# Weed Management: Key to No-Tillage Crop Production

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## INTRODUCTION

No-tillage production of crops has been a goal of agriculturists for decades, The primary factor limiting development was the inability to control weeds present at crop planting and those that developed later. Until the early 1950's, tillage was the only method available to prepare a seedbed, temporarily free it of weeds, and control weeds that developed after the crop had emerged.

Prospects for controlling weeds by alternate means, however, improved during the 1950's with the advent of a host of new herbicides, These discoveries probably led Harper (1957) to write, "... For efficient longlasting weed control, ploughing should be avoided, surface tillage reduced to a minimum and any weed seeds which are formed should be left on the surface to be killed by spraying when they do germinate." The discovery and subsequent developnent of a new class of non-selective herbicides in the U.K. and marketing of the contact herbicide, paraquat in the U,S, around 1960 provided the reality of no-tillage crop production. New crop production techniques soon were developed and adopted in many areas of the U.S. An estimated 87 to 90 million acres of U.S. cropland were in some form of reduced tillage in 1983 and another 10 to 12 million acres were planted no-tillage (Magleby, et al., 1984).

These herbicides plus other new selective ones made no-tillage crop production possible, but even with the many compounds available, weeds and weed control remain the dominant concern. Results of a survey of 25 leading corn-producing states in 1980, led agronomists in three states to list lack of herbicide effectiveness and an increase in perennial weeds as major reasons for concluding that no-tillage corn production likely would nutincrease in their states by 1990. No-tillage corn acreage was predicted to decrease in two of the 25 states surveyed, and greater weed problems and difficulty of cultivation were listed as reasons for their expected decline (Worsharn, 1980).

Poor weed control was listed by respondents in 24 of the 25 states as a serious problem and was predicted to worsen if no-tillage corn acreage increased, Insect control was the next most-listed problem in 14 states, Respondents in all the 25 states listed perennial weed control as a problem currently encountered in no-tillage corn, Perennial weed control was given by respondents in 16 states as the most important problem. Insects and poorly-drained, cold soils were the next most-listed (12 states) factors limiting the expansion of no-tillage corn acreage (Worsham, 1980).

A widely-held view among scientists is that weeds are the most important single problem limiting acceptance of no-tillage cropping systems. Farm acceptance will be expanded as the herbicides now being developed to meet weed problems as they arise are incorporated into no-tillage weed-management systems. For example, control of some perennial weeds with the non-selective, systemic herbicide, glyphosate, and of perennial grass weeds in broadleaf crops with new, post-emergence "grass" herbicides is now possible. The remainder of this paper provides examples of developing weed-management systems to fit specific situations.

## WEED MANAGEMENT PROGRAMS

The major techniques or tools employed in cropping systems, both conventional and no-tillage include: (1) crop rotation, (2) crop competition, (3) mechnical tillage, (4) biological and predator control and (5) herbicides (Lewis and Worsham, 1981; McWhorter and Chandler, 1982).

These tools are discussed as they are employed in both conventional and no-tillage systems.

No-tillage systems have the same requirements for economic and effective weed control as do conventional tillage systems. The major difference is that more burden is placed on chemical methods of weed control. In most reduced- and in a11 no-ti1lage systems, herbicides must be relied upon for preplant, preemergence and postemergence control of weeds. Tillage after planting is rarely an option.

Thus, the essential components of weed management in these cropping systems consist of (1) control of existing vegetation at planting, (2) residual weed control and (3) postemergence weed control.

Use can be made of crop rotations, crop competition and biological methods to integrate these Components into a total weed management program. There is a delicate balance to the effectiveness of these methods.

<u>Crop Rotation</u>

Specific weed species tend to increase under cultural practices unique to the production of different crops. This is becoming increasingly evident and is an important factor in herbicide-weed-crop associations. Crop rotations must not be overlooked as an important weed-management tool, along with the array of herbicides available, Weaknesses in herbicide programs for specific weeds are much easier to overcome in some crops than in others. For example, weeds such as lambsquarter are more easily and/or economically managed in corn than in soybeans, peanuts or cotton. Large-seeded, broadleaf weeds such as cocklebur, morningglory and sicklepod can be controlled at three different times during the life cycle of corn, whereas only postemergence applications can be used effectively in soybeans. Timing is critical and crop tolerance may be marginal (Lewis and Worsham, 1981). Deep-rooted, broadleaf perennials such as trumpetcreeper, bigroot morningglory and horsenettle can be managed in corn but not soybeans.

Rotating crops helps prevent the build-up of problem weeds. Equally, if not more important, the herbicides also will be rotated in crop rotation. Perennial crops such as some hay crops, fruits, permanent pastures and rangelands are not rotated as frequently as annual crops, but some of these can be intermixed into long rotation sequences (Aldrich, 1984).

Rotations are similar in reduced- and no-tillage systems. Exceptions exist where a heavy residue mulch or a killed living mulch may interfere with planting or introduce other undesirable factors. For example, the widely held view of crop specialists has been that peanuts cannot be planted and grown successfully without tillage before planting to bury plant residues. Traditionally, burial of all plant residues has been recomnended as a means of reducing disease and insect problems. However, experimental work in at least four Southeastern states has been successful in planting peanuts into various kinds of mulches and residues (Worsham, 1985). In double- and triple-cropping, no-tillage is beneficial because crops in the sequence can be planted sooner with less loss of land use, soil moisture, time and labor.

Crop Competition

Just as weeds compete with crops for light, nutrients, water and space, crops also compete with weeds. A grower can increase crop competitiveness appreciably by planning well to encourage it. This is possibly the most overlooked weed management tool. Crop competitiveness is increased by using combination of production practices to maximize vigor of the plant. Shading of weeds by the crop is an important factor. High-quality seed of vigorous cultivars, proper fertilization and liming, effective disease and insect control, narrow row spacing and timely planting are all important in giving the crop an advantage over weeds. Cultivars may also vary in their competitiveness through rooting habits and morphological characteristics that provide dense shade. The sooner the crop canopy closes the better the weed control with or without herbicides (Lewis and Worsham, 1981; Klingman and Ashton, 1982; Aldrich, 1984).

Many weeds interfere with crop growth through allelopathic effects. Some crops are allelopathic against weeds, but cultivars vary in their allelopathic effects on some weeds (Putnam and DeFrank, 1983; Radosevich and Holt, 1984; Rice, 1984).

Use of production practices to promote fast emergence, rapid growth and vigorous crops to shade weeds is common to all cropping systems. No-tillage systems may be at a disadvantage in certain years because crops planted in killed cover crops, heavy infestations of weeds or in fields with large amounts of previous crop residue usually emerge and grow more slowly during the first few weeks after planting. This is due to slower warming of soil in spring where a mulch cover is present and in years when it is dry at planting time the soil is drier where a living mulch is present as compared to a tilled field. The crop seedlings may be shaded during emergence if the mulch is excessive. However, the cover suppresses seedling weed development as well, Other factors influencing germination and early growth rates may be a temporary nitrogen deficiency and phytotoxic by-products of plant residues and microorganism decomposers (Putnam and DeFrank, 1983).

Mechanical

The major difference in mechanical weed-manaqement methods between no-ti1lage and conventional tillage systems is during primary and secondary cultivations. In conventional systems, tillage operations not only remove weeds to provide a weed-free seedbed, but also control weeds after the crop emerges. Limited postemergence tillage is possible in some reduced-tillage systems, but it is not possible with no-tillage culture, Exceptions include tillage with sweep cultivators in double-crop soybeans following small grain harvest where little or no straw residue remains. Ground driven rotary cultivators can be used if moderate amounts of residue are present. Some equipment manufacturers however, now advertise cultivation equipment designed to operate in "no-tillage" systems. All of these factors put heavy pressure on the herbicide component of weed management for complete control, whether preplant, preemergence or postemergence.

Biological and Predators

There are several outstanding examples of controlling weeds with other organisms. These have, in the past, included release of phytophagus insects and, more recently, use of fungal plant pathogens in a "bioherbicide" or "mycoherbicide" approach. The former has worked best in large areas infested dominantly with one weed species, the latter on selected weed species in row crops and orchards (Klingman and Ashton, 1982), Crop rotation, crop competition and crop allelopathy also are forms of biological control, These methods should be equally effective in conventional or no-tillage cropping systems,

Chemical

Weed-management systems for reduced- and no-ti1lage place great reliance upon the chemical component., The herbicide (or combinations of herbicides) must kill existing vegetation at time of planting (whether a living cover crop or weeds) and retain enough residual preemergence activity to provide control as necessary and often herbicides must be available for post-emergence control.

Lower herbicide rates or band treatments may be used in some instances to give growers temporary retardation of growth of existing vegetation (weed or crop) to permit establishment of an interplanted crop. Examples include the planting of small-seeded legumes into grass pastures, grasses into legumes and corn into coastal bermudagrass, tall fescue or other forage grasses. The success of reduced tillage systems requires keen and complex managerial decisions on the part of the grower,

## WEED ECOLOGY IN NO-TILLAGE

Problem weeds are simply defined as those not adequately controlled by currently available techniques or that require difficult and/or expensive methods. The list changes with time, geographical location and crop grown.

When both tillage and herbicides are used for weed control, the list of problem weeds is shortened. As either practice is reduced, the number of weeds causing problems often increases because of inadequate control (Witt, 1984). Most surely, weeds that are troublesome where both tillage and herbicides are used will become more so as tillage is lessened. With continued herbicide development, this list of problem weeds will diminish.

Eliminating tillage causes shifts in weed species present (Triplett and Lytle, 1972). Perennials, such as poison ivy, horsenettle, trumpet creeper and tree seedlings that are readily controlled by tillage, become established and persist in untilled fields. Weeds botanically related to the crop and others that escape control increase in number to become a dominant problem. A classic example of this developed in the United States when atrazine was introduced to control weeds in corn. At first, atrazine controlled most annual weeds found in corn fields. Fall panicum, never a problem weed before atrazine was widely used, tolerates atrazine and increased dramatically in continuous corn. Coupled with reduced cultivation, fall panicum pressure rendered atrazine inadequate as a sole herbicide in corn. A similar situation was brought about in the Southeast and Midsouth with nutsedge. As growers shifted to more herbicide use and less cultivation, nutsedge became a severe problem in crops. Within weed species, biotypes that tolerate herbicides have appeared. Biotypes of pigweed and lambsquarter resistant to atrazine have been identified and have become problem weeds in parts of the U.S. and Canada (Bandeen, et a1., 1982). Fortunately, these species are susceptible to several other herbicides and can be controlled.

A rather recent, encouraging development in weed ecology in no- or reduced-tillage systems is the discovery that many annual broadleaf weeds are suppressed if mulches, especially small grain cover crops, are left on the soil surface (Liebl and Worsham, 1983; Putnam and DeFrank, 1983; Shilling, et al., 1985). This beneficial effect, largely due to allelopathic interactions, can help suppress difficult-to-control annual broadleaf weeds in many broadleaf crops and possibly reduce the need for post-emergence herbicide applications.

## INDIVIDUAL COMPONENTS OF THE SYSTEM

### Existing Vegetation Control

Complete control of existing vegetation at planting is essential before crop emergence in no-tillage systems, except in cases where one crop is interplanted into another without tillage (Anonymous, 1983). This vegetation control is accomplished mainly with a quick-acting, contact herbicide, such as paraquat, or a slower-acting, translocated herbicide, such as glyphosate, In rare instances in the Southeast of sparse populations of very small annual weeds, residual herbicides with contact activity, such as cyanazine, atrazine + crop oil, linuron or metribuzin, might be used satisfactorily at planting without a contact herbicide.

Analysis of the weed spectrum and stage of growth before and at planting is essential for the grower to determine the herbicide and rate required to control the weeds most effectively and economically. Different situations frequently dictate different treatments. For example, no-tillage corn planting may be made into perennial grass or legumes sods, annual cover crops (grasses or legumes), annual broadleaf and grass weeds and a few perennial broadleaf and grass weeds. No-tillage soybeans have not been recommended up until now even when low infestations of perennial weeds are present. However, the availability of new postemergence herbicides now makes possible the control of perennial grass weeds in some broadleaf crops.

Residual Control

Herbicides used for residual control of annual weeds in reduced- and no-tillage cropping systems are essentially the same as those used in conventional tillage systems where similar weed species and populations are present. One exception is the use of a herbicide that must be soil incorporated (most dinitroanilines and thiocarbamates) and cannot be used with no-tillage or where large amounts of crop residues remain on the soil surface. However, research is underway to develop methods of applying these herbicides with no-tillage. Many preemergence herbicide labels and accompanying literature give directions for shallow soil incorporation when moderate amounts of surface mulch are present. This allows use of these herbicides while maintaining enough cover to control soil erosion.

Postemergence Control

Controlling weeds with postemergence herbicides in reduced- and no-tillage crops differs little from methods and chemicals used in conventional tillage systems. An array of herbicides that are applied postemergence to the crop and weeds is available for use in most agronomic crops. In no-tillage systems there generally is more reliance on postemergence herbicides. They are invaluable tools in controlling escaping weeds or those tolerant to preemergence applications. Postemergence herbicides also may be the primary means of controlling weeds that escape other treatments.

Available herbicides vary in selectivity for crop and weeds, application requirements, crop safety and effectiveness on small and large or annual and perennial weeds. Postmergence treatments in most crops consist of early-postmergence, over-top sprays--strictly directed sprays (directing the spray on small weeds under the crop and keeping spray off the crop foliage) and semi-directed sprays (directing the spray toward the base of the crop plant with some of the lower crop leaves being contacted).

The crop must tolerate rates of over-top sprays that control weeds present. Examples include atrazine and oil for small annual weeds in corn and sorghum; cyanazine for corn not beyond the 4-leaf stage; 2,4-D and dicamba for broadleaf annual and perennial weeds in corn and sorghum; sethoxydim and fluazifop for annual and perennial grass weeds in soybeans and cotton; bentazon and acifluorfen for small broadleaf weeds in soybeans and DSMA, MSMA or flumeturon for small broadleaf and grass weeds in cotton.

Selectivity for non tolerant crops is gained by directing the spray so that it touches only the base of the crop. This is accomplished by mounting spray nozzles on a rigid shank, a sliding or rolling support and/or having shields to cover the crop. To be used effectively, a height difference between crop and weed is necessary. Examples include DSMA, MSMA, fluometuron, diuron, cyanazine, linuron, dinoseb and oxyfluorfen in cotton; linuron, 2,4-DB, metribuzin, dinoseb and paraquat for grass and broadleaf weeds in soybeans and ametryn and linuron for corn. These and similar herbicides act mainly through contact activity and defoliate small weeds (and crop too if the foliage is sprayed). Directing sprays may be more difficult in no-tillage fields, if tall crop stubble (such as in double-crop soybeans, where the small grain was cut high) or if tall, dead weeds are present. Unless the crop is shielded with some type of fenders, splashing of the chemical onto the crop could occur. Examples of semi-directed sprays are 2,4-D and dicamba on larger corn. At this time, weeds need to be smaller than the corn for effective results. A listing of weed species controlled, timing, method of application and crop safety considerations are found on the label of each herbicide.

Postharvest Control

In many situations, especially where perennial weeds are present, an additional time of weed management treatment is after harvesting the crop. Here applications of translocated herbicides such as glyphosate, 2,4-D, or dicamba can be used for control of perennial grass and, for the latter two herbicides, perennial broadleaf weeds. This treatment is especially useful in crops that are harvested relatively early such as short-season corn for grain, corn for silage and tobacco.

## HERBICIDE SYSTEMS

Successful no-tillage crop production requires adequate weed control. This consists of kill of existing weeds or cover crops at time of planting, residual control of broadleaf and grass weeds and/or postemergence chemical control and occassionally after-harvest treatment. The system actually now consists of a series of weed management decisions or options at each of the above mentioned crop stages. We will discuss situations and requirements at each of these stages in general terms, then give specific weed situations and weed management options.

Formulating the System - Weed Management Options

The aim of the no-tillage grower is to match herbicide capabilities with weed species present or expected and crop grown to meet the requirements set forth earlier as to weed management. With the number of herbicides and herbicide combinations now available to the no-till grower, weed management is largely a series of options or decisions at several stages in the life of the crop. The following section gives examples of weed management options in corn and soybeans in the Southeast.

## No-Till Corn

A. Situation at Planting

| Situation at Planting | Management Option |
|---|---|
| 1. Small annual grass and broadleaf weeds less than two weeks old | Paraquat, glyphosate, or cyanazine plus residuals |
| 2. Horseweed | Glyphosate or 2,4-D |
| 3. Small annual grass and broadleaf weeds plus a few large perennial broadleaf weeds | Glyphosate or cyanazine plus 2,4-D plus residuals |
| 4. Small grain cover crop | Paraquat or glyphosate plus residuals |
| 5. Alfalfa or legume cover crops | Paraquat plus dicamba or glyphosate plus dicamba 7 days before planting plus residuals or dicamba after corn emergence |

B. Possible Combinations at Planting for "Knockdown" and Residual Control of Summer Annual Broadleaf and Grass Weeds

1. Paraquat plus alachlor plus atrazine
2. Paraquat plus metolachlor plus atrazine
3. Paraquat plus atrazine plus simazine
4. Glyphosate plus alachlor plus atrazine
5. Glyphosate plus metolachlor plus atrazine
6. Glyphosate plus atrazine plus simazine
7. Glyphosate plus alachlor plus simazine
8. Premix formulation of glyphosatelalachlor plus atrazine
9. Premix formulation of glyphosate/alachlor plus cyanazine
10. Premix formulation of glyphosate/alachlor plus atrazine plus cyanazine
11. Premix formulation of glyphosatelalachlor plus simazine
12. Cyanazine plus 2,4-D plus alachlor plus atrazine
13. Cyanazine plus atrazine plus alachlor or metolachlor

C. Early Postemergence Over Top (Corn Eight Inches Tall or Less)

For Broadleaf Weeds:
1. 2,4-D
2. Dicamba

D. Postdirected or "Lay-By"

| | |
|---|---|
| 1. Annual grasses | Ametryne or linuron plus surfactant |
| 2. Annual broadleaf weeds | 2,4-D, dicamba, ametryne plus surfactant or linuron plus surfactant |
| 3. Annual grass and broadleaf weeds | Ametryne plus surfactant or linuron plus surfactant |
| 4. Sicklepod | 2,4-D plus surfactant, dicamba, ametryne plus surfactant or linuron plus surfactant |

5. Perennial broadleaf weeds — 2,4-D plus surfactant or dicamba

E. After Harvest

1. Johnsongrass — Glyphosate

2. Perennial broadleaf weeds — Glyphosate or 2,4-D plus dicamba

No-Ti 11 Soybeans

A. Weed Management Options at Planting for Control of Existing Weeds

1. Small annual grass or broadleaf weeds — Paraquat, glyphosate or glyphosate/alachlor premix

2. Horseweed plus perennial broadleaf weeds — 2,4-D four to six weeks before planting, glyphosate/alachlor premix

B. At Planting for "Knockdown" Plus Residual Control (an option would be to use the "knockdown' herbicide and rely on postemergence herbicides for annual grass and broadleaf control and perennial grass control!.

1. Paraquat plus 1inuron or metribuzin
2. Paraquat plus linuron or metribuzin plus alachlor
3. Paraquat plus 1inuron or metribuzin plus metolachlor
4. Paraquat plus oryzalin
5. Paraquat plus oryzalin plus linuron or metribuzin
6. Glyphosate plus alachlor plus linuron or metribuzin
7. Glyphosate/alachlor premix plus 1inuron
8. Glyphosate plus metolachlor plus 1inuron

C. Postemergence Over Top

1. For annual grasses and johnsongrass — Sethoxydim or fluazifop

2. For annual broadleaf weeds — Bentazon, acifluorfen, bentazon plus acifluorfen, 2,4-DB (late Post)

3. For annual grasses and broadleaf weeds — Bentazon plus sethoxydim, acifluorfen plus sethoxydim, bentazon plus aciflurofen plus sethoxydim, acifluofen plus fluazifop

D. Postemergence Directed (for annual broadleaf and grass weeds)

1. Linuron
2. Metribuzin
3. Linuron plus 2,4-DB (sicklepod)
4. Paraquat

E. Postemergence with Wick Applicator

| | |
|---|---|
| For grasses and certain broadleaf weeds taller than the soybeans | Glyphosate |

## SUMMARY

The single factor that kept the idea of no-tillage crop production from becoming a reality much sooner - control of vegetation at planting and of weeds - is still the major factor reported as limiting expansion and adoption of no-till and causing grower problems. Much progress has been made, however, in the last decade in making new, chemical options available to the no-till grower. These herbicides plus use of the traditional weed control tools of crop rotation, crop competition, and biological control now make possible weed management in no-till crops under a wide variety of different situations. Probably the main limiting factor among growers is the managerial ability of making decisions on the many options now available to manage weeds in their no-till crops.

Weed management is now largely a series of options or decisions at several stages in the life of the crop. For example, at planting the grower must chose the most effective and economical of several alternatives for weed and/or cover crop kill. He can use a contact herbicide, a translocated herbicide, or a residual herbicide with contact activity - all depending on the situation. Also at planting, there are a great number of premergence herbicides and combinations of herbicides available to control annual broadleaf and grass weeds. Again the choice depends on weeds expected to be present. We know that leaving a mulch of cover crop residue, especially small grains, on the soil surface suppresses many broadleaf weeds and more than makes up for any preemergence herbicides retained in the mulch.

There are a number of herbicides for over-top treatment in soybeans that will control annual broadleaf weeds and perennial and annual grasses; and in corn and sorghum, annual and perennial broadleaf weeds. There are postdirected herbicides for use in corn, cotton, soybeans, and sorghum for control of annual broadleaf and grass weeds. Escaped perennial grasses and certain annual broadleaf weeds can be controlled after they get taller than a soybean crop by use of recirculating sprayers or wick applicators. An additional time for attacking many perennial broadleaf and grass weeds, especially if a no-till crop is to follow the next year, is after harvest of a shorter-season crop.

With the many management options now made possible by a wide variety of herbicides, weed management in no-till crops, even hard-to-control weeds, many perennials and weed population shifts, can be handled by making the proper management decisions.

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