PEST MANAGEMENT DECISIONS IN NO-TILLAGE AGRICULTURE

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No-tillage (NT) systems involving corn are becoming increasingly popular in the South because of the advantages apparent with these operations. NT is especially useful in various types of multi-crop systems that take advantage of the Southern resource of a long growing season. Non-continuous types of NT in which some form of tillage is utilized in a multi-crop sequence are most prevalent. Since corn often is planted later than normal in these systems, it may be subjected to greater infestations by pests. Continuous NT procedures are not as common in the South and usually are associated with sloping terrain with high erosion potential. It is important to distinguish between the two types of NT in a discussion of pest potential because the ecosystems undoubtedly differ greatly. Thus, unless otherwise specified the present discussion is concerned with non-continuous types of NT.

The insect complex attacking corn in the South causes millions of dollars in damage annually. For example, during 1976 in Georgia insect losses and cost of control in conventionally tilled (T) corn exceeded $14 million, while losses associated with virus diseases transmitted by insects was ca. $0.2 million (Suber and Todd 1980). Economic impact of pests in NT are not available, but research indicates that most problems are comparable to T systems (All and Gallaher, 1976).

Much of the present discussion is based on research conducted over the past 6 years in over 50 experiments in Georgia in which various NT systems were compared directly with T cropping. The experiments were located in 6 areas representing the major edaphic and climatic areas of Georgia. In the tests all cropping practices (e.g. irrigation, planting date, subsoiling, insecticide, hybrids, herbicides, cropping sequence) were the same in either tillage system and the only difference was the tillage operation in T plots. Insect populations were quantified using standard sampling procedures. Also observations of pest problems were made in farmers' fields and a survey was conducted of extension personnel, commercial pest managers, pesticide and agricultural equipment distributors, and seed company representatives to assess their views on pest potential in Southern NT systems.

Soil Insects - Ecosystems are undoubtedly greatly different in NT and T systems, and the variation is probably highest near the soil surface due to the presence of debris from former crops in NT. These conditions can have variable effects on soil insects.

The lesser cornstalk borer (**LCB**), Elasmopalpus lignosellus (Zeller), is a polyphagous insect whose outbreaks in T corn are usually associated with droughty soil conditions (Dupree **1965**). **LCB** infestations are substantially

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reduced in NT systems as compared to T systems (All and Gallaher 1977). This has been observed in over 30 experiments over a 6 year period and has been observed in growers' fields. All and Gallaher 1977 pointed out that higher soil moisture occurred in NT than T systems and proposed this as a factor inhibiting survival of LCB in NT. Later research indicated that a behavioral response of LCB is involved. Movement of radiolabeled larvae in relation to corn seedlings was distinctly different in NT than in T. Larvae released 20 cm from corn seedlings quickly located the plants in the T system; seedlings in WT systems were not located for up to 7 days after release (Cheshire et al. 1977, Cheshire and All 1978).

The billbug, Spenophorus callosus Oliver, feeds on various weeds, especially nutgrass, Cyperus rotundus L., in the larval stage and attacks corn only as adults. Overwintering adults migrate into corn fields from weeded areas and may cause extensive damage, especially in fields planted early in the season (Morgan and Beckham 1960). S. callosus produces damaging infestations in NT corn, and research indicates that problems can be greater than in T systems. In a recent experiment near Midville, Ga., S. callosus damage was 32.1 infested plants/100 m row in NT as compared to 19.0 infested plants in the T plots. The field had a moderate infestation of nutgrass that was poorly controlled with planting time applications of herbicides and the higher billbug populations were associated with the weed. Insecticide applications at planting time (Durant 1975, All and Jellum 1977) and after plants emerge (All and Jellum 1977) control S. callosus infestations in T systems; these methods also are effective in NT systems (J. All unpublished data).

Other soil insects such as the Southern corn rootworm Diabrotica undecimpunctata howardi Barber, seedcorn maggot Hylemya platura (Meigen), wireworms Melanotus spp., white fringed beetle Graphognathus spp., cutworms Agrotis spp. larvae have not developed quantifiable populations in experimental plots to assess their biopotential in NT systems. Also no reports of major infestations of these insects were expressed by the persons surveyed. However, damage to corn by these insects must be of concern to entomologists, especially in continuous NT systems where soil habitats are not periodically disturbed by tillage operations.

Whorl Feeding Insects - Important insects that infest the seedling stage of corn (not discussed as soil insects) in the South include the fall armyworm Spodoptera frugiperda (J. E. Smith, armyworm Pseudaletia unipuncta (Haworth), corn earworm Heliothis zea (Boddie), European corn borer Ostrinia nubialis (Hubner), and the Southwestern corn borer Diatraea grandiosella Dyar). Observations of all these insects in Georgia indicate that greatest damage can be anticipated in late corn plantings such as certain multi-crop systems involving NT (All and Gallaher 1976).

Infestations of fall armyworms are a major threat to corn in NT multi-crop systems and are a factor that may limit the potential of certain of these systems in the South. Research indicates that tillage systems have little impact on development of fall armyworm infestations (All and Gallaher 1976). Close inspection of corn in experiments comparing NT and T systems at various planting dates demonstrated that heavy infestations often occur in both cropping systems planted after mid-May. Oviposition and larval populations on 2-4 leaf stage seedlings developed more rapidly in T plots,, but populations and damage were similar in 5-leaf stage plants. Yield losses were comparable in either system. Efficacy of foliar insecticides was similar in either tillage system (J. All unpublished data).

Severe armyworm damage has been reported in late planted NT systems (Wrenn 1975) and damage from the other whorl feeders should be of concern in certain cases. However, our research indicates that the damage potential of these insects is not enhanced in NT as compared to T.

Stalk and Ear Feeding Insects - Many insects that attack these growth stages in the South are also major pests in Northern states. However, their reproductive potential often is enhanced in the warmer Southern climate. For example, first generation European corn borer damage early planted corn while second and third generation larvae infest corn of later planting dates. Our research indicates that European corn borer infestations are similar in NT and T systems. However, infestations were increased in late plantings and these often are associated with NT practices in multi-cropping sequences. We also noted a reduction in the number of infested and lodged plants in irrigated plantings (both NT and T) as compared to nonirrigated plants (All and Gallaher 1976). Low infestations of Southwestern cornstalk borers were observed in Northwest Georgia during 1976-1979. Whorl feeding and stalk borer damage were similar in either tillage system (J. All unpublished data).

We have observed corn leaf aphid, Rhopalosiphum maidis (Fitch), infestation of corn tassels in NT and T plots. In two experiments, extensive sampling in fields with moderate johnsongrass populations (significantly higher in NT than T) revealed that aphid colonization of corn tassels was higher in T (4.0 x 10 colonies/ha) than NT (2.7 X 10 colonies/ha) plots. However, many johnsongrass plants had colonies and if these are coupled with the aphid populations on corn, the overall number of colonies in NT was 3.5 x 10 colonies/ha as compared to 4.5 X 10 /ha in T. Thus in this case, the increased plant diversity of NT had a dilution effect on an insect population infesting corn. In certain experiments substantially higher populations of a spittle bug, Prosapia sp., have been observed in NT as compared to T plots. However, the numphai feeding on brace roots caused no apparent damage to plants.

Corn earworm and fall armyworm infestations in corn ears in NT parallels damage in T systems. Populations of both species were greater in plantings associated with multi-cropping and delayed corn planting dates. Damage by fall armyworm is especially severe in late planted corn with as many as 6 larvae causing complete destruction of some ears. Sampling indicated that damage was reduced in irrigated as compared to non-irrigated plots in both NT and T (All and Gallaher 1976).

Other insects associated with corn ears prior to harvest include sap beetles (Nitidulidae), maize weevil complex (Sitophilus spp.), Tenebrionidae, and Angoumois grain moth (Sitotroga cerealella Oliver)), and these are serious problems in the South. Infestations initiated in the field by these species increase in stored grain (Floyd 1971). Also, these pests may be implicated in distributing grain-infesting fungi such as Aspergillus flavus that produce mycotoxins in stored grain. Field infestations of certain of the stored grain insects may be increased in certain NT systems where corn is grown in the stubble of small grains. These insects are found in unharvested grain and data suggests that populations move into corn prior to harvest (J. All unpublished data).

Heavy populations of the ring-legged earwig, Euborellia anntrlipes (Lucas), were observed in NT corn ears; significantly more infested ears were sampled in NT plots (All and Gallaher 1976). These insects are not normally considered pests of corn, but they can produce damage to grain. Feeding near the tip of ears on the basal portion of the pericarp of kernels loosens the grain so that it is easily detached. All life stages were observed and as many as 10 individuals were counted in ears.

Epidemiology of Corn Virus Diseases - Research indicates that two virus diseases, maize chlorotic dwarf (MCD) and maize dwarf mosaic (MDM), are greater in certain NT systems (All et al. 1977, 1980). Leafhoppers transmit MCD in corn; the blackfaced leafhopper, Graminella nigrifrons (Forbes), is a major vector (Nault et al. 1973). Several aphid species transmit MDM, including the corn leaf aphid (Williams and Alexander 1965).

The epidemiology of the diseases is complicated by the fact that both viruses infect a variety of grasses including weeds (e.g. large crabgrass, Digitaria sanguinalis (L). Scop., and johnsongrass, Sorghum halepense (L.) Pers.) and small grains (e.g. winter wheat, Triticum aestivum L.) (Nault et al. 1976). Johnsongrass is the only known perennial host of the pathogens and in many areas it is an important factor in the spread of disease by acting as a reservoir of inoculum for vector transmission to corn (Damsteegt 1976).

We found that MCD and MDM were enhanced in NT as compared to T when johnsongrass was poorly controlled by the herbicides paraquat and atrazine (All et al. 1976). Data from these and other studies suggests that early season control of johnsongrass is very important in reducing disease in corn. Severity of the diseases is greater to young plants (Scheifele 1969), and thus the presence of even low populations of johnsongrass in fields when corn germinates greatly increases early season transmission by vectors. Recent tests showed that the herbicide glyphosate effectively controls johnsongrass in CT with corresponding reduction in disease (J. All unpublished data).

Optimum pest management of MCD and MDM involves integration of several control strategies to suppress the various factors involved in spread of the diseases (All et al. 1980). Vectors of MCD are susceptible to systemic insecticides (e.g. carbofuran) and hybrids are available that have disease resistance (Kuhn and Jellum 1975, Pitre 1968, Kuhn et al. 1975, All et al. 1976). Use of a resistant hybrid with a systemic insecticide was effective in controlling leafhoppers and decreasing MCD in NT. Grain yield was increased by up to 2333 kg/ha (All et al. 1977). Recent research in NT systems showed that an integrated chemical control approach using a systemic herbicide (glyphosate) to control johnsongrass plus a systemic insecticide (carbofuran) was highly effective (J. All unpublished data).

In summary, insect potential in NT systems in the South varies with the species involved and the type NT method. In general, non-continuous NT systems that have some form of tillage operation within a 1 or 2 year cropping sequence do not appear to develop greater insect infestations than T systems planted at the same time. However, certain insects such as billbugs produce greater damage in NT and concern must be shown for corn virus disease problems in NT systems where johnsongrass populations exist. Conversely, NT has control potential for lesser cornstalk borer. Obviously the environment that develops in NT systems differs greatly from T cropping, and the influence of these ecosystems on the biology of pest insects must be studied on an individual basis. Research indicates that standard control methods can be used in NT systems, but increased effort is needed in refining chemical application methodology for NT. Also, efforts in developing integrated pest management systems need to be expanded for NT.

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