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Mechanized minimum and no-till crop production for research farms

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IITA Research Guides

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Mechanized minimum and no-till crop production for research farms

Objectives. This guide is intended to enable you to:

- discuss tillage systems;
- discuss disadvantages of conventional tillage;
- describe minimum-tillage;
- describe no-till systems;
- list advantages and disadvantages of minimum/no-till systems;
- apply minimum-tillage planting.

Study materials

- No-till planters.
- Slides of conventional and minimum-tillage farming.

Practicals

- Compare conventional and minimum-tillage systems in the field.
- Practice minimum-tillage planting.

Questions

1 What are the three categories of tillage systems in use today?
2 What practices does conventional tillage typically involve?
3 What are the principles which motivate minimum-tillage?
4 Name examples of minimum-tillage practices.
5 What tillage system is described as the most radical of minimum-till system?
6 What are the operations of no-till?
7 What are the disadvantages of conventional tillage operations?
8 Why do annual crops provide little early-season soil cover?
9 How can you protect the soil when planting annual crops?
10 What is the protective action of crop residues on the soil?
11 How does minimum-tillage differ from conventional tillage?
12 What is strip-tillage?
13 What are the steps to follow in strip-tillage operations?
14 What is no-till?
15 For what crops have no-till planting procedures been widely adopted?
16 In what way does no-till offer savings to the farmer?
17 What are the limits with regard to slope in no-till planting in comparison to conventional planting?
18 What are the special features of mechanized no-till planters?
19 Why do no-till planters require more weight than conventional planters?

Mechanized minimum and no-till crop production for research farms

Abstract. Minimum-tillage has several advantages over conventional tillage. It is especially beneficial for tropical soils, which are easily ruined by conventional tillage operations. Minimum-tillage, strip-tillage and no-till farming can also save energy and labor costs.

1 Tillage systems

Tillage systems are classified according to the number of tillage operations involved and the equipment used. In general, three categories of tillage systems in use today are:

- conventional tillage,
- minimum-tillage,
- no-till.

Conventional tillage. Conventional tillage includes plowing plus two to five secondary tillage steps. The number of operations performed in conventional tillage varies by crop and area. Conventional tillage steps are:

- carrying out pre-plow operations (for example, shredding or disking crop residue);
- plowing to pulverize soil;
- ridging or bedding to shape soil;
- disk harrowing or field cultivating;
- harrowing with tooth-type harrows;
- using one- or multi-row cultivators (depending on crop, area, and weed problems).

Minimum-tillage. Minimum-tillage (also called optimum-, reduced-, or economy-tillage) is motivated by several principles:

- reduced energy and labor inputs can bring higher returns;
- conventional tillage reduces soil moisture and promotes soil erosion;
- homogenization of the soil is unnecessary;
- crop production does not depend on preparing a "clean field" (that is, no previous crop residues);
- soil should be disturbed as little as possible.

Minimum-tillage practices include:

- maintaining crop residue on the surface to conserve moisture and build soil organic matter;
- reducing the number of passes over a field;
- eliminating pre-plowing;
- passing once (instead of several times) with secondary tillage equipment such as disks or spring-tooth harrows;
- tilling strips for planting and leaving inter-row areas under residue;
- increasing use of herbicides to replace cultivation.

No-till. No-till systems can be seen in two ways as:

- the opposite of conventional tillage systems;
- the most radical of the minimum-tillage systems.

No-till supports the principles of minimum-tillage by reducing tillage to only one operation: opening the soil for the seed at planting time.

Conventional tillage is being used less and less worldwide. In the temperate, developed countries (especially the U.S.), farmers earn more from their production systems by reducing labor and energy costs through no-till farming. In the tropical, developing regions (for example, West Africa), researchers and farm operators are adopting reduced and no-till systems as a response to the limited fertility of shallow topsoils, which are easily destroyed by conventional tillage operations.

2 Disadvantages of conventional tillage

Conventional tillage employs many passes over a field with various soil-turning and soil-pulverizing pieces of equipment: moldboard plow, disk harrow, spike-toothed harrow, and so on. Such conventional tillage operations have many disadvantages; they:

- leave a fine soil which is prone to erosion;
- require expensive machinery and high fuel consumption;
- contribute to compaction of the soil.

In conventional tillage, land preparation methods invert the soil to bury any surface vegetation and crop residue. Land preparation is usually done by plowing with a moldboard plow and following up with one or more secondary tillage operations to prepare the seedbed for planting or to incorporate herbicides or other chemicals into the soil. The well-worked soil is vulnerable to erosion without the protection provided by the residue, especially during the early planting season.

Annual crops which are planted at the beginning of the rains provide little early-season cover because the plants are small in the early stages of growth.

Minimum-tillage systems provide needed soil protection by maintaining the residue from previous crops. Crop residues produce a mulch that reduces moisture evaporation, the impact of raindrops, and surface runoff. With minimum-tillage, plant residue is left in the field to protect against erosion from wind and water until the next crop is planted.

3 Minimum-tillage systems

Improved machine design and better herbicides allow many of today's crops to be produced under minimum or no-till systems. These systems leave residue on the soil surface, thus minimizing erosion and maintaining soil moisture.

Minimum-tillage. Minimum-tillage operations differ from conventional tillage as follows:

- pre-plowing operations are eliminated entirely;
- plowing operations are reduced. For example, chisel plow or disk harrow is used to loosen the soil prior to planting. This may be the only tillage operation before planting;
- secondary tillage is reduced also, often to only one pass with a disk or spike-toothed harrow;
- weed control is effected through the use of herbicides (for example, a pre-emergent herbicide applied during planting and herbicides applied at any time during the crop's growth), whereas conventional systems use tractors, animal traction, or human labor to cultivate the soil around the plants for weed control.

Strip-tillage. Strip-tillage is a minimum-tillage system in which the only topsoil to be tilled is a strip 10-20 cm wide in which the seeds are planted. The following are the steps used in strip-tillage:

- leave the crop residue standing in the field and slash it by hand or with a tractor-mounted rotary slasher (bush hog);
- then spray the field with a knock-down herbicide to kill weeds and grasses;

- next, use a rotovator with most of the blades removed to till strips at spacings of 50 cm-1 m for planting the crop. These tilled strips are 10-20 cm wide and 10-15 cm deep. They provide a well-prepared seedbed for planting the crop without the danger of erosion.

It may be possible to use an alternative to the rotovator to till strips through crop residue. A chisel plow, for example, set to the width of a conventional planter might, under the right soil types and conditions, leave a seedbed suitable for planting. More experiments with alternative equipment are needed.

4 No-till systems

No-till planting procedures only require tillage to open the soil and place the seed. No-till has been adopted widely for corn, soybeans, and cowpeas. For example, corn can be planted in the stubble from the previous crop or in a mulch of other cover crops which have been killed by a herbicide. The practice is spreading to other crops, including small grains.

Because it eliminates conventional tillage operations, no-till farming saves on energy and labor costs. Switching from conventional to no-till, in fact, can save up to 75 % of the energy used for standard tillage. Part of the saving is reduced, however, because of the need for increased chemicals to control weeds and insects. Nevertheless, other benefits make no-till systems highly cost effective for producing crops.

No-till planting can permit cropping of land too steep for conventional tillage. In the tropics, with shallow topsoil, a rule of thumb is that land steeper than 4 % slope should not be tilled. In such cases, no-till farming – whether mechanized or manual is the only alternative to terracing.

Mechanized no-till planters have some special features:

- they are heavier than conventional planters to enable them penetrate unprepared seedbeds;
- they have special coulters to cut through surface residues. Fluted coulters prepare a seedbed approximately 7 cm wide and 10-13 cm deep, while ripple coulters prepare a seedbed approximately 2-4 cm wide and 10-13 cm deep;
- their coulters are equipped with down-pressure springs to aid penetration;

- their coulters are adjustable to provide the desired degree of tillage;
- they have double-disk openers which open the soil and place the seed;
- they have heavy seed-firming wheels which close the seed furrow and firm the seedbed.

Use of no-till planters is increasing in planting a second crop immediately after the first crop. This reduces the time between harvesting and planting to provide the maximum growing season for the second crop. It reduces loss of soil moisture through evaporation, a result of conventional tillage.

Admittedly, the mechanized no-till planter is a substantial investment. Where the mechanized no-till planter is not available, two alternatives for research farms are:

- Plant by hand using a jab planter. Slash crop residue with machetes, spray herbicides to kill all biomass, and plant by hand without any tillage. In countries where labor is inexpensive, this method may be practical.

- Adapt conventional planters. Although little research has been done, standard tractor-drawn or animal-drawn mechanized planters might be modified to plant directly into non-tilled surfaces. Fluted coulters could be added, extra weight applied so the coulters can penetrate the soil, and weight applied to the press wheels to adequately close the furrow. More discussion and experimentation are needed.

5 Advantages and disadvantages

Minimum and no-till systems have a number of advantages and disadvantages. Every farm manager and farmer needs to decide what system works best for his/her situation. Minimum or no-till systems may not be suitable for all cases. Good management involves selection of the most appropriate system for particular soil and climatic conditions and the selection and operation of appropriate equipment.

Advantages of minimum and no-till systems are:

- Less energy and labor are required for tillage and planting.
- Energy and labor in the total production process are reduced.
- Fewer farm machinery is needed.
- Water runoff is reduced, which is beneficial in two ways: more water is available for the crop and soil erosion is reduced.
- Crop yields are equal to or better than under conventional tillage.
- Planting times are more flexible. Planting can take place immediately after a rain and there is no wait for tillage operations. In double-cropping situations (cowpeas after maize, for instance), harvesting, slashing, spraying, and planting can take place within a few days.

Disadvantages of minimum and no-till systems are:

- Specialized planting equipment is needed, although there are the alternative options of hand-labor and modified conventional planters.

- Herbicides such as paraquat must be used often and with accuracy. Application of a knock-down herbicide is critical since the farmer does not plow or till to control weeds and grasses. Herbicide application increases expenses to the point where herbicide costs may offset savings in labor and fuel. Application rates and time are critical.

  The first application must be early enough to allow new weeds to germinate before planting.

  The second application of paraquat must coincide with application of the pre-emergent herbicide immediately after planting.

- Weeds may persist after the crop is up and inter-row spraying of paraquat (or another product) may become necessary. Paraquat has a low LD 50 and is dangerous to apply.

- Applying herbicide and fertilizer is difficult due to the absence of rows or lines to follow.

- Crop residue left on the surface instead of turned under by tillage may create more insect problems, thereby requiring more insecticide.

- Fields look untidy to a person used to seeing a tilled field.

- Land cleared with a shear blade will still have stumps at ground level. These may damage the planter if the planting is done at too high a speed.

- If the ground is hard due to lack of rain, the planter may not be able to penetrate the soil.

- Sometimes, it is difficult to cover the seed in a no-till situation.

- Fertilizer is applied on the surface and not incorporated. A heavy rain immediately after application may wash the fertilizer away.

- Approximately 10 days before planting apply a knock-down herbicide, i.e. paraquat, 5 l/ha for broadleaf weeds, or Round-up, 5 l/ha for perennial weeds and grasses.

- Broadcast starter fertilizer on the surface: 200 kg/ha of 15 : 15 : 15 (NPK) before planting.

- Mow the field using a rotary slasher after the herbicide has killed the vegetation.

- In a no-till system, plant the crop seed in unprepared seedbed using a no-till planter. Suggested plant population for corn: 50-55 000 plants/ha.

- In a strip-till system, use a rotovator set up for strip tillage, then plant crop seed using a jab planter.

- Within 1-2 days after planting, apply a second treatment of paraquat at 5 l/ha plus a pre-emergent herbicide, for example, Primextra at 5 l/ha.

- If weeds become a problem after the crop emerges, use a backpack sprayer with a shield to spray paraquat between the crop rows. Be careful not to apply the herbicide to the crop.

- Hope for rain.

7 Bibliography

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8 Suggestions for trainers

If you use this Research Guide in training ...

Generally:

- Distribute handouts (including this Research Guide) to trainees one or several days before your presentation, or distribute them at the end of the presentation.

- Do not distribute handouts at the beginning of a presentation, otherwise trainees will read instead of listen to you.

- Ask trainees not to take notes, but to pay full attention to the training activity. Assure them that your handouts (and this Research Guide) contain all relevant information.

- Keep your training activities practical. Reduce theory to the minimum that is necessary to understand the practical exercises.

- Use the questions on page 4 (or a selection of questions) for examinations (quizzes, periodical tests, etc.). Allow consultation of handouts and books during examinations.

- Promote interaction of trainees. Allow questions, but do not deviate from the subject.

- Respect the time allotted.

Specifically:

- Discuss with trainees experiences and importance of minimum- and no-tillage (10 minutes).

  Present and discuss the main points of this Research Guide using the study materials suggested on page 3 (45 minutes). Do not expand your presentation beyond the minimum necessary to conduct the practical exercises.

- Conduct the practicals suggested on page 3 in group work; 3-4 trainees per group (½ day). Make sure that each trainee has the opportunity to practice. Have resource persons available for each group. Keep the groups busy. Provide shading and refreshment.

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