

DEEP BED FARMING

A FIELD MANUAL



WHY DEEP BED FARMING ?

The Tiyeni Deep Bed Farming (DBF) system incorporates elements of ‘conservation agriculture’ techniques and offers a much more productive alternative to traditional agricultural practices in Malawi, which in recent years have been characterised by declining crop yields and food insecurity. This has occurred as a result of various socio-economic and environmental factors, including:

- **DECLINING SOIL FERTILITY** – caused by the overuse of artificial fertilisers instead of compost / manure
- **INCREASING SOIL EROSION AND FLOODING** – created by destructive husbandry practices that facilitate increased surface runoff; topsoil loss in Malawi has been measured at 29 tonnes of soil per hectare per year by erosion
- **HARDPAN FORMATION** – created by destructive agricultural practices
- **CLIMATE CHANGE** – farmers are struggling to adapt to increasingly unpredictable weather across central and southern Africa. Malawi suffered major flooding and drought events in 2015, 2016, 2019, 2021, 2022 and 2023 which have resulted in drastic soil erosion, loss of crop production and reduced food security
- **POPULATION PRESSURE** – Malawi’s annual population growth rate is currently around 3%; the population doubles every 30 years while the extent of good quality arable land is declining



FIGURE 1

Conventional ridge garden with open-ended furrows
An estimated 29 tonnes of soil per hectare per year are lost from these farms
[FAO 1999]

Tiyeni builds farmers' resilience to these pressures and impacts through extension of its deep bed farming (DBF) system, which incorporates a range of non-destructive environmentally, economically and socially sustainable land management practices, developed over 17 years.

DBF is an innovative form of Malawian-led advanced agriculture. The package of low tech, climate resilient agriculture practices/technologies configure the landscape to zero water and soil loss, whilst improving soil fertility. DBF includes soil decompaction, contour terracing, swales, boxed and closed-end furrows and raised footpaths. Decompaction or breaking the hardpan aids infiltration and percolation of water to feed aquifers, while contouring, terracing, closed-end and boxed furrows and raised footpaths help to harvest water, prevent runoff and control erosion.

Soil health and fertility are improved using DBF through manure and compost application, residue incorporation, mulching, green manure cover crops, agroforestry, and crop rotation with legumes. The environment is further improved through reducing siltation, recharging aquifers and streams/rivers, eliminating water contamination from fertilisers and other artificial agriculture chemicals, and mitigating global warming through improved carbon sequestration.

More than 25,000 farmers in Malawi have so far taken up DBF. Maize yields are often as much as 8 tonnes per hectare which is more than quadruple the national average of 1.7 tonnes per hectare

PRINCIPLES OF DEEP BED FARMING

A) SOIL DECOMPACTION

Annual ridging by hand-hoe is the common method of land preparation in Malawi. Use of this system year after year has resulted in soil compaction which greatly affects the quality and quantity of crops cultivated. This is often referred to as 'hoe-pan'.

Decompaction of the land in the first year only to break the 'hardpan' of the subsoil, allows:

- deeper root growth
- soil aeration
- easier percolation of water
- higher moisture content within the deep beds
- easier construction of contour marker ridges and deep beds later in the process.

Note: As long as the deep beds are not trampled or compacted heavily during field operations over the years, then no further major tilling need be done in following years.

B) SOIL AND WATER CONSERVATION

DBF works to achieve the capture of all rainfall that lands on the fields and allow it to percolate into the soil. This is a fundamental part of catchment management and is achieved by:

- building contour marker ridges and planting vetiver grass to reinforce them
- alignment of planting beds exactly along the contour
- creation of boxed and closed-end furrows
- construction of raised footpaths to avoid creation of watercourses and subsequent gullies
- using other well-established methods of erosion control such as swales, recharge pits and check dams

C) SOIL HEALTH (FEEDING THE SOIL)

This is about regenerating the soil to become healthy and productive. Enhancing the biological diversity in the soil is an essential part of the DBF system through:

- composting
- mulching
- agroforestry
- green manure cover crops
- crop rotation
- intercropping with legumes



FIGURE 2

Crop comparison – DBF maize on the left, conventional ridge maize on the right

STEP BY STEP GUIDE TO DEEP BED FARMING

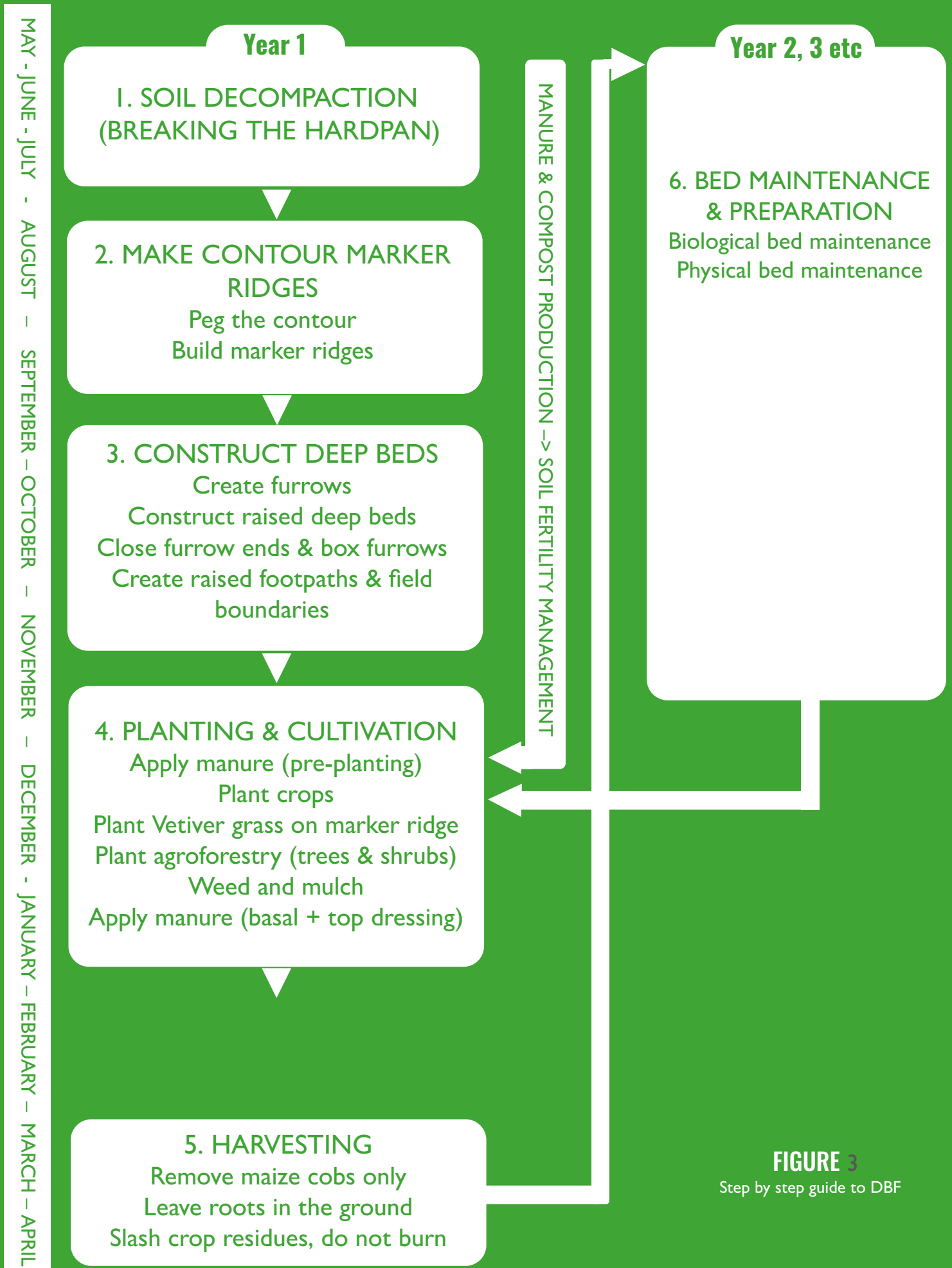


FIGURE 3

Step by step guide to DBF

1. SOIL DECOMPACTION (BREAKING THE HARDPAN)

The first step of DBF is to decompact the soil hardpan by deep tillage. This requires use of either a pickaxe or hoe (double-digging) to a depth of 30cm, or is carried out mechanically by using a tractor or an ox-pulled plough.

The best time in Malawi to break soil compaction is May – July when the soil is still moist, and the weather is still cool.

It is important to note that decompaction is done in the first year only. As long as the cultivation beds are not trampled or compacted heavily during field operations, breaking the hardpan only needs to be done once.

It should also be noted that any grass, crop residues or leaves should be incorporated into the soil during the deep-tillage and left to decompose. Burning crop residues is wasteful and should be avoided.

2. CONSTRUCT CONTOUR MARKER RIDGE

Contour ridges and terraces ensure that the cultivated area is level and prevent any runoff of rainfall which would cause severe soil erosion. Instead, rainfall stays on the land and infiltrates into the soil.



FIGURE 4

Contour aligned deep beds and boxed furrows ensure water stays within the field

A) PEG THE CONTOUR

Set up the line level

- i. Do not let the sticks penetrate the soil to ensure proper measurements
- ii. Cut a groove around each stick at exactly same height (ideally the neck height of the person who will read the line level)
- iii. Hang the level between 2 knots tied in the centre of this string
- iv. Set the 2 sticks upright on a level surface with the string tight. The bubble will be perfectly on centre if done correctly
- v. If the bubble is not central, the line is not level, so move one of the sticks (uphill or downhill) until it is level

Materials Required

1 line level (can be used by 50 farmers in one season with a minimum of 10 seasons lifespan)

2 straight – twin – sticks (2m long)

1 knife

1 hammer or 1 stone (as a hammer)

3 people (minimum)

Measuring tape (100m)

100 – 200 ridge marking pegs / ha

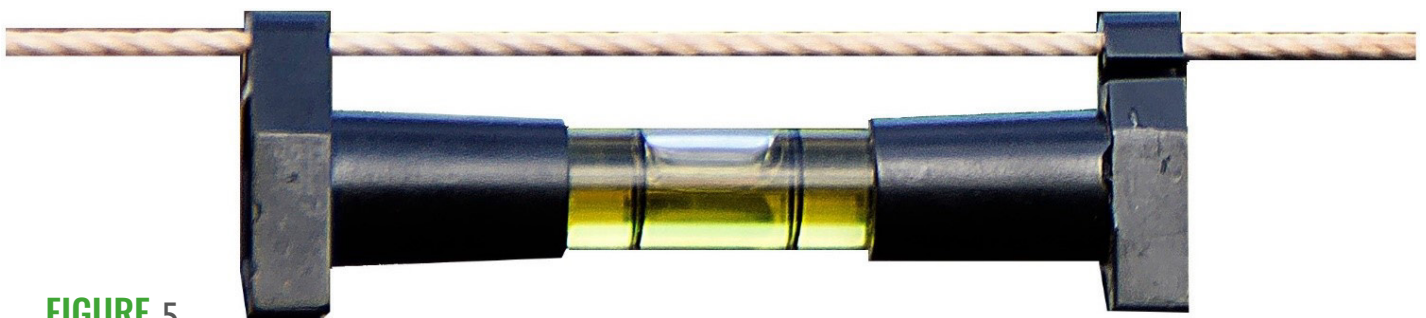


FIGURE 5

The Line Level - a level surface (contour ridge) is indicated when the bubble remains in the middle as shown below

Find the starting point in your land

Always start at the top corner of the field and note that all the cultivation should occur below this point. In the example below, a starting point higher than that indicated would not be feasible due to the steep slope of the land above.

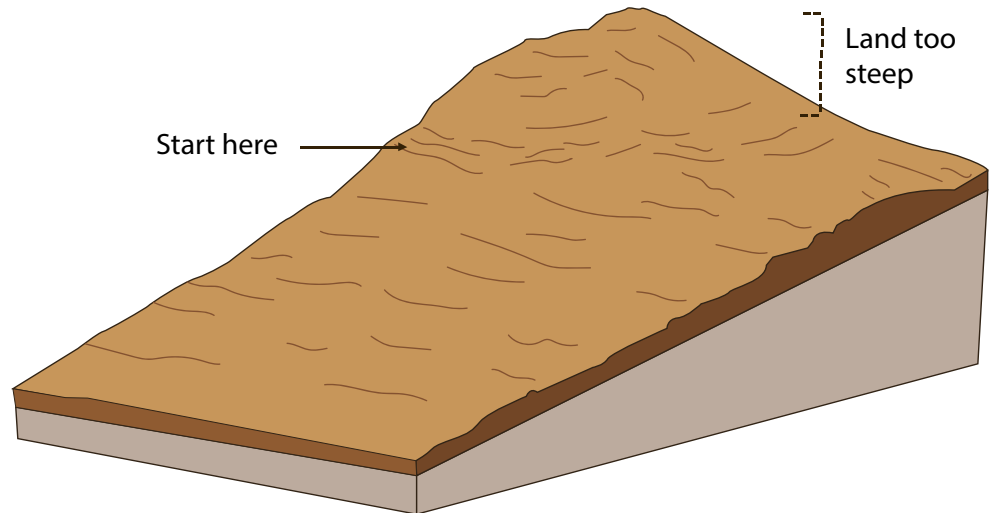


FIGURE 6

The starting point for pegging the contour ridge

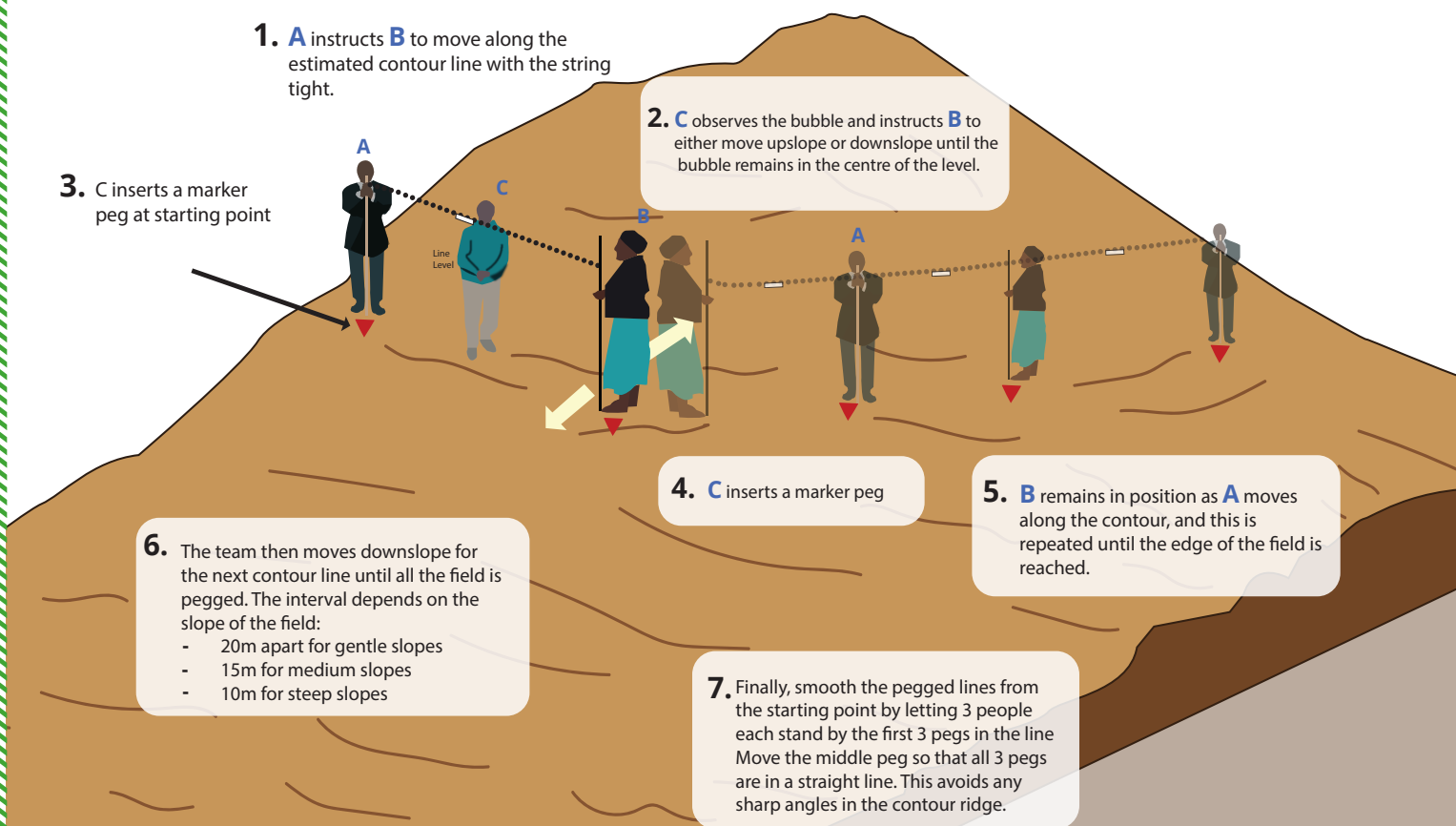


FIGURE 7

The process of pegging the contour ridge

B) BUILD CONTOUR MARKER RIDGES

Having established the route of each contour ridge, marked with pegs, the next step is to build a ridge that follows the contour, at a height of 0.5m, and a water catchment ditch 0.5m wide above that ridge. These marker ridges simply serve as guides to align deep beds parallel to them, again to maximise soil and water conservation.

The marker ridge is the foundation of the DBF system. If it is not constructed (and strengthened by planting Vetiver grass in it) properly, the rest of the garden will be at risk from being washed away by the run-off during heavy rains.

Note: in areas of higher or intense rainfall, marker ridges may need to be higher and catchment ditches wider.

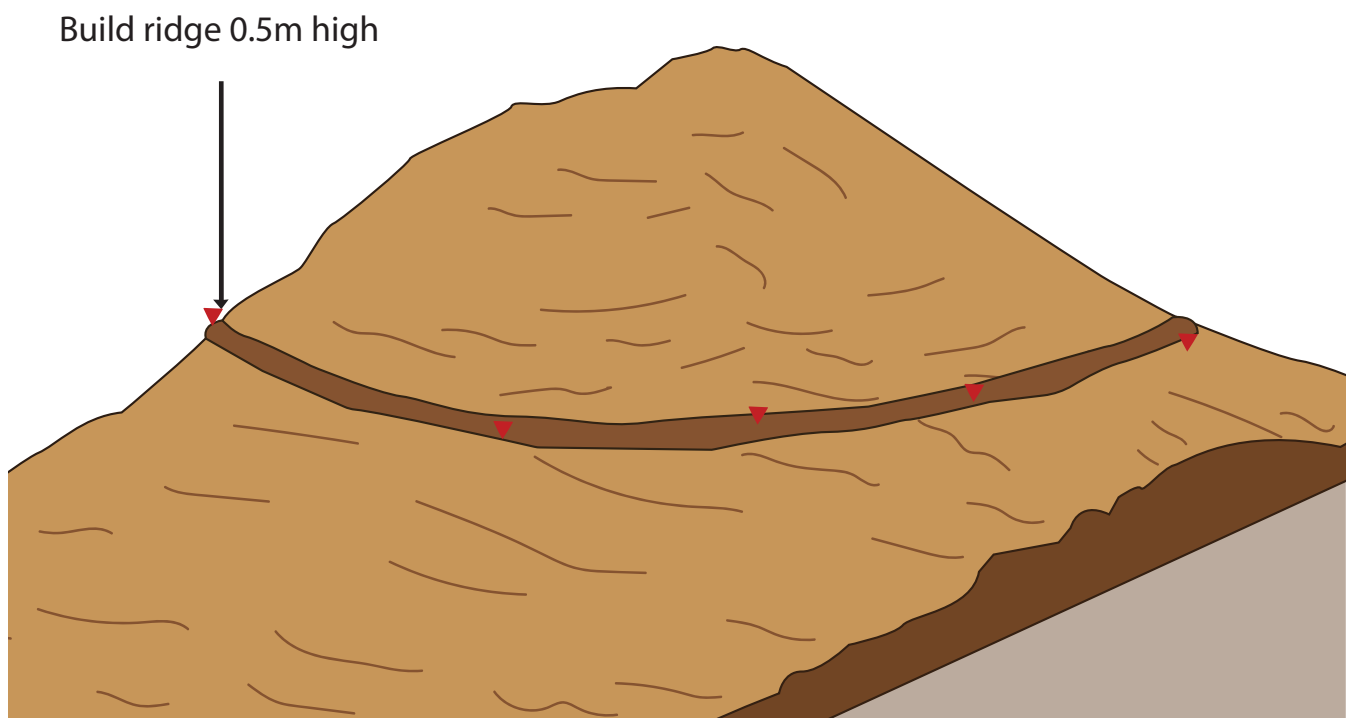


FIGURE 8

Location of contour marker ridge relative to pegs

3. CONSTRUCT DEEP BEDS

Cultivation beds are constructed following the line of the marker ridges, ideally between August and October, in the layout shown in Figure 9.

A) CREATE FURROWS

- i. Lay down a stick of 50cm to mark the 1st furrow from the marker ridge
- ii. Dig the soil to one side along the marker ridge. As you scoop the soil to one side, a furrow is made parallel to the marker ridges
- iii. Other furrows of 50cm wide are done the same way (25cm wide soil to one side and 25cm to the other side)

B) CONSTRUCT RAISED DEEP BEDS

- i. One side of a bed is already made as you were constructing the 1st furrow above (A)
- ii. Using a 1m long stick, mark the width of the bed at 1m
- iii. Scoop the soil upwards parallel to the marker ridge
- iv. The mound or bank formed becomes the raised deep bed which should be flattened on top

Materials Required

Hand hoe
Shovel (optional)
1m stick
50cm stick
30cm stick

C) CLOSE FURROW ENDS AND BOX FURROWS

- i. Close the furrow ends to above the level of surrounding fields to prevent water runoff and soil loss
- ii. Box the furrows every 3 - 5m to prevent lateral movement of water
- iii. Stagger the box furrows on alternate furrows

D) CREATE RAISED FOOTPATHS AND FIELD BOUNDARIES

- i. Avoid treading on the beds to avoid soil compaction by using the furrows and raised footpaths
- ii. Where furrows are closed, these can be used as footpaths up and down the field at 10 - 15m intervals
- iii. Walking across the slope can take place in the furrows only
- iv. Field boundaries can aggravate the formation of rills and gullies if not well constructed, hence closing furrow ends
- v. Both footpaths and field boundaries should be 50cm wide, slightly above the beds

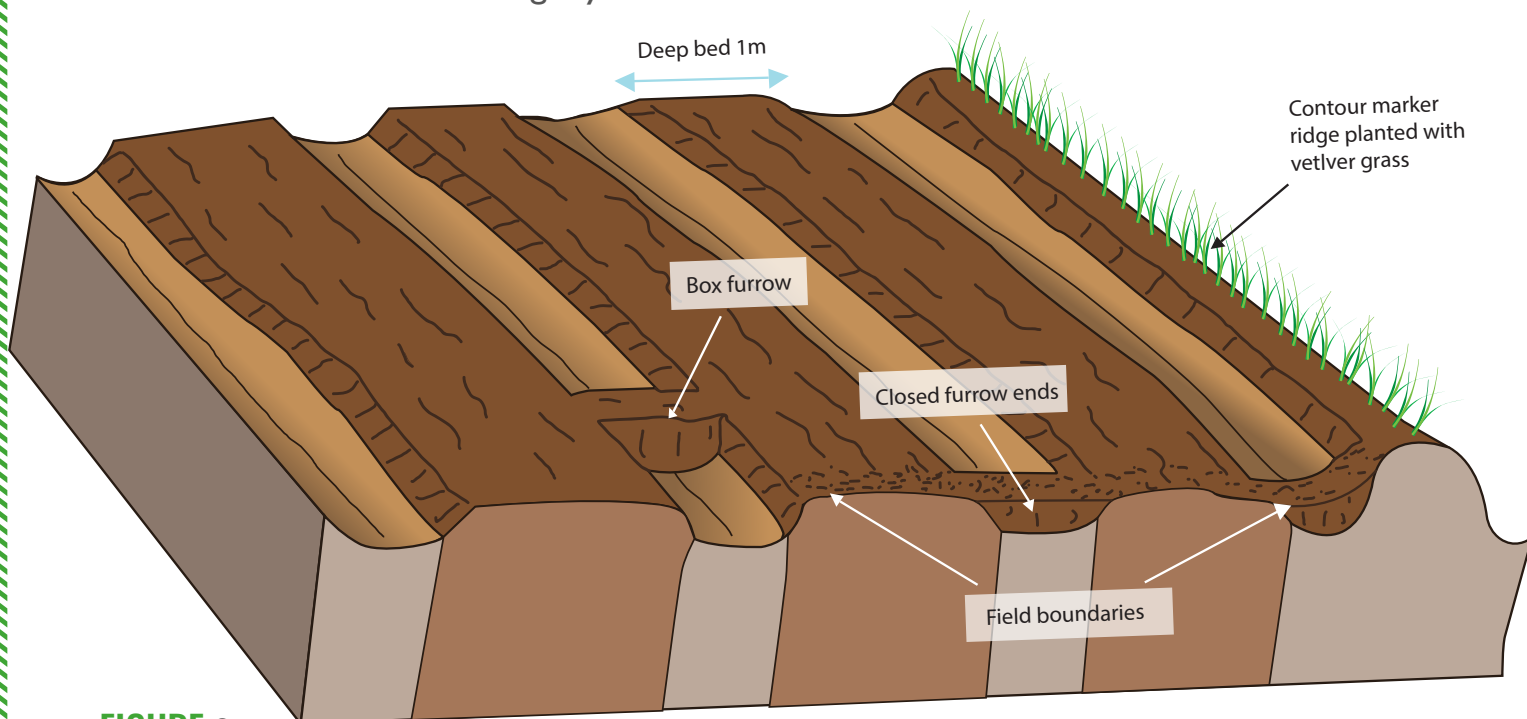


FIGURE 9

Layout of the deep bed farming system

4. PLANTING AND CULTIVATION

A) APPLY MANURE (PRE-PLANTING) – FERTILIZING THE SOIL

Apply 1 handful of compost manure in each planting station of maize no later than 1 month before planting (this will usually be October). Manure and soil need to be thoroughly mixed to avoid damage to seeds and seedlings.

Different crops require different applications of compost manure.

See section on manure and composting.

B) PLANT CROPS

Having completed construction of the deep beds and applied soil fertility measures, the deep beds should now be ready for planting. Deep beds have a much greater water holding capacity than standard conventional ridges, hence planting should be done with the first rains without hesitation (November – December).

Crop spacing for maize (see Figure 10)

- i. planting row spacing = 75cm (2 rows per bed 12.5cm in from edge of bed)
- ii. planting station spacing = 25cm
- iii. number of seeds per station = 1
- iv. one nursery bed should be planted with 3 rows to supply extra plants in case of failed germination

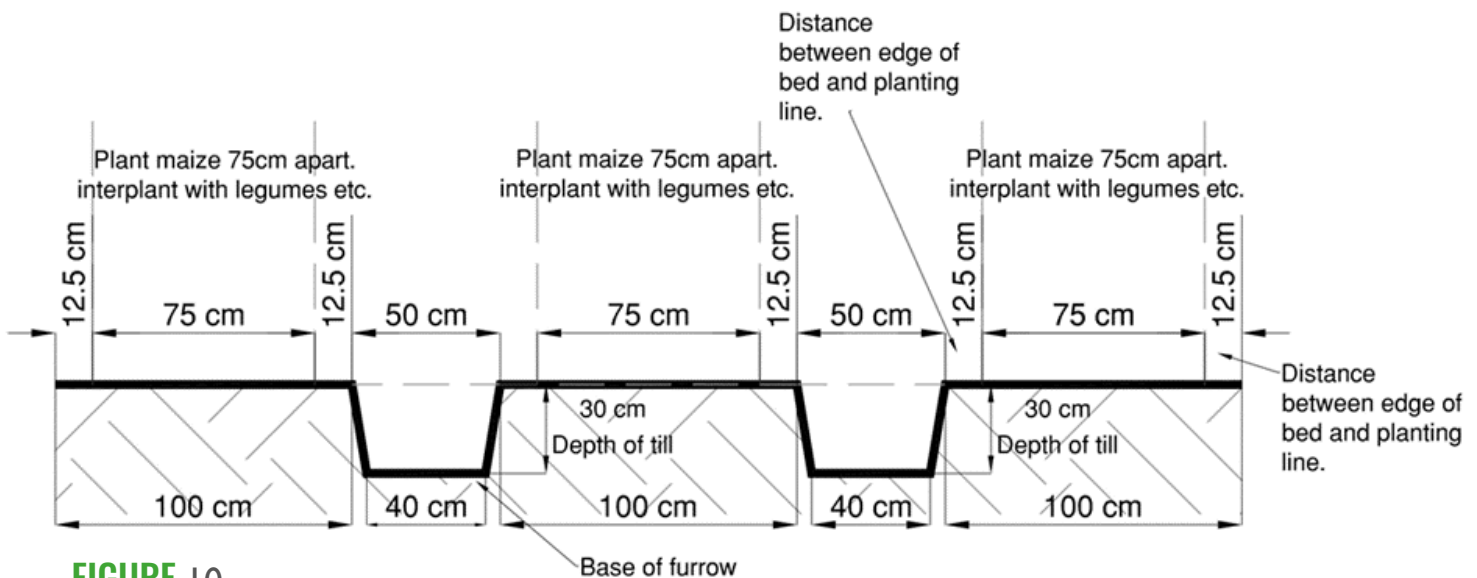


FIGURE 10

Cross section of deep beds

CROP ROTATION AND INTERCROPPING

Crop rotation is the practice of growing a series of different types of crops in the same area in successive seasons. In the DBF system crop rotation between legumes and cereal crops is encouraged. Intercropping with legumes (e.g. groundnuts, beans or soya) can be practiced where land is limited. Plant spacing and arrangement varies depending upon the crop varieties adopted. Different crops have different growing requirements in terms of root depths, nutrient demands, and the biological activities associated with these.

Benefits of crop rotation include:

- addition of various nutrients to the soil; a traditional element of crop rotation is the replenishment of nitrogen through the use of green manure in sequence with cereals and other crops, consequently bringing about an increase in the production of food grains
- reduction in the build-up of pathogens and pests that often occurs when one species is continuously cropped
- improvement of soil structure and fertility by alternating deep-rooted and shallow-rooted plants
- assistance in weed control and pest control. When a crop is changed, the cycle of disease or pest is broken. Northern Leaf Blight is a good example of a disease that has increased over the last several years, and can be reduced by rotating maize and soybeans
- reduction in the risk of total crop failure, so crop rotation plays a key role in enhancing livelihood resilience

C) PLANT VETIVER GRASS ON MARKER RIDGE

Vetiver grass should be planted on the upper side of the marker ridges with the first planting rains which are normally November to December.

Space the Vetiver at 10cm or one hand palm apart.

Vetiver grass (*Vetiveria zizanioides*) can have a significant impact on soil and water conservation:

- the roots grow exclusively downwards to a depth of up to 4m, helping to stabilise soil terraces and ridges, and preventing erosion by wind or rainfall runoff
- water is retained in the soil where vetiver grows, since the roots reduce the speed of subsurface water flow
- attracts species of stem borer, diverting these pests away from attacking food crops
- can be used for mulching, which increases water infiltration and reduces evaporation
- leaves can be used to feed livestock
- can be used for thatching materials, construction and craft making

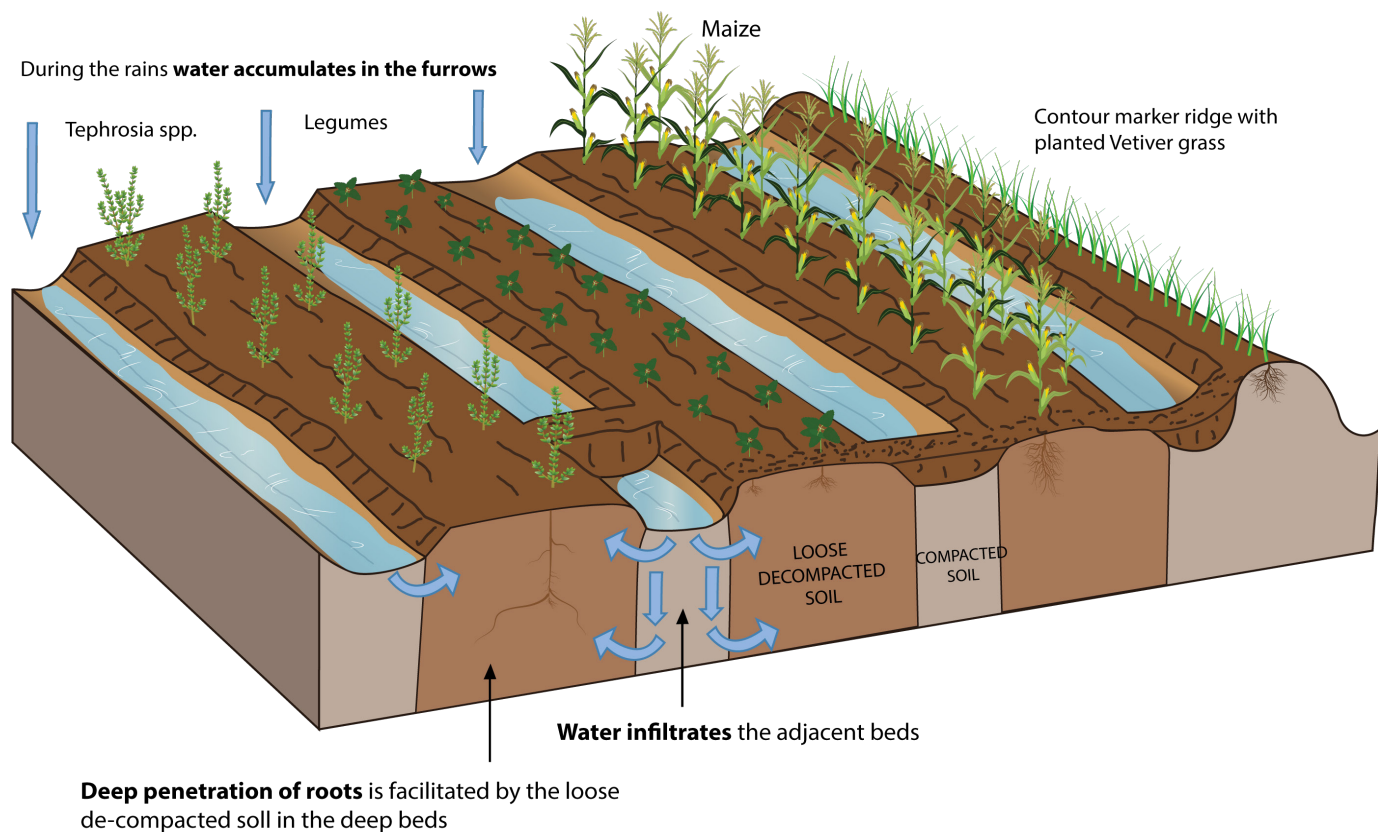


FIGURE 11

Layout of the DBF system during cultivation – here the deep beds have a typical multi-cropping arrangement where maize is grown alongside leguminous and other vegetable plants (beds are also rotated between growing seasons)

D) PLANT AGROFORESTRY (TREES AND SHRUBS)

Agroforestry involves land use management so that beneficial trees or shrubs are grown around crop cultivation systems. On the farm it usually involves the planting and incorporation of species that provide socio-economic or environmental benefits. These include:

- soil fertility – species such as *Tephrosia vogelii* and *Sesbania sesban* have been proven to have a positive impact on the yield of crops (particularly maize) grown around them due to their nitrogen-fixing capacity
- organic pesticides – the juice from the leaves of *Tephrosia vogelii* can be used as a natural pesticide
- fodder for animals – leaves of some agroforestry shrubs are palatable to livestock, and can therefore enhance meat and milk production
- fruit – papaya, mango and banana are commonly planted in or around farms, providing alternative income and nutrition
- timber and fuelwood – growing wood on farms reduces the pressure on natural forested areas
- ecosystem services – research suggests that on-farm trees and shrubs add to biodiversity, help stabilise the soil, enhance water infiltration, act as windbreaks and sequester carbon

For these reasons, agroforestry is a key part of the Tiyeni DBF system. Tiyeni encourages the planting of several species between December and January.

E) WEED AND MULCH

Weed Control

All crops planted in DBF are found to suffer less from weeds. This is because weeds can be discouraged by top dressing with mulch. However, some weeds need to be removed as soon as they appear. Weeds can be removed by:

- cutting the weeds with a dutch hoe or slasher
- pulling weeds while standing along the furrows
- using a small weeding hand-hoe without trampling on the beds (which would cause compaction)

Weeds can then be used as a mulch. Pulled weeds should be laid as mulch at the beginning of the day so that their roots dry out.

Some weeds, such as Khokwa (*Commelina diffusa*) should be removed entirely – they can be fed to the pigs or buried deep in the soil.

Note that crop rotation and cover crops help to control some weeds, e.g. sunflowers help reduce the growth of witchweed (*Striga spp.*) in a field where maize was cultivated previously.

Mulching

Mulching involves leaving a loose covering of organic material (e.g. maize stalks) on top of the cultivated raised deep-beds. This layer should be 5-7cm thick. The advantages of this include:

- protecting the soil from the direct impact of rain drops and sunlight
- maximizing water percolation
- protecting the soil from water and wind erosion
- reducing water loss from the soil by evaporation
- maintaining conducive soil temperatures for germination and growth of crops, and to support soil organisms
- encouraging termites to digest the mulch so that dry cellulose is taken down into the ground which acts as a fertiliser
- suppressing the germination and growth of weeds

F) APPLY MANURE (BASAL + TOP DRESSING) – FERTILIZING THE SOIL

Apply basal fertiliser at crop emergence

A basal application of 5 x 50kg bags of compost manure (often mixed with some NPK – this can be phased out in due course) per 1 acre (0.4ha) maize field should be applied between planting stations at crop emergence using cup number 22 (found in all shops of Agriculture Trading Centres)

Apply top dressing 2 weeks later

Apply a top dressing of 5 x 50kg bags of compost manure (often mixed with some Urea – this can be phased out in due course) per 1 acre (0.4ha) maize field. Apply between planting stations 2 weeks after applying basal using cup number 22 or apply top dressing before the 28th day from the date of planting maize.

5. HARVESTING

DBF is in high demand by farmers because it demonstrates a consistent increase in crop yields, compared to traditional farming practices. Yields approaching **10,000kg per hectare** for dried maize are attained by smallholder farmers practicing DBF.

- harvest only when maize cobs are completely mature / dry
- only harvest the maize cobs, leave roots in the ground
- maize stalks are cut and put on the beds, stooking is discouraged
- legumes such as beans and soya should be harvested using a sickle so that the roots remain in soil
- crop residues should not be taken away or burnt, but incorporated in the beds

6. BED MAINTENANCE & PREPARATION FOR YEAR 2

BIOLOGICAL BED MAINTENANCE

Plant green manure cover crops (GMCC) - any species of plant, usually a legume, whether it be a tree, a bush, a vine, a crawling or a waterborne plant, that farmers use to maintain or improve their soil fertility or control weeds [Bunch, 2019]. GMCC is becoming increasingly important in dealing with the impacts of climate change. Farmers who adopt DBF should plant GMCCs to get the most benefits of the technology.

Common crops that can be planted are pigeon peas, cow peas, lablab beans, mucuna, soybeans, peanuts, pumpkin, etc. Some of these such as pigeon peas and lablab beans are perennial.

Compost manure application and organic mulching are important bed maintenance practices which sustain the economic usefulness of the bed. These activities are done between October and May.

PHYSICAL BED MAINTENANCE

With time, the sides of the bed erode into the furrows where soil settles. When this happens, some minor physical bed repair activities may be required to maintain physical measurements of beds and furrows.

Physical maintenance practices also include reshaping boxes in the furrows, ensuring raised footpaths are high enough, and keeping closed furrow ends and field boundaries.

These activities are normally done between early December and end of February.

WEEDING

Continue weeding to planting in year 2.

Weed early when weeds are still small and before they flower. Weeding is done by cutting weeds at base using a light hoe. You should weed anytime when weeds appear in your field, even after harvesting your main crop.

If small weeds are pulled up, then it is a good idea to weed in the morning laying the pulled weeds as a mulch which the sun will dry out during the day.

MULCHES, MANURES AND COMPOSTS

Compost making is an essential part of Tiyei's DBF system. "Look after the land and it will look after you. Feed the soil, the soil will feed the plants and the plants will feed you."

Central to improving soil health and fertility is the application of appropriate composts and mulches. DBF involves the incorporation of these as vital components of good land husbandry and soil regeneration.

MULCHES

Mulches are formed by laying vegetative materials (such as crop residues, vetiver grass, agro-forestry leaves, pulled or cut weeds etc.) on the surface of the beds. The principle is to protect the soil from sun, impactful rain and wind, with all the benefits as outlined in section E above. The aim is to ensure that bare earth is never left exposed to the elements.

MANURES

Manure is the common name for animal dung, often mixed with animal bedding. Manure is commonly collected from cattle, pigs, goats or chickens. The chemical and nutritional makeup of these manures are different, but the high level of nitrogen in them all becomes a powerful ingredient in making good composts. They should be allowed to decompose in mixed compost as they should not be applied to beds while still 'fresh'.

COMPOSTS

Composts are a vital ingredient in making and feeding healthy soil. Healthy soil with all its millions of living organisms will feed and look after the plants, so it is the soil that needs care and feeding. There are many types of composts and many different ways of making them. However, they all have one thing in common - they are a mixture of natural ingredients: crop residues, leaves, cut grasses, maize bran, ash, charcoal and of course, water. Water is the 'activator' which starts the process of decomposition. Decomposition is the breaking down of all the materials in the mix to create compost. That is how it gets its name.

The two main methods of composting used in Malawi are Bokashi and Mbeya. The former uses fermentation in part of the process, and the latter uses more ash. However, farmers are best placed to decide what mixture is best for their land. More details of how to make different types of compost can be found in the Appendices.

SOIL KNOWLEDGE AND TESTING

Farmers know the most about their own land and are always encouraged to observe, know and understand how their soil is performing. Often, farmers may get the chance to have their soil tested in a government research laboratory, particularly if plants growing in it are not doing well. However, if the land is farmed under DBF principles, with mulch and compost, problems with the soil are much less likely.

TIYENI'S ROLE

TIYENI'S TRAINING PHILOSOPHY

The training of farmers by Tiyeni staff is a wholly collaborative methodology. It starts with a request from a community to learn about and adopt DBF, usually because they have observed DBF and its benefits elsewhere.

The training has 3 distinct but interconnected foundations: the Physical, the Biological and the Social. Earlier in this manual you will have seen the physical elements such as breaking the hardpan and forming the beds, marker ridges and footpaths, etc. You will also have seen the importance of soil care, plant care and soil health. These along with social capital are the fundamental foundations of a healthy farm with good land husbandry.

SOCIAL CAPITAL

Tiyeni and its staff adhere to a number of principles. The very first one is that we only train farming communities upon their request. Tiyeni's job is to react to the needs of farming communities by responding to these requests. The Tiyeni team then needs to engage with donors in order to cover the costs of training a community.

Once Tiyeni has found finance, Tiyeni and the village will arrange a meeting where training in DBF commences. Training takes place on different farmers' gardens to ensure all understand each other's land and share best practices. Training is carried out in a collaborative atmosphere, where, during each training day, farmers' ideas and challenges are discussed and suggested solutions activated. It is also at these times that misconceptions about farming, the soil and DBF are discussed.

Farmers are encouraged to take on the various elements of DBF, but these elements are a basket of different technologies and not all the elements apply to all the land. One size definitely does not fit all, and adaptive capacity is key. As a result of this, many farmers adopt those elements of DBF most suited to their particular land and circumstances. And during exchanges of ideas, Tiyeni staff are able to explain the reasons why some of those elements are so vital for the health of the soil and the livelihoods of the community, such as preventing water from running downhill, and never exposing the soil to the elements.

Without the right social approach, embedded into which is a healthy respect for the knowledge and skills of each farmer, the training of communities in DBF cannot be successful. The engagement of the farming communities is the bedrock upon which Tiyeni's philosophy is built.

IMPLEMENTATION

The sustainability of the DBF system is based on farmer adoption and retention of the technology, it normally takes one growing season for the farmer to make an informed decision. Each farmer is central to the development of DBF.

Tiyeni provides training and undertakes follow-up visits to all those trained to ensure that the technology is well followed and does not go 'off-message'. However, farmers often discuss variations to the methods because of their particular circumstances and this knowledge is often useful to Tiyeni staff.

The follow-ups are done in conjunction with the Agricultural Extension Development Coordinators (AEDC) and Officers (AEDO) of the Extension Planning Area (EPA) to make sure that the vital elements of DBF are not lost by mistake. Follow-ups of the activities in these EPAs are done twice, two months after training. The first follow-up is done in the sections while the second follow-up is done at the EPA level during their fortnight meetings.

Subsequent follow-up and supervision are increasingly done by District Agriculture Offices (DAO) and EPA staff (AEDCs and AEDOs), thereby ensuring sustainability. However, Tiyeni continues to monitor and supervise for a second full year, after which the project is handed over to the Ministry of Agriculture. Where appropriate and requested, a refresher course may be organised to meet some of the challenges AEDOs or Lead Farmers encountered during process.

For more information, go to our website www.tiyeni.org

RECORDING AND MONITORING

The success of Tiyeni over the years has hinged upon the sharing of ideas, experiences and practices of its application in the field. As a result, the Tiyeni method has been adopted, adapted and continuously improved from the grassroots up. It is only through observing and monitoring its impacts that this process can continue so that its benefits are maximised now and for future generations.

Monitoring and recording does not have to be technical or require specialist knowledge. Most farmers are active researchers, who constantly observe and take note of changes occurring in their farming environment. Farmers have a wealth of experience and knowledge of their land and the changes in environmental variables such as:

- soil and water quality and quantity
- vegetation including trees and shrubs
- animal and pest species
- crop yields
- climatic conditions such as rainfall and the occurrence of drought

Farmers are the eyes and ears of Tiyeni practice, and are the people best placed to observe and monitor the on-farm experiences and impacts of the DBF system over time. The sort of questions we ask are:

- Has adoption of the DBF system led to more household income being available?
- Has adoption of the DBF system led to an increase in well-being among those using it?
- To what extent have people's vulnerability to shocks and pressures changed? Are people more resilient now they have adopted the DBF system?
- Have deep bed users experienced an increase in food security?
- Has the DBF system sustained the natural resource base? Is there evidence of degradation, or enhancement?



DEEP BED FARMING FOR A SUSTAINABLE FUTURE

Founded in 2005, Tiyeni is a charity and non-governmental organisation dedicated to supporting the development of sustainable and resilient livelihoods among farmers in Malawi, through providing training and extension support in its unique Deep Bed Farming (DBF) method.

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