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Harlequin Bug Biology and Pest Management in Brassicaceous Crops

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ABSTRACT. Harlequin bug, *Murgantia histrionica* (Hahn), is a piercing-sucking pest of brassicaceous crops, particularly in the southern United States. The pest typically completes two to four generations per year, and overwinters as an adult in debris and weeds. Both adults and nymphs feed on aboveground plant tissues, leaving white blotches on leaves. Under heavy feeding pressure, plants can wilt and die. Chemical insecticides such as pyrethroids, organophosphates, carbamates, and neonicotinoids have been used for effective control of harlequin bug adults and nymphs. However, there is potential for cultural control of this pest using trap cropping. This paper reviews the biology and management of harlequin bug.

Key Words: *Murgantia histrionica*; harlequin bug; cole crops; trap cropping

Harlequin bug, *Murgantia histrionica* (Hahn) (Hemiptera: Pentatomidae), is a conspicuous and important pest of cole crops (Brassicaceae), particularly in the southern United States. Although harlequin bug has been recorded in the majority of the continental United States, it is not known to overwinter north of 40º N latitude, and infestations in northern states are likely due to seasonal migration aided by wind currents (Hodson and Cook 1960). Both adults and nymphs are piercing-sucking insects that feed on aboveground plant tissues, leaving white blotches, which make leafy crucifer crops such as collards and kale unmarketable. Under heavy feeding pressure plants can wilt and die potentially destroying entire fields of untreated cabbage or collards (Paddock 1915, Ludwig and Kok 2001). The pest status of this insect has risen over the past decade. This increase may be due to warming winter weather, which enables greater survival and reproduction (Walker and Anderson 1933), or possibly due to a decrease in the use of broad spectrum insecticides on brassicaceous crops. Most of the newer insecticides that specifically target lepidopteran pests do not control harlequin bug (Walgenbach and Schoof 2005). This paper is an overview of harlequin bug biology and discusses integrated pest management (IPM) strategies for its control in brassicaceous crops.

Historical Perspective

Harlequin bug, also known as harlequin cabbage bug or calico back (Howard 1895), is likely native to Central America and was first described and identified as *Strachia histrionic*a by Hahn in 1834, then later moved to the genus *Murgantia* by Stal in 1872 (Paddock 1918). The pest was introduced to the United States most likely from Mexico in the 19th century, and was first reported in Texas in 1864 (Walsh 1866). Because of its timing with the U.S. Civil War and the high pest infestations that followed in the southern United States, the bug was also referred to as the Sherman Bug named after the Union General William T. Sherman (Capinera 2001).

Considered a major pest of cabbage in the early 1900s, there were several reports of severe harlequin bug outbreaks following mild winters (Walker and Anderson 1933). Early management recommendations included destruction of overwintering habitat, handpicking, the use of soaps, and trap cropping with preferred host plants such as early radish, turnips, mustard, rape, and kale (Thomas 1915, Chittenden 1920, Fulton 1930).

With the introduction of broad spectrum insecticides, harlequin bug was found to be easily controlled chemically with organophosphates and carbamates (Rogers and Howel 1972, Wang 1978), and more recently with pyrethroids and neonicotinoid insecticides (Edelson 2004a, McLeod 2005, Walgenbach and Schoof 2005, Kuhar and Doughty 2009).

However, there has been a shift toward the use of narrow-spectrum, reduced risk insecticides, such as *Bacillus thuringiensis* for control of lepidopteran pests, which have typically been the primary pest concerns for cole crop management. The use of *Bt* and other narrow-spectrum insecticides serves the interests of both human and environmental safety as well as IPM, but typically does not provide management of hemipteran pests such as harlequin bug. This trend away from broad spectrum insecticides may result in a resurgence of harlequin bug as a major pest as has occurred with some other stink bug pests (McPherson and McPherson 2000).

Life Cycle and Description

Harlequin bug typically completes two to three generations per year; a fourth generation may occur in warm climates such as those in south Texas (Paddock 1915). Adults survive the winter under shelter in field litter and debris; however, all stages of the bug can be found throughout the winter months if temperatures are warm and host plants are available (Paddock 1915, White and Brannon 1933). Moreover, mild winters have been implicated in larger than average densities of harlequin bug during the season (Walker and Anderson 1933). Thus, warm winter climates may favor higher harlequin bug infestations. In the spring, large aggregations of adults can often be found on desirable host plants such as mustard and wild radish (McClain 1981).

Adult. Adults are typical pentatomid shield-shaped bugs, 0.25–0.5 inches (7–11 mm) in length, and brightly colored light orange to red with black and white markings (Fig. 1). Adults overwinter in crop debris and weeds, and become active in early spring when temperatures warm. Under laboratory conditions sex ratios are roughly equal to one and males and females live an average of 68.2 and 82 d, respectively (Streams and Pimentel 1963). Preoviposition periods have been estimated at a range of 7–30 d from eclosion (Canerday 1965, Zahn et al. 2008a) and variation of time to maturity can depend on temperature as well as host plant (Ludwig and Kok 2001). A female can lay 4–16 egg masses over her lifetime and a copulation event usually occurs between each oviposition, but is not necessary (Canerday 1965). Communication is aided by the use of vibratory signals through the host plant (Čokl et al. 2004, 2007) as well as a male-synthesized aggregation pheromone (Zahn et al. 2008b).

Egg. Egg masses are typically laid on the underside of host plant leaves in double rows of six (12 eggs total) (White and Brannon 1933). Eggs are barrel shaped and striped black and white, roughly 0.04

Fig. 1. Mating harlequin bug adults.

Fig. 3. Harlequin bug first instars on egg mass.

inches (1 mm) in length (Figs. 2 and 3). Optimal temperature for development is 84.2–89.6°F (29–32°C; Canerday 1965), and hatch occurs in 3–5 d in the summer, while springtime temperatures may necessitate 15–20 d for egg development (White and Brannon 1933).

Nymphs. Nymphs are black, orange, and white, but are smaller and do not have wings (Fig. 3 and 4). There are five instars and the duration between stadia increases with each instar, 2–5, 3–6, 7–11, 8–18, and 10–18 d, respectively, while total duration from egg to adult is 37–57 d at 75.2°F (24°C), 45% RH (Zahn et al. 2008b). First instars (Fig. 3) remain on or near the egg shell (White and Brannon 1933, Streams and Pimentel 1963) where they acquire symbiotic gut bacteria delivered from mother to offspring on the egg mass surface (Prado and Almeida 2009).

Hosts

Harlequin bug has been reported to feed on over 50 species of plants, but shows a strong preference for members of the Brassicaceae family, feeding on alternate hosts only in their absence (McPherson and McPherson 2000). Economically important cole crop species include broccoli, Brussels sprouts, cabbage, cauliflower, collard, kale, kohlrabi (*Brassica oleracea* L.), rape, rutabaga (*B. napus* L.), Chinese cabbage, turnip, broccoli raab, mizuna (*B. rapa* L.), radish (*Raphanus sativa* L.), horseradish (*Armoracia rusticana* Gaertn, May & Scherb), and arugula (*Eruca sativa* Miller). Wild hosts include: wild mustard (*Brassica* spp.), shepherds purse (*Capsella bursa-pastoris* (L.)), peppergrass (*Lepidium* spp.), bittercress (*Cardamine hirsute* L.), watercress (*Nasturtium* spp.), and other brassicaceous weeds (McPherson and McPherson 2000). Some nonbrassica weeds such as common pigweed (*Amaranthus* spp.) and lambsquarters (*Chenopodium album* L.) are also fed upon by harlequin bug (Capinera 2001).

Fig. 2. Harlequin bug eggs.

Fig. 4. Harlequin bug nymphs and leaf feeding injury on collards.

Sullivan and Brett (1974) evaluated several varieties of cole crops for resistance to pests and concluded that the mechanism of plant resistance to harlequin bug was by nonpreference and determined that mustard, turnip, kale, rutabaga, and Chinese cabbage to be preferred over cabbage, cauliflower, broccoli, collards, Brussels sprouts, radish, and kohlrabi.

Injury

Both adults and nymphs are piercing-sucking insects that feed on aboveground plant tissues, leaving white blotches (Fig. 4), which make leafy crucifer crops such as collards and kale unmarketable. Low pest densities often result in only cosmetic damage, but under heavy feeding pressure, plants can wilt and die (Ludwig and Kok 2001), and leaves can turn yellow and wilt (Fig. 5). Entire fields of cabbage or collards can be completed destroyed by high densities of harlequin bug, if left untreated (Paddock 1915).

Management Options

There are several insecticides registered for use on cole crops that are effective in controlling harlequin bug, including systemic neonicotinoids, that can be drench applied at planting or upon first observation of the pest, providing several weeks of protection. However, there are other nonchemical strategies that show potential for harlequin bug management including destruction of crop residues, trap cropping and, to a lesser extent, biological control using parasitic wasps.

Cultural Management

Because harlequin bugs overwinter in the previous crop residue, destruction or removal of the old crop can help manage the pest (Capinera 2001). Trap cropping, or the planting of one or more species of preferred plants near a protected crop to divert herbivore feeding (Hokkanen 1991) has great potential for the management of harlequin

Fig. 5. Harlequin bug leaf injury to untreated guard row (left) compared with insecticide-treated (right) collards plots in Painter, VA.

bug because the bugs use pheromones to aggregate in large numbers on preferred host plants (McClain 1981, Aldrich et al. 1996). Ludwig and Kok (1998) showed that early planted broccoli can serve as a trap to draw bugs away from the later-planted main crop. Destruction of the bugs is necessary to prevent dispersal from the trap crop. Because harlequin bug prefers certain plant species such mustard, turnip, and Chinese cabbage over crops such as cabbage, cauliflower, broccoli, collards, and radish (Sullivan and Brett 1974), there is great potential for using multiple cropping or intercropping approaches as a trap crop management strategy, particularly in the interest of reducing chemical sprays. Bender et al. (1999) found that intercropping cabbage (*B. oleracea*) and Indian mustard (*B. juncea*) reduced the need for two insecticide sprays in a heavy infestation of harlequin bug. This management approach has potential for harlequin bug control but needs further investigation, such as addressing selection of the proper plant species or variety, selection of the proper deployment of a trap crop (e.g., perimeter, intercropping, multiple trap crops, push-pull strategies, semiochemically assisted, etc.), as well as proper maintenance of that trap crop once the pest has established (Hokkanen 1991, Shelton and Badenes-Perez 2006).

Chemical Control

Over the past 30 years, broad spectrum chemicals such as pyrethroids, organophosphates, and carbamates have been widely used for effective control of harlequin bug nymphs and adults (Rogers and Howell 1972; Edelson 2004b; Edelson and Mackey 2005b, 2006b; McLeod 2005; Walgenbach and Schoof 2005). More recently, neonicotinoid insecticides including imidacloprid, thiamethoxam, acetamiprid, chlothianidin, and dinotefuran have also been shown to be effective for harlequin bug control (Edelson 2004a; Edelson and Mackey 2005a, c, 2006a; Kuhar and Doughty 2009). Surfactant type adjuvants are often recommended for cole crops to ensure good spray coverage when applying foliar insecticides. Soil applications (transplant water, soil drench, or drip chemigation) of the neonicotinoids imidacloprid, thiamethoxam, and dinotefuran have provided effective control of harlequin bug with residual efficacy lasting up to 30 d after application (Kuhar and Doughty 2009).

Chemical control options for organic producers are limited but there are several products which are registered for use in organic systems. Overall et al. (2007, 2008) reported significant control of harlequin bug nymphs on collards and turnips with spinosad, which demonstrated the highest toxicity (lowest LC_{50}) levels to harlequin bug nymphs in leaf dip bioassays over pyrethrins, and azadirachtin.

Biological Control

Harlequin bug has relatively few natural enemies. The bug produces several warning defense chemicals, some emitted from the metathoracic gland, and others expelled as a frothy liquid from the prothoracic gland when disturbed (Aldrich et al. 1996). Harlequin bug also sequesters glucosinolates from its host plants for its own defense (Aliabadi et al. 2002); hence, the black and orange aposematic coloration of this insect.

At least three species of native hymenopteran wasps parasitize the eggs of harlequin bug including *Ooencyrtus johnsoni* Howard (Encyrtidae), *Trissolcus murgantiae* Ashmead [*T. brochymenae* Ashmead] (Scelionidae), and *Telenomus podisi* Ashmead (Scelionidae) (White and Brannon 1933, Huffaker 1941, Koppel et al. 2009). Because of its success in the southern United States (Huffaker 1941), *T. murgantiae* was introduced into California as a biological control agent and later recovered from harlequin bug eggs (DeBach 1942). Surveys evaluating egg parasitism rates range from 8 to 50% of field collected eggs with higher rates of parasitism occurring in years of heavy harlequin bug infestation (Huffaker 1941, Ludwig and Kok 1998). In the 1990s, Ludwig and Kok (1998) primarily recovered *T. murgantiae* and *O. johnsoni* from harlequin bug collected in Virginia, but more recently Koppel et al. (2009) found only *T. podisi* in Virginia, with 63.5% of harlequin bug egg masses and 12.9% of the total eggs parasitized. As with a related species *Trissolcus basalis* Wollaston, *T. murgantiae* and *T. podisi* may use chemical volatiles emitted from female harlequin bugs to find the host eggs (Salerno et al. 2006, 2009).

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