High Residue Farming under Irrigation: Pest Management Considerations

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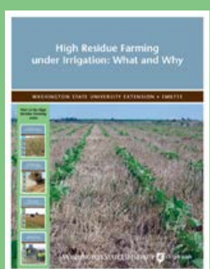
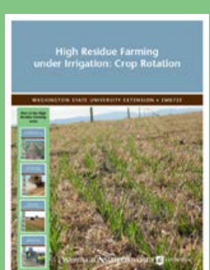
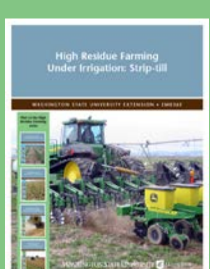
Part of the High Residue Farming series







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High Residue Farming under Irrigation: Pest Management Considerations

Andrew McGuire, Extension Educator, Ag Systems,
Washington State University Extension

This is the fourth in a series of publications on **High Residue Farming** (HRF) under Irrigation. It gives an overview of the effects of adopting HRF on the management of weeds, insects, and diseases.

For anyone wanting to implement or know more about a high residue farming system, the series includes:

EM071—High Residue Farming under Irrigation: What and Why provides an overview of high residue farming (HRF), including its benefits and challenges. It also discusses some special considerations for high residue farming in the irrigated agriculture regions of the far western United States (the "Far West").

EM072—High Residue Farming under Irrigation: Crop Rotation covers choosing a cropping sequence, specific cover crops, and special considerations for irrigated cropping systems in the far western United States.

EM073—High Residue Farming under Irrigation: Residue Management Through Planting explains how to plant crops into high residue conditions with a planter or drill. It covers residue management, planter and drill modification, and soil fertility adjustments.

EM036—High Residue Farming under Irrigation: Strip-till covers the benefits, challenges, and implementation of strip-till planting. This high residue farming system combines some of the benefits of clean tillage systems with the high residue cover.

What is High Residue Farming?

High residue farming (HRF) is an umbrella term that covers cropping systems in which the volume of soil that is tilled is reduced in order to maintain residue cover of the soil. **Crop residue** covering the soil provides the many benefits of HRF, though the specific amount of residue will depend on the previous crop, the current crop, and soil and climate factors.

No-till, strip-till, ridge-till, and vertical tillage are all variations of HRF. Many of these terms describe the type of tillage used (for instance, **strip-till**) or not used (**no-till**) and most have other names, such as **direct seeding** for no-till or zone tillage for shallow strip-till. Table 1 shows the range of tillage practices.

"High residue farming" (HRF) is an umbrella term that covers cropping systems where the volume of the soil that is tilled is reduced in order to maintain residue cover of the soil. Crop residue over the soil provides the many benefits of HRF, though the specific amount of residue will depend on the previous crop, the current crop, and soil and climate factors. No-till, strip-till, ridge-till, and vertical tillage are all variations of HRF. Many of these other terms describe the type of tillage used (strip-till) or not used (no-till) and most have other names, such as direct seeding for no-till, or zone tillage for shallow strip-till. Table 1 shows the range of tillage practices.

An increasing number of farmers in the far western U.S. (Figure 1) are adapting high residue farming (HRF) systems from other regions to their conditions and crops. This publication examines the general effects of adopting HRF on the management of weeds, insects, and diseases, with the goal of helping farmers anticipate potential problems when adopting HRF. Although this series of publications on high residue farming is focused on implementing HRF in irrigated agriculture, the effect of HRF on pests in any specific crop will be similar in both irrigated and dryland systems.

When HRF was first tried (with no-till corn in Kentucky, 1964; Owens 2001) many thought that

Table 1. Classification of tillage systems by tillage intensity and residue coverage.

Classification		Primary Tool(s)	Tillage Intensity	Residue Coverage
Clean-till		Moldboard plow	High, soil inversion	<30%
Clean-till		Heavy offset disk	High	<30%
Reduced-till		Chisel plow, disk	High	<30%
Reduced-till, Minimum-till, Mulch-till	High residue farming (Conservation tillage)	Chisel plow	Moderate	>30%
Strip-till		Strip-till implement	Non-uniform, moderate-none, 6–12″ deep	60–80%, bare soil in planted strip
Zone-till, Vertical tillage		Gang of coulters on planter, row cleaners	Non-unifrom, moderate-none, 1–2″ deep	60–80%, bare soil in planted strip
Direct seed, No-till*		Planter with row cleaners	None	60–80%, 0–80% in planted strip
Direct seed, No-till*		Planter without row cleaners	None	80–100%

*Direct seeding and No-till refer to the same practice.

Figure 1. Irrigated vegetable-growing areas of the far western United States.

increased pressure from weeds, insects, and disease would make the system fail. This did not occur, and through problem solving and adaptation, farmers and researchers have developed successful HRF systems for many crops in many locations. However, careful pest management, including consideration of the conditions and constraints that come with HRF, is an important part of this success.

There is little research on the pest effects of HRF in irrigated regions of the western US. Since HRF systems have been developed mainly in the midwestern US and Canadian prairie, much of the information presented in this publication comes from the conditions and crops (mainly corn and wheat) in those regions. Therefore, because the specific effects of pests on particular crops can vary greatly between regions, most of the information presented here is on general trends. Experience will tell us what holds true under the very different conditions of the **Far West**.

Effects on Weed Management

Tillage can kill weeds directly or prevent germination by burying weed seed. If seed is buried deep enough, it can also prevent successful emergence of seedlings from seed that does germinate. As tillage is reduced, the need for vigilance in weed management is increased. Anil Shrestha, IPM Weed Ecologist with the University of California, goes so far as to say, "There should be zero weed tolerance for no-till systems" (Pollock 2011; Shrestha 2006). Achieving this requires: 1) an understanding of the potential shift in weed species that often accompanies HRF; 2) maximum use of cultural and other non-pesticide methods of weed control (see the *Importance of Non-Pesticide Practices* section, below); and 3) an increased reliance on herbicides and the accompanying need to make them as effective as possible.

Weed species shift during the transition to HRF: Without tillage, all weed seeds are left on the soil surface, under crop residue. This environment favors small-seeded weeds, which are more likely to find conditions conducive to their germination and growth on the soil surface than are large-seeded weeds. Research has shown that HRF systems have more grass weeds (Wrucke and Arnold 1985) and fewer large-seeded broadleaf weeds in general, though small-seeded broadleaf weeds like lambsquarters and pigweed may still be a problem.

Without fall tillage, the weed populations in HRF systems also often shift away from summer annual weeds towards winter annuals, biennials, and perennial weeds (Kapusta and Krausz 1993). These weeds can be controlled with **burndown herbicides**, applied in the fall, spring, or both, or by rotating to herbicide-resistant crops. Perennial weeds will probably not be a problem in fields where potatoes, onions, or carrots are part of the crop rotation because of the tillage used with these crops.

Residue covering the soil surface also affects weeds, although the magnitude and direction of the effect is species-specific. Residue suppresses some weeds by blocking sunlight, decreasing temperatures, and providing habitat to insects that eat weed seeds. Higher levels of residue generally give better suppression (Chauhan et al. 2006), but can also hamper planting. Decomposing residues can release chemicals that suppress plant growth, including weeds. This is called **allelopathy** and can be important with residues from Brassica crops and cereal rye (Haramoto and Gallandt 2004).

Without tillage, HRF relies more on herbicides to control weeds. When no-till systems were being developed, it was thought that the crop residues would "tie up" herbicides. This, however, is not typically the case. Rain or irrigation will wash **residual herbicides** off residue and into the soil. In fact, pre-plant residual herbicides are routinely incorporated with irrigation water where it is available. However, thick mats of residue can prevent proper distribution of herbicides on the soil surface and reduce the efficiency of soil-active herbicides (Streit et al. 2003). Therefore, residue must be spread uniformly for effective application of residual herbicides.

Burndown and post-emergence herbicide applications are used widely in HRF systems. The recommendations are similar to those for clean tillage systems except that there is no cultivation backup treatment and interference by residues must be considered. Applied before planting, at planting, or after planting, burndown herbicides kill existing weeds. Use split applications (that is, apply 1/3 of the labeled herbicide rate early and the remaining 2/3 at planting) to catch both early and later germinating weeds. A residual soil-active herbicide mixed with the last burndown application can control later germinating summer annuals that would otherwise compete with the crop.

Timing herbicide applications is also more critical in HRF than in clean tillage systems because even if the application is unsuccessful, cultivation is not an option. The goal is to strike the right balance between treating weeds when they are small and treating after as many weeds as possible have germinated. When a mixture of soil-active and burndown herbicides is applied early, the residual's activity may dissipate too soon to catch weeds that can compete with the crop. Even with proper timing, one or more post-emergent herbicide applications may be required.

The increased reliance on herbicides in HRF systems requires that the proper rate be applied. As always when using pesticides, read and follow label instructions. The following factors, all affected by HRF, can affect herbicide activity and, therefore, the needed rate:

- Soil organic matter—with increasing soil organic matter levels (not residue), increase rates of soil-applied herbicides (within the labeled range). This is not a factor with post-emergence applications.
- Crop residue level—with increasing thickness of crop residue, increase rates.
- Timing—for early pre-plant applications of soil-active herbicides, increase rates or select more persistent chemicals.
- Size/density of weeds—when spraying larger or more numerous weeds, increase rates.

While specific guidelines have not been developed for every situation and product, herbicide manufacturers have tested their products in some HRF conditions. Look for "no-till" instructions on the product label.

The lack of **selective herbicides** for some of the specialty crops grown in the far western U.S. may limit the adoption of HRF. In these cases, consider high residue cultivators that allow tillage for weed control while preserving some residue cover (Creamer and Dabney 2002).

Lastly, the development of herbicide-resistant weeds is of special concern in HRF systems, given these systems' reliance on herbicides. In the Midwest, an increase in herbicide-resistant weeds threatens to force farmers to adopt more expensive herbicide systems or even increase tillage. To prevent the development of resistance, rotate **herbicide modes of action** using labeled tank mixes and use maximum labeled rates. In the irrigated Far West, our diverse rotations often demand this anyway, but with less diverse rotations, herbicide rotation should always be used.

Effects on Insect Management

Similar to weeds, reducing tillage can shift the number and type of insects in a field, but insect problems do not necessarily increase (Stinner and House 1990). Some aspects of HRF systems increase the *potential* for problems with specific pests. For instance, insects that overwinter in the soil or in crop residue and become active early in the growth of the crop benefit the most from tillage reduction. Although cooler soils may cause these insects to develop more slowly than in tilled soil, they can be more numerous because they have not been exposed to tillage. Other insects may decrease after a number of years of HRF. This may be due to increased survival of beneficial insects such as ants, ground beetles, rove beetles, and spiders—all of which can contribute to insect pest control.

In addition, because of the close relationship of some insect pests with weeds, the shift in weed species can affect insect populations. Here, good weed management, especially of grassy weeds, can help with insect control.

Every combination of crop and pest is unique, but the effects of HRF on some pests can be generalized (Figure 2):

- Slugs can cause extensive damage to seedlings, especially in low-lying wet areas. They are favored by unincorporated crop residue and cool, wet conditions. There are chemical controls but they can be expensive.
- Winged aphids are more often attracted to bare ground than to residue-covered ground. This can limit infestations in new stands but not after canopy closure.
- Black cutworms prefer to lay eggs in fields with unincorporated crop residue.
- Seedcorn maggots are more of a problem with recently incorporated residues or green manures

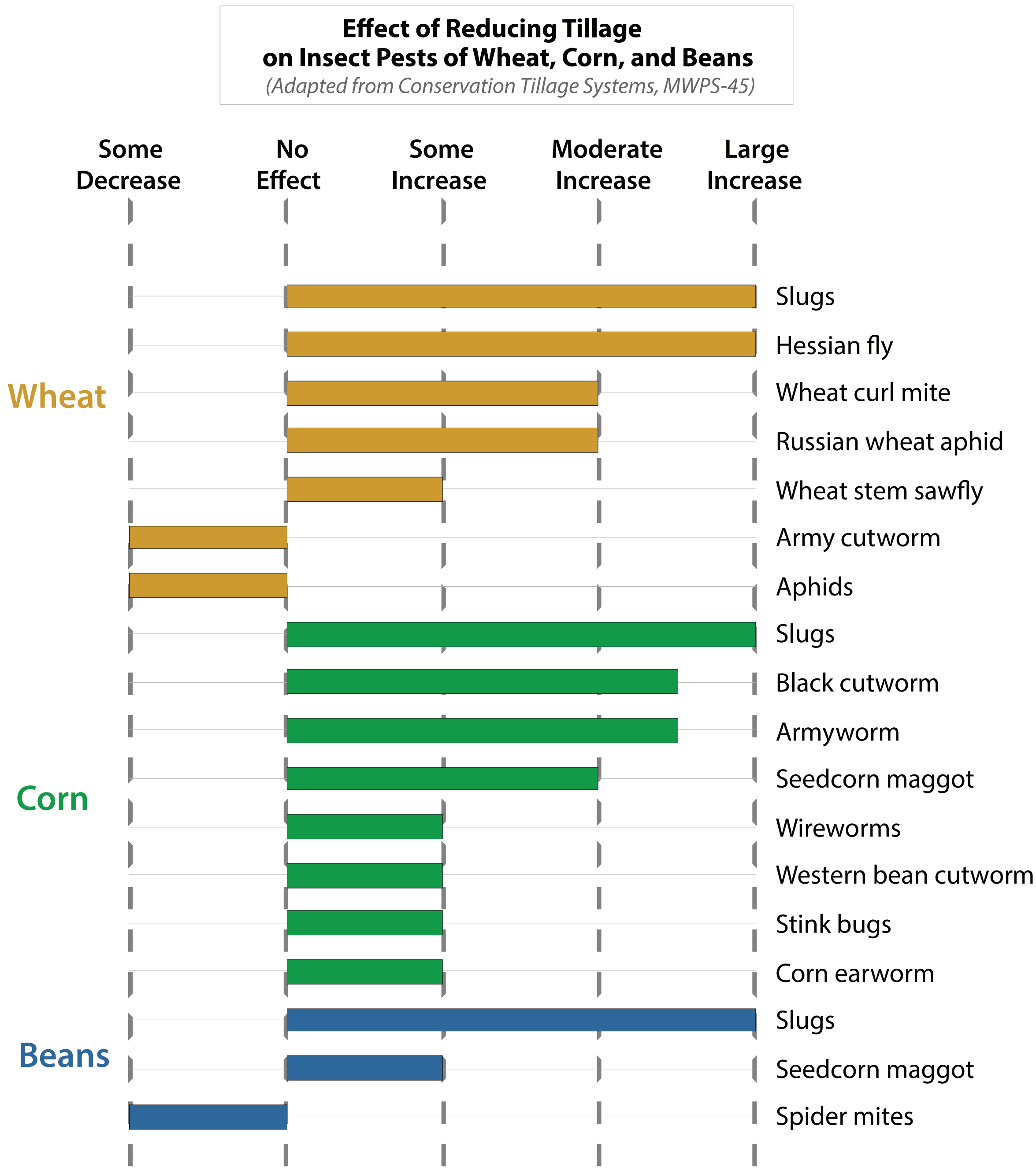

Figure 2. Effects of reducing tillage on pests of wheat, corn, and beans. Adapted from Conservation Tillage Systems, MWPS-45 (MidWest Plan Service 2000).

than where dead crop residue simply covers the soil (Hammond 1984).

- Wireworm numbers have increased in general in the past few years, with some research suggesting a link to reduced tillage (All et al. 1986), but other research finding no such link (Belcher 1989). Wireworms are most likely to increase and cause damage after grassy weed infestations, with reduced soil disturbance, and where cool soils delay germination.
- Corn earworms may be a greater problem when planting or crop development is delayed in no-till fields.

Planting corn into a grassy sod or wheat residue requires a high level of insect management. Wireworms and cutworms can be a problem. Wheat curl mite can also move from green grass to emerging corn and can infect crops with virus diseases like High Plains disease. Killing any grasses with herbicides several weeks before planting can reduce this problem and limit damage from foliage-feeding pests. Insecticide seed treatments should be considered when planting in a high risk condition like this.

In reviews of the research across crops, 28% of insects, and their damage, increased with HRF, compared with 43% where the number or damage decreased, with the remaining 29% showing no difference (Stinner and House 1990). Although every situation produces different results, this shows that insect control should not be an impediment to adopting HRF systems.

Best management practices for insect control under HRF are similar to those used in tillage systems, though these practices are arguably more important in HRF. For example, insecticide seed treatments may be more frequently used in HRF, and are the preferred control method for many insects in no-till systems. Extra vigilance should be used during the transition phase, when HRF's positive impacts on soil health and the populations of beneficial insects have not yet been realized.

Effects on Disease Management

Whatever the system, for disease to occur three things must come together: 1) a virulent pathogen, 2) an environment favorable to growth of that pathogen, and 3) a susceptible crop. When HRF was first tried, many thought that diseases would run rampant because the residue cover would provide the favorable environment. But in fact, the effects of reducing tillage on disease pressures are variable, depending on the disease, the environment, and the crop. Without previous experience, it can be difficult to predict how big of a problem disease will be in specific crops and climates (Krupinsky et al. 2002). While the risk of foliar diseases may increase, soilborne diseases may decrease in HRF systems over time because of increased biological activity and growing numbers of beneficial microorganisms (Bockus and Shroyer 1998). Pathogens that thrive in cool, wet soils may become more of a problem, while diseases favored by higher soil temperatures and drier soils may be seen less often.

Diverse crop rotations limit the probability that diseases will build up over time and therefore are critical for success in HRF. (See EM072—*High Residue Farming under Irrigation: Crop Rotation*.) In a diverse rotation, changes related to reductions in tillage are often small compared to those due to weather and other factors out of your control. In cases where disease is not fully controlled through crop rotation, then cultural, chemical, or biological controls—or a combination of those controls—can be used.

Importance of Non-Pesticide Practices

Without tillage, non-pesticide practices become more important. Essential practices for all pests in HRF include crop rotation, field sanitation, proper planting techniques, irrigation management, variety selection, and scouting and pest identification.

Crop Rotation

A diverse crop rotation is the backbone of an integrated strategy for controlling weeds, insects, and diseases. For weed management, strategic crop rotation (including herbicide-resistant crops when deemed useful) allows different herbicides to be used to control different problem weeds and limits the likelihood of developing herbicide-resistant weeds. It also allows sufficient time between similar crops for the **weed seed bank** to decline. For insects, those that live in the soil and those with limited mobility are most affected by crop rotation.

Many plant pathogens that survive in or on crop residues can be managed through the strategic choice of crop sequence in a diverse rotation. Given sufficient time between crops, these pathogens will decrease to tolerable levels. For corn, this includes foliar, ear, stalk, or stem rots.

For more information on crop rotation in HRF, see the WSU publication EM072—*High Residue Farming under Irrigation: Crop Rotation*.

Field Sanitation

Field sanitation can be more important in HRF than in traditional tillage systems. With direct-seeded corn, control of volunteer small grains and weedy grasses in and around fields 3 to 4 weeks before planting is necessary. If allowed to grow while the crop emerges, these weeds can serve as a **green bridge** for soilborne diseases and as hosts for viral diseases and their insect vectors. Keeping field borders free of problem weeds can also help.

Proper Planting Procedures

Plant density contributes to determining humidity levels within the crop canopy, therefore, growers should not exceed the recommended seeding rate for a given crop and variety. Combined with good weed control, proper plant density can allow good air movement through the crop canopy and limit disease development.

Getting the crop off to a good start is also important with HRF. Quick germination and emergence (see WSU publication EM073—*High Residue Farming under Irrigation: Residue Management Through Planting*) will reduce the opportunity for development of damping-off diseases, which may be promoted under the wetter soil conditions of HRF, and will make the crop more competitive with weeds. Planting at the proper depth and spacing, and with adequate available nutrients is also important. Consider using fungicide seed treatments if available; they are usually beneficial in HRF conditions.

Irrigation Management

Managing irrigation to optimize soil moisture is another method that can be used to control disease under HRF. Without spring tillage, residue-covered soils can retain enough water to get a crop through emergence without supplemental irrigation, even in the driest conditions. This can reduce soilborne diseases by avoiding saturated conditions after irrigating. Residue cover also reduces the amount of soil splashed onto the crop from irrigation or rain; this is thought to be the reason that white mold in beans is less severe in HRF systems.

Variety Selection

Selecting varieties that are resistant to, or tolerant of, insect and disease pests should not be overlooked. Careful variety selection may be the key factor in making HRF work with some crops. Some seed companies have made this easier by rating their varieties' ability to thrive in high residue conditions. Herbicide tolerance should also be considered when choosing varieties.

Scouting and Pest Identification

Regular and extensive scouting is especially important before planting and through crop emergence to catch weeds at the proper growth stage and treat them with the right herbicides. With insects and diseases, scouting—combined with anticipation of potential problems—can improve control. Reducing tillage may shift pest populations to unfamiliar pests. Learning to identify these new weeds, insects, and diseases is important for their management.

More Information on High Residue Farming

Although pest management in HRF systems will require more attention, especially when starting out, overall the problems are not necessarily worse—just different. With preparation, good planting practices, and diligent scouting, most problems should be minimized or controlled through management. You can be encouraged by the fact that no unresolvable pest problems have been found in HRF systems so far.

Here are some sources of further information on pest management in HRF:

Conservation Tillage and Weed Management. University of California.

No-till and Biological Control. University of Wisconsin.

Conservation Tillage Systems and Management. MidWest Plan Service, Iowa State University.

Effects of Reduced Tillage on Wheat Diseases, Kansas State University Extension.

Fusarium and Other Diseases in a Direct Seeding System, Saskatchewan Soil Conservation Society.

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Glossary

allelopathy. The suppression of plant growth by chemicals produced by other plants or microbes.

burndown herbicide. A non-selective herbicide used to kill all plants in the application area.

crop residue. The part of the crop plants that remain in the field after harvest.

direct seeding. Planting directly into untilled soils, without seedbed preparation.

Far West. In the Unites States, the regions of Washington, Oregon, Idaho, California, Arizona, and New Mexico that produce irrigated vegetables in rotation with agronomic crops such as wheat, corn, and alfalfa.

green bridge. Crop plant volunteers and weeds growing out of season that provide an environment for carryover and build-up of crop diseases and insects.

herbicide mode of action. The overall manner in which a herbicide affects a plant at the tissue or cellular level.

high residue farming. An umbrella term that covers cropping systems where the volume of the soil that is tilled is reduced in order to maintain residue cover of the soil.

no-till. See **direct seeding**.

residual herbicide. An herbicide that remains active in the soil for a period of time.

selective herbicide. An herbicide that kills only certain groups of plants; for example, one that kills broadleaf plants but not grasses.

strip-till. A system where the soil is tilled and crop residue removed or buried in a 6- to 12-inch-wide strip where the next crop will be planted. The residue-covered area between the strips is left undisturbed.

weed seed bank. The reserve of viable weed seeds present on the soil surface and scattered in the soil profile.

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