Methods for Sampling Soil Surface Arthropods in Bush Beans: Which One Is the Best?

HARSIMRAN K. GILL¹ AND ROBERT MCSORLEY*²

¹University of Florida, IFAS, Citrus Research and Education Center, Lake Alfred, FL 33850
²University of Florida, IFAS, Department of Entomology and Nematology, Gainesville, FL 32611-0620

ADDITIONAL INDEX WORDS. Berlese funnel, board traps, insect community, mulches, pest management, pitfall traps

Mulching with organic matter has been shown to reduce the incidence of some insect pests. However, to evaluate effects of mulches on insects, reliable methods are needed for sampling insects that are active or living on the soil surface. An experiment was conducted in fall 2007 at the University of Florida Plant Science Research and Education Unit in Citra, FL. The objective was to compare different methods for sampling soil surface arthropods. The experiment was conducted on 25 small field plots. Three sampling methods (Berlese funnel, pitfall traps, and board traps) were used to sample the insects and other arthropods in each plot. Soil surface arthropods collected using these sampling methods were identified to family level under a dissecting microscope. The total number of taxa collected in Berlese funnel samples was always <3, and it was concluded that the Berlese funnel is not a practical sampling method for sandy soils in Florida. The greatest variety of different taxa were sampled using pitfall traps, which were superior to board traps for collection of greater numbers of many arthropods such as staphylinid beetles, chrysomelid beetles, springtails, grasshoppers, leafhoppers, flies, spiders, small parasitoid wasps, and small plant-feeding insects like aphids, thrips, and whiteflies. Board traps were better for sampling crickets, earwigs, and click beetles. Pitfall traps and board traps provided similar numbers of ants and carabid beetles. Overall, pitfall traps caught more taxa and greater numbers, and therefore were the most effective sampling method compared to board traps and Berlese-funnel methods.

Mulching with organic matter around plants can limit evaporation of moisture, prevent freezing of roots, moderate soil temperature, improve water infiltration, and reduce growth of weeds (Gruda, 2008; Hartwig and Ammon, 2002; Hartwig and Hoffman, 1975; Powers and McSorley, 2000; Reeleder et al., 2004; Teasdale et al., 2004; Westerman and Bicudo, 2005). Plant mulches can be an effective way to provide shelter for predatory insects (Johnson et al., 2004). In sweetpotato (Ipomoea batatas (L.) Lam.), mulches from killed crop covers increased numbers of fire ants, rove beetles, and carabid beetles captured using pitfall traps (Jackson and Harrison, 2008). Mulches can also help to maintain soil moisture required for plant vigor and to promote plant tolerance to the attack of insect pests (Johnson et al., 2004). Mulch from sunn hemp (Crotalaria juncea L.) was effective in reducing incidence of lesser cornstalk borer, Elasmopalpus lignosellus (Zeller), on bean (Phaseolus vulgaris L.) (Gill et al., 2010). Many previous studies have examined the use of mulches for management of insect pests (Brown and Twankoski, 2004; Gill et al., 2010; Hooks and Johnson, 2004; Prasifka et al., 2006; Pullaro et al., 2006; Reeleder et al., 2004; Schmidt et al., 2007; Tremelling et al., 2002). For any study involving mulches, it is critical to have a sampling method that will reliably evaluate insects that are living and active on the soil surface where the mulch is placed.

Insects, related arthropods, and other invertebrates are commonly seen on the ground in fields, lawns, yards, and gardens. Many of these are very active on the soil surface in agricultural fields and often found there. Some of these insects are pests of plants, such as crickets (Gryllidae), cutworms (Noctuidae), leaf-feeding beetles (Chrysomelidae), grasshoppers (Acrididae), thrips (Thysanoptera), whiteflies (Aleyrodidae), and aphids (Aphididae); others, such as ground beetles (Carabidae), ants (Formicidae), spiders (Araneae), long-legged flies (Dolichopodidae), tiger beetles (Cicindelidae), and rove beetles (Staphylinidae), feed on plant pests and provide some help in biocontrol (Coleman and Crossley, 1996; Triplehorn and Johnson, 2005). Springtails (Collembola) and other soil insects are important for decomposition and nutrient recycling (Coleman and Crossley, 1996). Many arthropods are found in vegetation above the soil surface as well as on the soil surface. Insects on vegetation, flying insects, and other arthropods above the soil surface can be easily sampled using sweep nets, pheromone traps, beat cloths, and many other methods (Southwood and Henderson, 2000; Triplehorn and Johnson, 2005). This current research is intended to focus on common invertebrates that are typically found on the soil surface in agricultural fields and gardens in Florida.

Different arthropods can be easily collected from the soil surface by using sampling methods such as pitfall traps, wooden board traps, or in some cases, Berlese funnels. A pitfall trap is a container placed into the ground so that the top edge is level with the soil surface. Insects running or crawling along the soil surface will fall into the container and are captured (Brown and Twankoski, 2004; Teasdale et al., 2004; Westerman and Bicudo, 2005).
2004; Pullaro et al., 2006; Southwood and Henderson, 2000). The board trap is simply a piece of wood placed on the soil surface. Arthropods hiding under the board can be identified and counted when the board is picked up (Cole, 1946). A Berlese funnel can be helpful in sampling insects in debris and leaf litter on the soil surface. However, this method is more often used for sampling insects living in soil and leaf litter rather than directly on the soil surface. Also, it requires more equipment than the simpler pitfall or board traps. The trap looks like a funnel containing a piece of screen or cloth with a killing jar of alcohol below the funnel. An electric bulb is placed above the funnel and a soil or litter sample is placed on the screen or cloth. As the upper part of the material dries from the heat of the bulb, insects move downward and eventually fall into the killing jar (Crossley and Blair, 1991; Southwood and Henderson, 2000). The purpose of this research was to sample soil surface arthropods using three different sampling methods in order to determine the best sampling method for the soil surface arthropod community.

Materials and Methods

**Experimental plots.** Three different sampling methods (i.e., pitfall traps, Berlese funnel traps, and board traps) were compared. The sampling experiment was conducted in the context of a larger study that involved mulches derived from various cover crops. The effects of the five different mulch treatments on the insect community are summarized elsewhere (Gill et al., 2011). Field experiments were conducted in fall 2007 at the University of Florida Plant Science Research and Education Unit (29°24'N, 82°9'W), near Citra in Marion Co., FL. The soil at the experimental site was Arredondo sand (95% sand, 2% silt, 3% clay) with 1.5% organic matter (Thomas et al., 1979). The experimental field was sprayed with glyphosate (Roundup®, Monsanto, St. Louis, MO) to kill weeds on 26 Sept. followed by rototilling on 3 Oct. A total of 25 plots were established, each 3.0 m long and 2.4 m wide, and the distance between plots was 3.0 m. In order to compare the three sampling methods during the vegetable growing season in Florida, all plots were planted with ‘Roma II’ bush beans (Phaseolus vulgaris L.) on 4 Oct. Seeds were spaced 10 cm apart at a rate of 30 seeds per row, in two rows per plot. Various mulches from harvested cover crops (Gill et al., 2011) were applied on 11 Oct. The resulting mulches (3–5 cm deep) were a composite of leaves and stems and were applied manually surrounding the rows of bean plants. Plots were irrigated as needed using drip irrigation, and no insecticides were applied during the course of the experiment.

**Data collection.** Insects were collected from each of the 25 plots on two sampling dates (20 Nov. and 3 Dec.) using three different sampling methods: pitfall traps, wooden board traps, and Berlese funnels. Pitfall traps were used for capturing insects that run or move on the soil surface (Triplehorn and Johnson, 2005). A plastic sandwich container (14 cm × 14 cm × 4 cm, containing about 500 mL water) was used as a pitfall trap. One pitfall trap was placed in the middle of each plot, and buried so that the upper edge was flush with the soil surface. The traps were filled three quarters with water, along with 3 to 4 drops of dish detergent (Ultra Joy®, Procter and Gamble, Cincinnati, OH) to break surface tension, ensuring that the insects would remain in the trap. Pitfall traps were set out in the morning and collected before noon the next day (which was recorded as the sampling date). The traps were brought to the laboratory, kept in a cold room at 10 °C, and contents transferred and stored in 70% ethanol in vials. Insects and related arthropods were identified to order and family levels using a dissecting microscope.

Wooden board traps (Cole, 1946) were used to provide hiding places for sampling cryptic arthropods. One board trap (15cm × 15 cm × 2.5 cm thick) was placed on the soil surface near the end of each plot, which was 0.5 m away from the plot edge. On each sampling date, boards were tilted to one side, and insects were counted and identified to order and family level, followed by replacement of traps on the same spot until the next sampling date.

A soil sample consisting of six soil cores (2.5-cm-diameter × 15 cm deep) was collected from each plot on 20 Nov. Cores were mixed and a subsample of 100 cm³ soil was placed on a fine mesh screen in a Berlese funnel under a 60-W light bulb. Funnels were maintained for 48 h, and extracted arthropods were collected in 70% ethanol.

**Data analysis.** All statistical analyses were performed using the Statistical Analysis System (SAS) package (version 9.1; SAS Institute, Cary, NC). Data for each dependent variable (insect groups) were analyzed using analysis of variance to compare the numbers among treatments.

Results and Discussion

The main arthropod taxa collected in pitfall traps included Elateridae (click beetles), Gryllidae (crickets), micro-Hymenoptera (small parasitoid wasps), Dolichopodidae (long-legged flies), total-Diptera (included fungus gnats and other micro-Diptera along with Dolichopodidae), Cicadellidae (leafhoppers), Staphylinidae (rove beetles), Collombola (springtails), Chrysomelidae (leaf-feeding beetles, flea beetles), Carabidae (ground beetles), Formicidae (ants), Acrididae (grasshoppers), Araneae (spiders), Labiduridae (earwigs), and other plant feeders (thrips, whiteflies, and aphids). Arthropods collected by wooden board traps were mainly Labiduridae, Gryllidae, and Elateridae.

No more than three taxa were found at any one time in Berlese funnels, and included primarily mites (avg. 18.6/trap), enchytraeid worms (avg. 0.88/trap) and Collombola (avg. 2.40/trap). Only two other taxa were found, one aphid and one tenebroid (darkling beetles). Due to such low numbers of taxa collected in Berlese funnel traps, this sampling method was not considered for further comparison with the other two sampling methods.

A greater number of arthropod taxa was found in pitfall traps than wooden board traps on both sampling dates. On the first sampling date, Collombola, micro-Hymenoptera, Dolichopodidae, total Diptera, Cicadellidae, and Staphylinidae were more common (P ≤ 0.10) in pitfall traps, while Elateridae, Gryllidae, and Labiduridae were found in higher numbers in wooden board traps (Table 1). On the second sampling date, numbers of micro-Hymenoptera, Araneae, Collombola, Cicadellidae, Acrididae, Chrysomelidae, Dolichopodidae, total Diptera, other plant feeders, and other insects (mainly Noctuidae) were higher in pitfall traps than wooden board traps (Table 2). Only Labiduridae and Elateridae were more common under wooden board traps. In addition, ants and carabid beetles were consistently collected by both pitfall and board traps, but numbers did not differ (P > 0.10) with trap type. Across all plots and both trap types, numbers of ants averaged 4.81/trap and carabid beetles averaged 0.19/trap.

Pitfall trapping is the most commonly used method for sampling arthropods on the soil surface but is not without problems and biases (Gill and McSorley, 2011; Greenslade, 1964; Southwood and Henderson, 2000; Triplehorn and Johnson, 2005; Williams, 1959). Areas between plots were cleared to
reduce effects of background habitat (Melbourne, 1999). The traps used had relatively large openings, since larger traps are generally more efficient against a wider range of taxa (Ward et al., 2001). However, species-specific differences in activity are difficult to standardize in any case, and are particularly challenging in community studies (Topping and Sunderland, 1992; Ward et al., 2001). However, species-specific differences in activity are difficult to standardize in any case, and are particularly challenging in community studies (Topping and Sunderland, 1992; Ward et al., 2001). However, species-specific differences in activity are difficult to standardize in any case, and are particularly challenging in community studies (Topping and Sunderland, 1992; Ward et al., 2001). However, species-specific differences in activity are difficult to standardize in any case, and are particularly challenging in community studies (Topping and Sunderland, 1992; Ward et al., 2001). However, species-specific differences in activity are difficult to standardize in any case, and are particularly challenging in community studies (Topping and Sunderland, 1992; Ward et al., 2001). However, species-specific differences in activity are difficult to standardize in any case, and are particularly challenging in community studies (Topping and Sunderland, 1992; Ward et al., 2001). However, species-specific differences in activity are difficult to standardize in any case, and are particularly challenging in community studies (Topping and Sunderland, 1992; Ward et al., 2001). However, species-specific differences in activity are difficult to standardize in any case, and are particularly challenging in community studies (Topping and Sunderland, 1992; Ward et al., 2001). However, species-specific differences in activity are difficult to standardize in any case, and are particularly challenging in community studies (Topping and Sunderland, 1992; Ward et al., 2001). However, species-specific differences in activity are difficult to standardize in any case, and are particularly challenging in community studies (Topping and Sunderland, 1992; Ward et al., 2001). However, species-specific differences in activity are difficult to standardize in any case, and are particularly challenging in community studies (Topping and Sunderland, 1992; Ward et al., 2001). However, species-specific differences in activity are difficult to standardize in any case, and are particularly challenging in community studies (Topping and Sunderland, 1992; Ward et al., 2001). However, species-specific differences in activity are difficult to standardize in any case, and are particularly challenging in community studies (Topping and Sunderland, 1992; Ward et al., 2001). However, species-specific differences in activity are difficult to standardize in any case, and are particularly challenging in community studies (Topping and Sunderland, 1992; Ward et al., 2001). However, species-specific differences in activity are difficult to standardize in any case, and are particularly challenging in community studies (Topping and Sunderland, 1992; Ward et al., 2001). However, species-specific differences in activity are difficult to standardize in any case, and are particularly challenging in community studies (Topping and Sunderland, 1992; Ward et al., 2001). However, species-specific differences in activity are difficult to standardize in any case, and are particularly challenging in community studies (Topping and Sunderland, 1992; Ward et al., 2001). However, species-specific differences in activity are difficult to standardize in any case, and are particularly challenging in community studies (Topping and Sunderland, 1992; Ward et al., 2001). However, species-specific differences in activity are difficult to standardize in any case, and are particularly challenging in community studies (Topping and Sunderland, 1992; Ward et al., 2001). However, species-specific differences in activity are difficult to standardize in any case, and are particularly challenging in community studies (Topping and Sunderlan...
Literature Cited


