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# EC95-1560 Use of Cultural Practices in Crop Insect Pest Management

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# Use of Cultural Practices in Crop Insect Pest Management

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**This Extension Circular reviews what is known about the effects of rotations, tillage practices, and planting and harvest dates on crop insect management, focusing on major crops in Nebraska.**

Before the development of synthetic organic insecticides (pre-DDT era), rotations, tillage practices, planting and harvest dates, and other nonchemical cultural controls were commonly recommended for insect management. Research focused on crop rotation and other cultural practices for insect management. With the development of DDT and later insecticides however, research on nonchemical controls decreased markedly.

With the emergence of the concept of sustainable agriculture in the 1980s, there has been increased emphasis on the use of crop rotations, reduced tillage and other cultural practices to promote cropping diversity, provide on-farm sources of soil fertility and animal feed, reduce soil erosion, and reduce pest problems. A greater understanding of how these cultural practices affect insect pest management is needed before they will be widely used.

## Biological basis of rotational effects

Some rotational systems were developed by early agriculturalists through trial and error, without any understanding of the underlying mechanisms responsible for their success. In the last 100 years research has identified the basis for the effects of crop rotation in insect control. Two important factors influencing the impact of a particular rotation on an insect are the host range of the insect and its degree of mobility. Insect species vary in the range of food plants or ovipositional hosts that they will accept. Host selectivity may occur in either the egg-laying behavior of the adult or the feeding behavior of the larva. Some species have very specific requirements and will die or move away in the absence of their required hosts. Other insect species have a broad range of host plant species on which they will feed or lay eggs. Mobility of an insect species is important because it influences how far an insect can travel to search out an acceptable host plant when it is presented with a less preferred plant species due to crop rotation. Depending on the species and stage (adult or immature), the degree of mobility varies from a few inches to several miles. The European corn borer is a good example of a Midwestern insect pest that is not affected by rotating corn with a nonhost because of the flight capacity of the adult moth.

| Table I. Effect of crop rotation of corn on insect populations or potential damage. | | | |
|---|---|---|---|
| | *Corn Rotation* | | |
| *Pest* | *None* | *Soybeans* | *Pasture & Hay Crops* |
| Seed corn beetles | 0 | 0 | +[a] |
| Seed corn maggot | 0 | 0 | + |
| True armyworm | 0 | 0 | + |
| Chinch bug | 0 | 0 | + |
| White grubs | – | + | + |
| Wireworms | – | – | + |
| Corn root aphid | – | – | + |
| Billbug | – | – | + |
| Grape colaspis | – | – | + |
| Northern corn rootworm | + | – | – |
| Western corn rootworm | + | – | – |
| Black cutworm | 0 | + | 0 |
| Slugs | – | – | 0 |
| Thrips | 0 | ? | + |
| Spider mites | 0 | 0 | 0 |
| European corn borer | 0 | 0 | 0 |
| Southwestern corn borer | 0 | 0 | 0 |
| Southern corn rootworm | 0 | 0 | 0 |
| Corn earworm | 0 | 0 | 0 |
| Fall armyworm | 0 | 0 | 0 |
| Corn leaf aphid | 0 | 0 | 0 |

[a] + means the practice will increase the population or damage from that insect; – means it will reduce the population or damage; 0 means no effect; ? means effect unknown
Source: Luckmann and Metcalf (1975)

Many of our best examples of pests controlled by crop rotation involve insects, such as white grubs, wireworms and corn rootworms, whose major feeding stage occurs in the soil. The mobility of these larvae is measured in inches or at most a few feet over their life span. Host selectivity may occur through either the egg laying behavior of the adult or the feeding behavior of the larva. Pest management recommendations may focus on either selecting rotations that decrease certain pest populations or avoiding rotations known to favor certain pests.

Crop rotation, other cultural practices, and plant resistance are generally assumed to be compatible with biological controls and to form the basis for nonchemical pest control in Integrated Pest Management systems for many crops. However, there are some cases of incompatibility between plant resistance and biological control, and between some cultural controls (e.g., those involving cultivation) and biological controls. Many studies have documented the beneficial effects of strip-cropping or interplanting, but normally these practices are not considered as crop rotations, and will not be covered.

In some situations, crop rotation may favor biological control indirectly by reducing insecticide use. Certain rotations can control some crop insect pest species (*Table I*) and increased use of crop rotation would be expected to decrease the use of certain broad spectrum soil insecticides (e.g., those used for corn soil insect control). Most of these insecticides are nonselective and toxic to numerous predatory insects and mites in the soil.

Crop rotations also may indirectly affect pests by modifying the crop environment. Some insects are favored by increased surface residue or decaying organic matter. New rotations that change the amount of crop residue may favor certain pests. For example, black cutworms, although not directly influenced by crop rotation since they do not overwinter in the Midwest, are influenced by the degree of crop residue, because the moths prefer to lay their eggs in fields with crop residue or existing vegetation in April. In this example, tillage systems can affect insect populations if they increase or decrease crop residue in the spring or early season weed growth. Similarly, some early season crop pests, such as seedcorn maggots, are encouraged by newly tilled soil and the presence of decaying organic matter, which attracts the adult females to lay eggs. The use of cover crops and green manures should be carefully evaluated in light of the possibility of increasing damage from insect pests in some situations.

## Pests controlled by rotations

The western and northern corn rootworms are responsible for most insecticide use in Nebraska crops. The western corn rootworm is the predominant species throughout Nebraska, accounting for 80-95 percent of corn rootworms found in corn. According to the most recent pesticide use survey in Nebraska, in 1987 4.6 million pounds of insecticide active ingredient was applied to corn (96 percent of total insecticide used). Of all the corn insecticide used, most is applied against corn rootworms.

However, it has long been known that corn rootworms can be easily controlled by crop rotation. Corn rootworms have an annual life cycle and a host range restricted to grass species. Eggs are laid in the soil of a corn field during July and August, then overwinter and hatch the next spring. If corn is rotated the next year with a corn rootworm nonhost, hatching larvae will starve and die. Rotation with a broadleaf crop such as soybeans greatly reduces the need for pesticide use. Based on Illinois estimates, the chance of economic damage from corn rootworms changes from 2/3 for continuous corn to 1/1000 for corn after soybeans (*Table II*). Even some grass crops (for example, wheat and sorghum) can be used in a rotation with corn to control corn rootworms. Sorghum roots are toxic to corn rootworm larvae because of the presence of a compound which is converted to hydrocyanic acid when root tissue is injured.

**Table II. Probability estimates of economic soil insect damage in corn and suggestions for management according to cropping sequence, Illinois.**

| | ***Insect pest*** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Crop before corn* | *Wireworm* | *Cutworm* | *Corn rootworm* | *White grub* | *Seedcorn maggot* | *Billbug* | *Grape colapsis* | *Need for a soil insecticide* | *Pest management practice* |
| Soybeans | 1:100 | 1:25 | 1:1,000 | 1:500 | 1:150 | 1:1,000 | 1:1,000 | very low | Use planter box seed treatment; scout for cutworms; bait for wireworms. |
| Corn | 1:200 | 1:100 | 2:3 | 1:1,000 | 1:50 | 1:1,000 | 1:5,000 | moderate-high | Scout for rootworm beetles; treat corn if population exceeds 0.75 beetle per plant during August. |
| Small grains | 1:100 | 1:50 | 1:100 | 1:250 | 1:50 | 1:200 | 1:5,000 | low | Bait for wireworms before planting; scout for |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | cutworms at plant emergence. |
| Legume | 1:25 | 1:25 | 1:50 | 1:150 | 1:10 | 1:50 | 1:4 | low-moderate | Bait for wireworms before planting; scout for cutworms at plant emergence. |
| Grass sod | 1:10 | 1:25 | 1:500 | 1:10 | 1:25 | 1:50 | 1:1,000 | moderate-high | Use infurrow soil insecticide for wireworm and white grub; if no-till, scout for foliar insect damage as corn emerges. |
| Source: Kuhlman et al. 1988 | | | | | | | | | |

Under certain situations, however, rotating corn with another crop has not provided the expected degree of corn rootworm control. High populations of volunteer corn or certain flowering weeds which attract corn rootworm beetles to feed and lay eggs in the field may contribute to reduced control. Recently, it has been documented that some populations of northern corn rootworms can survive over more than one winter. This is proposed to be a characteristic selected for by intensive use of corn-soybean rotations in some areas of the Midwest. This has not been commonly reported in Nebraska, but has been reported from adjacent areas of South Dakota and Iowa.

Crop rotation should greatly reduce the use of insecticides against corn rootworms, the major target of most insecticide use in Nebraska. Although not well researched, reduced insecticide use in corn should encourage populations of various insect predators, especially those which spend a portion of their life in the soil (e.g., various beetle or fly larvae and soil mites). Increased biological control of several soil insects might be an added benefit from increased use of crop rotation in corn, although some rotations may slightly increase the occurrence of some soil insect pests (*Tables I and II*).

## Rotations which favor certain pests

Including certain grassy crops, such as pastures or sod, in rotations often increases the likelihood that white grubs or wireworms will be present in economically damaging numbers (*Table I*). In both cases this is because the adult stages prefer to lay eggs in these crops. These soil insects damage crops by feeding on the roots (white grubs) or by boring into the roots and base of the plant (wireworms). The larvae are less specific in their feeding preferences and will damage a wide variety of crops (some white grubs will also feed on decaying organic matter as well as live plant tissue). The lack of specificity of the larval stages may be adaptive, since as soil insects they have limited ability to search for different plant species, and this provides them a way to override the adult choice of egg-laying site.

These two pest groups actually consist of several species, which differ in their life cycle, damage potential, and behavior. In Nebraska, the white grubs which damage crops primarily belong to two genera, *Cyclocephala* and *Phyllophaga*, commonly referred to as annual and three-year grubs, respectively, in reference to their lifespan. The *Phyllophaga* white grubs have a greater potential to cause problems in subsequent crops because of their longer life cycle. They can cause economic damage to crops in the second and third years of their three-year life cycle. *Cyclocephala* white grubs have an annual life cycle, and are rarely economically damaging to field crops because their feeding is often completed as corn or other crops emerge.

Less is known about the wireworm species in Nebraska, which belong to several genera, including *Melanotus* and *Conoderus*. Some wireworm species take three to five years to complete the larval stage, and may require extended rotations or fallow periods to reduce their numbers significantly by cultural practices.

## Crop rotation from an area-wide perspective

Much crop rotation research has taken a single field approach, and for some less mobile insects, this may be appropriate. However, for more mobile insects, the rotational history of other fields (either on the same farm or surrounding farms) may affect insect pest management in adjacent fields. In Nebraska an example is chinch bugs in sorghum or corn. There are two annual generations of chinch bugs in Nebraska. The first generation develops on small grains, primarily wheat, and as wheat matures, immature and adult chinch bugs move out of wheat and attack any nearby grass crop, normally sorghum or corn. If wheat or other small grains are not grown in nearby fields, the potential for the first generation of chinch bugs to damage sorghum or corn is greatly reduced.

Bean leaf beetles may damage soybeans near alfalfa. Bean leaf beetles become active in the spring before soybeans emerge and often begin feeding in alfalfa. Soybeans near alfalfa may be at increased risk from bean leaf beetles, particularly after the first cutting of alfalfa which may force beetles to search for alternate food sources.

Spider mites may overwinter in alfalfa (twospotted spider mite) or wheat or other grasses (Banks grass mite). Corn or other crops near these fields, especially if downwind from them, may be infested with migrating spider mites earlier in the season, resulting in a greater risk of damage.

The use of crop rotation and other tactics in insect pest management must take a whole-farm and sometimes even an area-wide approach.

## Tillage practices

Cultivation was often recommended as a cultural insect control practice in the pre-DDT era, particularly for soil insect pests. Tillage can have a direct effect by physically crushing soil insects such as wireworms or white grubs, although often only a small portion of the total population is in the plow layer at a particular time. Spring or fall cultivations, which would be most practical, may miss many soil insects, which move below the plow layer to overwinter.

More commonly, tillage practices have more subtle effects. Tillage may modify the soil temperature and moisture, which will influence insect behavior as well as crop growth. Reduced tillage systems may have higher soil moisture, and be slower to warm up in the spring, thus reducing crop growth. This may increase damage from wireworms, white grubs and other seed and seedling pests, which have more time to feed on young plants. As the soil temperature warms up, and the soil moisture decreases in the summer these insects may move deeper in the soil and feed on less vulnerable plant parts.

Other examples involving common Nebraska crop pest insects include black cutworm in corn and the greenbug in sorghum. As discussed above, black cutworm moths lay their eggs in the spring and prefer sites with crop residue or green vegetation present before planting. Conservation tillage practices may increase these conditions; however, in the case of greenbugs in sorghum and wheat, surface residue reduces a field's attractiveness to flying greenbugs as they colonize fields in the spring. Greenbugs prefer fields under conventional tillage systems with more bare ground visible.

*Tables III-V* summarize the likely effects of reduced tillage systems on common insect pests of corn, soybeans and wheat in the Midwest.

Reduced tillage systems may increase populations of various predatory insects and mites in the soil. Crop residues encourage the growth of various small insects and mites, and other organisms which feed on decaying organic matter. As these populations increase, predatory insects and mites which feed on them build up, and will feed on various pests present in the soil. The lack of disturbance from cultivation encourages growth of these soil organisms. Studies have documented increased levels of predatory insects and predation on black cutworms in reduced tillage systems.

**Table III. Possible effects of conservation tillage systems on pests in corn.[a]**

| *Insect* | *Effect* | *Notes* |
|---|---|---|
| **Armyworm** | 0 to +++[b] | Ryegrass and other grass cover crops and hay crops are especially attractive to egg-laying armyworm moths. In no-till systems where the grass cover is not plowed under, larvae move from the grass to feed on corn. |
| **Black cutworm** | + to +++ | Adult black cutworm moths prefer to lay eggs in weedy fields and in fields with unincorporated crop residues. Increased populations of predators and parasitoids also develop, but an increase in black cutworm injury often occurs anyway. |
| **Corn earworm** | 0 to + | If planting date or crop development is delayed in no-till fields, corn is usually more attractive to egg-laying moths. This is usually a minor concern except for seedcorn producers. |
| **Corn leaf aphid** | 0 | |
| **Corn rootworms** | 0 | Adults lay eggs in late summer; subsequent tillage has little effect on the survival of eggs during most winters. In harsh winters with subnormal temperatures and subnormal snowfall, egg survival is somewhat greater with reduced tillage. |
| **European corn borer** | 0 to + | Conservation tillage favors greater survival of corn borers in crop residue, but effects in specific fields are minor because moths disperse from emergence sites to lay eggs in suitable fields throughout the local area. Where reduced tillage leads to delayed planting or slower germination (cooler soil temperatures), corn may be less susceptible to attack by first generation corn borers and more susceptible to second generation injury. |
| **Seedcorn maggot** | 0 to – | Adult flies prefer to lay eggs where crop residue has been partially incorporated into soil. No-till corn stubble may be less attractive to egg-laying flies, but cooler, wetter soils shaded by crop residues slow germination and increase the period of vulnerability to seedcorn maggot injury. |
| **Slugs** | +++ | Unincorporated crop residues and cooler, wetter conditions favor increases in slug populations and injury. |
| **Stalk borer** | 0 to +++ | Overwintering survival is greatest in conservation tillage systems. In no-till fields, serious injury is most likely where grasses were present to attract egg-laying moths the previous August and September. If corn is no-tilled into soybean stubble where weeds were controlled during the previous year, stalk borers are not a problem. |
| **Western bean cutworm** | 0 to + | Conservation tillage favors greater regional survival of western bean cutworms. Effects in specific fields are minor because moths disperse from emergence sites to lay eggs in suitable fields throughout the local area. |
| **White grubs** | + | Increases in grassy weed populations and reduced disturbance of soil favor survival of true white grubs. |
| **Wireworms** | + | Increases in grassy weed populations, reduced soil disturbance, and delayed germination caused by cooler soil temperatures may favor wireworm build-up and injury. |

[a]The range of effects notes the possibilities and worst case scenarios. Individual field experience may not confirm these extremes. Weather is directly tied to potential pest problems in to-till.
[b]"+++"=Substantial increase in pest population. "+"=Some increase. "0"=No effect. "-"=Some decrease in pest population.

Modified from : Steffey et al. (1992)

**Table IV. Possible effects of conservation tillage systems on insect pests in soybeans.[a]**

| *Insect* | *Effect* | *Notes* |
|---|---|---|
| **Bean leaf beetle** | 0 to | Tillage has little effect on foliar feeding by bean leaf beetles, unless planting dates are |

| | | |
|---|---|---|
| | +[b] | earlier. |
| **Grasshoppers** | 0 to + | Reducing tillage favors the survival of only those grasshopper species that lay eggs within fields. Those that lay eggs in weedy margins are not affected. |
| **Seedcorn maggots** | – | Seedcorn maggot populations are greatest in systems in which a live, green cover crop is incorporated into the soil. |
| **Slugs** | +++ | Unincorporated crop residues and cooler, wetter conditions favor increases in slug populations and injury. |
| **Spider mites** | – to 0 | Where crop residues help to retard soil moisture loss, plants may be less drought-stressed than in plowed fields; reducing drought stress slows spider mite outbreaks. |

[a]The range of effects notes the possibilities and worst case scenarios. Individual field experience may not confirm these extremes. Weather is directly tied to potential pest problems in to-till.
[b]"+++"=Substantial increase in pest population. "+"=Some increase. "0"=No effect. "-"=Some decrease in pest population.

Modified from : Steffey et al. (1992)

**Table V. Possible effects of conservation tillage systems on insect pests in wheat.[a]**

| *Insect* | *Effect* | *Notes* |
|---|---|---|
| **Aphids** | – to 0[b] | Prior crop residues may decrease the attractiveness of new stands of wheat to airborne aphids in the fall. (Seeding wheat after Hessian fly-free dates avoids most fall infestations of aphids.) By spring, it is unlikely that prior crop residues affect aphid invasion. |
| **Army cutworm** | – to 0 | Army cutworm prefers barren or freshly worked soil for oviposition, so surface residues might deter egg laying activities. Oviposition occurs in the fall after planting, so tillage effects would be within-field rather than regional. |
| **Greenbug** | – to 0 | Fall and early spring infestations are deterred by the presence of surface residues and favored by the presence of volunteer small grains. |
| **Hessian fly** | 0 to +++ | Hessian fly populations carry over where wheat stubble is not tilled and volunteer wheat is not controlled. Hessian flies from undisturbed stubble move to new wheat that is planted before fly-free dates. Hessian flies that infest volunteer wheat in the late summer and early fall overwinter in the volunteer plants and can move to additional fields in the spring (regardless of those fields' fall planting dates). No-till seeding of wheat into other crop residues poses no problem. |
| **Pale western cutworm** | – to 0 | Similar to army cutworm in that it cannot lay eggs on crusted soil, so other tillage relationships may also be similar. Also oviposit in the fall so tillage effects would be within-field for winter wheat. |
| **Russian wheat aphid** | 0 to + | Favored by presence of volunteer small grains. Adjusting planting dates is a more important cultural practice than modification of tillage. Tillage effects do not seem similar to those observed with greenbug, although moisture conservation from stubble mulch systems may reduce Russian wheat aphid effects substantially. |
| **Wheat curl mite** | 0 to + | Similar to Russian wheat aphid in that volunteer wheat management and adjustment of planting date are key cultural practices. |
| **Wheat stem sawfly** | 0 to + | Shallow fall tillage may provide up to 90% sawfly control. If only spring tillage operations are performed, approximately 25% of the larvae may be destroyed, depending upon the tillage implement used. Tillage passes that are shallow should expose the larvae in the stubble. |

[a]The range of effects notes the possibilities and worst case scenarios. Individual field experience may not confirm these extremes. Weather is directly tied to potential pest problems in to-till.
[b]"+++"=Substantial increase in pest population. "+"=Some increase. "0"=No effect. "-"=Some decrease in pest population.

Modified from : Steffey et al. (1992)

## Planting and harvest dates

Plant growth stages vary in their susceptibility to different pests, and pests may prefer certain growth stages upon which to feed or lay eggs. Planting and harvest dates and in some cases variety maturity may influence the degree of damage from certain pests. European corn borer moths prefer to lay their eggs on the taller corn in an area, and later growth stages are more favorable for corn borer larval survival, thus early planting may result in more damage from first generation corn borers. Earliest planted soybeans are most at risk from adult bean leaf beetles, which are active early in the season, and capable of searching out first emerging soybean fields to colonize. Planting dates have been used to manage Hessian flies for a long time. Fly-free dates have been established to guide fall planting, based on the seasonal occurrence of Hessian fly adults. Planting after the fly-free dates avoids much of the fall egg-laying by Hessian flies. Additional examples of pests influenced by planting dates and variety maturity in Nebraska crop production are shown in *Table VI*. Harvest date can be an important factor in managing the alfalfa weevil. If economically threatening levels of alfalfa weevils are present, and the crop is close to the bud stage, early harvest can effectively control larval alfalfa weevils. The lack of food and hot, dry conditions after harvest can cause considerable mortality to the weevil larvae. Harvest date also can influence yield loss from European corn borer larvae. Larval tunneling in the stalk and ear shank can cause stalk breakage and ear droppage. The later the crop is harvested, the more likely it is that some ears will not be harvested.

**Table VI. Possible effects of planting date and variety maturity on several crop insect pests.**

| *Insect* | *Effect* |
|---|---|
| **European corn borer** | Early planting of corn increases risk from first generation corn borers. Late planting increases risk from second generation corn borers; plants in green silk stage during moth flight most attractive for egg laying. |
| **Bean leaf beetles** | Earliest emerging soybeans are most at risk from adult feeding. |
| **Hessian fly** | Wheat planted before fly-free dates in fall is most likely to be infested. |
| **Corn rootworms** | Earliest silking corn is most at risk from silk clipping damage by rootworm beetles. Late silking corn may attract rootworm beetles from nearby fields in brown silk stage, resulting in more eggs being laid in later maturing fields. |
| **Western bean cutworm** | Least mature corn in an area is most at risk from egg laying by moths; moths are most attracted to corn at beginning tassel. |

## Constraints to use of cultural practices

There are a variety of constraints to the increased use of crop rotations and other cultural practices in insect pest management. Unsuitable (from an economical or other perspective) rotation crops may be needed to control some, and rotations may not control highly mobile pest species. Often rotation works against the soil stage of a pest insect. However, the soil stage of many pest species is the least well researched; in some cases the host range and behavior of a soil insect pest may be so inadequately understood that appropriate rotational systems cannot be recommended. In some cases, for example with white grubs and wireworms, control measures may need to address a species complex, rather than one species, and no rotational system will adequately control the complex, if the host range or life cycle of the different species varies greatly. Finally, pests can adapt to rotations, with the best known example being the northern corn rootworm.

An additional factor in the use of cultural practices in pest management is that they are a preventive strategy, which often needs to be implemented before the pest level is known, or damage is observed. Since DDT and other insecticides were introduced, pest management strategies have often emphasized post-damage control measures. Educational programs must emphasize more long-term planning for pest management if we are to take full advantage of the potential benefits of cultural practices in insect pest management.

## Conclusions

Increased use of crop rotation in corn production systems could greatly reduce crop insecticide use in Nebraska and other Midwestern states. Crop rotation has the potential to reduce pest damage on several other Nebraska crops as well. However, no one rotational system will control all potential pests.

New rotational systems might encourage pests previously not common in Nebraska, and this should be considered as new cropping systems are researched. In some cases, research on effects of crop rotations on insect pests was done over 50 years ago, using crop production systems vastly different from those used today. More research is needed on rotation effects on insects (both pest and beneficial species) in the cropping systems being developed.

Despite early concerns, adopting reduced tillage systems has not vastly increased insect pest problems in Nebraska. However, some pests, particularly early season pests such as wireworms, white grubs, and black cutworms, warrant careful early season scouting. Reduced tillage may encourage populations of various predatory insects and mites by increasing populations of their prey, various insects, mites, and other organisms which feed on decaying organic matter.

Planting dates and variety maturity also may be important factors to consider in limiting damage from certain pests.

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