Stale seedbed production of soybeans with a wheat cover crop

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ABSTRACT: Stale seedbed planting is a technique soybean producers have begun to adopt for the clay soils of the Delta. It is defined as planting in a smooth, weedy, but not recently disturbed seedbed. On these clay soils of the Delta, erosion may be a problem if a fall or winter tillage operation is necessary to smooth the seedbed, leaving no soil cover from residue or vegetation during the rainy, winter season. Wheat was investigated as a cover crop. Wheat as a cover crop did provide sufficient soil cover from vegetation, although in most years natural winter vegetation also was sufficient. Wheat as a cover crop did not affect soybean yields in any year of three experiments conducted over 6 years.

THE Mississippi River alluvial plain, the Delta, includes more than 3.7 million ha (10 million acres) of clay soils that shrink and swell or crack (*1*). The relatively flat topography of the region would suggest low potential for soil erosion. But recent work has demonstrated a basis for concern (*13, 14*). Because crop production on these soils requires drainage, runoff does occur from these areas. With runoff, soil loss is inevitable. Soil loss occurs as primary clay particles, and aggregates from these soils are transported by runoff water. In some cases, soil loss from these flat watersheds exceeds the established soil loss tolerances for agricultural land (*13, 14*).

These soils, while productive, are difficult to manage for row-crop agriculture (*1, 4*). Soil erosion during the winter between soybean harvest in November and new crop seeding in May can be severe. Alternative cropping practices can reduce sediment yields (*11, 12, 16*), even from clay soils (*3*). No-till practices are effective in reducing soil erosion. Wheat residue and vegetative cover, as in a wheat-soybean doublecropping system, also are effective aids in controlling soil loss during winter months (*3*).

One management technique that has shown promise is the stale seedbed concept developed for soybean production (*4, 5, 8*). This concept involves planting soybeans in a previously smoothed, if necessary, but not recently tilled, weedy seedbed. A smoothing operation, either disking or harrowing, if necessary, is performed sometime after harvest but well before spring seeding. If spring tillage must be performed, it should be sufficiently early to allow for subsequent rain to settle and firm the seedbed (*4*). This concept is well established for soybean production and has been well received. (Claude Derting, personal communication).

Our objective was to evaluate the ground covers in an undisturbed stale seedbed, in a winter wheat cover crop, and in a harvested winter wheat (doublecrop) production systems. We also compared early and late seeding of soybeans in a stale seedbed and wheat cover crop to provide information for producers and agricultural advisors contemplating use of this approach as an alternative management practice.

Study methods

Experiment 1. The study was conducted for 6 consecutive years (1984-1989) on a Tunica clay (clay over loam, montmorillonitic, nonacid, thermic, Vertic Haplaquept) near Stoneville, Mississippi. The soil is characterized by a high percentage of clay, poor internal drainage, and high water-holding capacity.

The study included three cropping systems (treatments) in separate irrigated and nonirrigated experiments. Treatments were continuous monocrop soybeans (SB), continuous wheat-soybean doublecropping (DCSB), and continuous monocrop soybeans with wheat as a winter cover crop (CCSB). Treatments were arranged in a randomized complete block design with four replicates in both irrigated and nonirrigated experiments. Plots were 16 m (52 feet) wide and 30.5 m (100 feet) long. Soybean row spacing was 1 m (40 inches). Data were analyzed separately each year for each irrigation regime and cropping system, then combined over all years for analysis. Differences among treatment means were significant when the F ratio was greater than required at $p=0.05$.

We collected soil samples from each plot during the growing season of each year to determine fertility levels. Soil pH ranged from 6.0 to 6.5; organic matter percentage ranged from 0.89 to 2.41; P and K levels in all plots were in the range considered adequate for these crops on this soil type.

Soybeans. Furrow irrigation was used in 1984; a lateral-move sprinkler system was used in subsequent years. Each plot in each replicate was irrigated separately by controlling gates or nozzles. Irrigation started when soybeans began to bloom and ended at the full-seed stage. Water was applied within this period whenever soil water potential at the 30-cm (12-inch) soil depth in three replicates averaged between −50

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and −70 centibars. Previous research with soybeans on clay soil indicated this tensiometer placement depth was optimum for maximum yield response (*6*).

Tillage of the SB plots (Table 1) consisted of nothing or a disking well before planting, when necessary, for seedbed smoothing. We used herbicides to kill weeds in the SB plots and the winter wheat cover crop in the CCSB plots prior to planting soybeans in May. In the DCSB plots, soybeans were no-till planted in burned wheat stubble after wheat harvest (June). We harvested the center four rows of each soybean plot for yield determination. Yields were calculated at 130 g/kg moisture (13.0%).

Extremely dry conditions were present throughout the soybean crop planting period in 1988, which resulted in no soybean crop in the nonirrigated experiment. On August 19, 1988, the entire nonirrigated experiment was disked twice, land-planed, and fallowed until the subsequent crop (wheat or soybean) was planted.

Soybean cultivars used were Centinnial in 1984; Braxton in 1985 and 1986; and Asgrow 5980 in 1987, 1988, and 1989. Soybeans were seeded at 33 seeds/m (10 seeds/foot); an adequate and uniform stand was obtained each year. The later-than-desired planting date of June 16 in the irrigated 1986 study was because of failed stands from the May 6 and May 23 plantings. Cultivation was performed in all soybean plots as needed, usually two times each season. Table 1 lists other aspects of weed control and production inputs.

Table 1. Cultural and management practices applied to soybeans and wheat grown near Stoneville, Mississippi, 1984-1989.

Year, System* and Crop	Dates: Tillage	Dates: Planting	Weed Control: Type†	Weed Control: Material‡	Harvest Date
1984					
SB					
Soybeans	Oct. 10, 1983	May 14	PRE	4, 7, 8	Nov. 8
			POST	5, 10	
DCSB and CCSB					
Wheat	Oct. 18, 1983	Oct. 18			June 5
Soybeans	Oct. 18, 1983	June 8	PRE	4, 7, 8	Nov. 8
			POST	1, 2, 5, 10	Nov. 8
1985					
SB					
Soybeans	March 13, 1985	May 3	PRE	4, 7, 8	Nov. 9
			POST	5, 10	
DCSB and CCSB					
Wheat	None	Nov. 15, 1984			June 4
Soybeans	None	June 4 (I)§	PRE	7, 8	Nov. 9
		June 26 (NI)	POST	5, 10 (I)	Nov. 9
1986					
SB					
Soybeans	Nov. 13, 1985	June 16 (I)	PRE	4, 7, 8	Nov. 19
	April 24, 1986	May 23 (NI)	POST	5	
DCSB and CCSB					
Wheat	Nov. 12, 1985	Nov. 13, 1985			June 16
Soybeans		June 18	PRE	4, 7, 8	Nov. 19
			POST	5	
1987					
SB					
Soybeans	April 10, 1987	May 5	PRE	6, 7, 8	Sept. 24
			POST	3, 10 (I)	
DCSB and CCSB					
Wheat	None	Nov. 19, 1986			June 9
Soybeans	June 9, 1987	June 29	PRE	6, 7, 8	Oct. 21
			POST	2	
1988#					
SB					
Soybeans	None	May 10	PRE	6, 8, 9	Oct. 12
			POST	10	
DCSB and CCSB					
Wheat	Oct. 22, 1987	Oct. 23, 1987			June 2
Soybeans	Oct. 22, 1987	June 2 (I)	PRE	6, 8, 9	Oct. 18
			POST	10	
1989					
SB					
Soybeans	Oct. 18, 1988	April 28 (I)	PRE	6, 8, 9	Oct. 5
		May1 (NI)	POST	10	
DCSB and CCSB					
Wheat	Oct. 18, 1988	Nov. 9, 1988			June 19
Soybeans	Oct. 18, 1988	June 20	PRE	6, 8, 9	Oct. 26
			POST	2, 10	

*SB, continuous soybeans; DCSB, doublecrop soybeans; CCSB, covercrop soybeans. CCSB was treated like DCSB in the fall for wheat planting but like SB in the spring for soybean planting, including the same planting date. Seeding rate of wheat for CCSB was half that for DCSB.
†PRE, preemergence application of herbicides; POST, postemergence application.
‡Herbicides used at labelled rates and coded as follows: 1, acifluorfen; 2, bentazon; 3, chlorimuron; 4, dinoseb; 5, fluazifop; 6, glyphosate; 7, metolachlor; 8, metribuzin; 9, pendimethalin; 10, DB + linuron.
§I, irrigated; NI, nonirrigated.
#Nonirrigated experiments not planted.

Wheat. Planting dates for wheat in the CCSB and DCSB treatments ranged from October 18 to November 19 over the 6-year period (Table 1). In all years except 1984 and 1986, plots assigned to the CCSB and DCSB treatments were disked twice and harrowed in the fall to prepare a seedbed (Table 1). Wheat was planted at a rate of 112 kg/ha (100 pounds/acre) in the DCSB treatment and at 56 kg/ha (50 pounds/acre) in the CCSB treatment. Because of the late soybean harvest date and excessive rainfall during the wheat planting season (October 1-November 15) in 1984, 1985, and 1986, wheat was broadcast-seeded with cyclone seeders at the rate of 135 kg/ha (120 pounds/acre). Rainfall received during the October to November planting periods in 1984, 1985, and 1986 totaled 32.3, 11.2, and 18.0 cm (12.7, 4.4, and 7.1 inches), respectively. These seedings were not always able to be covered by disking.

Wheat cultivars used were Southern Belle in 1983, Coker 916 in 1984, and Florida 302 from 1985 to 1988. Seed was treated each year with carboxin and metalaxyl. Except in 1986, all wheat plots in the DCSB treatment were fertilized in the spring with a single application of granular urea-ammonium nitrate at growth stage 5 (Feeke's scale) with a nitrogen (N) rate of 112 kg/ha (100 pounds/acre). In 1986, the application was split into two smaller applications with the same final N rate. Weed populations were not great enough to require treatment or to affect yields. Two applications of the fungicide Mancozeb, a coordination product of zinc ion and manganese ethylene bisdithiocarbamate, were required in wheat plots to control septoria leaf blotch (*S. tritici* and *S. avenae*) during spring of 1989.

Ground cover. We determined ground cover from crop residue or vegetation in experiment 1 only by a photographic method (*10*). Ten randomly selected locations in each plot were photographed in January of each year with the camera perpendicular to the ground and at a height to cover the full space between two adjacent soybean rows. Slides were projected onto a gridded screen. Locations where crop residue or vegetation occurred on intersecting grid lines were counted. Percent ground cover was the percentage of intersecting grid lines contacting crop residue or vegetation.

Experiment 2. This study was conducted from 1985 through 1987 near Stoneville, Mississippi. Soil type was Sharkey clay (very-fine, montmorillonitic, nonacid, thermic, Vertic Haplaquept). The soil is characterized by less than 1% organic matter, poor internal drainage, a high level of fertility, less than 0.3% slope, low bulk density, uniformity with depth, and no compacted zones. The most prominent feature of this soil is the high degree of shrinking or cracking that occurs as the soil profile dries. Plots were 12.2 m (40 feet) wide and 20 m (65 feet) long. Row spacing was 1 m (40 inches). Seeding rate was 33 seeds/m (10 seeds/foot). The design was a randomized complete block with a split-plot factorial arrangement of treatments in four replicates. Main plots were planting dates (early or late May), and subplots were cover crop treatment (none or winter weeds and winter wheat).

Soybean cultivars were Centennial in 1985 and Leflore in 1986 and 1987. This change was made to reflect progress in cultivar development. All tillage operations between harvest and planting were conducted with either a disk-harrow, a spring-tooth harrow, or both. After planting soybeans, all plots were cultivated two or three times when needed for weed control. Plots were furrow-irrigated as needed during reproductive development. Irrigation was started at beginning bloom and ended at near full-seed stage, with irrigation scheduling determined as in experiment 1.

Seedbed preparation treatments included (a) disking twice in the fall with a disk-harrow and not tilling again before planting soybeans and (b) disking twice in the fall with a disk-harrow, broadcast seeding to wheat at 50 kg/ha (45 pounds/acre) for winter cover, and not tilling again before soybean planting.

Early plantings were seeded on May 3, 1985; May 6, 1986; and May 5, 1987. Late plantings that were dictated by soil moisture conditions were May 31, 1985; June 16, 1986; and May 28, 1987. Table 2 lists tillage dates and herbicide inputs for the various treatments during the 3 years. Glyphosate 0.56 kg ai/ha (0.5 pounds/acre) was used to kill the wheat cover in March of each season. All other herbicide inputs were at labeled rates and times consistent with effective weed control.

We used a field combine modified for small plots to harvest the two center rows of the plots. Harvest dates ranged from October 23 to November 12. Harvested seed was weighed and adjusted to 130 g/kg (13%) moisture content for yield determination.

Table 2. Cultural and management practices applied to soybeans grown with limited tillage on clay soil near Stoneville, Mississippi, 1985-1987 (Experiment 2).

	1985		1986		1987	
*Planting System**	*Tillage Dates†*	*Herbicide Application‡*	*Tillage Dates*	*Herbicide Application*	*Tillage Dates*	*Herbicide Application*
Early	3/11 (D) 3/13 (ST)	PRE 2, 3, 4 POST 6	11/13 (D)	PRE 2, 3, 4 POST 6	11/4 (D)	PRE 1, 2, 3 POST 6
Early + wheat	None	PRE 1, 2, 3, 4 POST 6	11/13 (D)	PRE 1, 2, 3, 4 POST 6	11/4 (D)	PRE 1, 2, 3 POST 6
Late	3/11 (D) 3/13 (ST)	PRE 2, 3, 4 POST 5, 6,	11/13 (D)	PRE 1, 2, 3, 4 POST 6	11/4 (D)	PRE 1, 2, 3 POST 6
Late + wheat	None	PRE 1, 2, 3, 4 POST 5, 6	11/13 (D)	PRE 1, 2, 3, 4 POST 6	11/4 (D)	PRE 1, 2, 3 POST 6

*Soybeans were planted either early (early May) or late (late May or early June) into a stale seedbed that had been tilled previously with a disk or spring-tooth harrow. Wheat was present or not as indicated.
†Day/Month; D, disk-harrow; St, spring-tooth harrow.
‡PRE, preemergence application; POST, application after crop emergence. 1, glyphosate; 2, metribuzin; 3, metolachlor; 4, dinoseb; 5, fluazifop; 6, 2, 4 – DB + linuron.

Table 3. Ground cover from plant residue and vegetation cover in January following the indicated crop year in stale seedbed planting systems (Experiment 1).

	Percentage of Ground Cover by Year						
*System**	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*Mean*
Irrigated							
SB	83	25b†	78	79a	35	35	56
CCSB	85	36ab	75	61ab	45	40	56
DCSB	80	45a	75	57b	40	46	57
Nonirrigated							
SB	78	20b	43	77a	-	66a	57
CCSB	79	37a	49	40b	-	38b	49
DCSB	78	45a	50	57ab	-	41b	54

*Soybean planting system; SB, conventional monocrop soybeans; CCSB, soybeans with wheat as a cover crop; DCSB, soybeans doublecropping system.
†Means in a column within an irrigation treatment followed by the same letter or no letter are not significantly different at P = 0.05, Duncans new multiple range test. Nonirrigated crop was not planted in 1988.

Results and discussion

Ground cover measurements taken in January after soybean harvest and wheat planting revealed that ground cover was high, even on SB plots (Table 3). The key to ground cover was the vegetation. Seeded wheat provided vegetative cover in the CCSB and DCSB treatments. Natural winter weeds provided vegetative cover in the SB plots. The quantity of winter vegetation varied from year to year. It would be expected to be low in those years that fall tillage was performed—1984, 1986, and 1989—and high when fall tillage was not performed—1985, 1987, and 1988 in the SB treatment. Our data indicated this was not always so, however (Table 3).

The quantity of winter vegetation results from use or absence of tillage, timely rainfall, and growth-inducing temperatures. At this location, germination of winter annuals commences in the fall after the first cool period and rain, usually in October. If tillage occurred before this, then tillage would have no consequence on winter vegetation, as in the fall of 1984. Growth of winter vegetation after germination depends highly on temperature, given adequate moisture. Because we measured ground cover in January, there was greater variability in the amount of vegetation than if a later date were chosen, such as March or April.

The ground cover was greater than 30% in all cases in which wheat was planted in the CCSB and DCSB treatments, whether tillage was performed or not. Ground cover was low on the SB treatment in 1985, even though no fall tillage was performed. In this case, planting a wheat cover crop increased ground cover because the natural weed population was low. In contrast, in 1987 the SB plot was not tilled, while the CCSB and DCSB plots were disked lightly to cover wheat that had been broadcast-seeded. In this year, the untilled SB treatment had more ground cover than the CCSB and the DCSB treatments. There were no significant differences in percentage of ground cover among the treatments when averaged over the 6 years of the experiment. However, differences among treatments occurred in 1985 and 1987. These differences depended on the climatic, environmental, and, to some extent, the cultural factors during those winter seasons. In no case did planting wheat result in a vegetative cover of less than 30%. In some years, ground cover was less in the SB treatment when climatic conditions delayed germination, emergence, and growth of the natural weed population compared to those treatments in which wheat was seeded.

Results from experiment 1 (Table 4) with 6 years of irrigated data and 5 years in nonirrigated experiments showed no significant yield differences between SB and CCSB treatments in any year or in the combined analysis over all years. Likewise, in experiment 2 (Table 5) with 3 years of data there was no difference between SB and CCSB treatments.

As far as yield is concerned, a producer need have no qualms about using wheat as a cover crop in a soybean production program. If a wheat crop planned for harvest did not look promising in March or early April, a decision could be made to desiccate the standing wheat and plant a soybean crop. There would be no yield consequences for the soybean crop because of this decision. However, tillage probably should not be done on clay soils to remove the wheat crop because this could delay planting and conceivably reduce soybean yields (*2, 5, 6, 7*).

Other factors, such as planting date, irrigation, and doublecropping with wheat, have considerable influence on soybean yield. Irrigation provides yield stability and increases yield on clay soils in most years (*5, 6, 9*). Using wheat as a cover crop had no effect on the benefits of irrigation in experiment 1 (Table 4).

Delayed planting reduced soybean yields, even with irrigation and a wheat cover crop (Table 5). This had been documented previously for clay soils (*2, 6, 7*). There was no effect measured from using wheat as a cover crop so long as it did not delay planting. In fact, from a practical standpoint, desiccating a wheat cover crop and planting in the standing stubble could be an aid for planting soybeans on time. The requirement to chemically treat the field in late March or early April forces a producer to begin field work early. The field then will be ready for stale seedbed planting (*6*) as soon as spring weather will permit, after chemical treatment.

Doublecropping soybeans with wheat generally reduces soybean yield (*15*), but with the gain of a harvested wheat crop. Wheat yields in experiment 1 ranged from 2,560 to 4,190 kg/ha (38 to 64 bushels/acre), and averaged 2,180 kg/ha (43 bushels/acre). This is in line with results previously reported on these soils (*15*).

The soybean yield reductions associated with doublecropping in experiment 1 were 600 kg/ha on irrigated plots and 720 kg/ha on the nonirrigated plots (9 and 11 bushels/acre). This is only slightly more than the decrease of 500 kg/ha (7 bushels/acre) simply because of delayed planting in experiment 2 (Table 5). It thus becomes an economic exercise to determine whether to doublecrop or not. Regardless of the economically based decision, the wheat cover, whether provided from a planting intended for a harvested crop or for a cover crop, is useful for soil protection during the vulnerable rainy winter months.

Table 4. Soybean yield for 6 years in a stale seedbed planting system with wheat as a cover crop or as harvested doublecrop (Experiment 1).

System*	1984	1985	1986	1987	1988	1989	Mean
	Soybean Yields by Year (kg/ha)						
Irrigated							
SB	2,570	2,540	2,050	3,070a†	3,290ab	3,160a	2,780a
CCSB	2,760	2,740	1,910	3,120a	3,490a	2,990a	2,840a
DCSB	2,520	2,530	2,080	1,410b	3,050b	1,520b	2,180b
Nonirrigated							
SB	850	1,580	110	1,400a	-	3,350a	1,460a
CCSB	1,040	1,650	190	1,720a	-	3,300a	1,580a
DCSB	600	1,420	50	130b	-	1,510b	740b

*Soybean planting system; SB, conventional monocrop soybeans; CCSB, soybeans with wheat as a cover crop; DCSB, soybean doublecropping system.
†Means in a column within an irrigation treatment followed by the same letter or no letter are not significantly different at P = 0.05, Duncans new multiple range test. Nonirrigated crop was not planted in 1988.

Table 5. Soybean yields in a stale seedbed planting system with or without a wheat cover crop (Experiment 2).

Planting System*	1985	1986	1987	Mean
	Soybean Yield By Year (kg/ha)			
Early	3,100†	3,630a	2,810a	3,180a
Early + wheat	2,890	3,330a	2,900a	3,040a
Late	2,870	2,660b	2,510b	2,680b
Late + wheat	2,980	2,860b	2,470b	2,770b

*Soybeans were either planted early (early May) or late (late May or early June) into a stale seedbed that had been previously tilled with a disk or spring-tooth harrow. Wheat was present or not as indicated.
†Means in a column followed by the same letter or no letter are not different at P = 0.05, Duncans new multiple range test.

In conclusion

Sound agronomic practices and the stale seedbed planting system used in these experiment are consistent with high soybean yields. These practices include use of adapted cultivars, timely planting, irrigation, and effective weed control with a preplant foliar application prior to planting when tillage is not performed. When these practices are followed, good soybean yields can be expected.

Wheat as a cover crop does not affect soybean yields and is not necessary for ground cover, except in the occasional year when fall tillage is performed that results in diminished winter vegetation. On those occasions, a winter wheat cover crop may be warranted.

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