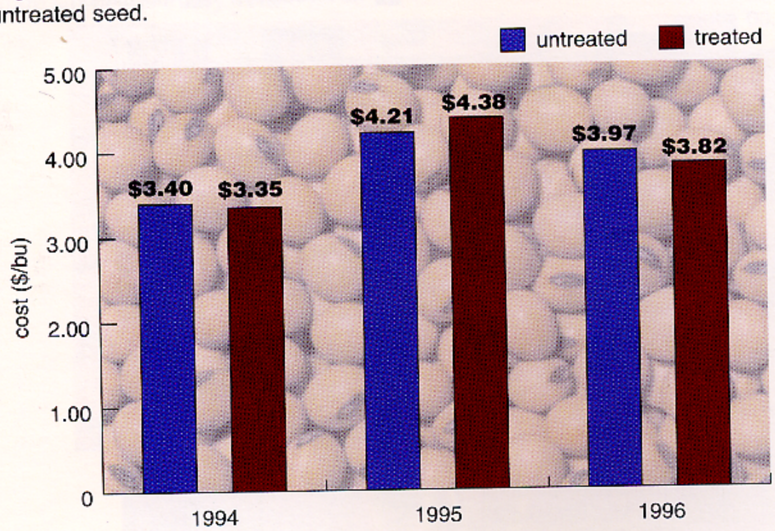


Figure 5c. Cost of production of no-till soybean using fungicide treated and untreated seed.



Inoculation

Like all legumes, soybeans must form a symbiotic relationship with soil rhizobia to fix nitrogen. Inoculating seed with rhizobia is a common practice, but is not always used by all growers. The development of new strains of rhizobia, new formulations of inoculants, and expansion of soybean into new areas have given reason to reconsider this practice.

Soybean inoculants were evaluated in 44 trials across seven states (Illinois, Indiana, Michigan, Minnesota, Ohio, South Dakota, and Wisconsin) during the 3-year period of this no-till study. Inoculant treatments and rates varied but always included a recommended rate for each product. There was a significant difference between regions (figures 7a and b). In the more southern states (Illinois, Indiana, and Ohio), inoculation had little effect on grain yields and production costs. But in the cooler soils of the more northern states (Michigan, Minnesota, South Dakota, and Wisconsin), inoculated soybeans yielded 3.8 bushels/acre more (8.6% increase) than uninoculated soybeans and the cost of production was reduced from $4.80/bushel to $4.18/bushel (13% decrease). Thus, in the northern part of the Midwest, using inoculants proved more profitable than using uninoculated seed.

Figure 7a. Yield of inoculated soybean in northern and southern midwestern states.

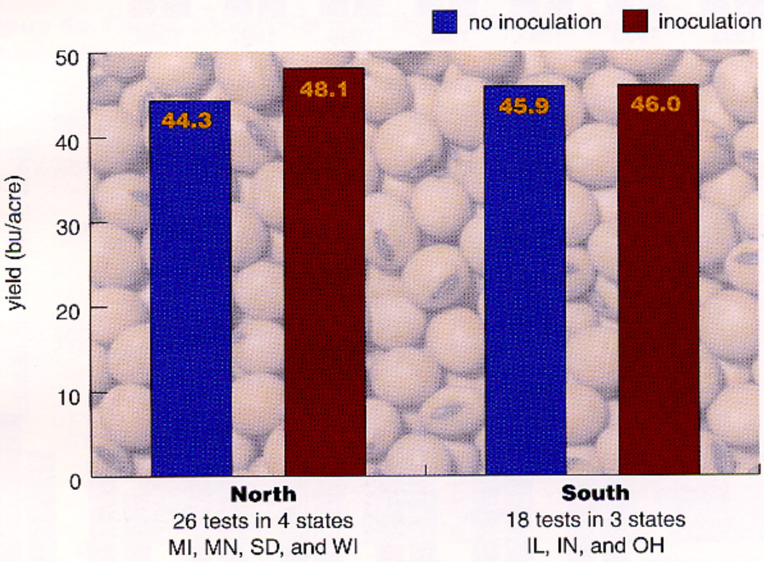
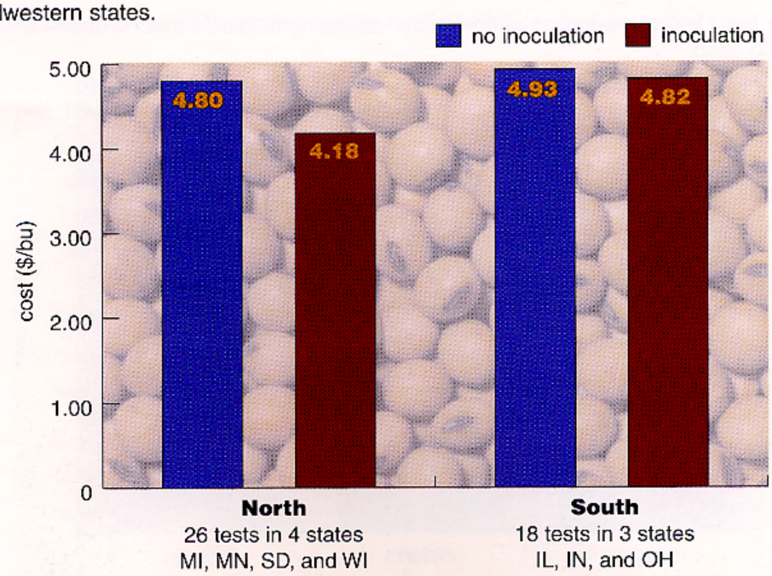


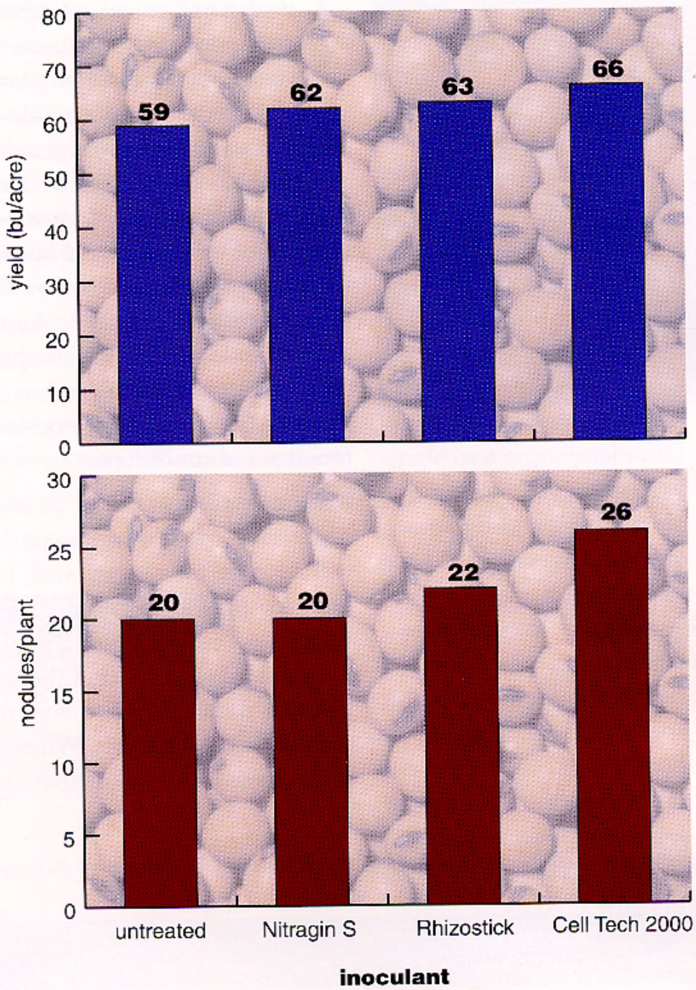
Figure 7b. Cost of production of inoculated soybean in northern and southern midwestern states.



Wisconsin studies conducted from 1995 through 1998 found similar results (figure 8). The use of inoculants increased yields an average of 4.6 bushels/acre (8%). In these studies, treated plants had an average increase of only 3 nodules/plant (13%) as compared to the untreated soybeans. The newer sterile seed treatment materials increased yields as much as 7 bushels/acre over the untreated soybean. This occurred even though the uninoculated soybean plants averaged 20 nodules/ plant and yielded more than 50 bushels/acre.

These findings may help to explain the differences in inoculant recommendations among states. For example, Extension offices in many midwestern states recommend that no inoculants are needed on silt loam and loam soils where well-nodulated soybean has been grown in the last 3–5 years and where soil pH has been maintained above 6. They also advise that seed should be inoculated every year when planted on sandy soils or in new soybean fields. However, in the upper Midwest, where soils tend to be cooler, the rotations longer, and a high percentage of soybeans are planted using reduced till and no-till, it is recommended that growers inoculate soybeans every year.

Figure 8. Yield and number of nodules of soybean treated with various inoculants. Wisconsin 1995–98.



Variety selection

This portion of the study examined whether some soybean varieties perform better under no-till conditions than when planted using conventional tillage. Most soybean varieties have a genetic yield potential in excess of 100 bushels/acre. They seldom produce to this potential because of environmental stresses. A variety's performance in a yield trial is a measure of both its performance in that environment and the production system used—it does not ensure comparable performance under a different set of conditions.

During this 3-year study, 36 tests compared soybean variety performance in no-till systems with performance using conventional or chisel/disk-tillage. Table 5 summarizes the average yield of the soybean varieties under NT compared to CT at each of the 14 locations. When averaged across all locations there was no difference between tillages in 1994 but in the other 2 years, yields using CT averaged 2–3 bushels/acre more than with NT. However, the main objective was to determine how closely performance in conventional-till trials predicts performance in no-till systems. Table 6 shows the results. In 1994, in five of the trials the same variety was the highest yielding variety in both tillage systems. In the next 2 years this result occurred only four more times.

When considered over all years, the relative performance of soybean varieties in the two tillage systems was most similar in tests conducted in Illinois, Iowa, and Michigan compared to tests in the other states. When averaged over all states, soybean variety performance tests conducted using CT was more accurate in determining top variety performance in NT than vice versa. We also found that test variability was greater in NT than in CT. This means that yield differences between soybean varieties measured in NT would have to be greater than yield differences measured in CT for the difference to be real.

Table 5. Performance of soybean varieties in conventional (CT) and no-till (NT) in North Central States.

Test location	Number of varieties	1994 NT	1994 CT	1995 NT	1995 CT	1996 NT	1996 CT
		bu/acre					
Illinois—Dekalb	27	59.7	59.1	48.6	52.1	52.0	54.4
Indiana—Butterville	11	54.1	46.4	38.2	55.0	33.5	39.8
Iowa—Maquoketa	20	—	—	62.5	58.5	52.0	54.9
Iowa—Rowley	20	61.6	64.1	49.4	49.6	45.2	45.4
Michigan—E. Lansing	13	62.8	68.3	56.1	57.0	58.0	58.1
Minnesota—Lamberton	32	48.3	54.8	46.0	48.2	40.0	59.9
Minnesota—Waseca	32	—	—	46.0	64.1	30.4	24.5
Ohio—Covington	27	46.7	56.3	—	—	—	—
Ohio—Custer	26	53.6	56.7	52.8	52.9	45.1	40.1
Ohio—Willard	27	52.0	46.7	52.8	43.1	48.5	55.5
S. Dakota—Beresford	22	—	—	38.2	37.6	38.8	41.4
Wisconsin—Arlington	28	57.7	50.2	62.0	66.7	51.5	57.5
Wisconsin—Janesville	28	54.6	53.2	64.0	63.8	56.5	60.2
Wisconsin—Lancaster	28	—	—	64.7	65.4	46.8	52.1
Average		55.1	55.6	52.4	54.9	46.0	49.5

Most agronomists and soybean breeders have felt that relative soybean variety performance is similar in NT to that under CT or RT unless plants are stressed. In NT and RT systems, the most common stress comes from disease—especially Phytophthora root rot, brown stem rot, Pythium, and Rhizoctonia root rot. Where these diseases occur frequently, it is particularly important to select resistant or tolerant varieties when planting no-till. Typically, soybean disease pressure is greater in NT than in CT. Therefore, proper variety selection is often more critical for no-till systems than for conventional-till systems.

Table 6. Yield performance ranking in no-till systems of the top-ranked varieties in conventional-till systems.

Test location	1994	1995	1996
	NT rank of top CT varieties		
Illinois—Dekalb	1	7	2
Indiana—Butterville	10	4	11
Iowa—Maquoketa	—	2	1
Iowa—Rowley	8	1	1
Michigan—E. Lansing	1	5	1
Minnesota—Lamberton	8	7	6
Minnesota—Waseca	—	17	—
Ohio—Covington	17	—	—
Ohio—Custer	1	9	19
Ohio—Willard	1	12	7
South Dakota—Beresford	1	14	3
Wisconsin—Arlington	2	2	3
Wisconsin—Janesville	5	8	3
Wisconsin—Lancaster	—	35	8

Weed control

Successful no-till soybean production depends on the use of efficient, cost-effective weed control programs. No-till production systems are more dependent on herbicides for weed control than conventional or reduced-tillage systems where soil is tilled in spring prior to planting. Most weed scientists and growers have found that emerged weeds must be controlled ahead of planting with an effective early preplant herbicide or with burndown herbicides. The availability of Roundup Ready soybean varieties has significantly altered the weed control options in no-till production.

Herbicides make up a significant cost in the production of no-till soybeans. One goal of this project was to identify situations, especially in no-till, where lower rates or lower cost herbicide treatments would provide cost effective weed control.

Six states (Indiana, Iowa, Michigan, Minnesota, Ohio, and Wisconsin) conducted 45 reduced-rate herbicide studies during the 3-year period. The results are summarized in table 7. Treatments consisted of herbicides used at either one-fourth or half the labeled rates and applied either as a single or a sequential postemergence application. The reduced rates were compared to a single treatment at the full rate. When averaged over all years and locations, the one-fourth rate applied as a single application yielded 3 bushels/acre less than the full-rate of herbicide applied once. Although the yield was lower, when herbicide costs are subtracted from the gross returns, profits were similar to the full-rate of herbicide—$235/acre compared to $232/acre. There was no difference in yield when herbicides were applied twice at one-fourth the rate, for either of the half-rate applications, or for the single full-rate application. When averaged across all tests, there was only 1 bushel/acre difference in any of these treatments each year. The most profitable treatment when averaged over all 3 years

Table 7. Soybean yield and returns as affected by various rates and timings of post-applied herbicides.

Herbicide rate	Treatment frequency	1994 (16 tests) bu/acre	1994 (16 tests) $/acre	1995 (16 tests) bu/acre	1995 (16 tests) $/acre	1996 (13 tests) bu/acre	1996 (13 tests) $/acre	Average (45 tests) bu/acre	Average (45 tests) $/acre
¼	1	45	240	42	220	46	244	44	235
¼	2	50	258	47	237	46	234	48	243
½	1	50	269	46	235	47	244	48	249
½	2	51	249	47	229	47	224	48	234
1	1	50	249	46	225	45	223	47	232
untreated	—	39	214	35	188	37	196	37	199

was the half-rate herbicide applied once which returned $249/acre over the herbicide and application costs. In all cases, soybean yields and returns were substantially higher with any of the herbicide treatments when compared to untreated soybeans. The success of these reduced-rate herbicide treatments was due in part to several factors. First, weed size and type were carefully assessed during the season to determine the ideal time for herbicide applications and, second, herbicide selection was matched to the weed spectrum.

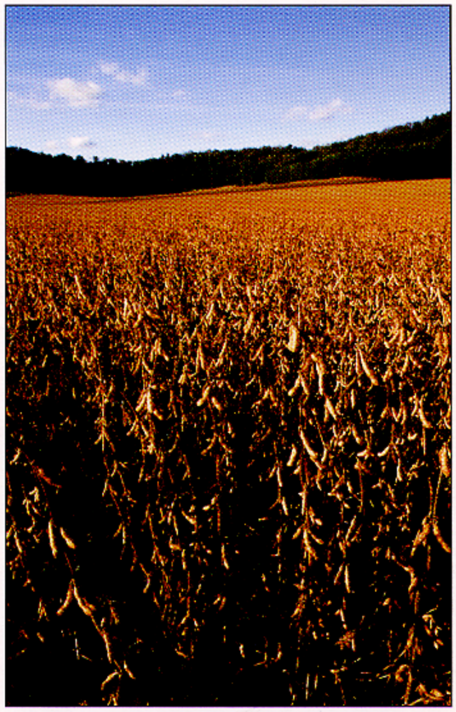
Success using reduced rates of herbicide application will also depend on the weed pressure in a particular field.

This study shows that growers can reduce the rate of many postemergence herbicides without reducing soybean yields. In return, growers could realize a greater return per acre due to lower herbicide costs. If considering using reduced rates, keep in mind that the manufacturer and commercial applicator are not liable for performance.

Summary

Most soybean producers in the Midwest will lower production costs when switching from conventional till to no-till. Many will also produce a greater profit. The bottom line depends on how well a producer manages the crop using no-till practices and how well yields are maintained with this system. The following production tips summarize the key findings of the 3-year project.

- Narrow and intermediate row spacings are more profitable than wide rows.
- Increasing the seeding rate drops production costs—up to about 225,000 seeds/acre.
- Fungicide seed treatments will increase yield enough to lower overall production costs 2 out of 3 years.
- Yield increases from inoculating seed are more likely to occur in the upper Midwest than in other parts of the region.
- When selecting varieties, use data from no-till performance evaluations if it's available. If diseases are a problem, look for high-yielding varieties that are also disease resistant or tolerant.
- Depending on the weed pressures in a field, reduced herbicide rates can effectively keep weeds in check without cutting profits.



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