

MESA REDONDA I.1

GENERAL ASPECTS OF WEED MANAGEMENT IN NO-TILL PLANTING

Thomas T. Bauman*

*Purdue University, Botany and Plant Pathology Department, West Lafayette, IN, USA, 47907-1155.

The problems of soil erosion and soil degradation are two of the biggest problems facing agriculture sustainability world wide and threatens our ability to produce abundant and affordable food for a world population that is expected to double in the next 50 years. In 1984, World Watch estimated that 23 billion metric tons of soil was being lost from crop lands in excess of new soil formation. If soils are allowed to erode, crop productivity suffers and if we are not able to maintain high levels of output, we will be forced into creating marginal agricultural land from forests and other areas to produce food. In addition to impacting crop productivity, sediment from erosion has negative impacts on water quality and wildlife habitat.

While crop residue management for control of erosion began in the 1930's and 1940's, modern no-till planting is only about 30 years old. Today, the switch from conventional moldboard tillage to no-till is occurring faster than the switch from the horse to the tractor. From 1960 to 1995, the number of no-till hectares in the United States has grown from just a few to 17.5 million. The switch from conventional moldboard tillage has been fueled by the public's concern about excessive soil

erosion and made practical by the introduction of effective herbicides.

Significant progress in chemical weed control was made in the late 1950's when atrazine was introduced. Farmers still had to rely on secondary tillage operations to control weeds because of the lack of effective herbicides. The inability to control weeds was the major reason for farmer reluctance to adopt no-till. In 1970, Chevron Chemical Company made an aggressive no-till promotion which was centered around paraquat as a burndown treatment, and is credited with starting the rapid adoption of no-till systems. Herbicides introduced in the 1980's provided better weed control, and some farmers began to use no-till in their crop production systems. Postemergence herbicide programs for both *Zea mays* (corn) and *Glycine max* (soybeans) are now available which allow farmers to comfortably adopt a complete no-till program.

The success of modern no-till planting also required better planting equipment. In 1966, a 5-cm wavy coulter was introduced by Allis Chalmers which provided a method for preparing a narrow seed bed that allowed the planter unit to function properly. The replacement of the planter

shoe with double disk openers, improvements in coulter design, seed drop mechanisms, and no-till drills occurred in the 1970's and 1980's and lead to improved planting in no-tillage situations. By the mid 1980's, the stage was set for no-till adoption .

Incentive for the adoption of no-till in the US was further introduced in 1985, when legislation was passed which stated that farmers could lose government farm program benefits if they did not comply with HEL (Highly Erodible Land) provisions of the 1985-1990 Farm Bill. This act of the United States Congress persuaded some farmers to switch from conventional tillage to no-till.

No-till farming methods are used on 35 million hectares worldwide. Two thirds of the no-till hectares are in North America (17.5 million ha in the United States and 6.1 million in Canada). Other areas of the world which utilize no-till are Brazil (5.3 million ha), Argentina (2.5 million), and Australia.

By the year 2000 it is predicted that no-tillage in *Triticum spp.* (wheat), corn, soybeans and *Oryza sativa* (rice) will grow to 62 million hectares. The areas expected to experience the greatest growth in the adoption of no-till practices are South America, Western Europe, Australia and South East Asia.

The number of no-till corn hectares in the United States has doubled in the last 5 years, from 8 to 18 percent of all planted hectares. In the United States., no-tillage is practiced on 8.3 million hectares in the Corn Belt, 2.3 million hectares in the Northern Plains, and 1.9 million hectares in the Appalachian region. The top ten no-till corn states are: Iowa, Illinois, Nebraska, Indiana, Ohio, Missouri, Kentucky, Michigan, South Dakota, and Wisconsin.

The largest increase in no-till over the last 5 years, has been seen in the number of no-till soybean hectares. In 1991, the

number of no-till soybean hectares surpassed the number of no-till corn hectares for the first time. The top states for growing no-till soybeans are: Illinois, Indiana, Iowa, Ohio, Missouri.

Last year, farmers in the United States continued to increase the number of no-till hectares more than ever (+1.7 million hectares), but the use of the moldboard plow is also increasing (+1.4 million hectares). Several million hectares of land were returned to crop production this year after having been idled by farmers receiving government payments to reduce crop surpluses. The main reasons attributed for the increase in heavily tilled hectares was to repair damage left by flooding or to break up heavy grass and weed infestations that had developed after years of lying idle. In the United States, 45 million hectares (39% of all planted hectares) are heavily tilled prior to crop planting.

In a no-till system, the soil is left undisturbed from harvest to planting except for nutrient injection. Planting or drilling is accomplished in a narrow seedbed or slot created by coulters, row cleaners, or disk openers. Coulters are also used for fertilizer placement. Weed control is accomplished primarily with herbicides, but cultivation may be used for weed control if necessary.

The advantages of no-till farming include: 1. lower input and equipment costs, 2. reduced soil erosion due to wind, water, and tillage, and 3. reduced labor costs. Some of the obstacles to successful no-till farming include: 1. slow soil warm-up due to high levels of crop residue, 2. the need for coulters to be added to planters and drills, 3. dependence on herbicides as the main source of weed control, 4. high levels of weed management are essential, and 5. fertilizer application and placement difficulties.

Zone-till and strip-till systems have been introduced in an attempt to speed soil

warming. These tillage systems are a modification of no-till where crop residue is removed from the planter row. If less than 25% row width is disturbed, it is considered no-till.

Some of the advantages of strip tillage include: 1. warmer, drier and less dense soil in row at planting, which allows more uniform seed placement, improved seed-to-soil contact, and reduced allelopathy, and 2. more vigorous early rooting, which promotes earlier crop maturity and increased yields.

Input costs for no-tillage systems are lower than tillage systems which include chisel or moldboard plowing. Much of the decrease can be attributed to reduced costs in seedbed preparation. Fewer field operations result in reduced costs. Fuel costs can often be reduced by 50 percent and similarly labor costs can be reduced by 40 percent. A reduction of 15 percent in total production costs per acre can be realized from the use of a no-tillage systems.

Herbicide costs may be higher initially due largely to the cost of burndown herbicides, but it usually decreases to the point where costs are similar to conventional system with time. As a rule, both product and rate of application for broadleaf and grass control treatments are the same for both conventional and no-till. If the presence of crop residue causes an increase weed pressure, the farmer needs to adjust the herbicide program to fit the tillage system. Tillage does provide some weed control and offers the farmer greater herbicide flexibility and perhaps some economic savings in weed control. Tillage also often provides very economical control of many perennial weeds with tap roots.

The amount of crop residue present in a field prior to tillage depends upon the previous crop and its level of production. Corn generates more residue than soybeans; thus, it is easier to maintain higher residue levels with a variety of

tillage systems after a corn crop. Corn, however, has a low tolerance for cool and wet conditions associated with high levels of crop residue. Therefore, to successfully grow continuous corn, some tillage is required for residue incorporation. A corn-soybean rotation generates less residue and allows greater tillage flexibility. Little residue exists following a soybean crop, and no-till corn often performs well in this system.

No-tillage systems require state of the art planters that are capable of providing good seed to soil contact and good crop stands. Row cleaning devices that remove residues from a 15 to 25-cm band over the row may improve stand establishment, early plant growth, maturity and yield of corn in no-tillage systems. Matching planting equipment with desired tillage system is very important.

Economic risk is increased as less tillage is performed especially for continuous corn. Delayed crop development and reduced yields often occur in wet and cool years. Risk is a factor that needs to be strongly considered by crop producers considering a change in tillage system. The risk of reduced yield, which increases costs, is higher for no-till because of less opportunities to correct previous mistakes.

Some of the risks and possible solutions for no-till systems include: 1. reliance on herbicides for weed control-(choose proper herbicide and application method), 2. interference of crop residue and vegetation with herbicide performance and/or sprayer pattern-(increase herbicide rate, proper timing of herbicide application, and maintain proper sprayer boom height), 3. difficulty in obtaining uniform seeding depth and seed-to-soil contact-(reduce planting speed, increase seeding rate, allow soil to dry before planting), 4. greater pest problems disease and insect rodent-(scout fields), 5. fertilizer placement-(knife in nitrogen, increase nitrogen rate if surface applied, inject or band potassium

and phosphorous into root zones), 6. wet soil under residues-(delay planting or use cover crop).

Some other advantages of no-till which help offset risks include: 1. more timely planting, 2. moisture conservation due to reduced soil drying, 3. lower rates of soil, fertilizer, and pesticide loss due to erosion, 4. less crusting of the soil after planting, 5. increased levels of soil organic matter and tilth, and 6. firmer soil conditions at harvest.

Indiana is located in the Eastern Corn Belt of the United States and has been a leading state in the adoption of no-till production. In Northern Indiana, continuous no-till corn plantings may have a yield disadvantage when compared to full-width tillage systems, especially when crop residue levels are high and soil drainage is poor. Early planting, uneven residue distribution, or uneven soil surface all contribute to reduced stand, uneven emergence, slow early growth, and delayed crop maturity. Grain yields of continuous no-till corn are often 14 percent lower than continuous conventional till corn. In contrast, grain yields of no-till corn, grown after soybeans, are only 3 percent less than conventional till corn after soybeans.

The use of strip tillage significantly increases soil temperature and improves growth, maturity and yield of continuous no-till corn. The effect of strip tillage on corn growth and maturity is less when corn is grown after soybeans. Strip tillage is usually not beneficial where traditional no-till is successful and may be of limited value when corn is grown in rotation with soybeans.

The time required for soils to warm is related to north-south location of the site in Indiana. Soils in Southern Indiana warm earlier and thus are adapted to a wider selection of tillage than soils in Central and Northern parts of the state. Soil temperatures measured 4 weeks after planting, are often higher in a no-till

system in Southern Indiana than in a moldboard plow system in Northern Indiana. The rapid warming of soils favors conservation tillage in Southern Indiana. Greater mulch cover also provides crops additional moisture during midsummer droughts that often occur in Southern Indiana.

No-till is also well adapted to well drained soils of Central and Northern Indiana even when planting into heavy corn residues. It is best adapted on soils that are sloping enough to dry in spring or on coarse textured soils with low organic matter.

Soybeans are less affected than corn by cool soil temperatures because soybeans: 1. have its growing points located above the soil surface, 2. tend to be planted later in the season after the soils have had time to warm, and 3. take up most of their potassium and phosphorus late in the season so nutrient uptake and subsequent early crop growth is less affected by the cool, moist conditions that exist in early spring.

Crop rotation has a huge influence on crop yield. Corn and soybean yields both tend to be 5 to 10 percent higher when they are grown in rotation with another crop. The yield penalty for cropping is greater in no-till than with other tillage systems. The higher yields obtained when crops are rotated may result from a decrease in disease and insect infestations, elimination in the release of toxins from decaying crop residues which inhibit seed germination, and improved weed control due to the use of a broader spectrum of herbicides.

The development of and advances in narrow row technology has been key for the successful adoption of no-till soybeans in Indiana. Nearly 95 percent of all no-till soybeans are planted in rows 25-cm or less wide and over three quarters of the double crop soybeans are planted using some type of no till system.

Why have narrow row soybeans become so popular?

1. Soybean yield 20 percent more when grown in narrow rows (<38-cm) instead of wide rows (76-cm). Soybeans planted in narrower rows are more efficient in intercepting and utilizing of sunlight than in wide row planting. The advantage for narrow row soybeans increases the farther north they are planted in the state.
2. No-till equipment has been designed to plant seed in almost any crop residue condition. The drill prepares seedbed for planting, then places the seed accurately at the desired depth, and then covers the seed to ensure seed-soil contact.
3. Narrow rows can significantly reduce weed pressure. The canopy closure of narrow row soybeans will occur approximately 35 days after planting, while it may take up to 75 days for the canopy of wide row soybeans to close. Canopy closure prevents sunlight from reaching emerging weeds. Also, the number of soybean plants associated with narrow row systems is higher, which allows them to compete better than wide row soybeans with weeds for nutrients and soil moisture. Many successful burndown and postemergence weed control programs are available to control weed escapes when necessary.
4. Soybeans are more tolerant to variations in planting population and depth than is corn and do not require starter nitrogen fertilizer.
5. Soybeans can tolerate some wheel traffic during early vegetative growth while not suffering significant yield loss. This is important should a postemergence herbicide application be needed to control late weed flushes or escapes.

Weed Management

Conservation tillage can increase weed management problems by eliminating the

use of tillage from the cropping system. Mechanical cultivation of the soil tends to reduce the presence of established weeds, and control of some weeds can be obtained during seedbed preparation. Weed densities can be reduced as much as 86 percent by a secondary cultivation after corn emergence.

While mechanical cultivation of the soil tends to reduce the presence of established weed, it also creates soil conditions that are ideal for seeds on the soil surface to germinate. The more the soil is tilled, the greater is the weed infestation. Seed germination is stimulated by both covering the seeds lying on the soil surface and by uncovering buried dormant seeds. A good weed management plan is essential for good weed control. Part of such a plan should include steps to prevent weeds from forming seeds.

Under no-till, weed populations tend to change so application methods, types of herbicides, and dosages often differ from those of conventional systems. As a rule, herbicides generally performed better under conventional tillage than under no-tillage.

In no-till most of the organic matter is located in the top 5-cm of the soil. This additional organic matter at the soil surface has implications in selecting a weed control programs. In soils with high levels of organic matter, humus and other organic compounds can interact with herbicides to influence their persistence in the soil, to inactivate them, or protect them from microbial degradation.

The corn yield reduction due to weeds is generally greater in no-till than in conventional tillage. The economic thresholds for early emerging *Abutilon theophrasti* (velvetleaf) ranged from 0.4 to 14 plants/m² in conventional tillage and 0.13 to 3.13 in no-till. Economic threshold value for management decisions is questionable due to variation among growing seasons and weed seed production from subthreshold populations.

Weed management in no-till requires a high level of management skills. Fewer weed control options are available with no-till, and the greater reliance on herbicides requires the farmer to pay greater attention to detail. The type of weeds present; the current, past and future weather trends; cropping sequences; and soil types are all factors which must be considered when developing a weed control program that does not adversely affect the environment.

A successful no-till weed control program requires:

1. The accurate identification of the weeds present,
2. The proper timing of herbicide applications,
3. Scouting and monitoring weed populations in fields to identify problem areas. Weeds which set seed in the fall will be the predominant problem weed the following year. The presence of certain weeds may dictate whether or not no-till planting is a viable option. Fields with low weed pressures are ideal candidates for no-till planting.,
4. Spot spraying herbaceous and woody perennial weeds,
5. Keeping fence rows and field borders free from aggressive weeds, and
6. Assuring even distribution of crop residue after crop harvest.

Traditional weed management tools such as crop rotations and crop competition are still applicable to no-till.

Some weeds are easier or more economical to control in one crop than in another. For example, perennial grasses are difficult to control in corn but can be managed effectively and economically in soybeans and *Gossypium hirsutum* (cotton). The crop rotation sequence also facilitates the rotation of herbicides which have different modes of action. The use of herbicides with various modes of action helps prevent the buildup of problem

weeds, harmful soil residues, and herbicide resistant weeds. Many of the new soybean herbicides have restrictions on rotational crops, so it is important that the herbicide label be carefully read to avoid problems in establishing cover crops or crops the next season.

Without cultivation, crop competition becomes an even more important component in a no-till weed control program. The shading of weeds by a vigorous crop canopy provides substantial control in no-till crops. This effect is especially important for double cropped soybeans and late planted *Sorghum bicolor* (grain sorghum). Quicker canopy closure allows later planting dates and helps reduce weed competition. Special attention should be given to seeding rates and planting depths, since greater weed problems result when crop stands are poor.

Types of herbicide applications

Early preplant herbicide applications need to be made before germination of summer annual weeds occurs. This type of application needs to be made from 10 to 45 days prior to planting of the crop. Application of the herbicides early in the season, when rains are more frequent, insures activation of the herbicides and helps spread out the work load. Fields receiving a timely herbicide application should be free of weeds at planting. This eliminates the need for a burndown treatment. Fields free of weeds early in the season may also prevent infestations of insects, such as the black cutworm that are attracted to weedy fields. Split applications of two-thirds of the labeled herbicide rate early followed by the remaining one-third at planting may be needed to provide season long weed control from preplant treatments of herbicides with medium longevity. Many early preplant herbicides have also have burndown activity on small weeds, so the addition of a crop oil or

surfactant to the herbicide mix improves their control. Early preplant herbicide treatments, with or without burndown herbicides, must provide a weed free field at planting, and several days beyond, to allow the crop to become established without weed competition.

Preemergence herbicide applications are applied at planting time. The addition of a burndown herbicide is required to kill vegetation present at planting. Preemergence herbicides control weeds by affecting germinating seed, so they must be applied at planting time prior to crop emergence.

The success of preemergence herbicide treatments depends on adequate rainfall to activate the herbicide soon after application. Without moisture, herbicide performance suffers. Herbicides that are soil-applied after planting are often preferred over treatments made prior to planting, especially if planters equipped with row cleaners move herbicide treated soil from the row to the row middles, which creates weed problems in the untreated zone.

Two types of preemergence programs are available: 1. full season preemergence program where the herbicides provide weed control throughout the growing season, and 2. a preemergence program where a herbicide with limited residual activity is used to provide early season control. Control of weed escapes is provided by the application of a postemergence herbicides or by crop competition.

Postemergence herbicide applications: No-till became more dependable with the introduction of good postemergence herbicides that controlled weeds after they had emerged. Without the discovery of postemergence herbicides no-till would have been impossible. Postemergence herbicides are most effective when applied to actively growing weeds when the soil moisture is good. Timing of application is critical for good results.

A Typical no-till program

Weed management in crops planted by the no-till method depends almost entirely on foliar and surface applied herbicides, because seed bed preparation is eliminated and cultivation cannot be utilized. In most no-till cropping systems, a mixture of a burndown herbicide plus one or more residual herbicides is normally used. The burndown herbicide kills both emerged grass and broadleaf weeds and any cover crop present at or before planting.

The introduction of the over-the-top grass herbicides in the 1990's had a major impact on no-till corn. These herbicides finally allowed no-till or conservation-till corn to be planted into *Sorghum halepense* (johnsongrass) infested fields. Control of other weeds obtained with standard surface applied herbicides can be used at planting, or a total postemergence program to control all the weeds in corn may be used.

No-till and conservation tillage systems rely heavily on herbicides to provide weed control, but the introduction of additional postemergence herbicides will allow applications on a as needed basis instead of a routine applications of a soil applied herbicide at planting.

Increases in organic matter in no-till help improve soil structure. The upper 2 to 5-cm of the soil will become more crumbly because of the additional organic matter and the effects of plant roots. The layer of soil beneath this becomes firmer, and adequate moisture, root channels, or earthworm holes must be present for plant roots to grow through this layer.

Summer storms produce less runoff from fields farmed with continuous no-till corn than from the same soils farmed with conventional tillage practices. The absence of tillage favors a continuous surface cover of crop residue and earthworm burrows, which have been shown to be preferential flow paths for water and chemicals,

especially during intense summer storms. Rainfall amount and intensity as well as antecedent soil moisture content affect the amount of water transmitted through earthworm burrows. High intensity storms on relatively dry no-till soils produce the greatest amounts of preferential flow.

Pesticide contamination problems most frequently involve those pesticides which are persistent or very mobile in the soil. Even relatively immobile pesticides can move rapidly to depths due to preferential flow paths which bypass the soil matrix. The factors that influence preferential flow, determine herbicide movement in the soil. Tillage systems seem to have little effect on herbicide movement. Herbicide movement via preferential flow can be expected to be greatest when high-intensity rainfall occurs shortly after application. Herbicide movement is less when rainfall is delayed or when low-intensity events precede a high intensity, percolate producing rain.

Tillage systems were found not to affect the dissipation rates of clomazone, imazaquin and imazethapyr when applied preemergence or preplant incorporated to conventional and reduced tillage soybeans. Herbicides that were incorporated, however, dissipated more slowly than those applied to the soil surface.

Cover crops

It was once thought that no-till production would require the use of more herbicides. But this may not be true. There has actually been an overall reduction in total herbicide use due to regulations and the advent of new herbicides that are used at lower rates. The use of preemergence herbicides may be reduced in some crops by planting no-till crops into good cover crop mulches.

The benefits of cover crops include: 1. provide control of wind and water erosion,

2. conserve soil moisture by reducing evaporation and increasing infiltration, 3. increase soil organic matter and improve soil structure, 4. increase fertility by recycling nutrients and provide nitrogen, if the cover crop is a legume.

Secale cereale (rye) has the ability to produce high biomass production of shoots and roots, its winter hardiness and the phytotoxicity of its allelopathic residues make this grass crop very effective in no-tillage cropping as a cover crop that also provides weed control. It is possible for an undisturbed small grain mulch to provide 75 to 80 percent early season control of a number of annual broadleaf weeds.

The duration of weed suppression by rye cover crop closely follows the disappearance of certain allelochemicals (diboa, diboa-glucosida and boa) from rye residue more than the disappearance of the residue itself. Postemergence herbicides will probably still be required for most crops, but if needed, are usually used at much lower rates than preemergence herbicides.

There are some problems associated with the use of cover crops: 1. the cost of cover crop establishment, 2. difficulty in killing the cover crop prior to planting, 3. leaching of nitrates, 4. lower soil temperatures in spring, 5. depletion of soil moisture in the spring, 6. unknown effects of releasing natural phytotoxins into the environment, 7. increase severity of insect, disease or rodent pests and 8. undesirable effect on the crop.

Management practices call for killing the cover crop with a non-selective herbicide 2 to 3 weeks prior to the planting the summer crop. This should eliminate problems with pests such as cutworms. The use of coulters or trash whippers on the planter to remove cover crop residue from the row reduces pest problems and improves early season crop growth. Annual weeds that are suppressed for about 4 weeks would not compete effectively with

corn and do not affect yields. The early season weed suppression by cover crops compliment the effectiveness of reduced rate herbicide programs. Weeds not suppressed by the cover crop will require the use of herbicides.

Genetically altered crops

The release of genetically altered crop varieties which have been altered to be tolerant to herbicides that they were previously sensitive has provided a powerful new weed management option. The development and marketing of some of these new crop varieties should make the control of some difficult to control weeds easier in conservation and no-till cropping systems. The introduction of corn lines tolerant to imazethapyr, sethoxydim, glufosinate, and glyphosate will enhance our ability to manage difficult weed complexes. Soybeans also have been modified to allow the use of glufosinate and glyphosate, and to tolerate higher rates of chlorimuron-ethyl and thifensulfuron. Other crops are also being modified to tolerate previously non-selective herbicides. The anti-synthetic pesticide forces, however, are mounting increasing opposition to this approach. If the labeling of foods containing genetically altered crops with foreign DNA is required this may negatively affect the adoption of this new technology.

The number of new herbicides reaching the market in the 1990's will likely be reduced. But the herbicides that are introduced will be used at extremely low rates and will be more environmentally acceptable.

Weed shifts

Species composition and population densities of weed communities reflect agronomic practices. The reduction or

elimination of tillage produces changes in the environment where weeds are managed, survive and reproduce. Major changes in weed population dynamics can result from a shift in tillage systems that include extensive annual soil disturbance to systems that minimize soil disturbance. The ecological and managerial aspects of these changes are varied and complex. New weed management systems and control technologies need to be integrated with established weed management practices to develop effective, economical and environmentally sound weed control strategies for the altered ecosystems created by conservation tillage production systems.

Weed population changes often reduce the effectiveness of traditional weed control programs. The ability to manage changes in weed communities is one of the main concerns expressed by producers adopting conservation tillage systems. Some general predictions about weed population dynamics have arisen as tillage is reduced. These include increased populations of biennials, summer annual grasses, volunteer crops, wind dispersed weeds, winter annual weeds, and simple and creeping perennials and the decrease of large seeded dicot species. The expected shifts in weed communities, however, do not always occur. Simple generalizations about weed communities changes are difficult to make.

Weed shifts from annual to creeping perennial weeds which can survive for 3 or more years are of particular importance in no-till systems. Perennial weed populations can increase in reduced and no-till cropping systems, since the plant's root system is not disturbed, and annual weed control practices are usually not effective on established perennial plants. Creeping perennial weeds have vegetative reproduction while simple perennial weeds usually have a perennial crown on a tap root. Because creeping perennials can

spread by vegetative reproduction and/or seed production, it is difficult to eradicate these perennial weeds from a field using only one method of control. It may in fact be impossible to completely eradicate perennial weeds from a particular field.

Creeping perennial weeds such as johnsongrass, *Ellytrigia repens* (quackgrass), *Cirsium arvense* (Canada thistle), and *Convolvulus arvensis* (field bindweed) are problems in conventional till systems and are even more difficult to control in no-till. Less aggressive creeping perennials like *Solanum carolinense* (horsenettle), *Solidago* spp. (goldenrod), *Toxicodendron radicans* (poison-ivy), and *Campsis radicans* (trumpet creeper) are becoming well established in continuous no-till fields. Simple perennials, such as *Taraxacum officinale* (dandelion), *Rumex crispus* (curly dock) and *Phytolacca americana* (common pokeweed) are rarely if ever a problem in conventional tillage systems, however they readily become established in no-till.

The statement that perennial weed populations increase as tillage decreases, must be made with caution. Even if a shift to perennial weed species occurs in reduced tillage systems, minimal increases in weed management will often prevent them from becoming serious pests if control measures that target the perennial weeds are utilized.

Weed seed production can also be affected by tillage systems. *Amaranthus retroflexus* (redroot pigweed) and *Digitaria sanguinalis* (large crabgrass) showed greater seed production in no-till than in till systems. Seedbanks of *Digitaria* were greater in no-till than in till treatment, whereas the seed banks of winter annual weeds were greater when tillage was performed.

Despite weed community changes, crop yields in conservation and no-till were generally equal or greater than that of conventional tillage. When a given weed was associated with one tillage system, it

was often present in other tillage systems but at lower densities; therefore, the herbicides used were generally the same within a crop for each tillage system.

Stands of both *Apocynum cannabinum* (hemp dogbane) and *Convolvulus arvensis* (field bindweed) were found to increase under no-till conditions. Field bindweed was found primarily in corn-soybean rotations and hemp dogbane was found in continuous corn. *Lepidium densiflorum* (pepperweed), *Lactuca serriola* (prickly lettuce), *Brassica kaber* (wild mustard), *Avena fatua* (wild oats), *Taraxacum officinale* (common dandelion), *Hordeum jubatum* (foxtail barley), *Conyza canadensis* (horseweed), goldenrod and *Setaria faberi* (giant foxtail) all are associated with no-till.

Major changes in weed population dynamics, especially the shift from annual to perennial weeds in no-till often reduce the effectiveness of traditional weed control practices and are particularly important in conservation tillage systems which rely entirely on herbicides for weed control. Poor understanding of weed population dynamics and lack of suitable control alternatives may result in increased herbicide usage in conservation tillage systems.

There are three categories for weed management of perennial weeds: 1. cultural control (crop rotation), 2. mechanical control (tillage), and 3. chemical control (herbicides). Acceptable control of a perennial weed often requires the integration of more than one method of control.

Since complete eradication of a perennial weed is almost impossible, the goal of perennial weed management should be to keep perennial weed populations below economic levels and to prevent its spread within a field and to other fields.

Several factors that influence herbicide control of perennial weeds:

1. Herbicide timing. For herbicide applications to be effective, the perennial weed has to be actively growing and new shoots should be coming from underground parts. If the perennial has been mowed, at least 15-cm of new regrowth is needed before a herbicide application. Fall herbicide applications often provide the best perennial weed control.
2. Perennial weeds should not be drought stressed or frost damaged at time of herbicide application.
3. Selection of the best herbicide and herbicide rate for the situation and crop rotation is essential. Additional spot treatments may be needed.
4. Perennial weed control will be greatest if the field has not been tilled prior to the herbicide application, but tillage might enhance control if done after herbicide application. Tillage might be necessary in emergency situations even in a no-till system.
5. Plan a crop, tillage, and herbicide program that keeps pressure on the perennial weed. Herbicides alone or a single herbicide application will generally not eradicate a perennial weed population.

Often more than one herbicide application, and/or the combination of tillage and crop rotation is required for good perennial weed control. Allelopathic suppression of weeds with a cover crop might be a possible alternative weed management strategy.

6. The use of narrow row spacing of the crop and a good postemergence herbicide program may provide control of perennial weeds in soybeans.
7. Effective control of simple perennial and creeping perennial weeds generally require the use of herbicides which are capable of moving to the underground buds. Glyphosate should be considered for burndown of both perennial grasses and broadleaves and well as for selective control in glyphosate tolerant crops. More than one application per year may be needed.

The control of perennial weeds is still difficult in all crops, and when difficult to control weed are present, no-till planting may not be the best choice. Fields with severe infestation of weeds may not be suited for no-till. Conventional tillage or another conservation tillage system might be better suited for this situation.