

Unit D: Agricultural Equipment Systems

Lesson 2: Operating, Calibrating, and Maintaining Agricultural Tillage Systems and Equipment

Student Learning Objectives:

Instruction in this lesson should result in students achieving the following objectives:

1. Explain the purpose of tillage systems and equipment used in agriculture.
2. Describe the operating principles of tillage systems and equipment used in agriculture.
3. Describe how tillage equipment is calibrated.
4. Explain how tillage equipment is maintained.

Recommended Teaching Time: 2 hours

Recommended Resources: The following resources may be useful in teaching this lesson:

Buckingham, Frank, and Arland W. Pauli. *Tillage*. Moline, Illinois; Deere & Company, 1993.

Phipps, Lloyd J., and Carl L. Reynolds. *Mechanics in Agriculture*. Danville, Illinois: Interstate Publishers, Inc., 1992. (Textbook, Chapter 227, 28, and 29)

List of Equipment, Tools, Supplies, and Facilities:

- Writing surface
- PowerPoint Projector
- PowerPoint Slides
- Transparency Masters
- Copies of student worksheets

Terms: The following terms are presented in this lesson (shown in bold italics and on PowerPoint Slide 2):

- Clean tillage
- Compaction
- Conservation tillage
- Flotation
- Minimum tillage
- Mulch-till
- Power hop
- Primary tillage
- Secondary tillage
- Tillage
- Traction

Interest Approach:

Lead a discussion with students on what they believe are the purposes or reasons for tillage. Show them various pieces of farm equipment (PowerPoint Slides 3, 4, 5, 6, 7, 8, and 9) and ask them to name the functions of each piece. Slides 3-7 are pictures of equipment that have been used in Afghanistan. Use this discussion to lead into the lesson's first objective.

SUMMARY OF CONTENT AND TEACHING STRATEGIES

Objective 1: Explain the purpose of tillage systems and equipment used in agriculture.

Anticipated Problem: What is the purpose of tillage systems and equipment used in agriculture?

(PowerPoint Slides 10 and 11)

- I. The goal of proper tillage is to provide a suitable environment for seed germination, root growth, weed control, soil erosion, and moisture control.

(PowerPoint Slide 12)

- A. **Tillage** is the mechanical, soil stirring actions carried on for the purpose of nurturing crops.
 1. The primary objective of any cropping program is continued, profitable production. Most farmers prefer to follow proven practices with readily available equipment.
 2. No tillage operation can be justified merely on the basis of tradition or habit. Any tillage practice which does not return more than its cost by increasing yield and improving soil conditions should be eliminated or changed.
- B. A tillage system is the sequence of tillage operations performed in producing a crop.
 1. **Primary tillage** is a deep, at least 15 centimeters, operation that loosens and fractures the soil to reduce soil strength and to bring or mix residues and fertilizers into the tilled layer. The moldboard plow; chisel and disk plow; heavy tandem, offset and one-way disks; subsoilers; and heavy-duty, powered rotary tillers are used for primary tillage.
 2. **Secondary tillage** is used to kill weeds, cut and cover crop residues, incorporate herbicides and prepare a well pulverized seedbed. Secondary tools operate at depths of 13 centimeters or less and include: light and medium weight disks; field and row-crop cultivators; rotary hoes; drags; powered and unpowered harrows or rotary tillers; rollers; ridge or bed forming implements and numerous variations or combinations of these.

Use TM: 2-1 (PowerPoint Slide 13) and TM: 2-2 (PowerPoint Slide 14) to provide examples of tillage equipment. Discuss the differences between equipment used for tillage and if it is used for primary tillage or secondary tillage.

Objective 2: Describe the operating principles of tillage systems and equipment used in agriculture.

Anticipated Problem: What tillage systems and equipment are used in agriculture?

(PowerPoint Slide 15)

- II. Tillage systems and equipment vary, depending on the soil conditions and personal preference. Because of the number and variations of the tillage systems used by farmers, it is difficult to give each system a meaningful name or precise definition. Some of the more common systems are:

(PowerPoint Slide 16)

A. **Conservation tillage** is defined as the field operations required for profitable crop production while minimizing soil erosion due to wind and water. It provides:

1. At least 30 percent of residue cover left after planting to reduce soil erosion due to water.
2. At least 450 kilograms per hectare of flat, small grain residues, or the equivalent, left on the soil surface during the critical erosion period to reduce soil erosion due to wind.
3. The emphasis is on soil conservation; but conservation of soil moisture, energy, labor and even equipment are sometimes additional benefits.
4. Protect the soil surface with crop residue or growing plants or by increasing the surface roughness or soil permeability.
5. Conservation tillage generally represents a broad spectrum of tillage and planting systems: chisel plow or subsoiler; blade plow; disk and/or field cultivate; strip till; ridge-plant and no-till.

B. Conventional tillage refers to the sequence of tillage operations traditionally or most commonly used in a given geographic area to prepare a seedbed and produce a given crop. With conventional tillage only a small amount of residue, less than 15 percent is on the soil surface at planting.

(PowerPoint Slide 17)

C. **Clean tillage** involves a sequence of operations which prepares a seedbed having essentially no plant residues on the soil surface. Many conventional tillage systems are also clean tillage systems, particularly those which include use of the moldboard plow.

D. **Minimum tillage** is the minimum soil manipulation necessary for crop production or for meeting tillage requirements under existing conditions.

(PowerPoint Slide 18)

E. Reduced tillage refers to any system that is less intensive and less aggressive than conventional tillage. Either the number of operations is decreased or a tillage implement that requires less energy per unit area is used to replace an implement typically used in the conventional tillage system.

F. **Mulch-till** is any conservation tillage system which includes the use of implements that till the entire soil surface. At least 30 percent of the soil surface must be covered with residue after planting.

G. Several tillage systems are named by the major tillage implements used.

1. The moldboard plow, chisel plow, or subsoiler are used for primary tillage, most often in the fall.
2. Various secondary tillage operations are performed prior to planting.
 - a. The blade plow is used for primary tillage after harvest of small grains. A blade plow has 1 to 1.5 meter wide “V” shaped blades that are operated at a relatively shallow depth.
 - b. Disk, field cultivator, or combination tool systems are not as deep as with moldboard plow, chisel plow, or subsoil systems.
 - c. No-till, zero-till, or slot-plant does not disturb the soil from harvest to seeding and from seeding to harvest. The only tillage is the soil disturbance done by the planter or drill.
 - d. Ridge-plant, ridge-till, or till-plant does not disturb the soil from harvest to planting. Crops are planted and grown on pre-formed ridges. Ridges are usually formed in the previous crop when cultivated.

Use TM: 2-3 and TM: 2-4 to illustrate tillage goals and benefits. Use LS: 2-1 to strengthen student understanding of residue management.

Objective 3: Describe how tillage equipment is calibrated.

Anticipated Problem: How is tillage equipment calibrated?

(PowerPoint Slide 19)

III. Designers of field machinery have tried to design machinery adaptable to a wide variety of situations.

- A. The tractor and tillage tool which it pulls must be properly setup for maximum tillage efficiency and desired performance. Adjustments to attain these objectives are related primarily to traction, flotation, and soil compaction. These factors are closely related and changes in soil-surface conditions, soil contact area, and vehicle weight will directly affect all three.

(PowerPoint Slide 20)

1. **Traction** is the linear force, pull, or draft, resulting from torque applied to tractor tires.
2. **Flotation** is the ability of tires to stay on top of the soil surface or resist sinking into the soil.
3. **Compaction** is the packing or firming of soil caused by wheel traffic. It is undesirable because it can restrict movement of air, water, and crop roots in the soil.

(PowerPoint Slide 21)

- B. Tractors are built with ample size and power for specific farming operations. To get maximum benefit, additional weight may be required to gain maximum drawbar pull and sufficient traction for high draft tillage implements. Adding ballast (weight) to drive wheels and tractor front end is the most common method of improving traction and helping increase drawbar pull. To be effective ballast must be adjusted for soil type and conditions as well as implement load.

(PowerPoint Slide 22)

1. Two wheel drive tractors will achieve optimum operating efficiency when static tractor weight split, weight distribution on front and rear axles, is set approximately 25 to 35 percent on the front and 75 to 65 percent on the rear axle.
2. Mechanical front wheel drive tractors should have a static tractor weight split of 35 to 40 percent on the front and 65 to 60 percent on the rear axle.

(PowerPoint Slide 23)

3. Four-wheel drive tractor static tractor weights vary depending on the type of implement used.
 - a. For standard towed implements, 51 to 55 percent on the front axle and 49 to 45 percent on the rear axle.
 - b. For hitch mounted implements, 55 to 60 percent on the front axle and 45 to 40 percent on the rear axle.
 - c. For towed implements causing high down loads on drawbars, 55 to 65 percent on the front axle and 45 to 35 percent on the rear axle.
- C. Pulling a lighter load at a higher speed reduces wheel slip without increasing soil compaction. Wheel slip, engine speed, and ground speed should all be closely monitored when field operations are performed that load the tractor close to a traction or power limit. Wheel slip should normally be in the 8 to 12 percent range to achieve peak traction efficiency. It should not exceed 15 to 20 percent in peak overload situations. This provides good traction while acting as a cushion for the engine and drive train to soften impact and sudden overloads. A radar monitor is recommended to precisely measure wheel slip. Another method involves counting the revolutions of a rear tire.

(PowerPoint Slide 24)

- D. Tire tread produced when pulling under load provides an approximate indication of proper weighting of the tractor.
1. When too much weight is used, the tire tracks will be sharp and distinct in the soil.
 2. When too little weight is used, the tire marks are entirely wiped out and forward is slowed.
 3. When the tires have proper weight, a small amount of slippage occurs. The soil between the cleats in the tire pattern is shifted but the tread pattern is visible.
 4. As a rule, if slippage can be seen, it is too much.

(PowerPoint Slide 25)

5. Under high drawbar loads in certain soil conditions, MFWD and 4WD tractors may experience simultaneous loss of traction and a bouncing, pitching ride which is termed **power hop** or wheel hop.
 - a. To temporarily regain control, engine speed and/or implements draft should be reduced until power hop subsides.
 - b. To permanently control power hop, the tractor ballast and tire inflation pressure should be adjusted.

(PowerPoint Slide 26)

E. Considerations for tillage implement set-up, adjustments, and safety practices include:

1. Properly adjusted implements not only do a better tillage job but save time and fuel in the field and reduce downtime for repairs and field adjustments.
2. Most problems with tillage tool performance are caused by improper adjustment or faulty components.
3. Instructions in the operator's manual for each tool should be carefully followed to obtain optimum performance in the field.
4. Tillage tool performance problems can often be prevented with simple maintenance operations at the beginning of each season.

(PowerPoint Slide 27)

5. Safety is a prime consideration in the design and manufacture of equipment, but there is not a safety device that can replace a careful operator. Follow the rules listed and the specific steps listed in the operator's manual for safety and welfare of the operator and bystanders.
 - a. Match equipment to the tractor. Attempting a job that is too big for the tractor is self-defeating. Dangerous mismatching usually occurs when a tractor is undersized for the tillage tool.
 - b. Provide proper tractor ballast and static weight split, as previously discussed, for tractor stability. Never pull from a point higher on the tractor than the recommended hitch point.
 - c. Match hydraulic connections. A serious error is to interchange hose ends on the auxiliary cylinder so the control valve operates in reverse. When the control is pulled for raising, the implement goes down, a real hazard. After hoses are attached between tractor and implement, carefully test for proper coupling.
 - d. Check implement position before hitching it to the tractor. The implement should be parked on a firm, flat surface. Block mounted implements securely before lowering the hydraulic lift. Position the tractor directly in front of the implement before starting to back toward it for hitching. Hitching is much easier with an assistant. If not assistant is available, a snap-close hitch, self centering hitch, or telescoping-tongue can ease hitching.
 - e. Use forethought in unhitching. Use hydraulic lift arms to support integral hitches. Do not try putting hitch pins in place while the tractor is in gear. Set brakes or put the transmission in park before getting off the tractor.
 - f. Don't permit people between tractor and tillage tool, especially when backing up to hitch. A foot may slip off the clutch or the implement may move, catching someone between the tractor and implement.

(PowerPoint Slide 28)

- g. Always lower the implement to the ground or use jacks, blocks, or transport links or lock pins when it's not in use or when working on the machine. If the equipment must be serviced in the raised position, use blocks, jack stands or other support on firm ground. Never depend on the hydraulic system to hold the tillage tool up.
- h. Pins used to connect the tillage tool to the tractor should be the proper size and secured with a clip or pin. Don't use makeshift pins such as a long bolt, which can break, bend or jump out under load. Use safety hitch pins that are easy to remove but have springs or clips to keep them in place. Three-point hitch links should also be secured with restraining clips or pins.
- i. Never carry riders on the tractor or permit others to ride on the tillage tool.
- j. Reduce speed when transporting over rough or uneven terrain.
- k. Check wings or outrigger locking mechanisms on fold up tillage equipment. They can fail and let the equipment fall during transport.
- l. Use proper lights and reflectors when transporting equipment on road or highway.
- m. When transporting, put the machine in as narrow a configuration as possible. Most wide equipment has a special transport position. Some places require a special permit to transport equipment wider than a specified width.

Use LS: 2-1 to help students understand calibration and determining residue coverage. Use LS: 2-2 to strengthen student understanding of wheel slip.

Objective 4: Explain how tillage equipment is maintained.

Anticipated Problem: How is tillage equipment maintained?

(PowerPoint Slides 29, 30, and 31)

- IV. Preventative maintenance should be given first consideration in the use of field machinery in order to reduce to a minimum the chances for breakage, costly repair bills, and loss of time. Adequate and timely adjustment, repair, lubrication, and protection from the weather determine the life of a machine.
- A. It is important to select the proper lubricant for the different parts of machines. Consideration must be given to the function each part has to perform. Secure a lubrication chart for the machine to be lubricated and follow its directions. A general rule is that all moving parts in contact with other parts require lubrication at the point of contact. A lubricant should not be placed on parts where it will collect dirt or grit, or the parts will wear faster than they will without lubrication. Inspect the crankcase oil and transmission grease, and fill or change according to the directions of the manufacturer. Use the proper equipment to lubricate the machines. If the machines have special fittings, lubrication equipment for these special fitting must be used. Inspect but do not molest or destroy the seal of parts of machines operating in a "sealed for life"

lubrication system. Consult the operator's manual for lubrication instructions for the machine and for the location of the parts to be lubricated.

- B. The proper use of field machinery decreases operating costs. Most field breakdowns can be avoided by systemically checking and repairing field machinery during the off season. Machinery inspection, repair and adjustment are considered necessary jobs to be performed. Follow the manufacturer's recommendations found in the operator's manual when performing maintenance on tillage equipment.

(PowerPoint Slide 32)

- C. Tillage tool performance problems can often be prevented with simple maintenance operations at the beginning of each season.
1. Lubricate according to instructions. Clean grease fitting to avoid forcing dirt into bearings.
 2. Clean, inspect, and lubricate or repack wheel and coulter bearings. Replace as needed.
 3. Examine hydraulic hoses, couplings, and cylinders for wear, damage, or leaks. Repair or replace as needed.
 4. Check for loose or missing bolts and nuts. Replace worn or broken parts.

(PowerPoint Slide 33)

5. Replace worn, dull, or cracked soil engaging components such as sweeps, shares, disks, or coulters.
6. Check and replace bent or cracked components such as standards or beams.
7. Check alignment of soil engaging components. Level the implement from side to side and fore and aft. Measure vertical distance from point to frame and distance between ground engaging tips. If any measurement is not essentially equal, consult the operator's manual for corrective action required.
8. Check operations of safety trips or reset mechanisms to be sure they function freely. Refer to the operator's manual for proper method of checking and adjusting.
9. Make certain all tires are inflated to the recommended pressure to provide level machine operation.

Use classroom discussion to reinforce the importance of preventative maintenance. Identify reasons this is critical for tillage equipment.

Review/Summary: Use the student learning objectives to summarize the lesson. **(PowerPoint Slide 34)** Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle.

Application: The following lab activities will be helpful to students in applying the lesson's content.

LS: 2-1 Determining Percent Residue Covering

LS: 2-2 Measuring Wheel Slip

Evaluation: Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the application activity. A sample written test is attached.

Answers to Sample Test:

Matching

1. F
2. C
3. D
4. B
5. E
6. A

Fill-in-the-blank

1. Tillage system
2. Conservation
3. Minimum tillage
4. Clean tillage
5. Preventative maintenance

Short Answer

1. The goal of proper tillage is to provide a suitable environment for seed germination, root growth, weed control, soil erosion, and moisture control, avoiding moisture excesses and reducing stress of moisture shortness.
2. Adding ballast (weight) to drive wheels and tractor front end.

Operating, Calibrating, and Maintaining Agricultural Tillage Systems and Equipment

Name: _____

Matching: Match each word with the correct definition.

- | | |
|---------------|----------------------|
| a. compaction | d. primary tillage |
| b. floatation | e. secondary tillage |
| c. power hop | f. traction |

- _____ 1. Linear force, pull or draft, resulting from torque applied to tractor tires.
- _____ 2. Simultaneous loss of traction and bouncing.
- _____ 3. Deep operation that loosens and fractures the soil to reduce soil strength and to bring or mix residues and fertilizers into the tilled layer.
- _____ 4. Ability of tires to stay on top of the soil surface or resist sinking into the soil.
- _____ 5. Used to kill weeds, cut and cover crop residue, incorporate herbicides and prepare a well pulverized seedbed.
- _____ 6. Packing or firming of soil caused by wheel traffic.

Fill-in-the-blank: Complete the following statements.

1. A _____ is the sequence of tillage operations performed in producing a crop.
2. To be considered _____ tillage, a system must produce, on or in the soil, conditions that resist the erosive effects of wind, rain, and flowing water.
3. _____ is the minimum soil manipulation necessary for crop production or for meeting tillage requirements under existing conditions.
4. _____ involves a sequence of operations which prepares a seedbed having essentially no plant residues on the soil surface.
5. _____ should be given first consideration in the use of field machinery in order to reduce to a minimum the chances for breakage, costly repair bills, and loss of time.

TILLAGE EQUIPMENT



(Courtesy, John Deere)

Chisel Plow



(Courtesy, Case Corporation)

Subsoiler (or V-Ripper)



(Courtesy, John Deere)

Disk



(Courtesy, John Deere)

Plow

TILLAGE EQUIPMENT



Disk Harrow
(Courtesy Case Corporation)



Field Cultivator
(Courtesy Case Corporation)



Rotary Hoe
(Courtesy Case Corporation)



Combination Tool
(Courtesy Case Corporation)



Row-Crop Cultivator
(Courtesy John Deere)

GENERAL TILLAGE GOALS

CONSERVE ENERGY

- Tractors
- Tillage
- Harvest and Transport
- Crop Drying
- Fuel Storage and Handling
- Alternate Energy Sources

WATER MANAGEMENT

- Water Management
- Irrigation
- Drainage

CONSERVE SOIL

- Cover Crop
- Strip Crop
- Crop Rotation
- Residue Management
- Tillage
- Contour Furrows
- Terraces
- Windbreaks
- Mulch and Manure

CONSERVE FERTILIZER

- Application Amount
- Application Timing
- Application Methods
- Reducing Runoff
- Alternate Fertilizers

CONSERVE PESTICIDE

- Choosing Use of Pesticides
- Application Timing
- Application Rate
- Application Method
- Nonchemical Methods
- Integrated Methods

TILLAGE SYSTEMS— CONSERVE SOIL

- ◆ **Expert assistance recommended**
- ◆ **Planning uses for agricultural land**
- ◆ **Consult USDA Land Classification System**

COVER CROPS

- **Better water infiltration**
- **Reduced erosion**

STRIP CROP

- **Combine with crop rotation**

CROP ROTATION

- **Improved soil structure**
- **Better management**
- **Reduces acreage of major crop**

RESIDUE MANAGEMENT

- Tillage
- Harvesting methods
- Insect problems
- Special equipment

CONTOUR FURROWS

- Lose some cropland
- Used for pastureland

TERRACES

- Costly to develop
- Costly to maintain
- Can increase row-crop acres
- Requires modified farming methods

WINDBREAKS

- Loss of land for production
- May be best alternative
- Requires maintenance

MULCH AND MANURE

- Reduce fertilizer requirement
- May cause excess buildup of salt

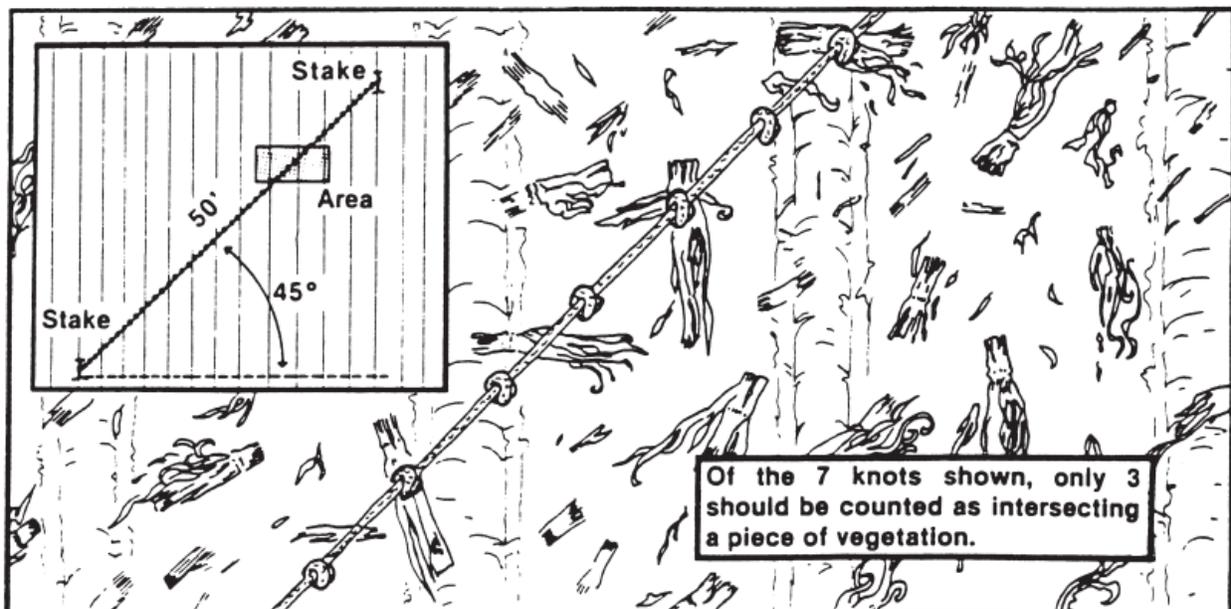
DETERMINING PERCENT RESIDUE COVERING—LINE TRANSECT METHOD

Equipment:

Approximately 15 meters of rope or a measuring tape.

Procedure:

1. Tie 100 knots in a rope about 15 cm apart or use a measuring tape as long as it has 100 equally spaced points.
2. Select an area in the field that is representative of the entire field.
3. Stretch the rope or tape diagonally across the crop rows so that it crosses at least one width of the farming implements used.
4. Count the number of knots in the rope or tape which are directly over a piece of residue. For accuracy in measurement follow these rules. (See illustration below.)
 - a. Do not move the rope or tape while counting.
 - b. Look straight down at the same edge or corner of each knot.
 - c. Leaning side to side will cause an overestimate of residue cover.



- d. Count only those knots or marks on a tape that have residue directly under the corner or edge.
 - e. Count only residue that is large enough to dissipate the energy of a rain drop that occurs during an intense storm.
5. The percent residue cover is equal to the number of points counted.
6. Repeat steps 2 to 5, at least three times, in the field and average the counts to get an accurate measurement.

MEASURING WHEEL SLIP

Procedure:

1. Mark a spot on the ground and a chalk mark on one rear tractor tire.
2. Drive the tractor under load with the implement in its normal operating mode for ten complete rotations.
3. Place a mark on the ground.
4. Repeat the trip without the implement and count wheel rotations between the two marks.
5. Estimate the fraction of the last rotation as nearly as possible.
6. Using the number of rotations on the second trip, the percent slip can be determined.
 - a. If less than $8\frac{1}{2}$ rotations are counted, add weight.
 - b. If more than 9 rotations are counted, remove weight.