

Mixtures of modern and historical wheat cultivars under organic management in western Canada

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Abstract

*Two historic (Red Fife and Marquis) and two modern (5602HR; AC Barrie) wheat (*Triticum aestivum*) cultivars were assessed to determine if cultivar mixtures provided a benefit to grain yield and disease and weed suppression in Manitoba over 3 site-years. 5602HR was the highest yielding sole cultivar while Marquis and AC Barrie were the lowest yielding sole cultivars. Red Fife yielded similar to 5602HR in several cases. Orthogonal contrasts across all site-years showed that 3 and 4 cultivar mixtures yielded similar ($P>0.05$) to 5602HR, the highest yielding monocrop.*

Introduction

Cultivar mixtures are typically used in production to maintain quality and yield while reducing pesticide inputs (Newton, 1997). Cultivar mixtures have been successfully utilized in spring barley (*Hordeum vulgare*) crops in Europe (Mundt, 2002). Few cultivar mixture studies have been conducted in Canada.

Wheat cultivars used before the advent of high input farming in western Canada (1880-1950) are considered by some organic farmers to be better suited for organic management. Older cultivars have been shown to be more responsive to mycorrhizal colonization than modern cultivars, which would enhance the cultivar's nutrient acquisition capabilities in lower fertility conditions (Hetrick et al., 1992). Wheat production in western Canada is often dominated by one or two major cultivars. AC Barrie is grown on over 40% of wheat hectares in the region; in Manitoba AC Barrie is grown on over 60% of wheat hectares. 5602HR is poised to become the next dominant wheat cultivar in the region.

Materials and methods

Three site-years of experiments were conducted on organically-managed land in Manitoba in 2004 and 2005. Fifteen treatments were tested in a randomized complete block design with 4 replicates. Two historic (Red Fife and Marquis) and two modern cultivars (5602HR and AC Barrie) were used in treatments of sole cultivars; and all two, three and four cultivar combinations. The treatments were seeded proportionally to achieve a final seed population of 300 viable seeds m^{-2} at a row spacing of 15 cm. Wheat was seeded in late May. Crop and weed density were assessed 3 weeks after seeding. Leaf disease was measured on 20 flag leaves sampled during mid-grain filling; percent leaf area infected was measured. Grain yield was assessed at maturity from samples threshed with a plot combine. Statistical analysis was carried out using analysis of variance and orthogonal contrasts.

Results and Discussion

Few significant differences in weed density were observed (Table 1). Only Marquis, of the historic cultivars, resulted in numerically fewer weeds than all other sole cultivar

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treatments. 5602HR, the most recently developed cultivar, had higher weed densities at Carman in 2005 than both historic cultivars; a similar trend was observed at the other two sites.

The major diseases were leaf rust (*Puccinia tritici*), Septoria leaf blotch (*Septoria tritici*) and tan spot (*Pyrenophora tritici-repens*). Surprisingly, Red Fife was the cultivar which consistently had the lowest leaf disease level (Table 1). One explanation for this observation is Red Fife's slower phenological development (7 days later), which may have allowed it to avoid disease. A full disease assessment in 2005 revealed that the lowest levels of disease tended to occur in mixtures that contained Red Fife, even when it was grown in mixtures with cultivars that in monoculture had a high disease level (e.g., Marquis and AC Barrie).

Few treatment differences for grain yield were observed in this study. At Carman in 2005, 5602HR has significantly higher yield than the majority of treatments (Table 2). It was interesting to note that 5602HR produced the highest grain yield at Carman in 2005, despite having the most weeds (Table 1) and the highest weed biomass (data not shown). While the modern cultivar 5602HR had a higher grain yield than Red Fife and Marquis at Carman in 2005, mixtures containing Red Fife and Marquis without 5602HR were comparable in grain yield to 5602HR (Table 2). Therefore, mixtures did display some yield compensation.

When combined across site-years, 5602HR yield significantly more than Marquis, AC Barrie and the Marquis-5602HR mixture. As Marquis and AC Barrie appeared to be the most affected by disease in all site-years (Table 1), it follows that their grain yield would be reduced compared to other treatments.

Orthogonal contrasts were used to compare the grain yield of the highest yielding cultivar, 5602HR, to mixtures with increasing levels of cultivar diversity. When combined across site-years, 5602HR significantly outyielded all two mixture treatments (Table 2). However, as the number of cultivars within the mixtures was increased, the yield gap between 5602HR and the mixtures decreased. In fact, the probability level of the contrast increased with each additional cultivar in the mixture; three and four cultivar mixtures yielded the same ($p > 0.05$) as the 5602HR monocrop (Table 2).

Conclusion

This preliminary study showed that cultivar mixtures provided some advantages over wheat sole cultivars. While cultivar mixtures did not provide consistent overyielding to sole cultivars, in two of three site-years, cultivar mixtures had the highest yield. Also, in the one case where 5602HR had the highest yield among sole cultivar crops, some mixtures were comparable in yield. Some of the advantage from mixtures in this study may have resulted from lower leaf disease offered by Red Fife.

5602HR, the most recently developed spring wheat cultivar in western Canada yielded well under organic management, despite high levels of weed infestation. However, long-term production of such "weedy" cultivars may allow weed populations to build up, causing future problems.

Tab. 1: The effect of wheat cultivars and wheat cultivar mixtures on weed population density and flag leaf disease severity (percent leaf area covered; %LAC) in field experiments conducted over three site-years in Manitoba. Numbers in columns followed by different letters are significantly different at P<0.05.

	Clearwater 2004		Carman 2004		Carman 2005	
	Weeds (m ⁻²)	Disease (%LAC)	Weeds (m ⁻²)	Disease (%LAC)	Weeds (m ⁻²)	Disease (%LAC)
Red Fife	2262	89 b	2331 ab	22 b	1696b	79 de
Red Fife-Marquis	2212	-	2298 ab	-	1711b	83 cde
Red Fife-5602HR	2094	-	2320 ab	-	1554b	73e
Red Fife-AC Barrie	2532	-	2216 ab	-	1873ab	72e
Red Fife-Marquis-5602HR	2133	-	2448 ab	-	1529b	80de
Red Fife-Marquis-AC Barrie	2141	-	2215 ab	-	1873ab	82cde
Red Fife-AC Barrie-5602HR	2526	-	2238 ab	-	1847b	73e
Red Fife-Marquis-AC Barrie-5602HR	2277	-	2582 a	-	1446b	91bcd
Marquis	2099	100 a	1958 ab	89 a	1345b	99a
Marquis-5602HR	2242	-	2010 ab	-	1532b	98a
Marquis-AC Barrie	2229	-	2200 ab	-	1539b	94abc
Marquis-5602HR-AC Barrie	2365	-	2237 ab	-	1900ab	97ab
5602HR	2311	98 a	2418 ab	61 a	2478a	93abc
5602HR-AC Barrie	2496	-	1840 b	-	1786b	98ab
AC Barrie	2440	99 a	2121 ab	89 a	1640b	97ab

Tab. 2: The effect of wheat cultivars and wheat cultivar mixtures on wheat grain yield (kg/ha) in field experiments conducted over three site-years in Manitoba, and contrasts comparing 5602HR with 2, 3 and 4 cultivar (cvs.) mixtures. Numbers in columns followed by different letters are significantly different at P<0.05.

	Clearwater 2004	Carman 2004	Carman 2005	Combined (3 site-years)
Red Fife	2474	2368 ab	1695 b	2179 ab
Red Fife-Marquis	2419	2334 ab	1711 b	2155 ab
Red Fife-5602HR	2290	2356 ab	1553 b	2066 ab
Red Fife-AC Barrie	2769	2251 ab	1872 ab	2297 ab
Red Fife-Marquis-5602HR	2332	2487 ab	1528 b	2166 ab
Red Fife-Marquis-AC Barrie	2341	2250 ab	1872 ab	2154 ab
Red Fife-AC Barrie-5602HR	2762	2273 ab	1846 b	2294 ab

Red Fife-Marquis-AC Barrie-5602HR	2490	2622 a	1446 b	2186 ab
Marquis	2295	1988 ab	1345 b	1876 b
Marquis-5602HR	2452	2041 ab	1531 b	2008 b
Marquis-AC Barrie	2438	2234 ab	1538 b	2070 ab
Marquis-5602HR-AC Barrie	2586	2272 ab	1900 ab	2253 ab
5602HR	2526	2456 ab	2477 a	2487 a
5602HR-AC Barrie	2729	1869 b	1785 b	2128 ab
AC Barrie	2668	2154 ab	1640 b	2033 b
Contrasts				
5602HR vs 2 cvs.	0.9575	0.2599	0.0013	0.0308
5602HR vs. 3 cvs.	0.9170	0.5899	0.0072	0.1063
5602HR vs. 4 cvs.	.08864	0.6017	0.0018	0.1734

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