Agriculture, Ecosystems and Environment 261 (2018) 25–32

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

Effect of bioenergy crop type and harvest frequency on beneficial insects

Myung-Bok Lee[a,b,*], Joshua W. Campbell[c], James A. Martin[b]

[a] Department of Wildlife, Fisheries, and Aquaculture, Mississippi State University, Mississippi State, MS 39762, USA
[b] Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA 30602, USA
[c] Deptartment of Entomology and Nematology, University of Florida, Gainesville, FL 32611, USA

ARTICLE INFO

Keywords:
Arthropod
Abundance
Diversity
Haying
Perennial prairie grass
Switchgrass

ABSTRACT

Switchgrass (*Panicum virgatum*) and a mix of native warm season grasses with forbs (NWSG-mix) have received attention as cellulosic biofuel sources. While numerous studies support greater biodiversity within those biofuel crops than corn, it is unclear how switchgrass and NWSG-mix affect beneficial insects such as pollinators (PO) and predators/parasites/parasitoids (PPP). Also, few empirical studies have explored the effects of biofuel crop harvest on insects. We investigated the responses of PO and PPP insects to those two biofuel crops and harvest frequency in Mississippi, USA, during 2011–2013. We established 16 fields on agricultural lands and randomly assigned each one of 4 treatments: switchgrass with single harvest; switchgrass with multiple harvests; NWSG-mix with single harvest; NWSG-mix with multiple harvests. We set up 3 sampling stations per field and conducted insect sampling 1–3 times monthly during summer to fall using colored pan traps. We tested treatment effects with general linear mixed models and redundancy analyses. While treatment effects varied by season and year, biofuel crop type influenced abundance and insect family diversity but harvest frequency did not. During summer, total abundance and guild-level (PO and PPP) abundance were high in switchgrass in 2011. During fall, total abundance and abundance of PPP were high in NWSG-mix in 2011 and 2012 and abundance of PO in 2011 and 2013. Family richness was also greater in NWSG-mix across seasons in 2011 and 2012 and during fall in 2013. More families tended to be associated with NWSG-mix than switchgrass. Our results suggest that 1) biofuel crop type is a more important factor influencing beneficial insects than harvest frequency and 2) compared to NWSG-mix, switchgrass may provide more resources for insects during summer or during the first year after establishment; however, NWSG-mix could enhance insect diversity and abundance of pollinators for a longer period of time.

1. Introduction

With growing demand for energy independence and reduction in carbon emissions, interest in biofuels has increased in North America and Europe. In the USA, the Energy Independence and Security Act of 2007 calls for 36 billion gallons of renewable fuels being domestically produced by 2022 and 16 billion gallons of the fuels from cellulosic sources (Perlack et al., 2011). While corn (*Zea mays*) is currently used as the main biofuel crop in the USA, using corn and other annual food crops for biofuel feedstock raises concerns about possible inflation of food prices, increase in nutrient (e.g., fertilizer) input, and reduction in air and water quality (Simmons et al., 2008; Valentine et al., 2012; Kwit et al., 2014). To avoid these economic and environmental issues, there has been a growing interest in using perennial prairie grasses such as switchgrass (*Panicum virgatum*), big bluestem (*Andropogon gerardii*), and Indiangrass (*Sorghastrum nutans*) as alternative crops. In particular, switchgrass has been extensively studied due to its high biomass yield potential and broad adaptability to a wide range of environmental conditions (Fike et al., 2006; Flaspohler et al., 2009; Fletcher et al., 2011; Voigt et al., 2012; Mitchell and Schmer, 2014).

Perennial prairie grasses have also received great attention from wildlife ecologists and conservation biologists because they may reduce the conflict between biofuel production and biodiversity conservation by land sharing (multi-functional agricultural land-uses to maintain biodiversity without reduction of production land) or land sparing (limiting intensive agricultural land-uses to a fixed area and sparing some land for conservation) in agricultural landscapes (Fargione et al., 2009; Robertson et al., 2012a; Kwit et al., 2014). Most perennial prairie grasses (native warm season grasses, hereafter NWSG) considered for biofuel crops are native to the North American tallgrass prairie. In several practices under Conservation Reserve Program (e.g., CP38, CP42), they are used to restore early succession/grassland habitats or planted at field margins to mitigate negative influences of agricultural land-use on biodiversity (Johnson and Schwartz, 1993; Fargione et al.,

* Corresponding author at: College of Forestry, Guangxi University, Nanning, Guangxi, 530004, China.
E-mail address: bok.ecology@outlook.com (M.-B. Lee).

https://doi.org/10.1016/j.agee.2018.04.001
Received 28 September 2017; Received in revised form 19 March 2018; Accepted 1 April 2018
0167-8809/

2009; Hartman et al., 2011).

A number of recent studies support greater diversity or abundance of arthropods (insects and spiders), birds, and plants in switchgrass monocultures and polycultures (e.g., NWSGs in mixture or mixed-NWSGs-forb prairie) than in corn monocultures (Gardiner et al., 2010; Robertson et al., 2011; Robertson et al., 2012b; Werling et al., 2014). Although perennial prairie grasses produce lower biomass yields compared to corn monocultures, they provide a greater array of ecosystem services including pest control, pollination services, and wildlife habitat (Werling et al., 2014). Mixed-NWSGs-forb prairie (NWSG-mix, hereafter) plantings also require low inputs (e.g., fertilizer, herbicide) for establishment and maintenance (Tilman et al., 2006). It is hypothesized that NWSG-mix plantings may increase biodiversity more than switchgrass monocultures because diverse plants could create spatially and temporarily heterogeneous habitats that can harbor a variety of species (Fargione et al., 2009). Several arthropod studies tested this hypothesis but their findings varied by study. For instance, Robertson et al. (2012b) reported greater family richness of terrestrial arthropods in mixed-grass-forb prairie plantings than in switchgrass plantings, supporting the hypothesis. Alternatively, Gardiner et al. (2010) did not find significant differences in abundance and species richness of beneficial insects (especially, bees) between those plantings. Thus, the relative effects of NWGS biofuel crop types (switchgrass planting vs. NWSG-mix planting) on arthropod communities remain unclear. In addition to the crop types, biofuel crop management such as harvest frequency and timing can influence biodiversity (Roth et al., 2005). For instance, single harvest (e.g., one cut during fall) or multiple harvests during multiple years is expected to improve wildlife habitat value by providing important resources for grassland bird species, compared to multiple harvests within a year (Fargione et al., 2009; Conkling et al., 2017). However, impacts of harvest frequency on arthropod communities have not been studied (Riffell et al., 2012).

Arthropods are key providers of ecosystem services including pest control, pollination, and serving as main food sources for breeding birds (Isaacs et al., 2009; Landis and Werling, 2010; Classen et al., 2014). The annual value of ecosystem services directly provided by beneficial insects is estimated to be $8 billion in USA and at least $57 billion in indirect services they provide as an important food source for game animals and commercial fisheries (Losey and Vaughan, 2006). Arthropods can also affect biomass and crop yields as well as establishment of biofuel crops negatively or positively by acting as pests, predators, or decomposers (Landis and Werling, 2010; Prasifka et al., 2010; Werling et al., 2011). Given their importance to agroecosystems, understanding relationships between arthropods and potential biofuel crop types and crop management is critical to developing management regimes minimizing biodiversity loss while maintaining benefits from ecosystem services and biomass production. In this study, we report how beneficial insects' (pollinators and predators/parasites/parasitoids) abundance, family diversity, and composition respond to NWSG biofuel crop types (switchgrass and NWSG-mix) and harvest frequency (single harvest and multiple harvests). We also consider possible seasonal variation in the responses of those two guilds, which is less examined in previous studies.

2. Methods

2.1. Study site and treatment

The study was performed at B. Bryan Farm in Clay County, Mississippi, during 2011–2013. The study area is part of the Blackland Prairie where the predominant land use is timber production (44%), livestock production (20%), and fields of soybeans and corn (28%) (Barone, 2005). B. Bryan Farm encompasses over 2100 ha of agricultural land and approximately 25% of the land base has been allocated to a myriad of conservation treatments under a diversity of conservation programs including Environmental Quality Incentive Program, Wildlife Habitat Incentive Program, and Conservation Reserve Program.

At B. Bryan Farm, we established four experimental blocks each composed of 4 fields previously under soybean production, resulting in a total of 16 fields. Fields were blocked based on soil type and adjacency to forest. All fields were 7–8 ha in size except two fields (5 ha). Within a block, we randomly assigned one field to each of the following four treatments: (1) NativeM, NWSG-mix with multiple harvests to simulate haying and biomass collection; (2) NativeS, NWSG-mix with a single biomass harvest; (3) SwitchM, Switchgrass monoculture with multiple harvests to simulate haying and biomass collection; (4) SwitchS, Switchgrass monoculture with a single biomass harvest. NWSG-mix included a mix of big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium soparium*), Indiangrass (*Sorghastrum nutans*), and selected prairie forbs (see Supplementary material, Table A.1 for the list of forbs). All grasses were planted in spring 2010 and harvest did not occur until 2012 to ensure establishment of grasses. In 2012, the first harvest (dormant harvest) was applied to all fields in early April and the second harvest (summer harvest) to SwitchM and NativeM fields in late June to simulate multiple harvests. SwitchM and NativeM also received one more harvest in between late June and early July 2013.

2.2. Insect collection

A set of colored pan traps, consisting of three 12 oz bowls (blue, white, yellow) filled with soapy water, were used for insect sampling (Campbell and Hanula, 2007). We placed one set of traps to the height of flowers or vegetation at three locations (sampling station, hereafter) within a field. Sampling stations were spaced > 25 m from the edge of a field to avoid edge effects and ≥ 50 m from the nearest station to minimize dependency between trap sets. A total of 48 sampling stations (3 stations x 16 fields) were established across study fields.

To account for seasonal variations in insect populations, we performed trapping each month during May-November in 2011, May-October in 2012, and June-October in 2013. One set of pan traps were installed at each sampling station twice (about 10–14 days apart) a month except May, August, September and November in 2011 (one sampling occasion), September and October in 2012 (one sampling occasion), and August in 2012 (three sampling occasions). While a total of 1236 trap occasions occurred across three years of sampling periods, 40 trap occasions were censored because of extreme wind or rain storms. Contents of each trap were collected three days following trap set up. Collected insect samples were preserved in a 70% ethanol solution for future identification.

2.3. Data analyses

While insect sampling was performed at all 16 fields, two fields (1 SwitchM and 1 SwtichS) established poorly. We excluded the data collected at those two fields and used the data from 14 fields, 42 sampling stations, for analysis.

Among insects captured, we focused on insects of two guilds, (1) pollinators (PO) and (2) predators/parasites/parasitoids (PPP), due to their importance in the provision of ecosystem services. We counted and identified all insects to family level. Many families were also identified to genus/species to verify the correct guild. We determined the guild (PO or PPP) of insects according to their most common foraging strategy at adult stage. Families belonging to Lepidoptera were considered pollinators given that all Lepidoptera collected were adult butterflies (and moths in some cases) and are often recognized as important pollinators.

To examine the effect of treatment on insect abundance and insect diversity at the family level, we used abundance (number of individuals) of beneficial insects (TOTAL, i.e., sum of PO and PPP), abundance of PO and of PPP separately, family richness (Richness,