RELAY CROPPING OF SOYBEANS INTO WHEAT

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INTRODUCTION

Irrigated corn has been a major crop in western Kansas. However, rising production costs and problems often associated with continuous corn have prompted farmers to look for other cropping systems. Climatic factors in northwest Kansas make conventional double cropping after wheat difficult. For double-cropping to be feasible, a relay intercropping system, where one crop is seeded before the other is harvested, will probably be needed.

Relay cropping is not a new concept. It is still used extensively in countries where hand labor is a major component of agriculture. In the United States, there are two basic types of relay cropping. In one, mechanical planters are used while trying to minimize crop damage, and in the other, a crop is seeded by aircraft into the existing crop.

Research on relay cropping was initiated in 1979 at the Colby Branch Experiment Station. The results obtained since that time have been highly variable, ranging from excellent crop yields to crop failure. Information on cultural practices for relay cropping is extremely limited. It is the objective of this publication to relate some of the successful practices, as well as problems, found in studies at Colby. These can serve as rough guidelines for relay cropping until more conclusive methods are developed.

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GENERAL CULTURAL PRACTICES

VARIETY SELECTION

Proper selection of crop varieties is important. Best results have been obtained with shorter wheat varieties, such as Newton, because there is much less straw for the soybeans to grow through. As wheat is the surest crop, high-yielding varieties should be a prime consideration. The growth stages of the interseeded crop are significantly delayed compared to conventionally grown crops and can result in reduced yields and/or low quality grain if the growing season is shortened by an early frost. Considering this, a producer might be tempted to choose an early maturing soybean variety, but this is incorrect according to research results from other states. An early maturing soybean often will not have a long enough vegetative stage to sufficiently exsert itself through the straw to reach more favorable growing conditions. The current recommendation is to select a standard or slightly later maturing soybean variety for your area. There also may be an advantage in selecting an indeterminate variety that has a longer flowering period. Varieties of soybean that tend to be prostrate will not grow through the straw and should be avoided.

FERTILIZATION

It is important to provide fertilizer specifically for the interseeded crop, in addition to the amount applied for the wheat. Two applications are recommended, one for the wheat in the fall and one for the interseeded crop in the spring or early summer. It is essential that the crop get a fast start once the wheat is harvested. In our plots, soybeans are fertilized after wheat harvest with 100 lbs./a of nitrogen in the form of ammonium nitrate.

WEED CONTROL

There are very few herbicides that are labeled for use in relay cropping because there is no break between crops. Herbicide selection problems include:

1. Damage to growing wheat
2. Damage to interseeded crop
    a. seedling damage
    b. postemergence damage
3. Inadequate control of existing weeds
4. Inadequate residual activity

In relay cropping it has been suggested that the wheat crop should be considered the main crop, with the interseeded crop being the "gravy". If this is true, we cannot accept much damage to the wheat. Herbicide selection with regard to the interseeded crop is especially difficult. In the case of aerial seeding, a herbicide may be too "hot" for a seed germinating on the soil surface. Postemergent herbicides can be a problem due to the poor growing conditions. Herbicide recommendations often are based on plant height but an interseeded crop may be over twice the height of conventional crops of similar age. Therefore, it is not easy to select a herbicide that will give adequate control of existing weeds without damaging the wheat or interseeded crop and provide residual control in the interseeded crop.

STAND ESTABLISHMENT

Generally, stand establishment of the interseeded crop hasn't been difficult. Irrigation may be necessary to provide a source of water for germinating seeds and young seedlings, which are growing a time of near maximum water use by the rapidly developing wheat.

WHEAT HARVEST

At wheat harvest, the soybeans are very spindly and considerably taller than conventionally grown soybeans of similiar age. The combine header may clip some of the soybean leaves but this should have little effect as long as clipping isn't too severe. On the positive side, cutting wheat at 14-16 inches evens soybean plant height and lets more sunlight through the stubble to the growing soybean plants. Minimizing combine tire traffic over the soybeans is a good idea, but many of the plants will spring back in a few days, after rain or irrigation. Evenly distributed straw is important also. A good straw chopper on the combine is recommended.

IRRIGATION

Irrigation after wheat harvest is important to ensure quick recovery and continued growth of the soybeans. Subsequent irrigations should be provided as needed.

Appearance of soybeans immediately after wheat harvest, 1982.

SPECIFICS FOR AERIAL INTERSEEDING

STAND ESTABLISHMENT

One of the main concerns with aerial seeding is stand establishment. Seeding date should be similar to that for conventionally grown soybeans but cold wet weather can cause the seed to rot on the surface. Seeding rate should be higher to help ensure uniform stands, with approximately 2-3 bu/acre seeded. Best germination and stand establishment has been obtained when soybeans were seeded onto dry soil followed by a heavy irrigation (2.0-2.5 inches). Dry soil before seeding was advantageous, since the seed often would roll into check cracks in the soil, effectively "planting" itself after irrigation sealed the cracks. The heavy initial irrigation helped because it left the soil surface wetter for a longer time period than multiple light irrigations. Subsequent irrigations for stand establishment were usually around 1 inch and were performed as necessary and as irrigation system capacity allowed. On our plots the second irrigation was performed approximately 10 days after the initial irrigation, as this is the time requirement of a typical full size center pivot to apply 2.5 inches.

Areas of moderately dense wheat growth provided more humid conditions, which aided in moisture absorption by the seed and thus better germination. It appeared that stand establishment of soybeans was better when the wheat had been planted with hoe openers instead of disk openers. This is probably because the small ridges left by the hoe openers channel the seed toward the more humid wheat row. After the seedling is established, it should be watched carefully to check for water stress. The soybean's very small root system at this stage cannot compete with the wheat. We have observed water stress on the seedlings in aerial-seeded fields when mechanically interseeded fields were showing no stress. Generally, stand establishment has been adequate as long as seeding rates have been adjusted and the techniques described above have been employed.

WEED CONTROL

There are unique weed control problems for aerial seeding. Normal rates of surface-applied herbicide may be too "hot" for seeds germinating on the surface. The 1-2 inches of soil covering seeds in conventional fields acts as a buffer between the herbicide and seeds. Another problem is weedy spots caused by improper aerial seeding. Nonuniform stands help increase weed competition. Some producers using aerial seeding have paid extra to seed the field twice, applying half the seed in each pass over the field to try to eliminate skips.

Broadcast interseeded soybeans were excellent in 1982.

Williams 82, a Group III variety, performed well in skip-row planting in 1984.

SPECIFICS FOR MECHANICAL INTERSEEDING

WHEAT PLANTING PATTERN

Most of our studies with mechanical seeding have involved leaving some of the wheat rows blank for traffic and planting lanes. Some years it may be possible to plant directly into solid-seeded wheat without too much damage to the wheat, but there will probably still be a significant reduction in the interseeded soybean yield. We are currently planting the wheat in 10 inch rows, with one of every three rows left blank. We adjust the seed gate mechanism so that the blank row does not affect the actual seeding rate. Straight rows and proper width "guess" rows for the wheat will make it easier to interseed soybeans.

SOYBEAN PLANTING CONDITIONS

Planting conditions between the wheat rows will probably stay wetter longer following precipitation. Planting date could be shifted earlier or later than normal as soil conditions and weather expectations dictate. The blank rows are centered on 30 inches, which is a popular spacing for row crops. This may save time, if much of your equipment is set up for 30-inch rows. A toolbar planter offset so that planters follow the wheels will minimize damage to the growing wheat. The soil behind the wheels can be fairly compacted, so you may need to adjust the depth mechanisms for planters behind the wheels. Double disk planter openers may help in cutting through any wheat that is in the "guess" row or any wheat lodged in the blank rows.

EXPERIMENTS WITH INTERSEEDING

In 1981 a study was initiated to determine if soybeans could be successfully interseeded into growing wheat. Two methods of interseeding, mechanical and broadcast, seeding were compared to conventionally planted monoculture crops. The broadcast seeding, simulating aerial seeding, was done manually with a cyclone seeder. The plots were sprinkler-irrigated immediately after seeding to enhance germination of the seed lying on the soil surface and seed washed into the dry soil cracks. The mechanically seeded plots were interseeded using a tractor-mounted unit planter where some wheat rows were left blank. These blank rows provided a traffic way for planting as well as extra light for the interseeded crop.

In the early spring of 1982, blank rows were obtained by chemically killing two of every five wheat rows. Wheat then grew in three 8-inch rows for each 40-inch width. As a result, the seeded area and seeding rate for the area mechanically interseeded were only 60% of those of the solid stand. In 1983, two of every five rows again were left blank, but they were left blank at seeding and the seeding rate was adjusted to approximately 60 lbs/a for both areas to be interseeded. In 1984, we changed our skip-row technique to one blank row with two seeded rows on a 10-inch spacing. This left gaps centered on 30 inches. In this case, 66% of the land area was planted compared to solid-seeded wheat. The wheat was fertilized with 100 lb/a of nitrogen in the form of

ammonium nitrate before drilling.

Since 1982, because of past weed control problems, herbicides were used. The application dates and herbicide combinations used are shown in Table 1. The wheat to be interseeded with the relay crops was sprayed in the spring after it had reached the jointing stage. However, the herbicide combinations used are not currently labeled for use in Kansas for relay cropping. Read the product label before applying agricultural pesticides. Pesticide use inconsistant with the label may result in violation of federal law.

Table 1. Herbicide combinations and application dates for wheat-soybean relay cropping experiments, 1982-1984. KSU Colby Branch Experiment Station.

Experiment	Years of Study	Herbicides		Application Date	
Preliminary	1982-1983	Surflan 4L	- 1.1 qt./a	4/21/82	5/04/83
		Banvel 4L	- 2.0 oz./a		
		2-4D LV Ester 4L	- 8.0 oz./a		
Herbicide*	1984	1. No Herbicide		-	
		2. Surflan 4L	- 1.1 qt./a	5/16/84	
		3. Dual 8E	- 1.5 pt./a	5/16/84	
		4. Lasso	- 2.5 qt./a	5/16/84	
		* All 4 treatments			
		Poast	- 1.0 qt./a	8/10/84	
		Blazer	- 1.0 qt./a		
		surfactant	- 1.0 qt./a		
Varietal	1984	Surflan 4L	- 1.1 qt./a	5/16/84	

In 1984 we started two new experiments, an interseeding method by herbicide study under sprinkler irrigation and a wheat planting method by soybean variety study under furrow irrigation.

Seeding dates and rates varied for the two interseeding methods and the monoculture soybean plots (Table 2). The rates were higher for the aerial-seeded plots to help give more uniform stands. Seeding dates differed due to soil or weather conditions.

After wheat harvest, interseeded areas were fertilized with 100 lbs./a of nitrogen in the form of ammonium nitrate. Irrigation was provided as necessary.

Table 2. Soybean varieties, seeding rates and planting dates, in wheat-soybean relay cropping experiments, 1982-1984. KSU Colby Branch Experiment Station.

Experiment and Interseeding Method	Soybean Variety	Seeding Rate bu/a	Planting Date
Preliminary			
Broadcast	Williams	2	6/01/82
Mechanical		1	6/21/82
Monocultural		1	6/08/82
Broadcast	Williams	2	5/25/83
Mechanical		1	5/26/83
Monocultural		1	5/26/83
Herbicide			
Aerial	Williams 82	3	6/04/84
Mechanical		1	5/16/84
Monocultural		1	5/16/84
Varietal			
Mechanical	1. Williams 82	1	5/16/84
	2. Pella	1	5/16/84
	3. Harcor	1	5/16/84

EXPERIMENTAL RESULTS

GERMINATION

Stand establishment under the broadcast interseeding method was good in 1982 and poor in 1983. Temperatures were low for several days following seeding in 1983. Cool temperatures, coupled with the wet conditions, lowered seed viability and vigor, adversely affecting the ability of the seed to become established. In 1984, there were stand reductions in the aerial-seeded plots where Surflan and Dual had been applied. Research in other states has shown Surflan to seriously affect germination. In 1984, some aerial-seeded soybean seedlings died due to water stress even after the initial rooting.

WHEAT YIELDS

Wheat yields were not significantly (.05 significance level) affected by herbicide in any of the years. However, as would be expected, wheat planted in the skip-row pattern gave significantly lower wheat yields than solid-seeded wheat (Table 3). In all years there was some yield compensation for the reduction in planted area, especially in 1983 and 1984 when seeding rates were the same for both wheat planting patterns, as shown by the yield ratios in Table 3. In 1982, the skip-row pattern was obtained by killing the wheat in the intended blank rows, and seeding rates were not adjusted. This may explain why the skip-row/solid yield ratio was so low in 1982. The overall average yield ratio of 0.77 is similar to figures reported elsewhere.

Table 3. Wheat yields from areas interseeded with soybeans, 1982-1984. KSU Colby Branch Experiment Station.

Wheat Planting Pattern	Wheat Yield, bu/a				
	1982	1983	1984 H	1984 V	Mean
Solid	59.6	56.1	65.3	48.5	57.4
Skip-row	38.0	44.5	51.9	41.7	44.0
Skip-row/Solid Land Ratio	0.60	0.60	0.66	0.66	0.63
Skip-row/Solid Yield Ratio	0.64	0.79	0.79	0.86	0.77

In 1984 studies, H = herbicide experiment and V = varietal experiment

SOYBEAN YIELDS

Yields of the interseeded soybeans were excellent in 1982 and poor in 1983 and 1984 (Table 4). The short time period between the Surflan application and soybean planting in 1983 and 1984 may have affected yields. In 1983, poor stands and hot dry weather after harvest also affected yields. The plots were irrigated after wheat harvest but never developed the growth necessary for good yields. In 1984, soybean growth rate decreased following a herbicide treatment of Poast and Blazer on August 10th. This application was later than recommended and may have decreased yields. Yields from mechanical-interseeded soybeans were higher than those from broadcast-seeded soybeans in every year except 1982. Mechanical-interseeded soybeans also remained more upright and were easier to machine harvest. Conventional monoculture soybeans gave nearly twice the yields of interseeded soybeans in every year but 1982. However, the monoculture area only had one crop harvested compared to the two crops for interseeded areas.

Table 4. Yields of soybeans in sprinkler-irrigated wheat-soybean relay cropping experiments, 1982 - 1984. KSU Colby Branch Experiment Station.

Planting Method*	Soybean Yields, bu/a			
	1982	1983	1984	Mean
Broadcast or Aerial	38.7	7.5	13.3	19.8
Mechanical	31.6	19.3	16.1	22.3
Conventional monoculture	46.6	29.5	42.9	39.7
Mean	39.0	18.8	24.1	27.3

* Surflan herbicide treatments for interseeding methods; Tolban, 1982-1983, and Dual, 1984, for monoculture plots.

In 1984, there was a significant herbicide effect on soybean yield (Table 5). Surflan-treated areas had significantly lower yields apparently because of decreased stands. Dual-treated areas, which also had somewhat reduced stands, gave lower yields than areas treated with Lasso. Although the areas with no spring herbicide application yielded relatively well, there would be considerable harvest problems to commercial operations because of significant weed growth.

Table 5. Yields of soybeans as affected by herbicide and planting method in a sprinkler irrigated, relay cropping experiment, 1984. KSU Colby Branch Experiment Station.

Planting Method	Soybean Yield, bu/a				
	None	Surflan	Dual	Lasso	Mean
Aerial	22.6	13.3	20.5	26.8	20.8
Mechanical	18.5	16.1	20.9	24.4	20.0
Mean	20.6	14.7	20.7	25.6	20.4
$LSD_{(.05)}$	Planting = NS Herbicide= 6.0				

In the furrow-irrigated study, both wheat planting method and soybean variety affected soybean yield (Table 6). Williams 82, a late Group III variety, had over twice the yield of the earlier maturing Group III variety Pella and Group II variety Harcor. Pella also tended to be prostrate and was difficult to harvest. Soybean yields in skip-row planted wheat were twice those of soybeans in solid-stand wheat but skip-row wheat yields were only 86% those of solid-stand wheat. Soybean yields for Williams 82 were much higher in this study than in a sprinkler irrigated herbicide study, but irrigation method was not the cause. Two possible reasons for this difference are the Poast-Blazer treatment applied only on the herbicide study and the slightly wetter soils at planting in the herbicide study.

Table 6. Soybean yields as affected by soybean variety and wheat planting method in a furrow-irrigated, relay cropping experiment, 1984. KSU Colby Branch Experiment Station.

Wheat Planting Method	Soybean Yield, bu/a			
	Williams 82	Pella	Harcor	Mean
Solid stand	24.0	5.7	10.2	13.3
Skip-row (2 rows, 1 blank)	40.8	20.7	20.0	27.1
Mean	32.4	13.2	15.2	20.2
$LSD_{(.05)}$	Wheat planting = 11.2 Soybean variety = 4.6			

CONCLUSIONS

At the present time, there are too many problems and too much year-to-year variability in yields to recommend a wheat-soybean relay cropping system. However, the studies are being continued to further develop methods and to attempt to identify causes of the variability. The system is risky, but information from studies at Colby suggest that attention to certain key areas can reduce that risk:

1. Variety Selection

A. Choose a high-yielding wheat of relatively short stature.
B. Choose a standard maturity indeterminate soybean.

2. Fertilization

A. Fertilize both wheat (fall) and interseeded crop (summer).

3. Germination and Stand Establishment of Interseeded Crops

A. Provide adequate moisture through irrigation.
B. Use higher than normal seeding rates to help give uniform stands.

4. Weed Control

A. Start with a clean field with low weed population.
B. Proper varieties, proper fertilization and uniform stands reduce weed competition.
C. Use herbicides as they become legally available.

5. Wheat Harvest

A. Cut wheat 14-16 inches above the ground, which may result in some clipping of interseeded crop leaves.
B. Use straw chopper on combine, and spread straw evenly

6. Irrigation

A. Provide adequate irrigation for germination.
Irrigate immediately after wheat harvest for quick growth.