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Weed Management in conservation agriculture

SUMMARY:
This technology describes how to better prepare the area for planting crops and manage weeds, so that they cannot interfere with crop development. In conservation agriculture systems, this management should facilitate the penetration of direct seeding equipment into the soil and into a favourable environment for seed germination, without obstructing the implement. Residue and cover crop management can be done either mechanically which can be done by using machetes, knives or sickles, knife rollers, crushers, mowers, etc. Or chemically by spraying herbicides, to desiccate or "burn" the vegetative cover and thus facilitate the subsequent planting of the commercial crop. This technology is part of a series on conservation agriculture.

KEYWORDS:
Crop residues [1]
Cover crops [2]

CATEGORY:
Agricultural mechanization [3]
Crop production [4]

DESCRIPTION:

Conservation Agriculture (CA) is an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment.

The three fundamental principles of CA are: (1) Direct planting of crop seeds, (2) Permanent soil cover, and (3) Crop diversity.

(see: Introduction to conservation agriculture (its principles & benefits) for more details)

Since soil is not tilled in conservation agriculture, the residues of commercial crops and cover crops have to be managed.

Residue and 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 (sloping or flat land); the degree of weed infestation; and the stage of development of the cover crop.

1. **Mechanical management**

It can be done by using machetes, knives or sickles, knife rollers, crushers, mowers, etc. or any similar implement. This section has three parts:

1. Manual mechanical management
2. Animal drawn mechanical management
3. Tractor drawn implements for mechanical management of cover crops

1. **Manual mechanical management**

- **Machete or knife**

A common practice in Latin America is to slash the weeds and residues of previous crops with a machete (*large knife*) before sowing. ***(Picture1)***

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

Advantages

- Easily available
- Cheap
- Common tool

Disadvantages

- Heavy and time consuming
- Re-growth 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 the commercial crop, usually resulting in the death of the cover crop. It is usually known as a tool for animal traction or for tractors, but the same principle could be applied to small rollers or similar tools being dragged by humans. This operation is best carried out after flowering but before maturity of the seeds of the cover crop. This way there is no need to apply a herbicide (= *weedkillers*) to desiccate *(= extreme drying*) the vegetative cover, and will substantially reduce the cost of production. In this case 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 re-sprout. Mechanical planting is also easier if the residues are not cut but still in contact with the soil.

- **Mowers**

Another form of slashing cover crops is with the use of mowers. Operator-carried motorised 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. ***(Picture2)***

1. **Animal drawn mechanical management**

- Knife rollers or chopping rollers

The knife roller is used to bend over and crush the weed or cover crop prior to planting the following commercial crop, usually 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 (= *weedkillers*) to desiccate *(= see the description above*) the vegetative cover. 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 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 also improves the weed control as compared to the standing residues or cover crops. ***(Picture3)***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 about a horizontal axle. The knife blades are arranged at equal spacing around the cylinder. The distance between the blades determines the crushing length. Staggered knives and knives set at an angle to the radius of the cylinder improve the action and reduce the shock impact on the draft animals. The body is placed in a frame which might also be provided with transport wheels and a cover to protect the operator. When pulled the cylinder rolls on the knife-edges, bending over and crushing the vegetation (Araújo *et al.*, 1993).

A simple knife roller can be made of a tree trunk, fitted with knife blades 22-25 cm apart around its circumference (= *the distance around a closed curve*). The knives can be made of strips of hardened steel, e.g. old vehicle leaf springs (Bertol and Wagner, 1987).Knife roller operation requires proper management to avoid re-growth. When bending and crushing the vegetation, it is important that the cover is at a uniform development stage and that no re-growth or mature seed shedding occurs during and after the operation. Therefore it is recommended to use the knife roller at 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 milk 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 or less uniform growing cycle (Monegat, 1991).

- **Crushers*(Picture4)***

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 shown by the following examples of tools used by farmers:

- Sledge (= *a land vehicle with a smooth underside or possessing a separate body supported by two or more smooth, relatively narrow, longitudinal* ***runners*** *that travels by sliding across a surface*) ***(Picture5).***
- Tree trunk without blades.
- Concrete tubes.
- Old car tyres (Paraguay). ***(Picture6)***

- **Mowers**

Mowing is less recommended for handling cover crops, as the stubble of the cut cover crop could re-sprout. Animal traction mowers are normally equipped with cutter bars using reciprocating knives. They might be driven by a ground wheel, 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.

1. **Tractor drawn implements for mechanical management of cover crops**

Construction details for a knife roller *(Picture7)* (according to http://www.rolf-derpsch.com/ [5])The

Knife Roller consists of a hollow steel cylinder, 6 mm thick, approx. 115 - 200 cm wide and 60 -70 cm in diameter.Ends are welded to be filled with water if needed.Approx. 8 - 12 blunt knives are placed every 19 cm.The knives are about 7 - 10 cm high and are placed parallel to the cylinder at an angle of 45° or 90°.Weight of each 200 cm cylinder is approx. 400 kg empty and 800 kg full of water.Three cylinders are often placed in such a way that two run in front and one in back allowing for greater working width.Cylinders are mounted on a frame to allow hydraulic lifting.(Derpsch, 2003)

- **Crushers**

Based on the principle of the knife roller, several options to bend over and crush the vegetation can be thought out. Some of these have been mentioned in the Animal Power section. For tractors a further alternative is to use modified disc harrows. Disc harrows ***(Picture8)*** with steel bars ***(Picture9)*** welded along their length will function well as a roller crusher.

- **Mowers**

As was explained in the animal power section *(see above)*, mowing cover crops is not normally recommended as it could lead to resprouting of the stubble. In addition the residues would be loose on the surface and not aligned as is the case when they are rolled down with a knife roller. This could complicate the planting as vegetation would accumulate around the planting assemblies.

Besides mowers, shredders ***(Picture10)*** are another type of machines used for mulch management. They consist of knifes, rotating vertically at high speed around a horizontal axle. Usually they reduce the biomass to small pieces. The advantages include a fairly even spreading of the mulch, the control of pests and diseases and the shredded pieces do not interfere with the planting operation. However, the biggest disadvantage of shredders is that the chopped residues decompose much more quickly which means they would not last as long on the soil surface as non chopped residues. Another serious disadvantage is the high energy consumption. For this reason shredders should only be considered in special cases for residue and cover crop management. Rotary slashers suffer from the same disadvantage.

The same principle applies to the cereal straw after combining. It is very important that the straw is uniformly distributed across the cutting width of the combine. In many cases modern combines are often equipped with straw choppers ***(Picture11).*** The straw chopper must be set in a way that all the straw and chaff is spread uniformly across the cutting width of the combine.

Under Conservation Agriculture it is preferable, even in the case of cereal straw, not to chop but simply spread the straw behind the combine harvester ***(Picture12).*** This saves energy and fuel, provides a longer lasting soil cover and reduces the danger of hairpinning - straw being push into the seed slot - during planting. Straw spreaders for combine harvesters are commercially available or could be built easily on farm. ***(Picture13)***

1. **Chemical management**

Chemical management of fallow vegetation or cover crops is done by spraying herbicides. Herbicides are applied to desiccate *(= see the description above)* or "burn" the vegetative cover and thus facilitate the subsequent planting of the commercial crop. This practice is normally carried out when the cover crop is not yet in the full flowering or milky growth stage, and it is necessary to sow the next crop, or when it is too late to use the knife roller. Different types of sprayers have been developed and these will be presented in two sections:

- Manual and animal traction
- Tractor operated

1. **Manual and animal drawn equipment for chemical weed management**

The lever operated knapsack sprayer is probably the most commonly used manual sprayer. ***(Picture14)*** The sprayer is carried on a person's back and therefore can be easily transported around the farm and used in different types of terrain.The tank makes up the largest part of the sprayer and can contain between 10 and 15 litres 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 which breaks it down into small droplets forming the spray.As the use of a knapsack sprayer is quite tiring because of carrying and walking for long periods, other sprayers have been developed, based on the same operating principle.

The tank is placed on a chassis of a wheelbarrow or a frame to which two bicycle wheels are attached. ***(Picture15).*** For human traction the tank can contain between 20-50 litres of liquid. One of the wheels is also used to operate the pump. The sprayer pump is activated via an eccentric and connecting rod transmission system from the wheel axle. As the sprayer is no longer carried, but pulled, the area sprayed can also be extended through the use of a multi-nozzle boom. Such a system could have working width of up to 5 m and the spraying time can be reduced to 0.6-1 hour per hectare (Araújo *et al.*, 1999).

Water availability is a serious limitation for applying herbicides in some regions. In this case low volume technologies using rotary nozzle sprayers ***(Picture16)*** are a viable alternative. Necessary application volumes can be reduced from 150-200 l/ha down to 10-20 l/ha.

Different types of sprayer

- Hydraulic nozzle
- Rotary nozzle/low volume
- Point sprayer (single nozzle)
- Boom sprayer
- Shielded sprayer/row crops

Weed wipers ***(Picture17)*** are relatively simple tools to apply herbicides by contact with the weeds. It is important to use the right concentration of herbicide and that the weed wipers produce a constant flow rate throughout their use. As there is no problem with drift, weed wipers can be used for inter-row weed control without danger to the crop, provided a minimum care is taken not to touch the crop rows.

Even if only herbicides of low toxicity are being used, the application of agrochemicals always requires maximum care and knowledgeable operators. The sprayers used must not leak and must be in good working condition, 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. ***(Picture18)***

1. **Tractor operated chemical cover crop and weed management.**

For applying herbicides the standard tractor boom sprayer is the most common equipment. Depending on the size this can be tractor mounted, trailed or self-propelled. For row crops, shielded sprayers can be used to apply herbicides between the lines without affecting the crop. (***Picture19***)

Using herbicides requires great care, knowledge and skill in order to avoid environmental or human health hazards. Spray equipment should conform to established safety standards and be in a safe working condition. There should not be any leaks, the controls should be working properly and the nozzles (= *a device designed to control the direction or characteristics of a fluid flow*) should be checked and replaced regularly. Operators should be trained and proficient in using sprayers. A badly applied herbicide application increases the production costs and might even endanger the crop.

Before spraying, the sprayer should be properly calibrated to make sure the correct dose rate is being applied. For herbicides, application nozzles should be chosen that provide a good even distribution across a level surface, provide good overlap even at varying boom heights and produce a coarse droplet spectrum to avoid drift. These are usually flat fan, deflector or flood jet nozzles. Depending on the nozzle and the required application rate the pressure should be low to avoid the formation of small droplets (1-2 bar).To avoid drift, spray booms can be equipped with drift shields or air-sleeves ***(Picture20).*** Where old or obsolete sprayers are available but not in proper working order, they can be upgraded at low cost by replacing only the liquid carrying technical components, ***(Picture21).*** Usually the tank and sprayer frame, often even the boom can still be used. It is advisable to replace pump, hoses, controls, filter units and nozzles with the respective lines.

This technology is part of a series on conservation agriculture:

1. Introduction to conservation agriculture (its principles & benefits) [6]
2. Animal traction and single-axle tractor drawn planters in conservation agriculture [7]
3. Direct seeding equipment for tractors [8]
4. Crop rotation in conservation agriculture [9]
5. Cover crop and residue management [10]
6. Weed Management [11]
7. Cover crop species, with a special focus on legumes [12]

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FURTHER READING:

More about Cover crop and weed management could be find on http://www.fao.org/ag/ca/3f.html [13]

Weed control in smallholder conservation agriculture leaflet (http://www.fao.org/ag/ca/Training_Materials/Leaflet_weedcontrol.pdf [14])

SOURCE:

Conservation Agriculture (CA) in FAO [15]

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Links:
[1] http://teca.fao.org/keywords/crop-residues
[2] http://teca.fao.org/keywords/cover-crops
[3] http://teca.fao.org/technology-categories/agricultural-mechanization
[4] http://teca.fao.org/technology-categories/crop-production
[5] http://www.rolf-derpsch.com/
[6] http://teca.fao.org/technology/introduction-conservation-agriculture-its-principles-benefits
[7] http://teca.fao.org/technology/animal-traction-and-single-axle-tractor-drawn-planters-conversation-agriculture
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[11] http://teca.fao.org/technology/weed-management-conservation-agriculture
[12] http://teca.fao.org/technology/cover-crop-species-special-focus-legumes
[13] http://www.fao.org/ag/ca/3f.html
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