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What you need to know about land preparation

There are five parts in understanding good land preparation. These components are an understanding of the:

1. role of tillage and land leveling in land preparation
2. reasons why good land preparation is important
3. different systems and equipment that are used for tillage
4. power requirements for tillage of different soil types using different equipment
5. basic setting up and operating equipment

After any study of land preparation you should understand the different tillage systems, tillage patterns and equipment used for land preparation. You should be able to select the most appropriate tillage system, tillage pattern and equipment for your situation.

Dry and level field

Wet and level field

The components of land preparation

The aim of land preparation is two-fold:

- to place the soil in the best physical condition for crop growth
- to ensure that the soil surface is left level

Land preparation is a combination of tillage practices that places the soil in the best physical condition for plant establishment and crop growth. To attain this condition:

- soil must be tilled to a depth so plants can develop a root system which will physically support the plant and also allow the extraction of sufficient moisture and nutrients so yield potentials can be realized
- soil disturbance should be sufficient to control weeds
- tillage must leave the soil surface level. Level fields improve water use efficiency and help control in crop weeds. The field also needs a drainage system that will allow the rapid removal of excess water.

Dry tillage

Wet tillage

An overview of tillage

Land preparation covers a range of soil disturbances from zero-tillage, which minimizes soil disturbance through to a totally 'puddled' soil, which actually destroys soil structure. When considering the choice of tillage system, it is very important to have clearly defined short and long-term objectives. These objectives may be to:

- decrease ped or clod size
- remove, incorporate or modify plant residue
- manage soil water (both wetting and drying)
- control weeds
- mix and incorporate soil amendments such as lime and basal fertilizer
- control or destroy insects, their eggs, larvae and breeding places
- reduce wind and water erosion by leaving a rough surface.

Because the soil is a complex biophysical medium, having both living and non-living components, any tillage operation has more than one effect. For example, if soil is tilled to control weeds soil ped sizes will be decreased; soil moisture will be lost and crop residues will be incorporated. It is important then to determine the primary objective of each operation and also any subsequent effects that may result from that operation.

Dry tillage

Wet tillage

The tillage requirements will vary according to cropping system to be used. What may be desirable for one may be totally inappropriate for another. A good example is the contrast between lowland and upland systems. Typically for lowland rice, fields are puddled in part to destroy structure and develop a hard pan to reduce water loss through deep percolation. Such a loss of structure and the formation of a physical barrier are totally undesirable in an upland situation.

Upland

Wetland

Primary Tillage

Primary tillage is the first working after the last harvest and normally the most aggressive tillage operation. It is normally undertaken when the soil is wet enough to allow the field to be ploughed and strong enough to give reasonable levels of traction. This can be immediately after the crop harvest or at the beginning of the next wet season. When there is sufficient power available some soil types are ploughed dry.

The objectives of primary tillage are:

- till the soil to attain a reasonable depth (10-15cm) with varying clod sizes.
- kill weeds by burying or cutting and exposing the roots
- soil aeration and water accumulation. Depending on the soil type and the plough the soil will normally be inverted aerating the deep layers and trapping water during a rainfall event
- chop and incorporate crop residues.

Ploughing using draft animal

Ploughing using disc plough

The implement most commonly used with an animal powered system is the moldboard plough. In clay soils, the fields often have to be fully saturated before tillage can be undertaken. In lighter texture soils such as loam or sand, tillage can be undertaken at moisture levels below field capacity. In 2-wheel powered systems both moldboard and disc ploughs are used. The disc is usually the preferred system as it takes less power and can handle obstacles much easier. When traction is a problem, cage wheels need to be fitted to the tractor.

In a 4-wheel tractor system, three-disc, seven-disc and offset ploughs are the most common. Tined ploughs are preferable in the upland systems but as yet not widely available in Asia. Moldboard ploughs are also not commonly used in tractor based systems.

Ploughing using disc plough

Ploughing using an offset disc

Care needs to be taken when using the moldboard and disc plough as a large cut-out furrow left in the middle of the field causes major problems with field levelness. If the soil is too dry or hard, unploughed strips may be left if the plough is not properly aligned or if the plan 'opens up' during working. For moldboard and disc ploughs fields are best ploughed in ‘lands’ so drainage channels are left at the outer edges of the field.

Primary Tillage Implements

The implements used for primary tillage are the moldboard, one-way disc, tine and offset disc ploughs.

Moldboard plough

The moldboard plough is most commonly used in animal and 2-wheel powered systems in Asia. Moldboards are still commonly used in the USA and Europe in upland farming systems. The number and size of moldboard shares (bottoms) vary according to the power source. Animals normally pull I plough share, 2-wheel tractors 1or 2 and 4-wheel tractors will pull 3-4 ploughshares. In Asia all systems are mounted on the tractor.

Moldboard plough for hand tractor

The moldboard plough causes total inversion of the soil sod and relies on the digging point for penetration. This plough cause the least damage to soil structure, works well in very hard soil conditions but does not have in built stump or obstacle protection mechanisms. They have very heavy power requirements and kill weeds through inversion and pulverization of the soil sod. The moldboard normally throws the soil in one direction but reversible models are available for larger 4-wheel tractors.

Soil inversion using moldboard plough

One-way disc

The one way disc plough is used in 2-wheel and 4-wheel tractor powered systems in Asia. The number and size of disc shares vary according to the power source. 2-wheel tractors will use 2 or 3 disc ploughs, while a 4-wheel tractor will pull 3,4 or 7 disc versions. In Asia all systems are mounted on the tractor.

Disc plough used in with 4-wheel tractor

The disc plough causes total inversion of the soil sod and relies on the ploughs in built weight for penetration. This plough works well in hard soil and heavy trash conditions and can ride over stumps or obstacle in the soil. The power requirement for the disc plough is less than a moldboard plough but it will ride out of the ground if soil conditions are very hard. The disc plough throws the soil in one direction and kills weeds through cutting, inversion and pulverization of the soil sod.

Offset disc

As the name suggests this is a disc plough that is capable of operating offset from the tractor. The plough is made up of between four and twenty-four discs mounted in two gangs. Each gang has a common center bolt and throws the soil in different direction. These ploughs are only used on 4-wheel tractors and are very versatile. An offset plough can be operated in any ploughing pattern. The offset plough can be either 3-point linkage mounted or a trailing version.

Offset disc for 4-wheel tractor

The very aggressive action of the plough gives good weed control and cuts and buries crop residues. This plough is also widely used in upland situations.

Offset disc for 4-wheel tractor

Tined plough

Tined ploughs are the most versatile primary tillage implement as they can be also used secondary tillage and modified to be used as a seed drill. Tine implements are used only in dry working situations as they cut the soil rather than invert the soil and kill weeds by cutting and lifting the weeds to the surface. Different size ploughshares or sweeps can be fitted to the tines. Sweeps range from 50mm to 500mm in width. These ploughs are widely used where residues need to be left on the surface. Tine ploughs have lower power requirements than disc and moldboard ploughs and are used with animals and 4-wheel tractors. These ploughs can be configured as 3-point linkage mounted or as trailing versions.

Trailing tine plough in operation

Primary tillage implements may be used for subsequent tillage operations; that is, for secondary tillage. Offset disc and tined ploughs are often used between primary tillage and planting.

Summary of tillage equipment performance

	Moldboard	**One way Disc**	**Offset disc**	**Tine Implement**
System	Animal,2-wheel,4-wheel tractor	2-wheel,4-wheel tractor	4-wheel tractor	Animal,2-wheel,4-wheel tractor
Width	1-3 shares	2-4 disc	9-21 discs	1-15 tine
Soil disturbance	High	Medium -high	High	Low

Plough action	Total inversion	Inversion	Inversion /cutting	Cutting
Soil Penetration	Share design	Machine weight	Machine weight	Weight/design
Weed control	Bury	Bury	Cut/bury	Cut
Handle obstacles	Poor	Good	Good	Medium -good
Power requirement	Heavy	Medium-heavy	Medium-heavy	Low-medium

Secondary Tillage

Secondary tillage is any working completed after primary tillage and is undertaken for

- reducing ped size,
- weed control,
- incorporation of fertilizers,
- puddling and
- leveling soil surface.

Secondary workings are usually shallower and less aggressive than primary tillage. In the animal powered system, the second working is normally undertaken with the moldboard plough when the field is fully saturated. The final workings are then completed using peg tooth harrows to puddle the soil and leave the surface level and ready for planting.

Harrowing operation

In 2-wheel tractor systems, the moldboard, the disc and the rotovator are used for second working. In some instances peg tooth harrows are also used if rotovators are not available. Cage wheels on the tractor are needed for traction in all soil types and these also help puddle the soil.

In 4-wheel tractor systems, seven-disc ploughs, offset disc ploughs and rotovators are the most commonly used equipment for second workings. In this system, fields are either mechanically puddled with tractors using a rotovator and leveling board or by tractors fitted with large cage wheels and harrows.

Rotary tilling using rotovator

It is common in many countries for the first two workings to be undertaken using tractors and the final working done by animals and harrows.

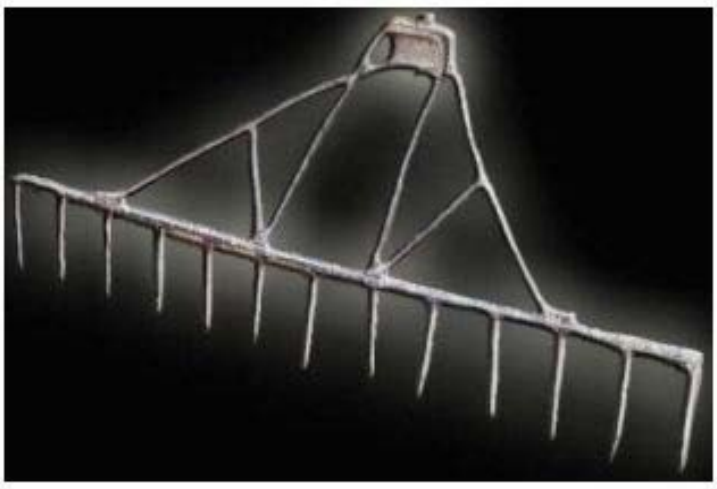
Problems of flotation and traction are a major concern in most soil types after the second working and during land leveling. In clay soils traction is improved if there is free water on the surface to clean the tires. In some of the sandy soils, flotation is a problem when excessive wheel slip causes the tires to break through the firmer surface layers and the tractor sinks.

Secondary Tillage Implements

The implements used for secondary tillage are the peg tooth harrow, disc harrow, tined cultivator, rotary tiller, and inter row cultivators.

Peg tooth harrow

Peg tooth harrows are widely used in animal and 2-wheel tractor powered systems for second workings, soil puddling and land leveling. The width of harrow depends on the number of animals and size of tractor engine but range in size from 1-2m depending on soil conditions. The teeth or pegs in the harrow can be made from wood but more modern versions use steel. The degree of aggression is determined by the angle of operation. The more upright the harrow the more aggressive is the action.



Spike tooth harrow for hand tractor

Disc cultivator

Disc cultivators are used with 4-wheel tractors and are made up of either 2 or 4 gangs of discs. The discs are smaller than on a one-way or offset plough and the machine is much lighter. The degree of aggression is determined by the gang angle relative to the forward travel. These implements are normally used in dry fields. The disc cultivator can be either 3-point linkage mounted or a trailing version.

The very aggressive action of the plough gives good weed control and cuts and buries crop residues. This plough is also widely used in upland situations.

Three-point linkage mounted

Tined cultivator

Tined cultivators are very versatile implements as they can be used for secondary tillage and modified to be used as a seed drill. Tine cultivator are used only in dry working situations as they cut the soil rather than invert the soil and kill weeds by cutting and lifting the weeds to the surface. Sweeps range from 50mm to 200mm in width. These cultivators are used where residues need to be left on the surface. Tine cultivators have lower power requirements than disc cultivators and used with animals and 4-wheel tractors. These ploughs can be configured as 3-point linkage mounted or as trailing versions.

Tine Cultivator

Rotovator

Rotovators are commonly used for secondary workings and especially seedbed preparation. They are used with 2-wheel and 4-wheel tractors in both upland and flooded fields. Rotovators have a very aggressive action, which pulverizes the soil and buries weeds and crop residues. In some flooded situations rotovators are used for primary tillage.

Rotary tiller - rotavator

Upland Tillage

Upland tillage is undertaken in locations where crops are grown in aerobic soil conditions. This means that the soils are non-puddled soils and there is no freestanding water in the fields. Soil moisture levels are critical when ploughing in an upland-farming situation. If the soil is too dry it will not till easily, the power requirement will increase and in clay soils large clods may be formed. In clay soils these large clods may cause problems when trying to decrease ped size to create a seedbed. If the soil is ploughed very wet, near soil saturation, smearing and soil sealing can become problems during seedbed preparation.

Animal powered systems use a moldboard plough, while 2-wheel and 4-wheel tractor powered systems use one-way disc, offset disc and tined implements. These systems often require more tillage operations to control weeds. In low land systems weeds are often controlled by

incorporation while in upland systems weeds are best cut and left on the surface to die.

Upland tillage

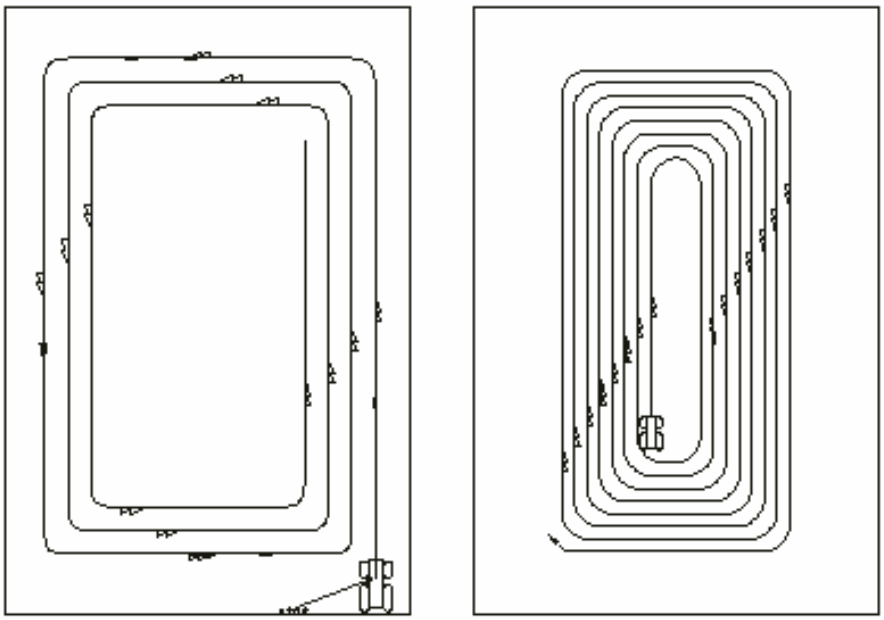
In these systems water erosion can be a problem and ploughing on the contour is recommended.

Tillage Patterns

An optimal tillage pattern reduces the time spent in non-productive work. One of the most important objectives of a tillage pattern is to minimize the number of turns and maximize the length of the tillage runs. There are several patterns that can be used when tilling a field. These are circuitous, up and back or headland and working in lands.

Circuitous pattern

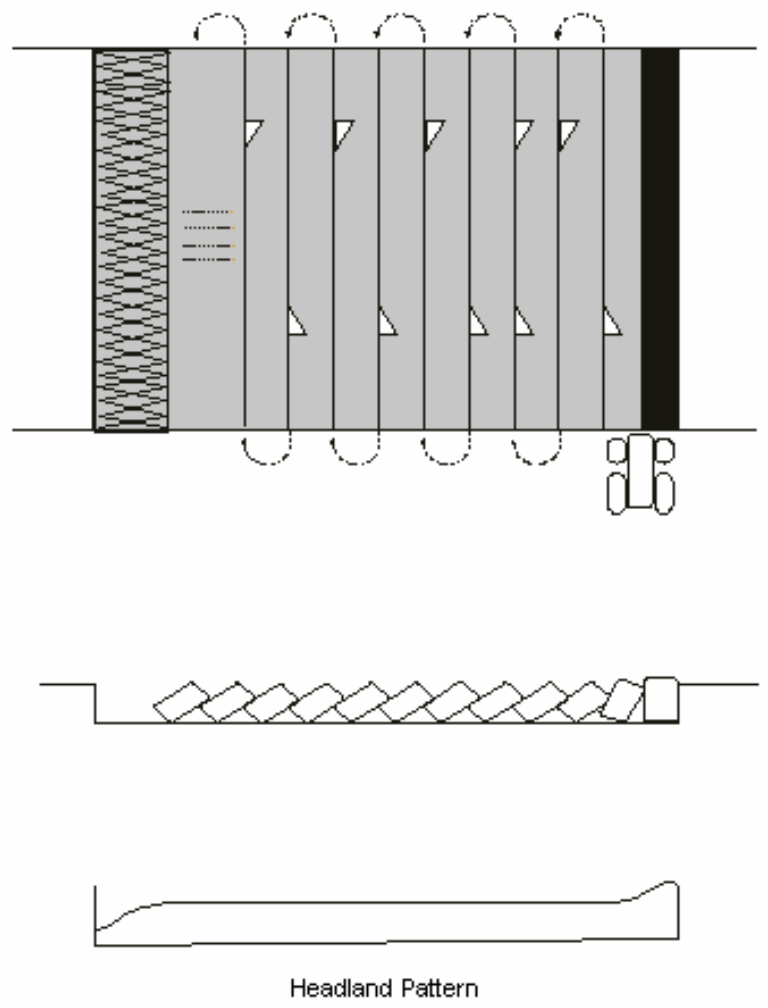
In a circuitous pattern the machine begins working along a boundary. It continues along the other boundaries of the land, returning to its starting point. This pattern works from the outside to the center of the field and is the most commonly used system for ploughing in Asia. It is commonly used with moldboards, discs and offset discs. This is the system that most animals are accustomed to working and it also requires less spatial judgment by the operator than working in a land type system. The major disadvantage of this system is that the field ends up with a large cut out furrow in the center. Over time the field ends up having an oblong saucer shaped depression in the center that is hard to drain and makes it difficult to get an even depth of cultivation, good weed and water control. A solution to this problem is ploughing out from the middle or working the field in lands



Circuitous Pattern

Up and back or headland pattern

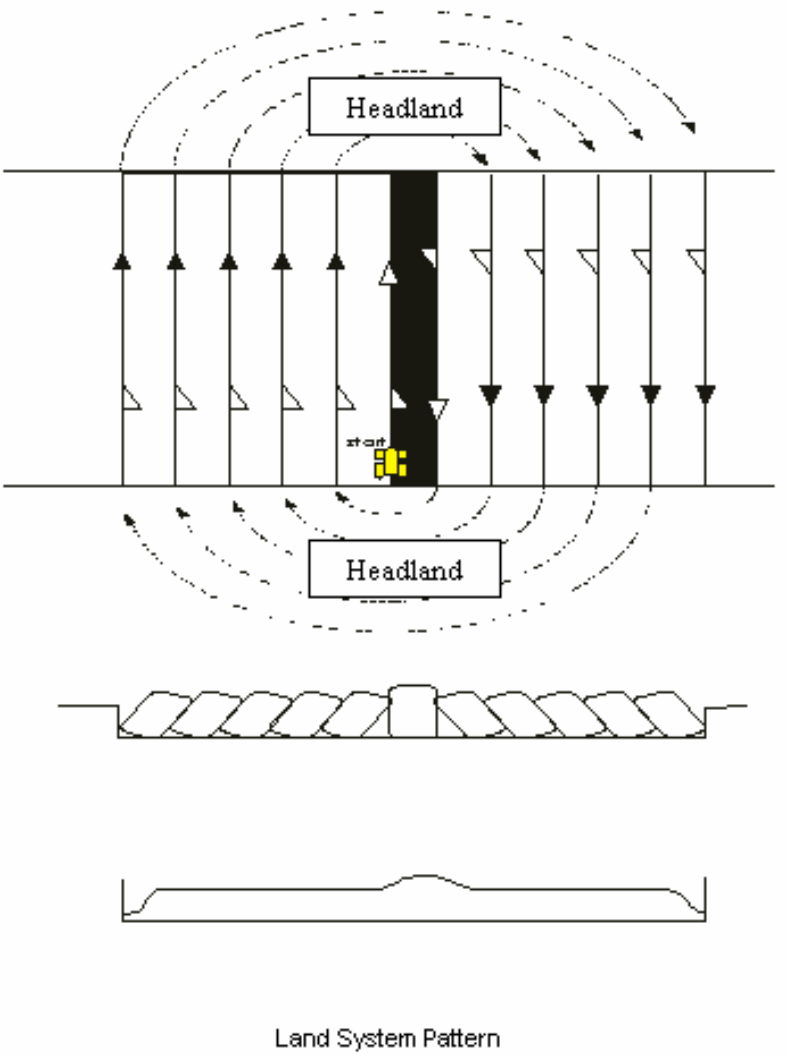
The field is ploughed in runs parallel to each other. It starts at one boundary of the field and ends at the opposite with turns being made on the headlands. This system can only be used for tined implements, rotovators, harrows and reversible ploughs. It is usually the most field efficient system and if equipment is correctly set up and operated should not leave furrows in the field.



Headland Pattern

Land system

This system requires ploughing to begin in the center of the field and works out to the edges. It requires some measurement of the field to establish the center point and if done correctly leaves a level field with drainage channels on the edges. This system can be used with all types of ploughs. In very large fields, a number of lands may be ploughed



Land System Pattern

Creating a 'Hard Pan'

In some soil types it is desirable to develop a ‘hard pan’ or impermeable layer to stop deep percolation of water below the root zone of the crop. This hard layer is best achieved by using an implement that actually smears the soil during its normal mode of action. The rotovator is the best implement for this operation. High levels of wheelslip from tractors fitted with cage wheels will also give a similar effect. Similarly disc ploughs, offset or tandem discs working in very wet soils can attain a similar effect.

Compaction rating	**Implement/operation**	
Worst	Rotovator	1
	Moist plough	
	Wet disk harrow	1.5
	Caribou/oxen	1.75
	Moldboard plough	2
	Human footprint	2
	Tractor (low tire pressure)	4
Least	Bulldozer	7

Creating a hard pan using a rotovator

Power Requirements

The power requirements for any tillage implement will depend on the depth of working, the soil moisture content and the soil texture. While speed of operation will have an effect on power requirements the actual range of working speeds for each operation are relatively constant and, therefore, the speed effect minimal.

Implements	**Approximate power requirement (Engine kW/m at 7.2 Km/hr using a Front wheel assisted Tractor)**		
Soil Types	**Clay**	**Loam**	**Sand**
Primary Tillage Implements			
Moldboard Plough	26	22	18
Disc Plough	25	21	18
Tine Plough	20	16	14
Offset disc Plough	24	20	16

Implements	**Approximate power requirement (Engine kW/m at 7.2 Km/hr using a Front wheel assisted Tractor)**			
Soil Types	**Clay**	**Loam**	**Sand**	**Wet**
Secondary Tillage Implements				
Tined Cultivator	14	11	9	

Inter-row cultivator	8	6	4	
Disc cultivator	18	16	14	
Rotovator	35	30	20	25-35
Puddler				7

Setting up an implement for use

To maximize the efficiency of the tillage operation, all implements must be safely attached to the tractor and leveled correctly before use.

The key points when using an implement are:

- all nuts retaining the discs, ploughshares and sweeps should be checked and tightened before use.
- 3-point linkage stabilizer chains should be attached relatively loose, but not so loose that the implement will hit the tractor tires.
- PTO shafts should be connected and secured correctly with all safety shields in place
- use depth control wheels or slides to set the operating depth or height on all implements
- implements should be level in two planes: front to back as well as side-to-side.
- depth of cut should be uniform across the furrows and the field should be left as level as possible after ploughing
- if the tractor is “pulling” to one side, then the plough is not correctly adjusted.
- the speed of operation will depend on the implement and the terrain. The range for most implements will be between 4-7 km/hr.

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