Read the following article and take the exam to become eligible for one Crop Management Continuing Education Unit for the Certified Crop Advisor Program.

Stubble Options for Winter Wheat in the Black Soil Zone of Western Canada

Winter wheat (*Triticum aestivum* L.) is a valuable alternative in a Canadian prairie cropping sequence. Winter wheat has many advantages over spring wheat, which includes diversifying the workload, higher yield potential, improved water use, and habitat for migratory game birds. From a weed management standpoint, it is important to employ diversified crop rotations that mitigate the dominance of major weeds.

Successful winter wheat production in most of western Canada requires planting a cold-tolerant cultivar into standing stubble that is capable of accumulating at least 10 cm of snow to insulate the crown of winter wheat and to improve survival. With the exception of pea and lentil (*Lens culinaris* Medik.), most crops are cut tall enough to allow for sufficient snow cover.

The time of the year when stubble will become available for winter wheat planting also is important when considering stubble options for winter wheat. Winter wheat should be sown from the last week of August to the end of the second week of September to allow sufficient growth to optimize winter survival and subsequent yield. This means that the previous crop must be harvested prior to the end of August for an effective crop sequence.

Canola (*Brassica napus* L.) is the most common stubble that winter wheat is planted into. Furthermore, with improvements in blackleg tolerance and weed control it is now possible to grow canola in shorter rotations, which makes canola stubble a common choice for winter wheat planting. Canola is often dry enough for combine harvest in time for winter wheat planting, but high chlorophyll content in the seed often requires that harvest be delayed. Greater growing degree requirements for high-yield cultivars and the potential for water stress in the drier southern regions causes producers in these areas to choose later-maturing canola cultivars. Therefore, the challenge of having canola stubble available for winter wheat plantings is often similar in southern and northern locations.

The large area of canola production, excellent weed control options for canola, and the relatively easy removal of canola volunteers in succeeding crops make canola an attractive stubble option for spring and winter cereal crop plantings. Pea and barley stubble may also have potential because of the relatively early time of maturity for these crops. Pea and barley stubble both mature relatively quickly, which means they would be a suitable stubble option in terms of availability at optimal dates for winter wheat planting. However, it is not known how winter wheat will perform on these stubble types.

Winter wheat can be a good option for cereal phases in Canadian prairie cropping systems, and awareness of feasible stubble options for winter wheat planting may improve producer adoption of winter wheat. The objective of this study was to investigate a range of cereal and non-cereal stubble options for succeeding winter wheat and spring cereal crops to determine sustainable crop sequence options for winter wheat grown in the black soil zone.

MATERIALS AND METHODS

Site Description and Experimental Design

The experiment was established on stubble sites at Brandon, Man., Canada in 2002, and at Indian Head, Sask., Melfort, Sask., and Lacombe, Alta., Canada in 2003. The study was conducted for four years at each location on a new stubble site each year. There were three stubble creation years followed by three years of cereal cropping.

Establishment Year

A new stubble site was established at each location in the first three years. Six crops were planted in 3-replicate RCB design at each site. The six crops were as follows: barley grain cultivar adapted to each location; barley silage cultivar adapted to each location; Roundup Ready™ canola (LG3455, etc.); pea cultivar adapted to each location; oat (*Avena sativa* L.) cultivar adapted to each location; Canada Western Red Spring (CWRS) bread wheat (AC Barrie). Each of the six crops was managed according to their end use purpose (grain or silage).

Year After Establishment

In the year after the establishment year, six cereal crops were randomly planted into standing stubble of each stubble type from the establishment year. The six cereals crops were as follows: CDC Osprey Canada Western Red Winter (CWRW) wheat; UM5809 (McClintock) CWRW winter wheat (lesser winter hardiness); AC Barrie CWRS wheat; AC Foremost

SOURCE: This article is adapted from the research paper "Stubble Options for Winter Wheat in the Black Soil Zone of Western Canada" by R. B. Irvine, G. P. Lafond, W. May, H. R. Kutcher, G. W. Clayton, K. N. Harker, T. K. Turkington, and B. L. Beres published in the Canadian Journal of Plant Science, 2013, 93(2): 261-270, 10.4141/cjps2012-198.

Canada Prairie Spring (CPS red) wheat (not included at Lacombe); AC Metcalfe barley; and oat. Winter wheat was planted by the optimal date (30 August to 15 September) at each location. Planting of winter wheat occurred immediately after main plot crop was harvested if harvest was delayed past the optimal date.

Data Collection

Crown depth was measured in the fall on 10 plants per winter wheat plot. Snow depth was measured at 5 locations in the middle of each winter wheat plot at monthly intervals throughout the winter. Soil temperature was collected with a datalogger in the winter wheat plots for 3 replicates using 1 sensor inserted at crown depth. Snow trap potential was assessed as follows: (stubble height (cm) x stubble stems per m of row x stubble rows per m)/100.

RESULTS AND DISCUSSION

Crop Responses

One goal of this study was to determine the responses of winter wheat, and assess yield and quality relative to other cereal crops. Winter wheat stands were adequate but slightly lower than the ideal reported in other studies. Winter wheat yields were greater than CWRS (Canadian Western Red Spring) wheat, similar to CPS (Canadian Prairie Spring) wheat, and less than oat or barley (Table 1).

The main effect for stubble type was statistically significant ($P < 0.001$) for plant density, and the crop by stubble type interaction for plant density was not significant ($P = 0.837$). Unprotected F tests indicated that CPS wheat plant density was slightly (about 15 plants m^{-2}) less when grown on barley-grain or CWRS wheat stubble vs. other stubble types (Table 1). The stubble effect for other crops was not significant ($P > 0.200$).

The main effects of crop and stubble type for cereal crop yield were statistically significant ($P < 0.001$). On average, the yield of crops grown on canola, pea and barley silage stubble most often was greatest, and yield on wheat and barley stubble most often was least (Table 1). Unprotected F tests showed that the effect of stubble type was dependent on the wheat/crop class. The effect of stubble type for yield impacted winter and CPS wheat the most, whereas, stubble type did not affect oat yield. For example, the average winter wheat yield was 1.4 T ha^{-1} greater when planted on canola versus CWRS wheat stubble. Average spring wheat and barley yields were about 1 T ha^{-1} greater when grown on pea vs. CWRS wheat or barley-grain stubble.

Kernel protein concentration generally was greatest for crops grown on wheat or pea stubble compared with canola and oat stubble (Table 1). This reinforces the notion that stubble types other than canola can be a good option for winter wheat producers to ensure optimal winter wheat yield and kernel quality. Increased N availability is often associated with an N benefit, especially from preceding N-fixing crop such as pea. In our study, cereal crop yields after pea stubble provided a rotational benefit for spring wheat and barley yields and protein concentration, but not for both winter wheat cultivars. It could be that temporal N mineralization patterns from grain legume residue may not be as synchronous with winter wheat N demands as it is with spring cereal crops.

The rotation benefit of the previous non-cereal crop to the succeeding cereal crop is well-documented. The benefit of including canola or pea prior to seeding winter or spring wheat, barley and oat clearly benefitted yield. Foliar diseases were assessed at one location to assess the non-N benefits of different stubble types.

Average leaf spot disease severity became more important as the growing season progressed from cereal heading to soft dough especially for the penultimate leaf. Average McFadden rating scale for leaf spot diseases at heading stage of the two winter wheat cultivars was 1.0 (average across penultimate and flag leaves). By the soft dough stage, average disease rating of the two winter wheat cultivars was 2.8 for flag leaves and 6.2 for penultimate leaves. Disease ratings often did not differ among stubble types, with a few notable exceptions. Leaf spot ratings for penultimate winter wheat leaves at the soft dough stage were greater for CDC Osprey winter wheat grown on wheat or barley silage stubble (data not shown). Average barley leaf disease severity at heading and soft dough was about 38 times greater on barley stubble versus other stubble types (data not shown). Ratings at either crop stage for CPS red wheat grown on CWRS wheat stubble were approximately double compared to other stubble types (data not shown). Therefore, a benefit of reduced leaf disease severity was clear when growing winter wheat or any other cereal crop on stubble types of dissimilar crop types. There were for leaf disease severity differences when winter wheat was grown on barley silage stubble compared with barley grain stubble; greater disease severity with barley silage stubble may have been a consequence of more conducive conditions (greater aboveground biomass) for foliar disease development.

Increased snow trapping could increase the thermal protection of winter wheat crowns in winter months and improve soil water availability the next spring. Our results suggested that average snow depth across winter months was about 3 cm less for pea and barley silage stubble versus canola and cereal stubble types (data not shown). The STP (snow trap potential) was greater for cereal grain crops, intermediate for barley silage, and least for canola and pea stubble (data not shown). The STP was also low for canola (29.8) but the value exceeds the minimum STP (>20) needed for successful winter wheat production. Lesser snow depth after barley silage did not influence grain yield performance, and none of the snow depth differences among stubble types were related to any plant stand differences. This indicates that plant stand survival and factors related to snow trapping were not important determinants of winter wheat production in this study. However, it could also reflect the fact that all stubble types but field pea created an acceptable STP for winter wheat, therefore, a negative crop response to lower STP values was not observed. It is clear that other factors related to stubble did influence plant stands as winter wheat plant density was 17 plants m^{-2} greater for canola and barley silage stubble, which also optimized winter wheat grain yield performance vs. barley grain stubble (Table 1). It is thought that the additional variability (site variance estimates for the two winter wheat varieties) for winter wheat plant density may be the reason this plant stand difference was not detected (data not shown). Therefore, future research should continue to focus on improving the consistency of winter wheat stand uniformity, regardless of the stubble types. There is also value in determining the reason for the improved winter wheat yields on barley silage stubble vs. barley grain.

Site Variability

In addition to mean responses, variability for crop responses across sites were modeled. Site interactions revealed the most variable treatments; i.e., treatments that deviate most frequently from average responses. Site variability is also a way to assess the risk of different management practices.

It was found that model fit was optimized when a site and site by stubble variance estimates were estimated for each crop. Site variance estimates for each crop were considerably greater than the site by stubble variance estimates for each crop (data not shown). There also were some differences for these site variance estimates among wheat/crop classes tested in this study. Site variance estimates were more variable for one or more of spring cereal stubble types compared with winter wheat and oat for all variables except plant density (data not shown).

Table 1. *Mean crop responses for data collected at four Canadian prairie locations in three years*

Variable / Crop	*Stubble*							
Plants (no. m^{-2})	*Wheat*	*Barley (G)*	*Barley (S)*	*Oat*	*Canola*	*Pea*	*Mean*	*LSD*
CWRW UM5809	175[z]	165	183	173	186	168	175	26
CWRW CDC Osprey	182	171	188	181	185	174	180	24
CWRS wheat	235	232	239	240	241	243	238	18
CPS wheat	*190*	*179*	*195*	199	196	206	194	15
Barley	196	189	199	191	202	197	195	15
Oat	248	*229*	239	245	243	247	242	17
Mean	204	*194*	207	205	209	206		9

Yield (Mg ha^{-1})	*Canola*	*Pea*	*Barley (S)*	*Oat*	*Barley (G)*	*Wheat*	*Mean*	*LSD*
CWRW UM5809	4.12	3.67	3.8	3.42	3.11	*2.77*	*3.48*	0.46
CWRW CDC Osprey	4.12	3.71	3.78	*3.21*	*3.04*	*2.78*	*3.44*	0.47
CWRS wheat	2.88	2.96	2.88	2.63	2.63	*2.32*	*2.72*	0.21
CPS wheat	3.88	4.02	3.82	3.41	3.42	*2.95*	*3.58*	0.28
Barley	4.77	4.97	4.63	4.59	*3.93*	4.42	4.55	0.3
Oat	4.94	5.07	5.3	4.87	5.03	4.92	5.02	0.4
Mean	4.12	4.06	4.03	3.69	3.53	*3.36*		0.19

Protein conc. (g kg^{-1})[y]	*Wheat*	*Barley (S)*	*Pea*	*Barley (G)*	*Canola*	*Oat*	*Mean*	*LSD*
CWRW UM5809	124	124	121	122	121	*117*	*122*	4
CWRW CDC Osprey	122	120	117	118	*117*	*113*	*118*	4
CWRS wheat	139	137	141	136	137	*134*	137	3
CPS wheat	122	120	121	119	*118*	*118*	*119*	2
Barley	116	118	118	120	117	115	*117*	3
Mean	125	124	124	123	122	*119*		2

Test wt. (kg hL^{-1})	*Canola*	*Pea*	*Barley (S)*	*Barley (G)*	*Wheat*	*Oat*	*Mean*	*LSD*
CWRW UM5809	78	76.6	77.8	75.7	*74.5*	76.2	76.5	3.5
CWRW CDC Osprey	74.7	75.3	74.9	74.1	74.7	74.6	74.7	1.8
CWRS wheat	76.3	76.4	76	75.4	75.8	*75.2*	*75.8*	1.1
CPS wheat	73.6	73.4	72.9	73	72.9	72.5	73	1.3
Barley	60.6	61	*59.1*	*58.8*	*59.8*	*59.4*	59.8	1.2
Oat	49.1	48.8	48.6	49.8	48.9	*47.4*	*48.8*	2.1
Mean	68.7	68.6	68.2	67.8	67.7	*67.6*		1

[z] Means for each variables are sorted in rank order according to stubble type means across crop. Means for each crop, and across crops, are separated according to unprotected LSD. Upper-yielding group (underlined) are those means similar to greatest mean based on LSD and then least-yield group (italicized) are remaining means or those means similar to smallest mean based on LSD. Those means that are either underlined or italicized are means in between greatest and smallest groups.

[y] Oat protein concentration data was not collected.

The site by stubble variances were statistically significant ($P < 0.05$) and/or greater for winter wheat varieties compared to other cereal crops for plant density, yield, protein content and test weight; the one exception was a lower variance estimate for CDC Osprey test weight. The site by crop by stubble variance estimates were statistically significant for all disease variables except for penultimate leaf spot ratings at heading (results not shown). The most noteworthy of the site by crop by stubble interactions was for soft dough ratings, which accounted for over half of the total variance associated with the random effects including site. It could be expected that disease infestations, and corresponding treatment effects, would be quite sensitive to environmental variations relative to other agronomic responses such as yield.

Additionally, statistically significant ($P < 0.05$) deviation predictions (difference from the overall mean for a given treatment combination across sites relative to the predicted means for the same treatment combination for a given site) were most frequently noted for winter wheat grown on pea or canola stubble, particularly for plant density and yield (data not shown). These findings indicate that previously-mentioned greater site by stubble variance estimates for winter wheat may be in part due to greater variability for winter wheat grown on non-cereal stubble types.

CONCLUSIONS

Winter wheat is a viable cropping option for western Canadian producers but adoption has not grown in recent years. To facilitate uptake of winter wheat, it is important to identify the barriers to adoption and develop improved management systems for winter wheat. Crop sequence options and stubble management for successful winter wheat establishment and production is a critical component of this system. Canola is generally considered to be one of the better stubble options to plant winter wheat. However, our results suggest that there are alternatives (e.g., barley silage stubble and pea) to canola that will produce high yields, and unlike canola, produce greater protein and more stable responses in the presence of environmental variation. Sowing winter wheat on barley silage stubble may be an ideal alternative stubble strategy. From an operational viewpoint, barley silage is harvested early enough in the fall (mid-August) to ensure winter wheat can be sown at the optimal seeding date, unlike canola that can be harvested significantly later, especially when later-maturing cultivars are grown in northern growing regions of the Canadian Prairies. Some stubble options for winter wheat explored in this study such as barley (grain) and oat were identified as intermediate or poor stubble options; however, these stubble types may be the only option for winter wheat plantings in some areas. Further crop sequence research is needed to ensure successful winter wheat production across the Canadian Prairies.

CAAR
Canadian Association of Agri-Retailers

Crop Management Forum

Join us at CAAR's Crop Management Forum
Nov. 19, 2013

Royal Oak Inn, Brandon, MB
8:30 AM – 4:00 PM

CCA's can earn CEU's. Visit **caar.org** for more information, including the agenda, and how to register.

NOTE: Date, time and location for all live training events are tentative and subject to change. All live events are subject to minimum attendance requirements.