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Grass Hosts of Cereal Aphids (Hemiptera: Aphididae) Between Wheat-Cropping Cycles in South Dakota

Louis S. Hesler[1] and Kurt J. Dagel[1]

Abstract

Several grasses may serve as alternative hosts for cereal aphids during the interim between small-grain crops in South Dakota, but field studies to determine which grasses are important have not been undertaken. We sampled annual and perennial grasses for cereal aphids in 18 counties in South Dakota in the month of August over three years. Eighty-five of 240 site samples had one or more species of cereal aphids, including 61 of 65 corn sites and 12 of 13 sorghum and sudangrass sites. Four species of cereal aphids were found during the survey: corn leaf aphid, 74 times; bird cherry-oat aphid, 27 times; greenbug, eight times; and English grain aphid, seven times. Abundance of corn leaf aphid on host plants was rated high seven times, moderate 11 times, and low 50 times, and presence only was noted at six other sites. Abundance of bird cherry-oat aphid was rated high four times, moderate four times, and low 19 times. Abundance of English grain aphid and greenbug was always rated low. All high ratings of corn leaf aphid and of bird cherry-oat aphid occurred on field corn. Nine moderate ratings for corn leaf aphid and three for bird cherry-oat aphid occurred on corn. Low frequencies of cereal aphids were found on volunteer small-grains and among weedy grass species such as rough barnyard grass, yellow foxtail, and green foxtail. Cereal aphids were not found on other weedy grasses or on noncultivated grasses. The results suggest that corn and, to less degree, sorghum served as predominant grass hosts of cereal aphids during August in South Dakota. Recent trends of expanding corn acreage in South Dakota may potentially lead to concomitant increases of cereal aphids and intensify the risk of fall infestation of winter grains by cereal aphids.

Wheat (*Triticum aestivum* L.) is a major grain crop grown in South Dakota and other areas of the northern Great Plains. Although wheat is produced throughout South Dakota, its production is concentrated in the middle of the state. Both spring and winter varieties of wheat are widely grown in South Dakota (USDA-NASS 2009). Spring wheat is typically established from late March to mid-May in South Dakota, whereas winter wheat is generally established from late August through late October, undergoes winter dormancy, and resumes growth in the spring. Despite large temporal differences in their establishment, both spring and winter wheat typically mature from early July to early August in South Dakota.

Wheat is subject to infestation by a complex of cereal aphids (Hemiptera: Aphididae) that includes *Rhopalosiphum maidis* (Fitch) (corn leaf aphid), *R. padi* (L.) (bird cherry-oat aphid), *Schizaphis graminum* (Rondani) (greenbug), and *Sitobion avenae* (F.) (English grain aphid) (Kieckhefer and Gustin 1967, Hesler et al. 2005). These cereal aphids cause yield loss in winter wheat (Pike

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and Schaffner 1985, Riedell et al. 1999, Kindler et al. 2002), and they are also important vectors of barley yellow dwarf virus and cereal yellow dwarf virus (Hewings and Eastman 1995), which cause disease and yield loss to winter wheat in South Dakota (Fitzgerald and Stoner 1967, Riedell et al. 1999).

By early August in most years, wheat and other small-grain crops have become largely senescent or have been harvested, and are therefore uninhabitable by cereal aphids (Kieckhefer 1984). Small-grain crops are not available again to cereal aphids in South Dakota until emergence of seedling winter grains commences in early September (Kieckhefer and Gustin 1967, Hesler et al. 2005). Thus, a span of at least 3 weeks transpires between small-grain crop cycles in which cereal aphids must find alternative hosts to persist in South Dakota.

Alternative graminaceous hosts of cereal aphids have not been identified under field conditions in South Dakota. However, Kieckhefer (1984) predicted that some grass species may play a relatively important role as alternative hosts of cereal aphids in late summer based on laboratory tests. In other areas of the Great Plains, noncultivated grassy hosts facilitate oversummering local populations of cereal aphids, such as the greenbug (Michels Jr. 1986, Anstead et al. 2003) and Russian wheat aphid (*Diuraphis noxia* Mordvilko) (Armstrong et al. 1991, Brewer et al. 2000, Weiland et al. 2009), and other arthropod pests of wheat, such as wheat curl mite (Brey et al. 1998). In Manitoba, cereal aphids may reproduce on a wide array of grasses in the field, although the time of year and growth stage of the grass hosts has not been specified (Robinson and Hsu 1963). Some cultivated grasses other than wheat, such as corn and sorghum, also serve as hosts of cereal aphids (Robinson and Hsu 1963, Blackman and Eastop 2000), and, if verdant, might also support cereal-aphid populations in August in South Dakota. Non-harvested small-grain seeds that fall to the ground may sprout as "volunteer" seedlings and also serve as hosts of cereal aphids during August. Altogether, there are several varied sources of potential grass hosts for cereal aphids. Thus, we hypothesized that noncultivated grasses, cultivated grass crops, and volunteer seedling grains each serve as alternative hosts of cereal aphids during the summer break between small-grain crops in South Dakota. We tested this hypothesis by sampling potential grass hosts for cereal aphids in South Dakota during August over three years, and report our results in this paper.

Study Sites and Methods

Various annual and perennial grasses were sampled for cereal aphids in 18 counties in South Dakota 7 through 31 August 1998, 2 through 25 August 1999, and 28 July through 31 August 2000 (Fig. 1). The 18 counties were located in eastern (97 site samples), central (105 site samples), and western regions (37 site samples) of the state, with the number of site samples per county indicated on Figure 1. Multiple habitats were sampled, including crop fields (e.g., corn and sorghum fields and weeds therein; fallow fields with volunteer small-grain plants), relict prairies and natural areas, and roadside vegetation. Each grass species sampled at a site was considered as a sample unit. In 1998, 32 sample units were surveyed in eastern and central counties, and statewide surveys were conducted in 1999 and 2000 among 127 and 81 grass-sample units, respectively. Several additional sites were visited but not formally sampled each year, as grasses were senescent, and therefore unfavorable hosts for aphids. In all, 240 grass-sample units comprising 55 kinds of host plants were surveyed for cereal aphids, and consisted of 98 samples from crop fields and 142 samples from other habitats. Corn (*Zea mays* L.) was by far the most common host-plant sampled, constituting 65 samples, whereas other host plants each comprised 15 or fewer samples.

Because habitats varied in patch size and the size and architecture of plants (e.g., small patches of prostrate grasses to large acreages of corn), we

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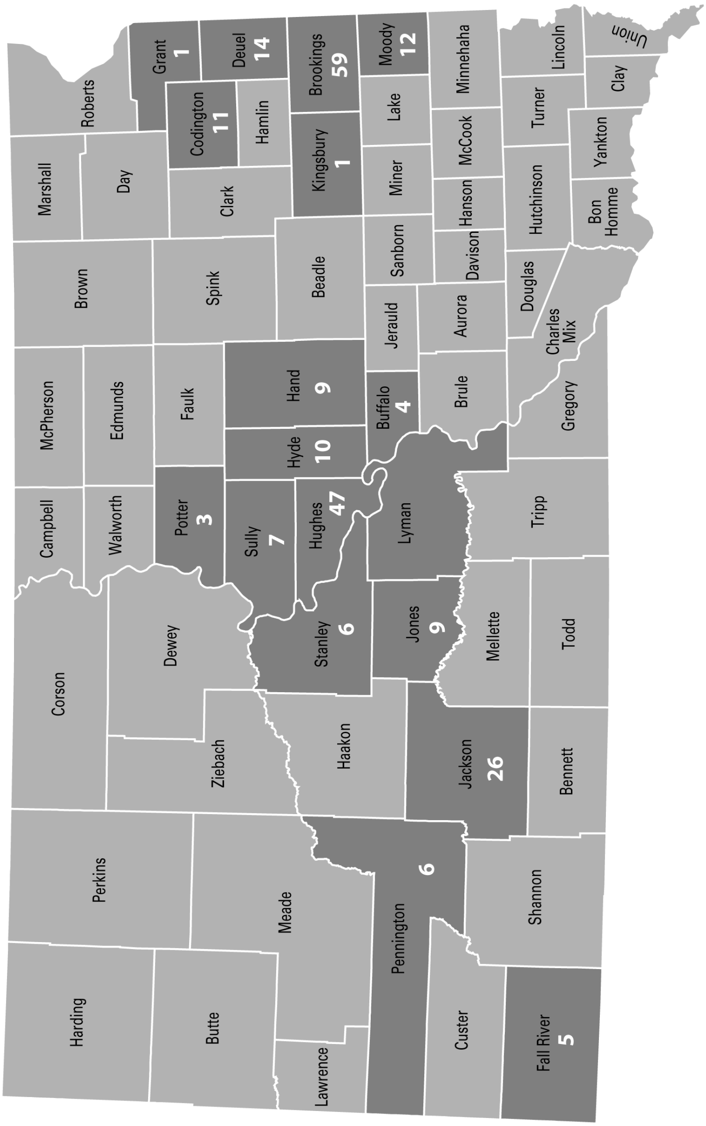

Figure 1. Counties sampled for cereal aphids (gray with number of samples) in South Dakota during the months of August 1998, August 1999, and late July through August 2000.

settled on timed searches as a standard sampling method. In some large grassland tracts, several sets of 50 to 100 sweeps using a standard sweepnet were conducted initially to pinpoint any grassy areas with aphids, but this method did not prove useful. Sampling time varied among sites, but about 15 minutes were usually spent per habitat. Large grassland tracts with multiple grass species and small, isolated patches of grasses received considerably more or less sampling time, respectively. Habitats were typically searched by walking a zigzag pattern through narrow habitats or a horseshoe pattern through other fields, with samplers stopping every few meters to search individual plants within a cluster for aphids. The above-ground parts of individual plants were sampled, with inflorescences, rolled leaves, and other aerial structures opened to check for the presence of cereal aphids.

Grassy host plants and any aphids on them were recorded at each site surveyed. Non-agricultural grasses and weeds were identified to species using standard guides (Pohl 1968, Barkley 1986, Johnson and Larson 1999), and aphids were identified to species using various keys (Olsen et al. 1993, Blackman and Eastop 2000, Stoetzel and Miller 2001). Aphid levels were categorized as low (<25 aphids per plant, typically a few large nymphs and adults distributed sparsely on a plant, or one or two viviparae with small nymphs), moderate (25 to 100 aphids per plant, usually a few small clusters on a leaf, flower head, or seed head), or high (>100 aphids per plant, characterized by many clusters of aphids widely distributed on one or more plant structures), except for six sampling units (five corn fields and green foxtail within a corn field) in which only aphid presence was recorded.

Results

Eighty-five of the 240 site samples had one or more species of cereal aphids, including 61 of 65 corn sites and 12 of 13 sorghum and sudangrass sites (Table 1). Some fields with volunteer small-grains had cereal aphids, including three of nine wheat sites, three of four oats sites, and one of three barley sites. Among weedy grass species, cereal aphids were found at three of four sites with rough barnyard grass, one of six sites with yellow foxtail, and one of two sites with green foxtail. Cereal aphids were not found on other weedy grasses or on noncultivated grasses.

Four species of cereal aphids were found during the survey: corn leaf aphid, 74 times; bird cherry-oat aphid, 27 times; greenbug, eight times; and English grain aphid, seven times (Table 2). Abundance of corn leaf aphid on host plants was rated high seven times, moderate 11 times, and low 50 times, and presence only was noted at six other sites. Abundance of bird cherry-oat aphid was rated high four times, moderate four times, and low 19 times. Abundance of English grain aphid and greenbug was always rated low.

All high ratings of corn leaf aphid and of bird cherry-oat aphid occurred on field corn. Nine of 11 moderate ratings for corn leaf aphid occurred on corn, one on sorghum, and one on volunteer wheat. Three moderate ratings for bird cherry-oat aphid were from field corn and one was from volunteer wheat.

All seven high ratings of corn leaf aphid occurred in eastern counties; intermediate ratings of corn leaf aphid occurred 5 times in eastern counties, four times in central counties, and twice in western counties; low ratings occurred 27 times in eastern counties, 19 times in central counties, and four times in western counties. High and intermediate ratings of bird cherry-oat aphid occurred at sites in eastern South Dakota. Five sites with low levels of bird cherry-oat aphid occurred in central counties, and 22 were from eastern counties. Six of the low ratings of English grain aphid were from eastern counties, and one from a central county. In contrast, six of eight occurrences of greenbug were from central counties and two from eastern counties.

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Table 1. Grasses surveyed and aphids found in South Dakota, August 1998, August 1999, and late July through August 2000.

Common name	**Scientific name**	**Sites**	**Sites with aphids**
Cultivated grasses			
Corn	*Zea mays*	65	61
Sorghum	*Sorghum bicolor*	11	10
Wheat	*Triticum aestivum*	9	3
Proso millet	*Panicum miliaceum*	5	1
Oats	*Avena sativa*	3	2
Barley	*Hordeum vulgare*	3	1
Sudangrass	*Sorghum bicolor* ssp. *drummondii*	2	2
Weedy grasses			
Yellow foxtail	*Setaria pumila* ssp. *pumila*	6	1
Barnyard grass	*Echinochloa muricata* var. *microstachya*	4	3
Green foxtail	*Setaria viridis*	2	1
Other weedy species [1]		5	0
Noncultivated grasses			
Smooth brome	*Bromus inermis*	15	0
Big bluestem	*Andropogon gerardii*	14	0
Switchgrass	*Panicum virgatum*	13	0
Prairie cordgrass	*Spartina pectinata*	11	0
Intermediate wheatgrass	*Thinopyrum intermedium*	8	0
Reed canary grass	*Phalaris arundinaceaa*	8	0
Crested wheatgrass	*Agropyron cristatum*	7	0
Indiangrass	*Sorghastrum nutans*	7	0
Sideoats grama	*Bouteloua curtipendula*	4	0
Other noncultivated spp. [2]		38	0
All grasses		240	85

[1] Other weeds on which no aphids were found included the following species each at three or fewer sites: sandbur (*Cenchrus longispinus*), three sites; cheatgrass (*Bromus tectorum*), one site; rough barnyardgrass (*Echinochloa muricata*), one site.

[2] Other noncultivated species on which no aphids were found included the following grasses each at three or fewer sites. Three sites: little bluestem (*Schizachyrium scoparium*), prairie dropseed (*Sporobolus heterolepis*), river bulrush (*Schoenoplectus fluviatilis*); two sites: common reed (*Phragmites australis*), bristly foxtail (*Setaria verticillata*), foxtail barley (*Hordeum jubatum*), witchgrass (*Panicum capillare*); one site: blue grama grass (*Bouteloua gracilis*), broad-leaved cattail (*Typha latifolia*), buffalograss (*Bouteloua dactyloides*), Canada wildrye (*Elymus canadensis*), common cattail (*Sparganium eurycarpum*), digitaria grass (*Digitaria* sp.), dryspike sedge (*Carex siccata*), green needlegrass (*Nassella viridula*), muhly grass (*Muhlenbergia* sp.), panicum grass (*Panicum* sp.), sand dropseed (*Sporobolus cryptandrus*), sedge (*Carex* sp.), sheep fescue (*Festuca* sp.), slender flatsedge (*Cyperus bipartitus*), softstemmed bulrush (*Schoenoplectus tabernaemontani*), stinkgrass (*Eragrostis cilianensis*), ticklegrass (*Agrostis scabra*), Torrey's rush (*Juncus torreyi*), cattail (*Typha* sp.), western wheatgrass (*Pascopyrum smithii*), wheatgrass, undet. sp. (*Elymus* sp.)

Table 2. Various grass hosts and population ratings of four cereal-aphid species on them in South Dakota during August 1998, August 1999, and late July through August 2000.

Grass host	Aphid rating[1]	Bird cherry-oat aphid	Corn leaf aphid	English grain aphid	Greenbug
Corn	High	4	7	0	0
	Intermediate	3	11	0	0
	Low	16	33	4	3
	Present	0	5	0	0
Sorghum / sudangrass	Intermediate	0	1	0	0
	Low	0	8	1	4
Volunteer wheat	Intermediate	1	1	0	0
	Low	2	0	0	0
Volunteer oats	Low	0	1	1	1
Volunteer barley	Low	1	1	0	0
Rough barnyardgrass	Low	0	3	0	0
Proso millet	Low	0	1	1	0
Yellow foxtail	Low	0	1	0	0
Green foxtail	Present	0	1	0	0

[1] Aphid rating: high, >100 aphids per plant, characterized by many clusters of aphids widely distributed on one or more plant structures; moderate, 25 to 100 aphids per plant, usually a few small clusters on a leaf, flower head, or seed head; low, <25 aphids per plant, typically a few large nymphs and adults distributed sparsely on a plant, or one or two viviparae with small nymphs; present, one or more aphids per plant but numbers not recorded. The lack of a particular rating for a grass host means that rating was not observed on that host.

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Discussion

The results of this study show that cultivated grasses, particularly corn and to less extent sorghum, serve as principal alternative grass hosts of cereal aphids between small-grain cropping cycles in South Dakota. Volunteer grain and weeds played a relatively minor role in supporting cereal aphids, whereas noncultivated grasses did not host cereal aphids.

The incidence of particular cultivated grasses as hosts for cereal aphids during August in South Dakota may largely be a result of soil moisture and grass phenology. Corn was a major host of cereal aphids in terms of sample sites in our study, and it is also one of the four major crops grown in South Dakota, particularly in the eastern half of the state (USDA-NASS 2009). Corn remains verdant in August in South Dakota if it receives adequate soil moisture. The lushness of corn, and therefore its suitability to cereal aphids, is favored by the practice of irrigation in many fields, and by an increasing rainfall gradient toward the east of the state.

Sorghum was the second most abundant host of cereal aphids. It is considered a minor crop in South Dakota that is grown mainly in the middle of the state, so its availability to cereal aphids is relatively limited. However, sorghum is tolerant of low soil moisture and often remains verdant through much of August in South Dakota.

Volunteer small grains are known hosts for cereal aphids, and management guidelines recommend controlling volunteer plants to limit aphids and barley yellow dwarf disease (Cook and Veseth 1991, Morrill 1995). However, we found few sites with volunteer grain, and a relatively low proportion of sites was infested with cereal aphids. Non-gleaned seed that falls to the ground requires adequate moisture to germinate, and unless rainfall occurs within a narrow window after harvest, these seeds will not germinate in time for aphids to colonize and develop populations that could potentially migrate to neighboring winter-grain fields. During our study (particularly 1999 and 2000), several areas in South Dakota received below-average rainfall, and therefore many fields were dry and not conducive to germination of volunteer grain.

Results from our study agree with the findings in some previous studies, but contrast with that of other studies. For instance, corn is a major summer source of corn leaf aphids and bird cherry-oat aphids that migrate to winter wheat in Washington and Idaho (Brown et al. 1984, Blackman et al. 1990, Blackmer and Bishop 1991), and likewise corn was the predominant host of these aphids in our study.

In contrast, Kieckhefer (1984) predicted populations of cereal aphids to persist on noncultivated grasses and weeds in South Dakota based on laboratory tests. Specifically, *S. avenae* and *S. graminum* were expected on wheatgrasses (*Agropyron* and *Thinopyron* spp.), *R. maidis* on warm season grasses (e.g., big bluestem [*Andropogon gerardii*], switchgrass [*Panicum virgatum*]), and all cereal aphids, especially *R. padi*, on various weedy grasses. However, these predictions were not met in our study, and may reflect differences between laboratory and field conditions, such as non-correspondence among aphid biotypes and plant varieties tested, harsher abiotic (i.e., more arid) conditions in the wild, etc.

Other studies have shown that noncultivated grasses and volunteer grain in western areas of the Great Plains can be important oversummering hosts of the greenbug (Michels, Jr. 1986; Anstead et al. 2003) and the Russian wheat aphid (Armstrong et al. 1991, Brewer et al. 2000, Weiland et al. 2009). However, Anstead et al. (2003) found more greenbugs on a wide range of hosts in western Kansas, whereas they found greenbugs only on Johnsongrass (*Sorghum halepense*) in August at two sites in central Oklahoma.

The reasons may be manifold for the varying degrees among studies to which noncultivated grasses served as oversummering hosts of cereal aphids. Brewer et al. (2000) posited that Russian wheat aphid is likely to persist on perennial noncultivated grasses through the summer if abiotic conditions, principally moisture, favored persistent plant growth. Anstead et al. (2003) suggested that greenbug may not colonize noncultivated grasses because of (1) poor host quality, (2) lack of adaptation to particular grass species, or (3) greater efficiency of natural enemies in some areas. Abiotic conditions made many noncultivated grasses inhospitable for aphids during our study, and this seemed to be the primary reason for their absence on these grass hosts. In addition to the sites with noncultivated grasses that we sampled, there were many other sites with senescent, brown noncultivated grasses that were obviously unsuitable for cereal aphids, which we did not sample. In some years, milder abiotic conditions in South Dakota may increase volunteer grain plants and make some noncultivated grasses favorable to cereal aphids in August, and we recommend additional study to determine grass hosts of aphids in such years.

Potential implications of the high incidence of cereal aphids on cultivated grasses need to be considered. Corn and sorghum account for nearly 5 million acres of farmland in South Dakota (USDA-NASS 2009). Bird cherry-oat aphid, corn leaf aphid, and greenbug are three of the major cereal aphids that colonize winter wheat in South Dakota (Kieckhefer and Gustin 1967, Hesler et al. 2005). These three aphid species are flight active in the summer and early fall in South Dakota (Kieckhefer 1976), and thus corn and sorghum acreage represents a vast source of aphids that could potentially migrate to winter wheat (Kieckhefer 1976, Kieckhefer and Gellner 1988). Recent demand for biofuel production has led to more corn acreage in South Dakota, whereas wheat acreage has decreased (USDA-NASS 2009). This trend may be predicted to concentrate cereal aphids in wheat-growing regions during August, and might have implications for their management in early-planted winter wheat in South Dakota (Kieckhefer and Gellner 1988). Furthermore, corn and sorghum are also reservoirs of luteoviruses that cause barley yellow dwarf disease (Brown et al. 1984, Irwin and Thresh 1990, Hewings and Eastman 1995), and this increases the potential consequences of concentrated aphid populations on cultivated grasses. We did not assess the origin and fate of cereal aphids on grasses that we sampled in August, but it may be important to track their movement in the landscape in order to determine pest-management ramifications of cultivated grasses such as corn and sorghum for cereal aphid-pest management and barley yellow dwarf epidemiology (Kieckhefer 1976, Blackmer and Bishop 1991).

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