The effect of incorporating the midge resistance (*Sm1*) gene in wheat

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Abstract

Orange wheat blossom midge, *Sitodiplosis mosellana* (Géhin), was first detected in Manitoba in 1901, but now is present in all three prairie provinces of western Canada. In severe infestations, this insect may cause significant yield losses to spring wheat. To mitigate losses, midge-resistant wheat varietal blends, consisting of cultivars carrying the *Sm1* midge resistance gene and 10% interspersed midge susceptible refuge, are now available to farmers. The refuge prevents this resistance to be overcome by the insect. To test the field performance of these varietal blends, relative to conventional midge-susceptible cultivars, four varietal blends were grown during four consecutive years, at eight locations in the provinces of Manitoba Saskatchewan and Alberta, in comparison to four conventional, midge-susceptible cultivars. Midge damage was higher in 2007 and 2010, than in 2008 and 2009. In general, the varietal blends, as a group, yielded more grain than the susceptible cultivars, especially when grown in environments with high midge pressure (5.5 - 35% seed damage). In environments with low midge pressure (0 – 2.6% seed damage), the varietal blend average yield advantage was smaller but still significant, indicating that some of the varietal blends had additional superior attributes, in addition to midge resistance. Significant differences in midge damage were observed within the resistant and the susceptible groups of the cultivars tested. Midge resistance did not protect wheat against loss of market grade.

Material and Methods

Four midge-resistant varietal blends (Fieldstar VB, Goodeve VB, Shaw VB and Unity VB) and four conventional midge-susceptible cultivars (AC Intrepid, CDC Teal, Katepwa and Waskada) were grown during four growing seasons (2007-2010), at eight locations in the provinces of Manitoba (Brandon), Saskatchewan (Indian Head, Melfort, Regina, Saskatoon and Swift Current) and Alberta (Lacombe and Lethbridge). Experimental design was a randomized complete block design, with 4 replications. Environments (year-locations) were categorized into three midge-pressure groups, based on seed damage results from the dissection of spikes collected before harvest from each plot, each year. Also, harvested seed samples were submitted to the Canadian Grain Commission (CGC) for seed damage assessment.

Results and Discussion

Cultivar performance in field trials

Midge-resistant wheat varietal blends did not completely escape the effect of the orange wheat blossom midge insect, but seed damage on resistant blends was much lower (3.7 %) than that experienced by midge-susceptible cultivars (8.5%). In general, the varietal blends, as a group, yielded more grain than the susceptible cultivars, especially when grown in environments with high midge pressure, but in environments with low midge pressure the comparative yield advantage of the varietal blends was smaller but still significant (Fig. 1).

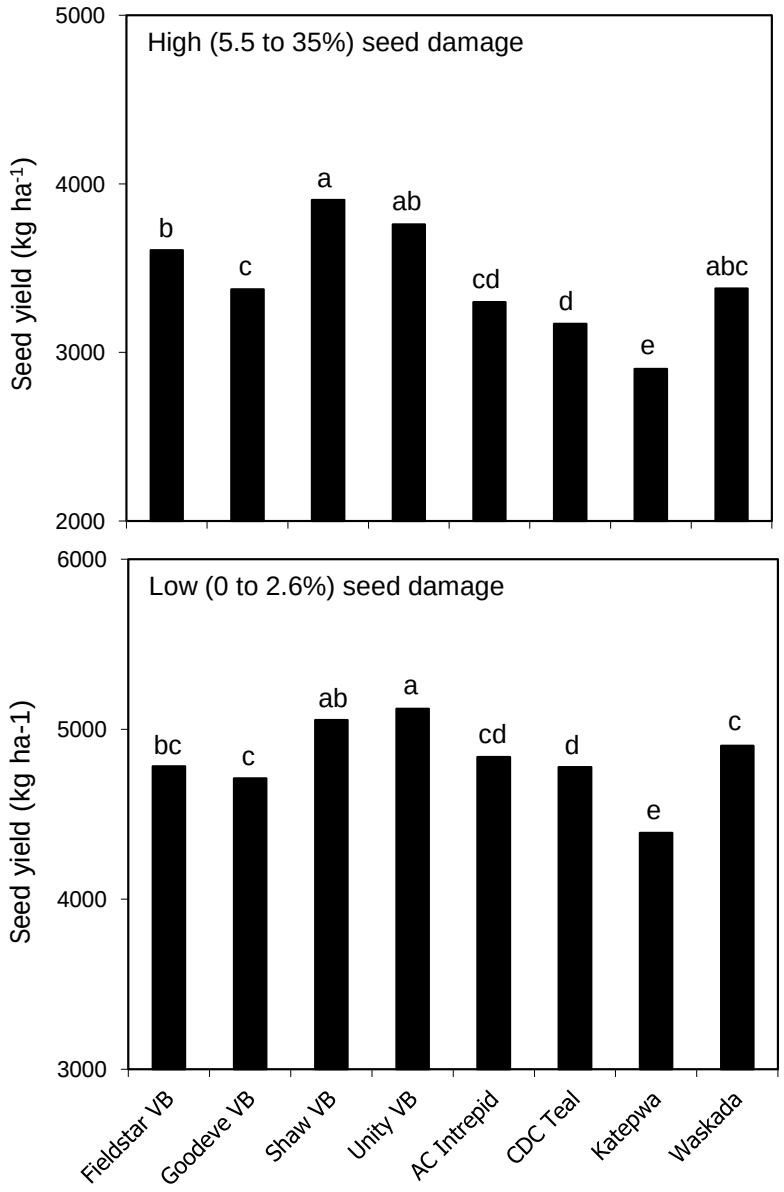

Figure 1. Seed yield of four midge-resistant wheat varietal blends (Fieldstar VB, Goodeve VB, Shaw VB and Unity VB) and four midge-susceptible wheat cultivars (AC Intrepid, CDC Teal, Katepwa and Waskada) , grown at eight locations in the three prairie provinces of Canada during the period 2007-2010, at two levels of midge pressure. Columns with same letters do not differ significantly, based on t-test at $P \leq 0.05$.

Seed yield was 29% lower in environments with high midge pressure (5.5 - 35% seed damage) than in environments with low midge pressure (0 – 2.6% seed damage), but this effect cannot completely be attributed to the degree of midge damage encountered in these two sets of environments. The weather conditions of the two years with higher midge incidence (2007 was 17% dryer and 4% warmer than normal and 2010 was 55% wetter and 9% colder than normal) were less conducive to high seed yield.

Seed damage in dissected spikes

Data obtained from dissected spikes indicated that, in years with high (Fig. 2, top graphs) and low (Fig. 2, bottom graphs) midge incidence, susceptible cultivars had a much larger proportion of seed damage than the resistant varietal blends. Much of this damaged seed was considered not harvestable (< 8 mg).

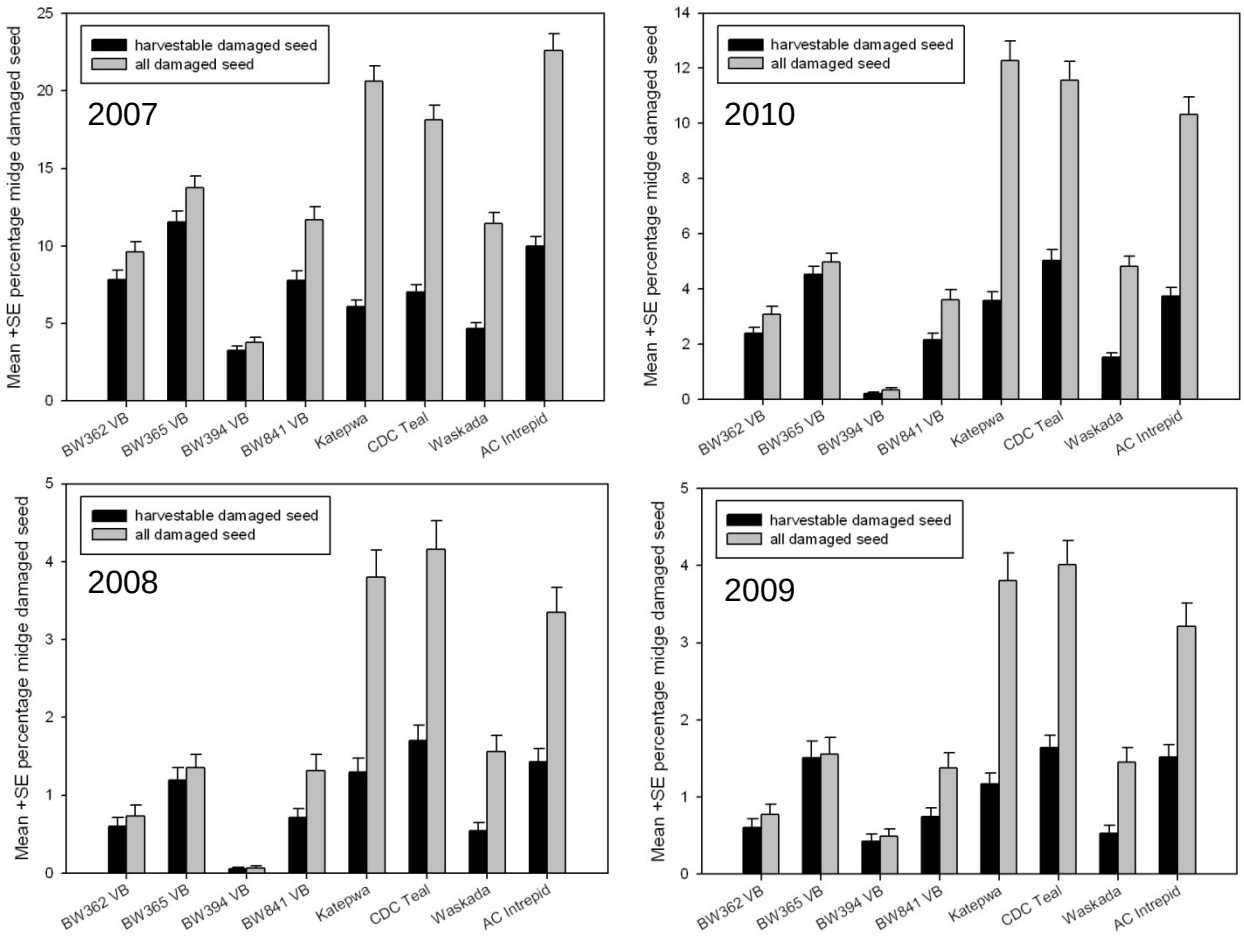

Figure 3. Percent damaged seed of four midge-resistant wheat varietal blends [Fieldstar VB (BW365 VB), Goodeve VB (BW841 VB), Shaw VB (BW394 VB) and Unity VB (BW362 VB)] and four midge-susceptible wheat cultivars (AC Intrepid, CDC Teal, Katepwa and Waskada) , in 2007 and 2010, the two years with highest midge pressure (top graphs), and in 2008 and 2009, the two years with lowest midge pressure (bottom graphs).

Seed damage assessment by CGC inspectors

In 2007, the year with highest midge incidence, with the exception of Shaw VB, all resistant varietal blends and susceptible cultivars had higher seed damage that the 2% seed damage threshold, above which wheat seed is downgraded to No.2 (Fig. 3). Among the susceptible cultivars, Waskada, which has oviposition deterrence, barely reached this threshold.

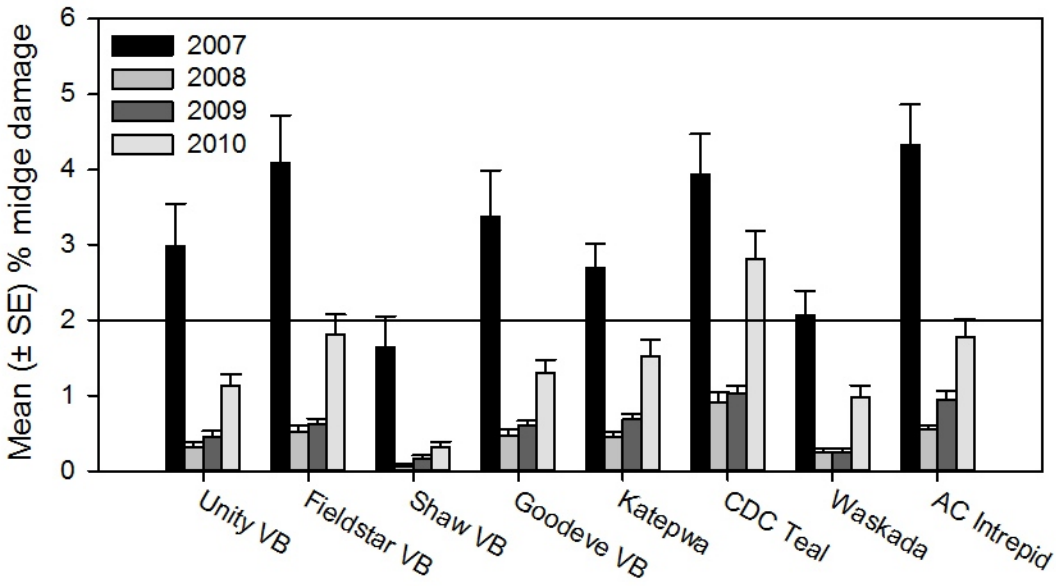

Fig. 3. Percentage seed damaged in experimental plots of resistant varietal blends (VB; contain a 10% susceptible refuge) and susceptible cultivars. Seed damage in samples of cleaned, harvested grain from each plot was estimated by grain inspectors at the Canadian Grain Commission (CGC). The horizontal reference line at 2% indicates the midge-damage tolerance limit for wheat to be graded as No. 1.

Conclusions

The wheat midge-resistant varietal blends used in this study were affected to a lesser degree by the midge insect than the midge–susceptible cultivars with which they were compared, and, as a group, they significantly out-yielded (15%) the midge-susceptible cultivars, even in environments with low midge pressure (4%), an indication that most of these new cultivars may have additional attributes, beside their resistance to midge. Thus, it is concluded that, under high midge pressure, these resistant varietal blends had an 11% yield advantage, independent of other gains in yield potential, which was considered directly derived from their resistance to midge.

In environments with high midge incidence, midge resistance did not protect wheat against loss of ‘market grade’, but it could increase ‘market value’ due to larger yields.

Among the resistant varietal blends, Shaw VB showed the highest level of resistance to seed damage caused by midge, and had the highest seed yield, when subjected to high midge pressure. Among the susceptible cultivars, Waskada, which has oviposition deterrence resistance, had the least seed damage and one of the highest seed yield.

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