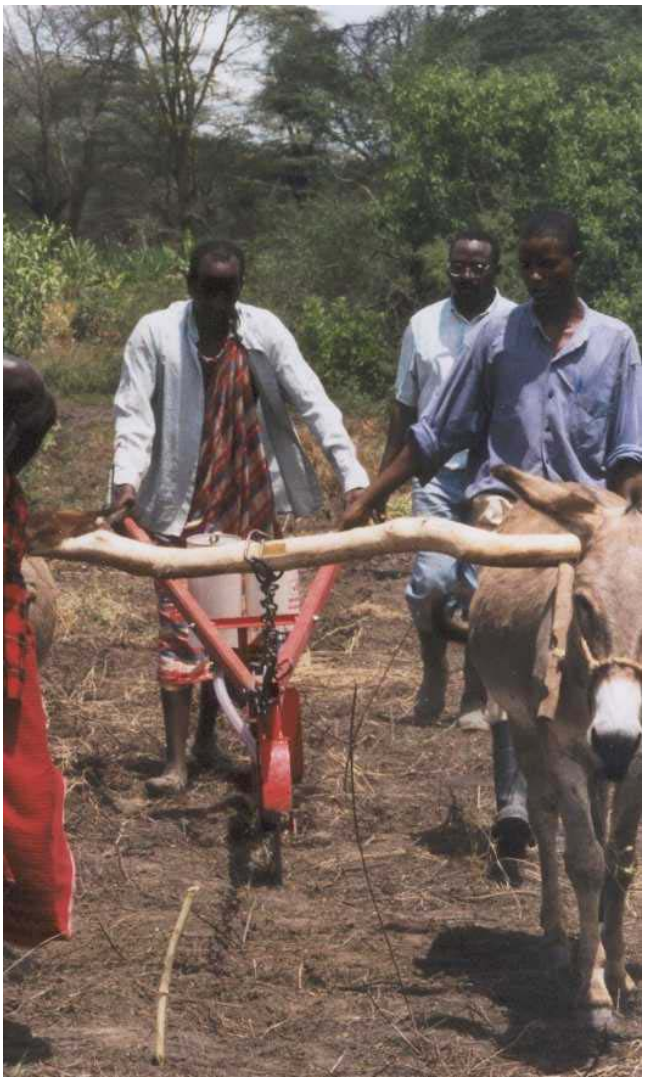
Conservation agriculture

what you should know about ……

tools, equipment and machines for manual use, animal traction and single axle tractors



Contents

List of plates

List of tables

List of figures

List of boxes

Acknowledgements

This module was prepared by Alexandra Bot and Theodor Friedrich.

Land preparation

Soil tillage or land preparation is one of the routine activities in most agricultural systems. Often, land preparation starts with burning fallow vegetation or previous crop residues in order to clear the land or to scare away wild animals or snakes.

Plate 1
This farmer is not only cleaning his field, but also 'cleaning his pockets' by burning the potential fertility of his soil.

Burning is usually followed by soil tillage. Depending on the possibilities of the farmer tillage can range from very extensive to very intensive. But why do farmers plough?

In the first place to prepare an adequate seedbed which permits a good germination of the seeds. They think that a soil well tilled, loose, levelled and with a lot of fine particles favours the contact between the seeds and the soil, which in turn lead to sowing at an adequate depth. In second place, farmers plough in order to control weeds. Other reasons for tillage may include enhancement of soil water storage and retention and warming-up of the soil.

Box 1. Functions of soil tillage

- Prepare seedbed
- Manage crop residues
- Incorporate fertilizers and agro-chemicals
- Control weeds
- Decompact dense layers
- Increase water infiltration
- Shape the soil surface (levelling, ridging)

Unfortunately, the method used to achieve any of the above mentioned objectives of tillage might produce a conflict with the other objectives. Each additional tillage operation for weed control also buries more residues and exposes moist soil to the surface, causing additional water loss. As the number of tillage operations is increased, the aggregation of soil is decreased leaving the soil more vulnerable for soil erosion (Godwin, 1990).

In this way, tillage operations have negative effects on the soil productivity and the economic return of the crops. They are responsible for the destruction of the soil and crop residues. Tillage also affects the availability of water and nutrients in the soil. Among the costs of tillage one should also count:

- increased erosion and loss of fertility
- increased evaporation and moisture loss
- decreased capability of the soil to hold water

Eroded soil can move on to other places, like ditches, lakes and reservoirs, water harvesting tanks or to the neighbour's field, taking with it organic matter, nitrogen, phosphorus and pesticides. Preventive measures, like the construction of terraces, are expensive. It is far more effective and cheaper to refrain from tillage and conserve the residues on the soil surface.

Soil tillage

Generally, tillage is defined by the type of activity carried out (Friedrich, 2000):

- **Inversion**: this type of tillage turns the soil in part that is worked. Surface layers are completely incorporated and deeper soil layers are brought to the surface. The argument that ploughing controls weeds is not valid when done every year, as the same amount of weed seeds is brought to the surface.
- **Mixture**: this operation mixes all materials homogeneously to a certain soil depth, which is usually around 10 cm.
- **Ripping**: this type of tillage breaks the soil open, in order to loosen the soil without moving the clods, for instance in soil decompaction operations (subsoiling).
- **Pulverize**: this operation is to crumble the soil clods in order to form a very fine horizon, i.e. the seedbed. It is executed within a few centimetres from the surface.

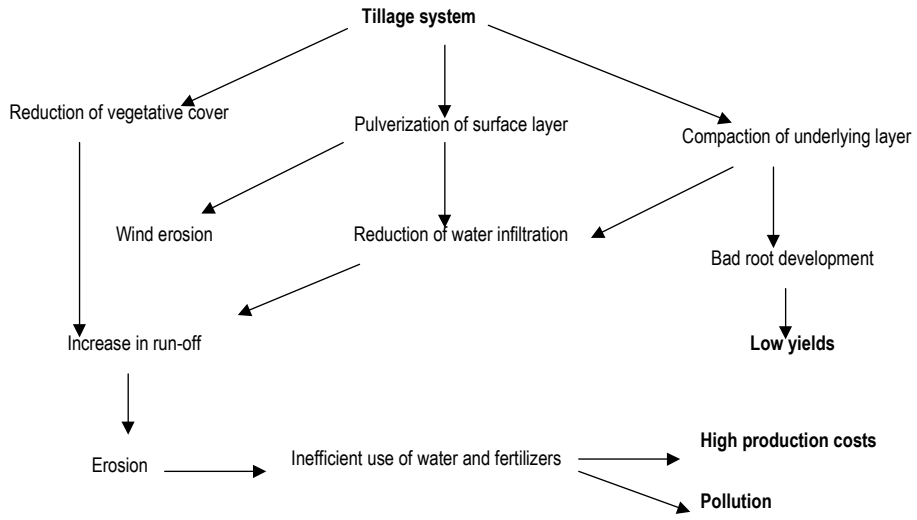
Both inversion and aggressive mixture affect the quantity of residues that are left on the soil surface. Ploughs and discs turn over the soil completely, whereas chisel ploughs break and mix the soil and cultivators only mix. Harrows pulverize the soil in order to prepare a seedbed.

At least four types of tillage operations can be distinguished in a conventional system (Krause *et al*., 1984):

- Clearing of the land and management of residues, including burning of fallow vegetation or residues
- Primary tillage
- Secondary tillage
- Crop management activities, like weeding, ridging, breaking crusts, etc.

But sometimes deep tillage or subsoiling is necessary to break dense and compacted layers deeper in the profile.

Figure 1.
Consequences of badly chosen tillage practices



In tropical and subtropical areas, where the danger of erosion through rainfall is high, the soils are usually poor and eroded and the temperatures are high and thus decomposition is rapid, tillage systems are usually selected with the objective to prepare the topsoil to create a very fine seedbed. And in only attending this objective, tillage systems are applied that bring certain degradation processes with them (Figure 1) (Vieira, 1996).

The type and number of land preparation operations determine the quantity of residues left on the soil surface. For example, ploughing leaves less than 15% on the surface, as a cultivator leaves between 50 and 70% of the residues intact on the surface.

Table 1 Percentage of residues left on the surface with different land preparation activities

Type of land preparation	Resistant residues	Fragile residues
Residues after harvest	80-95	70-80
Plough	0-15	0-10
Plough and chisel	0-10	0-5
Discs (2 operations)	15-20	10-15
Chisel (2 operations)	30-40	20-30
Cultivator (2 operations)	40-50	30-40
Cultivator (1 operation)	50-70	40-60
Direct seeding	80-95	60-80

Box 2. Disadvantages of tillage

- ☹ Loss of soil moisture
- ☹ Limits water infiltration through surface sealing
- ☹ Destroys the soil structure
- ☹ Increases erosion risk
- ☹ Increases operational cost
- ☹ High demand on power, time and equipment

Therefore it is important to choose land preparation practices that protect the natural resources and at the same time improve productivity and reduce production costs. In conservation agriculture systems land preparation practices are reduced to almost no tillage at all.

Zero tillage or no-till practices are those activities in which the seeds are brought into the soil with the least soil disturbance possible. That means planting and sowing into the residues of previous crops and weeds. Therefore, farmers, extensionists and researchers have been developing not only instruments and equipment to seed into the residues, but also tools and implements to manage the crop residues and fallow vegetation.

Ploughs, chisels and subsoilers

The plough in its different shapes as traditional ardplough or as mouldboard plough is probably the most popular land preparation tool that is used in both developing and developed countries. There is no other tool that symbolizes agricultural development, like the plough. Tillage tools might still be necessary for some specialized operations even under Conservation Agriculture. This is why they will be discussed briefly in the training. However, under CA they disappear as commonly used implements.

Plate 2
Primary tillage in order to open the soil, resulting in moisture loss and higher weed infestation.
(*T. Friedrich*)

The plough is mainly used for primary tillage: opening up the soil with the aim of loosening it for good root penetration and cutting and burying weeds. The plough can be pulled by one or more pairs of donkeys or oxen. Disadvantages of the plough include:

- ☹ at the beginning of the rainy season stong animals are needed to draw the plough while at that time most animals are weak.
- ☹ repeated ploughing at the same depth can create plough pan or compacted layer
- ☹ turning the soil upside-down will result in loss of soil moisture through evaporation
- ☹ brings weed seeds from deeper soil layers to the soil surface while burying fresh weed seeds, resulting in the long term in more weed infestation in the field.

The design of the mouldboard, like the size and form, determines the quantity of crop residues that is left on the surface and the part that is mixed into the soil. The bigger and more curved the mouldboard the higher the amount of the residues that is inverted in the soil and thus fewer residues that are left on the surface. As a first step to convert from conventional plough based farming towards conservation agriculture, farmers might opt for tined implements like chisel or cultivator.

Chisels or rippers are sharply pointed, metal tines that can be attached to the ordinary plough beam (Moeller, 1997). Usually, farmers who want to avoid ploughing in minimum or reduced land preparation activities use chisels.

Plate 3
Animal drawn ripper
(*T. Friedrich*)

Plate 4
Magoye ripper with seeder attachment: a popular tool in South and East Africa.
(*J. Kienzle*)

It can also be used to break up plough pans or other impermeable soil layers, like crusts. Disadvantages include:

- ☹ poor weed control
- ☹ requires adequate soil condition (at crumbling point or dryer) to work properly
- ☹ residues and vegetation on the surface cloggs up the implement
- ☹ lifting stones and clods

Subsoilers are used to break up hard or compacted soil layers, with the aim to improve water infiltration and root penetration. It can be attached to the ordinary plough beam. It can also be used to break up dry soil. The point is brought right under the compacted layer and can be used up to soil depths of 25-60cm. With animal traction the maximum working depth of a chisel is around 30 cm. For this reason real subsoiling is not possible with animals, but shallow compactions can be broken using adequately shaped chisels.

Plate 5
Chisels used for deep ripping with animal traction need to be narrow and pointed. Right side: Subsoiler attachment for traditional plough, left magoye ripper attachment (*T. Friedrich*)

Cover crop, residue and weed management

The objective of cover crop, residue and weed management is to prepare the area for planting of seeds of the subsequent commercial crop and to manage the weeds so that they cannot interfere with the crop development. In conservation agriculture systems, this management should facilitate the penetration of direct seeding equipment in the field without obstructing the implement and favour the germination of seeds.

It is desirable that the residues form a good soil cover that protects the soil for quite some time against the impacts of rainfall and that liberates allelopathic chemicals to suppress the germination of eeds. The release of these chemicals should be slow and gradually until the commercial crop is able to compete with the weeds. One of the factors influencing the release of allelopathic chemical is the decomposition of organic matter (Almeida, 1988).

Residue/cover crop management can be done either mechanically or chemically, or a combination of the two, depending on the possibilities of the farmer, the topography (slope or flat land), the degree to which the area is invaded with weeds and the development stage of the cover crop.

Mechanical management

Mechanical residue/cover crop management can be done by mowing or by rolling the residue/crop down using knife rollers, crushers.

Machete or knife

Common practice in Latin America is slashing the weeds and residues of previous crops with a knife or machete before sowing.

Plate 6
The use of a machete or knife is a popular tool to control cover crops in Latin America.
(*T. Friedrich*)

The residues are left on the surface and the subsequent crop is sown into it.

Box 3. Advantages and disadvantages of machete.

Advantages
☺ Easily available
☺ Cheap
☺ Common tool

Disadvantages
☹ Heavy and time consuming
☹ Regrowth of weeds

Knife rollers or chopping rollers

The knife roller is used to bend over and crush the weed or cover crop vegetation prior to planting of the commercial crop, resulting in the death of the cover crop. This operation is best carried out after flowering but before maturity of the seeds of the cover crop. In this way there is no need to apply a herbicide to desiccate the vegetative cover, which will substantially reduce the cost of production. It is important that the knife roller only breaks and crushes but does not cut the cover crop plants so that they dry out and die. If the plants are cut the stubble might stand up again and re-sprout. Mechanical planting is also easier if the residues are not cut but still in contact with the soil. Rolling down the residue or cover crop cover improves also the weed control as compared to the standing residues or cover crops.

The knife roller is a simple and relatively cheap piece of equipment that can be made on the farm. It consists of a cylindrical body that rotates freely over a horizontal axle. The blades are arranged around the cylinder with equal distances apart. The distance between the blades determines the crushing length. Staggered knives and knives set at an angle to the radial of the cylinder improve the action and reduce the impact on the draft animals. The body is placed in a frame which might also provide transport wheels and a protection for the operator. When pulled the cylinder rolls on the knife-edges, bending over and crushing the vegetation (Araújo *et al*., 1993).

Plate
Animal traction knife roller in transport position (*T. Friedrich*)

A simple knife roller can be made of a tree trunk, adorned with "knives" at a distance of 22-25 cm apart around its circumference. The knives can be made of strips of hardened steel, e.g. the leaf springs of an old motorcar (Bertol and Wagner, 1987).

It needs proper management to avoid regrowth. In case of bending and crushing the vegetation it is important that the cover has a uniform development stage and that no regrowth or seeding occurs after the operation. Therefore it is recommended to use the knife roller in the following growth stages of the cover crop (Calegari, 1992):

- for legumes: between full flowering and formation of the first pods;
- for grass species: during the milky stage;
- for other species, like oil radish: between flowering and maturing of the seeds.

If mixtures of cover crops are used, it is important to choose those species with a more of less uniform growing cycle (Monegat, 1991).

Plate 7
Knife roller drawn by oxen is a popular tool on small to medium farms in southern Brazil.
(*T. Friedrich*)

Crushers

Based on the principle of the knife roller, several options to bend over and crush the vegetation can be thought out. Basically anything that is round and more or less heavy would qualify as show the following examples of tools used by farmers:

- sledge
- tree trunk without blades
- cement tubes
- old car tyres (Paraguay)

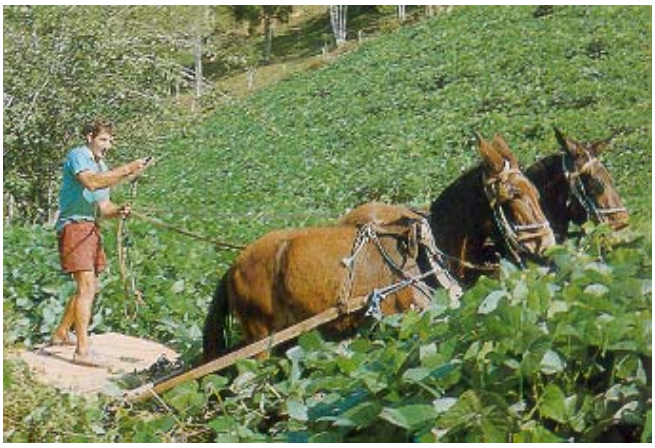


Plate 8
A sledge drawn by horses to manage a cover crop of *Mucuna*.

Plate 9
A culvert used to crush the cover crop previous to the current onion crop.
(*V.H. de Freitas*)

Plate 10
Cover crop crusher made of old tyres (*M. Piñalva*)

Mowers

Mowing is less recommended for handling cover crops, as the stubble of the cut covercrop could resprout. Animal traction mowers are normally equipped with cutter bars using reciprocating knives. They might be driven by ground wheels, which is only suitable for horses, or they might use a small petrol engine. However, animal draft mowers are very rarely used for cover crop management.

Another form of slashing cover crops is with the use of manual or mechanical mowers. Operator carried moterized mowers are in some countries becoming an alternative to using the machete. The result is a good cover, because the greater part of the biomass remains intact after cutting.

Plate 11
A mechanical hand mower to control the vegetation.

Chemical management

Chemical management of fallow vegetation or cover crop is done by spraying herbicides. Herbicides are applied to desiccate or “burn” the vegetative cover and thus facilitates the subsequent planting of the commercial crop. This practice is normally carried out when the green manure/cover crop is not yet in the full flowering or milky growth stage, and it is necessary to sow the next crop, or when the farmer is too late for using the knife roller.

Different types of sprayers have been developed. The lever operated knapsack sprayer is probably the most commonly used manual sprayer. The sprayer is carried on a person's back and therefore be easily transported around the farm and used in different terrains.

The tank makes up the largest part of the sprayer and can contain between 10 and 15 liters of liquid when full. A hand lever on the side of the tank, which is moved up and down, is used to create the required pressure (Moeller, 1997). The pressurized liquid is released through a nozzle at the end of a hand lance and broken down into small droplets forming the spray.

Plate 13
The knapsack sprayer is probably the most common sprayer in the world.
(*T. Friedrich*)

As the use of a knapsack sprayer is quite tiresome because of carrying and walking for long periods, other sprayers have been developed, based on the same principle.

The tank is placed on a chassis of a wheelbarrow or a frame to which two bicycle wheels are attached. For human traction the tank can contain between 20-50 liters of liquid. The wheels are also used to operate the pump. For this, the lever is connected to a hydraulic piston that is being activated by the movement of the wheel. As the sprayer is no longer carried, but pulled the area sprayed can also be extended through the use of a boom to which the hose containing the nozzles is attached. This way up to 5 meter wide can be treated at the same time. Labour is reduced to 0.6-1 hour per hectare (Araújo *et al*., 1999).

Plate 14
An adapted knapsack sprayer for manual traction.
(*T. Friedrich*)

Water availability is a serious limitation for applying herbicides in some regions. In this case low volume technologies using rotary nozzle sprayers are a viable alternative. Necessary application volumes can be reduced from 150-200 l/ha down to 10-20 l/ha.

Plate 15
Operator carried rotary nozzle herbicide sprayer.
(*T. Friedrich*)

Box 4. Different sprayers

- Hydraulic nozzle
- Rotary nozzle/low volume

- Point sprayer (single nozzle)
- Boom sprayer
- Shielded sprayer/row crops

Weed wipers are relatively simple tools to apply herbicides by contact to the weeds. Important is to use the right concentration of the herbicide and that the weed wipers produce a constant flow rate throughout the use. As there is no problem with drift weed wipers can be used for interrow weed control without danger to the crop, provided a minimum care is taken not to touch the crop rows.

Plate 15
Weed wiper
(*T. Friedrich*)

Even if only herbicides of low toxicity might be used, the application of agrochemicals requires always maximum care and knowledgeable operators. The sprayers used must not leak and be in good working conditions, the nozzles regularly cleaned and replaced. Operators should be trained in

calibration and handling of sprayers to make sure that a maximum result is achieved with a minimum of herbicides.

Bigger sprayers, which have a larger boom and can contain more liquid, have been developed for animal traction, although these are more suitable for flat areas. For hilly areas it is recommended to use models with a shorter boom.

Plate
Animal traction boom sprayer
(*T. Friedrich*)

Direct seeding

Planting stick or hand hoe

Direct seeding is practiced in a lot of places in the tropical world, although the terminology is not used as such.

Plate 16
A farmer in the steeplands of southern Honduras using a planting stick to sow his maize.
(*A.J. Bot*)

Plate 17
"Frijol tapado" or braodcast beans, sown over the residues of the former vegetation in Costa Rica.
(*A.J. Bot*)

Seeding or planting in large parts of Africa is done by using a hand hoe. The hand hoe used for planting purposes usually differs from the one used for tillage and weeding in that the blade is thin and narrow. Basically we are talking about direct seeding/planting if planting is done without any land preparation prior. In Latin America a planting stick (*huizute - El Salvador*) is commonly used to plant maize and sorghum and usually beans are broadcasted over the covered surface, without any land preparation.

Manual direct seeder or hand jab planter

In order to speed up the process of planting a hand jab planter (or *matraca* in Spanish) was developed. It is a hand-held tool that allows the farmer to plant from a standing position and faster than with any other hand tool (average 2 days per hectare). The tool is made of two long levers joined with a hinge to form a V with a pointed tip. The pointed tip is pushed into the soil. By closing the V shaped levers the tip is opened to release the seed into the soil. At the same time new seed and eventually fertilizer is charged into the metering mechanism. The planter is pushed into the soil at every step, allowing a regular spacing. Disadvantages include:

- ☹ "arms" are sometimes too weak and easily damaged by powerful farmers
- ☹ tip gets clogged with soil, when not properly designed or handled and used in very moist clayey soils

One of the modifications to the planter is a second box, opposite of the seedbox to contain fertilizer. This allows the farmer to fertilize and plant at the same moment. If the jab planter is provided with a second hopper to apply fertilizer and seeds in one operation, it should ideally have two separate delivery tubes and points to make sure the seed and fertilizer is not deposited too close to each other.

Plate 18
A Maasai in Northeastern Tanzania evaluating the hand jab planter.
(*A.J. Bot*)

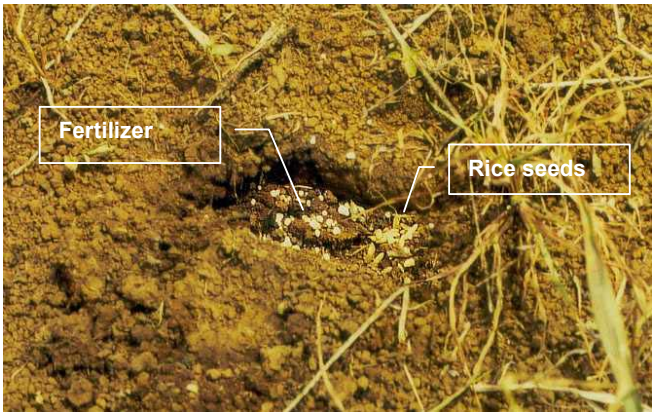


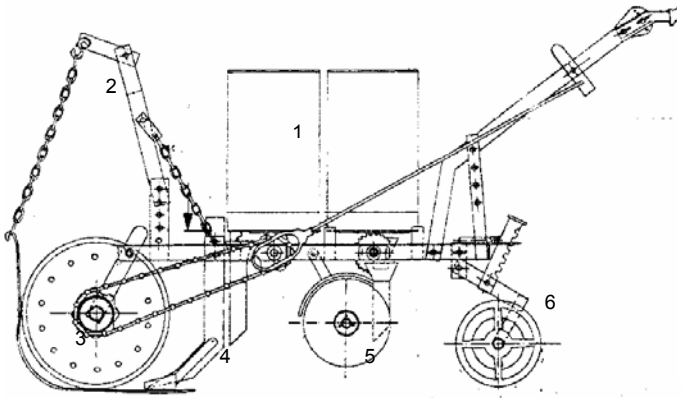
Plate 19
The distance between seeds and fertilizer deposited in the soil by a hand jab planter is about 2 cm wide and 1-2 cm deep.
(*A.J. Bot*)

Animal traction and single-axle-tractor drawn planters

Direct seeding implements for animal traction and single-axle-tractors have been designed to manage residues on the soil surface and at the same time to place the seeds and possibly fertilizer in the soil. Therefore direct seeders have following working elements:

- a disc to cut the (cover) crop residues and open a slot in the soil
- a furrow opener to place the fertilizer – usually a chisel
- a furrow opener to place the seed – either a chisel or a double disk
- wheels to control the planting depth and eventually press the seed row
- presswheels to close the slot in order to secure a good contact between soil and seed

Figure 2
Basic design of an animal drawn direct planter (Adapted from Riveira *et al*.)



Legend

1. Measuring and distribution of fertilisers and seeds
2. Point of engagement of regulator for transferring weight of the planter to the cutting disc
3. Cutting disk
4. Chisel Furrower and fertiliser- tube
5. Disk Furrower and seed-tube
6. Depth control and Press wheel

The efficiency of the disc that cuts the (cover) crop residues depends on various factors:

- soil conditions: texture, resistance to penetration, humidity and porosity
- straw and residue conditions: resistance to be cut, humidity, quantity and management
- seeder: weight and dynamics
- disc: size, shape and profile

For good results it is recommended:

- to work during the warmest hours of the day (after 10 in the morning);

- work when the straw is either green or completely dried, never when it is wilted;
- operate when humidity level reaches the point of soils being friable;
- when using animal traction, never try to seed when more than 5 tons of dry matter per hectare is left on the surface.

Plate 21
Cutting disc.
(*T. Friedrich*)

Inefficient cutting leads to an accumulation of residues between the different parts of the seeder and results in seed and fertilizer deposition problems, i.e. irregular spacing or complete absence of seeds (Ribeira *et al*., 1999).

Plate 22
Accumulation of residues occurs when residues are too humid or the implement is adjusted inappropriately.
(*S. Vaneph*)

The soil needs to be firm enough to facilitate the cutting through residues, otherwise those will be pressed into the soil, resulting in hairpinning and bad soil contact of the seed. Blockage of the equipment could also result from not proper cutting of residues on soft soils (Casão and Yamaoka, 1990). The cutting discs have either smooth edges that facilitate penetration into the soil or curved edges if more soil movement id desired, for instance when *Fusarium* infestation is expected and a drier soil is needed, or to improve the turning of the disk and avoid blockage.

Furrow openers for seed and fertilizer on animal traction or micro-tractor planters are usually a chisel tine or hoe, double discs or by rolling punch type injection. Usually the furrow opener is placed just before or on the tip of the tubes that drop the fertilizer and the seeds.

The performance of the furrow opener depends on its geometric characteristics, the speed, the texture and density of the soil, the quantity of residues and the pressure placed on it by the seeder. It can be formed as:

- a chisel tine: commonly used in soils that have a higher resistance to penetration, but results in more problems with clogging up the implement with residues, and can not be used in areas with stones, trunks or a lot of roots; chisels are preferred for animal drawn implements as they require less weight due to the better penetration characteristics;
- double discs, either the same diameter or not and placed in an angle forming a "V" to each other. The additional effect is that residues not yet very well cut, are cut by these discs resulting in less obstruction of the implement. The implement has less capacity to penetrate the soil, especially in clay soils (Ribeira *et al*., 1999). Disks of different diameter and offset axles have better self cleaning and penetration characteristics than those of similar diameter. If double disk openers are used at all, the offset double disks of different diameter are therefore the preferred option for animal traction planters.

Following are the most common furrow-types created by animal traction direct planters (Baker *et al*., 1996):

1. V-shaped slots;
2. U-shaped slots;

In conservation agriculture, V-shaped slots are almost always created by two discs which touch and are angled outwards their tops. The angle of the V is usually about 10 degrees. Each of the angled discs pushes roughly an equal amount of soil sideways when both discs are at the same angle to the vertical. Biggest advantage of vertical double discs is their ability to handle surface residues without blockage. The construction is relatively simple and maintenance free.

Plate 23
Planter with double disk coulters and cast iron press wheels
(*T. Friedrich*)

When the front edges of the two discs leave a gap open at ground level, this can cause problems with residues entering. This can be avoided through:

☺ placing a third disc ahead of, or in between the two angled discs, which cuts the residues; or,
☺ positioning one of the two discs forward of the other as to present a single cutting edge; or
☺ replacing one of the two discs by a smaller one; the larger disc becomes the leading edge to cut the residues.

Disadvantages of V-shaped slots:

☹ needs high penetration forces
☹ intolerance to sub-optimal soil conditions
☹ tendency to 'tuck' residues into the slot (hairpinning)

☹ tend to concentrate seed and fertilizer at the base of the slot if applied together

Slots that can be distinguished from V-shaped ones by a broader base are called U-shaped slots. U-shaped slots are in animal traction and micro-tractor planters usually formed by the following furrow opener types:

- hoe or chisel openers
- power till openers

All of these designs produce some loose soil on the surface near the slot that can be used to cover the slot again. Hoe and chisel type openers burst the soil upwards; power till openers chop the soil with a set of rotating blades; and furrow openers scoop the soil out from the slot zone.

Plate 24
Working elements of a power tiller furrow opener.
(*T. Friedrich*)

Hoe type openers refer to any shaped tine or chisel, which is designed to vertically penetrate the soil. Seed is delivered either down the inside of the hollow tine itself or down a tube attached to it, which is usually open at the back. The biggest disadvantage of hoe openers is the fact that they do not handle even modest levels of residues without blockage, unless a leading disc is placed ahead of the hoe opener to cut the residues.

Plate 25
Planter with hoe openers for fertilizer and seed following the cutting disc.
(*T. Friedrich*)

Advantages of hoe openers:

☺ low cost
☺ they penetrate the soil better requiring less weight of the implement which make them ideal for animal traction
☺ they do not tuck residues into the slot, but 'brush' them side ways
☺ they do not create smear surfaces at the sides of moist planting furrows creating a better seedbed

Disadvantages:
☹ problems with stones and obstacles
☹ requires a good cutting disc for long residues
☹ considerable soil movement depending on shap and width

The rolling punch injection is another form of furrow opener. It handles residues quite well, but tends to clog when used in sticky soils.

Plate 27
Two row rolling punch injection planter.
(*T. Friedrich*)

Plate 27
Single row rolling punch injection planter.
(*T. Friedrich*)

It is recommended for annual crops that fertilizer should be placed about 5 cm besides and under the seeds. In a direct seeder this would mean that the ripping device for fertilizer is placed outside the line of work compared to the seeder. However, in animal drawn direct seeders the fertilizer is placed under the seed, but in the same line.

Plate 28
Detail of the inside of the seed container with seed plates to distribute the seeds.
(*V.H. de Freitas*)

Seedplates inside the containers are controlling the plant density in the field. They are activated to turn by the movement of one of the wheels either with a chain or gear. The distance between the soil and the tube defines the preciseness of planting: if the distance is bigger, the chance that the seeds deviate from the optimal planting distance is bigger.

Plate 29
Both the seed plate and the fertilizer sloth are activated by the movement of the wheels. In this case a chain connects the moving parts.
(*A.J. Bot*)

Seedplates in animal traction planters can be custom made by the planter manufacturer. To reduce seed damage the diameter of the plate should be large enough, so that the revolution speed of the plate is not too high. Animal traction planters with small metering disks should only be used with oxen and not with horses, as horses have higher forward speeds. Most modern animal traction planters use now standard disks as for tractor planters which can cope with the speed of any draft animal.

Plate
Standard tractor planter seedplate in a simple animal traction planter (*T. Friedrich*)

For a long time, scientists have thought that the best cover for seeds was loose soil. Obviously this thinking was derived from situations with tilled seedbeds. However, especially under dry conditions it can be observed that seeds under mulch cover germinate better than those covered by loose soil. Since under tilled conditions (loose soil) the macropore system in the vicinity of the seeds is completely destroyed the soil moisture equilibrium and the capillarity is disturbed. In undisturbed soil, the soil humidity equilibrium is intact providing optimal exchange of moisture between soil particles and pores. This allows the capillary supply of soil water to the soil surface while reducing the evaporation loss with the mulch cover. In conservation agriculture, soil moisture loss takes place in the slot, and depending on the type of slot more or less moisture is lost (table 2 and figure ..).

Figure 3
Moisture loss from different slot shapes and the position of the seed in the different slots (after Carter, 1994).

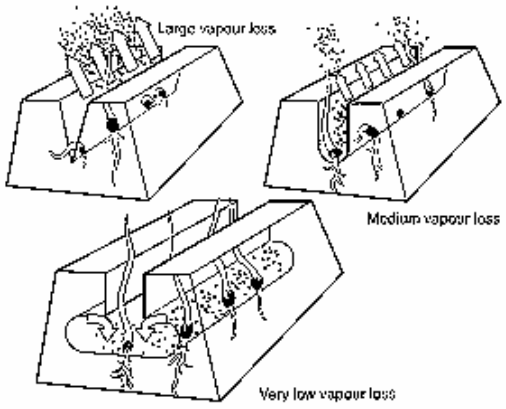


Table 2 Effect of slot shape on slot drying rates (Baker *et al*., 1996)

	V-shaped slot	U-shaped slot	Inverted T-shaped slot
Daily loss of relative soil humidity (%)	3.7	2.4	1.7

Table 3 Wheat seed and seedling responses to no-tillage openers in a dry soil and soil of adequate moisture (Baker *et al*., 1996)

	V-shaped slot		U-shaped slot		Inverted T-shaped slot	
	Moist	Dry	Moist	Dry	Moist	Dry
% seedling emergence	42%	10%	70%	31%	68%	59%
Germinated seeds that	58%	72%	30%	22%	32%	23%

had failed to emerge						
Ungerminated seeds	0%	18%	0%	47%	0%	18%

The inverted T-slot traps water vapour within the slot, which germinates the seed. Pressing on the seeds in V- and U-shaped slots before covering the seeds improves their performance, especially in dry soils.

The wheels at the back of the implement serve to press humid soil or crop residues on the slot in order to place the seed into close contact with the soil. Some seeders lack this wheel and in that case it is the operator of the planter who puts the seeds into contact with the soil, as s/he walks on the slot.

Surface residues are an important resource for promoting seedling emergence from dry soils and it is possible to obtain more effective seedling emergence from a dry soil by direct seeding than by tillage, provided the correct technique and equipment are used.

The so-called "planter clinics" are gatherings of farmers and technicians where people learn and equipment is adjusted to fit the different realities of farmers in different agro-ecological conditions. Adjustments to make the implement more stable when used on steep slopes through the use of an extra pair of wheels, or an adjustment to the cutting disc to avoid *Fusarium* incidence in beans are two examples.

Plate 30
"Planter clinic" where people learn and implements are adjusted.
(*A.J. Bot*)

Plate
Demonstration of a single row animal traction direct planter
(*T. Friedrich*)

The animal traction prototype seeders where made to plant one row at the time, but by now exist planters that can seed more rows. Multi-row versions might even provide an operator's seat.

Plate 31
A two row ride-on seeder for animal traction.
(*T. Friedrich*)

Plate 32
A microtractor used for direct seeding.
(*T. Friedrich*)

Other information on direct seeders

Already a lot of manufacturers of zero tillage equipment have posted their products together with information on the Internet. FAO Agricultural Service tries to bring as much information together as possible in their on-line database on Conservation Agriculture Technology, which is accessible through: http://www.fao.org/ag/catd/index.jsp

The database provides information on different models of conservation agriculture equipment for manual use, animal and mechanized traction. Technical, agronomic and commercial information for direct planters and seed drills, rippers, equipment for residue handling and specially developed sprayers can be viewed from this site. Complete addresses are provided, including links directly to webpages of the manufacturers.

References

Almeida, F.S. 1988. A alelopatia e as plantas. IAPAR Circular 53. Londrina.

Araújo, A.G., R. Casão Jr., and P.R. A. Araújo. 1993. Recomendações para dimensionamento e construção do rolo-faca. In: Encontro Latinoamericano sobre Plantio Direto na Pequena Propriedade. Anais. IAPAR. Ponta Grossa. p. 271-280.

Araújo, A.G., R.S. Yamaoka and D.A. Benassi. 1999. Máquinas para pulverição em solos de baixa aptidão agrícola. In: Uso e manejo do solos de baixa aptidão agrícola. O. Muzilli and C. Castro Filho (Eds.) IAPAR Circular Técnica 108. p. 154-167.

Baker, CJ., K.E. Saxton and W.R. Ritchie.1996.No-tillage seeding. Science and practice. CAB International, University Press Cambridge. 258pp.

Bertol, O. and O. Wagner. 1987. A knife roller or chopping roller. In: ILEIA Newsletter. Vol. 3:1. p.10-11.

Carter, M.R. 1994. Conservation tillage in temperate agroecosystems. Lewis. Boca Raton. 390pp.

Casão Jr., R. and R.S.Yamaoka. 1990. Desenvolvimento de semeadora-adubadora direta a tração animal. In: XIX Congresso Brasileiro de Engenharia Agrícola, Piracicaba. Anais. p. 766-777.

Derpsch, R. and A. Calegari. 1992. Plantas para adubação verde de inverno. IAPAR Circular 73. 80 pp.

Friedrich, T. 2000. Conceptos y objetivos de la labranza en una agricultura conservacionista. In: Manual de prácticas integradas de manejo y conservación de suelos. FAO. Soil and Water Bulletin 8. Rome. p. 29-37.

Godwin, R.J. 1990. Agricultural engineering in development: tillage for crop production in areas of low rainfall. FAO. Agricultural Services Bulletin 83. Rome. 124 pp.

Krause R., F. Lorenz and W.B. Hoogmoed. 1984. Soil tillage in the tropics and subtropics. GTZ. Eschborn. 320pp.

Moeller, O. 1997. Farmers' Tools. Farmesa, FAO. Zimbabwe. 115 pp.

Monegat, C. 1991. Plantas de cobertura do solo. Características e manejo em pequenas propriedades. Chapecó. 337pp.

Ribeira, M.F.S., A.G. Araújo, R. Casão Jr. and D.A. Benassi.1999. Máquinas para semeadura direta em solos de baixa aptidão agrícola. In: Uso e manejo do solos de baixa aptidão agrícola. Muzilli and Castro Filho (Eds.) IAPAR Circular Técnica 108. p. 139-152.

Vieira, M.J. 1996. Uso del arado de cincel para la producción agrícola y la conservación de suelos y agua. MAG-FAO, San José, Costa Rica. 41 pp.