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Article · January 2012

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2013. Science for Biomass Feedstock Production and Utilization.
Proceedings of the 2012 Sun Grant National Conference, vol. 1, 318 p.

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RECENT DISCOVERIES AND DEVELOPMENT IN THE ENTOMOLOGY OF BIOENERGY CROP PRODUCTION

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Abstract
Since 2004 the pest insects of switchgrass (*Panicum virgatum*), prairie cordgrass (*Spartina pectinata*), and cup plant (*Silphium perfoliatum*) were studied in South Dakota and Wisconsin. The switchgrass moth (*Blastobasis repartella*) and the switchgrass midge (*Chilophaga virgati*) significantly reduce tiller biomass and destroy seed production on switchgrass. The cordgrass moth (*Aethes spartinana*) and the cordgrass bug (*Ischnodemus falicus*) together can produce devastating reductions in tiller biomass and plant health of prairie cordgrass. The giant eucosma (*Eucosma giganteana*) reduces cup plant biomass to subeconomic harvest levels. All of these pests produce economic injury levels within three years of planting in monocultural agronomic plantings, but are negligible in natural occurrences of eachplant species. Mixed species plantings involving switchgrass, prairie cordgrass, and cup plant have highly reduced infestation rates indicating the value of predators and parasites. Mixed plantings involving cup plant also provide a viable basis for maintaining or enhancing native bee pollinator populations. By producing floral and extra-floral resources the inclusion of cup plant in mixed species plantings is attractive to bees, as well as resources for predators and parasites of pest species. Our cumulative results and interpretations support ecological community stability models where more complex combinations of plants support a greater diversity of insects and a proportionately reduced loss of plant biomass. We predict that multispecies plantings for bioenergy production could be relatively free of pesticides and intensive management.

Keywords: cup plant, switchgrass, prairie cordgrass, Blastobasis repartella, Chilophaga virgati, Eucosma giganteana, native insects, biomass impact

Introduction
In the northern Great Plains and western Great Lakes regions switchgrass (*Panicum virgatum* L.), Prairie cordgrass (*Spartina pectinata* Bosc *ex* Link), and cup plant (*Silphium perfoliatum* L.) are the primary native plant species being studied as biomass feedstock crops. Published agronomic reviews on native species of plants, including these three species, typically summarize plant adapted insect associates as either seemingly nonexistent or limited in diversity and largely inconsequential (e.g., Vogel 2004, Parrish & Fike 2005, DOE 2006). This lack of recognition of host specific phytopages provides opportunities to make numerous new biological discoveries, specifically: species new to science, new arthropod/plant associations, new host/parasite relationships, new recognition of pest potential, calculations on potential biomass loss, new pollinator records and associations, new understanding on the nature of native prairie communities involving switchgrass, and new hypotheses on management of native species of arthropod on agronomic stands of native plant species. Most of these new discoveries are so recent that publication of findings remains pending.

Reports of insect associates of all three plant species are in the insect taxonomy literature with host records since the late 1800's in some cases. Ainslie's (1917) study of the cordgrass moth may be the first

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substantive ecological study involving our three target plants, with Johnson and Knapp (1996) providing the first study of the agronomic impact of the cordgrass bug (*Ischnodemus falicus* Van Duzee). The long lapse of focused study is closely correlated with the height of prairie plow-up, rural development and urbanization in the Great Plains and Midwest, causing the realized catastrophic ecological destruction and fragmentation of native communities with delayed research on their insect species.

All native plants have suites of insect and other arthropod species that feed upon them and move with their native plant hosts into agronomic environments where they express new pest dynamics. Bringing these arthropods into a cultivated monocultural environment provides ecological releases that are relatively rare in natural communities. In agronomic plantings of switchgrass, prairie cordgdrass, and cup plant insect predation is the single most important limiting factor to the maximization of biomass feedstock production. Studies on geographic differences in insect diversity, specific potential pests, insect-plant interactions, and predator/parasitoid guilds are only recently begun.

Switchgrass, *Panicum virgatum*

Nyoka et al. (2004) reported tiller damage by what became the first known host specific pest of switchgrass and was shortly thereafter recognized as *Blastobasis repartella* (Dietz) (Lepidoptera: Oecophoridae), the switchgrass moth (Adamski et al. 2010, Prasifka et al. 2010). The switchgrass midge *Chilophaga virgati* Gagné (Diptera: Cecidomyiidae) was discovered as a species new to science (Boe and Gagné 2011), and is probably the most destructive insect on switchgrass by causing 100% seed loss on infested tillers and c. 65-70% biomass reduction per tiller.

Adamski et al. (2010) reported the only known parasitoid of the switchgrass moth, *Bassus difficilis* Muesebeck (Hymenoptera: Braconidae) which was found recently in high numbers in the switchgrass canopy. The first known parasitoids of the switchgrass midge, a *Platygaster* sp. (Hymenoptera: Platygastridae), is new to science, as is at least one species of *Aprostocetus* (Hymenoptera: Eulophidae). Future work will elucidate the impact of these parasitoids on their hosts and the relative amount of seed and biomass production protected by their natural biocontrol relationship. A *Steneotarsonemus* (Acari: Tarsonemidae) mite is now know to feed on the adaxial surfaces of leaf sheaths. This is apparently a species new to science.

Prairie Cordgrass, *Spartina pectinata*

In South Dakota, *Ischnodemus falicus* (Say) (Hemiptera: Lygaeidae), the cordgrass bug, occurs in high numbers in natural and agronomic plantings, apparently producing two generations annually and frequently causing near total loss of spring growth. The adults overwinter and cause extensive damage to maturing tillers, impacting both seed viability and biomass production.

The cordgrass moth, *Aethes spartinana* (Barnes and McDonnough) (Lepidoptera: Tortricidae) has a larva that feeds in the spikelets (Ainslie 1917, Prasifka et al. 2012) and on the embryonic caryopses. Prasifka et al. (2012) reported infestation rates upwards of 70% per spike. In South Dakota, seed loss has probable normal rates of 15-20% per spike by the first two larval instars that apparently compete for food with a newly discovered gall midge larva (Cecidomyiidae). It now appears that the combination of the cordgrass moth larva and the midge, which is a species new to science, may be the cause of widely reported seed production and viability problems of prairie cordgrass. The first known parasitoid of the cordgrass moth is a species of *Euderus* (Hymenoptera: Eulophidae) and is new to science. Also new to science is a species of *Aprostocetus* wasp was found parasitizing the larvae of the new to science gall midge. Another undetermined parasitoid wasp may be parasitizing the larva of the cordgrass moth. In both South Dakota and Wisconsin, we found another *Steneotarsonemus* mite on the adaxial surfaces of leaf sheaths. This is apparently a species new to science and related to the other new species discovered on switchgrass.

Cup Plant, *Silphium perfoliatum*

The larva of the giant eucosma moth, *E. giganteana* Riley is the primary cause of massive damage to cup plant (Johnson and Boe 2012). This insect is found in all South Dakota agronomic and wild situations, but the incidence of damage in wild cup plants is negligible. In both South Dakota and Wisconsin this moth produces comparable levels of damage in plants on dry sites that is persistent, but plants in mesic sites express visually significant recovery from earlier meristem feeding damage by lateral growth. All plantings of two years of age or older are infested. Early summer damage is done by the first three larval instars feeding in the apical meristematic tissues, including floral buds. There are commonly 35-60 individuals per meristem that typically kill the apex and stop most stem growth, resulting in a 100% floral loss in most stands by late June to late July. Crude biomass loss can exceed 50% on infested sites. Some stems will produce lateral inflorescences in August that will mature, but usually at a population rate of 5-10%, if at all, on dry sites. Plants on mesic sites can produce profuse lateral growths that compensate for the damaged original leader. In late July and early August the larva leaves the stem apical feeding site and moves to the stem base ≤1.5 cm above ground level and burrows into the rhizome where it remains and feeds until winter. In early spring it spins a cocoon within the rhizome void created by feeding and the adult usually emerges in mid to late June. There are no known parasites, but the larval mortality rate ≥98% per plant.

Larvae of gall-making wasps of the genus *Antistrophus* (Hymenoptera: Cynipidae) feed in cup plan stem pith in South Dakota and Wisconsin. These wasps are parasitized by other wasps, mostly *Tetrastichus* sp. (Hymenoptera: Eulophidae), but parasitism rates and species identity require elucidation.

The larva of the tumbling flower beetle, *Mordellistena* cf. *aethiops* Smith (Coleoptera: Mordellidae) tunnels the stem pith and can cause extensive decay. This beetle appears not uncommon in southern Wisconsin.

Cup plant possesses characteristics of a keystone forb supporting native pollinators. A minimum of 12 species of native bee, fly, and beetle are already known from agronomic cup plant plots, with numerous others from wildland sites.

Summary

Observations and experimentation to date indicate biodiverse groups of arthropods on each species of native plant. In combination on switchgrass, *B. repartella* and *C. virgati* may induce upwards of 25-30% loss of potential biomass per plant in monocultural plantings. Higher levels of annual biomass loss can be expected on Prairie cordgrass infested with both *I. falicus* and *A. spartinana*. Cup plant losses in monocultural agronomic conditions will devolve to nearly 100% lost of seed crop and 50-60% loss of crude biomass due to abbreviated growth, failure of inflorescences, and overall lack of vigor. Extensive larval damage to rhizomes diminish the carbon-sink capacity of cup plant.

Experiments remain necessary to evaluate the plant community complexity to bring loss rates close to natural negligible levels without the use of costly production additives. The impact of the *Steneotarsonemus* mites on each grass is yet to be measured. Similarly, the parasitism rates by the various wasps on their hosts and the relationship to seed and biomass productivity of the plants is unmeasured.

Preliminary data suggest that cup plant intermixed with switchgrass and prairie cordgrass is a viable augmentative species for supporting and enhancing late season native pollinator guilds. Further, sampling in mixed plantings of grasses and forbs indicate that biodiverse plantings can simultaneously enhance native pollinator and parasitoid/predator guilds, and reduce pest species impacts while producing superior biomass feedstock performance.

References

Adamski, D., P. J. Johnson, A.A. Boe, J.D. Bradshaw & A. Pultyniewicz. 2010. Descriptions of life-stages of *Blastobasis repartella* (Lepidoptera: Gelechioidea: Coleophoridae: Blastobasinae) and observations on its biology in switchgrass. *Zootaxa* 2656: 41-54.

Ainslie, C.N. 1917. A Few Notes on the Life History of *Phalonia spartinana*. *The Canadian Entomologist* 49: 93-96, pl. VI.

Boe, A.A. and R.J. Gagné. 2010. A New Species of Gall Midge (Diptera: Cecidomyiidae) Infesting Switchgrass in the Northern Great Plains. *Bioenergy Research* 4: 77-84.

DOE (U.S. Department of Energy). 2006. *Breaking the Biological Barriers to Cellulosic Ethanol: A Joint Research Agenda*. DOE/SC-0095, 206 pp.

Johnson, P.J., A. Boe, and D. Adamski. 2010. The Switchgrass Moth, *Blastobasis repartella*. *Proceedings of the South Dakota Academy of Science* 89 (2010): 277 (abstract).

Johnson, P.J. and A. Boe. 2012. Three Interesting Insects and the Cause of Reduced Vigor of Cup Plant (*Silphium perfoliatum*) in Agronomic Plantings. *Proceedings of the South Dakota Academy of Science* 90: 214 (abstract).

Johnson, S.R. and A.K. Knapp 1996. Impact of *Ischnodemus falicus* (Hemiptera: Lygaeidae) on Photosynthesis and Production of *Spartina pectinata* Wetlands. *Environmental Entomology* 25(5): 1122-1127.

Nyoka, B., P. Jeranyama, V. Owens, A. Boe, and M. Moechnig. 2007. *Management Guide for Biomass Feedstock Production from Switchgrass in the Northern Great Plains*. Brookings: Sun Grant Initiative North Central Center, South Dakota State University, Brookings, SGINC2-07.

Parrish, D.J. and J.H. Fike. 2005. The Biology and Agronomy of Switchgrass for Biofuels. *Critical Reviews in Plant Sciences* 24: 423-459.

Prasifka, J.R., J.E. Buhay, T.W., Sappington, E.A. Heaton, J.D. Bradshaw, M.E. Gray. 2011. Stem-boring caterpillars of switchgrass in the Midwestern United States. *Arthropod Biology* 104(3): 507-514

Prasifka, J.R., J.D. Bradshaw, A.A. Boe, D.K. Lee, D. Adamski, M.E. Gray. 2010. Symptoms, distribution and abundance of the stem-boring caterpillar, *Blastobasis repartella* (Dietz), in switchgrass. Bioenergy Research 3: 238-242.

Prasifka, J.R., D.K. Lee, J.D. Bradshaw, A.S. Parrish, and M.E. Gray. 2012. Seed reduction in prairie cordgrass, *Spartina pectinata* Link., by the floret-feeding caterpillar *Aethes spartinana* (Barnes and McDunnough). *Bioenergy Research* 5: 189-196.

Vogel K. P. 2004. Switchgrass, pp. 561-588. *In* L.E. Moser, B.L. Burson and L.E. Sollenberger (eds.), *Warm-Season (C_4) Grasses (Agronomy)*. Monograph 45. Madison: American Society of Agronomy-Crop Science Society of America-Soil Science Society of America.