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FiBL

African Organic Agriculture Training Manual

A Resource Manual for Trainers

MECHANISATION IN SMALLHOLDER ORGANIC PRODUCTION

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Responsible authors:
Elsa Kanner (FiBL), Timothy Harrigan (USA), Saidi Mkomwa (Kenya), Irene Kadzere (FiBL), Gilles Weidmann (FiBL), Brian Ssebunya (Uganda), Joseph Phakati (Zambia), Robert Burdick (USA)

Illustrator: Deogratius Okudi (Uganda)

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The manual is intended for use by trainers during the training of farmers on diversification of agricultural production and other farm-related activities.

Comments and recommendations for improvement to this version are welcome.

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MECHANISATION IN SMALLHOLDER ORGANIC PRODUCTION

SET OF TRANSPARENCIES

How to use this Manual

This manual is for use by trainers of trainers, trainers of farmers, and farmers to explain the principles, challenges and opportunities for smallholder organic farmers to apply mechanisation to reduce drudgery in organic farming, focussing on crop production. Farmers live in various contexts that will require unique adaptations of the guidelines discussed in this training manual. Thus, the training manual invites participants, through didactic suggestions, to discuss this broad topic of smallholder mechanisation in organic farming in Africa as it relates to their own specific contexts. The training manual also helps foster conversations between farmers and the organic networks, extension workers, and other support systems that will help each farmer to develop and refine mechanisation options that work best in their own unique situation. The case studies used in the training manual are meant to be examples only, and not meant to be taken as best practices. They help the trainer to portray or visualise some of the operations in a more applied way. During the training sessions, the trainers can add their own experiences or case study examples which are more contextual for the training situation. Trainers may benefit from other training materials on certain topics found in the “African Organic Agriculture Training Manual” at organic-africa.net.

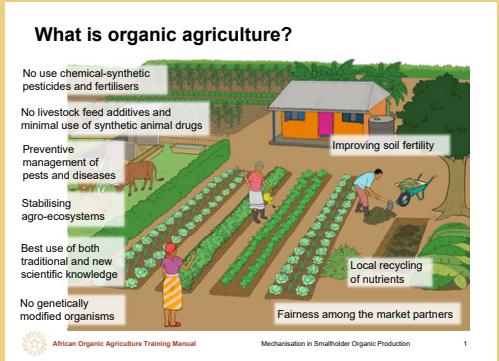
Key learning targets

The key learning targets for trainers of trainers and or trainers of farmers:

- Develop a more in-depth understanding of the principles and practices of organic farming as they relate to labour requirements during farm field operations.
- Appreciate some mechanisation options which suit different field practices in organic farming.
- Understand the key factors that can influence the choice of farm implements/ machines for various field operations.

- Recognise that there are tools which are suitable for field operations on small farms, and implements that are appropriate for larger-scale farms.
- Appreciate the crucial nexus between crop and livestock in mixed cropping systems as relates to draught power supply.
- Understand that farmers can have access to farm machinery through different models, i.e. direct ownership, shared or group ownership, or accessing services provided by local entrepreneurs.

DEFINITION OF ORGANIC AGRICULTURE



1. Introduction

1.1. Smallholder farming in Africa

Most of the food produced in Africa, particularly in sub-Saharan Africa, is from smallholder family farms. African smallholder farmers face many challenges which constrain their yields and productivity resulting in low incomes and food insecurity. One of the main bottlenecks in smallholder farming is that 60 to 80 percent of African land cultivation is still performed with hand-held tools, relying almost entirely on human muscle power. This results in a high level of drudgery, particularly for women who perform most of the farming work. It is also a disincentive to farm and an incentive for men and youth to migrate from rural areas to cities for other employment opportunities. The reliance on human power with the use of hand tools contributes to reduced farm output and food and nutrition insecurity.

1.2. What is organic agriculture?

Organic agriculture is a set of practices that seek to sustain agricultural yields while conserving nature and protecting the health of the farmers and consumers. It is a way of producing good quality farm products in harmony with nature. Organic farmers use a combination of traditional and scientific knowledge to reduce soil erosion, ensure nutrient recycling through addition of organic matter, diversify production to manage pests and diseases, and only use naturally derived inputs when required. Organic farmers optimise the growing conditions of crops by enhancing the natural fertility of the soil to ensure good nutrient and

Discussion on labour related bottlenecks

Discuss with the farmers/ participants what the main labour related bottlenecks are that they face in farming. Discuss each challenge for the main production systems prevailing in the area. Find out from the participants how they have tried to resolve such bottlenecks and which levels of success they have achieved..

water supply, creating diverse cropping systems and promoting natural enemies of pests, recycling organic materials and manures and using natural inputs while renouncing chemical pesticides and fertilisers. Along with sustainable yields and health benefits, fewer negative environmental impacts, more biodiversity, and an environment free of potentially dangerous chemicals are among other benefits of organic farming. More details on the principles and practices of organic agriculture can be found on the IFOAM Organics International website at ifoam.bio.

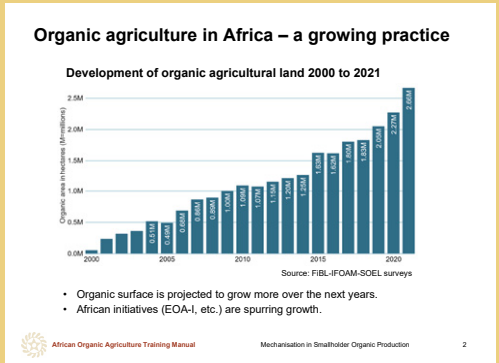
Despite the many benefits of organic farming, there are several drawbacks which often limit or constrain smallholder farmers from practicing organic farming optimally. Some of these bottlenecks include:

- **Weed management challenges**: Under conventional farming, some farmers can use technologies such as herbicides to keep the weeds on their farms under control. These chemicals are not permitted under organic management. Alongside the weed intensity challenges are labour bottlenecks to achieve timely and effective weed control. Farmers can suffer yield losses due to high weed competition. Besides, plantation crops such as coffee, cacao, bananas, citrus and others are often planted in large monocrops and can demand much labour for weeding and other operations.
- **High pest and disease infestations**: High pest and disease pressure calls for appropriate techniques to manage these pests and diseases to prevent economic yield losses in a situation where synthetic chemicals are prohibited.

1.3 Organic agriculture in the context of Africa

Often referred to as ecological organic agriculture (EOA) on the African continent (in reference to the large numbers of farmers who practice agroecology), organic practices are one of the many methods being considered to improve food and nutrition security as well as incomes for smallholder farming households on the continent. Many African countries are taking steps to include organic agriculture in the conversations and debates about food, nutrition and farming at the governmental level. In 2011, a high-level decision was taken through the African Union (AU) Heads of State and Government to recognise EOA as important in sustainable farming and poverty reduction. An EOA Initiative (EOA-I) was launched to mainstream EOA practices in national policies, plans and strategies by 2025. Though still a relatively small movement on the continent as a whole, organic ag-

ORGANIC AREA IN AFRICA



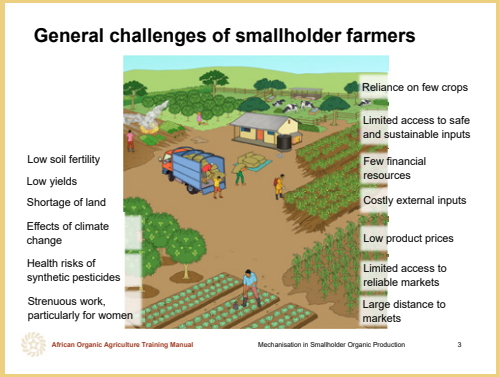
Sharing of knowledge on organic farming practices and experiences

Invite the particants to share their knowledge on organic farming by asking the following questions:

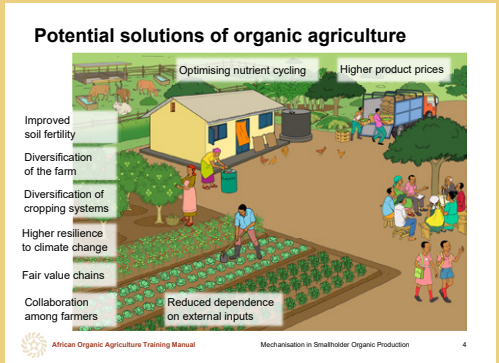
- What is your understanding of organic farming – have they ever heard about it?
- Are there any farmers who are practicing organic farming in the area?

If so, discuss the main crops grown under organic management and the key practices which the organic farmers carry out compared to conventional. In the process, take note of any farm implements or tools mentioned by the participants in relation to organic production. Also take note of the key challenges mentioned or implied by the farmers in relation to organic practice which might have a bearing on mechanisation.

CHALLENGES OF SMALLHOLDER FARMERS



POTENTIAL SOLUTIONS OF ORGANIC AGRICULTURE



riculture in many African countries is a growing practice projected to grow and expand over the coming years.

Some research has shown that, in Africa, with healthy soils, locally-adapted best practices, and appropriate use of technology, smallholder organic farmers can be as successful as conventional farmers in terms of yields, and will be able to maintain those yields in the long term.

2. Why mechanisation for smallholder organic farmers in Africa?

Whether organic or conventional, smallholder farmers in Africa face many challenges related to labour, productivity and other aspects. Mechanisation is seen as one of the strategies to help address some of the constraints facing smallholder farming. Suitable mechanisation can contribute significantly to yields and overall farm output and efficiency. Additionally, it can save a lot of time for women, youth and men alike and enable them to invest the time in other productive and income-generating activities thereby contributing to broader development objectives. Proper mechanisation can also allow farmers to innovate and diversify their production and income streams for greater resilience to socio-economic and climatic shocks.

Additionally, mechanisation options are only one part of the farming equation. A farmer with few mechanisation advantages can have a more productive farm than a neighbour with more advanced tools simply because of a better understanding of soils, cropping systems, and an openness to learning. Successful farmers are curious and seek information from friends, neighbours, extension services, and research organisations to learn and improve their practices.

Smallholder farmers growing annual crops and/or plantation crops (such as cocoa) must take many factors into account when beginning to practice, or when considering conversion to organic agriculture. One major consideration for new or aspiring organic farmers is labour, particularly if they have been using techniques such as herbicides for weed control, e. g. farming on larger pieces of land where hand weeding is not feasible with limited labour. In cases such as this, appropriate mechanisation options are vital to making their organic farming operations profitable and sustainable.

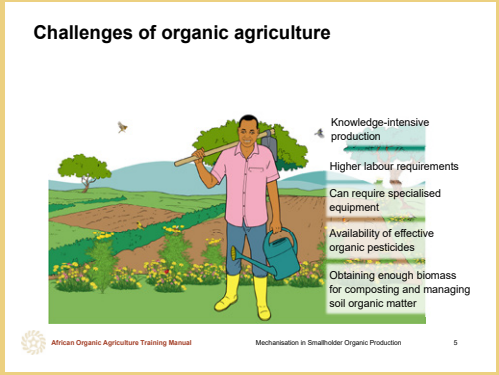
However, targeted information on mechanisation options for small-scale organic farmers in Africa is not widely available, thus, the concept for this Train-

Discussion on the development of organic farming in the area

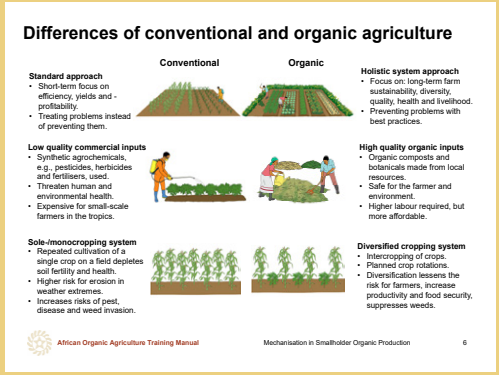
Discuss with the participants how organic farming has developed in the area in the past years by asking the following questions:

- Have you observed an increasing interest in organic farming practices?
- Is there an increasing demand from consumers for pesticide-free organic products?
- Do you know of any organic programmes being promoted in the area?
- Who are the main agents promoting these initiatives?
- Is there any component of mechanisation involved?

CHALLENGES OF ORGANIC AGRICULTURE



DIFFERENCES BETWEEN ORGANIC AND CONVENTIONAL AGRICULTURE



ing Manual was born. The Training Manual is not meant to be a compendium of agricultural equipment, rather to promote conversations between trainers of smallholder organic farmers and those interested in conversion to organic agriculture. It presents some of the benefits and key challenges of organic agriculture and how mechanisation can help smallholder farmers achieve their goals.

This Training Manual addresses smallholder farmers who are producing at different levels, using hand and draught animal mechanisation, although a discussion of some motorised (e. g. tractors) implements is also included. The Training Manual focuses on organic-friendly mechanisation options for compost making, land preparation, planting, fertilising, and soil cover. A limited discussion on mechanised primary processing, i. e. threshing, shelling and dehulling, is also included as these postharvest operations can be a burden to women, particularly for small grains like millet and sorghum. Mechanisation options for harvest, transport, and seed saving/treatment are available in other sources and hence are excluded from the current training manual.

While organic and conventional agriculture overlap in many ways, some practices are unique to organic agriculture, particularly in mechanisation. These differences will also be the focus of this Training Manual.

3. An overview of mechanisation in organic crop production

Some of the basic field level operations in organic agriculture which have a significant bearing on labour and would benefit from mechanisation are outlined in this section and discussed in more detail and with examples in subsequent sections. These include:

1. Making compost, especially for larger-scale production
2. Practicing minimum tillage to maintain healthy soils
3. Fertilising – applying organic materials (compost, well-rotted manure, etc.)
4. Managing green manures and soil cover crops
5. Planting into covered soil or minimally tilled soil with proper equipment
6. Timely and effective weed management
7. Primary processing of small grain cereals including maize

COMPOST PRODUCTION

3.1 Preparing good quality compost and applying it to the field

Organic farmers prepare compost for fertilising their crops while enhancing the organic matter content of their soil and its overall fertility and health. Composting is a controlled process that requires care to ensure that plant and animal biomass decompose well to produce a suitable product that plants and soils can benefit from. The five steps involved in making a good compost can be labour intensive, especially if farmers intend to apply the compost on large fields or farms. These steps, described in more detail in later sections, can be mechanised to some extent.

i. Collecting materials from non-contaminated sources
ii. Mixing and watering the materials or biomass
iii. Piling the mixed materials
iv. Regular monitoring of the composting process
v. Turning the compost piles, or heaps

Applying organic materials for fertilisation

Organic farmers fertilise their soil with well-rotted farmyard manures and compost rather than commercial synthetic fertilisers. Successful organic producers understand that feeding their soils before and after every planting is the key to sustainable production. The objective of fertilising in organic farming is to feed the plants and soils together unlike some synthetic fertilisers which aim to provide nutrients to the crop only. Farmers can benefit from equipment that helps with the process of making these natural fertilisers, e. g. for composting as discussed already in previous sections, and in applying the organic fertilisers to the fields.

3.2 Practicing minimum tillage, and considering tillage equipment to maintain healthy soils

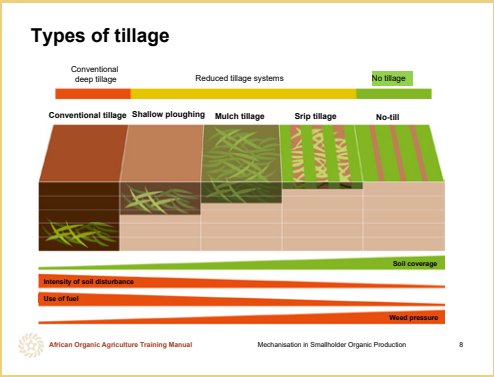
Mechanisation can promote and maintain soil health by reducing soil disturbance and tillage in both seedbed preparation and weeding operations. Organic farmers transitioning from conventional to organic agriculture may start by using a plough if it is the equipment they currently have. Still, over time, they are

Discussion on compost production

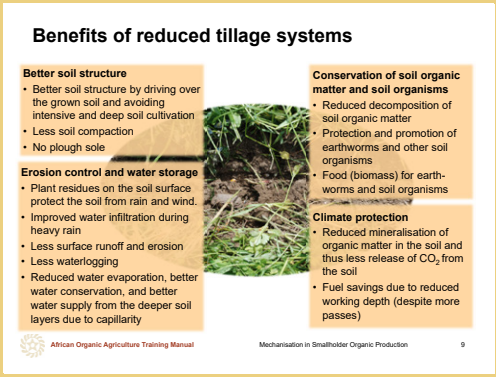
Discuss with the participants the challenges related to compost production by asking the following questions:

› Do you make compost on your farm, or do you know farmers who make compost? Do you or they face any challenges related to compost production?
› If no farmers are making their own compost, what are the main reasons for this? Are any of the reasons related to the lack of appropriate equipment?
› Do you/they use any kind of mechanisation for compost production? If so, what kind of mechanisation is used?

TYPES OF TILLAGE



ADVANTAGES OF REDUCED TILLAGE



encouraged to transition to minimum/conservation or no-till practices such as skim ploughing, direct seeding, and minimum tillage weeding equipment which reduce damage to the soil and help to preserve organic matter.

Healthy soils are key for healthy crops. Frequent intensive tillage with a mouldboard plough can degrade soil quality and health over time. Ploughing loosens the soil and buries crop residues. The loosened soil allows air to enter into the soil rapidly and this results in an acceleration of the breakdown and loss of humus from the soil. The close mixing of crop residues, moisture, oxygen (in air), and microorganisms during ploughing speeds the decay of new organic matter and its loss from soils. On the other hand, low disturbance or minimum tillage leaves crop residues in the top few inches of soil where it improves infiltration of rainfall or irrigation water, reduces evaporation of water from the soil, reduces soil crusting and erosion by water or wind, and releases crop nutrients into the root zone.

Types of tillage

a) **Deep/conventional tillage:** Use of a plough or other implement that works at a soil depth of up to 25 cm and inverts the soil completely.
b) **Minimum/conservation tillage:** Tillage using a variety of implements that work at a relatively shallow depth (generally less than 10 cm) and do not lead to complete inversion of soil.
c) **No tillage:** A method of farming where soil is not routinely tilled and crops are seeded directly using hand-held, animal-drawn or motorised implements. The planting holes or furrows are prepared by cutting through crimped green manures or dead plant residue on the soil surface.

The type of equipment used can also have a significant effect on soil health. As well as promoting minimum tillage, organic agriculture also focuses on reducing practices that can lead to soil compaction. Soil compaction can be caused by many processes, including farm operations. For example, heavy farm equipment can cause soils to compact if repeatedly used on fields without a remedial strategy to the compaction. Other common causes of compaction besides heavy equipment include heavy rainfall, e.g. on bare soil or freshly ploughed fields, some irrigation methods, and other factors. The use of heavy equipment such as

Exploring applied methods for land preparation

Explore with the participants and find out what land preparation approaches are applied by farmers in the area. Discuss the types of tools and equipment and other resources which the farmers use for land preparation. Are there any bottlenecks which have a bearing on mechanisation? If farmers apply reduced tillage for soil preparation – which methods and tools do they use? Have they observed any advantages compared to deep tillage?

GREEN MANURING AND SOIL COVER

PLANTING

tractors is a major contributor to soil compaction. Therefore, if tractors are used, minimum/conservation tillage or no-tillage options can help to avoid soil compaction by limiting the number of passes by the tractor over the field. However, the weight of more complicated machinery such as the direct seeders used in no-till agriculture must be balanced with the benefits of the no-till method.

As far as possible, organic farmers are encouraged to use reduced tillage as described in more detail in later sections of the training manual.

3.3 Managing green manures and soil covers

Green manuring is one of the key strategies towards soil fertility management in organic farming. Green manure plants such as velvet beans (Mucuna species) Dolichos beans, Sunnhemp, Cowpea and others are grown and, before flowering, are ploughed under to mix them with the soil in order to improve the physical structure and fertility of the soil while providing nutrients to the subsequent crop. Further, organic farmers aim to keep soils covered as much as possible during and between growing seasons. The farmers understand that keeping their soil covered preserves moisture, prevents erosion from rain and wind, and promotes healthy soils. Between growing seasons, they may use cover crops, green manures, and intercropping and/or mulching during the growing season. To manage the green manures and cover crops in organic farming where reduced soil disturbance is observed, the farmers can use equipment which cuts and turns these plants or crops into a mulch layer that protects their soil, adds nutrients back to the soil, and suppresses weeds.

3.4 Planting into covered soil or minimally tilled soil

When farmers reduce tillage intensity, planting equipment requirements will also change to a large extent, in particular for the animal draught-powered and motorised systems. The farmers will need to use implements which enable them to plant in fields prepared with minimum or no tillage equipment. Also, when cover crops or mulches are left on the fields, the farmers should use equipment that can help them easily and accurately penetrate and plant through these soil covers and plant mulches. Tools and implements such as a hoe with a long blade,

Discussion on planting practices

Discuss with the participants about their planting practices.

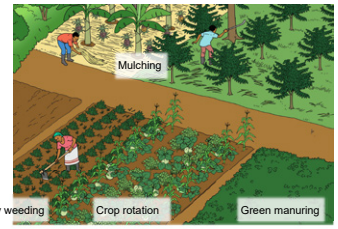
- What types of tools or machinery are commonly used?
- Are there local sources for these tools/ equipment?
- Have any of the participants or farmers practised or seen other implements for planting other than a hoe and mouldboard plough?

Discussion on green manuring

Discuss with the participants if there are any green manures grown by any farmers in the areas from where the participants come from. Have any farmers attempted to use green manures before? Discuss how they manage the green manures.

WEED MANAGEMENT

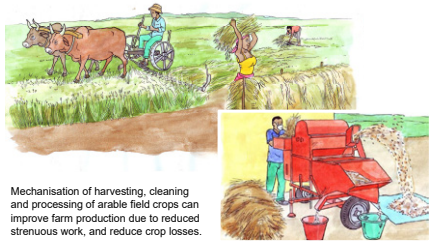
Managing weeds timely and effectively



Despite the application of preventive measures to control the weeds, organic farmers depend on effective weeding tools for best results while minimising time and effort.

HARVESTING AND PROCESSING

Primary processing/cleaning of selected arable field grain crops



Mechanisation of harvesting, cleaning and processing of arable field crops can improve farm production due to reduced strenuous work, and reduce crop losses.

a jab planter, or no-till planters (motorised and animal powered) are essential to the farmer for successful planting and seedling emergence.

3.5 Managing weeds timely and effectively

Weed control is one of the main challenges faced by organic farmers. Organic farmers understand that weed control requires more effective planning and earlier, more targeted weeding practices with the right equipment to achieve good results. They use hand-held tools and mechanical cultivation as well as preventive measures such as crop rotation and mulching to control the weeds. Mechanical cultivation can involve different weeding tools dependent on the type of crop and the stage of crop growth. Therefore, the farmers prioritise equipment that can help maximise results while minimising time and effort.

3.6 Harvesting and primary processing/cleaning of selected arable field grain crops

Harvesting, cleaning and processing arable field crops is tedious for many smallholder farmers. In particular, the harvesting of small grains such as millets and sorghum, and their subsequent primary processing, i.e. threshing, shelling and dehulling, can consume time and energy from smallholder farmers. Sometimes farmers spend considerable amounts of money to hire labour in order to harvest crops timely before they become spoiled from weather elements, or by pests and diseases. Mechanising these operations can improve their production and utilisation due to reduced strenuous work.

4. Key factors for consideration in smallholder mechanisation in Africa

The appropriateness of a farm machine, implement or tool for field operations depends on many factors. Farmers should consider their local conditions and needs when they select appropriate machinery and equipment for their farms. These and other factors influence, to a large extent, the types of tools/equipment

Discussion on techniques for weed control

Discuss the techniques applied by farmers to manage or control weeds in the area. Take note of the main tools/implements used.

Discussion on techniques for primary processing of grains

Explore the topic of mechanisation in primary processing of grains in the area. List all the practices and associated tools/implements or machinery used. Discuss how the farmers access these tools/implements/machinery.

which organic farmers can use to assist in their field operations. Nevertheless, the principles of soil health, reduced tillage, soil cover, and timely weed control are applicable to all smallholder farmers regardless of the context, and farmers require suitable tools or machines to support the application of these principles.

Some of the key factors to consider in smallholder farm mechanisation include:

- **Type of farm enterprises and their components, e.g. horticultural and arable field crops and types**: Planting maize and sesame definitely require different planting machines due to their seed size differences. Some crops are more appropriate for certain machines while others are not. For example, delicate and highly perishable products such as lettuce and grapes for the fresh market are better handled by hand. Threshers and shellers are suitable for small and large grains.
- **Size of farm operations**: Very small fields do not require the use of tractors for land preparation and planting, as the size will make it difficult for the tractors to turn, for example.
- **Agro-climatic characteristics of the area and soil types**: The use of heavy machines in very wet conditions can worsen the soil compaction risks.
- **Cultural values, traditions and taboos**
- **Availability of tools and equipment at the local level, the terrain, and access to infrastructure in and outside the farm, e.g. for transporting the tools/equipment**: In many areas, motorised equipment of machinery are not available due to low demand, poor road infrastructure and other factors. It is important for farmers to select equipment for which they can easily find backup services and parts.
- **Cost (for purchasing or hiring) and access to financing**: The added advantage of purchasing or hiring a machine or equipment should be considered as this can lead to debt or economic losses for the farmers.
- **Ability, technical capacity and skills levels of farmers to operate them**: Many machines or equipment require specialised handling and operation for proper functioning.
- **Types of energy or power needed (hand-operated, diesel, electrical, solar, etc.)**: Some motorised tools, equipment, pumps or machines require electricity or fuel to operate. If these are not available in the area, then it will not be suitable for the farmers to buy them unless alternatives such as solar energy is compatible.

Discussion on ownership of tools

For the tools/equipment mentioned, discuss the following issues:

- Which ones are owned by individual farmers?
- Are there any group ownership models to the tools/implements/machinery?
- Are there any entrepreneurs providing mechanised services for land preparation, weed control, pest and disease control, harvesting, primary processing, e.g. shelling, threshing, dehulling?

Discuss the advantages and disadvantages of individual ownership, group ownership and the service provider approaches.
Take note of these and revisit them at a later time during the training when discussing about the economics of mechanisation

› Availability of repair services such as spare parts, and/or experts to service the machine: Good backup services for repair and maintenance are important.

The variability in conditions and contexts afore mentioned illustrates why this training manual is to be used as a guide only to discuss case-specific appropriate-scale mechanisation options in a collaborative exchange between farmers, extension agents, and other organic farming resources, and not as a mechanisation 'recipe'.

5. Selected farm tillage operations and their pros and cons

As already outlined in an earlier section, tillage is one of the main field operations on a farm and demands significant amounts of labour and time, regardless of the farm size. Organic farmers strive to take care of their soils and the surrounding environment in order to reduce the negative impacts of farming on the ecosystem. In this section, the learners will discuss the key pros and cons of the major approaches to farm tillage, namely: deep/conventional tillage, minimum/conservation tillage, and no tillage. The learners will learn about the relationship between these tillage types and mechanisation in later sections.

5.1 Deep/conventional tillage

Inversion tillage with a mouldboard plough (either animal-powered or motorised, e.g. by a tractor) is often the basis of deep/conventional tillage. In this method, soils are disturbed up to 25 cm, and weeds and crop residue from the previous crop are incorporated into the soil to encourage their decomposition and create a 'clean table' at the soil surface. Because of the ridges and furrows left by this type of tillage, a secondary tillage operation is often used to create a level seedbed. An example is ploughing followed by disking or harrowing.

Pros:
- Aerates the soil providing favourable conditions for crop growth and water retention.
- Good weed control because weeds are buried by soil inversion. In the process, some pests and diseases can be controlled, too.
- Equipment widely used and understood, and often favoured in cultural traditions.

Cons:
- Degrades and compacts soil when used consistently over time leading to decreased yields.
- Most soils managed with conventional tillage have lost at least half of the original organic matter from the topsoil due to wind and water erosion.
- Excessive power requirement from either draught animals or a tractor.

5.2 Minimum tillage

Minimum tillage involves less inversion, is performed at a shallower depth (generally less than 10 cm), and aims for fewer tillage passes overall. If combined with good management of plant residues, the wide range of minimum tillage systems can retain at least 30 % residue cover on the soil surface throughout the year, thus offering protection.

Pros:
- Minimises soil disturbance, thus retaining soil structures, topsoil, and organic matter.
- Requires less power from either hand tools, draught animals, or a tractor.
- Can increase timeliness of operations when less work is required.

Cons:
- Does not aerate the soil as much as deep/conventional tillage – requires healthy, well aerated soil as a baseline.
- Controls weeds less than deep/conventional tillage – requires more intensive and timelier weed management.
- Some equipment is not commonly used and therefore not widely available, and may not be well accepted by local cultural traditions and would need community sensitisation.

5.3 No-tillage

No-tillage refers to a system where cover crops or crop residues are left on the field as mulch, and planting is done directly through the mulch or into a planting hole/basin or ripped furrow/line.

The process of no-till agriculture

1. Slash or knock down the vegetation or the plant residues from the previous crop in the field and leave it as a mulch.
2. Dig planting holes or basins with a hand hoe, or open narrow planting furrows, while retaining the mulch or residues on the soil.
3. Plant either directly into the planting basins with a daba or jab planter.
4. Fertilise with compost or well-rotted livestock manure or other types of farmyard manures.
5. Retain mulch to suppress weeds and hand weed as necessary.
6. Harvest the crops.
7. When practical, seed a cover crop into the mulch, or leave the field fallow covered by mulch between crops.

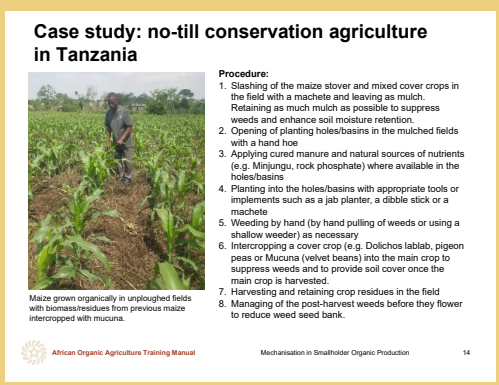
Pros:

- Allows for the least soil disturbance of all tillage methods, thus retaining the good soil structure, topsoil (protected from wind and water erosion), and organic matter.
- Generally requires the lowest power or energy from either hand tools, draught animals, or a tractor.
- Can also increase timeliness of operations when less work is required than for deep or minimum tillage operations.

Cons:

- Does not aerate the soil as much as deep tillage, but similar to minimum tillage. Requires a healthy, well aerated soil as a baseline.
- Controls weeds less than deep and minimum tillage – requires a well-designed weed management system adapted specifically to no-till.
- Similar to minimum tillage, some equipment is not commonly used and therefore not widely available, and may not be well accepted by local cultural traditions hence the need for sensitisation.

CASE STUDY ON NO-TILLAGE



Case study: no-till conservation agriculture in Tanzania

Maize grown organically in unploughed fields with biomass/residues from previous maize intercropped with mucuna.

Procedure:

1. Slashing of the maize stover and mixed cover crops in the field with a machete and leaving as mulch. Retaining as much mulch as possible to suppress weeds and enhance soil moisture retention.
2. Opening of planting holes/basins in the mulched fields with a hand hoe
3. Applying cured manure and natural sources of nutrients (e.g. Minjungu, rock phosphate) where available in the holes/basins
4. Planting into the holes/basins with appropriate tools or implements such as a jab planter, a dibble stick or a machete
5. Weeding by hand (by hand pulling of weeds or using a shallow weeder) as necessary
6. Intercropping a cover crop (e.g. Dolichos lablab, pigeon peas or Mucuna (velvet beans) into the main crop to suppress weeds and to provide soil cover once the main crop is harvested.
7. Harvesting and retaining crop residues in the field
8. Managing of the post-harvest weeds before they flower to reduce weed seed bank.

Case study: Organic farmers using no-till conservation agriculture in Tanzania

Despite the many cases where smallholder farmers turn to the use of herbicides to control weeds when they practice conservation agriculture (CA), many smallholders use non-chemical methods of weed control such as no-till agriculture. This is compatible with organic farming and this combination can help farmers to reap more benefits, both economically and environmentally. In this case study, organic farmers in the Chato and Geita districts of Tanzania have been using the principles of no-till agriculture to suit their context.

The Africa Inland Church in collaboration with World Renew are supporting thousands of smallholders in Chato and Geita districts of Tanzania to practice conservation agriculture-based organic farming, which in this case can also be described as organic, no-till agriculture. CA is a term for a system of agricultural practices that shares many similarities with organic agriculture in terms of minimal tillage, care for the soil, crop rotations, and soil cover. The divergence between CA and organic is primarily in the use of herbicides in a limited capacity by CA farmers to help with weed control. However, there are organic practitioners of CA as well as shown in this case study.

The following are key stages in the implementation of no-till organic agriculture and an indication of the tools the farmers use:

1. Slashing maize stover and mixed cover crops in the field with a machete, and leaving the biomass as mulch. As much mulch is retained as possible to suppress weeds and enhance soil moisture retention.
2. Using a hand hoe to open planting holes/basins in the mulched fields.
3. Applying cured manure and natural sources of nutrients, e.g. Minjungu rock phosphate, where available in the holes/basins.
4. Using appropriate tools or implements such as a jab planter, a dibble stick or a machete to plant into the holes/basins.
5. Weeding by hand-pulling the weeds or by using a shallow weeder.
7. Intercropping a cover crop, e.g. Dolichos lablab, Pigeon peas or Mucuna (velvet beans) into the main crop to suppress weeds and to provide soil cover once the main crop is harvested.
8. Harvesting, and retaining crop residues in the field.
9. Managing post-harvest weeds before flowering to reduce weed seed bank.

Discussion on reduced tillage

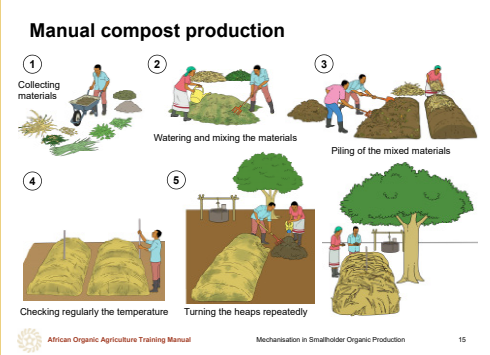
Discuss first in small groups and then in the large group the following questions:

- Do you currently practice conventional tillage? What are the perceived benefits? What equipment do you use, and at what depth?
- What are your thoughts after having heard about reduced tillage? Do you know farmers who practise reduced tillage? What are their experiences with it?
- Can you imagine using a different tillage method? What might be the challenges? What might be the benefits?

Note

The narrative of an organic CA farmer from Arumeru is available at: https://www.youtube.com/watch?v=loorM79a6oo

MANUAL COMPOST PRODUCTION



MECHANISED COMPOST PRODUCTION

6. Mechanisation options for different field operations on smallholder farms

Mechanisation options will be discussed in these sections for the following farm operations:

- Compost making
- Conventional versus reduced tillage
- Land preparation
- Planting
- Soil cover and weed management
- Harvesting and primary processing of selected arable land crops

6.1 Compost making and associated tools and implements

Making compost for gardens and smaller fields – manual methods

To make compost for use in backyard gardens and relatively small areas, farmers can produce compost mostly with hand held tools or instruments as illustrated.

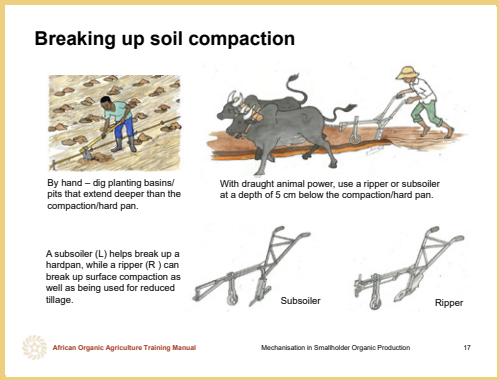
The main tools required for compost making include:

- A sickle, machete or cutlass to cut the biomass
- A rake and/or garden fork to use in heaping the raw materials
- A wheelbarrow or other carrying containers to carry manure
- A watering can or bucket
- A shovel (and fork) for turning the decomposing materials
- A thermometer for measuring the temperature of the compost heap, or a simple stick as illustrated

Mechanised compost making for gardens and smaller fields

Mechanised compost making has many applications in smallholder farming. It can be done by farmer groups, a single farmer who has a large field, a single entrepreneur farmer who produces compost for sale in addition to meeting his or her own needs, or a group of youths who can take compost making as a business. In this case, the amount of raw materials to be handled are too large for manual techniques except if labour is not a constraint. The raw materials are placed in rows and tractor-drawn machines used to handle the operations, particularly

BREAKING COMPACTED SOIL



heaping the raw materials and turning the heaps during decomposition. This makes compost preparation a more efficient and less tedious process, but can be costly especially considering the cost of specialised machinery, the operator of the machinery, fuel for the tractor, the tractor itself and other considerations. Farmers are encouraged to assess and evaluate the benefits of such investments before incurring the costs.

6.2 Mechanised land preparation in compacted soils with hardpans

If soil compaction or a hardpan is present, remediation will be part of the land preparation process. Cover cropping and leaving a field fallow are long-term options to combat these problems, and are useful for revitalising degraded or compacted soils. For example, deep-rooted cover crops can do the hard work of soil revitalisation and aeration. However, cover cropping will not be discussed further in this training manual and trainers are encouraged to refer to other sources for details.

In the short term, farmers can use suitable mechanisation to deal with soils that are compacted and/or have a hard pan present. Mechanised options and strategies are available for hand-, draught-animal and machine powered systems.

Combating compacted soils/hard pans using hand tools

Digging planting basins is effective for combating natural soil compaction or a hardpan caused by repeated ploughing/hoeing. Using a hand hoe, a pick/mattock, or shovel, dig planting basins that extend at least 5 cm deeper than the hard pan to allow plant roots to penetrate lower soil layers. This is discussed in more detail in further sections.

Breaking soil hardpans by draught animal power-driven implements

Hardpans often develop after years of mouldboard ploughing at the same depth. A hardpan inhibits water infiltration and root penetration. If a hardpan is present, a subsoiler may be useful to break it up before planting. A subsoiler is similar to a ripper, but is designed particularly for breaking up a hardpan, rather than with the added loosening and aeration functions of a ripper. A subsoiler should

KNOCKING DOWN VEGETATION BY HAND

Slashing vegetation manually

Knocking down cover crops or vegetation in a fallow field with a machete.

Slashing weeds with a Billhook (Nyengo).

ANIMAL-DRAWN KNIFE ROLLER

Animal-drawn knife roller

Animal-drawn knife roller in working position. In this type, the metal blades are welded to a metal ring fitted on a solid wooden trunk, with wheels attached for easy transport to the field.

(Photo: Saidi Mkomwa)

Animal drawn knife roller in transport position with staggered and increased numbers of knives.

(Photo: Saidi Mkomwa)

be set to run about 5 cm below the hardpan. It should be noted that using a sub-soiler requires high pulling energy from draught animals, and the deeper it is set the more labour-intensive it will be. Therefore, if a hardpan is suspected, a few holes should be dug with a shovel to verify its existence and the required depth of tillage.

A ripper can break through compacted soil closer to the soil surface. This tool is discussed in more detail further sections.

6.3 Land preparation in healthy soils without compaction

Once compacted soils and/or hard pans have been dealt with, the farmers must choose their preferred method of land preparation. The chosen method depends on the availability of labour, draught animals or a tractor, field size, and many other factors. The following sections describe no-till and minimum tillage land preparation options for farmers with either hand tools or draught animals.

a) No-till land preparation – knocking down existing vegetation

Farmers interested in no-till land preparation should be equipped with the knowledge and skills on how to deal with plant residues, cover crops or vegetation, e.g. on fallow fields. The first step is to knock down any remaining vegetation or cover crops that are present in the field and leave it as mulch on the soil surface. If many trees are present and it is justified to cut some of them in order to open up land for crop production, then suitable implements such as a motorised chainsaw can be used, depending on the size of the trees to be cut. Farmers can ask their neighbours, or extension agents where they can source such an implement which can help them to clear the trees efficiently compared to using a hand axe. Specialised or trained operators should use a chainsaw as it can be dangerous to unexperienced users.

Slashing vegetation by hand

Slashing annual and succulent perennial vegetation by hand can be done with simple tools like a machete or a billhook and is the primary option for most smallholder farmers. Depending on the type and amount of vegetation, this can be labour-intensive. The farmers should only perform this task when preparing a fallow field or knocking down a cover crop.

TRACTOR-DRAWN KNIFE ROLLER IN GHANA

Case study: tractor-drawn knife roller

Using a tractor-drawn knife roller in the humid tropics of Ghana

- The good rainfall allows vigorous growth of indigenous weeds. These are rolled down and crushed with the use of a tractor drawn roller crimper.
- The full soil cover with biomass allows for effective suppression of weeds without the need for any additional measures.
- Tractor-drawn roller crimpers are expensive and generally unsuitable for small plots of land.

A tractor-drawn roller crimper used by the Centre for No Till Agriculture at Amanche in Ghana (Photo: Kofi Boa)

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MANUAL FIELD PREPARATION

Digging planting pits

1. Dig small holes along the rope.

2. Fill some compost or rotten manure into every hole and cover it with topsoil.

3. Place the seeds into the refilled holes.

4. Cover the planting lines with dry mulch.

Hand hoe dug planting basins in a mulched field (Photo: Saidi Mkwoma)

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Slashing vegetation with draught animal or tractor power

If draught animal or tractor power is available, several options are available to flatten crops to create a mulch cover on the field.

a) Many locally-made tools have been developed to flatten cover crops (e.g. dragging a log or tyres over the cover crop), but these often do not work well. If they are too light to crimp the plant stem, they will not kill the cover crop and will not be very effective.

b) A knife roller is recommended if a farmer is willing to invest in a crimping implement. A knife roller is a heavy implement with raised wedges that neatly and thoroughly break the stems of the vegetation or cover crop. It is more effective than a beam or tyre in killing a cover crop and laying it down flat as mulch. This equipment can be manufactured by a local blacksmith, given a set of plans. Efficient plant crimping with a knife roller requires the weeds to be crushed but not detached from their stems. The operation should be continuous and comfortable on the necks of the oxen or donkeys where the yokes/harnesses come into contact. Helpful modifications include increasing the number knives from six to eight or ten, and using serrated half-length blades instead of full-length blades as illustrated.

Farmers can look at options of hiring this equipment as it may be too expensive to own, and besides it might not be used throughout the year. When farmers are working in groups, they can also decide to buy the knife roller as a group and develop good rules on how to share and take care of the implement.

b) No-till land preparation – opening holes or lines for planting

After mulch has been laid down on the field, the next option is to consider planting. If the soil underneath the mulch is healthy and well-aerated, a farmer may plant directly into the mulch.

However, if farmers need to plant seeds by hand because animal-drawn or tractorised direct planting tools are not available, or if the soil is not very healthy or well-aerated, they may consider additional planting area preparation to ensure good results.

MANUAL RIPPING FOR FIELD PREPARATOIN

Field preparation by ripping by hand

A hand ripper minimises soil disturbance, time, and effort by confining preparation to planting lines.

A locally-produced hand ripper from Laikipia, Kenya (Photo: Saidi Mkomwa)

ANIMAL-DRAWN RIPPING FOR FIELD PREPARATION

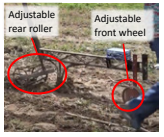
Field preparation by ripping with draught animal power

- Ripper shank designed to be mounted on the standard for a mouldboard plough as commonly used in parts of Kenya and Rwanda

(Photo: Robert Burdick)

- Ripping plough locally manufactured in Burkina Faso without a front wheel and/or a roller on the back.
- Due to the missing stabilisation, a wider shank is used.
- This type makes use by both human and draught animals more difficult, but is relatively simple and cheap to produce.

(Photo: Robert Burdick)



- Ripping plough from Burkina Faso with an adjustable front wheel and a rear roller to control the ripping depth, and to improve stabilisation.
- The narrow shank reduces the pull for the draught animals, however, it is more complicated and expensive to produce.

(Photo: Timothy Harrigan)

Additional preparation of no-till fields by hand

Depending on the soil, labour availability, and crops to be grown, there are several additional no-till options for farmers with hand tools, including digging planting pits or hand ripping.

Digging planting pits reduces soil disturbance by only digging the pits themselves but overcomes issues of compaction and hard pans by loosening the soil around where the seeds will be planted. Planting pits can be dug into mulched or bare soil. Before or during planting, the farmer can add fertiliser (good quality compost and/or other additives such as rock phosphate) to each pit. The advantages of planting pits are that they can be dug slowly before the planting season when the farmers have time. They aid in water collection and retention, and can help to localise limited resources such as compost to the area where the crops will grow (compared to broadcast applications). These planting holes can be renewed and reused yearly. The disadvantage is the labour-intensive process of digging the pits, particularly in the first year. When crop rotations, e. g. with legumes, are involved, the farmers need to ensure that the planting spacing is ideal every season for the crop in question. Notably, legumes such as groundnuts are spaced more closely than maize hence the farmers need to adjust the spacing to suit the legume crop in such a way as not to lose yields due to wide spacing.

An alternative way to reduce tillage is to 'rip' lines into the field where the fertilisation and planting will occur using a hand ripping tool, and again overcomes issues of compaction or hard pans by loosening the soil where the seeds will be planted. The soil disturbance is minimal, as it is confined to the planting rows. The ripping tool can be used at a minimal depth, typically 10 to 15 cm.

Field preparation by ripping with draught animal power

If draught animal power is available, ripping along planting lines can be done with an animal-drawn ripper (aka chisel plough).

Like ripping by hand, ripping with draught animals opens up a row of soil 15 to 20 cm wide and 10 to 15 cm deep. Depending on soil conditions, ripping can be at different depths. For example, in healthy, well-aerated soils, a ripper can run shallow at depths of 8 to 12 cm for planting. In very dry areas or consolidated soil, a ripper may be used at a depth of 12 to 20 cm before rains to capture moisture in the soil. Ripping at 15 to 20 cm in dry soil will require considerable draught power, so farmers must take care not to over-burden draught animals.

RIPPER USE IN DRY SOIL

Case study: using a ripper in dry, compacted soil

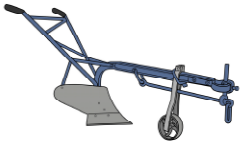
Preparing lines for planting in two passes with a ripper in Koumbia, Burkina Faso:
1. Shallow initial pass (left)
2. Deeper second pass (right) to achieve planting depth

Two passes are recommended in dry, compacted soil, especially if there is a hard pan. This procedure also reduces strain on the animals.

(Photos: Robert Burdick)

MOULDBOARD PLOUGH

Mouldboard plough



- A mouldboard plough can be used as a starting point to reduced tillage, but should be replaced by more appropriate minimum or no-tillage implements.
- The mouldboard plough turns the top layer of soil over to cover weeds or cover crops, and incorporate manure, compost, or other amendments.
- The conventional working depth of 12 to 15 cm should be reduced to 6 to 8 cm.
- At reduced working depth, weed control and seedbed preparation are still ensured.

A ripper has several advantages, particularly if the same planting lines are used year after year. With the addition of organic inputs, manure, and compost, ripping will become easier each year, and soil fertility will improve in the planting lines. Rippers can run through standing cover crops, mulches, or plant residues to reduce weed control and soil moisture loss challenges. However, rippers can be a challenge in some types of mulch as long-stem plant residue can become tangled and clog it. This is another factor that comes into play when choosing a cover crop. Farmers can discuss these types of technical details with neighbours, extension agents, and equipment manufacturers in order to make informed choices.

Rippers are available as conversions from mouldboard ploughs, as part of a multi-function toolbar, and as stand-alone tools. Even though a ripper looks small compared to a mouldboard plough, it is important to consider the pulling power needed, especially when working in hard or dry soils. Ideally, the width of the ripper point should be less than 4 cm, with some form of wing behind the point to lift and fracture the trench. The wider the ripper soil working parts, the greater the draft. If more than 8 cm in total, the ripper will be very difficult to pull. If ripping at greater depths, an 8 cm ripper may be as hard to pull as a mouldboard plough.

Case study: Using a ripper prior to the rainy season in very dry, compacted soils in the tropical savannah zone of Burkina Faso

Farmers in the tropical savannah zone of Burkina Faso face many challenges in preparing their fields for planting before the rainy season begins. The area receives 800 to 900 mm of rain annually, primarily in the rainy season from June to September. Soils are low in active clay and organic matter, and over-cultivation and over-grazing have further degraded the soils. Coming into the field preparation season, the soil is very often almost bare, as grazing animals have eaten any stubble left from the previous season. The intense heat of the dry season and the animals' hooves have left the soil hard, dry, and compacted. Furthermore, draught animals are often in poor condition after the long dry season, as there is a shortage of food as available grasses and crop residues are completely grazed. Farmers in this region do not usually store hay or other food for the draught animals.

While farmers in this region commonly use ploughs, efforts are made to introduce reduced tillage equipment such as rippers. The ripper, although it is easier to pull than a plough, is still often too difficult for the thin animals to pull through the hard soil. Therefore, the farmers make two passes with the ripper, each at approximately 10 centimetres, to reach the desired depth of 20 centimetres for planting.

Measurements done on the 'average draught force', or the force required to pull the ripper by the oxen, showed that the force to pull the ripper was approximately one half of that required to pull the traditional 20-cm mouldboard plough. This greatly reduced the burden on the oxen. Also, even with the two passes required with the ripper, the field was prepared in half the time usually spent for full width tillage with the plough.

The ripper loosened a band of soil about 20 cm wide, leaving the inter-row area undisturbed. This so-called 'strip tillage' builds soil health by conserving soil moisture, reduces tillage intensity, and can retain a protective crop residue cover on the soil surface (if already present).

The farmers were happy with the results, but despite this, the uptake of such technology, despite its clear benefits, is still not widespread.

c) Land preparation with shallow tillage

If farmers are not yet ready for a no-till system, they may choose to prepare their fields using tillage methods which reduce the depth of soils disturbed.

Shallow tillage by hand

Farmers can employ minimum tillage techniques by using the tools they already have, but at a lesser depth. For example, farmers can use a hand hoe to disturb only the top layer of soil to prepare a field. This conserves the organic matter and humus present in lower soil layers and reduces exposure of soil microorganisms to the scorching sun.

Shallow tillage with draught animal power

When draught animals are available, several shallow tillage options are possible for field preparation.

SKIM PLOUGH

Skim ploughing

- Skim ploughs disturb, but do not invert the top layer of soil at a depth of 5 to 8 cm
- Options for skim ploughing: a moulboard plough with removed mouldboard, a cultivator running at a minimal depth, or traditional ploughs such as the ard plough
- Loosens the soil for planting and uproots weeds.

Farmer ploughing in Ethiopia with a traditional ard plough, which acts at a reduced depth compared to a mouldboard plough and does not invert the soil.

(Photo: Pixabay)

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SEEDBED PREPARATION

Tractor powered seedbed preparation

Single-axle tractors

Rotary hoe for use on heavy soils mainly

Note: Rotary hoes work the soil intensively. This degrades soil structure. Therefore, their use should be strictly limited.

Tractor powered

Spring tine cultivator with a cage roller / packer for use on light soils

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A mouldboard plough used at reduced depth can be considered a step towards minimum tillage. Although it is not a minimum tillage tool, it is included here as a bridge tool, because converting to minimum or low-till systems may be a process in which the farmer starts to experiment with familiar tools he or she already owns or has access too. However, reduced depth mouldboard ploughing should be replaced with a less aggressive reduced tillage implement as the farmer progresses and gains experience and access to more appropriate minimum tillage equipment.

A mouldboard plough is commonly the first implement a farmer will purchase when beginning with animal power. It turns the top layer of soil over to cover weeds or cover crops and incorporate manure, compost, or other amendments. Farmers interested in reduced tillage can use the plough at a reduced depth of 6 to 8 centimetres, rather than at the conventional depth of 15 to 20 centimetres. This approach has several advantages: the shallow depth will still achieve weed control and seedbed preparation, while significantly reducing the pulling forces on the draught animals. This means that the work will be easier for the animals, allowing them to accomplish more work in a day, or smaller animals, such as donkeys, could be used in regions where draught cattle are unavailable or are not affordable.

d) Skim ploughing

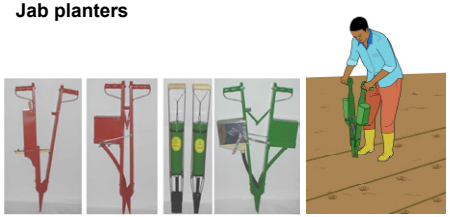
Skim ploughing is disturbing, without inverting, the top layer of soil at a depth of 5 to 8 centimetres with various implements rather than the traditional 15 to 20 centimetres with a mouldboard plough as described above. Various implements that loosen soil but do not invert it include a moulboard plough with the mouldboard removed, a weeding tool such as a cultivator running at a minimal depth, or traditional ploughs that are used in some regions such as the ard plough.

The process of skim ploughing is most effective on fields with little standing vegetation, and serves to both loosen the soil for planting as well as uprooting weeds. Skim ploughing alone may be sufficient for direct planting in coarse-textured sandy soils. For heavier soils, it may be necessary to combine skim ploughing for weed control with ripped planting lines for optimal planting conditions.

The advantages include saving time, reduced pulling force for the animals, and less soil disruption. A variety of implements can be used for skim ploughing, making it a flexible option for farmers lacking access to a diverse array of equip-

JAB PLANTERS

Jab planters



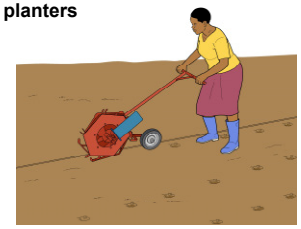
Different types of jab planters, without fertiliser hoppers (left) and with fertiliser hoppers (right)

(Photos: Saidi Mkomwa)

A jab planter can increase planting efficiency and reduce drudgery in cleared fields or fields covered by mulch.

PUNCH PLANTERS

Punch planters



- Punch planters can increase the accuracy and ease of planting.
- They are useful on tilled or untilled fields.
- Added weights can help to ensure proper planting depth in thick mulch or compacted soil.

ment. Farmers who already own a mouldboard plough can remove the mouldboard to create a suitable skim plough. A weeder with attachments or 'sweeps' designed for working at shallow depths such as 'low crown sweeps' will also work well in level seedbeds. There are a variety of purpose-built tools for skim ploughing available regionally.

6.4 Planting and mechanisation options for hand-powered, animal-drawn and tractorised systems

Once field preparation is complete, farmers then consider planting options. Mechanisation options for planting depend on how the land was prepared, and available equipment and labour.

Planting by hand

If farming by hand or in cases where draft power or motorised systems are not available, there are several mechanisation options to increase the speed and accuracy of planting and reduce drudgery.

a) Jab planters

When a farmer plants directly into a field with mulch or crop residues, or wants to reduce the drudgery of bent-over planting, a jab planter or a punch planter can be a very effective tool.

A jab planter allows the farmer to stand, and with each 'jab', place a seed at the correct depth. With practice, this works well on a mulched field and on a prepared field with bare soil. Some versions of this planter have an attached hopper/holder for fertiliser so with each 'jab', fertiliser is placed into the soil with the seed. Unfortunately, these hoppers are rarely suitable for compost-type fertiliser so it is usually necessary to fertilise by hand. Despite this drawback, this planter saves time, increases the accuracy of planting, and decreases the drudgery of bent-over sowing. A row marker, such as a string or scribed line, helps create straight and evenly spaced rows.

b) Punch planters

A punch planter is another hand tool that can increase the accuracy and ease of planting. These tools are useful on tilled or untilled fields. Added weights can

ANIMAL-DRAWN PLANTERS (1)

Animal-drawn planters for use in soils with mulch

Direct injection planter with fertiliser hopper as used in Southern Africa. The front coulter cuts through a cover crop to allow the planter easy access. The back drive wheel serves to turn the seed plates.

(Photo: Robert Burdick)

A direct planter prototype from Tanzania. The idea was to make the planter as low-cost as possible. In theory, this planter could be used through cover crops.

(Photo: Robert Burdick)

ANIMAL-DRAWN PLANTERS (2)

Animal-drawn planters

Planter prototype from Burkina Faso designed for use in fields with or without residue.

(Photo: Robert Burdick)

A direct injection planter with fertiliser hopper from South Africa without coulter for planting into mulch.

(Photo: Robert Burdick)

Operator view of the planter with the seed covering discs.

(Photo: Robert Burdick)

Seed delivery plate inside a planter with modified backing plate to avoid grains sneaking behind and messing everything up.

(Photo: Robert Burdick)

help to ensure proper planting depth in thick mulch or consolidated soil. Like jab planters, punch planters are often equipped with a fertiliser hopper most appropriate for commercial fertiliser. Equipment manufacturers claim that punch planters are the fastest method of planting by hand, and advertise a planting rate of 10 hours per hectare for one person.

Planting with draught animal power

When draught animals are available, multiple options exist for planting. Some are best suited for planting into cleared fields, while others can plant both into cleared fields and into mulch or residues in no-till fields.

Planters that are best for mulches and residues usually have a front coulter wheel that slices or parts the mulch ahead of the planting apparatus. Many models with similar functions are made in various parts of Africa, and can usually be locally manufactured by artisans given a set of plans and/or training.

Similar models are available for cleared fields with no coulter on the front. These are simpler to produce but are less practical for farmers aspiring to no till, or planting into a mulch.

Tractor-drawn planting

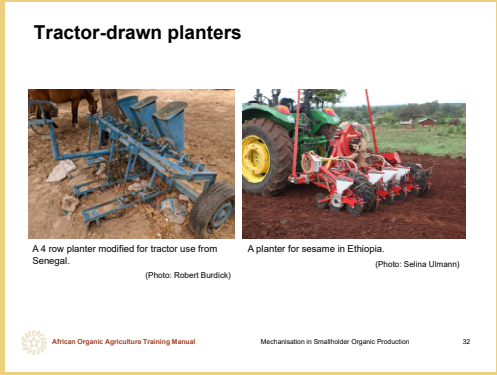
Tractor-drawn planters are similar in design and function to draught animal-pulled equipment, with varying designs depending on whether it is best used on a cleared field or is able to plant through mulch or residue.

Case study : Planter mechanisation in Burkina Faso

On-farm innovation is a key component in the process of continuous improvement of farming systems. In Burkina Faso, advances in planter mechanisation facilitated seed placement, plant population, and crop rotations and helped build soil health. Farmers had incentives to innovate to improve their farming systems to provide food for their families, increase household income, and enhance soil fertility and productivity. Changes to intensive tillage and planting methods were understood to be crucial in building soil fertility.

A team comprised of engineers and practitioners worked closely with the local farming community to develop mechanisation for smallholder farmers compatible with local economic, social, and environmental conditions. The team developed an inexpensive, rugged, and functional planter for low-distur-

TRACTOR-DRAWN PLANTER



PLANTER IMPROVEMENT

bance tillage and built and repaired it with local materials and knowledge.

Zone tillage and planting for soil health

The animal-drawn planter matched the low-disturbance tillage of the in-line subsoiler for zone tillage. Compared to a mouldboard plough, the in-line subsoiler enhances soil health by conserving soil moisture, reducing tillage intensity, and retaining a protective residue cover on the soil surface.

Maize planter for low-disturbance tillage

In early meetings, women reported that planting was one of their most difficult tasks. Maize is typically hand-planted by women and young girls using a short-handled hoe, placing two seeds every 16 inches. This spacing represents a comfortable action with the hoe and a small step between seed pockets. Two seeds per pocket assure the successful germination of at least one plant resulting in few skips within the row.

The team noticed that animal-drawn planters introduced to the area decades ago were widely rejected by farmers because of their high cost and poor performance. The success of the in-line subsoiler inspired several planter innovations to improve performance in minimally disturbed soil:

- The team reduced the cost of the planter by 50 % by replacing the seed plate spiral bevel gear drive with an inexpensive, open spur gear drive built by local blacksmiths.
- The team partnered with a training center in Bobo Dioulasso to create planter seed plates to improve the fit and functionality for maize, sorghum, millet, and cowpea.
- An innovative furrow opener was developed to slice through the minimally disturbed soil while reliably placing the seed at the correct depth.
- The high crown sweeps used as furrow closers on the old-style planter with a set of small concave discs better suited to low-disturbance conservation tillage. The new discs covered the seed and rolled over the residue without plugging.
- Finally, the width of the press wheel was reduced by 50 %. The old-style press wheel was suitable for ploughed, pulverised soil but did not provide sufficient localised pressure to firm the soil in the narrow tillage zone created by the in-line subsoiler.

FERTILISER APPLICATION

Fertiliser application with draught animal power

A simple drag can greatly improve efficiency and decrease the drudgery of applying larger volumes of organic fertiliser.

The above features enabled the seeds to be placed at a uniform depth and spacing, ensuring that seeds germinated faster and more consistently. Experiments in farmer's fields showed that using the planter increased maize grain yield by 50 to 150 % compared to hand planting. Farmers who tested the planter with their maize crop for one to two years also mentioned that birds did not consume the planted seeds because they could not find them. Using the planter had the added advantage of reducing the need to plant twice – which was often required when planting by hand because of a low germination efficacy. Additionally, it enabled farmers to plant early before the rains.

6.5 Fertilisation on smallholder farms and mechanisation options for different settings

As discussed previously, organic agriculture relies on the application of organic fertilisers like compost to supply crop nutrients. Because these organic fertilisers require a large volume and are often unsuitable for a hopper on commercial jab planters or animal-drawn planters, compost is most commonly applied by hand. However, some simple tools can increase the efficiency of this task.

Fertiliser application by hand

Organic producers often apply fertiliser by hand. Implements such as a wheelbarrow and shovel are helpful, but any type of container used for carrying can move the compost.

Fertiliser application with draught animal power

If draught power is available, a simple piece of equipment such as a sled or 'drag' can help with the distribution of compost or manure. The compost or manure can be piled on the sled, and while the animals pull the sled along the rows, as a person can walk beside using a shovel or bucket and apply it.

Mechanised application of bulk organic fertilisers is a challenge. Various organisations are working on options to solve this challenge. In the absence of suitable compost/manure spreaders, organic farmers must take into account the time and effort for fertiliser application into their seasonal planning. This is a task whereby addition labour can be sought by the farmers depending on the urgency of the operations.

MECHANISATION FOR HAND WEEDING

Mechanisation of hand weeding

A shallow weeder can be a very efficient hand tool for removing weeds.
(Photo: Saidi Mkomwa)

A hand-held weeder with protective discs, as used for row crops by small farms in Europe.
(Photo: FiBL)

ANIMAL-DRAWN WEEDING

Animal-drawn weeder with duckfoot sweeps

Weeder from Burkina Faso with three sweeps with low angle low crown for shallow weeding
(Photo: Robert Burdick)

Weeder in action; it can also be used as skim plough with a 3-times higher area performance and a much lower draft necessary draft than a traditional plough
(Photo: Robert Burdick)

6.6 Soil cover, weed control and associated mechanisation options

Keeping the soil covered between the growing seasons (cover cropping or mulching), or using various strategies to keep soil covered during the growing season (intercropping, relay cropping, or mulching) are a key part of weed management (and soil fertility as well as pest and disease management too) in organic farming. Because no herbicides are used, preventing weeds from emerging in the first place is an important step. Organic farmers commonly use crop rotation and application of well-cured compost and other inputs to help avoid bringing weed seeds into the field in the first place.

As mentioned previously, the idea of maintaining soil cover with live plants or mulch to suppress weeds is relatively simple, but the actual timing, choice of crops, field preparation, etc. is quite complex and variable with the region, rainfall, soil type, and needs of the farmer. These agronomic concepts are not covered in detail in this manual.

a) Mechanical weeding

Even with soil cover strategies, some mechanical weeding is necessary in most farming systems. Farmers benefit from an awareness of mechanical weed management techniques to enhance other strategies.

Mechanical weed control is the most common and effective method of direct weed control for organic farmers. It is used for the initial land preparation and during the later stages of the crop growth. When weeds have been 'allowed' to develop deep and extensive root systems, they can only be controlled through mechanical methods.

Mechanical weed control involves weeding the entire field or being limited to selective inter-row or intra-row weeding. Whichever tools are used, weeding should be done when weeds are small, and certainly before they flower and produce seeds. The weather and soil conditions while weeding significantly influence the tool's efficacy or method used (e. g. mechanical weeding is less effective when soils are wet during or after weeding operations).

Weeding by hand

Hand weeding can be the most labour-intensive method of weeding, but simple tools can ease the burden.

TRACTORISED WEEDER

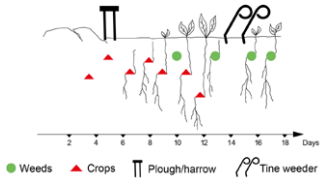
Tractorised weeder

A two-wheeled tractor with weeding sweeps from Senegal.
(Photo: Robert Burdick)

FALSE SEEDBED

Controlling weeds between sowing and crop emergence: blind harrowing

In ploughed fields with bare soil weeds can be controlled using a tine weeder.



After emergence of the weeds, but before emergence of the crop weeds are removed with a tine weeder.

Weeding with draught animal power or tractorised power

With draught animal power or tractorised power, weeding can be more precise and timely. Because no herbicides are used in organic farming, weeding must be carefully managed to avoid major weed problems. A comprehensive plan combining the correct equipment with the early and frequent use of that equipment can help to minimise weed pressure. Depending on the crops grown, soil type, equipment and labour available, and other factors, a 'comprehensive weeding plan' will be different for each farm. However, it is worth mentioning some specific equipment that can be a large help in weed control.

For example, with a tine weeder, a farmer can 'blind harrow', or run over the full width of the field to rid it of weeds before the crop emerges. This is done when the weeds are very small (e. g. 2 cm or less). The shallow action of the tine weeder uproots the weeds without disturbing the crop. Tine weeders have been developed to be pulled by both draught animals and tractors.

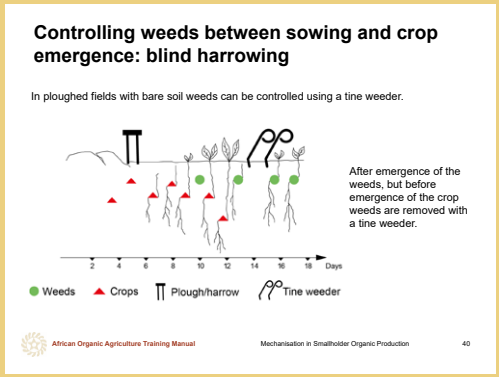
b) Creating a false seedbed to reduce hand and mechanical weeding

Another process is creating a 'false seedbed', whereby a seedbed is prepared early (2 to 4 weeks before normal planting) to leave sufficient time for two weeding operations before the crop is planted, thereby exhausting early weed pressure.

6.7 Harvesting and primary processing

This training manual focusses on field operations and touches to a very limited extent on harvest and postharvest mechanisation options. In view of the bottlenecks faced by smallholder farmers, especially women, in harvesting and cleaning small grains and legumes, even maize, a few examples of primary processing implements and machinery are presented here in the accompanying slides. These reduce drudgery and time spent by women in postharvest operations involving such crops and increase the attractiveness towards growing and utilising these nutritious crops.

BLIND HARROWING



MECHANISED HARVESTING

7. The cost and benefits of mechanisation

Even if a piece of equipment mentioned above seems promising, each farmer must carefully evaluate the potential costs and benefits of investing in new machines or technology. Now that some mechanisation options have been presented, it may be useful for farmers to consider the following didactic exercise.

7.1 Equipment hire/rental

Another consideration for smallholder farmers may be equipment hire or rental from local service providers. Particularly for larger types, smallholder farmers are encouraged to consider machinery hire services at a fee rather than buying to own due to reasons of capital costs, running costs, need for shelter, need for expert operation and maintenance. Besides, not all equipment is used throughout the year. A growing number of innovative business models offering mechanisation services throughout the year and across villages and districts is another way to access farm power for smallholders.

Some of the key factors to consider for group ownership:

- Cost of the equipment and initial capital outlay
- Availability of all farmers to raise the required contributions
- Availability of the equipment for purchase
- Technical capacity of the group/group members to operate and maintain the equipment and machine
- Group size, modalities to use and sharing in view of timing of critical operations such as land preparation, planting, harvesting, etc. Suitable communication channels and feedback loops are crucial in group ownership.
- Accountability and responsibility in operating and maintenance
- Disposal of the old equipment and replacement

Discussion on costs and benefits of mechanisation

Discuss the following questions regarding the costs and benefits of mechanisation:

- What costs will change with the new mechanisation?
- How will mechanisation improve the farm income? Will it reduce production costs, increase harvests, improve produce quality, and save time to allow other types of income generation (e. g. a home garden, milk production, etc.)?

MECHANISED PRIMARY PROCESSING

Postharvest processing

Tractorised forms of harvestors and threshers are also available.

Other relevant equipment, not shown, include shellers of different sizes and powering mechanisms.

Dehuller

COMPARISON OF COSTS FOR MECHANISATION OPTIONS

Comparison of hand-held, animal-drawn and tractorised mechanisation options in smallholder faming

Issue to consider	Hand-held	Animal-drawn	Tractorised
Scale of operation	Home gardens and small farms	Home gardens, small to medium farms	Medium to large scale farms
Availability	Commonly available	Can be available, but require animal draught power	Less commonly available
Indicative initial capital outlay	• Hoe: as little as USD 5 or lower • Jab planter: minimum of USD 60 to 80	• Bull: minimum of USD 300 • Ox-drawn plough, yoke and ropes: USD 150	• 2-wheel tractor: about USD 600 • 16 horsepower tractor: at least USD 2,300
Technical know-how by farmers	Simple	Medium	Highly specialised knowledge and skills
Ownership models	Individual	Individual and group	Own use, hire services through entrepreneurs etc.
Operational costs maintenance and / replacement	• No fuel needed • Low replacement costs • Might require some additional labour for households with elderly or vulnerable people	• No fuel required • Animal draft power needed • Supporting materials like yoke, ropes are needed • Manpower to guide animals and/or control the implement • Depreciation and replacement	• Fuel required • Replacement costs for implement parts • Depreciation and replacement

8. Further reading

The authors recommend the following resources in the 'African Organic Agriculture Training Manual' at www.organic-africa.net for further reading:

- Module nr. 1: Definition and Benefits of organic agriculture for African farmers
- Module nr. 2: Soil fertility management
- Module nr. 4: Pest, disease and weed management
- Module nr. 5: Animal Husbandry
- Module nr. 8: Conversion to organic farming

Additional external resources include:

- The African Conservation Tillage Network (ACT) is an organisation dedicated to promoting Conservation Agriculture (CA) in Africa. www.act-africa.org
- International Centre of Insect Physiology and Ecology (icipe). Push-Pull Technology. http://www.icipe.org/impacts/demonstration-research-impacts-communities/push-pull-technology
- Howard G. Buffet (2015). In Support of Conservation Agriculture for Smallholder Farmers; http://www.campaignforrealfarming.org/wp-content/uploads/2012/09/Howard-G-Buffet-Nature-July-5-2012.pdf
- Kasisi Agricultural Training Centre is a not-for profit organisation based in Zambia and promoting sustainable organic agriculture. https://katczm.org/
- The Howard G. Buffett Foundation Centre for No-Till Agriculture (HGBF CNTA) in Ghana https://centrefornotill.org/ demonstrates the adoption of smallholder conservation agriculture (CA)
- Bowman, G. (1997). Steel in the field: a farmer's guide to weed-management tools. Sustainable Agriculture Network.
- IIRR and ACT. 2005. Conservation agriculture: A manual for farmers and extension workers in Africa. International Institute of Rural Re-construction, Nairobi; African Conservation Tillage Network, Harare.
- Rodale Institute. (2022). The difference between organis and conventional. https://rodaleinstitute.org/why-organic/organic-basics/organic-vs-conventional/
- Rodale Institute. 2020. Regenerative Agriculture and The Soil Carbon Solution.