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Information courtesy of the Midge Tolerant Wheat Stewardship Team

Midge Tolerant Wheat

The Midge Tolerant Wheat Stewardship Team is a broad industry coalition representing plant breeders, government, seed growers, seed distributors and producer groups. See the complete list of partners and more details at www.midgetolerantwheat.ca.

MIDGE TOLERANT WHEAT
Plant · Protect · Preserve

Introduction

Wheat midge infestations can reduce crop yield and lower the market grade of harvested grain. For example, in 2006, Prairie growers lost approximately $40 million due to midge damage, which caused both downgrading and yield reduction. For an average wheat grower, these losses can range from $20 to $75 per acre.

Crop damage occurs when the midge larvae feed on the developing wheat kernel. Grain damage ranges from a slight change in shape, to a kernel that is completely shrunken and deformed, to complete abortion of the kernel. The damaged kernels can cause downgrading in wheat samples and 40-50 per cent are blown out of the combine during harvest.

Producers currently try to control wheat midge fly with insecticides, but it's difficult to assess which fields need spraying and the window for effective application is short. Insecticides also destroy beneficial parasitoids of midge.

New midge tolerant wheat varieties will be commercially available starting in the spring of 2010, under the names of AC® Unity VB, AC® Goodeve VB, AC® Glencross VB and AC® Fieldstar VB. These new midge tolerant varieties offer large savings for Prairie wheat growers since they will reduce downgrading and yield losses caused by wheat midge. There should also be a significant drop in the use of costly insecticides.

Wheat Midge Life Cycle

The orange wheat blossom midge is well known across most of western Canada. The life cycle of the wheat midge has four stages:

Adult – The adult midge is a very small, fragile orange fly about half the size of a mosquito, approximately 2 to 3 mm long - two black eyes cover much of its head. The midge has three pairs of legs that are long relative to its body size. Its wings are oval shaped, transparent and fringed with fine hairs.

In late June or early July, midge begin to emerge from the soil as adult flies, mate, and the females lay eggs on the newly emerged wheat heads. Midge emergence peaks in mid-July. Female midge, live for less than seven days and lay an average of 80 eggs.

Eggs – Egg laying generally takes place after 8:30 p.m. when wind speeds are less than 10 km/h and the air temperature is greater than 15°C. Eggs are laid, either singly or in clusters of three or four eggs, on the wheat heads. The egg stage lasts four to seven days, depending on environmental conditions, especially temperature.

Larvae – Upon hatching, the small orange larvae move from the spikelet surfaces into the florets to feed on the developing kernels. Larvae feed and develop for two to three weeks, growing to 2 to 3 mm in length before crawling off the wheat head to bury themselves in the soil. Over-wintering larvae may remain dormant until conditions are favourable for development, whether that is the following spring or several years later.

Pupae – Once temperature and soil conditions end the over-wintering period, the larvae become active and move to the soil surface to pupate. Emergence of the adult flies begins in late June or early July and can continue for up to six weeks.

Midge Distribution

Wheat midge is distributed throughout all wheat growing areas, where it lies in wait for optimal conditions to allow local populations to flourish. Although infestations have been

primarily located in central Saskatchewan and western Manitoba, they are moving into Alberta as well.

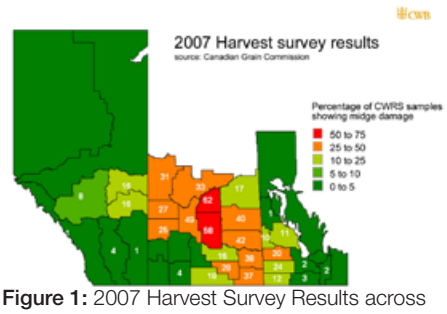

Figure 1: 2007 Harvest Survey Results across the Prairies

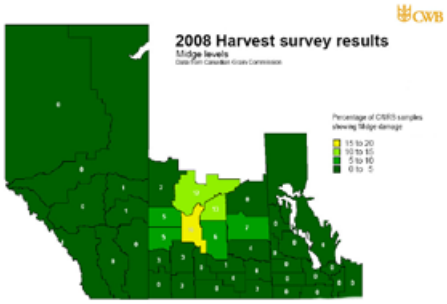

Figure 2: 2008 Harvest Survey Results across the Prairies

Harvest survey maps from the Canadian Grain Commission (CGC) in 2007 and 2008 (Figures 1 and 2) show that while damage is variable from year to year, damage from wheat midge can appear on as many as 62 per cent of CWRS samples graded by the CGC in a given year.

Midge Emergence

Midge emergence can be modeled using accumulated temperature calculations called Growing Degree Days (GDD). The Canadian Wheat Board provides midge emergence maps for the Prairies, updated daily from mid-June until the end of July.

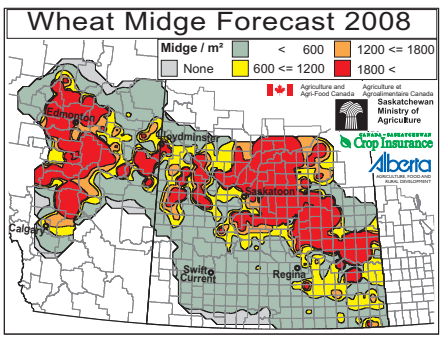

Figure 3: Wheat Midge Forecast for 2008

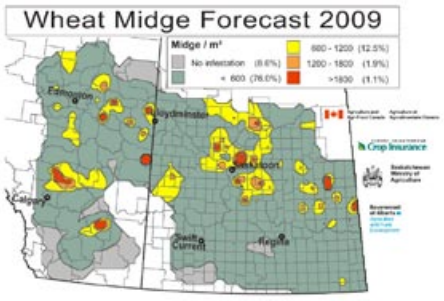

Figure 4: Wheat Midge Forecast for 2009

Wheat Midge Forecast maps for 2008 and 2009 (Figures 3 and 4) also show variability from year to year, with lower pest numbers expected in 2009.

Midge Tolerant Wheat

New midge tolerant wheat varieties will provide wheat growers with more flexibility in crop rotations and seeding dates, and also enable a significant drop in the use of insecticides, the traditional means of dealing with wheat midge.

The midge tolerance in each of the new varieties originates from a single gene – *Sm1*. Using traditional plant breeding techniques, Agriculture & Agri-Food Canada (AAFC) wheat breeders moved this gene into four spring wheat varieties that also boast superior yield and agronomic traits:

AC® Unity VB
AC® Goodeve VB
AC® Glencross VB
AC® Fieldstar VB

AC® Unity VB, AC® Goodeve VB, and AC® Glencross VB will become commercially available in 2010, whereas AC® Fieldstar VB, will be available in spring 2011.

These four varieties are not genetically modified organisms (GMOs). The *Sm1* gene is a naturally occurring gene in wheat. *Sm1* was incorporated into CWRS wheat through crossing with a winter wheat variety from the U.S. This used traditional plant breeding techniques, not biotechnology.

These varieties were developed by AAFC wheat breeders in Winnipeg and Swift Current using funds from AAFC, the Western Grains Research Foundation check-off program and variety distributors.

About the Varieties

Midge tolerant wheat varieties will be sold as a blend of two varieties (VB stands for varietal blend). The varietal blend will have 90 per cent of one variety that is midge tolerant and 10 per cent of another variety that is midge susceptible. Blending of these tolerant and susceptible varieties will occur at the breeder seed stage of pedigreed seed production, verified with a test for the presence of the refuge prior to crop certification.

Three of the registered varieties are Canada Western Red Spring (CWRS) wheat. Two of these will be distributed by SeCan and one will be distributed by Alliance Seed Corporation. The other registered variety is Canada Western Extra Strong (CWES) wheat and will be distributed by Faurschou Farms.

The initials VB refer to varietal blend, and appear after the varietal names AC® Unity, AC® Goodeve, AC® Glencross, AC® Fieldstar and future varieties to be released.

All these spring wheat varieties boast superior yield and agronomic traits. Please contact the variety distributors for more information, or e-mail the addresses below for variety-specific information:

- For information on AC® Unity VB, e-mail unity@midgetolerantwheat.ca
- For information on AC® Fieldstar VB, e-mail fieldstar@midgetolerantwheat.ca
- For information on AC® Goodeve VB, e-mail goodeve@midgetolerantwheat.ca
- For information on AC® Glencross VB, e-mail glencross@midgetolerantwheat.ca

How the *Sm1* Gene Works

When midge larvae begins to feed on the seed, the *Sm1* gene causes the level of phenolic compounds (naturally occurring organic acids in wheat kernels) to elevate more rapidly than in wheat kernels without the *Sm1* gene. The higher levels of phenolic acids cause the midge larvae to stop feeding and the larvae starve to death.

The mechanism that triggers the production of phenolic acids does not operate if midge larvae

Table 1: Midge Tolerant Variety Descriptions

Variety Name	Refuge Variety	Class	Distributor	Commercially Available
AC® Unity VB	AC® Waskada	CWRS	SeCan	Spring 2010
AC® Goodeve VB	AC® Intrepid	CWRS	Alliance Seed Corporation	Spring 2010
AC® Glencross VB	AC® Burnside	CWES	Faurschou Farms	Spring 2010
AC® Fieldstar VB	AC® Waskada	CWRS	SeCan	Spring 2011

are not feeding on the seed, and in addition, these acids are reduced to normal levels by the time wheat reaches maturity – thus not affecting the quality or food value of the harvested grain.

Challenges with Single Gene Resistance

It took more than 15 years and a huge financial investment for researchers to move this single gene, *Sm1*, into spring wheat varieties. It is the only known gene that confers tolerance to wheat midge.

Tolerance based on a single gene has a history of becoming ineffective over a relatively short period of time as insect populations change. The insect population traits can shift because a small number of midge carry a mutation allowing them to attack varieties carrying the *Sm1* gene and survive. Wheat midge which are able to attack plants with the *Sm1* gene are called virulent.

A very low level of virulent midge exists within the natural midge population. However, if virulent midge mate with other virulent midge, a large virulent population quickly builds up and the *Sm1* gene could become ineffective within 10 years. For example, Hessian fly resistance genes in spring wheat in the U.S. are deployed without a refuge. These genes were quickly overcome due to shifts in the Hessian fly population.

Non-virulent wheat midge cannot survive the *Sm1* gene contained in midge tolerant wheat. If non-virulent midge mate with virulent midge, the progeny of this cross will be non-virulent since non-virulence is the dominant trait.

Interspersed Refuge System

In order to preserve the effectiveness of the *Sm1* gene, an interspersed refuge system – planting a blend of a midge tolerant variety with a susceptible variety – is required. This system helps prevent the build-up of midge that are able to attack wheat carrying the *Sm1* gene. This can extend the life of midge tolerance from as little as 10 years to 90 years or longer.

In an interspersed refuge system (Figure 5), the refuge variety (AC® Waskada, AC Intrepid, or AC® Burnside) is evenly distributed (inter-seeded) throughout the field. This is different to the Bt corn refuge management system where the refuge is grown as a block beside or within the same field. An interspersed refuge is used instead of a refuge block system because the adults mate at the emergence site, so this makes it highly likely that virulent midge mate with non-virulent midge.

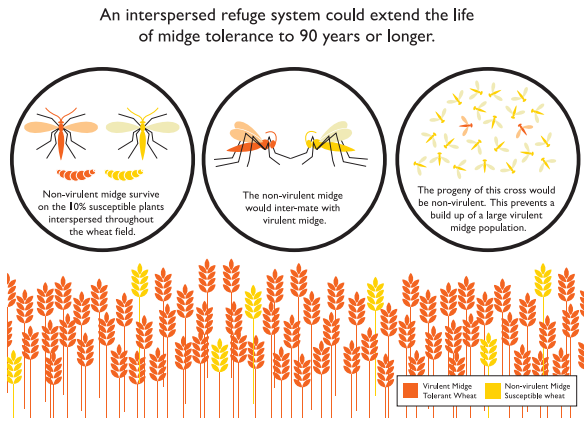

Figure 5: Illustration of Interspersed Refuge System

However, this refuge system does mean that 10 percent of the crop (the refuge variety) will suffer severe damage under a heavy midge infestation.

Together, farmers and seed growers are responsible for maintaining an interspersed refuge system in midge tolerant wheat. This is necessary to preserve midge tolerance because:

- The tolerance is based on a single gene, which has a history of becoming ineffective over time. An interspersed refuge system could extend the life of midge tolerance from as little as 10 years to 90 years or longer
- It took researchers more than 15 years to move this single gene into spring wheat varieties.
- No other known source of midge tolerance has been identified so we all need to work together to maintain this valuable trait for today and for generations to come.

Consequences of a Pure Stand

If midge tolerant wheat is grown in a pure stand, only virulent midge will survive (Figure 6). The virulent midge would mate only with other virulent midge. A large virulent population quickly builds and feeds on tolerant varieties. Without an interspersed refuge system, midge tolerance could break down within 10 years.

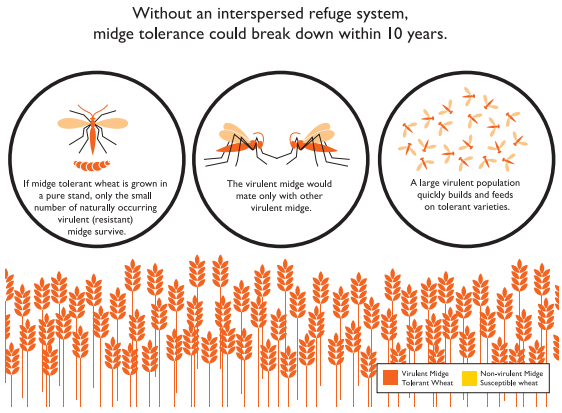

Figure 6: Illustration of Break-Down of Midge Tolerance without Refuge System

Effectiveness Versus Insecticides

As the varieties are new, there is very little experience comparing field scale use of insecticides versus field scale production of varieties carrying the *Sm1* gene. However, it appears that the *Sm1* gene is effective in protecting the crop from large scale losses in yield due to wheat midge. There may be some down-grading in varieties carrying the *Sm1* gene since the midge larvae need to feed briefly on the wheat kernels before they die.

Limit the Use of Farm-Saved Seed

In addition to the refuge system, farmers are required to limit the use of farm-saved seed to one generation past Certified Seed. This condition is critical because wheat midge may attack the refuge variety and the level of the refuge in farm-saved seed may change substantially over multiple generations. For example, under an extremely heavy midge infestation, the susceptible refuge variety could sustain up to 50 per cent yield loss. To keep the refuge at the desired level of 10 per cent of the plant population, it is necessary to limit the use of farm-saved seed to one generation past Certified Seed.

Farmers are also required to sign a stewardship agreement, which is necessary to make sure that the importance of the refuge is communicated to farmers and that the refuge is followed. We as an industry need to preserve midge tolerance so farmers can continue to benefit from this technology. The agreement ensures that all farmers will maintain the interspersed refuge system in midge tolerant wheat and extend the useful life of the *Sm1* gene for as long as possible.

Stay Informed

In a November 2008 survey (Figure 7), 384 farmers across the Prairies were asked "If you wanted more information about midge tolerant wheat, which would be your preferred source of information?" Of the respondents, who were allowed to choose more than one answer, 57 per cent said seed dealers, 28 per cent said crop protection retailers, and 19 per cent said crop consultants were their preferred source of information. Farmers will be asking about this technology, so be informed.

Here are a few benefits of midge tolerant wheat to share with your farm customers:

- Prevent an estimated $36 per acre* loss from midge damage down-grading and yield reductions.
- Reduce reliance on insecticide applications, the traditional method of midge control.
- Gain more flexibility in crop rotations and seeding dates.

*Based on the economic threshold of one midge per 4 to 5 wheat at flowering = estimated 15 per cent yield loss if not controlled. Higher midge levels can lead to greater losses. 15 per cent x $6.00/bu wheat x 40 bu/acre = $36.00.

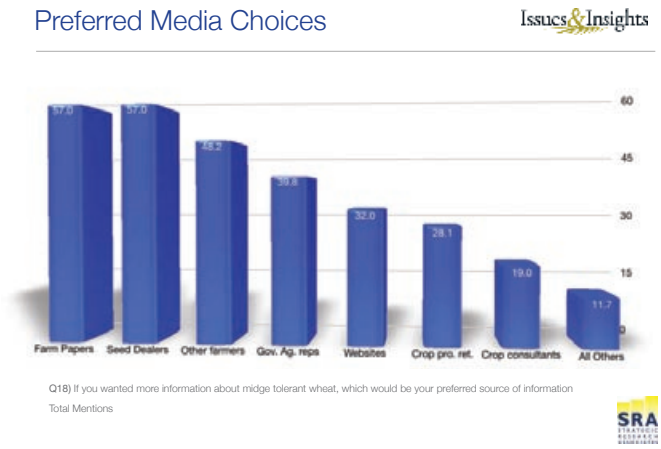

Figure 7: Prairie Farmers Responses to November 2008 Survey Question Regarding Midge Tolerant Wheat

More information on the varieties, the refuge systems and the distributors is available at www.midgetolerantwheat.ca.

Summary

The introduction of four new midge tolerant wheat varieties – AC® Unity VB, AC® Goodeve VB, AC® Glencross VB, and AC® Fieldstar VB – will offer large savings for Prairie wheat growers since they will reduce downgrading and yield losses caused by wheat midge. The tolerance gene, *Sm1*, is the only gene known to confer midge tolerance, and has been incorporated using traditional breeding methods.

Because this is the only known source of midge tolerance, the varieties must be protected. The use of an interspersed refuge system will help slow the development of virulent midge populations and allow the varieties to be effective for up to 90 years. Farmers are also required to limit saved seed to one generation after certified seed, and sign a stewardship agreement to ensure they understand the importance of and comply with the variety protection practices. ◆