Farmers Training Notes **7**

SOIL TILLAGE
in Organic Agriculture

KOAN

Kenya Organic Agriculture Network

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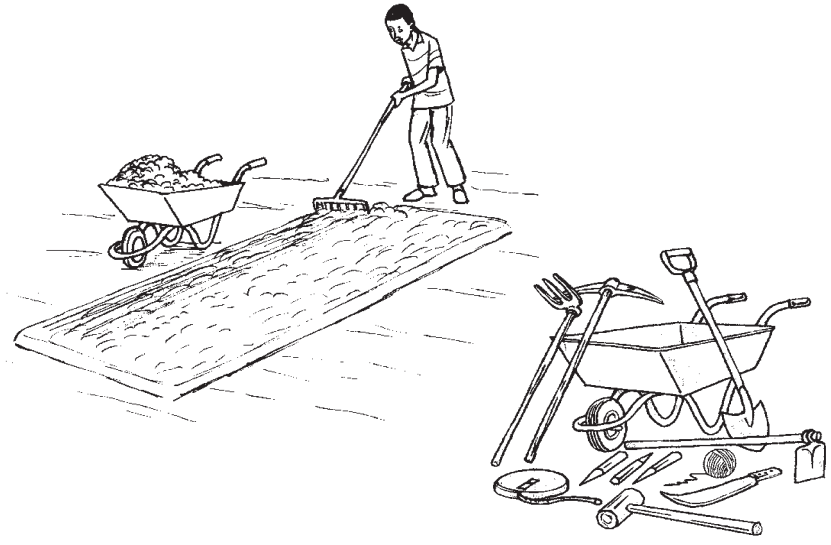


INTRODUCTION

Soil tillage refers to mechanical manipulation of the top soil with the aim of improving its conditions which may affect crop performance. It can also be defined as the use of implements for working on the land in preparation for crop planting.

The soil is the foundation of farming and proper tillage to maintain its fertility is vital. Different places have different types of soil and their tillage requirements and fertility maintenance defer greatly. Good examples are sand and clay soils which have very poor soil structures and the only way to bring them to a loamy texture is to add organic matter. Still, when organic matter is added or incorporated into any soil, it is necessary to work it well into that soil so that the nutrients it holds can be easily accessible to crop roots.

Objectives of soil tillage

- Creating favourable conditions for the germination, emergence and growth of cultivated crop plants
- Conserving and improving the soil as a growth medium for cultivated crops

- Enhancing control, reduction, or even elimination of weeds, pests and diseases
- Incorporation of organic matter into the soil through burying of crop residues
- Shaping crop growth and management techniques with the aim of controlling soil erosion
- Improving water infiltration as well as crop root penetration and expansion

Types of soil tillage systems

There are many tillage methods which farmers can practice depending on time, crop to plant and the nature of the soil, among other things. The type of soil tillage approach or technique that a farmer adopts is influenced by several factors, the ecological factor being uppermost. A major ecological factor that takes lead over the others is rainfall; or availability of water, over time, for crop growth. Some of the soil tillage systems include the following:

Stubble or post harvest cultivation

This system only emphasizes on shallow tillage after harvest for the purpose of clearing out crop residues, weeds and restoration of soil structure in readiness for the next crop. Over 90% of smallholder farmers do this season after season. In places with low rainfall, this system may not be very rewarding and can cause severe erosion.

Zero tillage

Zero tillage is a type of cropping system in which crops are planted into previously undisturbed soil by opening a narrow slot of sufficient width and depth to obtain proper seedbed coverage. It offers the advantage of maintaining better moisture in the soil by retaining the crop residues and reducing evaporation; however, this advantage is offset by the difficulty of trying to plant a small seeded crop at a consistent shallow depth through plant residue. Specialized equipment has been designed for commercial large scale farmers for zero tillage operations (i.e. planting into crop residue), but there is little equipment improvisation for this purpose designed for smallholder farmers.

Main primary tillage

This is deeper cultivation done in the period between two crop seasons to eliminate deep rooted weeds and loosen up the sub-soil for better root penetration of the crops to be planted. Organic farmers should not practice deep cultivation unless it is necessary for root crops. Hardpans can be successfully broken using a single deep tine cultivator.

Crop management tillage

This involves digging shallowly to control weeds and improve root and water penetration as the crops emerge. Several techniques are employed under this system:

Deep tillage approaches/ techniques

Deep tillage systems or approaches are used for:

- Incorporating well rotted manure or compost periodically thus maintaining good soil structure for long periods
- Reducing the need to cultivate as often, therefore allowing a protective vegetative cover as long as possible within a rotation programme
- Loosening and aerating the soil at a deeper level
- Uprooting deep rooted weeds.

Specific soil tillage techniques

All soil tillage techniques or approaches described here have one issue in common: deep digging to improve water penetration and retention, improve soil air distribution and facilitate crop root penetration. These techniques include:

- Double dug beds
- The *mazimbuko*/fertility trench
- 5-9 or multiple seed holes
- *Mandala* garden
- Sunken beds.

All the five techniques are very ideal for both intensive kitchen gardening and smallholder subsistence/sustainable farming.

Double Dug Beds (double digging)

Double digging or making of double dug beds (DOB) is a tillage technique that involves digging to break the hardpan, loosen the soil and encourage vertical, instead of lateral, root penetration. The technique calls for thorough mixing of loosened soil and compost in a systematic procedure that ensures a sustainable bed for healthy crop growth and development, even under adverse conditions.

Importance of double dug beds

- In the preparation of double dug beds, hardpans, which are mostly found 20-30 cm below the surface of the soil, are broken.
- In the absence of hardpans, available water from rainfall or irrigation will infiltrate to lower soil layers.
- Plant roots are enabled to penetrate deeper where they will acquire nutrients and moisture for overall crop growth.
- Double dug beds avail enough volume of fertile soil. This soil will allow closer spacing, hence more crop output from a limited unit of land.
- Double dug beds are easy to work on and make it easy to calculate the expected produce.
- Double dug beds will cater for continous crop growth due to the fertile nature of the beds. This way, there will be a continous supply of food throughout the year and mostly where water for irrigation is available.

Where to make double dug beds

Double dug beds are important organic farming sites that can be very useful to:

- Smallholder farmers in high, medium and to some extent, low rainfall areas. In high and medium potential areas, the beds are continually sustained with water from natural rainfall. Such beds can be used for up to 3 years before they can be renewed. Bed renewal, however, will depend on the type of crops that the farmer usually grows – heavy, medium or low feeders or the crop's suitability for making green manure.
- In low rainfall areas, it is recommended that the beds are thoroughly watered at 6 month intervals or after every harvest in order to replenish the moisture levels at the bottom of the beds. It is important to note that in the absence of adequate moisture, crop roots may not be able to adequately use the available soil nutrients.

- On the other hand, periodic (2 week's interval) drip irrigation has produced very good results in dry areas. Due to the cost factor and water availability, drip irrigation is limited to very few beds, in most cases.

N/B

Use of double dug beds in large scale organic farms is hampered by labour and input (compost) costs and is not encouraged, unless done on specific high value crops like herbs.

URBAN GARDENERS

It has been established that a good amount of vegetables used in many cities all over the world are grown within those cities in small, intensively cultivated gardens. This is a common practice in East Africa, with Nairobi being a good example. Double dug beds can be very suitable for such settings as they can be easily managed. Compost for use in such beds can be generated from organic kitchen waste and left overs, or at minimal cost from peri-urban areas.

Ideal double dug beds sites will also include farm areas that have been trampled on and cannot be useful for direct planting. Such areas will include old cattle *boma* sites, deserted homestead sites, disused community sites and areas crisis-crossed by paths no longer in use. They could also include farm areas that have been subjected to soil erosion hazard and require rehabilitation such as across a former gully or rehabilitated flood plains.

How to make Double Dug Beds

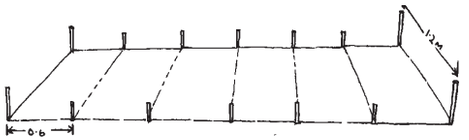
Making double dug beds requires commitment. It is not an activity for the lazy, but at the end of everything, the committed farmer will be proud of his/her labours. The following are the steps for making a double dug bed:

Step 1

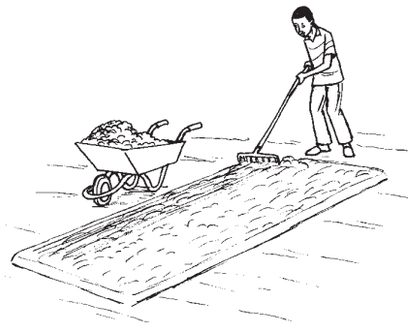
The following implements are used and should, therefore, be made available:

- Digging implements – fork jembe, panga, mattock
- Measuring tools – Tape measure, string, wooden pegs and mallet
- Soil transfer tools – Shovel, wheel barrow
- Enough compost (not farm yard manures).

Site selection



Double dug beds are dug along the contours. Measure out a strip, 1-2 meters wide and 7 meters long for an ideal DDB (length can be longer but width is constant). Where 2 or more DDBs will be made alongside each other, leave out a 60cm lane or path in between. Drive in the wooden pegs and tie the string to indicate the measurements. Along the string length, drive in pegs at 60cm intervals on both sides.

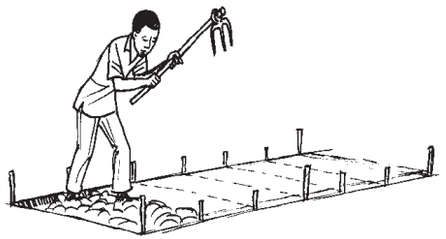


STEP 2

Onto the measured outstrip, spread a thick layer of compost; if you have to use manure, it must be well decomposed.

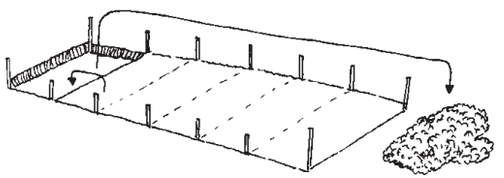
Step 3

Dig up the strip you have manured, mixing the soil with the compost thoroughly. Digging must be deep enough to loosen all the top soil. All the pegs must be left intact or replaced if dislodged during the digging.

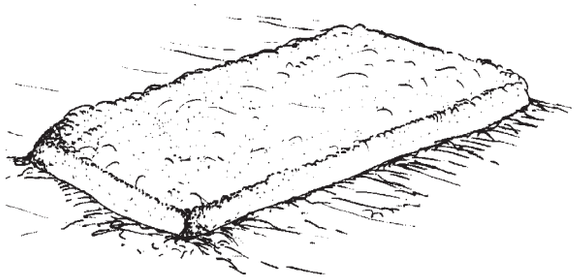


Step 4

Remember the 60 cm segments you measured out? Now we shall make use of them! From the first segment, remove all the top soil /compost mixture and transfer it to the end of the 7m strip, next to, **but not** on, the last segment. If necessary, dig further to remove all the top soil, transferring it onto the heap you have just created at the end of the strip. You will know when all the top soil has been removed by noting the soil colour change to red or when you hit the hardpan or even when you have gone down to 30-45 cm into the bed.

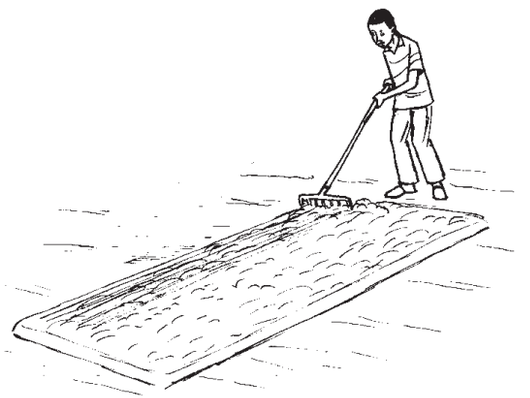


Step 5



- Continue digging into the first segment to break the hardpan. If the hardpan is tough, use the mattock to break it loose. Once you are satisfied that it is loose enough, level it out and add a layer of either compost or decomposed manure, or chopped green vegetation.
- Now start on the second segment and draw the soil /compost mixture into the first segment, on top of the compost/chopped green vegetation layers. Draw all the top soil, soil/compost mixture down to the hardpan level.
- Repeat the process of breaking the hardpan of the second segment as you did the first segment, finally adding a layer of compost, decomposed manure or chopped green vegetation on it……then going on to the third, fifth and last segment.

Step 6

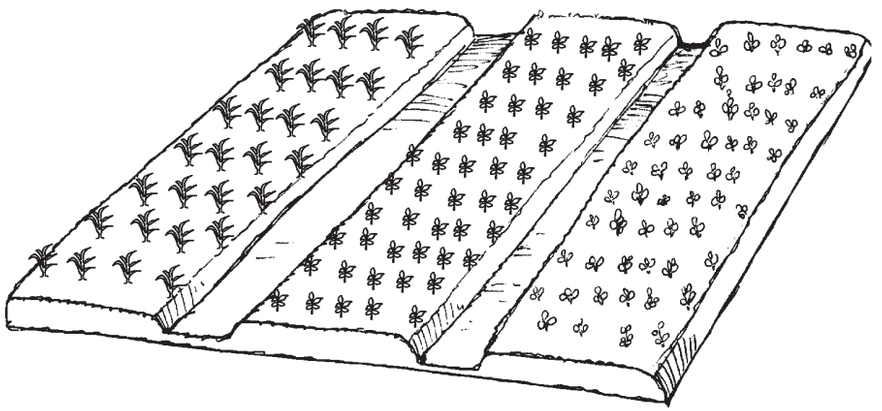


Repeat step 5 until segment 6 is empty. As in the previous cases, break the hardpan in it, add compost or chopped green material onto the loosened hardpan. Now draw the entire soil/compost heap from segment 1 into it. All the segments are now filled.

Step 7

Naturally, the bed is unevenly raised above the normal ground level. Using a rake, level it out after removing all the marker pegs and string and evenly add a layer of mulch. Your double dug bed is ready. You can plant your crop immediately or later as you desire.

Below are examples of double dug beds made side by side and used for different types of crops which are at various growth stages.



Economic importance of DDBs

- Double dug beds are an assured means of food security for both the smallholder and urban farmer as they can support crop growth throughout the year with minimum input.
- Double dug beds are continuous seedbeds that sustain soil fertility, and natural flora and fauna with minimum disturbance, ensuring a continuity of life necessary for healthy environments.
- Double dug beds serve as a means of soil conservation due to the nature of their construction. This ensures continuous crop production, sometimes with surpluses for local sale.

CONSERVATION TILLAGE

This is a soil management practice that minimizes as much as possible, the exposure of the soil components to sunshine, wind or direct rain drops, to sustain physical and chemical properties. In so doing, the soil will maintain its constituents, both living and non-living, moisture and organic matter, intact and readily available for crop use.

Importance of conservation tillage

Due to the minimal disturbance of the soil cover, conservation tillage ensures that:

a) Soil erosion is effectively controlled
b) Soil moisture is conserved for present and future use by crop
c) Weed seeds are denied a suitable medium for development
d) Micro-climates that are unfavorable for pests and diseases are maintained
e) Minimum labour, time and capital are used once a specific conservation practice is put in place
f) There is less oxidation or loss of nitrogen which is a crucial crop requisite.

Factors influencing types or methods of conservation tillage

Different types of conservation tillage are practiced in various parts of the world. The differences vary owing to several factors like:

Climatic conditions

The types of conservation tillage carried out in high rainfall areas may be different from those carried out in low rainfall areas. In both high and low rainfall areas, the methods used are largely dictated by rainfall patterns, water availability and the type of soil.

Soil condition

Certain textural and structural characteristics of the soil may dictate against a conservation tillage method. Very loose sandy soils may be unsuitable for a conservation tillage method due to their inability to retain adequate soil moisture levels. Equally, heavy clayey loams may not be suitable for a particular method due to its nature of being easily water logged.

Type of crop

Every ecological zone has a range of crops that can only be grown in it. A particular crop, however much favoured by a farmer practicing conservation tillage, may not do well under certain ecological conditions, irrespective of the type of conservation tillage method adopted.

Growth habits of crops

A conservation tillage method intended for annuals may not auger well for perennial crops. Equally, a conservation tillage method intended for spreading crops like cucurbits will not do for upright crops like maize.

Farm size

Certain conservation tillage methods are only adaptable by smallholder farmers and would be uneconomical in terms of labour time and final output when done on large scale holdings.

Types or methods of conservation tillage

Among others, one of the most important characteristics of organic farming is protecting the long term fertility of the soil by maintaining high organic matter levels and fostering soil biological activity with minimum mechanical interventions. In this regard, some form of very minimal soil tillage will definitely take place even in conservation farming. The major thrust of the various methods of conservation farming is to, as much as possible, maintain soil as a natural productive component. The activities carried out are only intended to enhance crop growth and productivity, with minimum soil disturbance. Following are a few notable conservation tillage methods that are practiced by smallholder farmers in East Africa.

Zero or minimal tillage

Devised by Mr. Masanobu Fukuoka of Japan, this tillage practice seeks to minimize human interference with the environment, such that no mechanization, synthetic fertilizer and chemical inputs are used whatsoever. A farmer is only expected to sow and harvest on natural soil. The crop will be expected to complete ably with its wild neighbours and yield naturally. However, a mulched manured bed is provided to give the crops a head start over weeds.

Permaculture

This system calls for an integrated system which uses perennial crops ; fruit or leguminous agroforestry species, which are self supporting as well as soil enriching, desired and adaptable crops and livestock. This is a holistic system

where the soil is least disturbed but where each enterprise is contributing to the enrichment of the soil in all ways. Multi-storey cropping is a component of permaculture practiced in East Africa.

sack garden

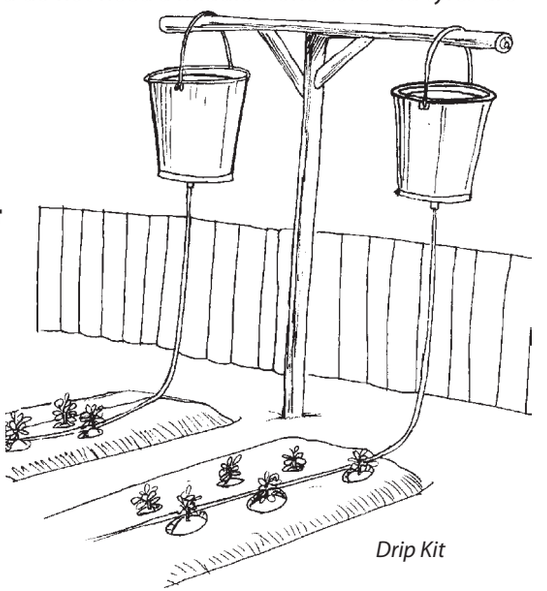
Portable gardens, wheel gardens

It may be argued that these methods involve some levels of soil disturbance - but the main thrust of conservation tillage here comes into existence after establishing the structure.

In portable gardens, old sisal sacks are filled with a mixture of soil, compost and sand at the ratios of 3:2:1 for clayey soil, and 4:2:1 for sandy loams, in that order. The middle core is filled with small loose stones to avail water to the bottom of the sack. Seedlings are planted in the holes perforated along the sides of the sack. At the open top, a repellant weed or crop is included e.g. onions or Mexican marigold to keep off pests from seedlings. Watering is done through the middle core regularly. These are useful in urban areas, although most smallholder farmers are also using them around their homesteads as there is plenty of kitchen water around. Wheel gardens are narrower and do not need a middle stone core. Old tyres are used. In these systems, the soil is never disturbed throughout the entire crop growth.

Bucket irrigation kits, bottle and container water feeders

These methods are practiced by enlightened small holder horticultural farmers in areas with unreliable rainfall, or where high value market cropping is being done. It is also crucial on soils which are too light to retain soil moisture



Drip Kit

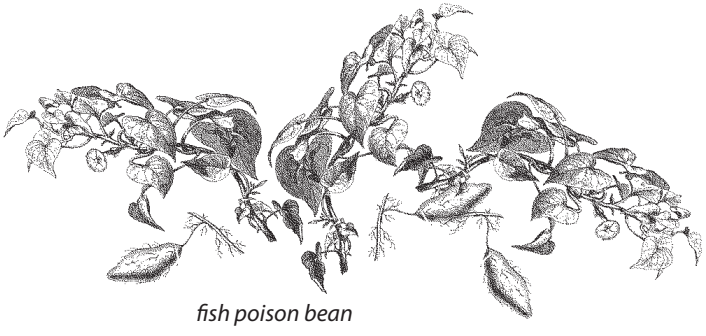
for the required periods. There is least disturbance of the soil, except that on which the crop is growing.

Green manure crops

Deep rooted crops and plants are incorporated in a farm unit to bring up valuable nutrients within a shallow-rooted crops range. Examples of these crops include the pigeon pea and sunhemp *(Crotolaria parasitica)* and such plants as fish poison bean *(Tephrosia vogelii)*. Tuberous crop plants like sweet potato *(Ipomoea batatus)* are useful green manure crops that provide a valuable soil cover and stubble that keep the soil soft, moist and ready for re-use without further tillage.

sunhemp

fish poison bean



fish poison bean

Some of the material in this book was adapted from the books below:

1. Sustainable Agriculture – by ILRI
2. Natural Pests and Disease Control – by Henry Elwell and Anita Maas
3. Organic Farming – by John Njoroge
4. Soil Fertility Management - by John Njoroge

BOOKLETS IN THE FARMERS TRAINING NOTES SERIES

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Kenya Organic Agriculture Network (KOAN) is the National Coordinating Body for organic agriculture activities in Kenya. KOAN's mandate is to coordinate, facilitate and provide leadership and professional advisory services to all members and stakeholders in the areas of production, technical training, marketing, certification, lobbying and advocacy. It seeks to promote the organic agriculture movement in Kenya, to evolve and become a highly beneficial and integral industry with direct impacts on the environment, poverty reduction, employment and wealth creation.

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