Biology and Management of Slugs in Reduced-Tillage Corn

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BIOLOGY

Slugs, primarily the gray garden slug, *Deroceras reticulatum* (Muller), are sporadic pests of corn produced in reduced tillage systems in the mid-Atlantic area. These gastropods, which are related to snails but without shells, are variable in color, ranging from cream (juvenile stages) to dark gray with darker reticulate or mottled markings (adult stage). The crawling length of a mature slug is about 2 inches. These terrestrial mollusks are active on the soil surface throughout the year, except during droughts or periods of freezing temperatures. During adverse conditions, they manage to stay alive by moving down in the soil for protection. Eggs also are covered with a thick gelatinous layer, which enable them to resist extremes in temperatures and moisture.

Gray garden slugs overwinter primarily as eggs; however, during mild winters, some adult and juvenile slugs survive. Eggs hatch during late March through May, and young slugs develop into sexually mature adults by late summer. Drought conditions during the summer can cause high mortality. Adults can live 9-12 months and lay 300 eggs in clusters of 20 to 30 placed in pockets in the soil. Eggs resemble small frog eggs about 1/8" or more in diameter. Most egg laying takes place in the fall when soil moisture are more favorable; however, if moisture levels fall below 60%, egg laying is severely curtailed. There is one and sometimes a partial 2nd generation per year in Maryland; however, slug activity and generation turnover are highly variable because of extremes in weather.

Slugs can cause economic damage to germinating and seedling corn during prolonged moist, cool periods of the spring, especially in continuous cornfields. Fields most likely to have slugs are those no-tilled for a number of years and exhibiting an abundance of surface residue and decaying vegetation, which provides food, shelter and optimum micro-environmental conditions. The time of egg hatch relative to corn planting is an important determinant of economic injury. Slug damage generally has a greater impact on plant stands if early spring weather allows slugs to hatch and become partially grown prior to corn planting. Delays in planting due to wet weather can have the same effect; however, late plantings have a greater chance to outgrow or tolerate slug injury because of better growing conditions.

DAMAGE

Slugs feed on corn shortly after germination by severing the young sprout or shredding the tender leaves of seedlings, resulting in plant death or retarded growth. They

eat foliage with the aid of a tooth-covered rasp on the upper jaw, which serves to grate their food. Plant stand reductions are greatest when moist soil conditions prevent the seed slot from closing completely during the no-till planting operation. This situation provides an access route and an ideal refuge for slugs to feed directly on the germinating seed and tender hypocotyls. below the soil surface. Such feeding either destroys the endosperm or severs the growing tip of the sprout, thus preventing germination. If the seed slot is properly closed to provide good seed-to-soil contact, slug injury is confined mainly to the above ground parts of the seedlings and thus has less economic impact.

Established seedlings are able to tolerate a considerable amount of slug injury before corn growth and yield are severely affected. Studies in Maryland have shown that plants in the 3-leaf stage can generally outgrow slug damage, even at high infestation levels, provided that weather conditions are favorable for plant growth. Therefore, any practice that enhances rapid seed germination and seedling growth can act as a cultural management tactic by shortening the window of opportunity for slugs and increasing the plant's tolerance to injury.

MONITORING

Monitoring for slug activity prior to planting helps to identify fields with the greatest potential for feeding damage. However, there is no easy way to estimate population densities of slugs and their eggs. One method is to search the trash and soil surface at night with a flashlight and count the number of slugs/square foot of surface area. Slugs are most active during warm, moist and calm nights, between the hours of 11 PM and 2 AM. The gray garden slug is very sensitive to windy conditions, so windy nights should be avoided. As a general rule, average population counts of more than five slugs per square foot indicate a potential for economic injury. Visual searches at night, however, do not provide any information on egg density.

Another sampling method is to examine the soil around the brace roots and remaining crowns of old corn stalks during the day. The old stalk base is uprooted and tapped against the ground to loosen the soil, which is then examined for slugs and egg clusters. This direct method is time-consuming and reveals only about 30 to 50% of the slug stages; however, heavily infested fields can be quickly identified.

CULTURAL MANAGEMENT

Since slug problems have been brought about by changes in cultural practices, these same practices can be manipulated to make conditions unfavorable for slug development and survival. The following should be implemented in cornfields with a history of slug problems or where preplant counts have detected high levels of slug activity.

1. The most effective way to minimize losses caused by slugs is to change tillage practices. Many farmers with perennial slug problems have had to chisel plow or switch to conventional tillage to reduce the available food and shelter. Generally, switching back to tillage practices for just one growing season can drastically reduce slug numbers.

2. A change in tillage may not be feasible in fields locked into continuous corn or

corn-soybean conservation systems. In these situations, planting should be delayed until higher soil temperatures favor rapid seed germination and plant growth. Also, planting into wet seedbeds should be avoided to minimize the chances of not completely closing the seed slot.

3. Another way to alter the surface microhabitat without changing tillage practices is to use trash wheels on the corn planter. These residue management devices are designed to push corn stalks and other surface residue aside, thus forming a 10" to 12" band of relatively clean soil surface in front of the planter opener. The cleaned surface area allows the soil in the seedbed to warm up faster, encouraging rapid seed germination and seedling growth. Cleaned rows also reduce germination problems resulting from pieces of surface residue that are often jammed into the seed slot over the seed (hairpinning). The addition of a wavy coulter between the trash wheels effectively loosens the soil ahead of the planter opener for ideal seed placement and also improves the ability of the press wheels to completely close the seed slot. Maryland studies have shown that the use of trash wheels at planting can help to reduce the injury caused by slugs. In three experiments, slug activity and damage were reduced by 20%-30% in plots planted with trash wheels (Figure 1A-B). Trash wheels also increased the stand density by as much as 2,000 plants per acre but yield was significantly higher in only one of the experiments (Figure 1C-D).

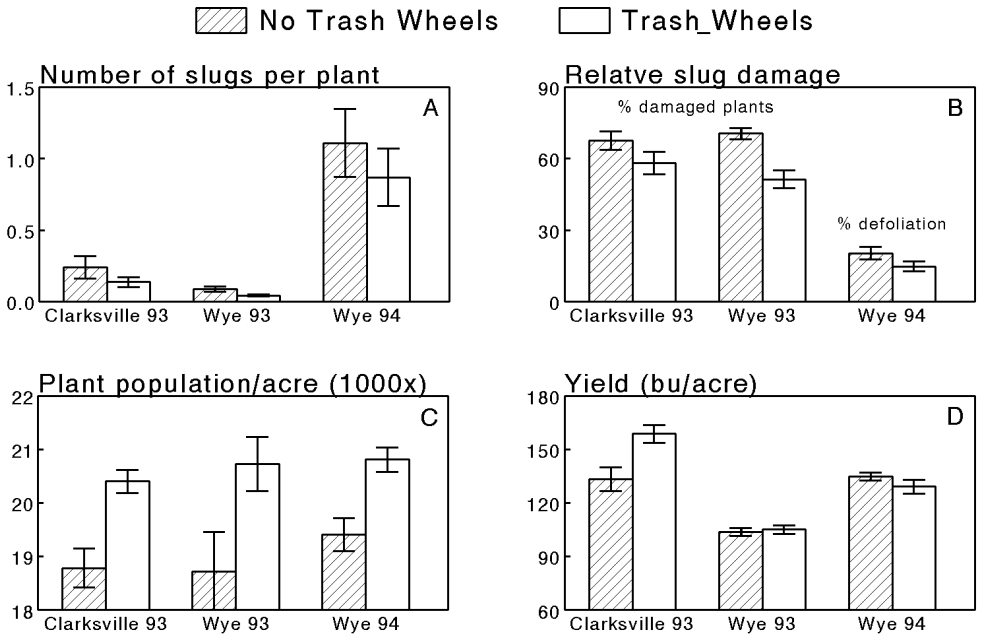


Figure 1. Effects of surface residue management with trash wheels on slug activity, feeding injury, plant stand, and grain yield in no-till corn. Means and standard error bars are given for three seperate exprements. 1993 and 1994.

4. Another cultural practice that promotes rapid growth of corn seedlings is the use of starter fertilizer at planting. A common practice in corn production is to apply a portion of the total nitrogen requirement at planting, either as a drilled application along side or a banded

application over the seed slot. Studies have shown that the extra boost in growth resulting from the immediate availability of nitrogen helps corn seedlings tolerate and outgrow slug injury. In three experiments, the combination of trash wheels and starter fertilizer had the greatest reduction in the amount of slug injury to young corn plants (Figure 2).

Figure 2. Effects of surface residue management and starter fertilizer on the feeding damage caused by slugs. Means and standard error bars are given for three experiments. 1993 and 1994.

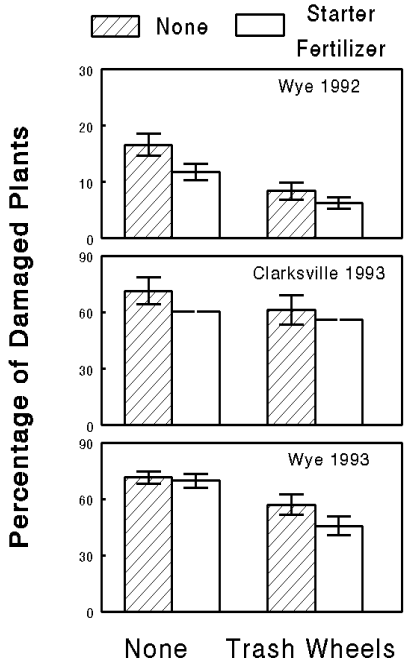
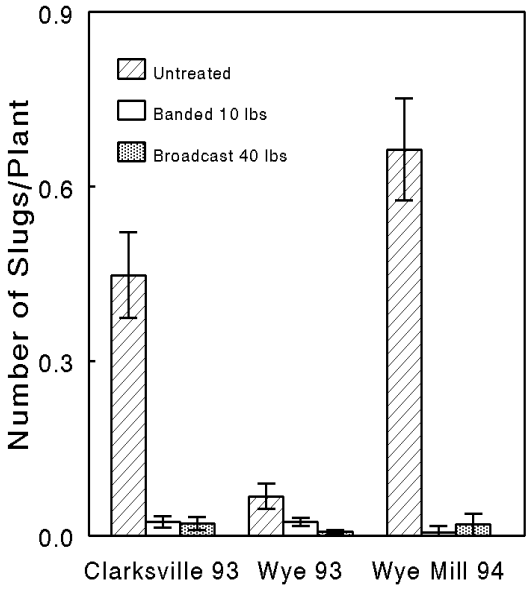


Figure 3. Effects of Deadline Bullet bait applied at planting on slug activity. Means and standard error bars are given for three experiments. 1993 and 1994.



CHEMICAL MANAGEMENT

Despite the increasing importance of slugs as pests of corn, there has been little progress in the development of effective chemical controls in the U.S. Various formulations of metaldehyde bait have been improved for use on corn and other field crops. This chemical is effective both as a nerve poison if ingested at high concentrations and as a dermal irritant which causes slugs to secrete large amounts of mucus, resulting in desiccation. The efficacy of metaldehyde baits is highly dependent on temperature and humidity. Effective control is more likely if the bait is applied following a rain or irrigation which increases slug activity; however, heavy rains following application can lead to control failures because of reduced residual action and increased slug recovery from the water loss effects. Generally, metaldehyde-based baits are expensive, inconvenient to apply, and inconsistent when used to control slugs in field crops.

Deadline M-Ps (4% metaldehyde) at 10 to 40 lbs per acre and TrailsEnd LG (3.5%

metaldehyde) at rates up to 20 lbs are labeled for slug control on field corn. Deadline is a soil surface treatment that is either broadcasted or banded and should be applied in the early evening. Both rates of 10 and 40 lbs/acre applied at planting provided greater than 90% control of slugs and reduced feeding intensity by 80% (Figure 3). Because of the high price, the application of 10 lbs. of bait banded over-the-row is the most cost-effective. TrailsEnd should be band over the row at planting or slightly later. Field testing of TrailEnd in 2002 resulted in about 60--70% control with a rate of 9-10 lbs per acre banded, comparable to control by DeadlineM-Ps.

In heavily infested fields, rescue treatments of urea-based nitrogen have been applied at night as a direct contact irritant to slugs. The control efficacy of this approach can be erratic because of night-to-night fluctuations in slug activity, which are due primarily to windy conditions. However, studies have demonstrated that broadcast treatments of 30% urea-based nitrogen, applied at night when slugs are actively feeding on plants, can cause significant slug mortality. In one experiment, infestation levels ranged up to 3 slugs/plant in the untreated plots. After 24 hours post-treatment, spray volumes of 20 gallons/acre consisting of 5, 10, and 20 gallons of the nitrogen formulation reduced slug densities by 48%, 74%, and 81%, respectively (Figure 4). The 10-gallon rate mixed 1:1 with water may be the best choice because of the reduced cost and less risk from direct injury to the corn foliage. Although the cost of a nitrogen spray may be partly offset by the added fertility, it is doubtful whether much of this nitrogen becomes available for plant growth.

Figure 4. Effect of 30% urea-based nitrogen applied as a broadcast spray at night on slug activity. Means ± one standard error. Number over bar indicates % control. 1994.