IANR Conservation Efforts

The Institute of Agriculture and Natural Resources has a long history of emphasizing soil and water conservation in its teaching, research and extension programs. The Agriculture 2001 Committee stressed the importance of continued emphasis on soil and water management and conservation in the interest of long-term agricultural productivity and quality of life in Nebraska.

Recent IANR programs dealing with ecofallow, other conservation tillage techniques, irrigation scheduling, pumping plant efficiency, and other irrigation management techniques have markedly improved our ability to conserve soil, water and energy resources in production agriculture. Even greater savings are possible, and will become necessary. The new conservation project described in this issue is designed to increase the adoption of existing conservation tillage and water management practices by Nebraska farmers.

The project is jointly supported by the Nebraska Governor’s office, the University of Nebraska Foundation, and the Cooperative Extension Service. The United States Soil Conservation Service and the Natural Resource Districts have cooperated in selection of six target areas and program planning. This project represents a significantly expanded commitment to the conservation of energy, water and soil in Nebraska agriculture.

Research in the Agricultural Experiment Station and the Conservation and Survey Division are further refining and developing production agriculture techniques and systems to better conserve soil, water and energy resources in Nebraska. Faculty of the College of Agriculture and the School of Technical Agriculture at Curtis are integrating new knowledge regarding the conservation practices and systems into their teaching programs.

Conservation and responsible management of the natural resource base which undergirds Nebraska’s agricultural productivity is, and will continue to be, a major area of program emphasis within the Institute of Agriculture and Natural Resources.

Vice Chancellor for Agriculture and Natural Resources .......... Roy G. Arnold
Dean and Director, Agricultural Research Division .......... Irvin T. Omtvedt
Dean and Director, Cooperative Extension Service .... Leo E. Lucas
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Research results of the Nebraska Agricultural Experiment Station are available to anyone regardless of race, color, religion, sex or national origin.
Energy, Soil, Water

Program Stresses Conservation

By Dave Parrish

Try to visualize 100 million tons of topsoil. That's about the amount lost to erosion annually in Nebraska. Soil erosion and subsequent sedimentation is one of the major water quality problems in our state.

U.S. Soil Conservation Service reports, from 1982, indicate that the heavy rains in the spring and summer of that year resulted in $260 million of losses due to soil erosion.

The importance of protecting our soil and water resources, while conserving energy, has been widely discussed in recent years, and has led to the initiation of a new IANR program aimed at the conservation of energy, soil and water through conservation tillage, ecofallow and water management technology.

Water Control Coming of Age

Erosion control programs began in the eastern United States in the late '20s and spread as far west as Nebraska by the early '30s.

"Widespread soil conservation work dates from the 1930's when the federal government began to take a direct hand in conservation. The Federal Soil Conservation Service, in cooperation with the University of Nebraska College of Agriculture and the Conservation and Survey Division, began a program of erosion control in 1934 with demonstration projects in Boone and Nance Counties.

By 1936 there were projects in Douglas and Otoe Counties as well, and demonstration work in erosion control was being carried forward by 16 Civilian Conservation Corps (CCC) camps scattered throughout the central and eastern parts of the state."

(From James C. Olson, History of Nebraska.)

The man who was in charge of the 300 CCC camps scattered throughout the midwest, 1913 NU College of Agriculture graduate William Chapline, Jr., says the bulk of CCC work was erosion control. "One phase of that work was endeavoring to control gulley cutting in hilly agricultural areas." He adds that small dams and grass plantings on the drainage areas were used as control measures, as were terracing and tree plantings.

Subsequent research has shown that as much as 50 percent of soil losses to erosion can be saved by conservation tillage methods. On-farm fuel requirements for tillage and planting can be reduced as much as 70 percent, and a 50 percent labor savings can be realized. Also, research has shown that irrigation scheduling has reduced irrigation water needs by as much as 35 percent.

These and other programs for agricultural conservation are discussed in detail elsewhere in this issue. They are all part of the new Agricultural Energy Conservation Project of the Cooperative Extension Service.

Program a Partnership

The program officially got under-

"There is a potential savings of 11.9 million gallons of fuel if one-half of Nebraska farmers adopt a no-till concept and if the remaining producers limit their tillage operations to two diskings or less."

Governor Bob Kerrey

(Continued on next page)
Program...

at a July 18 press conference in the state capital, when Governor Robert Kerrey announced the availability of $500,000 from his energy overcharge fund for the project.

The University of Nebraska Foundation, represented at the press conference by Foundation board chairman D. B. Varner, agreed to match the half-million dollars.

Varner said later, "The governor's office approached the foundation to match a gift of $375,000 for support of the Agricultural Energy Conservation program as proposed by the Cooperative Extension Service. The gift represents part of the refund to the state from oil companies as a result of overpricing."

Varner then recommended to Governor Kerrey that the amount be increased to the half-million dollar mark and the Foundation would match it.

The governor's reply was favorable. Varner said, but he also suggested that the Cooperative Extension Service commit $73,563 annually to the program during its five-year duration.

In announcing the gifts to his staff, Leo Lucas, dean and director of the Cooperative Extension Service, said, "I am delighted that the University of Nebraska Foundation and Governor Kerrey are investing both dollars and their confidence in the Cooperative Extension Service with this interdisciplinary thrust."

"This investment will allow us to add six Extension technologists that will be a systems approach in expanding conservation tillage, ecofallow and irrigation water management technology."

Target Areas to be Selected

The educational conservation program will be conducted at six target areas across the state. Four of the target areas in eastern Nebraska will aim at expansion of conservation tillage and irrigation water management practices, according to Roy Arnold, NU vice chancellor for agriculture and natural resources. Two more target areas will be selected in western Nebraska to expand the ecohallow concept.

The Extension technologists, along with project leaders Gail Wicks, Paul Fischbach and Elbert Dickey, will work with producers, federal and state agency personnel and agribusiness concerns to develop educational programs that will demonstrate proven conservation practices that will save Nebraska farmers and ranchers real dollars in fuel and labor costs, as well as soil and water losses.

Arnold said specific goals of the program include, but are not limited to, reducing irrigation energy consumption by 20 percent, and expanding conservation tillage and ecohallow acres in the state by 20 percent. "The attainment of those goals would mean substantial savings for Nebraska's economy," he said.

Savings Potential Great

In announcing the funding for the program, Governor Kerrey said "There is a potential savings of 11.9 million gallons of fuel if one-half of Nebraska farmers adopt a no-till concept and if the remaining producers limit their tillage operations to two diskings or less."

Extension director Lucas pointed out that in the last five years, ecofarming practices have increased farmers' income by $11 million and saved additional time, money, energy and equipment used in rebuilding terraces alone.

The drain on our land and water resources grows every year. Research on cropping systems and tillage practices have shown that these losses can be reduced, while permitting more effective use of the land and water resources we have.

The Agricultural Energy, Soil and Water Conservation project will allow these proven practices to be effectively demonstrated to Nebraska farmers in real-life situations.

Continuing concern for preserving our soils and increasing regulatory demands to reduce sediments in surface water also increase the impetus for farmers to carefully evaluate their current tillage systems.
Producers ‘Break Tradition’

By Elbert C. Dickey

Through Extension educational program efforts, row crop producers in Nebraska are gradually “breaking tradition” and adopting conservation tillage methods to reduce soil erosion.

Since 1980, Extension specialists have presented conservation tillage information annually at more than 30 meetings with total attendances exceeding 3,000 people. In addition, Extension agents have provided leadership in developing demonstration plots that compare various tillage systems.

Soil erosion in the state exceeds 100 million tons annually. About 75 percent of this occurs in row crop production areas, primarily in eastern and south central parts of the state. Increased use of soil conservation practices could prevent a large portion of this loss. But producers are somewhat reluctant to change their traditional farming methods and adopt conservation methods.

Although soil erosion occurs and is a concern, farmers generally have not seen corresponding yield decreases. In some cases, producers acknowledge that technological inputs such as fertilizer, irrigation, and improved hybrids are masking erosion losses. But, they are reluctant to change, partially because they are farming the way their fathers taught them.

Two Programs Evolve

Because climate and crop production differ in various areas of Nebraska, two major conservation tillage educational programs have evolved - ecofallow production systems centered in southwest Nebraska and moving into the south-central area, and conservation tillage for row crop producers, primarily located in eastern to south-central Nebraska.

Ecofallow farming methods, well adapted to lower rainfall areas, generally have a fallow period where crop residues remain on the soil surface to conserve soil moisture. By adopting ecofallow methods, farmers can now produce two crops every three years in southwest Nebraska.

In eastern Nebraska, however, use of conservation tillage systems generally does not result in yield increases, thereby decreasing the incentive to change farming methods.

Extension conservation tillage educational programs in the eastern part of the state are encouraging farmers to adopt conservation tillage methods. Five major components of these programs include:

- Determining tillage and planting methods being used;
- Evaluating those practices, including advantages, disadvantages, and limitations of various systems;
- Developing educational materials for the targeted audience;
- Providing an in-service training program for Extension agents and related agency personnel;
- Delivering the educational program to the target audience - primarily row crop producers.

Educational Materials Developed

As a first step in targeting materials needed to support the program, Extension specialists developed NebGuides highlighting advantages and disadvantages of basic tillage systems. The NebGuides also emphasized erosion control through residue management. Slide-tape units containing similar information were developed for Extension agents’ use. Extension specialists distributed additional NebGuides pertaining to weed control, insect and disease considerations, and economic comparisons to assist the producer in making tillage management decisions.

More than 240 Extension agents and Soil Conservation Service personnel attended an in-service train-

(Continued on next page)
Soil Erosion: Mechanisms and Control

By Elbert C. Dickey, Paul J. Jasa and J. Kent Mitchell

In 1977 alone, the United States lost almost 2.5 billion tons of soil through erosion. During the same year, Nebraska had nearly 120 million tons of erosion. Compared with the magnitude of the problem, the basic cause - raindrops - may seem insignificant. Yet falling raindrops strike the ground with surprising, cumulative force. With no residues, mulch or vegetative cover to absorb the impact, rain is especially erosive on bare cropland. To understand the problem more fully, the mechanisms of erosion are discussed.

RAINFALL. When it rains, drops bombard the soil surface at impact velocities of up to 20 miles per hour. The constantly pounding raindrops dislodge soil particles and aggregates and splash them up to 3 feet away. This detachment of soil particles initiates the soil erosion process.

A raindrop falling on a thin sheet of water detaches soil particles more readily than one falling on dry soil. Splash erosion increases with surface water depth, but only up to a depth about equal to the raindrop diameter. Once the water becomes deeper, the splash effect is reduced. When rain hits vertically on a flat surface, the splash is equal in all directions. On a slope, more of the splash goes downhill than uphill. In a wind-driven rainfall, splash movement of soil depends on slope and wind direction.

During rainstorms, a twofold problem often occurs: the rain may be too intense to be absorbed and it may seal off the surface, thus reducing infiltration of the water and causing more runoff. If water could always filter into the soil, the splashing of soil particles would be of minor concern. In many cases, however, water collects in low places, eventually overflows, and then begins to travel downhill, carrying soil particles with it.

Water flowing off the soil surface provides the mechanism for transporting particles loosened by rainfall. Although described as sheet flow, this type of flow seldom occurs in an uninterrupted sheet. Usually the water detours around clods, spills out of small depressions, and in general moves with sluggish irregularity. Even so, the water is able to carry soil particles.

The transport ability of runoff is influenced by the energy level of the flow, which in turn is dependent on
the depth of flow and slope of the land. Flat areas have little or no runoff; consequently, little transport occurs. Runoff from steeper areas flows at greater velocities and may have considerable transport capability.

**RILLS AND GULLIES.** Under certain conditions, water from sheet flow (inter-rill) areas will run together, forming small rivulets or rills. This type of flow usually covers only a small percentage of a field, but because the flow is concentrated, it also causes erosion by detaching additional soil particles. The rills thus created leave small channels that can be filled in by tillage operations. Rill flow usually detaches less material than does splash erosion. However, a few soils are very susceptible to rill erosion and wash away easily. Furthermore, while a rill is forming, raindrops continue to detach soil within shallow rills and from the surrounding soil surface. Because the flow is concentrated, rills have an exceptional capacity to transport these detached particles since practically no sedimentation occurs. Rills gradually join together to form progressively larger channels, with the flow eventually proceeding to some established streambed. Some of this flow becomes great enough to create gullies, which cannot be removed with normal tillage operations. In many areas of Nebraska, gully erosion has done considerable damage to fields by removing valuable topsoil and by dividing fields into small parcels that are inefficient to farm.

Rills and gullies often progress upward at a head-cut or overfall (small waterfall). As the pool below the overfall enlarges, the turbulent water undercutts the overfall; eventually the soil sloughs off and is transported downstream. Through similar processes, the banks of streambeds can be undercut and eroded if flow velocities are excessive.

**SEDIMENT.** Sedimentation from soil or other materials carried by moving water may occur with sheet, rill, gully and stream flows. Ponding is apt to occur in small depressions or above contour furrows in inter-rill areas. It may also occur above small debris dams formed from residue in rills and gullies, terrace channels, or reservoirs in large streams. Large particles tend to settle in quiet pools formed at these sites. When the water is slowly released, much of the material is left behind as sediment. Also, dense vegetation can reduce the flow velocity, thereby allowing soil material to be deposited. Effects of this process are sometimes seen in grassed waterways where the center gradually fills in with sediment.

All three processes, detachment, transport, sedimentation, occur during an erosive rainfall event. The extent is determined by the amount and intensity of rainfall, topography of the land surface, vegetative cover, and character of the soil.

**SOILS AND GROUND COVER.** Each type of soil has its own inherent susceptibility to the forces of erosion, in large part because of particle size distribution and organic matter content. Although large-grained materials are easily detached by raindrop splash or flowing water, they are not easily transported. On the other hand, fine soils such as clays and fine silts that bond together tightly are not easily detached, but once free they are transported with little difficulty. For this reason, fine materials can be carried considerable distances, while larger particles may be deposited

(Continued on next page)
Mechanisms and Control...

somewhere along the flow path.

Residues and vegetative covers play an important role in hindering the erosion process. For example, residue lying directly on the ground absorbs the force of a falling raindrop and thus reduces splash erosion. Residue completely covering the soil surface eliminates splash erosion.

Canopy covers from growing crops will also greatly reduce drop erosion. Close growing crops such as corn, grain sorghum and soybeans catch raindrops and keep them from hitting the soil directly. Much of the water runs down the plant stem, although some of it runs off the leaves. Falling on bare soil, these drops cause a small amount of detachment, but since they have not fallen far enough to reach an erosive velocity or any significance, detachment is less than with no canopy cover.

Not only do ground covers stop raindrops and keep them from detaching soil particles, they also prevent surface sealing and reduce rainfall induced soil compaction, which restricts infiltration of water into the soil. With greater infiltration there is less runoff.

Even when no particles are detached by raindrop splash, runoff itself, forming larger and larger rivulets, can eventually loosen soil particles. By slowing down the velocity of flowing water, residues and vegetation are helpful in reducing flow erosion and allowing sedimentation to occur. In a highly susceptible soil, some rill erosion may occur beneath the mulch cover, but the flow is impeded and the degree of erosion reduced.

CONTROL. Several practices for controlling erosion are available to landowners and producers. Briefly defined, these practices include:

Conservation tillage: tillage and planting methods which minimize the number of trips across a field and leave a protective cover of residues on the soil surface. These residues protect the soil from raindrop impact during the critical erosion period from seedbed preparation to crop canopy establishment. Residue covers also limit the transportation of soil downslope by reducing runoff rates.

Contour farming: the practice of tilling and planting around the hill or on the contour. Furrows created around the hill by contour farming help prevent formation of rills and gullies down the slope. Contour farming can reduce the erosion by 50 percent of that which occurs from up and down hill farming.

Strip cropping: a series of alternate strips of crops laid out so that field operations are performed on the contour. This system is most effective when strips of small grains or close-growing perennial grasses and legumes are alternated with row crops. Planted on the contour, these strips create vegetative filters and can reduce soil erosion losses considerably.

Terraces: a series of across slope channels, with tillage and planting running parallel to them. Terraces reduce soil erosion by breaking a long slope into several short sections. This reduces the speed of runoff and the amount of sediment that can be transported. Runoff collected in the terrace channel can be stored for infiltration into the soil or safely carried by grassed waterways or tile outlets to lower ground.

Waterways: natural or constructed watercourses and outlets that are shaped or graded, then planted with suitable vegetation or lined with an erosion-resistant material. Designed to dispose of runoff without eroding or flooding, waterways serve as outlets for terraces, diversions, or other concentrations of water.

Ponds and debris basins: structures designed and constructed to hold and control the release of runoff, preventing it from reaching erosive speeds. These structures trap the sediment from the runoff by allowing deposition and infiltration to occur before the excess water is slowly released.

Many other erosion control methods can be helpful, such as the use of seasonal cover crops and grade stabilization structures, land use conversion, and vegetated field borders. Used singly or in combination, all of the methods discussed can help reduce erosion and runoff. The choice among them will depend on the local soil, topography and climate, as well as on farming practices and operator preference.
Can We Measure
The Economics of Erosion?

By H. Douglas Jose

Soil conservation has been an important objective of government for half a century. And even though there are a number of alternative methods of control available, most observers agree a satisfactory solution has not been achieved. Each year there are cases of soil erosion that are starkly visible. In addition, there are many other results of soil erosion that are not as readily seen, such as water pollution and sediment damage.

We can look at soil conservation by first asking if there really is a problem and why has the government allocated so many resources to soil conservation since the Dust Bowl days of the 1930's?

The Problem

Any problem is defined as the difference between what is and what ought to be or could be. For example, there is a farm income problem if net income is not high enough to at least maintain equity and to allow the desired standard of living. Similarly soil erosion is a problem if it is higher than generally accepted levels or higher than the levels could be.

The next consideration for any problem is the cost of removing or solving that problem as compared to the costs incurred by allowing it to persist. There is a tradeoff, for example, in all government programs between the benefits of the program and the cost to the taxpayer. There are alternative methods of erosion control available but these have not been universally and successfully applied. The interest in soil conservation and the amount spent on research and regulation attest to this. The levels of expenditure would lead us to conclude the costs of soil erosion damage are greater than the costs of solving the problem.

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Time Considerations

The costs of soil erosion control have some unique aspects. Soil erosion may have an effect on the production costs of an individual producer but it also affects many other segments of society. For example, sediment in roadside ditches is evidence of soil loss from fields and it increases local taxes for ditch clearing and road maintenance. Another consideration is the time aspect of the returns to soil erosion projects. Soil erosion control will pay dividends for many years. But the amount of the returns to \(\ldots\)

Economics of Reduced Tillage

The economic advantage of reduced tillage is the cost savings of the reduced number of passes over the field. The savings result from reduced expenditures for fuel, repairs, maintenance and labor. There may also be reduced ownership costs if fewer tillage machines are owned and used.

On the other side of the ledger the reduced tillage systems may encourage new insect and disease pests. There will also probably be higher costs for weed control. Many producers have expressed the opinion that herbicide costs should not increase with reduced tillage. We recently surveyed a number of farmers who have been practicing reduced tillage for a number of years and their experiences verified the hypothesis that chemical costs will increase.

Fewer trips over the field will result in reduced fuel consumption but this saving by itself will not be sufficient economic justification for a reduced tillage system. Saving a gallon of fuel per acre, for example, will result in a cost saving of only about $1 per acre. More significant is how the labor saving is used. Cash hired labor costs could be reduced or it could mean more land can be cropped with the same labor. Farming more land could result in higher returns to machinery investment and the operator's labor and management. The reduced labor requirements could also produce more effective use of labor during peak periods resulting in more timely completion of field operations.

Let's turn to the other side of the income ledger and look at the cash inflow implications of conservation tillage. There has not been enough research completed to conclude yields will go up or down. The yield response will be determined by the interaction of the reduced tillage with a number of other variables such as soil characteristics, the amount and distribution of rainfall and the topography of a field. Reduced tillage by itself could result in higher yields and hence higher gross income due to the soil moisture conservation aspect, assuming other factors such as insects and disease were taken care of and did not reduce yield.

A reduced tillage system does require a higher level of management. A number of factors that can influence the success of the reduced tillage system have already been mentioned. The operator has the challenge of minimizing the negative influence of these factors and maximizing the positive influence. Typically we describe things like rainfall and disease as uncontrollable variables - factors of production beyond the control of the decision maker. It is true we can't control the rainfall but we can control its impact as well as the impact of some of the other variables. But there are a large number of these variables and there are many interactions possible between them. The challenge of reduced tillage as a production system is to be aware of these interactions and to be in a position to respond to them if they occur.

Summary

The economics of conservation tillage come down to a few basic questions:

- Will society demand better soil conservation to reduce the public cost of environmental damages caused by soil erosion?
- For the individual farm operator, what are the alternative uses of the labor made available by reduced tillage operations?
- What are the added costs from reduced tillage including the cost of the higher level of management versus the expected added returns? Many of the added returns will be realized through maintaining the productivity of the land in the future.
- What is the value of net income in the future versus net income now?
Weed Control Essential In Reduced Tillage

By Alex R. Martin and Gail A. Wicks

Tillage in crop production has been used primarily to control weeds and to prepare a seedbed. Weed control is essential in any crop production system and as tillage is decreased, greater reliance is placed on herbicides for weed control. Greater management ability is required to control weeds as tillage is eliminated. Under no-till there are fewer opportunities to correct mistakes and the control of escaped weeds can be more costly than under clean-tillage.

Weed species change as tillage operations are reduced. Certain perennial weeds tend to increase under reduced tillage since there is less disturbance of their root systems. When tillage is completely eliminated there are fewer potential annual weed problems because the weed seed is not planted with tillage, but there are fewer control options.

Ridge or Till-Plant

The ridge or till-plant system is an intermediate tillage practice between no-till and the various disc and chisel systems. The sweep on a till-planter moves as much as 70 percent of the previous year’s weed seed out of the crop row to where the seedlings can be destroyed by cultivation. (Figure 1). This reduces the number of weeds that develop in the crop row. Cultivation reforms ridges for next year’s planting operation. The till-planter effectively deals with the volunteer corn problem by moving dropped ears and kernels from the rows to the row middles where the volunteer corn can be removed by cultivation. Shattercane has also been successfully controlled when this planting method is followed over several years.

The herbicide programs applicable in the till-plant system are similar to no-till. Preemergence and postemergence herbicides can be used, preplant-incorporated herbicides cannot. Emerged weeds before planting can be controlled by 2,4-D, paraquat, Roundup, or a low rate of atrazine. A shallow discing or a preplant cultivation between the rows using wide sweeps can also be used to control weeds. Broad spectrum preemergence herbicides can be broadcast or band applied. The broadcast treatment offers greater flexibility in timing cultivations. Often one cultivation or hilling for furrow irrigation in conjunction with a preemergence herbicide is sufficient to provide excellent season-long weed control.

Chisel or Disk and Plant

The predominant tillage operations for row crop production in eastern Nebraska involve chiseling or discing and surface planting or in some cases listing. In some instances the soil may be chiseled, or disc ed once in the fall followed by one or two tillage operations in the spring before planting. These systems may leave as much as 50 percent of the previous year’s crop residue on the surface.

All herbicide options, preplant incorporated, preemergence and postemergence, can be used with systems that include two tillage operations in the spring. Herbicides applied in bands with cultivation provide crop yields comparable to broadcast applications.

There is a tendency to perform more tillage than necessary when using preplant incorporated herbicides. Crop residue does not “tie up” herbicides, it prevents herbicides from coming in contact with the soil or weeds. Rainfall or sprinkler irrigation is needed to move the herbicide into the soil. Heavy residue may interfere with incorporation of herbicides.

Soybean stubble and heavily grazed corn and sorghum stubble do not have to be tilled before application of a preplant incorporated herbicide. Large amounts of corn or sorghum residue should be worked once before herbicide application.

Basalin, Prowl, and Treflan require two tillage operations for adequate incorporation. The second operation can be made any time after (Continued on next page)
Weed Control...

the first. Eradicane, Sutan+, and Vernam can be adequately incorporated with one pass if the soil is mellow and has been worked once previously. One tillage operation is required for surface mixing other herbicides. Regardless of the implement used and the number of passes, good incorporation results only when the soil is dry and mellow enough to permit good mixing.

Many surface planters are equipped with furrow openers and result in a shallow listing operation. Preplant surface blended or shallow incorporated herbicides can be moved out of the row area by the furrow openers resulting in a band of weeds in the crop row. Where furrow openers will be set to cut more than 1 inch deep, a preemergence herbicide application is preferable. When using a lister, preplant incorporated herbicides are not effective because much of the treated soil is moved out of the crop row.

No-Till

Most, but not all weed problems can be controlled in no-till row crop systems if the program is carefully developed. It is important to recognize those situations that cannot be handled. No-till does not cure weed problems, so don’t plant into a weed problem for which there is no solution. The first no-till experience should be in a field without serious weed problems. As the farmer gains skill and confidence, the practice can be moved to more difficult weed management situations.

With no-till, the soil is undisturbed before planting although stalks are usually chopped or heavily grazed before planting in corn residue. Under this system heavy reliance is

Figure 2. Because of the early planting date with corn using no-till systems, emerged weeds are usually small or not visible.

Figure 3. Emerged weeds are likely to be present when no-till planting sorghum or soybeans.
placed on herbicides to control weeds that may be present at planting and to control weeds germinating later. This usually requires a combination of a postemergence and residual preemergence herbicide. Broadcast herbicide applications are required with no-till. Herbicide treatments must be tailored to the situation for maximum weed control at the least cost. Established weeds at planting time must be controlled for no-till to be successful. Because of the early planting date with corn, emerged weeds are usually small or not visible. (Figure 2). Preemergence corn herbicide treatments containing atrazine will control annual weeds less than 1 inch tall and provide residual control. An additional postemergence herbicide often is not needed. A decision after field examination is important here.

The addition of crop oil will improve control of emerged weeds. Established broadleaf weeds at planting can be controlled in corn with 2,4-D alone or in combination with a preemergence herbicide. The addition of 2,4-D to treatments containing atrazine or Bladex also improves postemergence grass control. Grasses taller than 3 inches are best controlled by adding paraquat to the preemergence herbicide. Emerged volunteer corn and annual and perennial weeds can be controlled with Roundup before crop emergence.

Sorghum and soybeans are usually planted later than corn so emerged weeds are likely to be present at planting (Figure 3). Atrazine or Igran + AAtrex in sorghum will control emerged annual grass and broadleaf weeds less than 1 inch tall. To kill larger weeds before emergence, paraquat should be added to residual herbicides for sorghum and soybeans. Roundup is effective in controlling volunteer corn and annual and perennial weeds before sorghum or soybean emergence.

Where established weeds are present, an alternative to a postemergence herbicide is a shallow disking before planting. While this is no longer no-till it may be the most economical solution to some problems while maintaining most of the advantages of no-till.

If the planter is equipped with sweeps or furrow openers, preemergence herbicides must be applied after planting to avoid moving the herbicide treated soil out of the crop row causing a strip of weeds. A band application of a preemergence herbicide could be used if herbicides had been applied before planting. With slot planters herbicide application can be preplant or preemergence. However, some slot planters disturb more soil than others resulting in a narrow band of weeds.

**Weed Control Limits**

There are weed control limitations with no-till systems. Preplant incorporated herbicides which are required to control certain weeds such as shattercane cannot be used with no-till systems. The exception would be that certain herbicides including Eradicane and Sutan should be applied through a center pivot sprinkler with the water providing incorporation. Where a serious weed problem requiring a preplant incorporated herbicide exists, no-till crop production would be unwise.

Volunteer corn can be a serious problem under a slot-plant system. Many farmers have found that grazing encourages volunteer corn and sorghum if pastured while the ground is wet. Herbicides are not available to selectively control volunteer corn in corn or sorghum. A better approach is to use a planter equipped with sweeps or furrow openers to move the dropped ears, heads, and kernels between the rows where the plants can be removed with cultivation. If the potential volunteer crop population is not great, planting can be delayed until emergence of the volunteer crop. Then Roundup should be used to kill the emerged plants. However, Roundup rates may need to be high for effective control and so it would not be cost effective. Shallow disking should also be considered.

Perennial weeds including common milkweed and hemp dogbane increase under no-till systems because there is no disturbance of their root systems by tillage. Roundup applied through a selective applicator can be used in soybeans to hold these weeds in check. Fall applications of 2,4-D or 2,4-D + Banvel can be used in corn and sorghum to control hemp dogbane.

Large sweeps or power driven cultivators are available for use in no-till crop production. Fields should be monitored closely early in the season for weed problems. A timely cultivation can rescue a weedy field where a herbicide has not performed satisfactorily. No-till cultivators can control weeds while still retaining most of the conservation aspects of no-till crop production. In some cases postemergence herbicides may be used effectively, but the weed problem must be identified early so timely application can be made.

Under no-till systems the accumulation of organic material at the soil surface tends to absorb some of the herbicide and results in a lower surface soil pH. The net effect is the lowering of s-triazine herbicide longevity. Liming to maintain correct soil pH averts this problem.

Poor weed control is the most common stumbling block in no-till crop production. Most of these problems can be traced to a poorly designed weed control program, incorrect timing or poor application. Herbicide applications which are acceptable under conventional tillage may not be adequate for no-till. Remember, tillage covers up spraying mistakes. Application is critical under no-till systems since weed control is dependent on herbicides. Adequate control of most annual weeds can be obtained in no-till systems with currently available weed control programs. It is essential that these weed control programs be carefully designed and implemented.

No-till crop production is definitely the wave of the future. This production system has many environmental, conservation, and long-term economic advantages. Weed control is still the major deterrent even though effective programs are available for most situations. Indications are that no-till farmers will see many more usable tools in their herbicide arsenals in the future. Major companies are now developing a variety of postemergence herbicides that promise to be a real help in no-till. The future of no-till crop production is bright. ☐
Herbicides Important in Ecofarming

By Gail A. Wicks and Alex R. Martin

Weeds are the biggest obstacle limiting expansion of conservation tillage. A variety of herbicides have provided farmers with additional tools to control weeds. Often the success of a program is dependent upon weed control. Nebraska has two important areas in conservation tillage, one is row crop production and the other is ecofarming which centers around small grain production. It is important for the grower to realize that herbicide selection is but one part in the development of a sound weed control program. Herbicides can be used to advantage in several places in crop rotations involving winter wheat, sorghum, corn, and soybeans. These options will be discussed in detail for winter wheat since it is the predominant small grain crop in Nebraska.

In Growing Winter Wheat

Often weeds (prickly lettuce, lambsquarters, kochia, Russian thistle, and common sunflower) that are problems after wheat harvest could have been eliminated earlier in growing wheat. An application of 2,4-D, 2,4-D + Banvel, or Glean when wheat was in the tillering stage would aid in reducing these species and other broadleaf weeds. An aerial application of 2,4-D as a harvest aid treatment when the wheat is in the hard dough stage would prevent most broadleaf weed growth after harvest. Glean is a very versatile but persistent herbicide and for the present should not be used in rotations if other crops besides wheat are grown.

After Wheat Harvest

The optimum time to apply herbicides after wheat harvest varies with fields. Past management influences weed species and growth. Wheat varieties vary in their competitiveness with weeds. Increasing seeding rate, decreasing row spacing, using the optimum plant date and use of fertilizer have reduced weed growth populations in winter wheat. The longer the application of atrazine is delayed the less dissipation there is so weed control the next season should be better.

The length of the spraying season is governed by the number of sprayers and the weather conditions suitable for spraying. Several custom applicators are spraying 10,000 to 20,000 acres after wheat harvest. This may take several weeks depending upon rain and wind conditions.

Figure 1. Most no-till fields need additional herbicides in the spring to ensure full season weed control.

Figure 2. Several farmers have been growing one or more crops of no-till sorghum before going back to wheat.

Figure 3. Wheat residue protects the soil from erosion.
Rainfall is usually not uniform in an area so some fields will be ready to spray before others. If feasible, custom applicators will move to drier fields.

Wind is a constant threat to spraying in the Great Plains. Applicators should be building and using wind screens on their sprayers to improve application effectiveness. A large custom applicator in southwest Nebraska, has estimated that wind shields have improved spraying efficiency 15 to 20 percent.

Weedy fields should be sprayed as soon as straw has settled and weeds are exposed. A heavy weed population can use 3 inches of soil water within 30 days after wheat harvest. This water cannot be replaced and therefore next year’s crop yield will suffer. Fields with low weed pressure can be sprayed later. Ideally most fields should be sprayed by 30 days after wheat harvest. Weed seed production is reduced by spraying early. There is no need to grow more weed seed for the next crop. Also, rainfall in Nebraska diminishes as the summer progresses so early applications have the best chance for rain to move the herbicides into the soil. However, sometimes July is hot and dry. Atrazine applied when it is hot and dry is subject to some loss if it does not rain within a week. Often weeds die without herbicides during these conditions so atrazine application could be delayed.

Volunteer wheat can be difficult to kill with atrazine. Some farmers apply as much as 3 lb/A of atrazine after harvest before volunteer wheat emerges. Control is usually satisfactory unless there are a lot of heads that were not threshed or lot of grain has been thrown out of the combine. Some farmers wait until volunteer wheat emerges then use atrazine at 1 to 2 lb/A with paraquat. This kills off one crop and provides preemergence control for the next flush of weeds. Some farmers keep their planting options open by using a low rate of atrazine, or by using Sencor/Lexone, Bladex or Roundup.

Sequential Applications in Spring

Most fields need additional herbicides in the spring to top off the atrazine applied the previous fall (Fig. 1). Extension Service publication EC 84-130 has several options for corn, sorghum, soybeans and winter wheat listed in the Reduced Tillage Systems - Ecofarming Section. Herbicides can be applied several days in advance of planting which spreads out the spring work load. For example, Bladex can be applied 0 to 45 days before planting corn, 45 to 60 days for winter wheat, and 30 to 45 days in sorghum.

Dual has performed very well when applied several days before planting and can be used on corn, sorghum, and soybeans. Definite time frames have not been established. The rate used and amount of rain would influence length of weed control. However, in 1982 at North Platte, an April 15 application provided excellent control of barnyardgrass in corn that received atrazine at 2.5 lb/A after wheat harvest. In sorghum, where atrazine at 1 lb/A was used after wheat harvest, control of some broadleaf weeds like sunflower and cocklebur were not adequate with an early Dual + 2,4-D application, Dual is not effective on these weeds regardless of application time. Atrazine or Bladex would be necessary to control sunflowers and cocklebur preemergence. It is necessary to use Concep II-treated sorghum seed if Dual is used.

Lasso can be used on corn, sorghum, and soybeans and should be applied no more than 5 days before planting. If sorghum is to be planted in fields treated with Lasso, use screen-treated sorghum seed. Igran can be used only for weed control in sorghum. Some injury has occurred if Igran is applied after planting sorghum. This has been associated with failure to cover the seed properly during planting on wet soils or soils low in organic matter. If low rates of atrazine are used after wheat harvest, atrazine should be used with Dual, Igran or Lasso to improve broadleaf weed control in corn and sorghum.

Sencor/Lexone, Surflan, Prowl, Dual, Lasso can be applied prior to planting soybeans. Timing on Dual and Lasso have previously been mentioned. Surflan should be applied 10 to 20 days before planting soybeans. Suggested time for Prowl application is 0 to 20 days before planting. All of these herbicides should be combined with herbicides, such as, Sencor/Lexone to insure adequate broadleaf control.

Continuous No-till Sorghum

The winter wheat-ecofallow sorghum-fallow rotation has been very successful. There is still sufficient wheat stubble remaining the second year after sorghum that several farmers have been growing one or more crops of no-till sorghum before going back to wheat (Fig. 2).

The old wheat stubble lasts for about 2 years and if the fields are not grazed the sorghum stubble will help protect the soil from erosion. These fields are treated with Bladex in April to provide weed control until May 15 or later. If there is enough rainfall to extend moist soil to a depth of 3 ft. or more sorghum is planted. Additional herbicides are applied near planting time to extend weed control throughout the growing season.

Atrazine should be part of the herbicide combination to improve broadleaf weed control and lessen the herbicide cost. If there is not sufficient soil moisture the field is fallow and planted to winter wheat. Selected farmers have been very successful with continuous no-till sorghum. This production systems protects the soil from erosion (Fig. 3).

Ecofarming Options

Several options are open for ecofarming in several crops. These options should be studied, labels should be read, and decision should be made early as to what weed management system to use. Remember herbicides are only a part of the program and they do not always control weeds 100 percent of the time. Many other facets of crop production influence weed growth.

Finally, do a good job of sprayer calibration and application. A quality job of spraying the small grain is essential and skips and overlaps can’t be tolerated. The sprayer should be equipped with a marking system. Dust generated by fast moving ground sprayers with large wheels can interfere with paraquat and Roundup performance.


Conservation Tillage Aids Wildlife

By Ron J. Johnson, Kent E. Holm, and Ann E. Koehler

Conservation tillage has been a welcome relief for some of Nebraska’s favorite wildlife. The plant residues on the soil surface that catch the snow and rain and hold the soil in place also provide nesting sites for birds such as pheasants, mourning doves, quail and meadowlarks. Pheasant numbers have noticeably increased in areas of southern Nebraska where ecotilling has been widely adopted. And although the meadowlarks haven’t been censused, their numbers are probably benefiting as well from this new nesting habitat. Farmers who have been using conservation tillage, especially no-tillage, have probably seen some of these birds in their fields and may have spotted a few nest sites.

Other wildlife benefiting from conservation tillage are small rodents whose presence may be both harmful and helpful. On the harmful side, thirteen-lined ground squirrels, kangaroo rats, deer mice, and others at times dig and consume newly- planted corn seeds and the kernels attached to young seedlings. This damage occurs during the first three weeks following planting. After this, the corn is large enough that the rodents no longer bother it. However, in some fields, the damage during this period has been quite severe. In addition, rodents sometimes attract predators such as badgers and snakes. The badgers dig holes to catch a rodent dinner, and the holes cause problems for farm machinery.

On the helpful side, the food habits of some of these rodents may be beneficial if the damage-causing rodents are prevented from consuming corn seeds and seedlings. Potential benefits include consumption of crop-damaging insects such as grasshoppers and insect larvae such as cutworms and wireworms; consumption of weed seeds; and consumption of waste grain that often produces unwanted volunteer plants during the following growing season.

The University of Nebraska is investigating several aspects of rodents in conservation tillage fields to find ways of preventing damage while maintaining the beneficial aspects. First, a project has been undertaken to study the overall impacts or rodents in no-tillage fields. Preliminary trapping has resulted in the capture of thirteen-lined ground squirrels, Ord’s kangaroo rats, deer mice, northern grasshopper mice, house mice, pocket mice, harvest mice, and short-tailed shrews. The short-tailed shrew is actually not a rodent but rather a tiny mammal that eats insects and sometimes mice. Results of this study will show which rodents are present in Nebraska fields, where in the fields they occur, and what foods, including corn, they are eating. Information about the study fields, the rodents, and the crop damage can then be compared and evaluated. This will allow better predictability of rodent responses to damage controls including the use of toxic baits or repellents.

Second, two chemicals, thiram and Mesurol®, are being evaluated as potential seed-treatment repellents. Field tests over three growing seasons show that both of these chemicals, if applied at the proper rates, are effective in repelling thirteen-lined ground squirrels and are safe for the corn plants. Some additional repellency tests are currently underway.

By understanding the interrelationships among ground-nesting birds, rodents, and conservation tillage systems, we will be better able to work with nature’s systems to profit from the beneficial aspects yet control the damage problems. In other words, with conservation tillage we may be able to have our cake and eat it, too.
Erosion Magnitude Seen In Nebraska

By David T. Lewis and William Reinsch

Very few acres of sloping farmland in Nebraska have escaped erosion by running water. In addition, most of our nearly level land such as that in the Platte River valley and the plains of south central Nebraska and the Panhandle has felt the effect of erosion by wind. The Sandhills too, have seen the ability of wind to move sand from land broken from sod and left bare, from overgrazed rangeland, and from existing or newly formed blowouts. Some of our soils have been eroded to the point where large areas of soil no longer have the properties needed to classify them with their non-eroded or slightly eroded counterparts.

We see evidence of the effects of the magnitude of soil erosion in Sandhills blowouts, in blown out center pivots, in dust clouds swirling in the winds of March above the Plains and in soil piled in road ditches. We see rills and gullies on sloping land, and sediment piled up, burying fences at the foot of slopes. Many of the hillsides in the eastern part of the state are light brown or gray where originally the rich black topsoil of the prairie covered them.

Three research efforts are examples of work attempting to document the amount of soil moved from its original site by agents of erosion. In one of these studies, a 200 acre watershed representative of southeastern Nebraska was selected in Otoe county. Here we found that as much as 23 inches of soil had been washed from the convex parts of the hillsides. In total 201,780 metric tons of soil had been removed from the sloping parts of the watershed. Sediment amounting to 106,700 metric tons (24" depth) had been deposited on the concave part of the watershed, along the small drainageway that served to remove water from the area. Since 95,080 metric tons of sediment could not be accounted for in the watershed, it is probable that it had been moved from the watershed, entering the larger stream that served as an outlet for the drain through the watershed.

The watershed studied was part of a mapping unit of Wymore silty clay soils that have been severely eroded. There are 91,500 areas of this soil in Otoe county, and probably twice that amount in Johnson and Nemaha counties, as well as some in Lancaster county. If we expanded the figures stated above for a 200 acre watershed to the counties indicated, the figures become too large to comprehend. Table 1 suggests the magnitude of the erosion problem in Lancaster county, adjacent to Otoe county.

Table 1. Past erosion and erosion hazard in Lancaster County, Nebraska

<table>
<thead>
<tr>
<th>Total acres of sloping upland</th>
<th>388,176 A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderately eroded land</td>
<td>192,956 A (49%)</td>
</tr>
<tr>
<td>Severely eroded land</td>
<td>18,700 A (4.8%)</td>
</tr>
<tr>
<td>Acres needing conservation treatment</td>
<td>206,017</td>
</tr>
<tr>
<td>Annual sheet and rill erosion (cropland)</td>
<td>2,314,586 ton (7.13 T/A)</td>
</tr>
<tr>
<td>Annual wind erosion (cropland)</td>
<td>63,688 ton (0.2 T/A)</td>
</tr>
</tbody>
</table>

A second study was completed in the loess hills area of northeastern Nebraska in Stanton county. Here sediment entrapped in basins associated with a discontinuous parallel terrace was measured. Seven basins on soils representative of the area were part of the study. Table 2 shows the amount of sediment entrapped in each basin.

Table 2. Sediment in basins of a system of discontinuous, parallel terraces.

<table>
<thead>
<tr>
<th>Basin No.</th>
<th>Drainage Area (Acres)</th>
<th>Sediment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.3</td>
<td>10.1</td>
</tr>
<tr>
<td>2</td>
<td>0.9</td>
<td>12.8</td>
</tr>
<tr>
<td>3</td>
<td>1.3</td>
<td>13.2</td>
</tr>
<tr>
<td>4</td>
<td>1.2</td>
<td>7.5</td>
</tr>
<tr>
<td>5</td>
<td>1.5</td>
<td>3.3</td>
</tr>
<tr>
<td>6</td>
<td>1.5</td>
<td>4.0</td>
</tr>
<tr>
<td>7</td>
<td>1.3</td>
<td>6.9</td>
</tr>
</tbody>
</table>

Note that the figures are for only one month during the growing season. This was a month when the crop was up and formed a nearly complete canopy over the row. Even so, the loss in the area of basin 1 amounted to about 0.08 inch of topsoil. Multiply this by the number of months the soil is bare and unfrozen, for example, 5 as a minimum, and by the number of years that land has been cultivated (60 to 70 perhaps) and it is possible to see the depth of soil that had been lost. Certainly, the amount exceeds the depth of original topsoil. Hence, those hills are often called the "buckskin hills," based on their color since the topsoil has gone.

A third example of erosion, this time from wind, is provided by a LANDSAT study of the southeast 7½ minute Arthur quadrangle in the Sandhills. In that area, slightly larger than 3 by 4 miles, or about 9,000 acres, there are 162 blowouts of a size ranging from 1 to 60 acres. In total, about 10 percent of the rangeland is nonproductive because of the damage by wind.

These studies suggest the severity of past erosion, and of erosion to come if something is not done.
Conservation Tillage
Effective, Inexpensive Erosion Control

By Elbert C. Dickey, David P. Shelton and Thomas R. Peterson

Soil erosion and subsequent sedimentation have been identified as major water quality problems in Nebraska. Annually Nebraska soil, water or wind losses are estimated at more than 100 million tons with about 75 percent of these losses coming from row crop production areas. Topsoil losses are critical but erosion results in loss of fertilizers and pesticides as well. Based on Soil Conservation Service estimates, soil erosion from unusually heavy rains in the spring and early summer of 1982 resulted in $260 million losses.

Conservation tillage is one of the most effective and least expensive methods of controlling erosion. The term “conservation tillage” includes any tillage method that leaves at least 20 percent of the soil surface covered with crop residues after planting. This minimum residue cover can reduce soil losses by 50 percent of those which occur from clean tilled or residue free fields. In many cases this degree of erosion control is more than adequate. On steeper slopes, greater amounts of residue are required and in some situations, structural practices such as terraces will also be needed to achieve adequate erosion control.

Tillage Systems

A variety of tillage systems which leave a surface cover of 20 percent or more are available for use in corn and grain sorghum residues. These include chisel, disk, rotary till, ridge-plant and no-till systems. Brief descriptions of these systems are:

Chisel—a chisel plow produces a rough surface and can leave 50 to 75 percent of the crop residue on the soil surface. The rough surface and residue work together to trap moisture while minimizing both wind and water erosion. In extremely heavy residues, such as those associated with irrigation, a light disking or chopping operation may be necessary before the fall chisel plow operation to avoid potential clogging problems. A fall chisel plow operation followed by a single spring disking generally leaves adequate residue to be considered a conservation tillage system. To minimize residue coverage and erosion, avoid additional spring tillage operations.

Disk—In general, a single pass of a tandem disk will leave 40 to 70 percent of the residues on the soil surface. The cutting and burial action of the disk minimizes adverse effects of residue on subsequent tillage and planting operations. Two diskings or a disking followed by another secondary tillage operation such as a field cultivation are commonly used conservation tillage systems. Like the chisel plow system, additional tillage operations should be avoided to leave the minimum residue cover of 20 percent. While fall disking will help save valuable time in the spring, wind erosion con-
trol and trapped snowfall will be less than with fall chiseling because of flattened residues and a relatively smooth soil surface.

Rotary Tiller—A powered rotary tiller (similar in concept to a garden tiller) can be mounted ahead of planting units to create a one-pass tillage-planting system. With the rotary till system, residue is not disturbed from harvest until planting. This system is well adapted to medium and lighter textured soils as well as most furrow irrigated areas. The rotary tiller can be set to till only the tops of ridges developed during the previous irrigation season, thereby limiting fuel and labor use. Good management of the rotary tiller is essential to leave adequate residue cover. Excessive or deep tillage will not leave enough residue and will increase fuel and labor needs.

Ridge Plant—This system is also referred to as a till-plant or annual ridge system. Seed is planted into ridges formed during cultivation of the previous crop. These ridges dry and warm-up quickly allowing earlier spring planting, especially on soils that tend to be wet. Before ridge planting, residues are often shredded or chopped to avoid clogging. Ridge planters usually have a sweep or double disk furrowers mounted in front of each planting unit to push residues and clods to the row middles, leaving a cleanly tilled strip where the crop is to be planted. To be most effective in erosion control, till-planting should be done on the contour or around a hill rather than up and down hill.

No-till—With no-till systems, seeds are planted into previously undisturbed soils with planters designed and equipped to plant through residue into firm soil. Also called zero-till or slot-plant, no-till offers the best erosion control since virtually all residue is left on the soil surface. Mulch created by the residue provides excellent erosion control and it also minimizes moisture losses caused by evaporation. The moisture saved means crop yields can be increased during dry years or in lower rainfall areas. However, the residues can slow soil drying and warm-up which may delay planting in wet springs. Good management is essential for weed and pest control to ensure high yields with no-till systems.

Chisel, disk and rotary till systems allow incorporation of fertilizers and pesticides and offer a variety of management options for producers. However, with ridge plant and no-till, incorporation is limited or non-existent. With these systems, herbicides for weed control are required. Crop cultivation for weed control is an option for all conservation tillage systems but cultivators capable of going through heavy residues without clogging are required for ridge plant and no-till systems.

Erosion Control

Rainfall simulation techniques have been used in Nebraska to evaluate the erosion control potential of various tillage systems. Studies conducted at the High Plains Agricultural Laboratory near Sidney, at the Northeast Station near Concord and the Rogers Memorial Farm near Lincoln have shown that no-till systems can reduce erosion by 90 percent of that which occurs from moldboard plowed or other cleanly tilled, residue free systems (Figure 1). Just as important, any tillage system which leaves 20 percent or more of the soil surface covered with residues will reduce soil erosion losses by at least 50 percent. (Table 1).

Soybean production offers both challenges and opportunities for erosion control. Soybeans produce a loose, mellow soil surface and very fragile residue covers. Thus land where soybeans have been grown are more vulnerable to erosion. Research sponsored in part by the Nebraska Soybean Development, Marketing and Utilization Board has recently shown that for equivalent tillage operations, erosion from soybean production areas is 30 to 40 percent greater than from corn production areas (Figure 2). However, the loose, mellow soil is easy to notill into and the fragile residue reduces potential equipment clogging problems.

Unlike corn and grain sorghum residues, disk tillage systems cannot be considered as conservation tillage systems when used for soybean residues. A single tandem disking will bury and incorporate almost all the residue, leaving an unprotected soil surface, which results in excessive erosion.

Fuel and Labor

Limiting tillage operations or switching to reduced tillage systems offers both fuel and labor savings in addition to erosion control and moisture conservation. Traditional tillage systems which involve moldboard plowing require approximately 5.3 gallons or diesel fuel per acre (Table 2). Fuel savings achieved by adoption of conservation tillage range from 23 percent by switching from a plow to a chisel system to nearly 70 percent with the use of no-till. Even switching from the commonly used disk system to no-till can result in more than a 45 percent fuel savings.

Labor savings of over 50 percent are possible with a change from the moldboard plow system to the no-

(Continued on next page)
Table 1. Residue cover and cumulative soil loss after 2 inches water applied to various tillage systems.

<table>
<thead>
<tr>
<th>Field Operations</th>
<th>Percent cover remaining</th>
<th>t/ac</th>
<th>Erosion(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moldboard plow, disk, disk, plant</td>
<td>6.3</td>
<td>7.9</td>
<td>--</td>
</tr>
<tr>
<td>Chisel plow, disk, plant</td>
<td>34.6</td>
<td>2.1</td>
<td>73.9</td>
</tr>
<tr>
<td>Disk, disk, plant</td>
<td>20.6</td>
<td>2.2</td>
<td>72.0</td>
</tr>
<tr>
<td>Ridge plant</td>
<td>33.6</td>
<td>1.1</td>
<td>86.4</td>
</tr>
<tr>
<td>No-till plant</td>
<td>38.9</td>
<td>0.8</td>
<td>91.1</td>
</tr>
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</table>

**Corn Residue, 10% Slope**

<table>
<thead>
<tr>
<th>Field Operations</th>
<th>Percent cover remaining</th>
<th>t/ac</th>
<th>Erosion(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moldboard plow, disk, disk, plant</td>
<td>1.6</td>
<td>14.3</td>
<td>--</td>
</tr>
<tr>
<td>Chisel plow, disk, plant</td>
<td>7.2</td>
<td>9.6</td>
<td>32.9</td>
</tr>
<tr>
<td>Disk, disk, plant</td>
<td>5.4</td>
<td>14.3</td>
<td>0</td>
</tr>
<tr>
<td>Disk, plant</td>
<td>8.5</td>
<td>10.6</td>
<td>25.9</td>
</tr>
<tr>
<td>Field cultivate, plant</td>
<td>18.0</td>
<td>7.6</td>
<td>46.9</td>
</tr>
<tr>
<td>No-till plant</td>
<td>32.7</td>
<td>5.3</td>
<td>62.9</td>
</tr>
</tbody>
</table>

**Soybean Residue, 5% Slope**

<table>
<thead>
<tr>
<th>Field Operations</th>
<th>Percent cover remaining</th>
<th>t/ac</th>
<th>Erosion(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moldboard plow, springtooth harrow</td>
<td>8.9</td>
<td>3.1</td>
<td>--</td>
</tr>
<tr>
<td>Blade plow three times, rodweed</td>
<td>29.3</td>
<td>0.8</td>
<td>74.2</td>
</tr>
<tr>
<td>Twice, plant</td>
<td></td>
<td>0.1</td>
<td>97.7</td>
</tr>
<tr>
<td>No-till plant</td>
<td>86.0</td>
<td>0.1</td>
<td></td>
</tr>
</tbody>
</table>

**Wheat Residue, 4% Slope**

1Water applied at rate of 2.5 inches per hour. Field operations were up and down hill.

Table 2. Typical fuel and labor requirements for various tillage systems.

<table>
<thead>
<tr>
<th>Tillage System</th>
<th>Fuel</th>
<th>Labor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>gal/ac</td>
<td>hr/ac</td>
</tr>
<tr>
<td>Moldboard Plow</td>
<td>5.28</td>
<td>1.22</td>
</tr>
<tr>
<td>Chisel</td>
<td>4.08</td>
<td>1.05</td>
</tr>
<tr>
<td>Disk</td>
<td>3.03</td>
<td>0.84</td>
</tr>
<tr>
<td>Rotary-till</td>
<td>2.45</td>
<td>0.71</td>
</tr>
<tr>
<td>Till-plant</td>
<td>2.26</td>
<td>0.73</td>
</tr>
<tr>
<td>No-till</td>
<td>1.66</td>
<td>0.60</td>
</tr>
</tbody>
</table>

Till systems. Substituting a chisel plow for a moldboard plow results in nearly a 15 percent labor savings since the field capacity for a chisel plow is greater than for a moldboard plow. A reduced number of operations and increased field capacity for the disk tillage system can save about 30 percent of the labor required for plowing. These labor savings can allow farming more acres with timely operations.

**No Best System**

No one conservation tillage system is clearly superior for the range of field conditions encountered. For example, no-till offers the best erosion control but requires the highest level of management. For each soil type, two or three tillage systems may be well adapted. The best system will depend on equipment availability, the producer’s management ability and climatic conditions.

Limiting tillage operations saves soil and water while conserving fuel and labor.
Conservation Tillage:
Fertilizer Programs Should Match System

By Gary Hergert and Richard Wiese

Conservation tillage systems differ markedly across our state's varied soils, climate and crops. Nebraska soils change in texture from sands to clays, amounts of annual rainfall change the climate from east to west, and the sequence and kind of crops grown varies in different areas. Generally tillage systems fall into crop production categories—dryland and irrigated. Fertilizer programs for irrigated crops grown where conservation tillage is practiced do not differ greatly. For dryland cropping, however, fertilizer programs differ substantially. In this discussion the programs will be divided into two areas: ecofallow in the west and dryland conservation tillage cropping in the east.

Potential Fertility Problems

Conservation tillage brings about some primary shifts in soil-plant relationships. The soil environment in which plant roots grow is affected most. Shifts are found in the status of soil water, soil temperature, soil aeration, nutrient movement, biological activity and weed/herbicide problems. The plant nutrients of concern will be nitrogen, phosphorus, zinc, and possibly iron and sulfur.

Nitrogen problems with the extra soil water in conservation tillage may come from additional nitrate leaching, additional denitrification, greater immobilization of applied nitrogen in a higher zone of biological activity or from volatilization of nitrogen from an increased shift to surface application. Because there is less residual soil nitrate found in soils with conservation tillage systems, higher nitrogen fertilization may be needed.

Cooler temperatures in conservation tilled soils reduce early season release of nitrogen, phosphorus and sulfur from the soil organic matter. This slower release may increase nutrient deficiency problems during

(Continued on next page)
Fertilizer . . .

early crop growth. Greatest concern is with soil phosphorus which, when limited to early crop growth, can reduce root development. Root development is normally slower in the early part of the growing season under conservation tillage systems.

With limited or no tillage, incorporation of broadcast phosphorus may not be possible, and other means of applying phosphorus must be used. Fertilizer phosphorus can be placed with planting equipment and, with limited tillage over a period of years, can result in a buildup of phosphorus in the upper few inches of the soil. Research has shown deep placed phosphorus to be an effective method of application.

Zinc, iron and sulfur are less of a plant nutrient consideration than nitrogen and phosphorus. Zinc and sulfur, however, may be a problem in cold, low organic matter soils. Whether or not these two nutrients become a problem depends upon spring weather and the soil. Iron problems are limited to very high pH soils which may or may not have limited internal drainage.

Another soil environment problem is development of an acid soil over time. Alternatives to liming acid soils must be sought since incorporation of lime requires considerable tillage which defeats the purpose of conservation tillage. Acid soils are a main concern in eastern Nebraska and in some of the more easterly irrigated sands. Under the eco-fallow system, surface soil acidity may develop, but at soil levels below 5 or 6 inches the soil may be calcareous.

Fertilizer Practices

Conservation tillage, with a primary objective to maintain soil surface residue, is accomplished with sprinkler irrigation systems easier than with row irrigation where surface residue is eventually destroyed through soil shaping. As stated earlier, fertilizer nutrient use for irrigated crops does not differ greatly across the state. The amount of nitrogen needed by corn or sorghum grown under conservation tillage will be similar to nitrogen rates in conventional tillage, when residual soil nitrates are considered in crop nitrogen needs. If lower residual soil nitrate is found in conservation tilled fields rather than in conventional tillage, the difference would be expressed as a lower nitrogen required for conventional tillage. Application, timing and incorporation of nitrogen will be similar for efficient nitrogen use. Various nitrogen applicators are available to apply all the different nitrogen sources and materials, either alone or with tillage and irrigation water.

Phosphorus is less mobile than nitrogen in soils and placing phosphorus in an active crop root zone area is important in conservation tillage. Band application of phosphate in the row close to the seed at planting is an effective placement method. Any fertilizer placed in direct seed contact requires caution. Normally phosphate fertilizers containing both nitrogen and potassium are safely applied with the seed when the nitrogen plus the potassium does not exceed 10 to 20 pounds per acre. Best guidelines for phosphorus use on all crops will be soil tests for phosphorus from each field.

The most probable micronutrient needed for some field crops is zinc. Zinc can be applied with phosphate fertilizers at rates of 1 to 2 pounds of zinc per acre with starter to avoid all potential zinc deficiencies in corn. Benefits from sulfur are frequently limited to sandy soils that have less than one percent organic matter.

Dryland Conservation Tillage

Two objectives should be met, if possible, when applying nitrogen on dryland fields where conservation tillage is practiced: incorporation of nitrogen fertilizer materials into the soil under the crop residues; and timing the application with the crop’s demand for nitrogen. To meet the nitrogen objectives, part of the nitrogen can be applied with pre-plant tillage or with planting equipment. The major portion of nitrogen can be applied with tillage as a sidedress to meet the corn crop peak demand.

The same approach can be used for grain sorghum. The small grains offer a greater challenge but depend on whether spring or fall seeded small grains are grown. Nitrogen can be partially applied in the fall and partially in the spring for the fall seeded small grain.

Phosphorus applications depend upon the level of soil phosphorus reported in soil tests. The field soils with low or very low soil phosphorus need more attention to fertilizer placement. Fall seeded wheat yields improve considerably by deep placed bands of fertilizer phosphorus or by seed placed bands. Band-placed phosphorus is more important for wheat and possibly alfalfa than it is for corn, grain sorghum or soybeans. Yield increases simply occur more frequently with wheat and alfalfa than with corn, grain sorghum or soybeans.

Western Nebraska Eco-Fallow

Nitrogen benefits on eco-fallow corn or grain sorghum depends upon soil moisture, rain, and residual nitrate levels of the soil. The amounts of nitrogen fertilizer for the crops in sequence will range from zero to 110 pounds per acre depending upon residual soil nitrate to a large degree. No nitrogen is needed when residual nitrate levels exceed 100 pounds per acre. Application can coincide with tillage without a special application, but there will be times when a separate application is necessary.

The probability of a yield increase from applied phosphorus affects the decision to use phosphorus. Soil tests are still the best guide. Most often phosphorus can be applied at planting to meet the phosphorus needs of the crop. □
PUMP Improves Irrigation

By Paul E. Fischbach and Mark A. Schroeder

One of Nebraska agriculture’s largest energy users is irrigation. Nearly seven million acres are currently irrigated with 70,087 irrigation wells. The energy required for pumped irrigation is estimated at an equivalent 240 million gallons of diesel fuel in Nebraska. Rapid and continuing increases in energy costs and recent low commodity prices have placed many irrigators in poor cash flow situations.

Keeping the energy input for irrigation at a minimum is important and places greater emphasis on efficient pumping plant performance. Tests conducted by the University of Nebraska between 1956-1962 and in 1977 indicated the typical irrigation pumping plant was using 30 percent more energy than necessary due to poor pumping plant performance.

When energy was cheaper, paying an extra 30 percent for energy to irrigate was not considered serious.

The Pump Unit Management Program was implemented to demonstrate irrigation fuel savings. Demonstrations (below left) on proper pumping plant adjustment were conducted by the Cooperative Extension Service throughout Nebraska.

However, energy prices have risen dramatically during the past decade. Diesel fuel prices have risen from $0.15/gallon to $0.95/gallon, propane from $0.15/gallon to $0.65/gallon, electricity from $0.015/kWh to $0.065/kWh, and natural gas from $0.30/mcf to $3.00/mcf.

Typically, a diesel-powered pumping plant lifts water from 100 feet below ground level, supplies 70 pound per square inch pressure to an 800 gallon per minute center pivot irrigation system. Assume that the pumping plant performance is at the average energy performance level for the state of 77 percent of the Nebraska Pumping Plant Performance Criteria (NPPPC) and the irrigator is applying 12 inches of water annually on 130 acres. In 1973, the total annual fuel cost would have been $829. In 1983 those costs would have been $5,253. By improving the efficiency to 100 percent NPPPC this irrigator could save 1,288 gallons of diesel fuel annually. In 1973, the savings would have been only $193 but in 1983 the energy savings would be $1,224.

PUMP

The Pump Unit Management Program, known as PUMP, was implemented by the Nebraska Cooperative Extension Service in 1980 to address the problem. The program was conducted by the Agricultural Engineering Department with funding from the Department of Energy and the Nebraska State Energy Office and was developed to create an awareness of the potential energy savings from proper pumping plant performance.

Performance Demonstrations

A key element of the program was targeted to irrigators, with several demonstrations held in the state during the irrigation seasons of 1980, 1981, and 1982. The demonstrations showed the benefits of performance testing and the methods available to improve pumping plant efficiency and reduce energy consumption.

The demonstrations were held at... (Continued on next page)
farmer-owned pumping unit sites in most of the irrigated counties within the state. Extension agents scheduled and promoted the demonstrations. Technologists tested the pumping plant at each well site to determine its operating characteristics (i.e. lift, pressure, pumping flow rate, and energy consumption) under normal operating conditions. Test results indicated the energy performance of the pumping plant, and the technologists determined whether adjustments to the pump or drive unit were necessary. Adjustments to the pump or engine were made when appropriate. The pumping plant was then retested to determine any performance change.

The public demonstrations were held in the afternoon or evening. During the demonstration, the technologist explained the test procedure, the test results, and changes made to the pumping plant. Discussion on pumping plant operation, problems, and adjustments was a major part of the demonstration. One hundred forty-one demonstrations were held and over 4,000 irrigators attended during the three year period. As a result of the demonstrations and other special testing, 189 pumping plants were tested.

**Evaluation Criteria**

The Nebraska Pumping Plant Performance Criteria (NPPPC) were used to evaluate and rate power unit and pump performance. The NPPPC represent the energy performance level which can be expected from a properly designed and maintained pumping system. It is a compromise between the most efficient pumping plant possible and an average pumping plant. The present criteria are shown in Table 1.

The recommended criterion for diesel pumping plants was changed from 10.9 water horsepower per hour/gal to 12.5 whp/h/gal in 1981. This reflects the increased efficiency of newer diesel engines due to improved engine design, increased use of turbocharging of the intake air, and the use of inter-coolers (after-cooling).

**Pumping Plant Test Results**

A summary of the performance checks made on the pumping plants during the past three years (1980-1982) is found in Table 2. The tests included the four common energy sources used to pump water: diesel, propane, natural gas and electricity.

Results of these tests also indicated that the pumping plants had an average rating of 77 percent of NPPPC. The average pumping plant was using 30 percent more energy than necessary. In Nebraska, that is equivalent to nearly 60 million gallons of diesel fuel wasted annually by inefficient pumping plants. Over one-third (38%) of the pumping plants were using between 30 percent to 200 percent more energy than necessary according to the NPPPC. Seven percent were using over twice the energy required to accomplish the pumping job efficiently. Eleven percent met or exceeded the NPPPC. The performance ratings ranged from a low of 33 to a high of 126. Both of these pumping plants were diesel powered. The pumping unit with the 33 rating was consuming three times the fuel required to accomplish the pumping requirements.

In-field adjustments to many of the pumping plants improved the energy efficiency and reduced the annual pumping costs. Approximately three of five (59%) pumping units benefited from rather simple field adjustments to the power unit, pump, or both. These adjustments increased the energy efficiency an average of 14 percent with a corresponding reduction in energy cost. Table 3 summarizes the results from adjustment to 111 pumping plants.

Pump adjustments resulted in pumping rate increases of up to 500 gpm and energy savings up to $1,350 per year. Average energy savings were $306 per adjusted pumping plant based on reported energy cost, acres irrigated, and irrigation depth applied. The procedure required less than one-half hour of labor for most pumping plants.

**Pump Adjustments**

The most common adjustment made which improved pump performance was the adjustment of the pump impellers within the pump bowls. Improper installation and wear were two reasons cited for needed adjustment. After the adjustment, energy saving resulted because the pump became more efficient, pumping more water without an increase in speed and the time to pump a given amount of water was reduced.

Most spark ignition engines benefited from an adjustment to the ignition timing or carburetor. Ignition parts such as spark plugs, points, and ignition plug wires were checked and/or replaced before adjustments made.

Ignition timing was set for each engine to match its actual operating speed and load. Since most irrigation engines primarily operate at constant speed and load, the timing was specifically set for that particular pumping plant.

Setting the fuel/air mixture for the engine is very important for both economy and engine life. The carburetor adjustment provided the most significant increase in fuel economy compared to the ignition timing adjustment. Most engines were found to have an overly rich fuel/air mixture, which caused poor fuel economy. No attempt was made to make engine adjustments to diesel engines as specialized equipment would be needed to check injection patterns and injection timing.

**Other Adjustments and Pumping Plant Problems**

Pump and engine adjustments were the easiest and most common means of improving and maintaining proper pumping plant performance. In many cases, however, other problems limited the best efficiency possible from the pumping plant. Additional savings could be realized only from repair or replacement of pumping plant components. A cost analysis would be needed to determine whether expenditures for repair or replacement were warranted based on the individual pumping plant test results. Table 3 shows the average energy savings potential which would result form further increase in the pumping plant performance to meet the NPPPC.
Forty-one percent of the pumping plants were not adjusted for various reasons. Many of the pumps were operating according to the pump manufacturer’s specifications and were adjusted properly before the test. Other pumping plants were operating at or above the NPPPC and no attempts were made to adjust them.

In some cases, adjustment caused poorer pumping plant performance. This usually occurred with a direct-coupled electric motor and pump. The increased pumping rate from placing the pump in correct adjustment caused some wells to be over pumped, resulting in air pumping and poor performance. A smaller pump was recommended in these cases.

The increased flow rate (and pressure on sprinkler systems) after the pump adjustment raised the horsepower requirement of the power unit in other instances. This caused overloading of some initially undersized electric motors. A larger motor or lower capacity pump was recommended to correct the problem.

Other pumping plants were not properly designed for the pumping conditions. A specific pump model has a peak operating range in which it is most efficient. If the pressure and water output of the system did not fall within this range, the pump was inefficient. Purchase of a more efficient pump was recommended.

Some power units were not properly matched to the horsepower requirements of the pump. Engines perform best when operated at 80-100 percent of their continuous power rating. Oversizing and undersizing of engines contributed to poor efficiency. Changing the gear head ratio would allow the engine and/or pump to operate more efficiently in many cases.

Finally, in-field adjustment to the pump or engine could not compensate for excess wear of the pump or engine. Major overhauls or replacement of the pump and/or engine would be required to bring the performance up to the NPPPC.

Well Problems

Poor performance was also due to the pump drawing air from the well. Reducing the pump speed to the point where air was no longer being drawn into the pump usually restored the performance. At this point, the pump capacity did not exceed the well capacity.

Pump speed could not be slowed on direct coupled electric systems to reduce the pumping rate. Solutions to eliminate air pumping were to lower the pump bowls or replace the pump with smaller capacity. Certain wells would benefit from an acid treatment to remove encrustation at the well screen. This would improve the well efficiency and increase the well capacity.

**Pumping Plant Testing Services**

Several firms are currently available in the state which can test irrigation pumping plants for energy efficiency. These firms, including well drillers, engineering and crop consultants, public agencies, and others, can make recommendations to improve the energy efficiency of pumping units. Many also perform the actual adjustments, repair, and replacement.

Pumping plant tests and adjustments performed by these firms have already saved an estimated 350,000 gallons of diesel fuel equivalent during the past three years. These savings occurred from a relatively small number of pumping plants (1,506). Several thousand more pumping plants could benefit from the tests. On the average, those plants needing adjustments will pay back the cost of the tests in less than a single pumping season.

### Table 1. Nebraska Pumping Plant Performance Criteria (NPPPC)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>gallon</td>
<td>12.5</td>
<td>100</td>
<td>23%</td>
</tr>
<tr>
<td>Propane</td>
<td>gallon</td>
<td>6.9</td>
<td>100</td>
<td>19%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>mcf/1000ft³</td>
<td>6.7</td>
<td>100</td>
<td>17%</td>
</tr>
<tr>
<td>Electricity</td>
<td>kilowat-hr</td>
<td>0.885</td>
<td>100</td>
<td>66%[3]</td>
</tr>
<tr>
<td>Gasoline</td>
<td>gallon</td>
<td>8.7</td>
<td>100</td>
<td>17%</td>
</tr>
</tbody>
</table>

1. The water horsepower which can be produced for one hour from a unit of energy if the pumping plant is considered efficient. Criteria assumes 75% field pump efficiency and 95% drive efficiency (electric drive efficiency = 100%). Assumes no cooling fan. Electric motor efficiency = 88%.
2. Based on average Btu energy content of fuel source: Diesel: 140,000 Btu/gal; Propane: 92,000 Btu/gal; Natural gas: 590 Btu/ft³; Electricity: 3.415 Btu/kWh; Gasoline: 128,000 Btu/gal.
3. Efficiency as given is wire-to-water efficiency calculated at the pump site. Overall efficiency from power generation plant to water is approximately 17 percent.

### Table 2. Nebraska pumping plant test results - 1980, 1981, 1982

<table>
<thead>
<tr>
<th>Pumps tested</th>
<th>100+</th>
<th>90-100</th>
<th>75-89</th>
<th>50-74</th>
<th>49 or less</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of total</td>
<td>11%</td>
<td>22%</td>
<td>22%</td>
<td>38%</td>
<td>7%</td>
<td>100%</td>
</tr>
<tr>
<td>Average Performance Rating — 77</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Rating on scale of 0-100+ with 100 equivalent to performance meeting the Nebraska Pumping Plant Performance Criteria.


<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>43 of 69</td>
<td>14.9</td>
<td>507 gal</td>
<td>442 gal</td>
<td></td>
</tr>
<tr>
<td>Propane</td>
<td>16 of 17</td>
<td>15.5</td>
<td>595 gal</td>
<td>949 gal</td>
<td></td>
</tr>
<tr>
<td>Natural Gas</td>
<td>19 of 27</td>
<td>14.2</td>
<td>81 mcf</td>
<td>67 mcf</td>
<td></td>
</tr>
<tr>
<td>Electric</td>
<td>33 of 76</td>
<td>12.2</td>
<td>1900 kWh</td>
<td>1900 kWh</td>
<td></td>
</tr>
</tbody>
</table>

Average energy savings — 14.0%

1. Energy savings per adjusted pumping plant for 130 acre-feet of water.
2. Adjustments resulted in savings on 117 (59%) of 189 pumping plants tested.
3. If pumping plant performance increased to 100 rating.
Scheduling Key To Efficient Irrigation

By Paul E. Fischbach and Gary W. Buttermore

Irrigation scheduling is applying the right amount of water at the right time to maintain economic crop production.

Nebraska’s average rainfall varies from 15 inches per year on its western borders to over 30 inches per year on its eastern borders. Rainfall during the cropping season can vary from 2 inches to over 20 inches. Therefore, to have efficient irrigation it is important to use rainfall effectively in the irrigation scheduling procedures.

Studies by the U.S. Geological Survey show that the amount of water pumped from the ground water reservoir from 1969 to 1972 varied from 14.2 to 25 acre-inches per acre in irrigated counties of the Upper Blue River Basin. Studies by the Bureau of Reclamation also show similar amounts of water delivered to the farms in the McCook, Nebraska and Torrington, Wyoming areas. The average amount of water used for surface irrigation is about 20 acre-inches per acre per year in Nebraska.

Surveys by the Agricultural Engineering department, University of Nebraska, show that irrigators using center pivot sprinkler systems applied 12 to 30 inches of water per acre in the Imperial and O’Neill areas of Nebraska in 1973. Calculated water losses varied from 0 to 15.3 inches. Surface irrigators in the Wood River area of Nebraska from 1979 to 1983 had water application amounts from 0 to 53.3 inches of water per acre. Calculated water loss varied from 0 to 35 inches.

A survey conducted by the Clay County Extension Service and Clay County Groundwater Conservancy District showed irrigation amounts from both surface and sprinkler systems averaged 22.0 inches per acre from 1970 to 1975. An irrigation scheduling program was initiated in 1976 and from 1976 to 1982 water application amounts averaged 13.1 inches. Rainfall averaged only 1.3 inches more for the growing season during this period. Therefore, irrigation scheduling resulted in an average reduction in irrigation amounts of 7.6 inches or 35 percent.

Recent research over a period of years at the University of Nebraska field laboratory at Mead and the North Platte Station shows that 8.0 to 11.2 inches of irrigation water produced maximum corn yields. Also, 8.5 to 9.7 inches of irrigation water produced top yields of sugar beets at the Northwest Agricultural Laboratory near Alliance.

Consequently, if improved irrigation management practices were used to schedule irrigations, nearly 35 percent of the water and energy could be saved. For sprinkler irrigation, the problem appears to be making effective use of the rainfall and stored moisture in the soil profile. For surface irrigation, the problem is the same plus excessive runoff and deep percolation. Reuse systems could reduce the runoff losses to near zero. Also, better irrigation management practices could reduce deep percolation losses so they are negligible. Water applications that exceed two inches each irrigation usually result in part of the irrigation water percolating below the root zone. If the root zone is completely refilled at each irrigation, the chances of deep percolation are great if rainfall occurs soon after irrigation.

Surveys indicate that most of the irrigation systems now in use have excessive capacity. Because of fear of drought and lack of information on actual soil and water conditions, the farmers use that excess capacity to apply unneeded water. Many systems are started early in the growing season and operated nearly continuously regardless of rainfall, soil water conditions or actual crop needs. Deficit irrigation scheduling and irrigation management programs are needed on how to operate and manage an irrigation system to make the most efficient use of rainfall and soil water stored within the crop’s root zone.

Energy requirements for irrigation from the ground water supply are directly proportional to the amount of water applied, lift from the ground water reservoir and pressure on the irrigation system. Consequently, it is obvious that irrigation water losses due to runoff or deep percolation represent excess energy requirements. Also, rainfall losses due to
runoff or deep percolation during the growing season represent excess energy requirements. Therefore, the root zone should not be completely refilled each irrigation. There should be room within the root zone of the crop for 0.5 to 1.0 inch of rainfall should it occur.

**Nitrate Leaching**

Research has shown that excessive water application (more than the soil will retain within the root zone) leaches some of the nitrogen from the root zone. Sandy soils with low water holding capacities are more subject to nitrate leaching than fine textured soils with higher water holding capacities. The data shows that the amount of nitrate leaching varied from 5 to 10 pounds of nitrogen per inch of excess water applied (Table 1).

It appears increment feeding of the nitrogen to the crop and applying less water than the soil will hold within the root zone, could eliminate any nitrate leaching due to irrigation. However, nitrogen produced by the soil during the off-season or nitrogen not used by the crop could be leached by excess rainfall, in the fall or spring.

**Irrigation Scheduling**

Pilot scientific irrigation scheduling projects show that 7.3 inches of water could be saved (35 percent of the water). Many schedulers did a fine job of scheduling the water at the right time but the operator of the equipment had control of the amount of water applied. The most critical part of irrigation scheduling is to apply the right amount of water at each irrigation according to the water needed for that particular soil and crop. There is also a difference between recommending the needed amount of water and the irrigator accomplishing it with the irrigation system. The irrigator must have an efficient irrigation system and the knowledge and desire to operate it properly. Consequently, nitrogen management and water management must be practiced with irrigation scheduling.

Motivation to accomplish this is dollars saved. At present day prices the estimated savings is $18.62 per acre for gated pipe systems and $30.73 per acre for center pivot systems in diesel fuel equivalents and nitrogen saved (Tables 2 and 3). Although irrigation scheduling can save 7.3 inches of water per acre, the water saved is usually left in storage in the ground water reservoir for future use and is probably not available for another use. Therefore, if scientific irrigation scheduling with proper nitrogen management and water management was carried out on all the irrigated acres in Nebraska, it would save annually **$122.5 million** in energy and **$52 million** in nitrogen fertilizer. In addition, it would save 52.6 million acre inches of water on 7.2 million acres.

During the 1983 irrigation season, some form of irrigation scheduling was practiced on 2.6 million acres. With an average savings of 7.3 inches of water per acre, 19.0 million acre inches of water were saved for Nebraska (Table 5). In addition, $19.9 million worth of nitrogen fertilizer and $44.2 million worth of energy was saved. The total estimated amount of nitrogen and energy saved was **$64.1 million** in 1983.

---

**Table 1. Nitrate leaching with excess water (soil texture-fine sand) 200 lbs. N/ac with nitrogen applied at various times.**

<table>
<thead>
<tr>
<th>Preplant</th>
<th>Sidedress</th>
<th>Increment applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>5</td>
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</tbody>
</table>

**Table 2. Estimated savings with gated pipe systems in Nebraska (diesel powered).**

<table>
<thead>
<tr>
<th>Diesel fuel saved</th>
<th>Nitrogen saved</th>
<th>Total saved-fuel + &quot;N&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>$/ac</td>
<td>$/ac</td>
<td>$/ac</td>
</tr>
<tr>
<td>$1.50</td>
<td>$10.95</td>
<td>$1.05</td>
</tr>
</tbody>
</table>

Water saved - 7.3 in/ac
Fuel saved - 1.50 gal/ac in at $1.00/gal
Nitrogen saved - 7.0 lbs/ac in at $0.15/lb

**Table 3. Estimated savings with center pivot systems in Nebraska (diesel powered).**

<table>
<thead>
<tr>
<th>Diesel fuel saved</th>
<th>Nitrogen saved</th>
<th>Total saved-fuel + &quot;N&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>$/ac</td>
<td>$/ac</td>
<td>$/ac</td>
</tr>
<tr>
<td>$3.16</td>
<td>$23.07</td>
<td>$4.21</td>
</tr>
</tbody>
</table>

Water saved - 7.3 in/ac
Fuel saved - 3.16 gal/ac in at $1.00/gal
Nitrogen saved - 7.0 lbs/ac in at $0.15/lb

**Table 4. Estimated potential savings of energy, nitrogen and water in Nebraska with irrigation scheduling.**

<table>
<thead>
<tr>
<th>Energy Saved*</th>
<th>Nitrogen Saved</th>
<th>Water Saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>M, ac</td>
<td>M $</td>
<td>M $</td>
</tr>
<tr>
<td>Sprinkler</td>
<td>3.6</td>
<td>83.1</td>
</tr>
<tr>
<td>Surface</td>
<td>3.6</td>
<td>39.4</td>
</tr>
<tr>
<td>TOTAL</td>
<td>7.2</td>
<td>122.5</td>
</tr>
</tbody>
</table>

*Energy saved could be adjusted by a factor of 0.91 to reflect the savings potential with an energy composite of 33% diesel at $1.00/gal, 30% electric at 5.0kWh, 15% liquid petroleum gas at $0.65/gal, and 23% natural gas at $3.10/mcf. Energy saved shown is as if all the pumping plants were diesel.

**Table 5. Acres scheduled in Nebraska.**

<table>
<thead>
<tr>
<th>Year</th>
<th>Million Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>0.8</td>
</tr>
<tr>
<td>1979</td>
<td>1.2</td>
</tr>
<tr>
<td>1980</td>
<td>1.6</td>
</tr>
<tr>
<td>1981</td>
<td>2.0</td>
</tr>
<tr>
<td>1982</td>
<td>2.3</td>
</tr>
<tr>
<td>1983</td>
<td>2.6</td>
</tr>
</tbody>
</table>
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