RELAY INTERCROP WHEAT-SOYBEAN PRODUCTION UTILIZING GLYPHOSATE AS A WHEAT HARVEST AID TO INCREASE SOYBEAN GRAIN YIELDS AND MAINTAIN WHEAT GRAIN YIELDS

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Introduction:
Cropping systems in Upstate Missouri have shifted from wheat in the rotation to a corn-soybean rotation due primarily to economic considerations. Wheat is important for reducing erosion of highly erodible soils. In order to keep wheat in the rotation, double-crop soybeans are commonly grown. However, double-crop soybean production is risky for farmers due to dry summers and early frost. Relay intercropping soybean into wheat prior to wheat harvest has been proposed as a method to reduce risk associated and increase farm profitability (Duncan et al., 1990).

Relay intercrop production involves overlapping growth cycles of two or more crops. Intercropping is common with legumes seeded into small grains. Specifically, relay intercropped wheat and soybean production involves planting wheat in 15 inch rows in the fall and intercropping 15 inch soybean in late April. Previous research has evaluated relay intercropped soybean planted in the southern United States (Porter and Khalilian, 1995), Missouri (Reinbott et al., 1987), Kansas (Duncan et al., 1990), and Nebraska (Moomaw and Powell, 1990). However, this research did not include soybean seed coat technology. Light and moisture may be limiting for relay intercropped soybean production in wheat. Therefore, wider wheat row spacings have been utilized to allow relay intercropped soybeans to intercept more light, and polymer coated soybeans have been utilized to allow earlier planting dates into wheat to reduce mechanical injury to wheat while limiting soybean interference.

Soybean seed treated with a polymer coating that was temperature and moisture sensitive delayed germination of 7 to 10 days in previous research (Nelson, unpublished). This reduces the likelihood of the soybean competing with wheat for water, light, and nutrients. In addition, this allows early planting of soybean into the wheat and subsequently reduces mechanical damage to wheat. Relay intercropped soybean production has been challenging in Northeast Missouri due to dry weather in late June which may cause stress to the soybean plant.

In order to address this production challenge, research conducted from 2003 to 2005 utilized glyphosate (Monsanto, 2005) as a wheat harvest aid to reduce the impact of wheat on relay intercropped soybean grain yield while maintaining wheat grain yields. This research compared relay intercropped wheat-soybean treated with a harvest aid at different timings to full-season soybean, double-crop wheat-soybean, and wheat only production systems.

Methods:
Field experiments were conducted in 2003, 2004, and 2005 at the University of Missouri Greenley Research Center near Novelty, MO (40.035997 N, 92.243783 W) and at the Hundley-Whaley Center near Albany, MO (40.251282 N, 94.326977 W) in 2004. Experiments were arranged in a randomized complete block design in plots 10 by 40 ft with four replicates at each

site/year. The soil was a Putnam silt loam (fine, montmorillonitic, mesic Vertic Albaqualfs) at Novelty and Grundy silt loam (fine, montmorillonitic, mesic Aquic Argiudolls) at Albany. Soil properties and cultural practices were recorded in Table 1. 'Pioneer 25R37' was no-till drill seeded at 120 lbs/acre in 7.5 and 15 inch rows. The soybean planting systems were no-till planted in 15 inch rows with a split-row planter at 180,000 seeds/a. 'Hubner 5143NRR' Intellicoat[1] soybean were planted in the full-season and relay-intercrop systems. Non-coated 'Hubner 5143NRR' were planted in the double-crop system. Glyphosate (Monsanto, 2005) was applied at 22 oz/a plus diammonium sulfate at 17 lbs/100 gal on June 10, June 17, and June 24 approximately three, two, and one week prior to wheat harvest, respectively. Wheat development stage (Zadok et al., 1974) was determined on June 20 and 24 at the Novelty sites. Wheat samples were collected from each plot at the Novelty sites to determine test weight. Plots were maintained weed-free with two postemergence applications of glyphosate plus diammonium sulfate. Moisture and grain yield were determined and final yield adjusted to 13% moisture for wheat and soybean.

Input costs (Table 2) were utilized to calculate gross margins for the production systems (Plain et al., 2000). The gross margin was calculated as the difference between gross receipts and marginal costs between production systems. All data were subjected to analysis of variance using PROC ANOVA (SAS, 1999) and subjected to an *F Max* test for homogeneity (Kuehl, 1994). Data were combined over years and locations when variances were homogenous. Means were separated using Fisher's Protected LSD at p=0.05.

Results:

- Wheat matured earlier with a June 10 and 17 (3 and 2 weeks prior to wheat harvest, respectively) preharvest application of glyphosate (data not presented).
- Wheat test weight was reduced with the June 10 and 17 timings in 2003 at Novelty, and the June 10 application in 2005 compared to non-treated wheat at Novelty (Table 3).
- Wheat grain yield was 11 bu/a greater in 7.5 inch rows when compared to 15 cm rows.
- Wheat grain yield was reduced 13 and 6 bu/a when glyphosate was applied 3 and 2 weeks prior to harvest (June 10 and 17 application dates, respectively).
- The harvest aid treatment did not affect soybean population in a relay intercrop system.
- Soybean grain yield with glyphosate applied to wheat 1, 2, and 3 weeks prior to harvest was 4, 6, and 8 bu/a greater than non-treated relay intercrop soybean, respectively.
- Soybean grain yield with glyphsoate applied to wheat 1, 2, and 3 weeks prior to harvest was 8, 10, and 14 bu/a greater than double-soybean, respectively, with no risk of an early frost reducing soybean grain yields in the relay intercrop production system.
- Gross margins for the systems in Upstate Missouri with wheat at $2.90/bu and soybean at $5.50/bu was ranked full season soybean > relay intercrop soybean with a harvest aid = relay intercrop soybean = 7.5 inch wheat followed by double-crop soybean > 7.5 inch wheat > 15 inch wheat.

[1]Landec Ag, Inc., P.O. Box 898, Monticello, IN 47960.

Recommendations:

- Plant relatively short, early maturing, awnless winter wheat in 15 inch rows with a planter calibrated to deliver the same recommended seeding rate for 7.5 inch row wheat. Wheat varieties prone to lodging should not be selected for a relay intercrop production system.
- An area with few winter annual weeds should be selected, or a fall applied weed management system with herbicides such as metribuzin or thifensulfuron should be used.
- Plant polymer coated soybean with the same planter used for sowing wheat. Coated soybean treatments should delay germination and should be planted prior to jointing of wheat. In Northeast Missouri (counties in the same latitude as Knox and surrounding counties), farmers should target planting relay intercropped soybean the last week of April. This planting date may be closer to the second week of April in wheat fields near I-70. This minimizes mechanical injury caused by sowing soybean into wheat.
- Farmers in Upstate Missouri may experience extensive rainfall from late April to mid-May. The planting date for relay intercrop soybean should take rainfall events into consideration since 15 inch wheat may yield up to 20 bu/a less than 7.5 inch wheat. In general, 15 inch wheat will average 11 bu/a less than 7.5 inch wheat.
- One week prior to wheat harvest or after the late dough stage of wheat development (Zadok stage 87, Feeke's stage 11.2), a glyphosate preharvest treatment may be applied to wheat in the relay intercrop production system to maximize wheat grain yields and increase soybean grain yield. Earlier glyphosate application timings (2 and 3 weeks prior to wheat harvest) resulted in reduced wheat grain yields and test weight. Applicators should follow label restrictions (Monsanto, 2005) for preharvest wheat applications such as glyphosate should be applied after the hard-dough stage with 30% or less moisture; a seven day preharvest interval is required; and preharvest applications are not recommended for wheat grown for seed. Fields less prone to drought stress may not need a preharvest glyphosate application for wheat.

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Table 1. Soil properties, fertility, and planting dates at Albany in 2004 and Novelty in 2003, 2004, and 2005.

	Novelty			Albany
	2003	2004	2005	2004
Soil properties				
pHs	6.1	6.8	6.2	5.7
OM (%)	2.9	3.3	2.6	2.8
Fertilizer (N-P-K)				
Fall (lb/acre)	12 October 2002	31 October 2003		11 November 2003
	40-50-60	40-50-60		50-50-50
Spring (lb/acre)	18 March 2003	14 March 2004	1 March 2005	2 March 2004
	50-0-0	50-0-0	90-60-80	50-0-0
Planting date				
Winter wheat	11 October 2002	17 October 2003	8 November 2004	11 November 2003
Full season and relay-intercropped soybean	23 April	29 April	25 April	28 April
Double-crop soybean	7 July	28 June	29 June	1 July

Table 2. Custom crop production costs used to calculate gross margins (Plain et al., 2001). Seed cost was the actual production cost at the time of this research. Fertilizer cost was an average of local distributors in the fall, 2005.

Crop production expenses and returns	Wheat	Soybean
Planting	$11.74/acre	$11.69/acre
Average fertilizer application	$6.44/acre	$3.68/acre
Average fertilizer rate	93-53-63	9-53-63
	$65.92/acre (RI, DC)	$28.72/acre (FS)
Seed	$30.56/acre	$46.80/acre (RI and FS, coated)
		$33.60/acre (DC, non-coated)
Weed control		
Custom application		$8.80/acre (FS), $4.40/acre (RI), $4.40/acre (DC)
Herbicide		$12/acre (FS), $6/acre (RI), $6/acre (DC)
Harvest	$21.68/acre	$22.33/acre
Receipts	$2.90/bu	$5.50/bu

[a]Abbreviations: DC, double-crop wheat followed by soybean; FS, full-season soybean; RI, relay intercrop wheat-soybean.

Table 3. The effect of wheat row spacing, soybean planting system, and glyphosate harvest aid application timing on wheat test weight at Novelty in 2003, 2004, and 2005; wheat grain yield at Albany in 2004 and Novelty in 2003, 2004, and 2005; soybean soybean population at Novelty in 2003, 2004, and 2005; and soybean grain yield at Albany in 2004 and Novelty in 2003, 2004, and 2005.

Crop production system		Harvest aid application date	Wheat test weight			Wheat yield	Soybean population	Soybean yield	Gross margins[a]
			2003	2004	2005				
Wheat row spacing	Soybean planting system		---------- lb/bu ----------			bu/acre	plants/a	bu/acre	$/acre
None	full-season	None					112772	49.1	136.18
15 inch	relay intercrop	June 10	54.0	59.9	55.9	33.9	94380	33.7	57.55
15 inch	relay intercrop	June 17	58.6	60.1	58.1	40.8	77440	32.4	68.83
15 inch	relay intercrop	June 24	59.6	59.5	57.2	46.0	88572	30.3	72.25
15 inch	relay intercrop	None	60.2	60.0	55.9	45.3	88572	26.0	59.79
15 inch	double-crop	None	61.0	60.3	57.0	46.4	129712	22.4	43.29
15 inch	None	None	61.0	60.3	57.0	46.4	0	0	-1.83
7.5 inch	double-crop	None	61.0	60.2	58.3	57.5	135520	18.8	55.75
7.5 inch	None	None	61.0	60.2	58.3	57.5	0	0	30.26
LSD (p=0.05)			1.5	NS	1.7	5.032	15390	3.3	22.56

[a]Gross margin was calculated as the difference between the gross receipts and marginal cost for each production system.