Russian Wheat Aphid

An introduced pest of small grains in the High Plains

A brief history of the invasion

The Russian wheat aphid, *Diuraphis noxia* (Mordvilko), is native to the steppe country of southern Russia. It was first detected in North America near Mexico City in 1980 and was discovered near Lubbock, Texas, in March 1986. By the fall of that year, infestations were reported in New Mexico, Oklahoma, Colorado, Nebraska, Wyoming and Kansas.

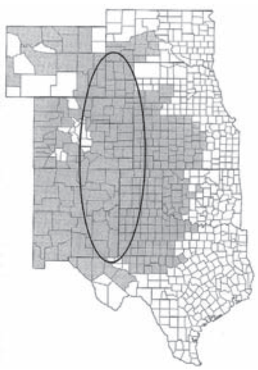

Figure 1.

The aphids spread rapidly throughout wheat-producing regions of the western United States and proved to be well adapted to the arid conditions of the High Plains. Following introduction, the Russian wheat aphid caused hundreds of millions of dollars in wheat and barley production losses through reduced yields and pesticide treatment costs. Annual direct yield losses peaked at $274 million in 1988 but dropped to less than $10 million by 1993. Russian wheat aphid still appears periodically across the High Plains in southwestern Wyoming, southeastern Nebraska, eastern Colorado and New Mexico, western Kansas and the panhandles of Oklahoma and Texas (*Figure 1*).

Description and damage

The Russian wheat aphid is a small, lime-green aphid with a distinctive football-shaped body (*Figure 2*). The legs, antennae and cornicles are short compared to most other aphids. Viewed from the side, the terminal segment of the abdomen has a supracaudal structure that looks like a double tail. The greenbug is similar in color (*Figure 3*), but the dark green stripe, long antennae and cornicles, which are often longer than the body, make it easy to distinguish from the Russian wheat aphid.

Figure 2. Russian wheat aphid

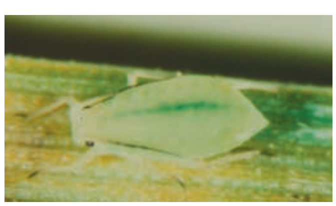

Figure 3. Greenbug

Russian wheat aphids prefer to feed in rolled leaves on the upper parts of the plant (*Figure 4*). Greenbugs typically are found on the undersides of lower leaves and do not cause leaf rolling. Damage to wheat plants is noticeable from a distance. Besides rolled leaves and trapped heads, Russian wheat aphid feeding causes purple or white longitudinal streaking on the leaves (*Figure 5*). Leaves damaged by greenbugs turn brown and appear scorched. When searching for the Russian wheat aphid in wheat, it is often useful to look for damage first then for the aphids.

Figure 4. Leaf unrolled to expose Russian wheat aphids

Figure 5. Purpling and rolling of leaves

Biology and life history

The Russian wheat aphid reproduces asexually. All aphids are female, and each gives birth to live daughters carrying embryonic granddaughters. This telescoping of generations, combined with rapid, asexual reproduction is the key to the explosive population growth achieved by many aphid species.

In Asia, the Russian wheat aphid may produce a sexual generation in the fall, with mated females laying eggs that overwinter. Although sexual females have been found in North America, males have not, and it appears that the aphid population reproduces without sexuality. This inability to produce overwintering eggs may have limited the northern range of the Russian wheat aphid in North America. The aphid is more cold tolerant than greenbugs, however, and easily survives Kansas winters.

Russian wheat aphid nymphs are relatively sedentary and gregarious on the plant, forming dense colonies. As colonies increase in size, the aphids benefit from feeding as a group, developing and reproducing at higher rates and reducing their individual risk of attack by natural enemies.There are four or five molts from first instar to reproductive adult. Maturation requires from nine to 55 days depending on temperature. Low temperatures delay development and reproduction, but temperatures above 25 ºC (77 ºF) cause mortality. Each wingless adult can produce as many five or six nymphs per day in warm weather, or only one every 10 or 20 days when temperatures approach freezing.

Unlike most aphids, the Russian wheat aphid feeds on wheat until the plant is mature and can often be found in developing heads. When the wheat plant dries down as it matures or in response to heavy aphid feeding, an increased proportion of the immature aphids develop wings that look like shoulder pads on third and fourth instar nymphs.

These winged, or alate, adults differ in biology and appearance from their apterous (wingless) sisters. They may feed for several days on the plant where they were born, but they do not begin reproducing. Rather, they soon respond to sunlight by flying and may be carried on wind currents for long distances. Their function is to seek a suitable host plant and initiate a new colony.

When descending from the sky, the Russian wheat aphid responds only to the green or yellow-green color of young plants and the contrast with dark backgrounds. Consequently, infestations often begin along field borders where the contrast between young plants and bare soil is greatest. In natural plant communities, an alate aphid must probe and sample many plants before finding a suitable one, but host location is hardly a problem for Russian wheat aphids that light on a wheat field. With significant wing muscles and fat bodies that store energy for flight, alate aphids have small reproductive organs and produce few daughters. The daughters invariably develop into wingless adults accelerating colony growth in the second generation.

The Russian wheat aphid is capable of modifying growth of the host plant. Longitudinal leaf rolling allows high density colonies to form in a protected location, somewhat like the galls formed by other aphids. Rolled leaves may create a favorable microclimate for the aphid colony, buffering it from temperature extremes and reducing the risk of desiccation when relative humidity is low. In addition, many larger aphid predators and parasitoids that attack Russian wheat aphids are less likely to encounter them in rolled leaves or less inclined to forage in such close quarters. Aphids hidden in rolled leaves are better protected from contact insecticides even if they are susceptible to them. Consequently, materials with systemic activity are superior for Russian wheat aphid control.

Host plants

A variety of wild grasses can serve as host plants for the Russian wheat aphid and may be important for aphid survival when cereal crops such as wheat and barley are not available. In order to persist in a region, Russian wheat aphid must have host plants year round. Cool-season grasses important for this insect include wheat grasses, bromegrasses, wild ryes and jointed goatgrass. Jointed goatgrass is exceptionally suitable because of its close relationship with wheat. Although reproduction tends to be lower on warm-season hosts such as grama grasses and pearl millet, they can serve as potential hosts.

In Kansas, the most critical period for Russian wheat aphid survival is during the summer between wheat harvest and wheat emergence. Cool- or warm-season grasses that remain alive during the summer are important for Russian wheat aphid survival during this period. According to studies in Colorado, Canada wild rye, *Elymus canadensis* (L.), and crested wheat grass, *Agropyron cristatum* (L.) are two of the most important summer hosts for the Russian wheat aphid. Prolonged drought can force grasses to die or go dormant, reducing the chances of the pest surviving the summer.

Neglected volunteer wheat can be just as important to Russian wheat aphid survival as the presence of wild hosts. Some years immigration from infested crops a long distance away also has a considerable effect. Fields do not have to be close to alternate hosts to become infested.

Resistant varieties

Various genetic sources of resistance to Russian wheat aphids were identified in the late 1980s, and two were eventually incorporated into commercial wheat varieties. One source developed by K-State is available in the variety Stanton (derived from PI 220350 containing the resistance gene designated Dny). The other, developed by scientists in Colorado, is in the varieties Halt, Yumar, Prowers and Prairie Red (derived from PI 372129 containing the resistance gene Dn4).

K-State research shows that resistant varieties dramatically reduce the reproductive rate and nymphal survival of Russian wheat aphid. The effect of natural enemies is usually greater on aphid colonies feeding on resistant plants than on susceptible ones. Resistance screening typically is performed in a greenhouse using heavy aphid infestations without natural enemies, so varieties demonstrating resistance under these conditions perform well in the field where biological control lends a helping hand.

There was concern that breeding for plant resistance might make the aphids less suitable as food for natural enemies, but it actually can enhance biological control. Russian wheat aphids and greenbugs grown on resistant varieties are as nutritious and acceptable for predators as those grown on susceptible varieties. In fact, the aphids may be stressed in various ways by the resistant plant, making them more vulnerable to natural enemies. For example, significant numbers of aphids are dislodged from plants by foraging predators, and some die. The aphids feeding on resistant plants may be smaller, weaker and less likely to return to the plant once dislodged. Because resistant varieties exhibit less leaf rolling when infested, the aphid colony is more exposed to natural enemies and abiotic sources of mortality.

Biological control

Faced with astronomical aphid populations and declining wheat production in the late 1980s, the U.S. Department of Agriculture mounted an unprecedented, far-reaching program to explore the ancestral range of the Russian wheat aphid and find natural enemies. At least 120 scientists from 20 countries participated in the program, which imported more than 12 million beneficial insects of at least 24 species. These insects were cultured, mass produced and released at numerous sites in 16 states for about five years. The majority of these insects were already represented in the United States by similar, locally adapted native species.

Of the introduced insects, one species of parasitic wasp, *Aphelinus albipodus*, has conclusively established, but its effect on Russian wheat aphid is limited to a small portion of the aphid's current range. On the other hand, the number of native predators and parasitoids capable of preying on and parasitizing Russian wheat aphids have gradually increased, and some have extended their range to coincide with regions now infested by the Russian wheat aphid.

Two factors have contributed to the gradual, area-wide decline of Russian wheat aphid: the development and distribution of resistant varieties in the most seriously affected regions, and gradual increases in the populations of native natural enemies. Because of the failure of the classical program against this aphid and the potential non-target effects of introduced biological control agents, it is generally agreed that massive, indiscriminate introduction of exotic species should not be the first response in the event of an invasion of another aphid pest of small grains.

Natural enemies

Predators and parasitoids that attack other grain aphids also feed on the Russian wheat aphid, but not all are effective at reaching them in rolled leaves. Exclusion cage studies in western Kansas indicate that the convergent lady beetle, *Hippodamia convergens* (*Figure 6*), also the key predator of greenbug in the region, is one of the most important natural controls. The seven-spotted lady beetle, *Coccinella sepempuncata*, is common in wheat fields in early spring and may play a role in reducing Russian wheat aphid numbers. Similarly, Aphidiid wasps, including the greenbug parasitoid *Lysiphlebus testaceipes* (*Figure 7*) also attacks and develops on the Russian wheat aphid.

Figure 6. Convergent lady beetle

Figure 7. Aphidiid wasp

Wasps in the genus *Praon* belong to the same family but form distinctive mummies with a pedestal-like structure (*Figure 8*). Other smaller predators and parasitoids that normally have little effect on greenbug populations have found Russian wheat aphid colonies in rolled leaves are an ideal foraging environment because their own risk of predation and parasitism is reduced. Several of these are shown above. Clockwise, from left they include small hover flies (*Diptera: Syrphidae*) (*Figure 9*). Small ladybeetle species in the genus *Scymnus* have larvae with distinctive waxy filaments and can also be found feeding in Russian wheat aphid colonies (*Figures 10 and 11*). The introduced parasitic wasp *Aphelinus albipodus* (*Hymenoptera: Aphelinidae*) and other native *Aphelinus spp*. are small and stealthy and forage effectively in rolled leaves (*Figure 12*).

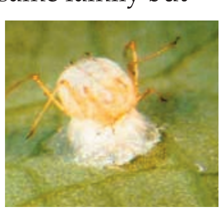

Figure 8. Mummified aphid (Praon sp.)

Natural enemies of the Russian wheat aphid

Figure 9. Hover fly

Figure 10. Scymnus beetle

Figure 11. Scymnus beetle larva among aphids

Figure 12. Aphelinid wasp (Aphelinus spp.)

Various entomopathogenic fungi can cause diseases in Russian wheat aphids, but most require substantial humidity to be effective, which makes them a less likely cause of death in arid regions where the aphid is most prevalent.

Evolution of the Russian wheat aphid

In spring of 2003, outbreaks of Russian wheat aphid in commercial wheat fields of Prairie Red were discovered in several counties in eastern Colorado. This led to suspicions that a new genetic strain, or biotype, of this aphid had evolved with the ability to overcome resistance in these varieties.

This is not surprising because many greenbug biotypes have evolved over the years and overcome various sources of wheat and sorghum resistance. Extensive acreages have been planted to Russian wheat aphid-resistant varieties in the worst affected areas over the past decade, and this could have generated strong selection pressure that favored aphids with resistance-breaking mutations.

It is surprising, however, that two separate and supposedly distinct sources of resistance should be overcome in a single evolutionary event. Although no genetic changes have yet been characterized in aphid clones established from the Colorado infestations, bioassays performed at K-State have measured improved performance on resistant varieties. In fact, this new "biotype 2" Russian wheat aphid appears more virulent to virtually all commercial wheat varieties grown in Kansas than the original biotype 1, and the progresson of damage symptoms is far more rapid, especially between 65° and 75°F.

Often a resistant variety is more productive than susceptible alternatives when under pest pressure, but less productive in its absence. Similarly, the altered genetics that enable an insect to overcome a particular source of plant resistance may not perform as well on other varieties. This may explain why many regions sampled in eastern Colorado in 2004 were found to contain both aphid biotypes. Laboratory tests have shown that biotype 2 performs better on varieties expressing resistance to biotype 1 than on related varieties that lack the resistance gene. Cultivars bred for resistance to biotype 1 have not been widely grown in Kansas because they often do not yield as well as in the absence of significant Russian wheat aphid pressure.

More tests are underway to study the diversity of Russian wheat aphid populations. There may be several biotypes of this aphid in the United States. Preliminary results from Kansas tests show that the old biotype seems predominant at the locations tested. However, biotype 2 could be present in counties near the Colorado border based on its predominance in reports from eastern Colorado during 2004.

These changes are a reminder that insect populations are dynamic and can change over time. Growers should select wheat varieties adapted to their area and use resistant varieties where insect pressure warrants. They also must remain alert for Russian wheat aphid populations that adapt to damage-resistant varieties.

Russian wheat aphid management

When natural enemies and host-plant resistance fail, producers must rely on insecticides to limit aphid damage. Two insecticide options are currently available. One option is to use a seed treatment, which can provide early season protection but is only cost effective where there is a high probability of significant Russian wheat aphid activity. The other option is to use insecticides to reduce aphid numbers after populations have been detected in the field.

Deciding when to treat for Russian wheat aphids is based on economic thresholds. The economic threshold is where the damage from the aphid equals the cost of control.The economic threshold during the jointing stage can be estimated using the formula:

$$ET = (CC \times 200) \div (EY \times MV)$$

ET = *economic threshold or the percent of tillers that needs to be infested to justify treatment*
CC = *control cost per acre*
EY = *expected yield per acre*
MV = *market value per bushel*

If populations are below the threshold, then the damage that the aphids are expected to cause will not exceed the treatment cost and treatment is not needed. After the flowering stage, substitute 500 for the 200 in the numerator of the formula. Note, after heading it takes even higher levels of Russian wheat aphid to justify control.

For information on pesticides labeled for Russian wheat aphid control, check the current version of the K-State Research and Extension publication MF-745, *Wheat Insect Management Guide*.

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Figure 1: Elliott, N.C., Hein, G.L., Carter, M.R., Burd, J.D., Holtzer, T.O., Armstrong, J.S., and Waits, D.A. 1998. Russian wheat aphid (Homoptera: Aphididae) ecology and modelling in Great Plains agricultural landscapes, pp 31-64. In S. S. Quisenberry and F. B. Peairs [eds.], Response Model for an Introduced Pest - The Russian wheat aphid. Fig. 1, p. 33. Thomas Say Publications, Entomological Society of America, Lanham, Maryland.

Figures 2 and 3: Frank Peairs, Colorado State University

Figures 4 and 5: Phil Sloderbeck, Kansas State University

Figures 6, 9 and 10: J. P. Michaud, Kansas State University

Figure 7: Texas A&M Extension Service

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