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Extension FactSheet

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Modified Relay Intercropping

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Harvesting Two Crops in the Same Year

Wheat is a flexible, adaptable plant (H. Lafever, 1990) with a growing season that starts with planting in the fall and ends with harvest in the early summer. This adaptability allows farmers to capture some 66% of the traditional growing season — May 1 to September 30 — to produce a second crop through the interplanting of soybeans into wheat in June. This practice is known as Modified Relay Intercropping (MRI).

An MRI system involves the production of two different crops, with different growth and development requirements, in one growing season. In an MRI system, soybeans are planted into standing wheat between 20 and 30 days prior to wheat harvest.

In addition to allowing the harvesting of two crops in the same year, the MRI cropping system has the potential to increase farm income while hedging production risk and protecting the environment at the same time.

MRI is sometimes confused with Relay Intercropping (RI), another cropping system. Relay Intercropping recommends the planting of polymer-coated soybeans from May 1 to May 15 (Beuerlein, 2001).

In contrast, MRI recommends the planting of regular soybeans from around June 1 to June 20. The goal of this planting date is to have a well-established soybean plant of 6 to 8 inches in height (V2 to V4 growth stage) at wheat harvest.

In the MRI system, two crops — wheat and soybeans — are harvested in the same year. However, because of the difference in crop growth requirements and grain markets, farmers can effectively hedge production and price risk in an MRI system in most years. Producers considering using an MRI system should plan to grow wheat in such a manner (wheat rows less than 15 inches in width) that yield is not significantly reduced from wheat grown in a conventional system.

Long-term research at The Ohio State University's Ohio Agricultural Research and Development Center (OARDC) (D. Jeffers, 1995), in Crawford County (Prochaska, 2003), and other locations in Indiana (A. Kline *et al.,* 2001) has shown that MRI or RI wheat will yield about 90 percent of conventional wheat.

Modified Relay Intercropping (MRI) permits the planting of soybeans into standing wheat, allowing farmers to harvest two crops in the same year. This system hedges risks and protects the environment.

Because of the high probability of growing wheat in an MRI system at about 90% of conventional wheat, farmers may hedge their crop production risk in an MRI system through the opportunity (option) to grow and harvest a crop of soybeans. Soybean production in an MRI system is more speculative than wheat production due to the need for adequate rainfall in July and August.

In six years of replicated field trials, soybeans averaged 30 bushels per acre, with a range from 5 to 41 bushels per acre. Wheat yields have averaged 73 bushels per acre, with a range of 65 to 83 bushels per acre (through 2000). Conventional monocrop wheat and soybeans averaged 62 and 42 bushels respectively from 1990 to 2000 in Crawford County. MRI has been implemented successfully by farmers in other areas of the state — Van Wert, Hancock, Morrow, Huron, Seneca, and other locations.

Finally, in the MRI system, a crop is growing in the field for 12 consecutive months of the year. Thus, soil protection and concomitantly water quality is preserved. MRI is also a low pesticide input system in that 2,4-D (1 pint/acre) may be the only herbicide (applied to wheat) needed to control weeds in both the wheat and the soybean crop that follows it.

MRI Research Results (All Plots in Crawford County.)		
6-Year Average Yields in MRI System		
Year	Soft Red Winter Wheat Yields*	Soybean Yields*
1994	65 bu/acre	41 bu/acre
1995	72 bu/acre	27 bu/acre
1997	70 bu/acre	28 bu/acre
1998	73 bu/acre	41 bu/acre
1999	83 bu/acre	5 bu/acre
2000	76 bu/acre	37 bu/acre
Average	73 bu/acre	30 bu/acre

* Yields represent Grand Mean for the year over all treatments. (Prochaska, 2001.)

Evaluation of USDA Soybean Inoculant in a Modified Relay Intercropping System	
Treatments	Yield (bu/A)
Control	37.2
USDA Inoculant	37.1

F<1, NS. (Prochaska, 2001.)

Effect of Split N Application to Wheat on MRI Soybean Yield		
Treatment	Single N	Split N*
3-Year Average	33.9	30.2

F value = 0.36, NS. (Prochaska, 1997.)

* Split N treatment consisted of two applications of nitrogen to wheat with total Spring N application of at least 103 lbs/A. Single N application rate was about 65 lbs/A.

Effect of Split N Application to Wheat on MRI Wheat Yield		
Treatment	Single N	Split N*
3-Year Average	65.2	72.5

F value = 3.4, NS. (Prochaska, 1997.)

* Split N treatment consisted of two applications of nitrogen to wheat with total Spring N application of at least 103 lbs/A. Single N application rate was about 65 lbs/A.

Advantages of Intercropping

1. Potential for increased farm profitability.
2. Lower fixed costs for land and machinery as a result of the production of a second crop in the same field.
3. Better utilization of farm management labor, time, and equipment.
4. Low cost of production for MRI soybeans (as a result of a lower weed-control cost).
5. Hedge production risk (two crops in one growing season).
6. Hedge commodity price risk by being able to market both wheat and soybeans.
7. May be used for conservation compliance planning.
8. May be adapted to most available farm equipment.
9. Perhaps more consistent yield results for both wheat and soybeans than in other double-crop systems. (McCoy, 2001.)

Disadvantages of Intercropping

1. Not adaptable to droughty, poorly drained, or very heavy clay soils.
2. Potential increase in soybean pests such as Soybean Cyst Nematode.
3. Success of soybean crop is highly dependent on timely and adequate July and August rainfall.
4. Soybeans are susceptible to early fall frost damage.
5. Wheat susceptibility to Fusarium head scab (not worse in wheat to be interplanted). In the event of severe infection, may greatly reduce the potential profitability of the system.
6. Possible additional machinery cost.
7. Requires very timely field operations.

Modified Relay Intercropping — Row Spacing

Different wheat row spacings have been used successfully in MRI. Wheat is a very adaptable plant and will compensate for different row spacings by tillering. It should be remembered that sunlight is the energy source responsible for wheat and soybean production. Thus, a primary goal of MRI is to capture and utilize as much sunlight as possible. **Light, or the lack of it, has a profound effect on the growth of intercropped soybeans.** Different MRI systems have used row spacings from 10 to 15 inches. Wider spacings are possible; however, other production factors such as soybean planting date and the soybean weed control program will need to be considered.

Soybeans planted too early into well-tillered wheat often will become very tall and spindly (etiolated) due to lack of light. In general, weak plants do not grow well. In MRI, soybeans planted about 20 to 30 days prior to wheat harvest have provided the most consistent yields. Theoretically, earlier planted soybeans should yield better; however, as was mentioned earlier, competition with wheat may produce a weak soybean plant. Conversely, if soybean growth is vigorous, wheat growth and perhaps yield is diminished (D. Jeffers, 1995). Therefore, in MRI, soybeans are planted into wheat that will soon ripen and allow more light onto the developing soybean plant.

Wheat yields in Ohio were found by Beuerlein *(Profitable Wheat Management,* 1990) to not be significantly different for 7- and 10-inch wheat row spacings. The yield difference between 7- and 14-inch wheat was only about 3 bushels per acre. This research attests to the ability of the wheat plant to change its growth habit and thus continue to yield at high levels at wider row spacings.

It should be noted that the wheat plant is very competitive with most weeds. However, wide row spacing or thin wheat may promote greater weed pressure in the subsequent soybean crop. Finally, there is an interseeding effect on wheat yield. Three years of trials in Crawford County plots (S. Prochaska, 2003) resulted in wheat yield reduction data of 10 and 14 percent. This correlates well with earlier research done in Ohio by D. Jeffers *(Profitable Wheat Management,* 1990).

Wheat Production in Modified Relay Intercropping

Here are some guidelines to help farmers who are considering a Modified Relay Intercropping system.

1. Select a well-drained field.
2. Adjust fertility. Wheat nitrogen needs will be about 1 lb N per bushel of expected yield based on this equation:

   N (lb/a) = 40 + [1.75 x (yield potential - 50)].

   Wheat will use 0.64 lb P_2O_5 /bu and 0.36 lb K_2O /bu, but application should be based on a soil test. Soil pH should be between 6 and 7. Calculate the row spacing needed to allow equipment to run through the wheat to plant soybeans. Great Plains and Sunflower type units have been used successfully. A tool bar planter with older John Deere 70/71 flex units may also be used to plant soybeans into wheat. Very hard ground may make it difficult to cover seed.
3. Sow wheat into rows with a spacing of 10 to 15 inches, to allow soybean planting with tractor and planter (or drill). Ten- to 12-inch row spacing in studies has been used successfully in research plots and by farmers utilizing the MRI system.
4. Set up a tramline system in the wheat to facilitate soybean planting. Tramlines allow for straight driving and for equipment to move through wheat, thus protecting the wheat from being run down by the equipment.
5. Seed wheat on or soon after the Hessian fly-free date.
6. Sow wheat at 23 to 28 seeds per feet of 10-inch row (attempt to achieve a seeding rate of around 1 to 1.3 million seeds per acre).
7. Plant wheat 1 to 1.5 inches deep.
8. Select a thin-line type of wheat (such as Agra 962) of relatively early maturity to allow more light onto MRI soybeans and to facilitate early wheat harvest. Many wheat varieties have been tested with most high-performing wheat able to be interseeded. Hopewell, Patterson, Countrymark 547, and Agra 962 are recent wheat varieties that have performed well. Wheat variety selection is also thought to be important from the standpoint of possible autotoxic effects on the soybean. New wheat varieties are being developed that are better suited to MRI.
9. Apply an appropriate broadleaf herbicide on wheat, such a 2,4-D LV ester prior to Feeke's growth stage 6, if broadleaf weeds are a problem. If application timing on broadleaf weed growth is good, this is often the only herbicide needed for both wheat and soybeans.
10. Harvest wheat as soon as it can be threshed (20% to 25% moisture). Cut wheat right at the top of the soybean plant. Be sure straw is chopped and spread evenly behind the combine. All of these actions allow more light to reach the soybean plants.

Soybean Production in Modified Relay Intercropping

Here are some guidelines to help with soybeans in a Modified Relay Intercropping system.

1. Adjust fertility for two crops. Pay attention to P and K needs of the soybeans. Soybeans will use 0.8 lbs of P_2O_5 and 1.4 lbs of K_2O per bushel of production.
2. Plant soybeans at a rate of 4 to 5 seeds per foot of row.
3. Plant at a 1-inch depth or perhaps deeper. Crusting should not be a problem in this system.
4. Select a soybean of 3.0 to 3.4 relative maturity and one that will produce strong vegetative growth and is tolerant of dry weather. Defiance, Resnick, and Pioneer 9301 are examples of soybeans used successfully in this system. Roundup Ready soybeans such as Asgrow 2701, Asgrow 3302, Pioneer 93BO1, and Pioneer 9333 have also performed well in this system and can be used where weeds are a significant problem.
5. Plant soybeans into the wheat approximately 20 to 30 days prior to wheat harvest. Evaluate wheat vigor and soil moisture to determine the soybean planting date. If wheat is vigorous with little light reaching the row middles, delay soybean planting. We have successfully intercropped to June 22. The last date to intercrop is when wheat stems begin to break.
6. Avoid the use of cell-membrane-disrupter mode-of-action herbicides (Blazer, Reflex, Flexstar, Cobra, Resource) on MRI soybeans. Soybeans in an MRI system are in a weakened state after wheat is combined and may be less able to recover from herbicide stress compared to conventional soybeans. Thus, for best results, control broadleaf weeds before soybean planting or two to three weeks after wheat harvest if non-Roundup Ready soybeans are planted so as to allow soybean plants to harden. Roundup Ready soybeans have performed satisfactorily in MRI systems and should be used where annual and/or perennial weeds are a problem.
7. When planting soybeans into wheat, place metal arrow-shaped spreaders in front of all tires to move wheat out of row middles to allow for passage of equipment. These spreaders may also be necessary ahead of planter units. Narrow tires on the tractor may also facilitate planting of soybeans into wheat and reduce plant damage.

8. Row guidance systems may also be used to facilitate interseeding.

MRI Returns per Acre

Returns for MRI systems have been favorable when compared to conventional wheat, soybeans, or corn. Gross dollars per acre for 160 bushel corn, 55 bushel soybeans, and 80 bushel wheat (no straw sold) are compared here for one set of prices.

Returns for MRI Systems	
Corn	160 bushels/acre x $1.95/bushel = $312/acre
Soybeans	54 bushels/acre x $5.39/bushel = $291/acre
Wheat	80 bushels/acre x $2.50/bushel = $200/acre
MRI	73 bushels/acre x $2.50/bushel = $183/acre 30 bushels/acre x $5.39/bushel = $162/acre Total = $345/acre

More complete enterprise budgets for conventional soybeans, wheat, and MRI are shown on the next page.

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Typical Budgets for Wheat, Soybeans, and Intercrop Using 6-Year MRI Replicated Plot Average Yields and Loan Rates for Grain Prices						
			Monoculture	**Monoculture**	**Intercrop**	**Intercrop**
	Item	**Unit Price**	**Wheat 77 bu**	**Soybean 54 bu**	**Wheat 73 bu**	**Soybean 30 bu**
Receipts	Wheat	$ 2.50	$ 193.00		$183.00	
	Soybean	$ 5.40		$292.00		$162.00
Variable Costs						
Seed	Wheat	$ 7.00	$ 14.00		$ 14.00	
	Soybean (RR)4	$ 18.00		$ 25.00		$ 10.00
Fertilizer[1]	N	$ 0.20	$ 16.00		$ 15.00	
	P_2O_5	$ 0.24	$ 12.00	$ 10.00	$ 11.00	$ 6.00
	K_2O	$ 0.12	$ 4.00	$ 9.00	$ 3.50	$ 5.00
Herbicide						
2,4-D Ester	1 pt	$ 16.00	$ 2.00		$ 2.00	
Roundup	26 oz			$ 8.00		
Select (grass spot spray)[2]						$ 5.00
Fuel, lubricants, trucking			$ 6.00	$ 6.00	$ 6.00	$ 4.00
Repairs			$ 7.00	$ 12.00	$ 7.00	$ 7.00
Miscellaneous			$ 12.00	$ 12.00	$ 6.00	$ 6.00
Interest on operating capital (10% for 6 mos.)			$ 5.00	$ 5.00	$ 5.00	$ 2.00
Fixed Costs (less land and management)						
Labor 2 hrs @ $8/hr			$ 16.00	$ 16.00	$ 16.00	$ 16.00
Machinery and equipment[3]			$ 45.00	$ 45.00	$ 23.00	$ 22.00
Land charge			$ 90.00	$ 90.00	$ 45.00	$ 45.00
Total Costs per Acre			$229.00	$238.00	$153.50	$128.00
Per Acre Returns to Management			$(36.00)	$ 54.00		$ 63.50

1 Crop removal applications of phosphorus and potassium applied.

2 Assumes spot spraying 1/4 acreage; tank mix would cost about $20/acre.

3 Assumes splitting machinery and land charge between the soybean and wheat crop.

4 Roundup Ready soybeans planted in conventional systems, now RR in MRI system.

5 Represents return per acre for both wheat and soybeans.

Original budget from *Profitable Wheat Management*. Revised by Dr. S. Prochaska.

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