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Land Rolling Does Not Influence Productivity of Subsequent-Year Spring Wheat

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Abstract

Land rolling is a common practice in the northern Great Plains and upper Midwest to push rocks to the soil surface after planting annual grain legumes and forage crops to protect harvest equipment despite the potential to increase weed density and soil erosion and decrease crop yield. Field trials were conducted in 2005 and 2006 to determine if land rolling the previous season influenced weed density or productivity of spring wheat (*Triticum aestivum* L.) planted following summer fallow or two crops planted the previous season, pea (*Pisum sativum* L.) and barley (*Hordeum vulgare* L.). Density of green foxtail [*Setaria viridis* (L.) Beauv.] and total weeds in spring wheat were influenced by year, planting date, and crop grown in the previous year, but land rolling had no influence on weed density. Yield of spring wheat was greater following summer fallow than following pea and barley, likely due to 0.9 inches greater available soil water at planting and 1.0 inch greater water use. Land rolling × previous crop interaction affected preplant soil water content with rolled fallow having 1.1 and 1.6 inches greater water content (0- to 4-ft depth) than rolled barley or pea, respectively; soil water content at planting did not vary for previous crop where no land rolling occurred. Spring wheat water productivity was 0.15 lb/acre-inch greater when the previous year's crops were planted at the early date than when planting was delayed. Land rolling in the previous year did not influence weed density, grain yield, protein concentration, and water use or water productivity of spring wheat.

Disciplines

Agriculture | Agronomy and Crop Sciences | Weed Science

Comments

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A.W. Lenssen* and U.M. Sainju

Abstract

Land rolling is a common practice in the northern Great Plains and upper Midwest to push rocks to the soil surface after planting annual grain legumes and forage crops to protect harvest equipment despite the potential to increase weed density and soil erosion and decrease crop yield. Field trials were conducted in 2005 and 2006 to determine if land rolling the previous season influenced weed density or productivity of spring wheat (*Triticum aestivum* L.) planted following summer fallow or two crops planted the previous season, pea (*Pisum sativum* L.) and barley (*Hordeum vulgare* L.). Density of green foxtail [*Setaria viridis* (L.) Beauv.] and total weeds in spring wheat were influenced by year, planting date, and crop grown in the previous year, but land rolling had no influence on weed density. Yield of spring wheat was greater following summer fallow than following pea and barley, likely due to 0.9 inches greater available soil water at planting and 1.0 inch greater water use. Land rolling × previous crop interaction affected preplant soil water content with rolled fallow having 1.1 and 1.6 inches greater water content (0- to 4-ft depth) than rolled barley or pea, respectively; soil water content at planting did not vary for previous crop where no land rolling occurred. Spring wheat water productivity was 0.15 lb/acre-inch greater when the previous year's crops were planted at the early date than when planting was delayed. Land rolling in the previous year did not influence weed density, grain yield, protein concentration, and water use or water productivity of spring wheat.

Previous Research on Land Rolling

Land rolling is done commonly in the northern Great Plains and upper Midwest to protect grain legume and forage harvest equipment from damage by rocks that occur or extend above the soil surface (Olson et al., 2004; DeJong-Hughes et al., 2016; Kandel, 2018). Several studies have shown that land rolling can influence grain legume yield. Lenssen (2009) documented that dry pea (*Pisum sativum* L.) yield was decreased by land rolling in Montana. Likewise, Olson et al. (2004) reported results from studies conducted in the Canadian Prairies where land rolling resulted in lower yield for pea and lentil (*Lens culinaris* Medik.). Conversely, DeJong-Hughes et al. (2016) reported that yield of soybean [*Glycine max* (L.) Merr.] was not influenced by land rolling at five growth timings ranging from pre-plant to V3 stage in Minnesota.

Land rollers push rocks and corn root balls into the soil from the force exerted by the weight of the large steel cylinder, with or

Crop Management

Core Ideas

- Information is not available on the influence of land rolling on subsequent-year spring wheat yield.
- Previous-year planting date and previous crop influenced weed density in spring wheat.
- Land rolling in the previous year did not influence weed density in spring wheat.
- Land rolling in the previous year did not influence spring wheat yield, grain protein, water use, or water productivity

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Abbreviations: MAP, monoammonium phosphate; WP, water productivity; WU, water use.

Conversions: For unit conversions relevant to this article, see Table A.

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Table A. Useful conversions.

To convert Column 1 to Column 2, multiply by	Column 1 Suggested Unit	Column 2 SI Unit
5/9(°F– 32)	Fahrenheit, °F	Celsius, °C
9.29×10^3	square foot, sq ft	square meter, sq m
67.19	60-lb bushel per acre, bu/acre	kilogram per hectare, kg/ha
10	percent, %, w/w	g/kg
12.87	pound per bushel, lb/bu	kilogram per cubic meter, kg/cu m
25.4	inch	mm

without the addition of ballast. The force exerted by land rolling can compact soil, and soil compaction is known to decrease water infiltration rate and hydraulic conductivity (Horton et al., 1994). Al-Kaisi measured water infiltration rate on tilled loam, clay loam, and silty clay loam soils in Iowa and found decreased infiltration rate (reported in Rueber and Holmes, 2012). Conversely, Lenssen (2009) reported that water use and water use efficiency (water productivity) of pea were not influenced by land rolling on a sandy loam soil.

Land rolling can have other unintended effects that may or may not influence yield. Lenssen (2009) reported that densities of eight weed species, including green foxtail, kochia [*Bassia scoparia* (L.) A.J. Scott], horseweed [*Conyza canadensis* (L.) Cronquist], prickly lettuce (*Lactuca serriola* L.), redroot pigweed (*Amaranthus retroflexus* L.), Russian thistle (*Salsola iberica* Sennen & Pau), ribseed sandmat [*Chamaesyce glyptosperma* (Englm.) Small], and tumble mustard (*Sisymbrium altissimum* L.), averaged over barley, pea, and summer fallow, were doubled or tripled following land rolling. Despite applying herbicides to manage grass and broadleaf weeds, weed biomass under pea at harvest was 48% greater with land rolled at planting than without (Lenssen, 2009). Overall, literature is scant on the influence of land rolling on soil properties and crop production. To our knowledge, published information is not available on whether or not the productivity or weed community associated with the subsequent season's spring wheat crop is influenced by land rolling. Consequently, we conducted a study on spring wheat productivity and its associated weed community following three crops and two planting dates with and without land rolling in the previous year.

Experiment Location and Site Description

Details of the experimental site were provided by Lenssen (2009), including soil description and the land rolling study that preceded results reported here. Briefly, the experimental site was located on the Roosevelt and Sheridan County Conservation District Farm, 11 km south of Froid, MT (N 48.25627, E -104.49180). The soil was a Dooley fine sandy loam (fine-loamy, mixed, superactive, frigid Typic Argiustolls) (NRCS, 2002). A weather station within 250 yd of the plots was used for recording precipitation and air temperature. The initial land rolling study was conducted in 2004 and 2005 in a split-plot randomized complete block design. The whole-plot treatment was planting date of the previous crops. Split plots were a factorial of three previous cropping treatments with and without land rolling. Previous crops were: (1) 'Majoret' field pea, (2) awnletted 'Haybet' barley for hay production, and (3) summer fallow. Although no crop was planted in summer fallow, fallow plots were tilled identically as for pea and barley plots at each date. The land roller was a steel cylinder 10 ft wide and weighing 5324 lb, including the carriage frame. Ballast was not added to the roller. There were four replications of each subplot treatment. Individual subplot size was 10 ft wide and 30 ft long.

Methodologies

In 2005 and 2006, prior to planting spring wheat, soil was sampled from each plot and separated into 0- to 6-, 6- to 12-, 12- to 24-, 24- to 36-, and 36- to 48-inch depths. Samples were weighed, oven-dried at 221°F until dry, and reweighed, from which water content at each depth was determined. Preplant water content ($PREH_2O$) at the 0- to 48-inch depth was calculated by summing water contents for individual depths within each plot. Spring wheat 'Reeder' was planted in late April with a no-till drill equipped with double-shoot Barton (www.flexicoil.com/barton.asp) disk openers on 8-inch centers for low disturbance, single-pass seeding and fertilization. Seeding rate was 900,000 pure live seed/acre. The N fertilization rates at planting were 70, 90, and 90 lb N/acre for wheat following summer fallow, pea, and barley crops, respectively. Sources of N fertilizers were urea and monoammonium phosphate (MAP). Spring wheat also received 50 lb P_2O_5 from the MAP and 40 lb K_2O from muriate of potash at planting. All fertilizers were applied in a band located approximately 2 inches to the side and 2 inches below the seed row. Each year, the experimental area received a preplant application of 3 lb a.e./acre of glyphosate [*N*-(phosphonomethyl)glycine] in 7 gal/acre water prior to planting. Prior to spring wheat attaining boot stage, Zadoks 40 (McVay et al., 2010), tank-mixed 0.61 lb/acre bromoxonil (3,5-dibromo-4-hydroxybenzonitrile) and MCPA (2-ethylhexyl ester of 2-methyl-4-dichlorophenoxyacetic acid) (0.921:1) and 0.08 lb a.i./acre fenoxaprop-P {ethyl (RS)-2-[4-(6-chloro-1,3-benzoxazol-2-yloxy)phenoxy]propionate was applied for broadleaf and grass weed management.

Prior to the in-crop tank-mixed herbicide application (Zadoks 37–39) (McVay et al., 2010), weed community was determined

Table 1. Monthly and long term growing season precipitation and air temperature, Froid, MT.

Month	2005	2006	115-yr avg.
Total precipitation		inches	
April	0.24	3.15	1.18
May	3.78	1.73	2.05
June	6.69	2.17	2.95
July	1.50	1.18	2.05
August	1.81	1.42	1.57
Cumulative precipitation (Apr.-Oct.)	14.02	9.65	9.80
Mean air temperature		°F	
April	46.4	48.2	46.4
May	50.0	57.2	55.4
June	62.6	64.4	64.4
July	69.8	75.2	71.6
August	66.2	69.8	69.8

by identifying to species and counting all emerged weeds in five 1.08 ft^2 circular quadrats/plot. Within each quadrat, weeds were clipped at ground level and composited into paper bags. Weed samples were transported to the laboratory, dried in a forced-air oven at 131°F, and weighed.

Plant heights of spring wheat were determined prior to harvest from 10 stems per plot in 2005; stem heights were not determined in 2006. Grain yield for spring wheat was determined with a self-propelled combine harvester equipped with a 4.9-ft-wide header. Grain samples were dried in a forced-air oven at 131°F, cleaned using combinations of sieves and wind, and weighed. Grain yield results are presented as 100% dry matter concentration. Post-harvest soil sampling to a depth of 48 inches was done within 2 days of spring wheat harvest; sample handling and post-harvest soil water content ($POSTH_2O$) calculations were done as described for preplant soil water content. Water use (WU) by spring wheat was calculated as: $WU = PREH_2O + PRECIP – POSTH_2O$. The PRECIP term refers to precipitation received from preplant to post-harvest soil sampling. Water productivity (WP, syn. water use efficiency) (bu/acre-inch) for spring wheat was calculated as: WP = GY/WU, where GY is wheat grain yield (bu/acre) (Farahani et al., 1998).

Data were analyzed with PC-SAS (SAS Institute, 2012) using the MIXED procedure with year, planting date, previous crop, land rolling and their interactions as fixed effects and rep(year) and rep × planting date interaction as random effects (Littell et al., 1996). Planting date as the main-plot treatment and a factorial combination of land rolling and crop type as the split-plot treatment were used for data analysis. Weed counts were transformed with $\text{Log}_{10}(x + 1)$ prior to analysis to normalize distribution; however, data were retransformed to actual count for presentation of results. Mean separations were done using the least square means test (Littell et al., 1996) with differences among treatments reported significant at $P = 0.05$.

Table 2. Density of green foxtail, ribseed sandmat, red root pigweed, and total weeds in spring wheat prior to the in-crop herbicide application, Froid, MT.

Parameter	Green foxtail	Ribseed sandmat	Redroot amaranth	Total weeds
	no./sq ft			
Year				
2005	17.0 a†	12.5 a	4.9 a	41.7 a
2006	0.4 b	< 0.1 b	< 0.1 b	0.4 b
Planting date				
Conventional	6.7 b	5.3	2.0	17.0 b
Delayed	10.8 a	7.2	2.9	25.1 a
Previous crop				
Forage barley	7.3 b	5.5	2.8	18.8 b
Dry pea	13.5 a	8.1	1.8	27.9 a
Fallow	5.3 b	5.1	2.7	16.5 b
Land rolling (*R*)				
No	9.3	5.0	2.3	20.1
Yes	8.1	7.5	2.5	22.1
Significance	*P* > F			
Year (Y)	***	***	***	***
Planting date (P)	*	NS	NS	**
Y × P	NS	NS	NS	NS
Previous Crop (C)	***	NS	NS	***
Y × C	NS	NS	NS	NS
P × C	NS	NS	NS	NS
Y × P × C	NS	NS	NS	NS
Land rolling (*R*)	NS	NS	NS	NS
Y × R	NS	NS	NS	NS
P × R	NS	NS	NS	NS
Y × P × R	NS	NS	NS	NS
C × R	NS	NS	NS	NS
Y × C × R	NS	NS	NS	NS
P × C × R	NS	NS	NS	NS
Y × P × C × R	NS	NS	NS	NS

*Significant at the 0.05 level of probability; ** Significant at the 0.01 level of probability; *** Significant at the 0.001 level of probability.

† Means within a parameter followed by the same letter are not significantly different at $P \leq 0.05$.

Weather Conditions

Precipitation in 2005 was substantially above average from May into July, with cumulative seasonal rainfall 4.37 inches above the long-term average (Table 1). Conversely, after receiving nearly 2 inches more precipitation than the long-term normal in April 2006, the remainder of the growing season had below-average precipitation for every month through August. Monthly mean air temperatures in 2005 were cooler than normal, with 5.5°F lower in May than the same month of the 115-yr average. Monthly mean air temperatures in April, May, and August 2006 were above the long-term average.

Weed Occurrence

Eighteen and 13 weed species were identified in 2005 and 2006, respectively (results not presented), similar to the 22 species reported by Lenssen (2009). The predominant species

Table 3. Main effect means and significance for spring wheat plant height, yield, grain crude protein (CP) and test weight, preplant and postharvest soil water contents, water use (WU), and water productivity (WP) influenced by year, planting date, previous crop, and land rolling, Froid, MT.

Parameter	Plant height	Yield	Grain CP	Test weight	Grain N	Soil water			WP
						Preplant	Postharvest	WU	
	inches	bu/acre	%	lb/bu	lb/acre	inches			bu/acre-inch
Year									
2005	29.7	46.8 a†	15.4 b	59.0 a	76.6 a	5.4 b	3.4 b	15.8	2.98 a
2006	–	34.4 b	18.9 a	56.2 b	65.1 b	6.9 a	4.1 a	15.3	2.30 b
Planting date									
Conventional	29.7	41.0	17.4 a	57.5	72.3 a	5.9 b	3.7	15.2 b	2.72 a
Delayed	29.7	40.3	16.9 b	57.7	69.3 b	6.4 a	3.7	15.8 a	2.57 b
Previous crop									
Forage barley	29.3	39.0 b	17.1	57.7	68.1 b	5.9 b	3.8	15.2 b	2.61
Dry pea	29.9	40.2 b	17.2	57.7	70.2 b	5.8 b	3.7	15.3 b	2.64
Fallow	29.9	42.6 a	17.2	57.5	74.2 a	6.7 a	3.7	16.1 a	2.68
Land rolling (*R*)									
No	30.0	40.8	17.2	57.6	70.9	6.1	3.8	15.5	2.68
Yes	29.4	40.5	17.2	57.7	70.8	6.2	3.7	15.6	2.61
Significance	*P* > F								
Year (Y)	–	***	***	***	***	**	*	NS	***
Planting date (P)	NS	NS	**	NS	*	*	NS	*	*
Y × P	–	NS	NS	NS	NS	NS	NS	NS	NS
Previous Crop (C)	NS	***	NS	NS	***	**	NS	*	NS
Y × C	–	NS	NS	NS	NS	NS	NS	NS	NS
P × C	NS	NS	NS	NS	NS	NS	NS	NS	NS
Y × P × C	–	NS	NS	NS	NS	NS	NS	NS	NS
Land rolling (*R*)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Y × R	–	NS	NS	NS	NS	NS	*	NS	NS
P × R	NS	NS	NS	NS	NS	NS	*	NS	NS
Y × P × R	–	NS	NS	NS	NS	NS	NS	NS	NS
C × R	NS	NS	NS	NS	NS	*	NS	NS	NS
Y × C × R	–	NS	NS	NS	NS	NS	NS	NS	NS
P × C × R	NS	NS	NS	NS	NS	NS	NS	NS	NS
Y × P × C × R	–	NS	NS	NS	NS	NS	NS	NS	NS

* Significant at the 0.05 level of probability; ** Significant at the 0.01 level of probability; *** Significant at the 0.001 level of probability.

† Means within a parameter followed by the same letter are not significantly different at $P \leq 0.05$.

were green foxtail, ribseed sandmat, and redroot pigweed, which comprised 88% of observed individuals over the 2 yr. In addition, kochia and barnyardgrass [*Echinochloa crus-galli* (L.) P. Beauv.] accounted for 5% of the total individuals. Years differed for weed density, and the drier-than--normal condition in 2006, except in April, likely resulted in the decreased density of weeds in that year (Table 2). The observed weed community was similar to that previously reported by Lenssen (2009), except for a large decrease in wild oat (*Avena fatua* L.). Wild oat comprised 24% of total weeds in Lenssen (2009) compared with 4% of individuals in the current study. Although the experimental site had been under an integrated weed management system that included crop diversification, banded fertilization, and narrow row spacing (Anderson, 1999; Derksen et al., 2002; Anderson, 2008), it is unlikely that the wild oat seed bank was completely depleted within any treatment or plot area over a single year.

Planting date and the previous-year crop influenced green foxtail and total weed density, but interactions among treatments and years were not significant (Table 2). Delayed planting resulted in greater density of green foxtail and total weeds than conventional planting date in spring wheat. In contrast, green foxtail and total weed density were lower following dry pea than following forage barley and summer fallow. Gürsoy et al. (2019) recently reported soil planking, a mechanical method to prepare seedbeds, increased density of black nightshade (*Solanum nigrum* L.), Mexican groundcherry (*Physalis philadelphica* Lam.), purple nutsedge (*Cyperus rotundus* L.), and common reed [*Phragmites australis* (Cav.) Trin ex. Steud] but decreased density of bermudagrass [*Cynodon dactylon* (L.) Pers.] and field bindweed (*Convolvulus arvensis* L.), but weed densities were not presented for the subsequent year. In our study, land rolling crops in the previous year did not influence weed density in the subsequent year.

Table 4. Preplant soil water content (0–4 ft depth) influenced by the previous crop x land rolling interaction averaged across year and planting date, Froid, MT.

Previous crop	Preplant soil water	
	Rolled	Not rolled
	——— inches ———	
Forage barley	6.0 a†	5.9 a
Dry pea	5.5 a	6.1 a
Fallow	7.1 a	6.2 b

† Means within a parameter followed by the same letter are not significantly different at $P \leq 0.05$.

Spring Wheat Yield and Quality

Plant height of spring wheat did not vary for any treatment parameter or interaction in 2005 (Table 3), the only year height was measured. Conversely, year and previous crop were significant for grain yield (Table 3). Not surprisingly, spring wheat had greater yield in the wetter and cooler year, 2005, than in the drier and hotter year, 2006. Spring wheat yield in this study was greater than the state-wide average for Montana by 24 and 3 bu/acre, respectively, for 2005 and 2006 (MASS, 2019). Land rolling, and its interactions with other treatments and years, were not significant for spring wheat yield. Grain protein concentration was influenced by year and planting date of previous crops. The 2005 grain had lower protein concentration than the 2006 grain. Protein concentration was also greater for conventional than delayed planting. Dilution of N concentration due to increased grain yield probably reduced protein concentration in 2005. Differences in precipitation and air temperature between years likely influenced grain test weight. Test weight was greater in 2005 than 2006. Increased precipitation and air temperature probably led to the heavier grains in 2005.

The N accumulated in grain differed for year, planting date, and previous crop (Table 3). Land rolling and all interactions were nonsignificant. Grain N accumulation was 11.5 lb/acre greater in 2005 than in 2006. Earlier planting of the previous crop resulted in spring wheat grain accumulating 72.3 lb N/acre, 3.0 lb/acre greater than for wheat following delayed planting. Spring wheat following summer fallow accumulated 74.2 lb N/acre, 4.1 and 6.1 lb/acre more than wheat following pea and barley, respectively, despite being fertilized with 20 lb/acre less N. Spring wheat following summer fallow in semiarid environments often has greater yield (Lenssen et al., 2007a, 2013) and grain protein concentration and N accumulation than recropped wheat (Lenssen et al., 2007b), especially in drier years when soil water compromises soil organic matter turnover, reducing nitrate uptake and grain fill.

Soil Water

Preplant soil water content (0–4 ft) was influenced by year, planting date, previous crop, and the previous crop × land rolling interaction (Table 3). Prior to planting spring wheat, soil had 1.5 inches greater soil water content in 2006 than 2005. Pre-plant soil water was 0.5 inches less when the previous crop was planted at the conventional date, late April, compared with the delayed planting date (Table 3). Pre-plant soil water content was not influenced by land rolling following dry pea and barley forage production; however, land-rolled summer fallow had 0.9 inches greater water content than summer fallow that was not land-rolled (Table 4). Post-harvest soil water content (0–4 ft) differed for year and the year × land rolling and planting date × land rolling interactions (Table 3). Postharvest soil water content was similar regardless of land rolling in 2006 but was 0.5 inch lower with land rolling than without in 2005 (Table 5). Postharvest soil water content was not affected by land rolling with conventional planting of the previous crop but was 0.4 inches lower with land rolling than without with delayed planting (Table 6). Gürsoy et al. (2019) reported soil planking increased soil water content and penetration resistance in the 0- to 15-cm depth, but the potential influence on soil in the subsequent season was not reported.

Table 5. Postharvest soil water content for the year by land rolling interaction averaged across planting date and previous crop, Froid, MT.

Land rolling	2005	2006
	——— inches ———	
No	3.6 a†	4.0 a
Yes	3.1 b	4.2 a

† Means within a parameter followed by the same letter are not significantly different at $P \leq 0.05$.

Water use by spring wheat varied with planting date and previous crop (Table 3). Spring wheat used 0.6 inches more water with delayed than conventional planting date of the previous crops. As postharvest soil water content was not influenced by the planting date of previous crops, greater spring wheat water use with delayed planting was probably due to 0.5 inches greater available water prior to planting. Spring wheat following summer fallow used 0.8 to 0.9 inches greater water than wheat following dry pea and forage barley. These amounts corresponded directly to the greater soil water available to wheat following summer fallow. The WP was influenced by year and planting date; no other treatment factor or interaction was significant (Table 3). The cooler, wetter year of 2005 had superior WP compared with the hotter, drier year of 2006, a response by wheat reported from numerous studies conducted in semiarid regions. Increased grain yield but similar water use resulted in greater WP in 2005 than 2006. Spring wheat with the conventional planting

Table 6. Postharvest water content for the planting date by land rolling interaction averaged across year and previous crop, Froid, MT.

Land rolling	Planting date	
	Conventional	Delayed
	——— inches ———	
No	3.6 a†	3.9 a
Yes	3.8 a	3.5 b

† Means within a parameter followed by the same letter are not significantly different at $P \leq 0.05$.

date of previous crops had greater WP than with delayed planting date (Table 3). Similar grain yield, but lower water use, resulted in greater spring wheat WP with conventional than delayed planting date. Delayed planting is a cultural practice sometimes recommended for management of wild oat and other cool-season weeds in spring-planted cereals; however, decreased WP with delayed planting can occur due to decreased yield from drier and hotter conditions for a range of crops, including barley forage (Lenssen, 2009) and spring wheat (Lenssen et al., 2014). Despite the additional 0.5 inches of pre-plant soil water content and subsequently enhanced WU, spring wheat yield did not increase, resulting in decreased WP with delayed planting of previous crops. Land rolling the previous season exerted limited influence on subsequent spring wheat water relations or productivity.

Conclusions

Green foxtail and total weed density increased with delayed planting of previous crops as well as following dry pea compared with following forage barley and summer fallow. Conventional planting date of previous crops increased spring wheat grain protein concentration compared with delayed planting, but the trend reversed for preplant soil water content, WU, and WP. Preplant soil water content, WU, and grain yield of spring wheat was greater following summer fallow than when following dry pea or barley forage. Land rolling annual crops and summer fallow in the previous year did not influence weed density, grain yield, protein concentration, and water use or water productivity of the subsequent spring wheat. Although yield and water productivity of spring wheat and weed density can be influenced by planting date and previous crops, land rolling had minimal effects on subsequent spring wheat production. Although land rolling can increase the energy cost of crop production, land rolling places rocks to soil level, below the cutting height for grain and forage harvest equipment, reducing equipment damage without affecting yield of spring wheat the following year.

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