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CONSERVATION CROP ROTATIONS FOR DRYLAND WHEAT IN DOWNY BROME INFESTED AREAS

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INTRODUCTION

Downy brome is the most troublesome weed in dryland winter wheat/fallow cropping systems in the Pacific Northwest. Historically, control measures have relied on moldboard plowing and/or wheat stubble burning to bury or destroy downy brome seed. Although these practices can keep downy brome at manageable levels, soil erosion, runoff, and evaporative water loss can be excessive where soil is not protected by residue. Non-traditional crop management practices including spring cropping, rotations with broadleaf crops such as canola, chemical fallow techniques, and utilization of improved residue management techniques must be developed to provide cropping systems which maintain profitability while protecting soil resources.

METHODS

Large replicated plots were established in spring 1993 on a commercial field near Pilot Rock, Oregon (Gilliland site) to compare the effectiveness of several crop rotations for downy brome control in dryland wheat, soil and water conservation, and economic viability. A second location (Shaw site) was established about 3 miles from the Gilliland site in spring of 1994. This site was located on the same soil type and with the same crop rotation treatments as the Gilliland site. A conventional plow-based, winter wheat/fallow crop rotation was compared to cropping systems designed to optimize downy brome management and maintain soil residue cover for soil conservation. The experiment concluded after 6 years when all plots were planted to winter wheat (Gilliland site concluded in 1998, Shaw site in 1999). Individual plots were approximately 0.5 acre in size with four replications and were managed by growers and research station staff using field scale equipment.

Cropping systems treatments

1. Winter wheat/fallow rotation with chisel plowing and fall tillage of grain stubble.
2. Winter wheat/fallow rotation with chisel plowing, and a fall herbicide without stubble tillage
3. Winter wheat/barley/fallow rotation with chisel plowing and fall tillage of grain stubble.
4. Winter wheat/barley/fallow with chisel plowing and a fall herbicide without stubble tillage.
5. Winter wheat/fallow/canola rotation with chisel plowing and fall stubble tillage.
6. Winter wheat/fallow rotation with moldboard plowing and no fall stubble tillage (conventional).
7. Continuous, no-till hard red spring wheat (Shaw site only).

Primary tillage

Conservation tillage treatments (treatments 1 through 5) employed spring chisel plowing as the primary tillage. This is compared with the conventional, commercial practice of spring moldboard plow primary tillage (treatment 6). At the Shaw site, continuous no-till hard red spring wheat was evaluated (treatment 7).

Post-harvest tillage

Chemical fallow treatments (treatments 2 and 4) consisted of a post-harvest herbicide treatment (Roundup®, Landmaster®, or Sure-Fire®) in the fall if necessary, and again in the spring before chiseling for summer fallow preparation. The no-till, continuous hard-red spring wheat plots (treatment 7) received a post-harvest herbicide treatment (Roundup®, Landmaster®, or Sure-Fire®) in the fall if necessary, and again in the spring prior to seeding.

Tillage fallow treatments (treatments 1, 3, and 5) utilized a shallow, fall post-harvest disc tillage to "plant" downy brome seed while maintaining maximum surface residue. If necessary, a non-residual herbicide treatment (Roundup®) was used in the spring prior to chiseling. Wheat stubble was left undisturbed and no Roundup was applied in the fall on the conventional wheat/fallow treatment (treatment 6). Roundup was applied as necessary in the spring prior to moldboard plowing (treatment 6).

Evaluations were made of total weed populations with emphasis on downy brome at both sites in late January and again in late April each year. Total downy brome plants were counted in four 10-m^2 quadrats per plot. Surface residue cover measurements were made using a line transect method each December (Table 3). Crop yields at both sites were estimated by harvesting the entire plot area with commercial equipment.

During the early years of this study, plots were evaluated for general occurrence of diseases. As the experiment progressed, the level of sampling became increasingly intense to assess effects of rotations fully. From 1996 to 1999, diseases in wheat and barley were evaluated each spring by collecting plants from each plot, washing soil from the roots, and evaluating roots, stems, and foliage for the presence of disease symptoms. Particular attention was given to symptoms of strawbreaker foot rot (lesions near the base of stems), Fusarium foot rot (lesions on subcrown internodes or rotting of crowns), Rhizoctonia root rot (rotting of root cortex tissue and "spear tipping" of crown roots), take-all root rot (discoloration of vascular tissue mostly on seminal roots), and root lesion nematode (rotting of root cortex and restricted root branching). Disease severity ratings and percentages of plants or tillers affected by symptoms were recorded separately for each disease. A disease index then was derived by multiplying the average disease severity rating by the percentage of plants or tillers affected. During 1999, soil and root samples from the Shaw site were sent to the Oregon State University Nematode Diagnostic Laboratory for an estimate of nematode population levels.

RESULTS

Downy brome

In the wheat/fallow rotations, downy brome populations differed between plow and chisel treatments in the last year at the Gilliland site (1998). Chiselled plots that did not receive fall stubble disking had much greater levels of downy brome (52 plants/yd^2) compared to moldboard plowed plots (Table 1). In chiselled plots where grain stubble was fall harrowed, however, there was only a slight increase in downy brome infestations. The 3-year rotation of barley fallow/wheat had lower levels of downy brome compared to the wheat/fallow rotations that were chiseled (Table 1). Canola crops did not result in high levels of downy brome in subsequent winter wheat crops since a selective grass control herbicide (Poast®, Assure II®) was used in the canola (Table 1). The continuous no-till spring wheat treatment (treatment 7) had a very low downy brome density (Table 1). Wild oat populations increased slightly (data not shown).

Observing the changing downy brome severity in these different crop rotation treatments over the 6-year study period indicates that several management practices kept downy brome populations below

Table 1. Influence of crop rotations on downy brome at the Gilliland and Shaw sites. Trials were offset by 1 year: treatments at the Shaw site were the same as at the Gilliland site the previous year.

	Crop rotation* at Gilliland (first year shown) and Shaw (second year shown) sites.						1994 Gill.	1995 Shaw	1995 Gill.	1996 Shaw	1996 Gill.	1997 Shaw	1998 Gill.	1999 Shaw
	93/94	94/95	95/96	96/97	97/98	98/99	Downy brome per square yard (April)							
	Chisel													
1	TF	W	TF	W	TF	W	7	37	0	0	2	3	10	7
2	CF	W	CF	W	CF	W	14	42	1	0	5	1	52	10
3	B	TF	W	B	TF	W	1	0	65	1	<1	0	4	4
4	B	CF	W	B	CF	W	21	19	137	1	<1	0	10	9
5	TF	Ca	W	TF	Ca	W	-	-	0H	4	<1	1	3	7
	Plow													
6	CF	W	CF	W	CF	W	7	30	0	0	<1	7	1	7
	No-Till (at Shaw site only)													
7	SW	SW	SW	SW	SW	W	-	0	-	0	-	0	-	2

* TF - Tillage fallow (harrow grain stubble in fall and spray glyphosate in spring as needed).
CF - Chemical fallow (spray glyphosate in fall and spring as needed).
W - Winter wheat, Ca - Winter canola, B - Spring barley, SW - Hard red spring wheat.
H Replanted to spring wheat because of heavy downy brome infestation.
Gill. - Gilliland site.

damaging levels while maintaining adequate residue cover on the soil surface. Conservation tillage systems utilizing chisel plowing did not result in high levels of downy brome if barley or canola was included in a winter wheat rotation, or if harrowing of grain stubble was done in the fall after grain harvest in a winter wheat /fallow crop rotation.

Crop yields

Initial wheat yields where chiseling was employed were lower than plots receiving conventional moldboard plowing. However, after the second cycle of reduced tillage, wheat yields were similar regardless of primary tillage method used (Tables 2a and 2b). Overall winter wheat yields were low in 1999 due to lower than normal growing season precipitation. Canola yields were lower than expected due to heavy feeding from local deer and elk populations and dry conditions at time of seeding. Problems with canola stand establishment and insects also contributed to lower than expected canola seed yields. Barley yields in the first year during establishment of the new crop rotation were less than expected, but they improved as the rotation progressed (Tables 2a and 2b). Crop yields of hard-red spring (HRS) wheat are summarized in Table 2b. HRS yields in the first year were low (6 bu/a) due to dry conditions and inadequate fertility during the initiation of this crop rotation. Yields of HRS improved in years two through four. Low yield of HRS in 1998 (21 bu/a) likely was due to significant frost damage in that year. In the final year at both sites, all plots were planted to winter wheat. Low yields of winter wheat due to reduced soil moisture in rotations following canola or spring wheat compared to winter wheat following summer fallow.

Plant Disease

No disease reached epidemic proportions at either site nor appeared to restrict yields during this research. In addition, assessments of individual plant diseases often did not appear conclusive when viewed from the perspective of a single site during a single year. It was only after most of the experiment had been completed at both sites that trends became evident. Trends were seldom statistically significant. Comparisons of similar treatments at the two sites were offset by 1 year, thereby helping to eliminate potential confusion from seasonal changes in climatic factors. The most common diseases on winter wheat included Rhizoctonia root rot, a root disease complex including root lesion nematode, take-all root rot, and strawbreaker foot rot. Annual spring wheat at the Shaw site was affected by the root diseases (take-all and Rhizoctonia root rot) but was generally not affected by foot rot.

Strawbreaker foot rot (Table 3) was present in meaningful, significant amounts only during the final year at each locations. This foot rot was more prevalent in 2-year rotations than in 3-year rotations. Strawbreaker foot rot was also least prevalent in the rotation that included canola, compared to sequences involving only wheat and barley. Although this disease is seldom important in spring wheat, it occurred in relatively high proportions in winter wheat at the Shaw site during 1999.

During 1996 at the Shaw site, there was a comparison of three 3-year rotation treatments. Rhizoctonia root rot (Table 4), the root disease complex (Table 5), and take-all (Table 6) tended to be less damaging in the rotation that included canola than in rotations that only included cereals. During 1996 and 1997, there was a comparison of winter wheat in three 2-year rotation treatments. Rhizoctonia root rot at the Gilliland site was slightly less damaging in the moldboard plow system than in the conservation tillage systems (Table 4). This relationship did not occur at the Shaw site. Winter wheat was not

Table 2a. Influence of crop rotations on crop yields, Gilliland site.

Crop Rotation *						1993	1994	1995	1996	1997	1998
'93	'94	'95	'96	'97	'98	------------------------------ bu/a ** ---------------------------------					
Chisel											
TF	W	TF	W	TF	W	--	33	--	49	--	60
CF	W	CF	W	CF	W	--	37	--	53	--	55
B	TF	W	B	TF	W	0.5 ton/a	--	57	0.99 ton/a	--	61
B	CF	W	B	CF	W	0.5 ton/a	--	60	0.89 ton/a	--	61
TF	Ca	W	F	Ca	W	--	190 lb/a	40	--	378 lb/a	41
Plow											
CF	W	CF	W	CF	W	--	42	--	53	--	59

** Units expressed in bu/a for wheat yield, expressed as ton/a for barley, and lb/a for canola.

Table 2b. Influence of crop rotations on crop yields, Shaw site.

Crop Rotation *						1994	1995	1996	1997	1998	1999
'94	'95	'96	'97	'98	'99						
Chisel						------------------------------------ bu/a ** ----------------------------------					
TF	W	TF	W	TF	W	--	78	--	68		31
CF	W	CF	W	CF	W	--	79	--	71		33
B	TF	W	B	TF	W	0.30 ton/a	--	58	1.5 ton/a		27
B	CF	W	B	CF	W	0.35 ton/a	--	55	1.6 ton/a		32
TF	Ca	W	TF	Ca	W	--	1380 lb/a	48	--	1095 lb/a	20
Plow											
CF	W	CF	W	CF	W	--	90	--	71		31
No-Till											
SW	SW	SW	SW	SW	W	6	46	32	41	21	17

* TF – Tillage fallow (harrow grain stubble in the fall spray in spring as needed).
CF – Chemical fallow (spray in fall and spring as needed).
W - Winter wheat, Ca – Winter canola, B – Spring barley, SW – Hard red spring wheat.
** Units expressed in bu/a for wheat yield, and expressed as ton/a for barley, and lb/a for canola.

Table 3. Influence of crop rotations on strawbreaker foot rot (lesions near base of stem) at the Gilliland and Shaw sites. Trials were offset by 1 year: treatments at the Shaw site were the same as at the Gilliland site the previous year.

Crop rotation* at Gilliland (first year shown) and Shaw (second year shown) sites						1995 Gill.	1996 Shaw	1996 Gill.	1997 Shaw	1998 Gill.	1999 Shaw
93/ 94	94/ 95	95/ 96	96/ 97	97/ 98	98/ 99	(Strawbreaker foot rot: % plants infected)					
Chisel											
TF	W	TF	W	TF	W	-	-	1	8	16	41
CF	W	CF	W	CF	W	-	-	1	4	25	35
B	TF	W	B	TF	W	nd	6	0	0	13	16
B	CF	W	B	CF	W	nd	0	0	0	14	29
TF	Ca	W	TF	Ca	W	nd	0	-	-	5	13
Plow											
CF	W	CF	W	CF	W	-	-	0	5	10	33
No-Till (at Shaw site only)											
SW	SW	SW	SW	SW	W	-	0	-	0	-	15
				LSD (0.05)		-	ns	ns	nd	ns	19

* TF - Tillage fallow (harrow grain stubble in fall and spray glyphosate in spring as needed).
CF - Chemical fallow (spray glyphosate in fall and spring as needed).
W - Winter wheat, Ca - Winter canola, B - Spring barley, SW - Hard red spring wheat
nd = not determined, ns = not significant, A-≅ = no cereal produced.

Table 4. Influence of crop rotations on Rhizoctonia root rot (lesions and pruning of crown roots) at the Gilliland and Shaw sites. Trials were offset by 1 year: treatments at the Shaw site were the same as at the Gilliland site the previous year.

Crop rotation* at Gilliland (first year shown) and Shaw (second year shown) sites						1995 Gill.	1996 Shaw	1996 Gill.	1997 Shaw	1998 Shaw	1998 Gill.	1999 Shaw
93/ 94	94/ 95	95/ 96	96/ 97	97/ 98	98/ 99	(Disease index for Rhizoctonia root rot: 0=none, 4=severe)						
Chisel												
TF	W	TF	W	TF	W	-	-	0.8	1.5	-	0.5	1.4
CF	W	CF	W	CF	W	-	-	0.9	1.4	-	0.5	1.8
B	TF	W	B	TF	W	nd	0.9	nd	1.3	-	0.4	1.3
B	CF	W	B	CF	W	nd	1.3	nd	1.8	-	0.4	1.4
TF	Ca	W	TF	Ca	W	nd	0.5	-	-	-	0.1	1.8
Plow												
CF	W	CF	W	CF	W	-	-	0.5	1.5	-	0.5	1.6
No-Till (at Shaw site only)												
SW	SW	SW	SW	SW	W	-	nd	-	2.8	0.8	-	1.3
					LSD (0.05)	-	0.2	0.2	nd	-	ns	ns

* TF - Tillage fallow (harrow grain stubble in fall and spray glyphosate in spring as needed).
CF - Chemical fallow (spray glyphosate in fall and spring as needed).
W - Winter wheat, Ca - Winter canola, B - Spring barley, SW - Hard red spring wheat
nd = not determined, ns = not significant, A-≅ = no cereal produced.

Table 5. Influence of crop rotations on pruning of seminal roots (possibly Rhizoctonia root rot and/or root lesion nematodes) at the Gilliland and Shaw sites. Trials were offset by 1 year: treatments at the Shaw site were the same as at the Gilliland site the previous year.

Crop rotation* at Gilliland (first year shown) and Shaw (second year shown) sites						1995 Gill.	1996 Shaw	1996 Gill.	1997 Shaw	1998 Shaw	1998 Gill.	1999 Shaw
93/ 94	94/ 95	95/ 96	96/ 97	97/ 98	98/ 99	(Disease index for seminal root damage: 0=none, 5=severe)						
Chisel												
TF	W	TF	W	TF	W	-	-	2.3	1.4	-	1.1	2.4
CF	W	CF	W	CF	W	-	-	1.4	1.0	-	1.4	2.6
B	TF	W	B	TF	W	nd	1.7	nd	2.5	-	1.2	2.9
B	CF	W	B	CF	W	nd	2.1	nd	2.7	-	1.0	2.7
TF	Ca	W	TF	Ca	W	nd	1.1	-	-	-	0.7	3.2
Plow												
CF	W	CF	W	CF	W	-	-	2.2	0.9	-	1.6	2.7
No-Till (at Shaw site only)												
SW	SW	SW	SW	SW	W	-	nd	-	2.9	2.9	-	3.4
					LSD (0.05)	-	0.7	0.2	nd	-	0.6	0.7

* TF - Tillage fallow (harrow grain stubble in fall and spray glyphosate in spring as needed).
CF - Chemical fallow (spray glyphosate in fall and spring as needed).
W - Winter wheat, Ca - Winter canola, B - Spring barley, SW - Hard red spring wheat
nd = not determined, ns = not significant, A-≅ = no cereal produced.

Table 6. Influence of crop rotations on take-all root rot (lesions on seminal roots) at the Gilliland and Shaw sites. Trials were offset by one year: treatments at the Shaw site were the same as at the Gilliland site the previous year.

Crop rotation* at Gilliland (first year shown) and Shaw (second year shown) sites						1995 Gilli.	1996 Shaw	1996 Gilli.	1997 Shaw	1998 Shaw	1998 Gilli.	1999 Shaw
93/ 94	94/ 95	95/ 96	96/ 97	97/ 98	98/ 99	(Disease index for take-all root rot: 0=none, 5=severe)						
Chisel												
TF	W	TF	W	TF	W	-	-	1.7	0	-	0.4	2.0
CF	W	CF	W	CF	W	-	-	1.4	0	-	0.4	1.5
B	TF	W	B	TF	W	nd	0.2	nd	0.1	-	0.2	2.8
B	CF	W	B	CF	W	nd	0.5	nd	0.1	-	0.2	2.0
TF	Ca	W	TF	Ca	W	nd	0.1	-	-	-	0.1	2.9
Plow												
CF	W	CF	W	CF	W	-	-	1.0	0	-	0.2	2.5
No-Till (at Shaw site only)												
SW	SW	SW	SW	SW	W	-	nd	-	0.3	0.6	-	2.0
					LSD (0.05)	-	0.3	ns	nd	-	0.2	ns

* TF - Tillage fallow (harrow grain stubble in fall and spray glyphosate in spring as needed).
CF - Chemical fallow (spray glyphosate in fall and spring as needed).
W - Winter wheat, Ca - Winter canola, B - Spring barley, SW - Hard red spring wheat
nd = not determined, ns = not significant, A-≅ = no cereal produced.

grown on these plots during 1997 at the Gilliland site or 1998 at the Shaw site. All six treatments were planted to winter wheat at these sites during 1998 (Gilliland site) and 1999 (Shaw site). In 1996 at Gilliland=s, take-all was less damaging in 2-year rotations where the moldboard plow was used than where conservation tillage had been practiced. In the 3-year rotations at the Shaw site during 1996, and at the Gilliland site in 1998, root diseases were least damaging where canola was included as the second crop, compared to spring barley (Tables 4 to 6).

Residue cover

Percent residue cover in newly seeded winter wheat was higher in wheat/fallow rotations utilizing chisel compared to moldboard plowing (Table 7). Fall seeded canola provided high amounts of green cover going into winter. Chemical fallow during the fall resulted in greater levels of surface residue than did fallow treatments receiving fall tillage.

Table 7. Influence of crop rotations on crop residue at the Gilliland and Shaw sites. Trials were offset by 1 year: treatments at the Shaw site were the same as at the Gilliland site the previous year.

Crop rotation* at Gilliland (first year shown) and Shaw (second year shown) sites						1993 Gill.	1994 Shaw	1994 Gill.	1995 Shaw	1995 Gill.	1996 Shaw	1996 Gill.	1997 Shaw	1997 Gill.	1998 Shaw
93/94	94/95	95/96	96/97	97/98	98/99	---------- % cover ----------									
Chisel															
TF	W	TF	W	TF	W	5	19	82	94	25	22	67	80	31	53
CF	W	CF	W	CF	W	9	20	67	98	16	23	78	90	30	53
B	TF	W	B	TF	W	75	18	13	4	76	60	61	74	14	30
B	CF	W	B	CF	W	89	30	22	5	77	62	69	83	14	33
TF	Ca	W	TF	Ca	W	1	4	36	49	76	79	19	25	21	61
Plow															
CF	W	CF	W	CF	W	1	8	87	99	2	7	76	86	3	11
No-Till (at Shaw site only)															
SW	SW	SW	SW	SW	W	-	8	-	83	-	81	-	87	-	66
LSD (0.05)							9	9	5	10	8	8	8	6	10

* TF - Tillage fallow (harrow grain stubble in fall and spray glyphosate in spring as needed).
CF - Chemical fallow (spray glyphosate in fall and spring as needed).
W - Winter wheat, Ca - Winter canola, B - Spring barley, SW - Hard red spring wheat