Kansas State University Agricultural Experiment Station and Cooperative Extension Service

KANSAS CROP PESTS

K-STATE Research and Extension

Wheat Stem Sawfly

History

The wheat stem sawfly, *Cephus cinctus* Norton (Hymenoptera: Cephidae), is a herbivorous wasp that attacks a number of native grass species in North America. It was first reported attacking wheat in Canada in 1896 and soon spread to become a serious pest of spring wheat throughout the Dakotas, Montana, and Wyoming. The wheat stem sawfly has long been present in wild grass species over a much broader range, including Nebraska and Kansas, although neighboring wheat fields were unaffected.

Historically, only spring wheat was attacked. It was not until the 1980s that infestations were observed in winter wheat. By 1996, scientists working in Montana determined that the pest had evolved faster development and was emerging some 20 days earlier than it previously had, enabling it to survive in early-maturing winter wheat. Recent observations in Nebraska (2012) indicate that 50 percent of adults emerged by May 22, although this was a particularly early spring.

Collectively, research suggests that attacks on winter wheat may have been occurring for some time but went unnoticed because larvae did not complete development and cut stems. This may be the case in Kansas currently, with populations under strong selection to evolve faster development. It is not yet clear if recent winter wheat infestations in the Nebraska panhandle and northeastern Colorado result from local populations evolving to exploit winter wheat, or the southerly range expansion of an adapted strain. Local populations express significant variation in biology, behavior, and genetics that suggest regional adaptations. Presently, Kansas is on the southeastern boundary of the region experiencing wheat stem sawfly problems in winter wheat.

Figure 1. Adult wheat stem sawflies mating (above)

Figure 2. Female wasp ovipositing (right)

Identification

The adult wasp is about half an inch long with a black body and three broad, transverse yellow bands on the abdomen. Legs are yellow and wings are a dark, smoky grey. Females are significantly larger than males (Figure 1) with a short, curved ovipositor that is externally visible (Figure 2). Eggs are whitish and elongate, difficult to observe, and usually laid in the uppermost portions of the stem (Figure 3). Larvae are initially colorless (Figure 4), soon turning cream-colored with a dark head capsule; they feed inside stems, moving to the base of the plant as they mature. Infested stems typically contain abundant frass that looks like sawdust, and larvae wriggle into a characteristic S-shape when removed (Figure 5). Another insect commonly occurring in wheat stems is the wheat stem maggot, *Meromyza americana* Fitch. Its larvae are smaller and legless. Cleanly severed stems and stubble ends packed with frass (Figure 6) indicate the presence of wheat stem sawfly.

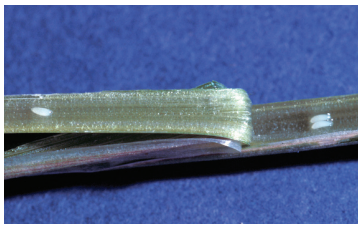

Figure 3. Eggs

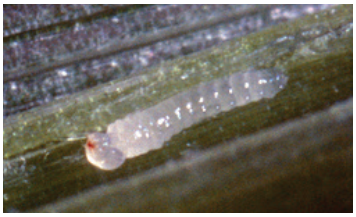

Figure 4. First instar larva

Figure 5. Mature larva in stem

Figure 6. Stubble cut by wheat stem sawflies

Biology and Behavior

The wheat stem sawfly has only one generation per year. Adults emerge from the previous year's stubble over a period of three to five weeks in spring. As with most insects, the emergence timetable is dictated by temperature and varies with latitude and among regional populations. Males emerge slightly ahead of females and mating takes place as soon as females emerge, unless severe weather

delays activity. Adults do not feed and live only about a week, but each female emerges with a full complement of up to 50 eggs. Like many other wasps, mothers can control the sex of their offspring. Fertilized eggs develop into daughters and unfertilized eggs, into sons. Females are more sensitive to host plant quality than males because body size is correlated with stem diameter and larger females emerge with more eggs. Consequently, females tend to lay fertilized eggs in larger diameter stems.

Taller, more developmentally advanced, plants tend to be preferred for oviposition. There is a strong edge effect; field margins sustain higher infestation levels when wheat stem sawflys immigrate from adjacent fields. Notably, females do not avoid laying eggs in plants already infested, even though larvae cannibalize each other until only one remains, usually the first to hatch. Western wheatgrass is a preferred host among wild grasses; smooth brome and quackgrass are also infested. Emergence from wild grasses occurs later than emergence from wheat, so wild hosts do not appear to serve as a major source of wheat infestation and probably support a different host race. Barley is a poor host relative to wheat; rye and oats are accepted for oviposition but do not support complete larval development. Recent research has shown that specific volatile chemicals emitted by host plants influence the oviposition preferences of the female and account for differences in attractiveness among some wheat varieties.

After feeding for about a month and passing through five instars, mature larvae descend to the base of the plant where they may girdle the stem (Figure 7), plugging the lumen of the stem with frass and overwintering in a silken coccoon in the chamber beneath. Although stem cutting tends to be associated with drying of the wheat, the behavior is variable and may interact with other environmental factors. Stems are not cut unless larvae complete development; a significant proportion of stubs may be cut at, or just below, ground level, and some larvae may mature without cutting at all. Significant variation in cutting propensity exists among regional populations, and the proportion of infested plants that are cut can vary greatly from site to site and year to year. Complete development requires a 90-day period of larval diapause under cold temperature conditions, followed by a pupation period that lasts up to three weeks. Pupation occurs within the stem (Figure 8) and adults emerge in mid to late spring. Although adults have been known to disperse as far as one mile, they are relatively weak fliers and tend to orient to the nearest suitable host plants.

Figure 7. Cut stubble showing frass plug (left) and emergence hole (right)

Figure 8. Pupation occurs within the stem

Larval girdling severely weakens the stem and leads to plants that lodge easily when stressed by wind. The main economic impact of wheat stem sawfly is lodged plants that cannot be picked up by the combine, and reduced harvest efficiency as slower combine speeds are required to salvage girdled plants. In addition, larval feeding disrupts translocating tissues and diminishes the photosynthetic capacity of the plant during the critical period of grain fill, reducing test weight and protein content. Both kernel weight and the number of kernels per head are affected, reducing grain weight by 10 to 25 percent and protein content by around 1 percent. However, estimates of per-plant yield reduction may underestimate yield impact at field level because of the tendency of larger plants with greater yield potential to be preferentially infested. Shriveled and misshapen kernels are another indication of wheat stem sawfly infestation (Figure 9), but these symptoms also may have other causes.

Figure 9. Shriveled and misshapen kernels may indicate infestation

Management

Cultural Control

Various cultural tactics are essential components of an effective wheat stem sawfly management strategy. It is most important to avoid planting wheat continuously in the same field once the wasp has been detected as this can lead to a very rapid increase in populations. Non-host

grains such as oats and rye can be planted as trap crop strips along field borders adjacent to last year's stubble. This approach can reduce infestation of wheat and decrease wheat stem sawfly populations, but is not effective when wheat stem sawfly is abundant or emerging from stubble within the same field.

Increasing wheat stem sawfly problems have been attributed to adoption of no-till practices that favor overwintering survival of immature stages. Thus, tillage has been suggested as a control tactic. Shallow tillage can be used to disturb and expose infested stubble on the surface, causing larvae within to either desiccate in summer or freeze in winter. Unfortunately, no-till is the most important means of soil moisture conservation on rain-fed acreage, so tillage is not an acceptable control tactic for this region. Additionally, tillage can yield inconsistent results in reducing adult wheat stem sawfly populations, because of its dependence on environmental factors to produce mortality. It also has negative impacts on beneficial parasitoids. Burning of stubble is also ineffective and associated with more negative (loss of organic matter) than positive impacts on the cropping system.

Work in North Dakota suggests that early swathing of wheat (once grain moisture drops below 40 percent) can be used to salvage yield and is usually recommended if infestation reaches or exceeds 15 percent of stems as the crop approaches maturity. Swathing requires investment in additional equipment and results in higher energy costs than direct combining. Sampling should be conducted at different places in the field — if the infestation is low, only field borders may need to be swathed. Swathing at a high cutting height (just below the heads) is recommended to help preserve beneficial parasitoids that pupate higher up in the stem.

Host plant resistance

Solid-stemmed (SS) wheat varieties have stems filled with pith to varying degrees. The SS trait presents mechanical resistance to boring larvae and has been effective in reducing both yield losses and local wheat stem sawfly populations. Early solid-stemmed varieties, such as 'Rescue' were developed in the 1950s and suffered from considerable yield drag, but more recently developed varieties have yield comparable with high-yielding, hollow-stemmed varieties. Newer solid-stemmed varieties include Choteau, released in 2003 from the Montana Agricultural Experiment Station; AC Lillian, released in 2006 from Agriculture Canada; and Mott released in 2009 from the North Dakota Agricultural Experiment Station. However, because expression of the SS trait interacts with environmental factors such as sunlight and temperature, cloudy and rainy weather can prevent the filling of the stem with pith and render solid-stemmed varieties more susceptible. Larvae in solid-stemmed plants have lower survival and less impact on yield, although they remain equally susceptible to parasitism. If wheat stem sawfly infestation reaches or exceeds 15 percent of plants, a solid-stemmed variety is recommended for planting in subsequent years. Although use of solid-stemmed varieties is currently a cornerstone of wheat stem sawfly management in the northern Great Plains, no such varieties have yet been developed for this region.

Chemical control

Insecticides are not recommended for wheat stem sawfly control for a variety of reasons. Wheat is a low-value crop grown on large acreage, making pesticide applications relatively expensive. Immature stages of the pest are all protected within the stem and trials indicate that seed treatments are ineffective, so treatments must target adults before eggs are laid. A number of insecticide labels claim to "aid in control of adults," but unfortunately, wheat stem sawfly adults emerge over an extended period and do not feed, substantially reducing their exposure. Adults must come into direct contact with an insecticide to be killed and are able to enter fields shortly after an insecticide application with minimal knockdown. Some insecticide trials timed sprays to target early, mid, and late emergence of wheat stem sawfly and found that as many as three applications of a pyrethroid insecticide only reduced infestation by half, a benefit that was far exceeded by application costs. In addition, pesticides will reduce populations of parasitoids and predators that will provide more cost effective natural control, even if it is not complete.

Biological control

Various natural enemies attack the wheat stem sawfly in its immature stages and help to suppress populations to varying degrees in different localities. The primary parasitoid of wheat stem sawfly larvae is the wasp *Bracon cephi* (Gahan), although *B. lissogaster* Muesebeck also contributes mortality in natural grassy areas. These wasps are ectoparasitoids that lay their eggs on wheat stem sawfly larvae within the stem (Figure 10), and then feed externally on their host. Although the parasitized larva feeds for some time, it does not survive to cut the stem and as a result, plant damage and yield impact are substantially diminished. Unlike the wheat stem sawfly, parasitoids have a second generation close to, or just after, wheat harvest and their effectiveness in different localities may partly depend on their ability to find alternative hosts for overwintering. Wheat should be harvested with a high cutting height (just below heads) to conserve parasitoids that pupate higher in wheat stems. Parasitoids have tracked infestations of wheat stem sawfly into Colorado and Nebraska, and they can be expected to contribute to mortality in Kansas, although no data is yet available.

Figure 10. Larva of Bracon cephi.

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Photo credits

Figures 1, 3, 4, 5, 7, 8, 10: R.K.D. Peterson, Montana State University.

Figures 2, 6: Pat Beauzay, North Dakota State University

Figure. 9: Canadian Grain Commission

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