IRRIGATED CROPPING SYSTEMS RESEARCH AT LIND

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Summary of Research Findings

An irrigated cropping systems study was initiated in 2000 at the WSU Dryland Research Station at Lind. The crop rotation is 3-year winter wheat – spring barley – winter canola sown *i*) directly into standing stubble, *ii*) after mechanical removal of stubble, or *iii*) after burning the stubble. The traditional practice of continuous annual winter wheat sown after burning and moldboard plowing is also included as a check treatment. First year (2001) grain yields averaged across residue and soil management treatments was 74 bu/a for winter wheat, 2.93 t/a for spring barley, and 2450 lb/a for canola with no significant yield differences within any crop. Winter wheat yields were lower than anticipated due to a late May frost. Over-winter water storage/retention was significantly reduced in all in plots where residue was burned in the fall. For winter wheat as well as for spring barley, Rhizoctonia and take-all root disease were low in all residue management treatments.

Objectives

Many deep-well irrigators in east-central Washington practice a continuous winter wheat rotation (i.e., grow winter wheat on the same field every year). Irrigated wheat grain yields range from 90- to 140-bushels per acre with residue production of 10,000 pounds or more per acre. After grain harvest in August, the traditional practice is to burn the stubble and invert the surface soil with moldboard plow tillage in preparation for sowing in September. Generally, growers feel they need to burn their fields because high residue levels hamper sowing. Alternatives to field burning are needed to reduce smoke emissions and maintain air quality.

Another reason why irrigated growers burn and moldboard plow winter wheat stubble is to control downy brome, a winter annual grass weed. Previous research has shown that long-term control of downy brome is very difficult in continuous irrigated winter wheat using direct seeding. Therefore, new crop rotation and stubble management strategies are needed to make direct seeding (without burning) work.

The objective of this long-term (6-year) project is to determine the feasibility of direct seeding into high levels of residue as a substitute for burning in irrigated cropping systems. Specific objectives are to:

1. Test a 3-year crop rotation of winter wheat – spring barley – winter canola. Crops will be sown with a Cross-slot direct-seed drill into *i*) standing stubble, *ii*) after mechanical removal of stubble, and *iii*) after burning the stubble. An additional treatment of annual winter wheat sown after stubble burning + moldboard plowing (sown with a double-disc drill) will be included as a check.

2. Evaluate and develop effective techniques for sowing crops into heavy surface stubble using direct seeding methods.
3. Document cumulative effects of a diverse direct-seed crop rotation under three stubble management practices on soil physical and biological properties, water use efficiency, diseases, weed ecology, and farm economics. Compare these effects to those under the check treatment (i.e., continuous winter wheat after stubble burning + moldboard plowing).

Materials and Methods

This study was initiated on 10 acres of prime cropland at the Washington State University Dryland Research Station at Lind. To obtain baseline residue levels to begin the experiment, the entire 10 acres was planted uniformly to Madsen winter wheat in September 1999. Grain yield (harvest August 2000) was 110 bu/a and straw production exceeded 10,000 lb/a.

Beginning in the 2001 crop year, a 3-year crop rotation of winter wheat – winter canola – spring barley was grown under three stubble management methods. These are sowing crops: *i*) directly into standing stubble, *ii*) after mechanical removal of stubble (i.e., after swathing and bailing), and *iii*) after burning of stubble. A check treatment of continuous annual winter wheat sown after stubble burning + moldboard plowing is also included. The experimental design is a split-split plot with four replications. Each portion of the 3-year direct-seed crop rotation in each stubble management method is sown each year. Thus, there are 40 plots (3 crops x 3 stubble management practices + the check continuous winter wheat x 4 replications).

Results and Discussion

2001 Crop Year. Hand broadcasting winter canola and then applying irrigation water resulted in spotty and inadequate stands. For this reason, spring canola was substituted for winter canola in 2001. We also had difficulty planting winter wheat into fresh winter wheat stubble in excess of 10,000 lb/a (this is not part of the crop rotation, but was necessary in the fall of 2000 to begin the rotation cycle). Planting spring barley into winter wheat stubble was not a problem because over-winter decomposition made the straw fairly friable. The Cross-slot direct-seed drill did not do well in the traditional check plots that had been burned and moldboard plowed. Grain yields for the 2001 crop year are shown in Table 1. Winter wheat suffered from frost damage during flowering. There was variability in grain yield among replications, resulting in no significant differences within residue management treatments. Spring barley was a pleasant surprise because it was easy to establish, there were no weeds, and grain yields were excellent. A total of 15 inches of irrigation water (6" fall, 9" spring) plus 8.3 inches of precipitation was used to produce these crops.

Soil Water Content. Soil water content in all 40 plots is measured to a depth of six feet by neutron attenuation in August (just after harvest) and again in April before irrigation water is applied. In April 2001, the stubble burn residue management treatment had an average of 2.1 inches less soil water compared to the standing stubble treatment (Table 2). These data well illustrate the accelerated soil water evaporative loss that occurs over winter from a bare soil surface compared to a soil surface covered with residue.

Table 1. Grain yields of winter wheat, spring barley, and spring canola in 2001 as affected by various stubble and soil management practices.

	Winter Wheat (bu/a)	Spring Barley (ton/a)	Spring Canola (lb/a)
Stubble burned	85	2.88	2574
Stubble mechanically removed	67	3.03	2486
Standing stubble	69	2.88	2282
Continuous burn & plow	75		
LSD (0.05)	NS	NS	NS

Table 2. Soil water content in the 6-foot profile in April 2001 (before spring irrigation) and in August after grain harvest with three crops and various stubble and soil management practices. The stubble was 10,000 lb/a from winter wheat in the 2000 crop year.[x]

	Winter Wheat		Spring Barley		Spring Canola	
	inches[y]					
	Apr	Aug	Apr	Aug	Apr	Aug
Stubble burned	8.58 c	5.21 b	10.72 b	5.84 a	9.68 b	3.96 b
Stubble mechanically removed	10.45 ab	5.39 b	12.70 a	6.58 a	11.33 a	4.81 ab
Standing stubble	11.62 a	6.45 a	13.00 a	6.04 a	11.84 a	5.35 a
Cont. burn & plow	10.01 b	6.63 a				

[x] Within-column averages followed by a different letter are significant at the 5% level.
[y] All plots received six inches of irrigation water in September 2000.

Weeds. Weeds within a 3 sq. yard area were identified by species, counted, and collected just before grain harvest in all plots. Samples were allowed to dry in a low-humidity greenhouse for several weeks before recording their dry weight. Weeds per unit area were lowest in the burn direct seed and burn + moldboard plow winter wheat treatments but there were no differences in spring barley or spring canola (Table 3). We achieved excellent stands of spring barley and there were no weeds in any of the residue management treatments for barley (Table 3).

Table 3. Weeds per unit area in winter wheat, spring barley, and spring canola measured just before grain harvest in 2001 as affected by various stubble and soil management practices.[x y]

	Winter Wheat	Spring Barley	Spring Canola
	Number per 3 sq. yards		
Stubble burned	1.3 a	0.0 a	4.7 a
Stubble mechanically removed	15.0 b	0.0 a	7.2 a
Standing stubble	14.0 b	0.0 a	11.0 a
Continuous burn & plow	2.7 a		

[x] Within-column averages followed by a different letter are significantly different at the 5% probability level.

[y] Percentage composition of weed species in the total population averaged across treatments was: downy brome, 42.7% (but found only winter wheat); Russian thistle, 13.6%; prickly lettuce, 10.4%; mares tail, 9.5%; other weeds, 23.8%. Other weeds were tumble mustard, tansy mustard, wild oat, field pennycrest, western salsify, and sowthistle.

Diseases. For winter wheat, the least take-all was measured in the standing stubble, whereas the least Rhizoctonia was in the stubble burned treatment (data not shown). The total root length and surface area were less in the burn + moldboard plow treatment compared to the standing stubble and mechanical stubble removal treatments (data not shown). These data paralleled the data for number of tillers (i.e., the standing stubble and mechanical removal had a greater number of tillers). These differences are probably a reflection of plant stand (data not shown) which was greatest in the burn direct seed and burn + moldboard plow treatments.

For spring barley, the levels of take-all were extremely low compared to winter wheat. Rhizoctonia levels were higher on barley compared to winter wheat, but there were no differences among residue management treatments in spring barley in terms of root infection, number of crown roots, or number of tillers. The same lack of difference was seen in root length measurements (data not shown) where overall levels of Rhizoctonia and take-all were low in all residue management treatments. The only disease data available with canola is for Rhizoctonia. More Rhizoctonia was isolated from the standing stubble than from the other residue management treatments (data not shown).

2002 Crop Year. Due to the failure to achieve adequate stands of winter canola following winter wheat in 2000, project researchers and growers decided to modify the crop rotation. Instead of winter wheat – winter canola – spring barley, the new rotation (which began in August 2001) is winter wheat – spring barley – winter canola. We had very good success sowing winter canola into barley stubble just after harvest and then applying six inches of irrigation water. The flush of volunteer barley that occurred after irrigating was controlled with Assure II grass herbicide. Winter canola stand establishment in 2001 in all residue management treatments was adequate (data not shown). We had no difficulty sowing spring barley into winter wheat stubble (after it had a winter season to partially decompose) during the first year of the study; thus, we have confidence in this method. Similarly, sowing winter wheat into canola stubble presents no problem.