Till Planting on Ridges
Michigan State University Extension Service
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Issued March 1983
12 pages

Extension Bulletin E-1683 • Cooperative Extension Service • Michigan State University • March 1983

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FIGURE 1. Where growing seasons are short, planting long season crops on ridges has been successful on level, medium textured lake plain, till plain, and outwash plain soils. The system is best adapted to wide row crops such as corn.

Till planting is a method of crop production whereby seedbed preparation and planting are completed in the same operation. The Soil Conservation Society of America defines *till plant* as "seedbed preparation for row crops by scalping the area of the old crop row and pushing soil and residues aside leaving a protected cover of crop residue on and mixed in the surface layer between the crop rows."

A soil ridge is a long narrow crest of soil material constructed with tillage implements. The dimensions are variable. When associated with planting a crop, the ridges are high enough to be easily noticed and narrow enough that only a single row is planted on each ridge. The dimensions are dependent upon the crop grown and the reason for ridging (Figure 1). The height decreases and the width increases as the soil material in the ridge settles and erodes.

Other terms such as ridge planting, ridge tillage, ridging, ridge till planting, etc. are frequently used to describe this crop production system. All terms are adequate if communication is good.

Till planting on ridges is not common in Michigan, but is now being actively advocated in the state. This situation is somewhat unusual because there are no Michigan research or extension publications dealing directly with this topic, therefore, there is little local information other than observations to support this concept.

This bulletin should be considered as an interim report, usable primarily until research is completed and summarized. The authors have been involved in tillage research, including some on till planting in the early 1950's. Their experiences, observations and recent research in Michigan and in nearby states serve as a basis for this bulletin.

1. Appreciation is expressed to Dr. C. M. Harrison, Professor Emeritus, Department of Crop and Soil Sciences for valuable assistance in the preparation of this bulletin.

Till Planting on a Ridge — Why?

There is increasing interest in till planting on ridges because some proponents list up to 20 reasons why this method should be preferred. From observations, it seems that the greatest advantage to ridge till planting is the drier and consequently warmer soil materials in the ridge top where seed is planted. This consideration becomes significant in the more northern latitudes, especially for early planted crops such as corn. When compared with conventional tillage methods this system requires less machinery.

There is another important consideration: this system prevents excessive soil compaction over the entire field because it represents a "controlled traffic" method. The wheels of tractors, harvesters, wagons, manure spreaders and sprayers should always travel in the furrow and use the same rows (Figure 2). Other areas in the field should not be subjected to traffic. Thus, there is much less excessively compact soil in ridge till planted fields.

Other advantages sometimes listed include little or no residues on the ridges to interfere with planting, residues in the furrow support farm implements when soil is wet, residues left over winter provide protection for wildlife and feed for livestock and a reduced reliance on herbicides because cultivation is possible.

Occasionally, claims of improved drainage, better protection from both wind and water, and increased yields are reported. Under the right circumstances, these may be advantages; but observations at several locations in Michigan and elsewhere suggest that these do not occur in every ridge till-planted field.

Because only three or four field operations are involved with this method, (ridge making, planting, cultivating and harvesting) there may be savings, especially in fuel and time requirements for crop production.

FIGURE 2. Corn being till planted on ridges. Most of the residues from the previous corn crop is located in the valleys where they support both planter and tractor tires. This represents a controlled traffic method which should reduce opportunities for excessively compact soil. Photo — Hiniker Company, Mankato, MN

Fuel and time requirements for till planting on a ridge are relatively low, as shown in Tables 1 and 2. Total energy and time requirements can be reduced from those shown by eliminating, where possible, some field operations such as stalk shredding.

Till Planting on a Ridge — Where?

A number of observations indicate that ridge till planting cannot and should not be used on all soils in the state. Accelerated soil erosion by water has been a problem in some fields with relatively long slopes, especially where the ridges were parallel to the slopes. Erosion was greatest when ridges were built after the harvest of small grains, soybeans or beans—crops which normally produce relatively small quantities of residues. To reduce soil erosion by water, the ridges should be on the contour or across the slope. This is difficult in many fields having short slopes with variable degrees of steepness.

Ridge till planting is not a practical alternative on some fine textured soils. For example, on a Charity clay soil in Saginaw County, ridges could not be constructed in one or even two cultivations without damage to a corn crop.

Ridge till planting is likely to prove advantageous on the level, medium-textured lake plains, till plains, and out-wash plains in the state, especially on those soils that are relatively cool in the spring due to slow internal drainage. In contrast, production problems with ridge till planting are likely on inadequately drained, compact and sticky clay soils and in fields with variable length and degree of slope.

The information in Table 3 suggests which tillage system might be most suitable for soil erosion control in Michigan under varying soil texture and slope conditions. It is not recommended on organic soils because erosion by wind may be a significant problem.

TABLE 1. Fuel requirements for ridge till planted corn in comparison with other production systems.

Field Operation	Production system			
	Moldboard plow	Chisel plow	No till	Ridge till
	---------------- Gal./Hr. Diesel fuel-----------			
Shred stalks	---	0.63	0.63	0.63
Moldboard plow	1.82	---	---	---
Chisel plow	---	1.12	---	---
Fertilizer, knife	0.64	0.64	0.64	0.64
Disk	0.63	0.63	---	---
Disk	0.49	0.49	---	---
Plant	0.63	0.63	0.73	0.82
Cultivate	0.42	0.42	---	0.42
Cultivate	---	---	---	0.42
Weed spray	0.11	0.11	0.11	---
Weed spray	---	--	0.11	---
Total	**4.74**	**4.67**	**2.22**	**2.93**

TABLE 2. Typical labor requirements for four corn production systems.

Field Operation	Production system			
	Moldboard plow	Chisel plow	No till	Ridge till
	--------Hours per Acre---------			
Shred stalks	---	0.17	0.17	0.17
Moldboard plow	0.38	---	---	---
Chisel plow	---	0.21	---	---
Fertilizer, knife	0.13	0.13	0.13	0.13
Disk	0.16	0.16	---	---
Disk	0.16	0.16	---	---
Plant	0.21	0.21	0.25	0.25
Cultivate	0.18	0.18	---	0.18
Cultivate	---	---	---	0.18
Weed spray	0.11	0.11	0.11	---
Weed spray	---	---	0.11	---
Total	**1.33**	**1.33**	**0.77**	**0.91**

TABLE 3. Recommended Tillage Systems* for soil erosion control in Michigan.

	Percent slope			
Surface soil texture	0-2	2-6	6-12	12-18
Sand Loamy sand Sandy loam	NT,MB,CP,RT[1],OD	CP,NT,OD	CP,NT	NT
Loam Silt loam Silt	MB,RT,OD	CP,NT,OD	CP,NT	NT
Sandy clay loam Clay loam Silty clay loam	MB,RT	CP	CP	NT
Sandy clay Silty clay Clay	MB	CP	CP	NT

*NT — No.till; MB — Moldboard plow; CP — Chisel plow; RT — Ridge Till; OD — Offset disk

[1]Droughty sands and loamy sands present stand and wind erosion problems unless irrigated.

Till Planters

In the past, till planters have been available in Michigan from both mainline and shortline companies. At the moment, two makes are conspicuous where ridge till planting is used in the state. Other till planters are reported to be available from mainline companies.

The *Buffalo All-Flex Till Planter* is advertised as the "original conservation tillage machine" (Figure 3). The planter consists of a "stabilizing disk" that slices through residues and activates the seed, fertilizer and pesticide hoppers. This is followed by a sweep or row cleaning discs which make a smooth planting area on top of the ridge. In this operation, 2 or 3 inches of soil material are removed from the top of the ridge. Trash guards move stalks, roots and other debris to each side of the row. The seed shoe firms a narrow slot in moist soil on the ridge. The seed shoe is followed by a press wheel which firms the seed into moist soil. The last part of the planter is a disk that covers the seed with granular soil material. Fertilizer, either liquid or dry, is placed to the side of the seed but not below the seed level.

The *Hiniker Econ-O-Till Planter* is advertised as being versatile in that it is well suited to conventional, minimum till and no-till systems in addition to till and ridge till planting. This planter unit as used for till planting involves two parts. The "*Econ-O-Till*" part includes a coulter for cutting through crop residues. The coulter is referred to as a "stabilizer gauge wheel." This wheel is followed by two opposing disks that clean and level the top of the ridge. A fluted coulter follows which "prepares a mini-seedbed" directly ahead of the planter.

The *Econ-O-Till* implement has a unique weight transfer system designed to improve soil penetration of the row cleaning disks and fluted coulters. The planter units represent the second part of the *Hiniker Econ-O-Till Planter*. There is a choice of planter units that can be used with this equipment. Adapter kits are available for most of the major kinds of planters.

The standard *Hiniker* was originally designed to handle liquid fertilizer, but now can be ordered to handle dry. The soil opener for the fertilizer is independent of both the tillage and planting units. It is reported that placement "may be from one to four inches to the side of the seed and as deep as four inches" into the soil.

Inquiries have been received about modifying standard or no-till planters for use on ridges. This has been successfully done, but the process requires some skills and an understanding of soil mechanics. No plans for such modification are now available.

Undoubtedly improvements in specifications of commercially produced planters will be made. Your decision on which planter unit is best should be made only after studying recent literature, talking with dealers and seeing the units operate in fields of your kind of soil.

FIGURE 3. Buffalo All-Flex Till Planter with dry fertilizer, seed, insecticide and herbicide hoppers, depth control disk, and trash guards. The sweep that clears a planting area is below and in front of the trash guards. A 10-inch zero pressure seed press wheel firms seed into moist soil. Photo — Fleischer Mfg., Inc., Columbus, NE

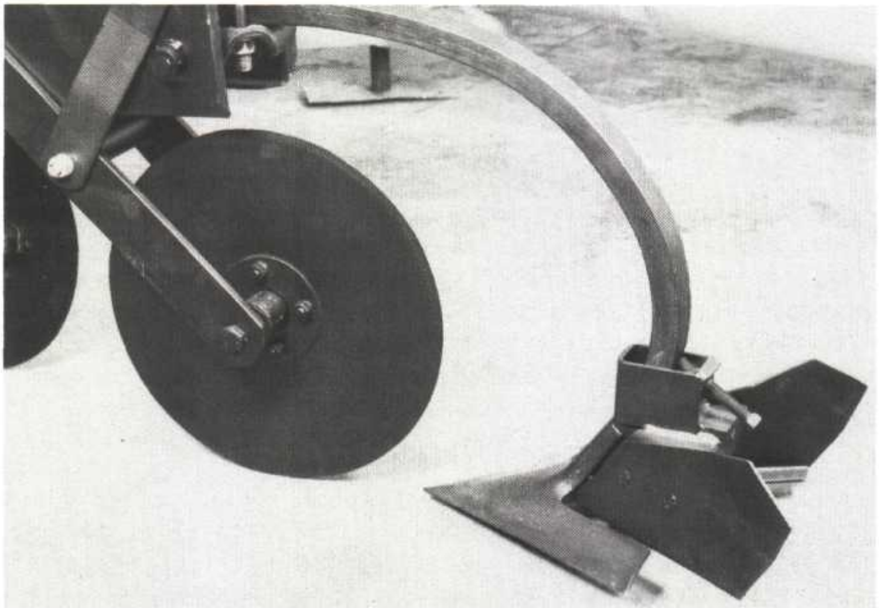

FIGURE 4. The Hiniker ridger features a one bolt adjustment system which allows the ridging attachment to the cultivator to slide on the sweep shank into the working position. The adjustable rolling coulter cuts and divides residue so that it does not collect on the shank. It also stabilizes the cultivator as it moves across a slope. Photo — Hiniker Company, Mankato, MN

Getting Started in Ridge Till Planting

The first step in any project is usually the most difficult. With ridge till planting the first step is determining that your field or farm is suited to this system of cropping.

The best advice is to start out on a relatively level, well drained field with soil that has good tilth, a high fertility level, not acid and has few weeds. In general, you are most likely to be successful on the most productive fields, especially those where perennial weeds, such as quackgrass, are not problems.

In general, it is best to solve your major production problems before you start with this system because there is little in the system that will directly solve the major crop production problems.

The second step is to select the ridger. This should be no major problem because several companies produce ridging implements (Figure 4). Ridging is practiced in many parts of the world. It has long been used with furrow irrigation but has not been used extensively in nonirrigated humid areas, such as Michigan.

Row spacing influences the size of the ridges that can be constructed. Obviously, the system is not well suited to narrow rows such as are recommended for soybeans. Ridging may be a possibility with 20-inch rows, but it is most easily achieved with spacings of 28 inches or wider (Figure 5).

There are three times when ridges can be construced: (1) fall on recently tilled land; (2) spring on either spring or fall tilled soil; and (3) at cultivation time. Cultivation time is preferred because the growing crop soon establishes a complete canopy, and soil-conserving crop residues are left after harvest on the soil surface.

Before ridging where crops are not growing, some primary tillage or cultivation may be necessary, principally to loosen the soil so that the ridgers will be effective. The chisel plow has been a favorite for tillage before ridge construction (Figure 6). Most of the ridgers currently used in Michigan form poor ridges on compacted or fine textured soil without preridging tillage.

Moldboard plowing in either the fall or spring leaves very little residue on the soil surface. Ridging is a relatively simple operation under these circumstances, but soil erosion during the winter or spring may be excessive. Chisel plowing, on the other hand, may leave more soil-conserving residues.

Like moldboard plowing, chisel plowing greatly reduces the feed available for livestock. Thus, fall tillage presents problems on some farms because ridging may intensify erosion problems by burying some of the residues and by providing furrows or channels for water movement across the surface of a field (Figure 7).

Spring tillage in Michigan is generally at a relatively shallow depth. It represents a soil drying process. Deep chisel plowing at this time usually is not advisable, because opportunities for puddling wet soil are high. Theoretically, sweeps used at a shallow depth on a chisel plow should loosen the soil sufficiently to permit ridge construction in the spring. Ridge building in the spring should be considered only on those soils with good structure—those that are not packed.

FIGURE 5. Ridges are easiest to build where row width is relatively wide such as with corn. This level field of medium textured soil is well suited to ridge till planting. Photo — Fleischer Mfg. Inc., Columbus, NE

FIGURE 6. This level, productive field composed of silt loam and clay loam soil materials is well suited to ridge till planted crops. Chisel plowing makes it easier to construct good ridges on these somewhat compacted soils.

Ridging on shallow tilled soils with corn stalks as residues is difficult unless the stalks are shredded.

As a word of warning, it should be recognized that a spring constructed ridge of sandy soil material which contains corn stalks dries very rapidly. This situation has caused delays in seed corn germination and plant emergence.

Some farmers start the ridge till planting system by building ridges at cultivation time (Figure 8). This is a good time on most medium-textured soil providing the soil is relatively dry. Building ridges during cultivation could be a problem for the modern cash crop farmer who is experienced with herbicides. He may no longer want to cultivate corn or soybeans.

On the other hand, this method should appeal to those who are interested in crop production methods that result in decreased dependency upon chemicals such as herbicides. This seems to be a real posssibility for organic farmers, if they can start with a relatively weed-free situation.

FIGURE 7. Ridging in the fall where total crop residue quantities are relatively low and where a portion of the residue has been buried with a chisel plow usually represents an undesirable situation because soil erosion is likely to occur during the winter months.

Essentials for Successful Ridge Till Planting

The essentials for successful ridge till planting appear to be identical to those of other planting systems, namely, that the soil should be in good physical condition, well-drained but moist, free from nutrient deficiencies and acidity and from chances for problems related to soil erosion, insects, diseases and toxic materials.

Three considerations must be made for successful ridge till planting. The first is an evaluation of soil characteristics, mainly texture and drainage. (Soil texture was considered in the section entitled "Till Planting on A Ridge — Where?".)

Some producers attempt to substitute ridge planting for tile and surface drainage. The results generally have been negative. A number of observations suggest that ridge planting cannot compensate for poor drainage even in a relatively dry year.

The second important consideration is length and steepness of slope. As previously suggested, soil erosion by water can be a problem where ridges run up and down hills, especially if they are on long steep slopes. Therefore, it now

FIGURE 8. This soil was ridged to prepare for ridge till planting next year. The ridges are approximately 8 inches high. The compact layer below the ridge represents a plow pan through which some roots have penetrated. With typical weather, the pan would limit root growth and therefore yields. Don't attempt to ridge till plant crops on compacted soils such as this.

seems that ridge till planting is best suited to the more level areas of the state.

The third consideration for successful ridge till planting is the planter, which must stay on the realtively narrow ridges. Its operation should not be significantly affected by crop residues or soil compacted at harvest time (Figure 9). The planter should place seed so that it is firmly in contact with moist soil, while at the same time locating a banded planting time fertilizer at equal distances to the side and below the seed. This point sometimes is ignored by planter manufacturers, but is important in the northern latitudes where low temperatures result in slow root elongation and nutrient uptake.

FIGURE 9. Soybean residue in field where corn will be ridge till planted next year. Notice the compacted soil material caused by the combine tire. In this instance the 34 inch tires affected all of the soil material in the valley between the rows.

Soil Characteristics of Ridge Till Plantings

The ridges in a till planted field should never be subjected to traffic. Where this condition exists, the soil material in the ridges is considerably different than the material between the ridges or the materials in conventionally planted fields. The soil material in the ridges should have both large pores and more pores than that in the valleys where the soil materials, due to traffic, may be excessively compact.

In the spring, the soil materials in the ridges are almost always warmer. The percent organic matter in the ridges may not be necessarily higher, but the total amount (weight) will be greater because the ridge-building process results in the surface soil high in organic matter being piled on top of the organic material. This also describes the movement of fertilizer materials which were broadcast before ridging.

The location and characteristics of crop residues is an important consideration and dependent upon time. Shortly after a crop such as soybeans is harvested, most of the residues are likely to be in the valleys for the simple reason that the valleys represent the lowest areas in the field. Fresh residues from high-yielding corn are usually located on the ridges unless they have been chopped. With time, however, many of the partially decomposed stalks slide into the valleys where they effectively decrease water runoff rates. They may be less evident where low or average yields are produced because residue production frequently is proportional to yield.

Crop residue decomposition starts immediately after harvest if temperatures are above the freezing point. The rate of decomposition is regulated by both temperature and moisture (Figure 10). Decomposition rates in the spring are relatively slow until planting time. Rates during the five months of the winter are also slow, but residue decomposition is usually much greater than many farmers anticipate because of the relatively long time span during these months.

The partially decomposed residues in the valley serve as a supporting mat for tractors and planters the following spring. At planting time the very top of the ridge is relatively free of residues and thus warms more rapidly than soil in the valley or the soil in chisel or moldboard plowed fields. The material in the top of the ridge is both moist and firm. These are two characteristics of an ideal seed bed.

Recall the definition of till planting as given on page 1; "scalping the area of the old crop row and pushing the soil and crop residues aside." The soil and crop residues are deposited on top of those residues already in the valley. This condition stimulates the decomposition rate of the residues so that they usually present no special problems at cultivation time.

Ridges are rebuilt at cultivation time, not only with mineral soil material but with the organic matter representing the crop residue located in the valley since harvest time. The new ridges usually range from 7 to 9 inches high and are both higher and narrower than before cultivation. The valleys are wider and deeper, thus the stage is set for both harvesting the present crop and planting another next spring.

Plant Nutrients

As with other planting systems, the use of commercial fertilizer and lime should be based upon soil test results. Root systems of corn and soybeans have been examined at several locations. It was concluded from these studies that banded planting time fertilizer is likely to be used more efficiently than broadcast because very few roots penetrate the valley areas between the rows. Furthermore, it is suggested that where there are no untrafficked furrows, only soil material in the ridges be sampled for soil testing. It seems illogical to sample areas where roots sometimes are inactive or not present.

The major, secondary and micronutrient requirements for ridge till planted crops are similar to those for crops planted on the same soil with other systems. Till planting on ridges should present no special problems related to the use of commercial fertilizer, lime or livestock manure, with one exception. In 1982 the nitrogen requirements of ridge-till planted corn on the University Farm were higher than those in moldboard or no-till systems as evaluated by nutrient deficiency symptoms and green plant tissue tests made in the field.

No data are available at this time on the need to use planting-time fertilizer with this system. Nothing in the system eliminates the need for planting-time fertilizer on low testing soils, especially where soils are likely to be cool, such as frequently occurs in Michigan. Thus, it is evident why the suggestion is made to start this system on high testing soils (Figure 11).

With the ridge till planting method, livestock manure is used as a top dressing and not as an incorporated treatment, unless it is injected into the soil. Injection into the furrow areas is suggested as a means of loosening this soil and locating it where movement of nutrients is unlikely. Large coulters

FIGURE 10. Chopping corn stalks is usually not necessary. When chopped, most of the residue falls or slides into the valley areas where it rapidly decomposes. The rate of decomposition is closely related to both soil moisture and temperature conditions.

FIGURE 11. High yielding ridged soybeans growing on a fertile lake plain soil. The effect of ridging upon soybean yields has not been well researched in Michigan. In this field, pods were very close to the soils surface which is not a desirable situation. Harvest is difficult, especially where rocks are present.

in front of the injection knives aid in preventing accumulation of trash and crop residues where this is attempted.

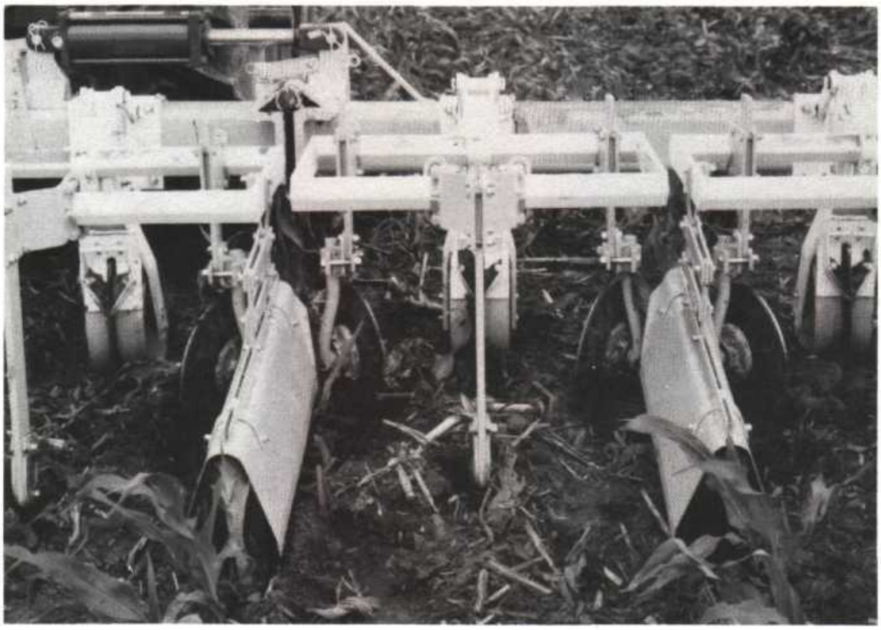

FIGURE 12. Cultivation may be essential for several reasons including weed control, the destruction of soil crusts, the formation of ridges and conditioning crop residues so that they rapidly decompose. Shields of the cultivator help to protect small plants, especially where ridges are not prominent. Photo—Fleischer Mfg., Inc., Columbus, NE

Cultivation

From a management viewpoint, cultivation may be desirable for two reasons: to control weeds and to destroy crusts. With ridge till planting there are two other reasons: to build or to rebuild the ridge and to condition crop residues to hasten decomposition.

Soil crusts in the ridge seem to be less of a problem than with other systems. The explanation for this is related to the use of crop residues and the reduction of implement and tractor traffic normally associated with this system. Because no water stands on the ridges, soil crust problems are reduced.

In some crops, weeds can be controlled exclusively with chemicals. Since ridging is a cultivation process, theoretically the need to use chemicals should be greatly reduced. This appeals to some farmers, especially those who are sympathetic to organic farming concepts.

Questions have been asked about herbicide movement during cultivation. Damage to the crop is unlikely because cultivating does not increase the concentration of the herbicide. Also by cultivation time, most crops are relatively tolerant to many of the chemicals.

One of the minor problems associated with cultivating herbicide treated ridged fields is that the cultivator exposes untreated soil in the valley. This permits some weed seed to germinate but the crop canopy should suppress weed growth. Weeds growing in the valley usually present no problems.

Growing crops on ridges lends itself well to band applications of herbicides over the row. This results in a reduction of herbicide costs.

Most Michigan farmers seem to prefer using herbicides and one cultivation. There may be some advantage to using two cultivations. The major functions of the first cultivation are to kill weeds and to condition the crop residues. The major function of the second cultivation is to rebuild the ridges.

Disk hillers and sweeps are currently used in Michigan for cultivation. Some farmers have modified their regular cultivators by using disks that are mounted in two rows. When first used, such cultivators are adjusted primarily for weed control and for conditioning crop residues so that they decompose rapidly. The front disk is adjusted to cut through some of the residues to hasten decomposition. Soil material may be thrown away from the row. When this is done, the surface of the field may appear to be almost level (Figure 12).

The second cultivation involves ridge building when soil and residues are thrown into the row. Sweeps may be used to loosen the material in the valleys in addition to controlling weeds, conditioning crop residues and supplying the ridge with granular soil material.

Only angle and depth are involved in the adjustment of disk hillers. For the sweeps, depth and soil tilth are the primary considerations.

Pest Control

Interestingly, pest control is seldom mentioned in the literature on ridge till planting. (Weeds are briefly considered in this bulletin under the section on cultivation.) No unusual insect or disease problems have been observed in Michigan where this system is used. While slug damage was common in 1982, the system appears to have no special capacity to generally increase or decrease the intensity of insect or disease problems.

Harvests

Two considerations should be made when harvesting ridge till planted crops. The first and most important is the complete collection of the crop (Figure 13). Under most circumstances, the production of crops in low ridges presents no special harvest problems except when lodging occurs. With dry beans and soybeans grown on high ridges, significant problems may develop when the plant stems fall in the valleys. Fortunately this is not common.

The second consideration is the prevention of excessively compact soil materials. Assuming that the soil material in and below the ridge is not compact, tractor, chopper, combine and wagon wheels should all be spaced so that they travel in the valleys and not on the ridges. The chances are great that the soil materials in some of the valley areas have been previously compacted. Since, on the average, approximately 90% of the compaction in a field occurs with the first trip across the field, extra soil compaction is not a major problem if the traffic is on previously traveled strips.

FIGURE 13. There is no apparent advantage to using ridge till plant systems with dry beans because soil temperatures are relatively warm at planting time. Many producers already "hill" their beans to help with harvests. Some "hills" are as high as the ridges that are common today. Thus there are no special problems in harvesting ridge till planted beans. Direct harvest, even of the erect varieties, appears to be an impractical consideration at this time because the lower pods are so very close to the soils' surface. In excess of 400 pounds per acre of beans were left in the field in this direct harvest field of ridge till planted erect navy beans.

Use Caution

On the basis of both limited research and a number of observations made at several locations in the state, ridge till planting appears to be a good if not a very good method of row crop production, especially for corn. Despite this, caution is suggested especially where soil is erosion prone and excessively compact. Caution represents a normal procedure used primarily where ideas and products have been subjected to only limited research. This is the situation in Michigan with ridge till planted crops.

Ridge till planting is currently promoted in some areas as a conservation tillage method. This is unfortunate because it is known to increase soil erosion where there is a noticeable slope. The USDA-SCS states that ridge till planting "must not be used on slopes over 4% unless contoured." Furthermore the SCS states that a "field should have a minimum amount of 1,000 pounds per acre of corn equivalent residue on the soil surface after a crop is planted." Unfortunately some crops like beans, soybeans, sugarbeets and small grains do not produce this amount. Where erosion is a problem, ridge till planted crops should not be grown without cover crops.

Caution is recommended because it is impossible to produce high crop yields on excessively compact soils, regardless of the system or planter used. The till planter is no exception. If till pans or compacted horizons are present, destroy them before starting with the ridge till planting system.

The best advice at this time on ridge till planting is to critically analyze each piece of literature that you read as well as each talk that you hear. Try to relate what you read, see and hear to the characteristics of the soils on your farm. You will then be able to make the right decision on how to produce field crops most efficiently and how to effectively conserve the environment.

Related Publications

1. Tillage Systems for Michigan Soils and Crops. Part 1. Deep, Primary, Supplemental and No-Till. M.S.U. Ext. Bul. E-1041
2. Tillage Systems for Michigan Soils and Crops. Part 2. Secondary Tillage and Cultivation. M.S.U. Ext. Bul. E-1042.
3. Conservation Tillage. M.S.U. Ext. Bul. E-1354.
4. No-Till Corn: 1. Guidelines. M.S.U. Ext. Bul. E-904
5. No-Till Corn: 2. Fertilizers and Liming Practices. M.S.U. Ext. Bul. E-905
6. No-Till Corn: 3. Soils. M.S.U. Ext. Bul. E-906
7. No-Till Corn: 4. Weed Control. M.S.U. Ext. Bul. E-907
8. Sod Seeding Birdsfoot Trefoil and Alfalfa. M.S.U. Ext. Bul. E-956
9. Crop Residue and Tillage Considerations in Energy Conservation. M.S.U. Ext. Bul. E-1123
10. Wind Erosion Control on Organic Soil. M.S.U. Ext. Bul. E-1229
11. Wind Erosion Control on Upland Soils. M.S.U. Ext. Bul. E-525
12. Soil Erosion by Water. M.S.U. Ext. Bul. E-1169

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