AN INTRODUCTION TO
CONSERVATION
AGRICULTURE
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- GIZ ‘Conservation Agriculture - Technical Guide for Technicians & Researchers’ 2018; and the Conservation Agriculture Poster 2018
- SCP Conservation Agriculture Manual (NNF 2016), Module 1
- Zamseed Homepage (www.zamseed.co.zm)
Introduction

Background

Conservation Agriculture (CA) is defined as an approach to manage agro-ecosystems for improved and sustained productivity, increased profits and food security, while preserving and enhancing the resource base and the environment. It was founded because of the need to improve soil conservation and reduce practices associated with soil erosion and degradation in cropping systems such as shifting cultivation, while at the same time conserving resources (e.g. water, land, diversity of crops, and labour) and maintaining or enhancing crop yields.

The use of the term Conservation Agriculture started in the early 2000s, and it builds on older concepts such as no-till, reduced tillage and conservation tillage. The use of such practices started far back in the 1930s in the United States of America, following a severe soil erosion crisis in the Mid-West which became known as the ‘Great Dust Bowl’. From there, CA spread to the rest of the world, into South America, Australia, Europe, Asia and Africa. In Africa, the significant use of CA started in the 1970s in Zimbabwe, following the introduction of economic sanctions which forced farmers to use economic production techniques that minimised machinery wear and fuel use in cropping. More efforts were initiated for CA in the smallholder sector in Zimbabwe in the 1980s, from where it spread to Zambia and other countries in Africa.

Conservation Agriculture is not about one specific technology; instead, it is based on a systems approach to farming which helps to conserve, improve and render more efficient use of natural resources through integrated management of available soil, water and biological resources. As such, it is a concept of agriculture which embraces a set of practices, and not a practice or technology in itself. Conservation Agriculture cannot be implemented according to a recipe, because it depends on the specific conditions of each farm. Conservation Agriculture strategies need to create favourable and enabling environments for farmers to adopt CA by encouraging good agricultural practice, facilitating access to inputs and agricultural services to increase productivity, supporting marketing capacities to increase farm revenues, and, to a certain extent, increasing farm labour through improved nutrition. While there is no doubt that without a strong understanding of correct tillage technologies that all efforts to promote CA will end in failure, it is also true that strengthening farmers’ enabling environments is critical for achieving the long-term adoption of CA.

In addition to the general benefits of CA, there are a number of reasons why practising CA in Namibia should be encouraged:

- Namibia is one of the most vulnerable countries to climate change, which results in increasingly erratic rainfall patterns that often lead to poor crop yields. As local communities are largely dependent on subsistence farming, the use of a more robust farming system such as CA increases local communities’ resilience, making them less prone and vulnerable to crop failure.

- Poor soil quality leads to the practice of shifting cultivation. This results in the degradation of natural resources and deforestation, which in return reinforces negative impacts such as soil degradation and the loss of biodiversity and habitats. In consequence, pressure on natural resources continues to increase.

- Namibia’s northern communal areas are blessed with wildlife, including flagship species such as elephants. Wildlife is a major source of income for local communities through tourism and hunting. However, wildlife and especially elephants are on the one hand highly dependent on an intact environment (especially forest areas), but on the other hand they are also a major threat to crop farming. Mapping wildlife corridors and encouraging farmers to stay permanently in their fields and outside corridors is a major contribution to maintaining intact ecosystems and a peaceful co-existence, which helps communities to thrive.
Purpose of this manual

In current agriculture systems, called conventional agriculture, land preparation is based on mechanical tillage methods which involve tractor-drawn or animal-drawn ploughing and hand hoeing. These tillage methods are the main causes of soil degradation, resulting from high rates of water run-off after rainfall and soil erosion. This is partly caused by poor water infiltration and poor soil water retention capacities associated with surface sealing and poor soil structure because of too little organic matter. Many farmers using rain-fed cropping testify that rainfall seasons are no longer as reliable as they were in the past. Therefore, if rain-fed cropping is to be sustained, farmers need to adopt soil and water conserving technologies and practices which ensure that every drop of rain water is put to good use, thus benefitting crops and cropping systems. This way, farming systems can thrive. Among other sustainable agriculture techniques, CA seeks to contribute positively towards addressing these challenges.

Although this manual is designed for local level facilitators of CA (e.g. farming instructors), it is also suitable for local level service providers and seed agents to use as a teaching tool.

This manual aims to equip local level facilitators with a clear understanding of CA, as well as the knowledge and skills regarding CA, in order to enable them to successfully teach it. It is very important that local level facilitators fully comprehend CA so that they can teach it to farmers for the benefit of sustainable production and natural resource management.

This manual consists of two sections:
1. Theory
2. Training

The Theory section focuses on four topics:
1.1 Conservation Agriculture – Concepts and Principles
1.2 Conservation Agriculture in Practice
1.3 Integrated Pest Management (IPM)
1.4 Work Organisation
1. Theory

1.1 TOPIC ONE
CONSERVATION AGRICULTURE – CONCEPTS AND PRINCIPLE

Introduction to Conservation Agriculture

Conservation Agriculture is defined as an approach to manage agro-ecosystems for improved and sustained productivity, increased profits and food security, while preserving and enhancing the resource base and the environment.

Conservation Agriculture is based on the following three principles:

I. Minimum tillage to reduce soil disturbance
II. Permanent organic soil cover (crop residue retained on the land and incorporated as part of soil improvement)
III. Diversification of crop species (in sequences and/or associations)

The three interlinked principles of CA are applied by implementing locally adapted practices and other complementary practices, which includes integrated crop management, and soil, nutrient, water, pest, energy, labour, and farm power management. This is also often known as ‘good agronomic practices’ (GAPs).

Conservation Agriculture involves the following procedures:

- **Timely implementation**: carrying out all operations at the best time in the cropping season, i.e. preparation, seeding/planting, fertilization (with both organic and inorganic fertilizers), and controlling weeds and insect pests.
- **Precise operations**: paying attention to detail and carrying out all tasks carefully and completely.
- **Efficient use of inputs**: not wasting any resources such as labour, time, seeds, crop residue, manure, fertilizer and water.
Conservation Agriculture includes the following benefits:

- **Saves money and time**: Farmers who start early with the first heavy rain can plant a larger area.
- **Spreads labour**: Farmers who start land preparation just after harvest allow for early planting.
- **Reduces wastage**: Accurate placement of fertilizer and seeds reduces wastage.
- **Concentrates early rainfall and harvests rain water**: This water harvesting approach accelerates germination and crop growth.
- **Minimises crop loss in drought years**: This results in improved food security.
- **Reduces weed population every year**: As the interior is never ploughed, weed populations will decline over time because they are prevented from seeding.
- **Diversified cropping strategies**
- **Diversified dietary intake**

**NOTES FOR THE FACILITATOR**

**LESSONS LEARNED**

Not everyone will be immediately convinced about Conservation Agriculture; therefore, be aware that there are challenges involved in practise CA.

**Take note of the following challenging factors:**

- The system requires high management skills and the dedication to learn from the farmer.
- In areas with poor drainage, CA tends to cause water logging due to poor infiltration and hinders evaporation, especially when mulch is used.
- Farmers may be reluctant to invest in improving the status of the soils they cultivate if they do not have clear rights to the land (land tenure system).
- Retention of crop residues in the field is a serious challenge in the initial years for many farmers, as there are competing uses for crop residues (e.g. fodder and fencing).
- As the more sophisticated forms of CA require specialized planting equipment and other inputs such as herbicides, the availability of such resources can become a problem.
- The affordability and accessibility of these resources to farmers can greatly hinder their adoption of CA.
- The lack of draft power for small-scale farmers and a limited supply of suitable soil cover and rotation crop seeds hinders the process of CA.
- People’s mind-sets can be negative towards CA (e.g. farmers, extension officers and policy makers). People tend to hold on to traditional methods of ploughing (conventional tillage) instead of adopting new technologies.
Controlling the initial increase of weeds is a challenge as labour is often limited, but if farmers control weeds throughout the year as recommended, CA can help to reduce the seed bank in the soil in the long run.

- Yields are reduced year after year due to poor weed management.
- *Cynodon dactylon* (‘ngwena’ or couch grass) has been the most difficult weed to control in CA.
- Delayed weed removal is the primary cause of losses in maize yields in smallholder agriculture.
- Weeds compete with crops for nutrients, water and space, which has a negative effect on yields obtained at the end of the season.
- Maize yield losses due to poor weed management practices have been gradually increasing on smallholder farms.
- Uncontrolled weed growth reduces maize yields from between 34.5% and 96%.
- Weeding and planting compete for labour at the beginning of the rain season.
- As farmers prefer to continue planting to take advantage of the moisture, it usually results in delayed weeding and leads to low grain yields.

### Conservation Agriculture systems

**Tilling using a tractor-drawn or animal-drawn ripper**

**Method:**
Prior to planting, open a line (row) in the soil.
Use a 180 cm weeding yoke and a 3.5 m chain.
Penetrate the soil at a depth of 15-30 cm.
There should be a distance of 90 cm between each line (row).

**Benefits of ripping:**
- Ripping is quick: it takes less than one hour to rip a one-hectare field.
- It conserves water between the rows.
- It prevents the formation of hard pan. This is achieved because the plough penetrates at a depth of 15-30 cm.
- It reduces water run-off as the water tends to concentrate within the prepared rows.

![Figure 2: Animal-drawn ripping](image)
**Basin method (pot-holing)**

This method allows for the preparation of land immediately after harvesting when the soil is still reasonably soft.

**Method:**

Start early by digging the basins just after harvest in an existing field, and work slowly. Permanent holes (basins) are dug at 70 cm intervals in one row. There must be a distance of 90 cm between each row. The basins should be 35 cm long and 15 cm deep and wide. Crop residue is placed in each row to provide soil cover and soil enrichment.

When using the basin method, the following resources are required:

- A field, which can be as small as 10 m x 10 m or larger.
- A length of rope which is marked off at 70 cm intervals (bottle tops can be used as the markers).
- A 90 cm stick to mark the distance between each row.
- Coca-cola tins (to be used as manure and fertilizer cups).

![Figure 3: Basin method (pot-holing)](image)

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**Transforming to Conservation Agriculture**

As CA is not trying to reinvent agriculture, the basic agricultural practices still apply. These include the following:

I. **Timely planning and management:** Whether or not one uses CA, it is important for farmers to plan properly for their season. They need to decide which crops they will grow well before each season starts. This helps to ensure that they plan correctly for the cropping operations and the necessary resources (inputs).

II. **Use of improved varieties:** Given the climate change and variability challenges experienced, the use of improved and adapted crop varieties is an essential step towards achieving good yields. New drought tolerant varieties of maize have been developed. These new varieties cope better in drought conditions and, at the same time, they do well in nitrogen stressed environments.
III. **Weed management:** Many farmers underestimate the role of timely weed management. For cereal crops such as maize, the most critical time for weeding is in the first four weeks. If weeding is not done in this period, severe yield losses may result. The use of herbicides and other techniques can go a long way to improving weed control in such systems where labour may be limited. The yield benefits of one weeding run can sometimes be equivalent to the yield increase resulting from the application of half a bag of top dressing with nitrogenous fertilizer!

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**Steps for practising CA for the first time in Namibia**

Farmers transforming to CA for the first time in Namibia need to adopt the following steps:

1. **Select the land:**  
   Good land selection is the first important step to becoming a successful farmer. Poorly selected land = poor yield; no profit and no food in your house. Good land = high yield; profit and food in your house. Good land is the foundation for your family business.

   Avoid areas with the following features:
   - **Hilly/sloping gradients**  
     These areas are not good because they contribute to soil erosion, and seeds and fertilizers are washed away in heavy rain.
   - **Low wet areas (dambos)**  
     These areas are not good because they collect water and drown plants.
   - **Fields with stubborn grasses (‘ngwena’ or couch grass)**  
     Tough grasses are weeds which compete with crops for water and nutrients.
   - **Fields with hard pans**  
     Hard pans are hard soil layers beneath the top soil. These hard layers prevent crop roots from penetrating and reaching nutrients and water, resulting in stunted crops.
   - **Wildlife areas**  
     Areas such as corridors or wildlife congregation points where wild animals could potentially damage crops should be avoided.

2. **Decide on the size of plots on which CA will be implemented for learning purposes.**  
   Deciding on plot sizes for learning purposes is necessary for the following reasons:
   - To determine the quantity of resources (e.g. seeds and manure) required
   - To determine labour requirements
     - To begin with, it is recommended that farmers start with 0.25 hectares or less for ripping, and 25 x 25 m for the basin method (pot-holing). In order for farmers to be able to manage well, it is better to start small (less is more).

3. **Identify a source of mulch to cover the target field.** Usually grass mulch from neighbouring non-arable fields can be used when CA is implemented for the first time.

4. **Make sure the field is near a source of manure** (e.g. a cattle kraal).
5. Decide on the type of equipment for establishing the crops (e.g. manual, animal-drawn or tractor-drawn equipment). Consider contracting a service provider if you want to rip the field.

![Diagram of good and bad land selection]

**Figure 4: Examples of good and bad land selection**

**NOTE**

Before proceeding to Topic Two, all of the above steps must be completed, and the field must be ready for land preparation!
Summary and benefits of Conservation Agriculture

The following figure illustrates the process of the three Conservation Agriculture principles:

![Figure 5: Interlinking of the CA principles](image)

**Benefits of minimum soil disturbance (tillage):**

- Maintains soil structure
- Minimises soil compaction and surface sealing
- Improves water infiltration and retention
- Reduces run-off and erosion
- Reduces the amount of draft power required to establish a crop
- Promotes the decay of weed seeds
- Saves between 30% and 40% of time, labour and, in mechanized agriculture, fossil fuels (compared to conventional tillage cropping)

**Benefits of soil cover (mulching):**

- Improves infiltration and retention of soil moisture
- Builds soil structure
  (Soil micro-organisms tend to work on mulch; this aerates the soil and allows for root penetration.)
- Prevents soil erosion
  (Mulching keeps existing water trapped in the soil, and it also stops rain water from washing the soil away. It does this by breaking the fall of the water and therefore lessens the force when the water impacts the ground.)
- Suppresses weeds
  (Mulch limits the amount of weeds that emerge in the open spaces of a field by restricting the necessary sunlight for them to grow.)
- Maintains soil nutrients
  (Not only does mulch keep soil nutrients from being washed away with the rain, it also releases nutrients into the soil. This happens as the organic material slowly decomposes on top of the soil.)

- Provides biological nitrogen fixing and shade
  (Living soil cover includes grasses or legumes. Due to the ability of legumes to fix biological nitrogen, they are often preferred for the purpose of green manure crops, including, among others, Dolichos lablab, Mucuna, pigeon pea, Desmodium species, cowpeas, and beans. Agroforestry leguminous trees such as Tephrosia vogelli and Leucaena and Acacia species can also be used to provide aerial soil cover through their shade, and their pruned biomass material – leaves and branches – can be applied as mulch.)

**Benefits of crop rotation:**

- Breaks hard pan and the life cycles of pests and diseases
- Increases the use of available nutrients and water
  (Roots of many different plants can explore for nutrients and water in the diverse strata of the soil profile.)
- Increases nitrogen fixation (planting legumes with cereals)
- Increases humus formation
- Reduces the requirement of artificial (inorganic) fertilizers
- Improves dietary intake
- Improves production of resilience through diversification

![Figure 6: Field with intercropped plants](image)
Land, like any other asset, is an important resource and needs proper care and management. Soil is the medium in which plants grow. These plants include crops, pastures, fodder, trees and all other vegetation. In reality, soil has different meanings for different people. For example, farmers consider soil as a medium that provides food, fodder and income; a housewife thinks soil is dirt; and builders look at it as a raw material for construction purposes.

The three basic components that a farmer needs to understand when moving from tillage agriculture to Conservation Agriculture are as follows:

- How to improve soil fertility
- How to conserve the soil
- How to capture/conserve soil water

Land preparation

Prepare the land by using the following procedures:

I. If the land has not been cultivated before, clear and remove unwanted shrubs, bush and stumps from the field.

II. Basin method (pot-holing):
   Start early by digging the basins just after harvest in an existing field, and work slowly.

   Method:
   - Dig permanent holes at 70 cm intervals in one row.
   - There should be a distance of 90 cm between each row.
   - Basins should be 35 cm long and 15 cm deep and wide.
   - Place crop residue in the rows to provide soil cover and soil enrichment.

III. Tilling using a tractor-drawn or animal-drawn ripper:

   Using an oxen-drawn or tractor-drawn ripper, carry out dry ripping to break hard pan. This can be done just after the first rain shower, but the best is to do it before the emergence of weeds.

   Method:
   - Use a tractor-drawn or animal-drawn ripper.
   - Use a 180 cm weeding yoke and a 3.5 m chain.
   - Prior to planting, open a row in the soil.
   - Each row should be 90 cm apart.
   - Penetrate the soil at a depth of 15-30 cm.
IV. Plan a good CA cropping system (e.g. crop rotation or growing legumes as intercrops – choose your crops carefully!).

V. Mechanically control any weeds before they exceed a height of 10 cm. Farmers should continue to do this throughout the season (from planting to harvesting).

VI. Fertilization should follow the standard local recommendations (see Table 1, Nutrient application rates).

VII. After harvesting, farmers should retain crop residues as soil cover for the following season, or relay crops to improve the nutrient status of the soil and to reduce the incidence of pests and diseases.

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**Soil conservation and fertility management**

**What is fertile soil?**

Fertile soil is soil that is able to supply all the essential nutrients required by plants for normal growth, in the right amounts and proportions. At the same time, fertile soil provides water, air and volume, which create the suitable conditions required for plants to draw these nutrients.

These essential nutrients (which can be likened to food for the plant) include nitrogen, phosphorus, sulphur, magnesium, calcium and potassium.

**How to identify productive soil**

In most cases, soils used for cropping cannot supply adequate nutrients to sustain crop production. This is simply because they contain fewer nutrients than required. There is often no difference in the amount of nutrients needed by crops for conventional tillage and CA systems.

Farmers can therefore improve the yield of their crops if their soils have the following characteristics:

- Loam or clay, or sand with loam or clay
- Loose in nature (not compacted), but able to form clods (clods are indicative of good soil structure)
- Show some signs of life (some soil creatures are visible, but the majority of them are invisible to the naked eye)
How to improve the organic matter content and fertility of soils

I. Livestock manure
Livestock manure, particularly cattle and goat manure, is widely used as organic fertilizer. When applied to soil, animal manure has many benefits for crop productivity and soil health. It is also not necessary to apply manure every year, and yields are often better in the second year of application.

Manure has been shown to work well in combination with mineral fertilizers. Different sources of manure could vary in quality. It is important to keep application rates at between 5-10 tons/ha of manure. Manure is applied two weeks before planting to ensure that it is ready for the crops.

Kraal manure is a valuable resource that farmers often fail to take full advantage of.

Advantages of using manure:
- Provides essential nutrients to crops
- Adds organic matter to the soil
• Improves soil structure
• Improves the soil’s ability to hold more water and nutrients
• Assists soils to resist compaction and crusting
• Increases infiltration of rainwater (thus minimising runoff and soil erosion)

Challenges of using manure:
• Promotes weed growth (particularly if the manure is not properly cured before application)
• Harbours pests and diseases, and weed seeds
• Labour intensive (handling and application)
• Nitrogen deficiency (if manure is mixed with low quality crop residues, crops may exhibit yellowing nitrogen deficiency symptoms during the first season of application)

II. Fertilizer
Farmers may decide to use mineral fertilizer to increase the soil fertility. This, however, requires good knowledge in order to avoid groundwater contamination and crop burning. It is recommended to use a mineral fertilizer D-compound, which is applied during land preparation. Urea is then applied once the crops have reached knee height.

The following table illustrates the recommended nutrient application rates.

Table 1: Nutrient application rates

<table>
<thead>
<tr>
<th>Practice</th>
<th>Manure Rates</th>
<th>Fertilizer Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>D-compound</td>
</tr>
<tr>
<td>Basin method</td>
<td>x2 440 ml coca-cola tins per basin</td>
<td>x2 coca-cola lids per basin</td>
</tr>
<tr>
<td>Ripping method</td>
<td>x2 hands full per pace</td>
<td>Apply 1 jar vaseline (100 ml) per 20 paces</td>
</tr>
</tbody>
</table>

Planting

Critical factors regarding planting include the following:

• **Timing:** Planting depends on the season, and it is one of the most difficult decisions a farmer has to make. When planting, timing is essential. A delay in planting often means lower yields. Early planting means that the farmer stands a chance to secure a good crop and to minimise weed growth!

(Note: Planting should always be completed within a day or two to ensure uniform crop height.)
• **When to plant seeds:** Farmers should plant seeds during or immediately after heavy rain. Never plant seeds several days after the rain when the soil is already beginning to dry; the soil must be wet enough to enable the seeds to germinate.

(Note: Legumes should be planted at least two weeks after the main crops.)

• **Thinning:** It is better to plant a few extra seeds and to thin the germinated plants afterwards, than planting too few seeds and then having to plant more seeds.

• **Gap filling:** After germination of the planted seeds, there may be some visible gaps between the young plants. As soon as these gaps are visible, supplement planting of extra seeds should be done. Supplement planting should be done before the germinated plants become too big and competitive for a seed to germinate underneath them.

The following table illustrates the proper planting techniques for the ripping method.

**Table 2: Proper planting techniques – ripping method**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Planting period</th>
<th>No. of seeds</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>First good rain</td>
<td>1 seed for every 20-25 cm</td>
<td>2.5 cm</td>
</tr>
<tr>
<td>Millet</td>
<td>First good rain, depending on variety</td>
<td>A pinch for every 30 cm</td>
<td>1.5 cm</td>
</tr>
<tr>
<td>Cow pea (bean)</td>
<td>First good rain</td>
<td>1 seed for every 7 cm</td>
<td>2.5 cm</td>
</tr>
<tr>
<td>Ground nut</td>
<td>First good rain</td>
<td>1 seed for every 5 cm, or 20 cm for traditional variety</td>
<td>2.5 cm</td>
</tr>
</tbody>
</table>

The following table illustrates the proper planting techniques for the basin method.

**Table 3: Proper planting techniques – basin method**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Planting period</th>
<th>No. of seeds</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>Good rain</td>
<td>4 seeds, thinned out to 3 plants after germination</td>
<td>2.5 cm</td>
</tr>
<tr>
<td>Millet</td>
<td>Good rain</td>
<td>A pinch</td>
<td>1.5 cm</td>
</tr>
<tr>
<td>Cow pea</td>
<td>Good rain</td>
<td>7-10</td>
<td>2.5 cm</td>
</tr>
<tr>
<td>Ground nut</td>
<td>Good rain</td>
<td>10 per basin</td>
<td>2.5 cm</td>
</tr>
</tbody>
</table>

*Figure 9: Cowpea crop  Figure 10: Maize hybrid (ZMS 402)*
The following table illustrates the recommended seed varieties.

<table>
<thead>
<tr>
<th>Seed Category</th>
<th>Type</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZMS – Maize</td>
<td>402 – Hybrid</td>
<td>Fast growing. Highly productive (7 tons/ha). Very early maturity. Drought tolerant.</td>
<td>Cannot be used as seed in the next season (must be purchased).</td>
</tr>
<tr>
<td></td>
<td>521 – OPV</td>
<td>Can be re-used as seed. Drought resistant.</td>
<td>Yield is not as high as that of the hybrid seed.</td>
</tr>
<tr>
<td>Traditional</td>
<td></td>
<td>Can be re-used as seed. It is cheap.</td>
<td>Low productivity, poor germination or may not even germinate.</td>
</tr>
<tr>
<td>606</td>
<td></td>
<td>Drought tolerant. Highest in yield among the hybrids (ZMS 402, 405 and 528). High yield of 8-9 tons/ha.</td>
<td>Medium maturity variety (3-4 months). Requires more rain; in short rain seasons the crops struggle to mature.</td>
</tr>
<tr>
<td>405</td>
<td></td>
<td>Early maturity hybrid. High yield of 5-7 tons/ha.</td>
<td>Cannot be used as seed in the next season (must be purchased).</td>
</tr>
<tr>
<td>528</td>
<td></td>
<td>Early maturity hybrid. High yield of 8 tons/ha.</td>
<td>Cannot be used as seed in the next season (must be purchased).</td>
</tr>
<tr>
<td>Mahangu (Millet)</td>
<td>Traditional pearl millet</td>
<td>Cheap and available.</td>
<td>Not very popular for consumption in the Zambezi Region. Eaten by birds.</td>
</tr>
<tr>
<td></td>
<td>Dola pearl millet</td>
<td>Not eaten by birds. Strong resistance to drought. Can grow on less fertile soil.</td>
<td>Must be purchased.</td>
</tr>
<tr>
<td>Beans</td>
<td>Cowpeas, Lutembwe and Bubebe (local names)</td>
<td>Drought resistant. Can be re-used again for 2-3 seasons (OPV).</td>
<td>If nutrients are applied, the crop tends to have more foliage and less fruits.</td>
</tr>
<tr>
<td></td>
<td>Runner bean</td>
<td>Grow well with good rains. They have more foliage, which is good for soil cover.</td>
<td>The crop cannot withstand a dry spell.</td>
</tr>
</tbody>
</table>

---

**Crop rotation and intercropping**

**Crop rotation**

Crop rotation involves different crops being planted in succession in a defined sequence on the same piece of land (see Figure 10). Crop rotation has the capability of reducing pests and diseases by breaking their reproductive cycles. It also has the potential to improve nutrient cycling in cropping systems if the species involved are of different rooting depths. If a legume such as cowpea is involved in the rotation, the succeeding cereal crop may benefit from the nitrogen fixing ability of the cowpea.

**Intercropping**

Intercropping involves two or more crops being planted on the same piece of land at the same time (see Figure 11). Intercropping can be a viable option in cases where farmers cannot practice full rotations due to certain circumstances (e.g. land holding size).

In some cases, a secondary crop may be introduced at a certain growth stage of the primary (main) crop. This type of intercropping is called **relay cropping**. Compared to mono-cropping, intercropping offers advantages such as the improved
use of resources (nutrients, water, light etc.), reduction of potential total crop failure, provision of diverse nutrition, and improved mutual association between crops (e.g. between a cereal and a legume, where the cereal can benefit from the nitrogen fixation ability of the legume).

Deciding whether to practice crop rotation or intercropping depends on a number of factors.

The following table can assist with making this decision.

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Rotations</th>
<th>Intercrops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pest and disease control</td>
<td>Very effective if crops in sequence do not harbour the same diseases and pests. Full season rotations are capable of breaking pest and disease cycles, resulting in reduced incidences.</td>
<td>May provide alternative hosts for pests and diseases if not carefully planned. Companion crops should not provide alternative hosts for pests and diseases.</td>
</tr>
<tr>
<td>Competition for resources</td>
<td>Competition is minimal in rotation since each crop is given a complete season to develop.</td>
<td>There is competition for resources between involved species. Competition can be minimised by introducing a secondary crop after the first crop has had a head start (relay cropping).</td>
</tr>
<tr>
<td>Productivity of associated cereals</td>
<td>Productivity of associated cereals is very high, especially following a leguminous crop. The succeeding crop benefits from the previous crop's effects.</td>
<td>Productivity is higher than monocropping systems, but competition between the species involved is a setback.</td>
</tr>
<tr>
<td>Water and nutrient use efficiency</td>
<td>There is less water and nutrient use efficiency as there is one crop in each season.</td>
<td>Water and nutrient use efficiencies are high, as more than one crop is produced within the same piece of land, within the same season.</td>
</tr>
<tr>
<td>Labour requirement</td>
<td>Less labour is required if only one crop is planted per season. But if land size allows, both crops can be grown and rotated in the following season, thus the labour demand will be higher.</td>
<td>High labour demand as more than one crop is planted per season.</td>
</tr>
<tr>
<td>Land use efficiency (LUE)</td>
<td>There is less land use efficiency as there is one crop in each season. But if two crops are grown, then the LUE becomes higher.</td>
<td>Land use efficiency is high as more than one crop is produced within the same piece of land, within the same season.</td>
</tr>
</tbody>
</table>

Weeding

Early and continued weeding is a critical factor in CA. If weeds are not allowed to seed, their seed bank in the soil will gradually decline. Farmers who stop weeding after the crop has matured, believing the weeds can no longer cause any harm, are making a serious mistake.

It is very important that farmers do not stop weeding when the crops have matured. If weeds are left to mature, their seeds will drop and remain in the soil, resulting in more of them the following season.

The effects of weeds on crops are as follows:
- Weeds rob crops of nutrients and water, which results in lower yields.
- Weeds hide pests and diseases, which attack and harm the crops.

![Weeding by hand and some hand-operated tools which can be used](image)

Equipment used for weeding and cover crops management in CA range from hand hoes to sprayers of different sizes. The type of equipment used depends mainly on the size of the land, but also on the availability of resources and technical know-how. The equipment can be categorised as those suitable for mechanical weed control or cover crops management, and those used in chemical weed control operations.

**Mechanical weed control**

Mechanical weed control should be limited to techniques which do not involve excessive turning of the soil. Instead, a farmer should control weeds by either pulling them out by hand, or by using appropriate mechanical tools.

The mechanical methods of controlling and managing weeds and, in some instances, cover crops are shallow weeding with a hoe or a surface hand-weeder; cutting with a slasher, machete (billhook) or a sickle; and crimpling by using an animal-drawn or tractor-drawn knife roller.

a) **Hand-operated tools**

A light hand hoe with a wide blade can be used to cut weeds just below the soil surface.

A slasher, machete (billhook) or a sickle can be used to cut weeds above the ground.

A surface hand-weeder (scraper) can be used to superficially scrape weeds from the soil surface, leaving the soil surface and residue intact. This tool is operated by hand and can be easily fabricated by local artisans; it is easy to use, effective and fast.
Although weeding with hand tools takes a long time and will limit the area under cultivation, it is, however, a viable option for smallholder farmers with less than 1 hectare.

**b) Animal-drawn or tractor-drawn knife rollers (chopping rollers)**
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 knives are arranged around the cylinder at equal distances apart. The distance between the knives determines the crushing length. Staggered knives and knives set at an angle to the cylinder improve the action and reduce the impact on the draft animals. The knife roller is used to bend and crush weeds or cover crop vegetation prior to planting the commercial crop. This operation is best carried out after the weeds and cover crop vegetation have flowered, but must be done before their seeds have matured. It is important that the knife roller only bends and crushes the plant stems and does not cut the stems, so that they can dry out. This way, there is no need to apply a herbicide in order to desiccate the vegetative cover.

**Chemical weed control**
Effective weed management is very critical for successful CA implementation. An integrated weed management approach is recommended where a mixture of cultural practices and the use of herbicides are combined. However, in this project, chemical herbicides are not recommended.
Integrated pest management, also known as 'integrated pest control', is a broad-based approach that integrates practices for the economic control of pests. IPM strategies can be confined to insect pests, or they can cover a broader range of other pests such as weeds, and pathogens which cause diseases.

**Causes of insect pests and diseases**

The emergence of insect pests and diseases is normally caused by high humidity, mono-cropping and retention of diseased residues, excessive use of mineral fertilizers, susceptible plant varieties, and drought.

**Controlling measures**

Measures to control insect pests and diseases include crop rotation, intercropping, manipulation of planting dates, use of chemicals, and the removal of alternative hosts and volunteer plants.

### The aims and benefits of integrated pest management

The approach of integrated pest management is more effective and economical than non-selective pest eradication and may result in lower pesticide application rates.

**The aims of integrated pest management are to:**

- suppress pest populations below the economic injury level (EIL);
- manage and control pests (weeds, insects and plant diseases) through the safe and environmentally sound use of pesticides, as well as IPM strategies that avoid total reliance on chemical pesticides;
- determine when and what action to take based on all available information such as crop monitoring for pest and damage thresholds;
- collect data, keep sound records, and seek advice and support from experts;
- practice regular scouting (monitoring) to identify and determine the extent of emerging pest threats, as well as the presence of natural enemies of pests; and
- monitor pest populations and life cycles to enable the more judicious and targeted use of pesticides for specific pests.

**The environmental benefits of IPM:**

- Reduce or eliminate the risk of surface and ground water contamination from pesticide runoff and/or leaching
- Reduce or eliminate pesticide drift and other environmental risks that pesticides may pose to air quality, soil quality and wildlife, including natural pest predators and important pollinator species that many crops rely upon (e.g. bees)

**The practical benefits of IPM:**

- Improve profits by reducing both chemical pesticide expenses and pest damage to crops and produce
- Expand pest control options
- Help prevent the development of pesticide-resistant pests
- Protect the health of families, employees, neighbours and livestock
Control methods

**Cultural control methods**

Cultural control methods are practices that reduce pest establishment, reproduction, dispersal and survival (e.g. using ash powder on the leaves of bean plants can reduce pests such as aphids).

A cultural control method for termites is to add organic material to the soil. Termites prefer to eat dead plant material. Their attacks are thought to be related to soils with low organic matter content, and because these soils do not contain enough food to sustain termites, they resort to feeding on living plant material. Adding compost or well-rotted manure on the soil surface and growing green manures helps to increase the organic matter in the soil. This organic matter and moisture attracts the termites, thus preventing the target crop from being attacked by them.

![Figure 14: Methods for controlling weeds](image)

**Biological control method**

The biological control method involves the use of natural enemies (e.g. parasites and pathogens) to control pests and their damage. Invertebrates, vertebrates, nematodes, plant pathogens and weeds have many natural enemies.

**Physical and mechanical control methods**

Physical and mechanical control methods involve killing a pest directly or making the environment unsuitable for them. These methods include mulching, weeding, steam sterilization of the soil for disease management, and erecting barriers such as screens or shade nets to keep birds and/or insects out.

A physical control method for termites is to manually destroy the termite mound and remove the queen. As many mounds have considerable dimensions and the building material makes them very hard, this method is labour intensive. The success of this method depends on eliminating the queen, who may be hidden deep inside and not easily found.

**Chemical control method**

The chemical control method involves the use of pesticides. With IPM, pesticides are used only when needed and in combination with other approaches for more effective, long-term control. Also, pesticides are selected and applied in a way that minimises their possible harm to people and the environment. With IPM, you will learn how to use the most selective pesticides which do the job as well as being the safest for other organisms, and the surrounding soil, water and air. Use pesticides in bait stations rather than as sprays. If spray is used, rather spot-spray a few weeds instead of an entire area. And, of course, the careful application of pesticides also saves money.
Seasonal activities

Conservation Agriculture is a highly seasonal farming activity, which depends on rainfall. Farming activities therefore depend on the starting point of the rainy season, which may shift. On account of the new patterns induced through climate change, rainfall may change in time, frequency and intensity.

Preparation of an annual work calendar helps to maintain an overview of activities that need to be implemented.

The following table is an example of an annual work calendar.

Table 6: Example of an annual work calendar

<table>
<thead>
<tr>
<th>Activity</th>
<th>June</th>
<th>July</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>March</th>
<th>Apr</th>
<th>May</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awareness creation / review meetings</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recruitment of new farmers</td>
<td>✗</td>
<td>✗</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land selection; Signing of agreements</td>
<td>✗</td>
<td>✗</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Fencing/livestock management</td>
<td>✗</td>
<td>✗</td>
<td></td>
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<tr>
<td>CA-training</td>
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<td></td>
<td></td>
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<tr>
<td>Organising land preparation (ripping/pot-holing/manure collection)</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Land preparation and manure application</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Seed distribution and planting</td>
<td></td>
<td></td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Follow-up after planting / re-planting</td>
<td></td>
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<td></td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top dressing</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>✗</td>
<td>✗</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitor weeding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Organise and conduct field days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Harvesting</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✗</td>
</tr>
<tr>
<td>Processing and weighing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✗</td>
</tr>
</tbody>
</table>
The generic activities that need to be included in one year, as well as when the training topics in this guide should be delivered, are reflected in the calendar below.

Figure 15: Annual Conservation Agriculture Calendar (based on the GIZ Conservation Agriculture Poster 2018)
Working with partners

Greater focus on working with partners is a new model that has been introduced for CA in this project. This includes working with lead farmers, service providers, and seed agents.

**Lead farmers** are model farmers who have better knowledge (often gained through the experience of practising CA for a number of years) and who mentor other farmers. An ideal ratio is 1 lead farmer: 9 farmers (trainees).

**Service providers** are trained people who have embarked on a small-scale enterprise. They, for example, will use a ripper they have bought and their animals (mostly oxen) to provide ripping services to other community members at a cost. In 2018, the rate for 1 hectare to be ripped in the Mashi and Sobbe Conservancies was about N$500.00; and in the Dzoti, Wuparo and Balyerwa Conservancies, the rate for 1 hectare to be ripped was N$1000.00. These service providers operate independently from government ripping services, which encourages business mentality within communities.

**Seed agents** are community members. These community member seed agents are employed by a seed company; are local experts on seed varieties; they educate farmers about the different seed varieties and their advantages and disadvantages; and they sell seeds. They generate a commission of 10% of the total sales under their agreement with the SCP CA partner ZamSeed, but this may vary according to the main partner.

The following figure illustrates the organisational breakdown of working partners.

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**Figure 16: Organisational breakdown of working partners**
2. Training

2.1 GENERAL TRAINING TIPS

Preparation:

- Prepare in advance to ensure that all the necessary materials (e.g. the Flipchart Sheets you would like to prepare before the workshop, enough copies of the Evaluation Form (Hand-out #1), and presentation and demonstration equipment) and visual aids are available.
- Wherever possible, use visual aids to enhance your training.
- This manual provides an outline of how training should proceed. Not all of the technical details are included here; therefore, you need to add the necessary technical details as you prepare for the workshop.
- Be aware of local customs – remember to open and close the training day with a prayer and to give due recognition to any traditional leaders present.
- Provide translation services where necessary.
- Print out pictures (from the Theory section) for visualisation.

General training and presentation guidelines:

- Keep an eye on the time to avoid wasting the participants’ time – but also keep in mind the time needed for translation, and, if necessary, be prepared to slow down to ensure understanding.
- Maintain good eye contact with the participants.
- Speak clearly.
- Keep your training language simple and appropriate to your audience.
- Provide clear instructions for activities and check to see if your instructions are understood.
- Where appropriate, summarise.

Visual presentation:

- Write clearly and boldly when using flipchart paper.
- Keep your visual aids visible. Avoid standing in the way of your visual aids and blocking the participants’ view.
- Use pictures to illustrate your narrative.

Involve the participants:

- Encourage questions and participation.
- Ask questions to get participants thinking about the topic and the key issues.
- Keep the group focused on the task, but take breaks if participants are tired and begin to lose concentration.
• Pay attention to participants’ body language for any signs of fatigue.
• Be patient and courteous with all participants.
• Acknowledge all comments and feedback from participants.

Training Icon Key for the Facilitator

This icon indicates directives for you, as well as the directives you need to give the participants regarding activities they are expected to undertake.
(The directives are all in italics.)

This icon, which is situated in a text box, indicates the Flipchart Sheets which contain the training information that you need to display/compile and convey to the participants.
(NOTE: These Flipchart Sheets can be prepared before the workshop or compiled during the workshop, as is best suited.)

Figure 17: Participants in a training workshop
WHO WILL USE THIS MANUAL TO DELIVER THE TRAINING?
This manual is intended to be used by training facilitators (farm instructors) and Technical Coordinators.

WHO IS THE TRAINING INTENDED FOR?
Lead farmers and trainee farmers.

DURATION
The duration of time needed to train the content of this manual is 12 hours (depending on the number of participants and the length of the practical demonstration activity).

OBJECTIVES
Participants who receive training will gain an understanding and knowledge of the following:

- What Conservation Agriculture is all about
- The benefits of CA, mulching and crop rotation
- The CA systems: tilling with oxen or a tractor, and the basin method (pot-holing)
- The advantages and disadvantages of each CA system (hand hoeing, ox tilling, and tractor tilling)
- What to consider when selecting and preparing land
- The recommended nutrients and their application rates for each CA system
- The critical factors and techniques regarding planting
- The negative effects of weeds and proper weeding techniques
- The aims and benefits, and control methods of integrated pest management (IPM)

MATERIALS REQUIRED FOR THE WORKSHOP

- A flipchart stand; at least one roll of flipchart paper; different coloured marker pens
- Prepared Flipchart Sheets (as required)
- Paper and pens for the participants
- Enough copies of the Evaluation Form
- A ripper, trained oxen, a 1.80 m yoke, seeds, manure, a manure can, a traditional hoe, a 90 cm stick, and the length of rope marked off at 70 cm intervals
## TRAINING CONTENT

<table>
<thead>
<tr>
<th><strong>LESSON ONE</strong></th>
<th>Introduction to Conservation Agriculture</th>
<th>1 ½ hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LESSON TWO</strong></td>
<td>Types of Conservation Agriculture</td>
<td>1 hour</td>
</tr>
<tr>
<td><strong>LESSON THREE</strong></td>
<td>Steps in Conservation Agriculture</td>
<td>3 ½ hours</td>
</tr>
<tr>
<td><strong>Demonstration</strong></td>
<td>Conservation Agriculture Practical Activity in the Field</td>
<td>4-7 hours (depending on the number of participants and length of the practical activity)</td>
</tr>
<tr>
<td><strong>Training Evaluation</strong></td>
<td>Assessment of participants’ understanding</td>
<td></td>
</tr>
</tbody>
</table>

*Figure 18: Demonstration for measuring the distance between rows*
LESSON ONE
INTRODUCTION TO CONSERVATION AGRICULTURE

OBJECTIVES
- Participants will gain an understanding of what CA is all about.
- Participants will gain an understanding of the benefits of CA.
- Participants will gain an understanding of the benefits of mulching and crop rotation.

QUESTION: What is Conservation Agriculture?
- Brainstorm the definition of Conservation Agriculture with the participants.
- Write their responses on the flipchart. (If any of the participants have correct answers, highlight these.)
- Once you have completed the brainstorming activity, either display the already prepared Flipchart Sheet or write the definition of Conservation Agriculture on the flipchart.
- Explain and discuss the definition.

Conservation Agriculture is a resource-saving crop production technology. It combines various practices which aim to increase yields and conserve the environment.

Conservation Agriculture is based on the following three principles:
1. Minimum tillage to reduce soil disturbance
2. Permanent organic soil cover (crop residue retained on the land and incorporated as part of soil improvement)
3. Diversification of crop species (in sequences and/or associations)

QUESTION: What are the benefits of Conservation Agriculture?
- Brainstorm the benefits of Conservation Agriculture with the participants.
- Write their responses on the flipchart. (If any of the participants have correct answers, highlight these.)
- Once you have completed the brainstorming activity, either display the already prepared Flipchart Sheet or write the list of benefits on the flipchart.
- Explain and discuss the list of benefits.
- Make sure that each point has been clearly understood by all the participants.
Benefits of Conservation Agriculture:

1. **Saves money and time**
   Farmers who start early with the first heavy rain can plant a larger area.

2. **Spreads labour**
   Farmers who start land preparation just after harvest allow for early planting.

3. **Reduces wastage**
   Accurate placement of fertilizer and seeds reduces wastage.

4. **Concentrates early rainfall and harvests rain water**
   This water harvesting approach accelerates germination and crop growth.

5. **Minimises crop loss in drought years**
   This results in improved food security.

6. **Reduces weed population every year**
   As the interior is never ploughed, the weed population will decline over time because weeds are prevented from seeding.

7. **Diversified cropping strategies**

8. **Diversified dietary intake**

**QUESTION: What are the benefits of mulching?**

- **Brainstorm the benefits of mulching with the participants.**
- **Write their responses on the flipchart. (If any of the participants have correct answers, highlight these.)**

- **Once you have completed the brainstorming activity, either display the already prepared Flipchart Sheet or write the list of mulching benefits on the flipchart.**

- **Explain and discuss the list of mulching benefits.**

- **Make sure that each point has been clearly understood by all the participants.**

**Benefits of mulching:**

1. **Improves infiltration and retention of soil moisture**
2. **Builds soil structure**
   Soil micro-organisms tend to work on mulch. This aerates the soil and allows for root penetration.
3. **Prevents soil erosion**
   Mulching keeps existing water trapped in the soil, and it stops rain water from washing the soil away.
4. **Suppresses weeds**
Mulch limits the amount of weeds growing in the open spaces of a field by restricting the necessary sunlight for them to grow.

1. **Maintains soil nutrients**
   Mulch keeps soil nutrients from being washed away with the rain. Mulch releases nutrients into the soil (this happens as the organic material slowly decomposes on top of the soil).

2. **Provides biological nitrogen fixing and shade**
   Living manure includes grasses or legumes. Because legumes can fix biological nitrogen, they are often preferred for the purpose of green manure crops. Leguminous trees can also be used to provide aerial soil cover through their shade, and their pruned biomass material (leaves and branches) can be applied as mulch.

---

**QUESTION: What are the benefits of crop rotation?**

- **Brainstorm the benefits of crop rotation with the participants.**
- **Write their responses on the flipchart. (If any of the participants have correct answers, highlight these.)**

- **Once you have completed the brainstorming activity, either display the already prepared Flipchart Sheet or write the benefits of crop rotation on the flipchart.**

- **Explain and discuss the benefits of crop rotation.**

- **Make sure that each point has been clearly understood by all the participants.**

---

**Benefits of crop rotation:**

1. Breaks hard pan and the life cycles of pests and diseases
2. Increases the use of available nutrients and water (Roots of many different plants can explore for nutrients and water in the diverse strata of the soil profile.)
3. Increases nitrogen fixation (planting legumes with cereals)
4. Increases humus formation
5. Reduces requirement for artificial (inorganic) fertilizers
6. Improves dietary intake
7. Improves production of resilience through diversification
OBJECTIVES

- Participants will gain an understanding of the CA systems: tilling with oxen or a tractor, and the basin method (pot-holing).
- Participants will gain an understanding of the advantages and disadvantages of each CA system (hand hoeing, ox tilling, and tractor tilling).

QUESTION: Can you describe the CA systems?

- Brainstorm descriptions for Conservation Agriculture systems with the participants.
- Write their responses on the flipchart. (If any of the participants have correct answers, highlight these.)
- Once you have completed the brainstorming activity, either display the already prepared Flipchart Sheet or write the descriptions of Conservation Agriculture systems on the flipchart.
- Explain and discuss the descriptions of Conservation Agriculture systems.
- Make sure that they have been clearly understood by all the participants.

Conservation Agriculture systems:

Tilling using an ox-drawn ripper or a tractor-drawn ripper

Method:
This type of CA requires an ox or a tractor, and a standard ripper. 
Prior to planting, open a line (row) in the soil with a ripper.
Penetrate the soil at a depth of 15-30 cm.
There should be a distance of 90 cm between each line (row).
Use a 180 cm weeding yoke and a 3.5 m chain.

Basin method (pot-holing)

Method:
Permanent holes (basins) are dug at 70 cm intervals in one row.
There must be a distance of 90 cm between each row.
The basins should be 35 cm long and 15 cm deep and wide.
Crop residue is placed in each row to provide soil cover and soil enrichment.
QUESTION: What are the advantages and disadvantages of each Conservation Agriculture system?

Either display the already prepared Flipchart Sheet or write the advantages and disadvantages of each Conservation Agriculture system on the flipchart.

Discuss the advantages and disadvantages of each Conservation Agriculture system.

During the discussion, ask the participants whether they have any questions.

Flipchart Sheet 6

The advantages and disadvantages of each CA system:

1. Hand hoeing
   Advantages:
   - The hand hoe is easy to handle.
   - This is an option for everyone.
   Disadvantages:
   - Hand hoeing has high labour requirements.
   - Very small fields are prepared with limited impact.

2. Tractor tilling
   Advantages:
   - A field can be prepared very quickly.
   - A large amount of land can be tilled.
   - It reduces run-off as water concentrates within the prepared lines (rows).
   Disadvantages:
   - As there are very few tractors available, feasibility is limited.
   - It is expensive; not everyone can afford it.

3. Ox tilling
   Advantages:
   - A field can be prepared very quickly.
   - A fair amount of land can be tilled, although less than when using a tractor.
   - There are more people who have oxen than people who have tractors.
   - It is less expensive than the cost of using a tractor.
   - It reduces run-off as water concentrates within the prepared lines (rows).
   Disadvantages:
   - Although there are more oxen than tractors, not everyone has oxen.
   - Although it costs less than a tractor, there is a still a cost involved.
OBJECTIVES

- Participants will gain an understanding of how to properly select and prepare land.
- Participants will gain an understanding of nutrients and their application rates for each CA system.
- Participants will gain an understanding of the critical factors and techniques regarding planting.
- Participants will gain an understanding of the negative effects of weeds and the proper weeding techniques for CA.
- Participants will gain an understanding of the aims and benefits, and control methods of integrated pest management (IPM).

QUESTION: When selecting land, which areas must be avoided?

- Brainstorm the areas that must be avoided when selecting land with the participants.
- Write their responses on the flipchart. (If any of the participants have correct answers, highlight these.)
- Once you have completed the brainstorming activity, either display the already prepared Flipchart Sheet or list the areas which must be avoided when selecting land on the flipchart.
- Explain and discuss the areas that must be avoided when selecting land. Make sure that the criteria have been clearly understood by all the participants.
- Ask the participants whether they have any questions regarding land selection.

Good land selection is the first important step to becoming a successful farmer.

Poorly selected land = poor yield; no profit and no food in your house.
Good land = high yield; profit and food in your house.
Good land is the foundation for your family business.

When selecting land, the following areas need to be avoided:

1. **Hilly/sloping gradients**
   These areas are not good because they contribute to soil erosion, and seeds and fertilizers are washed away in heavy rain.

2. **Low wet areas** (dambos)
   These areas are not good because they collect water and drown the plants.

3. **Fields with stubborn grasses** (‘ngwena’ or couch grass)
   Tough grasses are weeds which compete with crops for water and nutrients.
1. **Fields with hard pans**
   Hard pans are hard soil layers beneath the top soil. These hard layers prevent crop roots from penetrating and reaching nutrients and water, resulting in stunted crops.

2. **Wildlife areas**
   Areas such as corridors or wildlife congregation points where wild animals could potentially damage crops should be avoided.

**TAKE NOTE:**
- If the land has not been cultivated before, clear and remove unwanted shrubs, bush and stumps from the field.
- Make sure the field is near a source of manure (e.g. a cattle kraal).

**QUESTION: What are the basic first steps of land preparation for each CA system?**

- Brainstorm the basic first steps of land preparation for each CA system with the participants.
- Write their responses on the flipchart. (If any of the participants have correct answers, highlight these.)
- Once you have completed the brainstorming activity, either display the already prepared Flipchart Sheet or list the basic first steps of land preparation on the flipchart.
- Explain and discuss the basic steps of land preparation. Make sure that the criteria have been clearly understood by all the participants.
- Ask the participants whether they have any questions regarding land preparation.

**Flipchart Sheet 8**

**The basic first steps for preparing land:**

1. Measure the field to determine the quantity of resources (e.g. seeds and manure) required, and to determine labour requirements.

2. For hand hoeing (basin method/pot-holing): start early by digging the basins just after harvest in an existing field and work slowly.

3. For using an oxen-drawn or tractor-drawn ripper: carry out dry ripping to break hard pan. This can be done just after the first rain shower, but the best is to do it before the emergence of weeds.
QUESTION: What are the recommended nutrients and their application rates for each CA system?

- Either display the already prepared Flipchart Sheet or write the recommended nutrients and their application rates on the flipchart.
- Discuss the recommended nutrients and their application rates.
- During the discussion, ask the participants whether they have any questions.

Flipchart Sheet 9

The recommended nutrients:

1. **Mineral Fertilizer D-compound**
   - This is applied during land preparation.
   - (Application requires good knowledge in order to avoid groundwater contamination and crop burning.)
2. **Urea**
   - This is applied when crops have reached knee height.
3. **Manure**
   - This is applied two weeks before planting.
   - (Kraal manure is a valuable resource that farmers often fail to take full advantage of.)

Nutrient application rates for each CA system:

<table>
<thead>
<tr>
<th>Practice</th>
<th>Manure Rates</th>
<th>Fertilizer Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>D-compound</td>
</tr>
<tr>
<td>Basin method</td>
<td>x2 440 ml coca-cola tins per basin</td>
<td>x2 coca-cola lids per basin</td>
</tr>
<tr>
<td>Ripping method</td>
<td>x2 hands full per pace</td>
<td>Apply 1 jar vaseline (100 ml) per 20 paces</td>
</tr>
</tbody>
</table>

QUESTION: What are the critical factors and techniques regarding planting?

- Either display the already prepared Flipchart Sheet or write the critical factors and techniques regarding planting on the flipchart.
- Discuss the critical factors and techniques regarding planting.
- During the discussion, ask the participants whether they have any questions.
Planting depends on the season, and it is one of the most difficult decisions a farmer has to make.

**Critical factors regarding planting:**

1. **Timing**: When planting, timing is essential. A delay in planting often means lower yields; early planting means there is a chance to secure a good crop and to minimise weed growth!

2. **When to plant seeds**: Farmers should plant seeds during or immediately after heavy rain. Never plant seeds several days after the rain when the soil is already beginning to dry; the soil must be wet enough to enable the seeds to germinate.

3. **Thinning**: It is better to plant a few extra seeds and to thin the germinated plants afterwards, than planting too few seeds and then having to plant more seeds.

4. **Gap filling**: After germination of the planted seeds, there may be some visible gaps between the young plants. As soon as these gaps are visible, supplement planting of extra seeds should be done. Supplement planting should be done before the germinated plants become too big and competitive for a seed to germinate underneath them.

**NOTE:**

1. Planting should always be completed within a day or two to ensure uniform crop height.

2. Legumes should be planted at least two weeks after the main crops.

**Planting techniques – ripping:**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Planting period</th>
<th>No. of seeds</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>First good rain</td>
<td>1 seed for every 20-25 cm</td>
<td>2.5 cm</td>
</tr>
<tr>
<td>Millet</td>
<td>First good rain/later, depending on variety</td>
<td>A pinch for every 30 cm</td>
<td>1.5 cm</td>
</tr>
<tr>
<td>Cow pea (bean)</td>
<td>First good rain</td>
<td>1 seed for every 7 cm</td>
<td>2.5 cm</td>
</tr>
<tr>
<td>Ground nut</td>
<td>First good rain</td>
<td>1 seed for every 5 cm, or 20 cm for traditional variety</td>
<td>2.5 cm</td>
</tr>
</tbody>
</table>

**Planting techniques – basin method:**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Planting period</th>
<th>No. of seeds</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>Good rain</td>
<td>4 seeds, thinned out to 3 plants after germination</td>
<td>2.5 cm</td>
</tr>
<tr>
<td>Millet</td>
<td>Good rain</td>
<td>A pinch</td>
<td>1.5 cm</td>
</tr>
<tr>
<td>Cow pea</td>
<td>Good rain</td>
<td>7-10</td>
<td>2.5 cm</td>
</tr>
<tr>
<td>Ground nut</td>
<td>Good rain</td>
<td>10 per basin</td>
<td>2.5 cm</td>
</tr>
</tbody>
</table>
 QUESTION: What are the negative effects of weeds? What are the proper weeding techniques for Conservation Agriculture?

’ve Either display the already prepared Flipchart Sheet or write the negative effects of weeds and the proper weeding techniques for Conservation Agriculture on the flipchart.

‘ Discuss the negative effects of weeds and the proper weeding techniques for Conservation Agriculture.

‘ During the discussion, ask the participants whether they have any questions.

Flipchart Sheet 11

The effects of weeds on crops:

1. Weeds rob crops of nutrients and water, which results in lower yields.
2. Weeds hide pests and diseases, which attack and harm the crops.

Proper weeding techniques:

1. Weeding must be carried out early and must be practised continuously.
2. Weeds must be removed before their seeds mature, to ensure a decline in the seed bank and reduced regrowth the following season.
3. Mechanical weed control techniques should not excessively turn the soil.
4. Pull weeds out by hand, or use appropriate mechanical tools.
5. Appropriate mechanical tools:
   - Hand hoe
   - Slasher, machete or sickle
   - Surface hand-weeder (scraper)
   - Animal-drawn or tractor-drawn knife roller

 QUESTION: What are the aims and benefits of integrated pest management (IPM)?

’ve Either display the already prepared Flipchart Sheet or write the aims and benefits of integrated pest management on the flipchart.

‘ Discuss the aims and benefits of integrated pest management.

‘ During the discussion, ask the participants whether they have any questions.
The aims of IPM:

1. Suppress pest populations
2. Manage and control pests (weeds, insects and plant diseases) through the safe and environmentally sound use of pesticides
3. Avoid total reliance on chemical pesticides
4. Determine when and what action to take
5. Collect data, keep records, and seek advice and support from experts
6. Monitor pest threats, and the presence of natural enemies of pests
7. Monitor pest populations and life cycles to enable targeted use of pesticides for specific pests

The environmental benefits of IPM:

1. Reduce or eliminate the risk of surface and ground water pesticide contamination
2. Reduce or eliminate pesticide drift and environmental risks that pesticides may pose to air quality, soil quality, wildlife, natural pest predators, and important pollinator species (e.g. bees)

The practical benefits of IPM:

1. Improve profits by reducing chemical pesticide expenses, and pest damage to crops and produce
2. Expand pest control options
3. Help prevent the development of pesticide-resistant pests
4. Protect the health of families, employees, neighbours and livestock

**QUESTION:** What are the integrated pest management control methods for managing pests?

- Either display the already prepared Flipchart Sheet or write the integrated pest management control methods for managing pests on the flipchart.
- Discuss the control methods for managing pests.
- During the discussion, ask the participants whether they have any questions.
The IPM control methods for managing pests:

► Cultural control methods:
  ① Practices that reduce pest establishment, reproduction, dispersal and survival (e.g. using ash powder on the leaves of bean plants can reduce pests such as aphids)

► Biological control method:
  ① The use of natural enemies (e.g. parasites and pathogens) to control pests and their damage

► Physical and mechanical control methods:
  ① Practices that kill pests directly or make the environment unsuitable for them

(These methods include mulching, weeding, crop rotation, intercropping, steam sterilization of the soil, erecting screens or shade nets to keep birds and insects out)

► The chemical control method:
  ① The use of pesticides

- With IPM, pesticides are used only when needed and in combination with other approaches.
- With IPM, pesticides are selected and applied in a way that minimises harm to people and the environment (organisms, soil, water, air).

Figure 19: Woman gardener tending her backyard garden
While it is important that participants understand the theory of CA, it is also essential for them to learn through practical experience. By being practically involved, this activity gives the participants the chance to experience and become familiar with the processes of CA.

**NOTE FOR THE FACILITATOR**

- Advise the participants during their practical participation.
- Encourage the participants to ask questions.

1. **Demonstrate** the **ripping method** and/or the **basin method** to the participants.
   - Then, ask the participants to **practise** the tilling method/s.

2. **Demonstrate** correct **manure** and/or **inorganic fertilizer application** to the participants.
   - Then, ask the participants to **practise** manure and/or inorganic fertilizer application.

3. **Demonstrate** **planting** techniques to the participants.
   - Then, ask the participants to **practise** planting their respective basins or ripped lines (rows).

4. **Demonstrate** correct **mulching** to the participants.
   - Then, ask the participants to **practise** mulching their respective basins or lines (rows).

**2.7 TRAINING EVALUATION**

To evaluate the effectiveness of the training provided, ask the following questions and discuss their answers:

1. What did you like most about this training workshop?
2. What aspects of the training could be improved?

To further evaluate the effectiveness of the training provided, supply the participants with the **Evaluation Form** for them to complete (Hand-out #1).
An Introduction to Conservation Agriculture

EVALUATION FORM

Venue: ___________________________  Date: ___________________________

Facilitator/s: __________________________________________________________

<table>
<thead>
<tr>
<th>Evaluation</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The facilitator was knowledgeable about the workshop content.</td>
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<td>2. The workshop content was well presented by the facilitator.</td>
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<td>3. The workshop content was relevant.</td>
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<td>4. The workshop content was easy to understand.</td>
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<tr>
<td>5. I gained new information.</td>
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<td>6. I learnt new skills.</td>
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<td>7. The allocated time for the workshop was sufficient.</td>
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<td>8. The workshop met my expectations.</td>
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<tr>
<td>9. Workshop logistics:</td>
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</tr>
<tr>
<td>a) Notice for the workshop was given on time.</td>
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<tr>
<td>b) The venue was appropriate.</td>
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<td>c) Transport was well organised.</td>
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<td>d) Meals and accommodation were satisfactory.</td>
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</table>
ADDITIONAL QUESTIONS

1. Which aspect (or aspects) of the workshop did you find the most valuable, and why?
_________________________________________________________________________
_________________________________________________________________________
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2. Do you have any other comments/suggestions that could help with improving future workshops?
_________________________________________________________________________
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_________________________________________________________________________
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3. Do you need any follow-up training, or training in other areas? If so, please list them.
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
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