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Research

Comparison of bee composition in sunn hemp and other cover crops

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Abstract

Cover crops can be planted in rotation with cash crops to improve soils, assist in weed growth prevention, and help suppress plant pathogenic nematode populations. Experiments were conducted in northern and north-central Florida to evaluate bee populations within cover crop plants, including sunn hemp (Crotalaria juncea L.), sorghum-sudangrass (Sorghum bicolor L. Moench × S. bicolor var. sudanense [Piper] Stapf.), and cowpea (Vigna unguiculata [L.] Walp.). Almost 150 bees in 10 species and over 700 bees in 15 species were collected in pan (bee bowls) and blue vane traps, respectively. Both sets of traps captured bees from within all cover crop plots, indicating that these bees forage in disturbed habitats. The dominant bees collected, Melissodes spp., are ground-nesting solitary bees which may have been utilizing the ground below the plants and the border plot areas as a nesting site. Only a subset of the species composition associated with the cover crops was relevant to the pollination of sunn hemp, which requires large-bodied bees such as species of Xylocopa and Megachile.

Key Words: pollinators; Crotalaria; Xylocopa; Megachile

Resumo

Los cultivos de cobertura se pueden plantar en rotación con cultivos comerciales para mejorar los suelos, ayudar en la prevención del crecimiento de malezas y ayudar a suprimir las poblaciones de nematodos patógenos de plantas. Se realizaron experimentos en el norte y centro-norte de la Florida para evaluar las poblaciones de abejas dentro de las plantas de cultivos de cobertura, incluidos cáñamo sunn (Crotalaria juncea L.), sorgo-sudangrass (Sorghum bicolor L. Moench × S. bicolor var. sudanense [Piper] Stapf.), y caupí (Vigna unguiculata [L.] Walp.). Se recolectaron casi 150 abejas de 10 especies y más de 700 abejas de 15 especies en bandejas (tazones para abejas) y trampas de paleta azul, respectivamente. Ambos juegos de trampas capturaron abejas de todas las parcelas de cultivos de cobertura, lo que indica que estas abejas se alimentan en hábitats perturbados. Las abejas dominantes recolectadas, Melissodes spp., son abejas solitarias que anidan en el suelo y que pueden haber estado utilizando el suelo debajo de las plantas y las áreas de la parcela fronteriza como sitio de anidación. Solo un subconjunto de la composición de especies asociadas con los cultivos de cobertura fue relevante para la polinización del cáñamo solar, que requiere abejas de gran tamaño, como las especies de Xylocopa y Megachile.

Palabras clave: polinizadores; Crotalaria; Xylocopa; Megachile

Many Florida vegetable growers plant cover crops either before planting or after harvesting their main crop (Snapp et al. 2005; Newman et al. 2014) to improve soil conditions (Wang et al. 2005; Cherr et al. 2007), suppress weed populations (Adler & Chase 2007; Collins et al. 2008; Mosjidis & Wehtje 2011; Cho et al. 2015), reduce plant parasitic nematode densities (Crow et al. 2001; Bhan et al. 2010; Braz et al. 2016), and reduce insect pest populations (Pair & Westbrook 1995; Meagher et al. 2004; Tuan et al. 2014). One favorite species is sorghum-sudangrass (Sorghum bicolor L. Moench × Sorghum bicolor var. sudanense [Piper] Stapf.) (both Poaceae), which is a warm-season annual grass hybrid that is used as a catch crop following harvest of winter vegetables (Newman et al. 2014; Vendramini et al. 2015). However, these crops are important hosts used by the crop pest fall armyworm (Spodoptera frugiperda [J. E. Smith]; Lepidoptera: Noctuidae) (Sparks 1979; Pair et al. 1991), which overwinters in southern Florida before dispersing north in the summer months (Nagoshi et al. 2012). Alternative cover crops are of interest to Florida growers to combat the build-up of fall armyworm populations, including cowpea (Vigna unguiculata [L.] Walp. × Vigna unguiculata [L.] Walp.), which is a warm-season annual legume that can be planted in rotation with cash crops to improve soil health, help suppress weeds, and assist in the prevention of pest outbreaks (Newman et al. 2014; Vendramini et al. 2015).

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Both cowpea and sunn hemp cover crops have shown potential as key components in an area-wide management strategy for control of fall armyworm (Meagher et al. 2004). Cowpea is an important human food source in many parts of the tropics and subtropics since all parts of the plant can be eaten (Menssen et al. 2017; Xiong et al. 2018). In the USA, southern or black-eyed peas are an important food and are used also as a summer cover crop (Hutchinson & McGiffen 2000; Ngouajio et al. 2003; Wright et al. 2017). The first sunn hemp cultivar commercialized in the US was ‘Tropic Sun’ (Rotar & Joy 1983), but other varieties or germplasm lines from Africa and Asia also are used as cover crops in the US.

In addition, these cover crops may contribute to another ecological service by producing flowers that provide resources for pollinators and insect food for predators and parasitoids (Campbell et al. 2016). Studies have shown that early season flowering by cover crops can increase pollinator populations, which promote late season pollination in adjacent cash crops (Riedinger et al. 2014). Flower density and the diversity of the cover crop plants may influence bee visitation and native bee abundance (Saunders et al. 2013; Ellis & Barbercheck 2015).

Our research objective was to determine the bee community composition in plots of cowpea, sorghum-sudangrass, and sunn hemp cover crop plants and a standard crop of corn. Our hypothesis was that plots with flowers (cowpeas and sunn hemp) would be more attractive to bees and would result in higher captures in traps.

**Materials and Methods**

**BEETLE COMMUNITY COMPOSITION IN COVER CROP PLOTS**

In 2012, cover crops were planted at the North Florida Research and Education Center, Quincy, Florida, USA (30.5458°N, 84.5990°W) and at the University of Florida Plant Science Research and Education Unit, Citra, Florida, USA (29.4101°N, 82.1732°W). Three cover crop treatments were evaluated: the standard cover crop species sorghum-sudangrass, and the alternative species cowpea and sunn hemp. These experiments were part of a larger study to compare infestation of fall armyworm. Therefore, to encourage infestation of this species, corn (DKC 66-94 RR2, DeKalb Genetics Corp., DeKalb, Illinois, USA) was planted as the fourth treatment plot and served as a non-cover crop control treatment. The experimental design at both locations was a randomized complete block design with 4 treatments, 4 replications, and all plots planted to 91.4 cm row centers. Sorghum-sudangrass seed was Forage First Sudx SX-17 sorghum × sudangrass hybrid (Forage First, Nampa, Idaho, USA). Cowpea seed was ‘Iron & Clay’ and was purchased from Forage Genetics International, LaCrosse, Wisconsin, USA, now sold by Forage Genetics International, Citra, Florida, USA (29.4101°N, 82.1732°W). One blue vane trap was randomly placed in each treatment (row by number of paces), equaling 4 traps per location and date. Traps were moved from 1 treatment block to another after each sampling collection. Traps at Quincy were put out 12 Jul and sampled 20 Jul, 27 Jul, and 2 Aug, 10 Aug, 16 Aug, and 29 Aug. Blue vane traps (SpringStar Inc., Woodinville, Washington, USA) were placed at Quincy in 2012 and Citra in 2012. Blue vane traps were hung from 1.5 m poles so that the height of the trap was 1.5 m. Each trap contained an insecticide strip containing 10% 2,2-dichlorovinyl dimethyl phosphate (Hercon® Environmental, Emigsville, Pennsylvania, USA). One blue vane trap was randomly placed in each treatment (row by number of paces), equaling 4 traps per location and date. Traps were moved from 1 treatment block to another after each sampling collection. Traps at Quincy were put out 12 Jul and sampled 20 Jul, 27 Jul, and 2 Aug, 10 Aug, and 16 Aug; traps at Citra were put out 9 Aug and sampled 17 Aug, 24 Aug, 31 Aug, 11 Sep and 20 Sep. Bees were identified by KMW using various taxonomic keys.

**STATISTICS**

All analyses were conducted using SAS (2012). Bee bowl and blue vane data for each location and yr were first analyzed using Box-Cox (PROC TRANSREG) and PROC UNIVARIATE to find the optimal normalizing transformation (Osborne 2010). For the bee bowl samples, cover crop treatment differences of numbers of Melissodes spp. (Hymenoptera: Apidae) bees and total numbers of bees were compared using a randomized complete block design in PROC MIXED, with cover crop treatment as the fixed variable, and sampling date, date × treatment, treatment × block, and block as the random variables. For the blue vane samples, cover crop treatment differences of numbers of Melissodes spp., Bombus spp. (Hymenoptera: Apidae), and total number of bees were compared using PROC MIXED, with cover crop treatment as the fixed variable, and sampling date and sampling date × treatment as the random variables. In all analyses LSMEANS with an adjusted Tukey test was used to separate variable means.

**Results**

**COMMUNITY COMPOSITION IN COVER CROP PLOTS**

Ten species of bees totaling 147 individuals were found in all 3 colors of the elevated bowls at Quincy in 2012 (Table 1). Melissodes bimaculata (Lepelletier) and Melissodes communis Cresson (both Hymenoptera: Apidae) were the species collected in the highest numbers, composing 72.8% of the bees collected. There were no differences among cover crop treatments in number of Melissodes spp. or total bees collected (Table 2), which was unexpected because our hypothesis was that more bees would be recovered from the cowpea and sunn hemp plots. However, sampling date was a significant random variable (P = 0.0009) because fewer bees were collected from Jul through late Aug in 2012 (Fig. 1). All other random variables were not significantly different (P > 0.05).
Large numbers of bees were collected in the blue vane traps in Quincy and Citra, but this was driven by a few species (Table 1). In Quincy, *M. bimaculata* and *M. communis* bees composed 63.6% of the total captures from 15 different species, although there were also large numbers collected of *Xenoglossa strenua* (Cresson) and *Bombus impatiens* Cresson (both Hymenoptera: Apidae). More *Melissodes* spp. bees were collected in traps that were in the corn and sorghum-sudangrass plots than in the cowpea plots; numbers in the sunn hemp plots were intermediate (Table 3). As in Quincy, sampling date and sampling date × treatment were significant random variables, because fewer bees were collected as the season progressed (Fig. 3).

**Discussion**

Bee bowls and blue vane traps may be efficient indicators of species richness in agricultural habitats (Westphal et al. 2008; Joshi et al. 2015). None of our trials were designed to directly compare trapping methods, although certain trends were evident. Blue vane traps captured 3.6 times more bees than bee bowls when used at the same location (Quincy location 2012). *Melissodes bimaculata*, *M. communis*, *X. strenua*, and *B. impatiens* were collected in high numbers in blue vane traps, which has been documented in other studies (Stephen & Rao 2005, 2007; Kimoto et al. 2012; Geroff et al. 2014).

Bee bowls and blue vane traps may show a strong bias in the numbers and types of species found in different habitats, especially *Melissodes* and *Bombus* bees (Saunders & Luck 2013; Rhoades et al. 2017). The dominant bees collected, *Melissodes* spp., are ground-nesting solitary bees which may have been using the non-plant area within

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**Table 1.** Total number of bees (females, males) collected from bee bowl and blue vane traps at Quincy and Citra, Florida, USA, 2011 and 2012. Bee bowls in 2012 were set at a height of 1.5 m and were randomly placed in plots (row number by number of paces). Vane traps were randomly placed in plots.

| Year | Treatment | Bowl – Quincy 2012 (56 d) | Vane – Citra 2012 (39 d) | Vane – Quincy 2012 (35 d) |
|------|-----------|--------------------------|--------------------------|--------------------------|
| 2011 | corn      | 1.0                      | 1.0                      | 2.0                      |
|      | sorghum-sudangrass | 2.0          | 1.0                      | 0.0                      |
|      | cowpea   | 2.0                      | 1.0                      | 0.0                      |
|      | sunn hemp | 1.0                      | 1.0                      | 0.0                      |

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**Table 2.** Number of *Melissodes* spp. (*bimaculata and communis*) and total bees per 3 bowls (mean ± SE) per cover crop treatment in suspended bee bowls (2012, 56 d), Quincy, Florida, USA.

| Year | Treatment | Melissodes spp. | Total bees |
|------|-----------|-----------------|------------|
| 2012 | corn      | 1.04 ± 0.34 a   | 1.42 ± 0.39 a |
|      | sorghum-sudangrass | 0.92 ± 0.36 a   | 1.17 ± 0.48 a |
|      | cowpea   | 1.33 ± 0.43 a   | 1.79 ± 0.48 a |
|      | sunn hemp | 1.17 ± 0.35 a   | 1.75 ± 0.48 a |

**Note:**

1. Data were transformed using *Y* = *X*; Means followed by the same letter in each yr are not significantly different, *P > 0.05*.
2. Data were transformed using *Y* = *X*; Means followed by the same letter in each yr are not significantly different, *P > 0.05*.
cover crop species in early spring would have attracted more bees to these plants.

Cowpea produces small purple or white papilionaceous flowers and in Africa, honey bees, bumble bees, and the carpenter bee *Xenoglossa flavurofa* (De Geer) (Hymenoptera: Apidae) were found with pollen on their bodies during flowering (Pasquet et al. 2008; Asiwe 2009). Flower color was found to be important in which bees visited plants, because bumble bees preferred purple flowers and honey bees preferred white flowers (Leleji 1973). In the Amazon, pollination from a variety of bee species were shown to play an important complementary role in cowpea production (Vas et al. 1998). No information was found concerning bee species attracted to cowpeas in the US.

Only a subset of the species composition associated with the cover crops, as detected in the bowl and vane traps, was relevant to the pollination of sunn hemp (Meagher et al. 2019). Bee bowl traps have been shown to catch smaller-bodied bees disproportionately relative to larger bees (Cane et al. 2000; Roulston et al. 2007), and may under-sample bee species richness when there are abundant floral resources nearby (Mayer 2005; Wilson et al. 2008; Baum & Wallen 2011). We had hoped that sunn hemp would flower earlier in the season, but because of an error in ordering, a sunn hemp line that has short daylength flowering was used (Meagher et al. 2017). Pollination of the large yellow papilionaceous flowers of *Crotalaria* (Fabaceae) species occurs when bees land on the flower keel and wing petals and force their tongues into the nectar well at the base of the standard petal (Le Roux & Van Wyk 2012). Pollination generally requires large-bodied bees, such as *Xylocopa* spp. (Hymenoptera: Apidae) and *Megachile* spp. (Hymenoptera: Megachilidae) (Jacobi et al. 2005; Brito et al. 2010; Halbrendt 2010; Amaral-Neto et al. 2015). We only documented 2 *Xylocopa* specimens with blue vane traps, although actively counting visiting bees in later studies with other varieties of sunn hemp resulted in finding large numbers of *Xylocopa micans* Lepeletier and *Xylocopa virginica* (both Hymenoptera: Apidae) (Meagher et al. 2019). We believe that sunn hemp lines that successfully produce flowers earlier in the season can provide food and habitat for pollinators and beneficial insects (LeFéon et al. 2013; Meagher et al. 2017).

Traps placed in disturbed agricultural habitats may be used to survey and identify bee species that are present. Results from this study using passive traps and results from Meagher et al. (2019) using direct observations strongly indicate that many bee species are attracted to these cover crop plant species. However, comparing results from both studies suggest that several bee collecting methods are needed to determine which species are active in these habitats.

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**Table 3.** Number of *Melissodes* spp. (*bimaculata* and *communis*), *Bombus* spp. (*fraternus*, *impatiens*, and *pensylvanicus*), and total bees per trap (mean ± SE) per cover crop treatment in blue vane traps, Quincy (35 d) and Citra (39 d), Florida, USA, 2012.

| Location | Treatment         | Melissodes spp. | Bombus spp. | Total bees* |
|----------|-------------------|-----------------|-------------|-------------|
| Quincy   | corn              | 24.0 ± 6.2 a    | 3.2 ± 1.6 a | 35.2 ± 10.6 a |
|          | sorghum-sudangrass| 19.0 ± 5.0 a    | 2.0 ± 0.7 a | 28.4 ± 9.7 ab |
|          | cowpea            | 10.0 ± 6.0 b    | 5.0 ± 1.5 a | 18.2 ± 9.8 b  |
|          | sunn hemp         | 14.4 ± 3.7 ab   | 4.0 ± 1.8 a | 24.2 ± 6.7 ab |
|          | *F* = 5.1; *df* = 3, 12; *P* = 0.0168 | *F* = 0.6; *df* = 3, 12; *P* = 0.6371 | *F* = 5.6; *df* = 3, 12; *P* = 0.0121 |
| Citra    | corn              | 12.2 ± 4.5 a    | 1.4 ± 1.0 a | 14.0 ± 4.8 a  |
|          | sorghum-sudangrass| 7.8 ± 5.0 a     | 0.4 ± 0.4 a | 8.2 ± 5.2 b   |
|          | cowpea            | 5.6 ± 3.1 a     | 0.4 ± 0.4 a | 6.0 ± 3.2 b   |
|          | sunn hemp         | 8.8 ± 5.0 a     | 0.2 ± 0.2 a | 9.2 ± 5.3 ab  |
|          | *F* = 2.4; *df* = 3, 12; *P* = 0.1158 | *F* = 0.5; *df* = 3, 12; *P* = 0.6677 | *F* = 3.8; *df* = 3, 12; *P* = 0.0407 |

*Data were transformed using Y². Mean follows by the same letter in each location are not significantly different, *P* > 0.05.

*Data were log-transformed. Means followed by the same letter in each location are not significantly different, *P* > 0.05.
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