

Orange Wheat Blossom Midge

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The wheat midge is widely distributed throughout Europe and Asia and has long been recognized in many parts of North America. However, it has only recently developed into a serious insect pest of spring wheat in Montana.

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DURING THE 1980S, THE WHEAT MIDGE BECAME a key pest of spring wheat, with outbreaks occurring in the prairie provinces of Canada. The outbreak spread throughout western Canada and the northern Great Plains of the United States by the early 1990s. Significant damage to spring wheat crops has been reported in Alberta, Saskatchewan, Manitoba, Minnesota, and North Dakota. The midge also has been reported in southern British Columbia, and the panhandle of Idaho.

The 1990s outbreak resulted in low numbers of the wheat midge being reported in northeastern Montana. However, the Flathead Valley experienced an unprecedented outbreak in 2006. This was the first report of any economic significance in the state.

Spring wheat fields that normally would have yielded 80-90 bushels per acre instead produced less than 2 bushels. A conservative estimate put the

economic loss at over 1.5 million dollars in Flathead County. The midge has since been a reoccurring problem in northwestern Montana.

Unfortunately, the distribution of the midge appears to be expanding. The midge has recently been reported in several counties in the Golden Triangle production area. In addition, there also appears to be a resurgence of the midge in the northeastern part of Montana.

The insects' exact distribution is uncertain, but it may be established in other parts of Montana as well. The midge can remain undetected and exist at low populations for several years before becoming a significant problem. However, as was the case in the Flathead Valley, populations have the potential to increase rapidly when given the proper set of climatic conditions.

Damage

The wheat midge may be small, but its effects on wheat yields and local agricultural economies can be huge. Yield losses of more than 7 million bushels were reported in North Dakota during 1995, while annual economic losses in Canada can exceed \$100 million when insecticide costs and dockage penalties are considered along with yield reductions.

Spring wheat is the primary host in North America, while winter wheat is the key host in Europe and Asia. That said, the midge can also be found in winter wheat fields in Montana and may reproduce on late developing tillers. Durum wheat is another important host, with spring rye and triticale also being vulnerable. Barley can be an occasional host, but larval development is rare.



photo by Phillip Glogozzi, University of Minnesota Extension

FIGURE 1. Adult wheat midge.



FIGURE 2. Midge larvae feeding on wheat kernel.

Damage to the crop is not readily apparent since the insect feeds inside the wheat head. Damage can only be detected by threshing the heads and by inspecting the kernels. Upon inspection, orange-colored larvae can be found feeding on the developing seed (Figure 2). The larvae feed by exuding enzymes which break down cell walls and convert starch to sugar. Each larva is capable of reducing grain size by 30-50 percent, and it's not uncommon to find several larvae feeding on a single kernel.

The kernels may abort entirely, not fully develop, or only be slightly damaged. The extent to which the kernel is damaged largely depends on the number of larvae present as well as when feeding begins relative to the development of the kernel; smaller, immature seeds are most vulnerable to damage, while the larger more developed kernels are less affected (Figure 3). Concurrently, wheat plants are most susceptible when feeding occurs during early heading and declines once flowering is complete.

The most obvious impact of this pest is a reduction in yield. However, more subtle effects also occur. Small, shriveled seed and low test weights are common occurrences and are often mistaken for the effects of frost damage or drought stress. Damage to the seed coat allows easier water entry, often resulting in sprout damage and low falling numbers.



FIGURE 3. Midge-damaged wheat kernels.

In addition, damaged seeds are generally more susceptible to attack from pathogenic fungi, which can reduce germination and seedling vigor and result in dockage due to mold. Furthermore, the adults can act as a vector for diseases that infect wheat seeds (wheat scab and glume blotch).

The Enemy

The insect has one generation per year with four distinct life stages: egg, larval, pupal, and adult. The larvae over-winter within the top two to four inches of the soil surface inside a cocoon. As soil conditions improve in the spring, the larvae become active, emerge from the cocoon, and move closer to the soil surface to pupate.

Larvae can often be found on the soil surface during the last week of May if soil moisture is adequate (Figure 4). If soil conditions are dry, the



FIGURE 4. Midge larvae on soil surface.

larvae remain dormant (diapause). Dormancy periods of five years are not uncommon, and some reports indicate that these periods can last up to 13 years.

Once the midge has passed to the pupal stage, the adults will typically begin to emerge within two weeks. Pupation and adult emergence largely depends on soil temperatures. However, soil moisture also is critical, and June thunderstorms are often associated with major outbreaks. Adult emergence occurs over an extended period, with peak emergence occurring from mid-June to mid-July. However, the emergence period can extend into August.

The newly formed adult midge is a very small, orange-colored fly about half the size of a mosquito. Adults are relatively poor fliers, but they may be distributed over long distances by thermal updrafts and wind. During the day the adults stay within the crop canopy where humidity levels are high. In the evening the females become active, flying about and laying eggs on newly developing wheat spikes.

Due to the fragile nature of the midge, egg-laying generally takes place in the evenings from about 8:30 - 11:00 p.m., which coincides with higher humidity levels. In addition, egg-laying rarely occurs if wind speeds are greater than six mph or if air temperatures are less than 59°F. In short, warm calm evenings are required for egg laying.

The female lays eggs either singly or in groups of three to five on individual florets of the wheat spike. Although the females only live for about seven days, they will lay an average of 80 eggs. The eggs hatch in about four to seven days, depending on environmental conditions.



FIGURE 5. Larvae drop from wheat heads after rain or heavy dew.

Upon hatching, the small orange larvae move from the outer surface of the floret to feed on the developing wheat kernel. The larvae feed for two to three weeks before climbing up the awns and dropping to the soil surface in early August. This event requires either dew or rain to trigger the behavior (Figure 5). Upon reaching the ground, they immediately bury themselves into the soil and form a cocoon to over-winter and repeat the cycle.

Under dry conditions the larvae will stop development, will shrink back inside the outer skin and will remain within the wheat head until moisture conditions improve. If moisture conditions do not improve, the larvae will remain in the heads and get threshed out during harvest.

Management Considerations

Rotations

The first reaction is to plant anything other than spring wheat or durum wheat. Winter wheat would seem to be an option since grain filling is typically well underway by the time the adults emerge and start to lay eggs. However, late developing winter wheat tillers can still be vulnerable to egg-laying adults.

It should be noted that the midge is a major pest of winter wheat in Europe and Asia. Furthermore, insects can adapt to their environment. The wheat stem sawfly is an example of a pest that successfully made the transition from spring to winter wheat. Only time will tell, but for now winter wheat appears to be a viable option.

Other cereal crops are worth considering. However, the midge does attack other grasses, including barley, rye, triticale and intermediate wheat grass. Midge infestations on these plants are usually not serious enough to warrant control. While these grasses might allow the midge to complete its life cycle, the resulting population would be much smaller when compared to continuous spring wheat.

Peas, canola and other broadleaf crops are logical options to consider, but the overall effect of crop rotations on midge numbers is only a partial solution

given the fact that the insect can remain dormant for periods ranging from five to 13 years. Nevertheless, there are many reasons to consider a diversified rotation.

Insecticides

Insecticides are available for controlling the wheat midge, and recommendations can be found at the High Plains IPM guide, <http://wiki.bugwood.org/HPIPIM:SmallGrains>.

However, there are two points to consider before applications are made:

1. Economic Thresholds - are adult populations sufficient to warrant an application, and
2. Crop Stage - is the spring wheat crop vulnerable to damage from the midge.

Economic Thresholds Fields should be monitored from late boot through flowering in order to determine if populations warrant an insecticide application. There are several methods available for detecting the presence of the midge, but sex pheromone traps are perhaps the easiest (Figure 6). The traps should be put in fields about five days before heading, and placed at the height of the crop canopy. Periodic adjustments in trap height

are needed during the monitoring period as stem elongation occurs.

The traps should be placed about 75 feet in from the field edge and spaced about 300 feet apart. Three traps per 160 acres is the recommended density. Examine the traps every one to two days for the presence of midge. Traps can be purchased from Great Lakes IPM, www.greatlakesipm.com.

While pheromone traps can indicate whether or not adult emergence has occurred, their use is generally considered as an early warning system. Scouting should be initiated as soon as midge adults are found in the pheromone traps. Scouting should be start after 8:30pm to coincide with peak female activity, and fields should be inspected in at least three to four different locations. Insecticide treatments are recommended if one or more adults are observed for every six heads.

The midge is difficult to scout for. Densities might be high, but scouting efforts may fail to reveal their true numbers if evening temperatures are less than 59°F, humidity is low, or wind speeds are greater than 6 mph. And because adults emerge over several weeks, late developing tillers, or areas in the field where heading is delayed, such as low spots where soil moisture is favorable, will continue to be vulnerable to attack.

Farming practices that promote greater crop uniformity during heading have been advocated as a means to reduce midge damage and to improve insecticide efficacy. Uniform planting depths and the use of high quality, certified seed can promote uniform crop emergence, while higher seeding rates can reduce tillering. Together, these practices will favor uniform crop maturity.

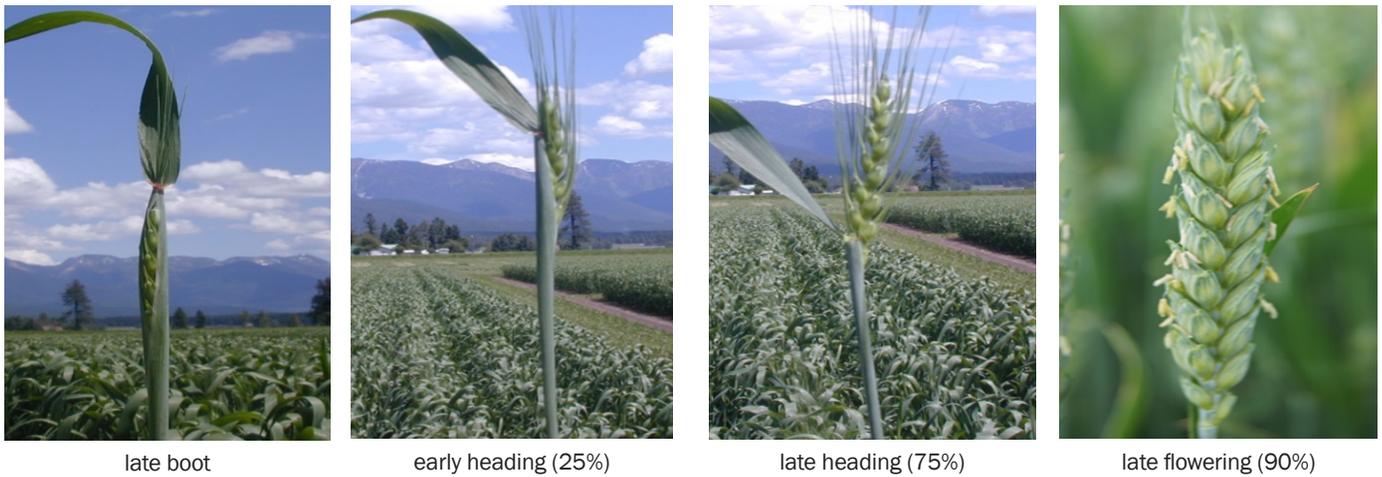
Crop Stage Although chemical control measures are available, their efficacy is highly dependent on precise timing of spray applications. Because adult emergence and egg-laying occurs over a period of several weeks, insecticides rarely provide complete control. However, damage can be minimized if insecticide applications are timed to protect the crop when it is most vulnerable.

Wheat is most susceptible to midge damage when egg-laying occurs from early heading through pollination (Figure 7). As such, fields should be



FIGURE 6. Midge adults in pheromone trap.

FIGURE 7. Highest risk of damage if egg-laying occurs from early heading to late heading.



monitored daily from the time the heads begin to emerge from the boot until the anthers are visible.

Provided that economic threshold levels are present, the optimum stage to apply an insecticide is when 70 percent of the crop is headed. Applications prior to this growth stage will result in reduced control. In fact, if only 30 percent of the crop is headed, you should wait up to four days before treating. Likewise, applications made after 70 percent heading may result in reduced control.

Insecticides affect the adults as well as the emerging larvae as they eat through the outer integument of the egg. However, insecticides are not effective in controlling older larvae, which are protected within the floret of the wheat spike. As a result, insecticides applied when 75 percent of the plants have begun flowering do not provide adequate control. Further, late applications have the potential to kill beneficial parasitic wasps (see below).

Insecticide application is recommended at dusk because female adults are most active at this time of day. However, early morning applications may also produce acceptable results. Through spray coverage is essential, and application methods which improve the uniformity and amount of spray deposited on wheat heads provide better control.

Planting dates

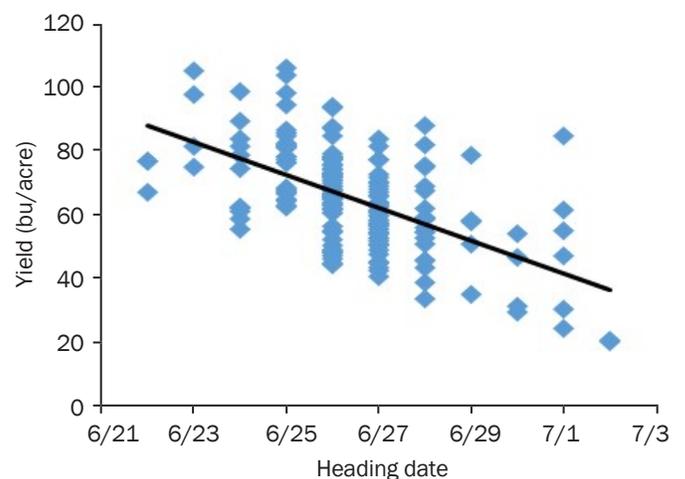
Since spring wheat is most vulnerable to attack from early heading through pollination, planting as early as possible may help the crop to develop beyond the

susceptible stage before the adults begin laying eggs. Selecting early maturing varieties also would help the crop to develop sooner and avoid damage from the midge (Figure 8).

Canadian researchers have developed a model that estimates midge emergence and wheat growth based on accumulated degree-days. This information can then be used to estimate the last advisable planting date. The following is provided only as a rough guideline to assist in scouting efforts.

The hibernating midge larva doesn't become active until the threshold temperature of 40°F has been reached, and this is the temperature upon which the model is based.

FIGURE 8. Effect of heading date on midge damage (symbols represent 64 different spring wheat varieties).



Observations indicate that first 10 percent of the females will have emerged after 1300 degree days have accumulated (Table 1). When using 40°F as the base temperature, spring wheat heading usually occurs at around 1000 to 1100 degree days. Spring wheat planted before 200 degree days have accumulated will typically head before peak midge emergence.

While this provides a rough estimate of when or when not to plant spring wheat, these predictions are only estimates. The accuracy of the model is dependent on the temperatures used in calculating degree-days, and the temperatures should represent the environment where the insects are developing. Temperatures at one site only give a rough estimate of insect development at another site a few miles away.

Several factors impact the accuracy of the model. First, soil temperatures are affected by several variables including soil texture, tillage, residue cover, and topography. In addition to variable soil

temperatures, crop development and maturity also varies with the spring wheat variety planted. Further, while temperatures generally drive the system, soil moisture is another critical aspect that impacts adult emergence.

All of these factors conspire together, making the use of degree-day models only rough estimates. Nevertheless, the model can be used to help eliminate unnecessary scouting and aid in making better management decisions.

Resistant Varieties:

A single resistant gene called Sm1 has been identified that causes death of the larvae as they feed on the developing kernel. This is a highly effective gene, and several Canadian varieties have recently been released that contain this trait. Efforts are currently underway to incorporate this gene into Montana-adapted spring wheat varieties (Table 2).

The extreme efficacy of this gene has raised concerns about the midge population developing resistance to it. As a result, the Canadian varieties are being sold as an “interspersed refuge” where 10 percent of the seed is susceptible to the midge and 90 percent of the seed has the resistance trait. It is hoped that this strategy will prolong the utility of Sm1 gene.

It will take a few more years to develop resistant wheats for Montana, but in the meantime, selecting early maturing spring wheat varieties is recommended to help the crop to develop out of sync with the midge.

Biological Control:

Fortunately, the expression “fight fire with fire” applies to the wheat midge. A small parasitic wasp (*Macroglanes penetrans*) attacks wheat midge larvae, helping to regulate populations.

The adult parasitic wasp is about 1/10-inch long and metallic black. The adult female seeks out midge eggs in which to deposit their own eggs. The parasitized midge larva continues to feed on the developing wheat kernel, causing damage to the spring wheat crop during the current season. The mature midge larva drops to the soil, forms a cocoon and over-winters along with the dormant parasite inside its body. However, in the spring the wasp larva develops rapidly, consumes its host, and emerges as an adult in July.

TABLE 1. Midge degree day model.

Degree Days	Event
450	the midge breaks the larval cocoon and moves close to soil surface and forms the pupal cocoon
1300	10% of the females will have emerged
1475	about 50% of the females will have emerged
1600	about 90% of the females will have emerged

TABLE 2. Effect of the Sm1 gene (CAP lines) on orange wheat blossom midge control, Kalispell, MT.

Cultivar	OWBM ¹	Yield	Protein	Test wt.	FN ²
REEDER	46	34	16.7	59	180
HANK	102	15	16.1	52	193
CAP34-1	0	49	14.0	60	333
CAP84-1	1	41	15.5	59	320
CAP84-2	0	42	15.5	60	328
CAP108-3	0	51	15.1	59	338
CAP197-3	0	51	13.1	60	350
CAP201-2	0	46	14.1	60	303
CAP219-3	0	42	13.7	60	301
CAP400-1	0	52	17.8	56	326

¹OWBM - orange wheat blossom midge (no./spike). ²FN - falling number (seconds).

Typically the wasp population lags behind the introduction of the midge by about one to three years, but once established, the impact can be considerable. This parasitoid is credited with controlling about 25 to 40 percent of the midge population in parts of Canada and North Dakota. In some instances, parasitism rates of greater than 75 percent have been documented.

Efforts to introduce the parasitic wasp into Montana are ongoing. However, proper use and timing of insecticide applications will be critical to encouraging the establishment of the wasp. Insecticides should only be used if current year populations of the wheat midge exceed the economic threshold. And insecticide use should be avoided if the crop has reached 75 percent flowering.

Summary

Fortunately there are several tools available for managing the midge. Each individual management tactic has merit. But, as with most pest problems, an integrated approach that uses a combination of methods will be necessary in order to minimize damage from the orange wheat blossom midge.

For further information, contact the Northwestern Agricultural Research Center at 406-755-4303 or online, <http://ag.montana.edu/nwarc/>.



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