

How to implement Conservation Agriculture

There are a number of different planting systems within conservation agriculture (CA). The choice depends largely on how much land you plan to cultivate and your access to no-till planting equipment and labour. It also depends a lot on the type of soil you have and the cover on top of the soil.

The three main systems are:

- * Hand planting
- * Animal drawn no-till planters and
- * Tractor drawn no-till planters

CA is a process of moving away from a high external input system towards a low external input system. We are aiming to maximise yields while using as little herbicides, fertilizers and pesticides as possible. The success of reaching our aim will depend largely on the quality of implementation of the three CA principles: a) not ploughing or disturbing the soil, b) keeping the soil covered with organic material or mulch, and c) the use of crop rotations and cover crops.

When we start to do CA it may take a while for the system to balance or to work well and for crops to grow well. In the first few years there are likely to be some problems with weed infestation, lack of organic matter in the soil and soil infertility issues, including acidity in the higher rainfall areas.

On smaller plots it is easy to introduce mulch to reduce the weed competition and this works for field crops as well as vegetables. On larger plots, while this is still possible, we usually spray herbicides on the field to kill weeds before and at planting, as well as after planting. As the ground cover increases and the weed seed stocks/ reserves in the soil decreases, less and less herbicide will be needed. The aim is to get to a point where no herbicide will be required.



Above: A plot of cabbages planted using the no-till method. Note the mulching that stops weeds from growing. From: Mr Simon Hodgson, Cover Crop Solutions, 2014

Reducing weeds by intercropping

Single planted plots have more weeds, because of the space between the rows of plants. Intercropped plots form a canopy that covers the soil a lot more quickly than single crop plots. This suppresses further weed growth.

Intercrop plots, with close spacing of crops may require only 1 weeding, or under ideal conditions no weeding at all. Single crop plots require 2-3 weedings in the season.



Left: A plot of beans where weed competition has reduced the growth and plants are yellowing.

Right: A maize and bean intercropped plot showing the lack of weeds and good growth of both plots.

(Pics from GrainSA SFIP, Bergville 2014)

Timely Preparation and Planting

Preparing the fields and planting in time is very important.

What operation?	When?
Land Preparation (digging basins, ripping, digging furrows)	July – October
Pre planting spray of herbicides	September- October (2 weeks before planting and at planting)
Application of basal fertility amendments (manure, compost, fertilizer*, lime)	October- November (at planting or 2 weeks before planting)
Planting; spray pesticide (cutworm and stalk borer), single crops and intercrops	October -November
First weeding and relay planting of legumes as intercrop or cover crop	As soon as weeds appear, 1-2 weeks after planting
Second weeding and top dressing; check for stalk borer and spray pesticide if required (5% shot hole damage on maize leaves)	December-January, just before top dressing (4-6 Weeks after planting)
Relay crop planting of winter cover crops and final weeding. Watch for pest damage during tasseling and cobbing and spray pesticide if required	February- March
Harvesting	May-June
Post-harvest management	June-July

**consider eco-friendly fertilisers where possible*

Land preparation for hand planting

NOTE: We have given very general recommendations for quantities of manure and fertilizer, based on a summer rainfall area of 700-800 mm rain per year with clay-loam (20-30% clay in topsoil) soils that tend towards being acidic. The maize yield target for this specific example is 4-8 ton ha⁻¹yr⁻¹. Maize plant populations could range between 40,000 to 70,000 plants per hectare.



Planting basins

Seeds are planted not along the usual furrow but in small basins or pits that can be dug with hand hoes without having to plough the whole field.

Step 1: Prepare basins [July–October]

- * Remove weeds from the previous season
- * Dig basins 15cm long x 15cm wide x 15cm deep
- * Basins should be arranged in rows. Basin spacing is 60cm in the row and 90cm between rows. A spacing of 75cm X 75cm can also be used.



The type and amount of fertilizer is specific for your field. If you do not have a soil sample result to work from there are general rules of thumb one can follow for your area.

Above: A field with basins prepared and waiting for planting.

Step 2: Add manure [Sept–Oct]

- * Apply 5-10 handfuls or one spade full of manure/compost in each basin and cover lightly with soil. If lime is being applied mix it in with the manure. Apply ½ food tin (250g) per basin. This is equivalent to 1ton/ha.
- * It is good to apply manure and lime some time before planting to allow these slow acting compounds to start working.

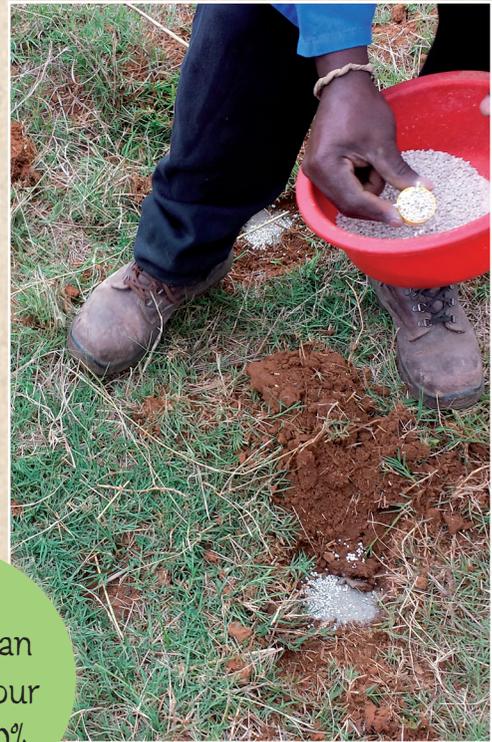


Above: (left) Adding manure to a basin and (right) adding lime to the basins using a matchbox.

Step 3: Planting [November–December]

- * Plant after good rains, when the soil is damp but not too wet and sticky.
- * If fertilizer is being applied, apply 1 level cool drink bottle cap or teaspoon per basin of MAP (around 4,2g/basin). Place this to one side of the hole and cover lightly with soil first before placing the seeds in the basin
- * Place 3 pips (seeds) in each basin
- * Cover the seeds with soil

Right: Adding one bottle top of fertilizer per basin



Proper weeding can increase your yield by 50%

Step 4. Weeding & thinning

[December–February]

- * 1st Weeding: as soon as weeds start emerging
- * Thinning: 2-3 weeks after germination, leaving 2 plants per basin
- * 2nd weeding: 4-6 weeks after crop emergence

Step 5. Top dressing with limestone ammonium Nitrate (LAN)

[January–February]

- * Apply LAN at 5-6 leaf stage; Use half a cool drink bottle cap or half a teaspoon full per basin of LAN (2,5g/basin).
- * Do not broadcast the fertilizer – apply it carefully near the base of each plant. In this way, all the fertilizer goes directly to the plant, nothing is wasted. Only apply fertilizer to moist soil – not dry.



Top dressing with half a teaspoon of LAN per basin.

Step 6. Harvest [March–July]

- * Remove cobs and leave stalks standing in the field
- * Cut stalks at the base
- * Spread the cut stalks in the field, between rows

Step 7. Management in dry season

[June–September]

- * Remove weeds that are still in the field
- * Prepare basins in the same positions as last season and start all over again!



Shallow planting furrows

This CA system uses a hand hoe and again you do not have to plough the field before planting. Like the planting basins, land preparation is best done before the onset of the rainy season from July to October.

Step 1. Prepare furrows

[July-October]

- * Remove weeds from previous season (either mechanically or chemically)
- * Dig furrows 5-10cm wide and approximately 2-5cm deep. Spacing depends on the planting system used. Space rows 50cm, 75cm or 90cm apart for maize. If the rows are spaced wide apart then more plants can be placed in the rows; for example one can use a 90cm between-row x 40cm in-row plant spacing, or one can plant in a square grid of 50cm between x 50cm in row spacing. For beans an in-row spacing of 10cm is used with 25cm, 30cm or 50cm between rows.

NOTE: The closer (denser) plants are to each other, the more they protect the soil and suppress weeds

Above: Lines of string have been placed to indicate the spacing for furrows – here 25cm for two rows of beans and 50cm for 2 rows of maize.

It is easier to weed when crops are planted further apart, but it is also easier for the weeds to grow.

Step 2. Add manure

[September–October]

- * Apply 2 spades -full of manure or compost per meter of row
- * If lime is being applied mix it in with the manure. Apply 1 food tin (500g) per metre of row.

It is good to apply manure and lime some time before planting to allow these slow acting compounds to start working

Right: Applying lime in the planting furrows

Step 3. Planting

[November–December]

- * Plant after good rains
- * If basal fertilizer, such as MAP is available, apply 2 level cool drink bottle caps or ½ of a matchbox per meter of row.
- * Place seeds 10cm-50cm apart in the rows, depending on whether you are planting legumes or grains
- * Cover the seeds with soil



Step 4. Weeding [December–February]

- * 1st weeding is done as soon as weeds start emerging
- * 2nd weeding is done around 4-6 weeks after crop emergence

Step 5. Top dressing with limestone ammonium nitrate [January–February]

- * Apply LAN at 5-6 leaf stage; Use a quarter of a cool drink bottle cap or a quarter of a tea-spoon full per plant of LAN (1,25g/plant). For beans you can use about half of this recommendation as they make their own Nitrogen and adding too much fertilizer can favour leaf growth over seeding.
- * Do not broadcast the fertilizer –apply it carefully near the base of each plant.

Step 6. Harvest [March–July]

- * Remove cobs and leave stalks standing in the field
- * Cut stalks at the base, flatten or leave standing
- * Spread the cut stalks in the field, between rows

Right: A field with good cover of maize stalks and remains. A relay cover crop is germinating through this cover.

**Step 7. Management in dry season** [June–Sept]

- * Remove weeds that are still in the field
- * Prepare the rows in the same positions as last season and start all over again!

Tramline intercropping

This is a CA system of spacing field crops in an intercropping system that minimises potential competition for light, water and nutrients, optimises the use of available land surface and maximises production. This can be done using hand or animal-drawn planters.

- * 2 Rows (tramlines) of maize are planted 75cm apart with an in-row spacing of 30cm
- * Then, in the 1.5m spacing between tramlines of maize, 2 rows of legumes are planted; with 50cm between rows and 3-5cm in row spacing.
- * Pumpkins can be spaced evenly along the tram line of maize at a reasonably low density to avoid crowding.



It is possible to use a **close spacing system** with tramlines as well. The idea is to plant the crops as close together as possible so that crop canopy forms early in the season reducing the need for weeding. Here the two rows of maize are planted with a spacing of 50cm between and 25-50cm in row spacing (depending on the desired plant population) and the two rows of beans are planted with a 25cm between row and 10cm in row spacing.



For this tramline system a mixture of basins and rows can be used, where basins are prepared for planting the maize and beans are planted in rows in between the maize basins.



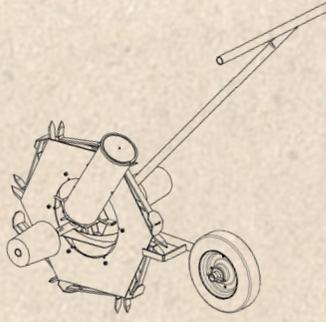
Using hand planters

No-till hand planters are designed to make small holes or openings in the soil and deliver either just the seed or seed and fertilizer into these holes. This leads to an absolute minimal disturbance of the soil and also decreases the labour needed for planting significantly.

There are a few different designs of hand planters that can be tried out and that are available. Some examples are shown below.

The Haraka hand planter

The Haraka planter shown here is a hand pushed rolling or rotating no-till punch planter that places seed of different kinds of crops including maize, beans and small seeded crops like cabbages, sorghum and cover crops 30cm apart in the row as it is being pushed. Fertilizer, if being applied, is placed on top of the soil next to the seed after planting. The Haraka planter is adapted for both sandy and clay soils. For clay soils, to assist in soil penetration to 4,5cm planting depth, weights can be added to the side of the wheel.



It is suitable for planting small to medium sized fields between 0.5 and 5 ha. The planter is currently one of the fastest type of hand planting tools and is supplied through Growing Nations and Eden Equip (www.eden-equip.co.za)

The MBLI hand planter

Afritrac (www.afritrac.co.za) supplies the Mealiebrand MBLI hand planter. This works similarly to a hoe and places both seed and fertilizer in two small holes alongside each other. Seed is placed in the hollow pipe handle of the planter and fertilizer is carried in the small pouch carried on the planter's back. Seed plates are available for a number of different seed types including maize, beans and smaller seeded grains such as sorghum. This planter is easy to use and adapted for sandy to medium high clay soils. It is most suitable for small fields up to 1ha in size.



The Matraca jab planter

The Matraca planter, a well-known jab planter imported from Brazil, supplies both seed and fertilizer alongside each other in two small holes at planting. It is pushed into the ground and then pulled open like a lever or pair of scissors to release the



seed and fertilizer. It is well adapted to sandy and clay soils, but needs reasonable arm strength to handle well. It is suitable for small fields up to 1ha in size. It is currently supplied by Inntrac Trading (www.inntrac.co.za)

Animal drawn planters

There are various types of animal drawn planters to use in CA systems. The first option is to only use a **ripper** to open furrows into which fertiliser and seed are placed manually (by hand) and covered by soil (see photo).

Right: Animal drawn ground ripper (from www.afritrac.co.za)



The second option is a complete **animal drawn no-till planter** that is designed for seed and fertilizer placement in the furrow made by a ripper tine attached to the planter. A basic and cheap version, modified from the well-known Safim planter, is offered by Afritrac (www.afritrac.co.za).



The **Napick planter**, imported from Brazil, is a more sophisticated animal drawn planter, but costs considerably more. Because of the springs and wheels on this planter, it is much easier to turn at the edges of the field.



Weeding

A combination of **agronomic** (mulching, mixed cropping, cover crops and crop rotation), **chemical** (herbicides) and **mechanical** (hand hoeing) methods of weeding can be used, depending on how serious the weed problem is and whether the chemicals and equipment can be obtained.

One of the most important benefits smallholder farmers want is for cover crops to control weeds.

- Roland Bunch

Herbicides

Advantages of chemical weed control

Herbicides allow us to control weeds and reduce the number of tillage operations as well as the critical timing needed for operations. This has allowed the widespread adoption of CA practices. Herbicides reduce the amount of human labour necessary.

Disadvantages of chemical weed control

Injury or damage to non-target species, crop injury or damage, herbicide carryover, weed resistance, container disposal problems and more recently, surface and groundwater contamination and the associated potential health risks from human exposure are risks. Another risk is poisoning from the actual application of the herbicides, if it is not done correctly.

A high degree of technical knowledge and skill is required for effective utilization of chemicals. Safety measures should always be used with chemical weed control.

Right: It is important to wear the necessary protective clothing – to wear goggles, a mouth and nose ventilator or mask, gloves, gumboots and a protective plastic suit. Sometimes people find it difficult to wear the whole kit. A minimum of goggles, gloves and boots should be worn at all times.



Using herbicides in Conservation Agriculture

Apply **non-selective herbicides** using a knapsack sprayer 2 weeks prior to soil preparation and planting. Apply the **pre-emergence herbicides** at planting.

Examples of **pre-emergence herbicides** are:

- Alachlor such as Lasso, Sanachlor, Alanex
- S-metolachlor + safener such as Dual S Gold
- Acetochlor such as Trophee CS, Relay, Guardian

NOTE: These herbicides kill weeds before they come up.

Examples of **non-selective herbicides** (which kill every growing plant) are:

- Glyphosate such as Roundup, No-plough, Mamba, Senator etc)
- Paraquate such as Gramoxone, Agroquat (VERY POISONOUS!)

NOTE: These herbicides will only work if applied to green, actively growing weeds!

Spraying herbicides

Start with a non-selective herbicide that will kill both grasses and broadleaf weeds. Glyphosate is one such herbicide and it is commonly known by the name of **Roundup** (produced by the Chemical Company Monsanto). It is generally used at a rate of 2-4l/ha, depending on the type and severity of weed infestation. This means that you will put 200-320ml of Roundup in each 16l of water to fill up a knapsack sprayer.

The speed at which you walk and the speed at which you pump the handle of the knapsack sprayer will determine how much of the herbicide you are spraying onto an area of ground. As a general rule the lever is pumped 1x every second. So if you walk at a steady pace (not fast and not slowly), spraying with the nozzle at knee height and recite the word 'one thousand' over and over again making one pump stroke per 'one thousand' – you should be doing it almost correctly.

Mostly, an application volume of 200l/ha is recommended. To see how close you are to this rate it is important to first practice and calibrate your spraying rate. This can be done by marking out an area of 10mx10m on hard dry ground. Then fill up the knapsack sprayer with 2litres of water. The operator should be able to walk and pump at a speed that means the 2l of water will cover the 10mx10m area.



Above left to right: It is important to make sure that the fittings are all working correctly during a test spray. A facilitator and new operator calibrate their walking and pumping speed and a good walking and pumping 'rhythm' is set up by experienced knapsack users. Note the distance of the nozzle from the ground.

Tips for spraying of herbicides

- * Weeds should be sprayed when in active growing stage, preferably at 4 to 10 cm in height
- * Spray in the cool part of the day
- * Do not spray when there is dew on the weeds, this dilutes the herbicide
- * Do not spray when there is a wind blowing
- * Do not spray when rain is pending
- * Use clean water to dilute the herbicide
- * Calibrate the sprayer before using to ensure the correct dose is applied.
- * Wear protective clothing and use the mouth and nose ventilator.
- * Dispose of the empty containers by washing out first and then burying.
- * It is important to know whether chemicals can be mixed together or whether they need to be sprayed separately. Some of this information will be given on the label of each chemical. Some of the chemicals react and interfere with each other, so mixing them will change how they react or stop them from reacting.
- * Only make up enough diluted mixture that will be used immediately
- * When working with undiluted chemicals it is VERY important to wear the protective clothing. All chemicals are poisonous in undiluted form and can be taken up into the human body through the skin and by inhaling. Gloves and a mask are an absolute minimum.
- * Storage of chemicals in a safe, lockable area where children do not have access is very important. Do not store the chemicals in cool drink bottles that can be mistaken and drunk from. All containers need to be clearly labelled.
- * Cleaning and maintenance of the knapsack sprayers is also important. After use, rinse with 3 full volumes of clean water – and push clean water through the nozzles as well.
- * Do not always use the same type of chemical to prevent weeds from building-up resistance
- * Use as many agronomic methods as possible (crop rotation, cover crops, mulching) to gradually replace the use of chemicals in weed control.



Above: The nozzles are at the tip of the sprayer where the liquid sprays out. The best nozzle for herbicides is known as an even or flat fan nozzle.



It is possible to control weeds effectively without herbicides IF agronomic practices are implemented well.

Do's and don'ts of spraying with herbicides

Herbicides are not a solution to lack of weed management. When your weeds are too large there is no herbicide that will deal with the problem!

Right: *Herbicides cannot take the place of good management. If weeds have been allowed to grow too large, herbicides cannot solve this problem.*



Herbicides can also kill your crops if you are not careful. Roundup will definitely kill maize and beans, as will Gramoxone. So once the crops are growing it is best to do hand weeding.



Above: *Left - An example of crops that were sprayed with herbicide after germination - where the farmer did not realise that the herbicides will also kill his crop. Middle; Necrotic spots and lesions where herbicide has drifted onto maize plants when applied in between the rows (in this case Gramoxone was used) and Right: An example of inter-row spraying of Roundup later in the season, which killed the beans that were planted there but only partially controlled the weeds that were already too mature for effective spraying.*

Herbicide spraying programmes

There are two general spray programmes that have been tried and tested in the smallholder context. Here the assumption is that the grasses such as nutsedge and couch grass will be significant problems.

Right: *A Yellow nut sedge plant.*

Roundup (Glyphosate) kills fast growing (green) broadleaf plants and grasses. If it comes into contact with your crops it will kill those as well. So it needs to be sprayed 1-10 days before the crops are planted. Do not enter and work in a field that has just been sprayed. It needs to be left for at least 24 hours. Glyphosate does not work well or at all on plants that are not actively growing or are old.



Gramoxone is a non-selective quick acting post emergence herbicide for broadleaves and grasses. Like Roundup it will kill anything it comes into contact with. It is a contact herbicide, so acts immediately and does not build up in the plants or in the environment. It is however a lot more poisonous to humans and animals than Roundup, especially in its undiluted form. It is partially inactivated on contact with the soil.

Dual Gold is mainly taken up through the shoots of germinating plants and seedlings. Weeds are therefore killed before emergence, at emergence or shortly after emergence. It is taken up mainly through shoots, rather than roots of plants.

1. Glyphosate and S-Metolachlor:

- a. Use Roundup turbo or max, 2 weeks before planting
- b. If it is still too dry and the soil is bare then –
 - i. Spray Roundup later just after planting (just after planting (assuming there has been some rain) or
 - ii. Spray Roundup just before planting and Dual Gold mixed with pesticides (Decis Forte) just after planting

OR

2. Paraquate

- a. Spray Gramoxmone 2 days to just before planting if there is longer grass and bigger weeds (Roundup is not so effective on these) and
- b. Spray Dual Gold mixed with pesticide (Decis Forte) just after planting if there are problems with grasses such as nut sedge and couch grass.

Dual Gold Must have rain within 2 weeks of spraying otherwise it becomes completely ineffective. If too much is sprayed it can kill beans or affect their germination. The same is true for Roundup. It is thus important to be very careful with herbicides if intercropping and crop rotation systems are to be used.

Roundup cannot be sprayed on bare ground or even if there is quite a lot of dust or dry loose soil in the field. This inactivates the Roundup.