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Alternative Crops in Double-Crop Systems for Missouri

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Double cropping increases the amount of time land is used for crop production and can increase potential profit. There are ecological as well as economic advantages to increasing the amount of time the land is used for production. A winter grain crop, traditionally wheat, can act as a cover crop to prevent erosion. A warm-season double crop, often soybean, may yield smaller returns than a full-season crop but often averages a positive net return. This high-intensity cropping system may reduce disease and pest incidence by breaking pest cycles.

There is a need to identify alternative crops that can fit easily into double-crop systems with little or no added equipment costs and with minimal change in management. Acceptable alternative crops will benefit farmers through decreased incidence of pests and diseases, improved soil erosion control, and reduced economic risk for the producer.

In a two-year study at the University of Missouri, five alternative crops were evaluated agronomically and economically based on their potential to perform well in a double-crop system in central and southern Missouri. Double crops planted after the harvest of canola or wheat or after a fallow period were evaluated at three locations throughout the state between 1992 and 1994. The agronomic and economic performance of soybean was compared with that of four alternative double crops: amaranth, buckwheat, pearl millet and sunflower (Figure 1).

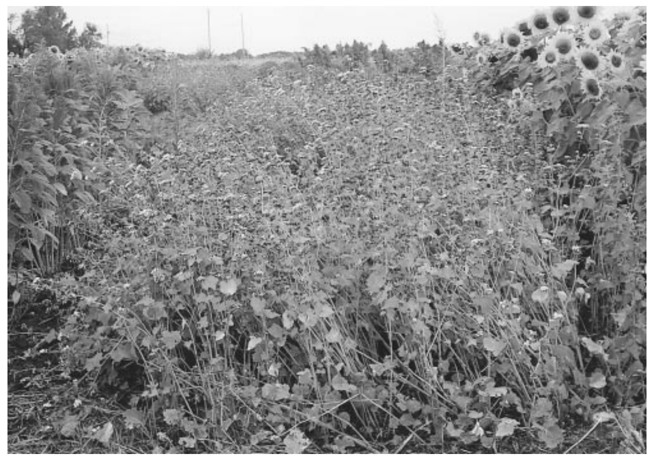

Figure 1. Amaranth (left), buckwheat (center), sunflower (right) and pearl millet (not shown) are potential alternatives in Missouri double-crop systems.

Uses and markets for alternative crops

Canola. Canola is a type of rapeseed. It differs from rapeseed in that it has lower levels of erucic acid and glucosinolates, both of which are undesirable in foods. Canola is also low in saturated fats, which makes it a good source of vegetable oil for human consumption. Rising consumer demand for canola oil is not being met by domestic canola production, often because of added costs for transportation between widely separated collection points.

Wheat typically yields more than canola, but has a lower value per unit of grain. The canola crop is similar to wheat in its growth and management, although canola is occasionally subject to winter kill in Missouri (see MU publication G 4280, *Canola — A Promising Oilseed*). Prices for canola fluctuate depending on prices of other vegetable oils, especially soybean.

Amaranth. Amaranth is referred to as a pseudocereal because it has some of the same uses as true cereal grains but differs in plant and seed type. It is high in the amino acids lysine and tryptophan, which are typically low in cereal grains. Amaranth is currently used in the specialty food market as an added ingredient in breakfast cereals, breads and crackers and has potential as an additive in animal feeds or for industrial use. Most amaranth undergoes processing into flour, but some grain is marketed directly by farmers to consumers.

Current markets for amaranth are small, and only

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a few companies process the grain. Production practices and costs for amaranth are similar to those for sunflower. Prices for amaranth are higher than those for other grains, provided a producer has a buyer or a marketing arrangement. However, undesirable agronomic characteristics of amaranth, such as shattering and lodging, indicate the need for further breeding efforts to improve the crop.

Buckwheat. Buckwheat is a pseudocereal that matures nine to ten weeks after emergence, making it an excellent option for double cropping in Missouri (see MU publication G 4306, *Buckwheat — A Multipurpose Short-Season Alternative*). Buckwheat is commonly known as a flour component in pancakes and baked goods. Buckwheat is also a primary ingredient in soba-style noodles made in Japan.

Production practices for buckwheat are similar to those for double-crop soybean. The crop is typically planted in narrow rows and is combine harvested with a grain head. Prices for buckwheat are slightly higher than for soybean on a per unit weight basis, but yields may be lower. Producers in Missouri are obtaining a positive net return despite added transportation costs. Buckwheat is increasingly recommended as a double-crop for Missouri in response to solid and expanding domestic and export markets.

Pearl millet. Pearl millet was domesticated in Africa for human consumption and has slightly better food value than either wheat or rice. Pearl millet is a drought-tolerant crop that shows a reduction in yield with a shortened growing season. Production practices for pearl millet are similar to those for soybean, except that pearl millet requires an application of nitrogen and may require cultivation for weed control because of a lack of labeled herbicides.

Pearl millet has been used in North America primarily as a forage crop but is finding increasing use as a grain crop. In Georgia, pearl millet is being used by large-scale poultry operations as a component of poultry rations. Unfortunately, the price of pearl millet is low and does not reflect the grain's value relative to its nutritional quality.

Sunflower. Sunflower is typically grown in Missouri as a component in birdseed mixes. Sunflower can be planted and managed with methods and equipment similar to those used for corn (see MU publication G 4290, *Sunflower — An American Native*). Future markets for sunflower include expanded processing of specialty varieties for use as a component in snack foods, birdseed mixes, baked goods and specialty oils. In addition, oil extraction and confectionery byproducts can be fed to livestock. Sunflower has slightly higher production costs than soybean, primarily because of the added nitrogen and equipment necessary with sunflower. Price of sunflower fluctuates with the price of soybean and other vegetable oils.

Premiums are paid for specialty sunflower, such as confectionery seeds, or varieties with oil high in oleic acid. In-state bird feed producers provide an important market for sunflower in Missouri.

Winter-crop management

Winter wheat and canola require similar methods of management (see MU publication G 4953, *Wheat-Soybean Double Crop Management in Missouri*). Winter canola, like winter wheat, is seeded in the fall and goes dormant over winter. Growth of canola resumes from living crown tissue in the spring.

Varieties. The best varieties of winter wheat and winter canola for double-crop production systems are those that consistently produce high yields and yet mature early enough to allow for timely planting of the following double crop. An important feature of a successful conola variety is resistance to winter kill.

Planting and fertilization. Seedbeds for canola and wheat should be prepared using methods typical for small-seeded grain production. Sites are either plowed or chiseled and then cultivated twice. Soil samples should be taken before planting winter crops at all sites and analyzed for pH and nutrient content. Nitrogen, phosphorus and potassium are applied before planting. Spring topdressed applications of nitrogen are made in March. Canola is typically planted in early to mid-September, a month earlier than wheat (see Figure 2).

Harvest. Winter crops are harvested with a combine in mid-June to early July. Canola harvest needs to be timely because of the potential for reduced yields due to seed shatter loss if pods become too dry.

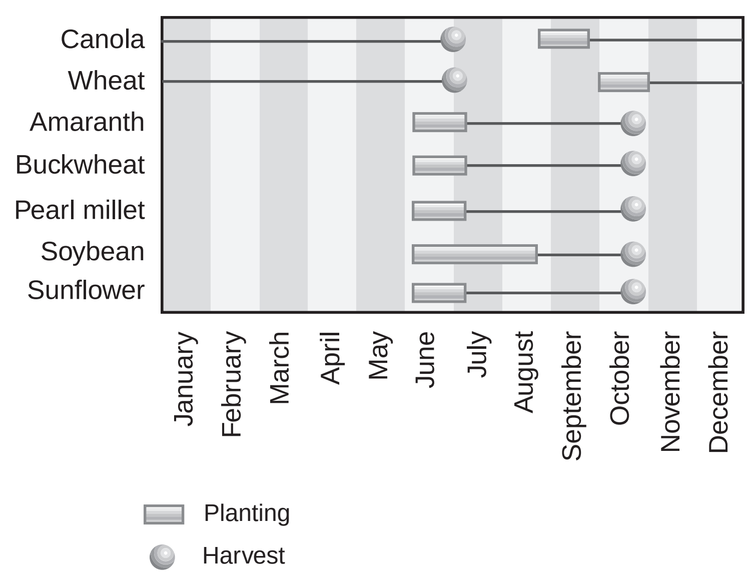

Figure 2. Range of planting and harvest dates for two winter crops and five double crops in a double-crop system.

Figure 3. Canola residue (right) is lighter and has less volume than wheat residue (left).

Double-crop management

No-till methods can be used successfully when planting alternative double crops. However, canola and wheat residues can occasionally clog furrows during planting, making them difficult to close. Canola stubble is lighter and has less volume than wheat residues and generally allows easier no-till planting (Figure 3). Some producers have reported better yields of soybean when planted after canola than when planted after wheat. University of Missouri test results indicate, however, that the effects of canola and wheat residues on following double crops are neither consistently positive nor consistently negative. In general, wheat residues, being thicker and slower to break down than canola residue, could be an advantage in reducing erosion and preserving topsoil moisture. However, wheat residues often complicate no-till planting and seedbed preparation by clogging equipment and furrows. Both volunteer wheat and volunteer canola can cause serious yield losses in sequential crops and must be managed with cultural or chemical controls.

Varieties. Improved commercial varieties are available for all of the double crops evaluated in this study. Varieties should be carefully selected to achieve the highest return in local markets. Resistence to pests is also a significant consideration for alternative double crops, as few pesticides are labeled for use with these crops.

Planting and fertilization. Because double crops cannot be planted until after wheat or canola harvest in late June or early July, yields for most of these double crops are lower than they would be if the crop were planted for optimum growth. A later planting date typically results in lowered grain yield because of inadequate summer rainfall and a shortened growth and maturation period.

The optimum planting time for buckwheat, unlike that for other crops in this study, occurs from mid-July to early August. The nine- to ten-week growing period for buckwheat gives the producer more flexibility, because buckwheat can be planted weeks after the harvest of wheat or canola and still produce maximum grain yield.

Nutrient application rates for double crops should be adjusted downward from those for full-season crops to reflect the lower yield potential (the exception being buckwheat). Producers should follow recommendations based on soil test results and realistic yield expectations.

Economic considerations

Although the alternative crops discussed here fit into Missouri's double-crop season, to be acceptable, they must also be economically competitive with the traditional double crop. The alternative crops in the Missouri study tend to show greater variations in grain yield than soybean, which is well adapted to the area and for which appropriate management has been optimized. To reflect possible yield variation, the Missouri study considered three alternative yield levels for evaluating the economic suitability of these double-crop options: average yield from field tests, base yield, and optimum yield.

Average grain yields from field tests for all crops except wheat were based on yields from the three sites in the Missouri study (see Table 1). "Base" yields of winter and double crops reflect the minimum estimated yield a producer in Missouri could expect in most years, assuming a good crop stand and no catastrophic events. "Optimum" yields for winter and double crops reflect the highest replicated yield values from tests conducted in this study.

Table 1. Grain yields in pounds per acre of five double crops, planted after wheat or canola.

Double crop	Winter crop	Average crop yield (lb/ac)
Amaranth	canola	891
	wheat	851
Buckwheat	canola	972
	wheat	892
Pearl millet	canola	1,015
	wheat	458
Soybean	canola	1,345
	wheat	1,455
Sunflower	canola	1,832
	wheat	1,623

Variable and fixed costs were considered in determining costs of production for ten double-crop systems (see Table 2). Since current regulations limit pest control options for alternative crops, estimated weed control costs among the double crops varied. No herbicides are labeled for use in amaranth and buckwheat. Some herbicides are labeled for use on soybean, sunflower and pearl millet; costs for one application of a preemergent or postemergent labeled her-

Table 2. Variable and fixed cost estimates per acre for two winter crops and five double crops.

	Canola	Wheat	Amaranth	Buckwheat	Soybean	Sunflower	Pearl millet
	Variable costs (dollars per acre)						
Fertilizer	26.27†	24.31	6.60	6.60	0.00	6.60	6.60
Herbicide	0.00	0.00	0.00	0.00	8.35	8.35	8.00
Insecticide	0.00	0.00	0.00	0.00	0.00	10.00	0.00
Seed	22.00	20.00	22.00	22.00	13.00	15.17	10.00
Labor	15.00‡	15.00	24.28	21.00	21.00	21.00	21.00
Machinery fuel, oil, repair	18.00	18.00	22.00	22.00	22.00	18.25	22.00
Lubrication	2.70	2.70	3.30	3.30	3.30	3.00	3.30
Transportation	2.00¶	0.00	6.00	4.00	0.00	2.00	6.00
Miscellaneous	5.67§	5.67	6.88	6.88	6.88	4.85	6.88
Interest	0.91	0.85	0.89	0.84	0.74	0.91	0.84
Total variable costs	92.55	86.53	91.95	86.62	75.27	90.13	84.62
	Fixed costs (dollars per acre)						
Land costs	62.22	62.22	0.00	0.00	0.00	0.00	0.00
Total costs	154.77	148.75	91.95	86.62	75.27	90.13	84.62

† The increased nitrogen application to canola was partially offset by a lower application rate for double crops. For canola and wheat-based systems, P and K application rates were the same and applied at winter crop planting. No spring nitrogen cost was assumed for soybean.

‡ Labor costs were taken from 1993 crop costs and 1995 projected crop costs in Missouri (Moore, 1994). Labor costs in double-crop amaranth reflect the use of increased cultivation and cultural weed control in the crop.

¶ Based on the cost of hauling soybean or wheat, $5.00 per acre was included in machinery fuel cost estimates for all crops. Costs assessed to transportation reflect the additional costs incurred in transport because of lighter weight, smaller seed size, and transport to elevators at a greater distance.

§ Miscellaneous costs were based on Moore's (1994) estimates for wheat, soybean and sunflower projected crop budgets in Missouri, and include any expected drying or storage costs for all crops.

bicide were assigned to these crops. Herbicide application costs were taken from experience in the two-year study. Because several insect pests are known to cause significant damage to double-crop sunflower in Missouri, one application of insecticide was assigned to this crop.

Since wide rows allow for cultivation in amaranth, this crop was assessed an additional $3.25 per acre in labor and operating machinery costs to reflect the use of increased cultural controls. Mechanical weed control options in buckwheat are limited because the crop is planted in narrow rows, so no additional labor charge was assessed to buckwheat.

Canola and wheat. Results of the study show that canola can be profitable in double-crop systems in central and southern Missouri at yields above base levels, although less so than wheat. Analysis of canola in this study does not incorporate the risk associated with the higher rate of winter kill, but this must be a factor in a producer's decision to grow canola. Improved management techniques and varieties are gradually reducing the risk of canola winter kill.

Amaranth. The high grain price for amaranth resulted in amaranth double-crop systems having the highest potential net return of the double-crop options (see Table 3). Moreover, double-crop amaranth was highly competitive with double-crop soybean on the basis of projected net return. Considering all yield estimates, double-croppped amaranth had net returns 1.5 to 10 times that of double-crop soybean after canola or wheat. Greater labor and transportation costs were included in the variable costs for double-crop amaranth production (see Table 2). An estimated 20 hours of labor per acre is required for amaranth cultivation and harvest. Increases in amaranth production may lower prices to $1.10 per pound, which would reduce the net returns estimated here by up to 50 percent. However, returns would still be above the net return for double-crop soybean at average and optimum yield levels.

Lack of market demand for amaranth in the United States has limited production to less than 5,000 acres annually. Consequently, amaranth is an option for only a small number of producers at this time.

Buckwheat. Buckwheat double-crop systems had net returns at average and optimum yield potentials that were lower than those for amaranth, soybean and sunflower (see Table 3). However, at base yield levels, net return for the double-crop systems includ-

Table 3. Net profit or loss for ten double-crop options at study yield levels, in dollars per acre.

Double crop system	Net return		
	Base yield	Average yield	Optimum yield
Wheat-amaranth	117.11	404.33	740.82
Wheat-buckwheat	12.08	120.82	183.51
Wheat-soybean	10.48	171.53	323.11
Wheat-sunflower	14.74	185.51	267.19
Wheat-pearl millet	17.84	57.97	143.38
Canola-amaranth	76.89	334.59	662.48
Canola-buckwheat	–28.13	51.08	105.17
Canola-soybean	–29.73	91.80	244.78
Canola-sunflower	–25.47	115.77	188.85
Canola-pearl millet	–22.37	11.77	65.05

ing buckwheat were slightly greater than those involving soybean. In a comparison of production costs, the main differences with soybeans are fertilizer and herbicide costs. Buckwheat receives an application of nitrogen that soybean does not, but a herbicide application on soybean makes total costs of production for the two double-crops similar.

Increased planting date flexibility makes buckwheat an acceptable alternative to double-crop soybean despite lower yield and return of buckwheat. As an emergency crop for late planting, buckwheat produces a positive net return after canola and wheat with average and optimum winter-crop yields, and after canola at base yields. Buckwheat has the potential to be used in a wide variety of food and feed products. The potential industrial uses for the crop have not yet been explored. Further expansion of the domestic and export market is necessary to ensure markets for increased production.

Pearl millet. Double-crop pearl millet was the least profitable alternative except at the base yield level. Because costs of production for double-crop pearl millet are similar to those for double-crop soybean, the poor economic competitive ability of pearl millet is primarily due to low potential grain yields and price for the crop. Pearl millet probably needs additional plant breeding to produce consistent yields that would make it a competitive double-crop option. Market expansion for pearl millet is likely to occur, but at a relatively slow pace until further research makes the crop more viable. Pearl millet is particularly adapted to sandy soils and drought and may fit a need in Missouri under those conditions.

Sunflower. At average yields, double-crop sunflower had greater net returns than double-crop buckwheat, soybean and pearl millet after canola or wheat. Costs for sunflower were about 20 percent greater than for soybean, partly because of additional nitrogen and insecticide inputs for sunflower. Prices used here are those offered on contract for high-oleic acid sunflower varieties by regional processors in 1994. The price of sunflower and canola fluctuates relative to the price of other oilseeds, mainly soybean, with a corresponding flux in available markets for the crop. Some oilseed-type sunflower has also been used by regional birdseed processors. Increased industrial use of specialty sunflower varieties has opened new markets for the crop.

Other double-crop options. Besides the crops discussed here, a few other possible short-season crops could potentially be double cropped after wheat and canola. These include foxtail millet (*Setaria italica*), mung beans (*Vigna raidata*), cowpeas (*Vigna unguiculata*) and dry edible beans (*Phaseolus* spp.). Of these, dry edible beans have shown the greatest promise in Missouri.

Summary

Of the five double crops evaluated in the University of Missouri's two-year study, soybean had the lowest cost of production. At average yield levels, net returns were greatest for wheat-amaranth, canola-amaranth, wheat-sunflower and wheat-soybean systems. At average yields, the lowest net returns resulted from canola-pearl millet and canola-buckwheat systems. Canola was shown to be less profitable than wheat in double-cropping systems for central and southern Missouri. Sunflower was shown to be an agronomically and economically viable alternative to soybean following either canola or winter wheat.

Considering prices, available markets and agronomic quality, buckwheat and sunflower appear to be the most promising double-crop options when compared with soybean at average, base and optimum yields. Further breeding efforts and market expansion would improve the suitability of amaranth and pearl millet as double-crop options to soybean for the lower-Midwest region.

Reference

Moore, Kevin C. 1994. 1993 Missouri M.I.R. crop costs: Projected 1995 crop budgets. *Farm Management Newsletter* FM 94-2. Department of Agricultural Economics, University of Missouri-Columbia, December.