Direct and Indirect Effects of Conservation Tillage on the Management of Insect Pests of Cotton

Michael J. Gaylor[1]

Introduction

Conservation tillage systems take many different forms. Systems proposed for cotton *(Gossypium hirsutum L.)* have ranged from winter-fallow with various types of reduced spring-tillage (including no spring-tillage) to double-crop systems using small grains, vetch *(Viciusaiiva L.)* or reseeding crimson clover *(Trifolium incarnutum L.)* as the winter-cover. Cover crops have been managed in a variety of ways, including I) planting directly into the growingcover crop, 2) using chemicals to hasten maturity or to kill the cover crop. and 3) waiting for the cover crop to mature before planting cotton. Although adoption of any of these systems is patentially beneficial, any of the systems also may cause unexpected consequences for management of pests of the crop. These consequences may be caused by direct or indirect effects of the system on insect populations in individual fields, or they may be caused by indirect effects acting on insect populations over the entire agroecosystem.

Results and Discussion

Direct Intrafield Effects

Since most insect pests of cotton attack the above-ground portion of plants, direct effects of soil tillage practices usually have been minor and relatively easy to determine. Normal tillage operations cause significant mortality to *Heliothis* spp. pupae (Fife and Graham, 1966; Hopkins et al., 1972; Roach, 1981a). Mortality was attributed to mechanical damage to larvae and to destruction of burrows. Reduced tillage would reduce mortality to pupae present in the soil when tillage occurred.

Tillage operations modify soil texture, temperature, and moisture, and may affect the behavior and survival of *Helioihis* entering the soil after tillage occurs. Prior to pupating, *Helioihis* prepupae moved further on smooth, compacted soil than on rough, soft soil (Roach and Hopkins, 1979). Fewer adults emerged from the compacted soil (Roach and Campbell, 1983).

Ultimately, in most years increased or decreased *Helioihis* survival within an individual field may be inconsequential because of the mobility of adult *Helioihis* spp. (Raulston et al., 1982). In some agroecosystems economically damaging *Helioihis zea* populations in cotton migrate to cotton from mature field corn *(Zea mays L.)* rather than increasing within the cotton field Landis et al., 1987). In other ecosystems, *Heliothis virescens* populations are thought to build within cotton fields in the same local area.

In South Carolina, in one year of a three-year study. *Helioihis* populations and damage were significantly lower in conservation tillage plots with no winter cover than in conventional tillage plots (Roach, 1981b), but no reasons for this difference were determined. There were no differences in *Heliothis* numbers or damage the other two years. In Alabama, *Heliothis* populations and damage to cotton did not differ among four cover crop treatments (conservation tillage) and a conventional tillage control except on one date in the two-year study. In late-July, 1981 cotton following clover received less damage to squares (4.2%) than cotton in the other plots (20.2%), but this difference was attributed to the stressed condition of cotton following clover causing this cotton to be less attractive to ovipositing moths (Gaylor et al., 1984). Thus, tillage systems have not been found to markedly impact *Heliothis* populations or damage within the same field.

One group of insects that is a potentially greater pest in conservation tillage cotton is the cutworms. In other crops (e. g., corn) cutworms are typically more damaging in conservation tillage fields (Harrison et al., 1980). These insects occur in damaging numbers only sporatically in cotton, hut seem to infest cotton fields with a heavy mulch in greater numbers than cotton with a clean soil surface. Significantly greater numbers of varigated cutworms Peridroma saucia (Hubner) were found in cotton with a heavy clover mulch than in cotton following hairy vetch *(Vicia villosa* Roth). No cutworms were found in cotton produced conventionally or in conservation tillage systems with no winter cover or a rye *(Secale cereale L.)* mulch (Gaylor et al., 1984). In contrast, Roach (198Ib) found no significant difference in black cutworm *Agrotis ipsilon* (Hufnagel) populations or damage in conventional and conservation tillage plots, but their conservation tillage plots had no winter cover.

Indirect Intrafield Effects

One way a tillage system might indirectly impact pest populations is through effects on predators or parasitoids. Predator populations in the herbaceous strata of cotton were not affected by tillage systems (Gaylor and Foster, 1987; Roach, 1981b). However, reduced tillage led to increased numbers of ground-dwelling predators, which decreased survival of *Heliothis* prepupae and pupae in cotton (Gaylor and Foster, 1987). Landis et al. (1987) found that *Helioihis zea* pupal survival in corn was not affected by previous tillage, but they suggested that their cages may have restricted movement of predators and parasites, and may have reduced *Helioihis* survival. A more important indirect effect occurs if reduced tillage systems delay planting or maturity of the crop. Conservation tillage systems which leave a mulch on the soil surface resulted in cooler soil temperatures than in hare soil (Grisso et al., 1984). Cool soil temperatures result in poor seedling growth and a greater incidence of seedling disease (Rickerl et al., 1988). Waiting until mulched soils have warmed to ideal temperatures results in delayed planting, and consequently, in delayed maturity. Even greater delays in maturity occur if cotton planting is delayed to allow the cover crop to mature. These delays

[1]Department of Entomology Alabama Agricultural Experiment Station, Auburn University, Alabama, 36849.

occur in conservation tillage systems designed to take advantage of the ability of a winter cover to reseed itself (e.g., crimson clover or vetch) (Touchton et al., 1984) or to harvest the winter cover in a double-crop system. In double-crop systems, cotton planting may be delayed for over 1.5 months (Baker, 1987). This much delay in maturity is contrary to the aims of most insect management systems (Adkisson et al., 1982) and has the potential of causing substantial late-season damage by boll weevil *(Anthonomus grandis Bohman)* and *Heliothis* spp. Other problems associated with a late-harvest are also economically damaging (Parvin and Smith, 1986).

In one study, however, boll weevil damage was substantially lower in cotton double-cropped with wheat *(Triticum aestivum* L.) than in cotton planted conventionally. The fields planted first (conventionally), in the mosaic of conventional and double-crop fields present in the area, acted as effective trap-crops for boll weevils (Gaylor and Foster, 1987). *Heliothis* spp. populations and damage were not significantly different between the early- and late-planted cotton. However, *Heliothis* populations were very low during both years of this study. The late-planted cotton produced fruit later than the conventional cotton, and thus, was vulnerable to insect attack later than conventionally-planted cotton. Also, the later planting made the double-crop cotton more susceptible to the drought that severely reduced yields in 1984. Irrigation and the development of varieties of cotton and cover crops that mature more rapidly may make double-cropping more feasible in the future (Baker, 1987; Roach and Culp, 1984), but effects of these modifications of double-crop systems on pest damage have not been determined.

Indirect Ecosystem Effects

Agroecosystem-wide effects of conservation tillage systems on pest populations and damage to cotton are difficult to determine, but these effects may be extremely important. In many ecosystems intensively managed for agriculture, because of high winter mortality and because spring hosts occupy a small portion of the total acreage, *Heliothis* spp. often do not cause economic damage to cotton until the third generation is produced in July. There have been no studies to determine effects on *Heliothis* populations in cotton of substantially increasing early spring host populations. This increase would occur if substantial acreage of cotton was produced in a conservation tillage system utilizing clover or vetch as winter cover crops. However, studies on the effects of reducing these host populations may allow inferences to be drawn about ecosystem-wide effects of utilizing conservation tillage systems that include cover crops that are good *Heliothis* hosts.

Crimson clover and hairy vetch are legumes which potentially could provide much of the nitrogen required for cotton production, and if allowed to mature, would not have to be replanted annually (Touchton et al., 1984). However, these hosts were among those supporting the largest populations of *Heliothis* in early spring (Stadelbacher et al., 1984; Harris and Phillips, 1986). Mueller and Phillips (1983) found over 100,000 *Heliothis* per acre during the spring on crimson clover. Fortunately, under present production systems, only a small portion of the total rural land acreage presently supports early spring hosts of *Heliothis.* In the Delta of Mississippi, only ca. 3.5% of the rural acreage supports weed hosts of first generation *Heliothis* spp. (Stadelbacher, 1982). A reduction of only 50% in the *Heliothis* larval population (by mowing weeds), in an area with only 3.5% of the acreage supporting *Heliothis* hosts, reduced the damage to cotton to below that in an unmowed control area (Harris and Phillips, 1986). If only one third of the ca. 1 million acres of cotton in the Mississippi Delta were produced with a winter cover of clover, the acreage of early-spring hosts would double. Assuming no increased mortality due to density dependent mortality factors, the *Heliothis* spp. produced probably would cause economic damage to cotton much earlier in the season than at present. Thus, insecticide applications would begin earlier in the season.

Summary

Effects of modified tillage systems on insect populations and damage to cotton are still unpredictable and may be site specific. For example, in an area where damaging *Heliothis* spp. populations immigrate to cotton from alternative crops, conservation-tillage may have little impact on damage. In an area where *Heliothis* populations build within cotton fields, reduced pupal mortality from reduced tillage may be important. Because of the mobility of insects, effects of modified tillage systems may extend far beyond field boundaries. These effects will be difficult to determine experimentally, but may profoundly influence the profitability of the agricultural enterprise. Thus. it is essential that agricultural scientists take a holistic approach to production research.

References Cited

Adkisson, P. L., G. A. Niles, J. K Walker, L. S. Bird, and H. B. Scott. 1982. Controlling cotton's insect pests: a new system. Science 216 (April): 19-22.

Baker, S. H. 1987. Effects of tillage practices on cotton double cropped with wheat. Agron. J. 79: 513-516.

Fife, L. C. and H. M. Graham. 1966. Cultural control of overwintering bollworm and tobacco hudworm. J. Econ Entomol. 59: 1123-1125.

Gaylor, M. J.. S. J. Fleischer, D. P. Muelheisen, and J. V. Edelson. 1984. Insect populations in cotton produced under conservation tillage. J. Soil and Water Conserv. 39: 61-64.

Gaylor, M. J., and M. A. Foster. 1987. Cotton pest management in the southeastern United States as influenced by conservation tillage practices. *In.* House, G. J. and B. R. Stinner. (eds.) Arthropods in conservation tillage systems. Entomol. Soc. Amer. Misc. Pub. 65: 29-43.

Grisso, R., C. Johnson, and W. Dumas. 1984. Cotton production in cover crops - a progress report, pp. 135-137. *In* Proceedings, Beltwide Cotton Production Conference.

Harris, V. E. and J. R Phillips. 1986. Mowing spring host plants as a population management technique for *Heliothis* spp. J. Agric. Entomol. 3: 125-134.

Harrison, F. P., R. A. Bean, and 0.J. Qawiyy. 1980. No-till culture of sweet corn in Maryland with reference to insect pests. J. Econl Entomol. 73: 363-365.

Hopkins, A. R, H. M. Taft, and W. James. 1972. Comparison of mechanical cultivation and herbicides on emergence of bollworms and tobacco budworms. J. Econ. Entomol. 65: 870-872.

Landis, D. A.. J. R. Bradley. Jr.. and F. Gould. 1987. Behavior and survival of *Heliothis zea* (Lepidoptera: Noctuidae) prepupae in no-tillage and conventional-tillage corn. Environ. Entomol. 16: 94-99.

Mueller, T. F. and J. R. Phillips. 1983. Population dynamics of Heliothis spp. in spring weed hosts in southeastern Arkansas: survivorship and stage-specific parasitism. Environ. Entomol. 12:1846-1850.

Parvin. D. W. and J. W. Smith. 1986. The economics of cotton harvesting in the midsouth with emphasis on early season insect control. pp. 22-28, *In* Prnceedings, Beltwide Cotton Cotton Production Research Conference.

Raulston, J. R.. W. W. Wolf. P. D. Lingren. and A. N. Sparks. 1982. Migration as a factor in *Heliothis* management. Proc. Internat. Workshop on *Heliothis* Management, 1981. International Crops Res. Inst. for Semi-arid Tropics. Patancheru. A. P. India. pp. 61-73.

Rickerl. D. H.. W. B. Gordon, E. A. Curl, and J. T. Touchton. 1988. Winter legume and tillage effects on cotton growth and soil ecology. Soil Tillage Res. 11:63-71

Roach. S. H. 1981a. Emergence of overwintered *Heliothis spp. moths from* three different tillage systems. Environ. Entomol.10: 817-818.

Roach. S. H. 1981b. Reduced- vs. conventional tillage practices in cotton and tobacco: a comparison of insect populations and yields in northeastern South Carolina. 1977-1979. J. Econ. Entomol. 74: 688-695.

Roach. S. H. and R. B. Campbell. 1981. Effects of soil compaction on bollworm moth emergence. Envirnn. Entomol. 12: 1882-1885.

Roach. S. H.and T. W.Culp. 1984. Anevaluation ofthree early maturing cotton cultivars for production potential and insect damage in reduced- and conventional-tillage systems. J. Agric. Entomol. I:250-255

Roach, S.H.and A.R. Hopkins. 1979. Heliothis spp. behavior of prepupae and emergence of adults from different soils at different moisture levels. Envirnn. Entomol. 8: 388-391.

Stadelbacher. E. A. 1982. An overview and simulation of tactics for management of Heliothis spp. on early-season wild host plants. Proc. Beltwide Cotton Res. Conf. 209-212.

Svadelbdcher, E. A,. J. E. Powell. and E. G. King. 1984. Parasitism of *Heliothis zea* and *H. virescens* (Lepidoptera: Noctuidae) larvae in wild and cultivated host plants in the Delta of Mississippi. Environ. Entomol. 13: II-67.1172.

Touchton. J. T.. D. H. Rickerl, R. H. Walker. and C. E. Snipes. 1984. Winter legumes as a nitrogen source for no-tillage cottnn. Soil Tillage Res. 4: 391-401