World Agroforestry Centre

CONSERVATION AGRICULTURE WITH TREES

GETTING STARTED

Joseph Mutua, Jude Capis and Mieke Bourne

Prepared by: Dr. Joseph Mutua (Kenya Network for Dissemination of Agricultural Technologies, KENDAT) , Jude Capis, and Mieke Bourne (World Agroforestry Centre, ICRAF) for the EverGreen Agriculture project

Layout and Design by Danyell Odhiambo

What is conservation agriculture with trees?

Conservation Agriculture With Trees (CAWT) is a practice that combines the principles of Conservation Agriculture with Agroforestry. CAWT involves the integration of crop-friendly trees, mainly high value agroforestry tree species and nitrogen fixing trees into the crop land with Conservation Agriculture practices.

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

Conservation agriculture is characterized by three principles namely minimum tillage, maximum soil cover and crop rotation and/or association. The emphasis is on the protection of the top soil layer which is responsible for sustaining crop life but is also the most vulnerable to erosion and degradation.

Agroforestry on the other hand can be simply defined as the inclusion of trees in farming systems and their management in rural landscapes to enhance productivity, profitability, diversity and ecosystem sustainability.

Why is CAWT good?

Conservation agriculture, including agroforestry, specialty crops, and permanent cropping systems, promotes food sufficiency, poverty reduction, and value added production through improved crop and animal production, and production in relation to market opportunities.

It is also worth noting that incorporating trees into crop farming may offer sustainability benefits such as producing more food while at the same time minimising the impact of food production on the environment and may also increase the resilience of the farm enterprise to climate change through greater drought resilience.

Principles of conservation agriculture

a) Minimum or reduced soil disturbance

This principle focuses on minimal or little soil disturbance such that the soil is not ploughed or turned. Continuous turning of the soil destroys its structure, eventually forming a hard pan that prevents water infiltration and proper crop root development. Instead of ploughing and harrowing, the soil could be sub-soiled using a sub-soiler and then ripped using a ripper to make furrows for seed placement.

Alternatively, direct planting could be done using a hand operated equipment such as the jab planter, animal or tractor drawn direct planter. Where animal drawn equipments are not used, farmers may dig planting holes for seed placement. These equipment are further explained in the booklet.

Minimum soil disturbance during land preparation

b) Maintaining soil cover

This principle focuses on having a protective layer on the soil surface. This is done by inclusion of live cover crops such as *Dolichos lablab*, *Mucuna*, sweet potatoes, cow peas, peas or beans etc or spreading of dead vegetative material from crop residue. Agroforestry tree species can also be used to provide aerial soil cover through their shade and for pruned material to be applied as mulch.

Minimum soil disturbance during land preparation

Covering the soil reduces its chances of being eroded by moving water or wind, conserves soil moisture, reduces weed growth and increases the rate of water infiltration into the soil while reducing evaporation.

c) Crop rotations/associations

Crop rotation is the practice of growing two (or more) types of crops with different characteristics in the same space in sequence e.g maize and beans. Farmers should plant several crops in rotation or as intercrops (crop mixes) rather than planting a single crop in a season or year so as to maintain the soil nutrient levels as well as reduce infestation by pests. Crop rotations should include legumes such as beans and pigeon peas as they fix nitrogen into the soil and improve soil fertility as well as deep-rooted crops which aerate the soil & high-residue crops which can be used for mulching.

Agroforestry and conservation agriculture

Agroforestry involves combing tree planting with another agricultural enterprise such as grazing animals or crop production or managing a woodlot for a diversity of special forest products (firewood, biomass, feedstock, straw mulch, fodder for grazing animals, and other traditional forest products). At the same time the trees are sheltering livestock from wind or sun, providing wildlife habitat, controlling soil erosion, and in the case of most leguminous species fixing nitrogen to improve soil fertility.

Farmers usually adopt agroforestry practices because they want to increase their income levels and want to improve the management of natural resources under their care as well as obtain products such as firewood, biomass and fodder for animals as well as material used as mulch.

Faidherbia albida growing in a cropland

Integration of woody perennials within CA practices

Growing legume trees and shrubs helps improve soil fertility by the fixing atmospheric nitrogen, thus enriching the soil with nitrates. With appropriate selection of tree species and good management this can substantially reduce the requirement for inorganic fertilizers.

In addition to this, spreading pruning materials (leaves and litters) of these nitrogen fixing legumes on the soil's surface adds carbon and enables better retention of water as well as increasing the content and efficiency of fertilizer use.

Pruning materials used as mulch also reduce the soil temperature, thereby enabling a better build up of soil fauna that helps crop productivity. Therefore, the integration of tested trees into farming practices (agroforestry) has the potential to sustain land productivity in addition to providing useful tree products such as firewood, fruit and fodder.

Why practice conservation agriculture with trees?

Conservation agriculture with trees (CAWT) provides the means to further prevent the destruction of precious soil, ensures higher and more stable yields while reducing production costs and increases labour productivity.

Benefits of practicing CAWT

Some of the benefits of practising CAWT may include:

- Increased yields and food security
- Better crop establishment and growth
- Improved soil fertility
- Weed suppression through mulching and tree canopy cover
- Reduced soil erosion
- Lower production costs and better returns to farming

Some of the initial setbacks may include:

- Change in mindset from the familiar conventional agriculture farming system
- High cost of inputs such as herbicides and equipment during the initial stages

How can a farmer practice CAWT?

Conversion to CAWT requires a change in mindset and the process is bound to be gradual. Farmers require clear guidelines to implement and manage the change at their own pace, learning, innovating and adapting along the way.

First, farmers need to recognise the shortcomings of their current farming practices and be willing to try other alternative forms of farming. This involves change from the easy and familiar conventional farming culture and this step is perhaps the most difficult part. Once a farmer expresses the desire, willingness and commitment to convert to CAWT, the general guide to follow is:

1. If burning crop or weed residues, grasses or any other types of vegetation has been part of the farming practice, you need to STOP doing this immediately. The material can be better used as a resource on the farm to provide protection to the soil and help build-up of soil organic matter

2. Based on the condition of the farm, you may need to take some corrective measures before switching to CAWT. Soils with low fertility should be improved with some cover crop species that can provide restoration cover, mainly legumes. If resources are available, you may have the soil tested for its nutrient content and level of acidity. This will give guidelines on the correct fertilizers and soil improvement methods to use, such as lime. If the farm lies on a sloping land, consider constructing appropriate soil conservation structures.

3. Many years of conventional tillage may have resulted in compacted soils. Check the presence of hard pans first and if present, remove by sub-soiling. Hardpans can easily be detected by digging a soil profile from which the hardpan will be clearly visible as a layer of compacted soil. A quick method is to uproot plants from the ground and observe the direction of root development. Roots pointing sideways indicate that the field most likely has a hardpan.

A hard pan is a dense layer of soil that restricts root growth and makes it difficult for water to penetrate through

4. Plant the main crop following recommendations by your agricultural extension officer only without the initial ploughing. You can use the common hand hoe to dig planting holes (pitting) as this practice will saves the time that would have otherwise been spent digging the entire field and weeding, and drastically reduces soil loss to rains. You can also make planting furrows using animal-drawn equipment such as the Magoye ripper instead of ploughing. Seed and fertilizer are then placed inside the furrow by hand or by using a jab planter, or even an appropriate animal-drawn planter. (**see photo on page 8**)

Ripping is the process of loosening the soil by making deep furrows (usually more than 30 cm deep) using a ripper where you intend to plant

5. In the initial stages there will be too many weed seeds still in the field. You may need to use herbicides to control the ensuing heavy weed growth. Gradually phase out herbicides as the cover crop intensifies and more soil cover becomes available to suppress weeds. In later stages the weed infestation will reduce drastically if appropriate weed control strategies are employed. Such strategies include constantly checking for weeds during the crop growing period (and after) and uproot or weed on the surface without turning the soil too much before they flower. If the farmer does not have access to herbicides or does not wish to use them, the alternative is to simply slash or slightly scratch the weeds till they are removed and leave them to dry on the surface.

Furrows made by a ripper

6. Plant a suitable cover crop between the rows of the main crop. The cover crop will eventually grow and spread to protect the soil and suppress weeds, even after the main crop has been harvested and depending on the cover crop, it may be planted with or after the main crop.

7. Practice crop rotations, changing crop sequence or intercrop with other crops (e.g. mucuna, lablab or pigeon peas intercropped with maize) as well as agroforestry tree species such as *Tephrosia spp, Leucaena spp, Calliandra calothyrsus* and *Gliricidia sepium* planted when the maize crop is around 45-60 cm high. This will decrease the occurrence of pests, diseases and weeds as well as protect the soil.

8. After harvesting the crop, the crop residue should left on the soil surface. If livestock is part of the farming practice and the crop residue is used as feed, you need to make sure that at least 30 to 50% of the residue is left in the field. You can do this by cutting the top part of the plant and leaving the stovers in the field as well as pruning the agroforestry tree species planted and the pruned material used as mulch. Once the system is established, the animals will have plenty to eat. The animals should be grazed in a controlled manner and not allowed to roam freely.

9. You should also plant more trees that fix nitrogen or produce plenty of biomass when shedding their leaves and place emphasis on having more trees the land in every possible way. Examples include *Gliricidia sepium, Calliandra calothyrsus, Leucaena trichandra* e.t.c

10. You can start CAWT conversion in a small area of the farm and gradually introduce the conservation system to larger areas as you learn what is good for your farm and the positive results achieved.

11. If you have terraces, you should plant live material such as vetiver grass, napier grass, lemon grass, pigeon pea, *Gliricidia sepium, Tephrosia vogelli*, and other strong-rooted crops to make the structures stable. (**see photo on next page**)

Gliricidia sepium a nitrogen fixing shrub intercropped with maize

12. You should aim to eventually reach a situation where you can plant without ploughing through direct seeding. Planting is easier when done with specialized equipment among them the most common being the jab planter, animal-drawn and tractor-drawn direct seeders. These are available in the market and are capable of planting through mulch. If you do not have these equipment, you can plant using a planting stick.

A farmer demonstrates how to plant using a jab planter

Main challenges in the adoption of CAWT

Despite the advantages of conservation agriculture as a farming system, its uptake by farmers especially smallholders, has been slow. This is attributed to the mindset of the farmers in their cultivation culture, coupled with other constraints associated with the technology such as availability and cost of inputs, competing use of crop residue, weeds and initial higher labour requirements.

Under the smallholder integrated farming system, crop residues are mainly burnt during land preparation or used as animal feed/bedding, construction material, for cooking fuel and mulch. However, if conservation agriculture is to succeed, the competitive use of the residue must be minimized to allow for as much residue as possible to be left in the field as mulch with the use of Agroforestry tree species as a complimentary strategy.

Weeds pose a serious challenge in the initial stages of conservation agriculture adoption. This is because thousands of weed seeds already exist in the soil waiting for the right conditions to germinate. This implies that the seeds will be the first to germinate at the onset of the rains thereby posing serious competition to the crops. Farmers usually respond to this challenge by going back to conventional weed control methods which involve too much soil disturbance, thereby negating the intent of conservation agriculture. Thus, the issue of weed control must be dealt with appropriately for conservation agriculture practice to succeed.

Weed management and control in a CAWT system

Weeding should be carried out when the weeds are young, before they flower, so as to prevent them from producing seeds. The first step in weed control is to use clean crop seeds that are free from weed seeds infestation, in order to minimize chances of importing weeds from other fields or areas. The different weed control methods used in CAWT include:

a) Manual weed control

Manual weeding should be limited to techniques which do not involve excessive turning of the soil. Instead, a farmer should slash or scrape the weeds with appropriate tools. A light hand hoe with a wide blade can be used to cut weeds just below the soil surface. A slasher or sickle can also be used to slash weeds above the ground.

A shallow hand weeder or scraper is another weed control tool which can be easily fabricated by local artisans. It is easy to use, effective and fast. Weeding by hand tools takes a long time and will limit the area under cultivation. However, this is a viable option for smallholder farmers with less than 1 hectare.

b) Weed control using cover crops and other forms of soil cover

Cover crops cover the soil quickly and tend to suppress weeds growth. They can be planted at the same time with the main crop if moisture is limiting, or slightly later (2 to 3 weeks after). A good cover crop is one that establishes quickly and produces a lot of green matter to cover the ground.

Smallholder farmers prefer a cover crop which fits into their normal cropping system and which has multiple purposes such as food, fodder, fuelwood, etc. Examples of cover crops include Lablab (*Lablab purpureus*) and velvet beans *(Mucuna pruriens*). it is important for one to choose a cover crop which can grow well in his/her area.

Nitrogen fixing agroforestry tree species grown in association with cover crops have the added advantage of providing additional cover material for the next season.

Mulch when spread on the soil surface in the right amount leaves no space for weeds to grow. The greater the amount of mulch the fewer weeds can grow through the mulch. If you do not have enough crop residue, you should consider bringing mulch from other sources such as prunings from trees. Do not use mulch plants that have flowered and produced seeds as this will introduce new weeds into the farm.

Crop rotation prevents the buildup of weed populations. If you are not able to rotate your main crop, try to plant a different cover or an intercrop each season.

Herbicides are quick and easy to apply. The soil is left undisturbed. However, herbicides are expensive, often hard to find locally and require specialized equipment and knowledge. It is very important to use the right amount of chemicals mixed with clean water. Before using herbicides, make sure you know what to use, the safety measures and quantities required. Training is necessary to use herbicides correctly and safely.

You will probably need to use a combination of these methods to control weeds effectively. Traditional weed control methods which include burning crop residue before ploughing and allowing cattle to graze in the fields are not recommended.

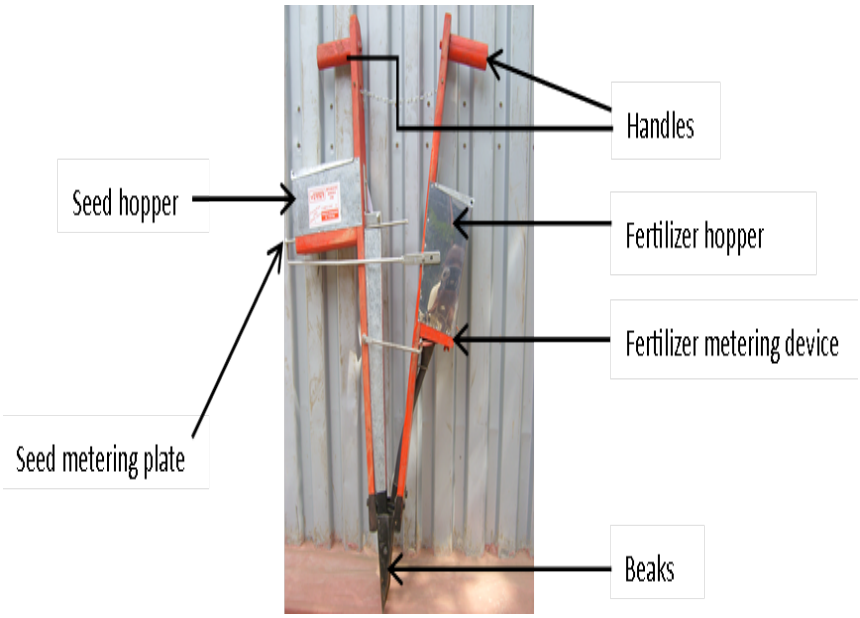
Equipments that can be used when CAWT

There are several equipment options available depending on size of farm, level of mechanization and CA practice.

a) Manual planting

In smallholder farming where farm sizes are small, and especially where animals used in cultivation such as oxen are not available, the hand hoe and the dibble stick and any other sharp pointed tool can be used to make planting holes. These tools are cheap and versatile and can be used to plant through mulch by opening planting holes only where you want to place your seed.

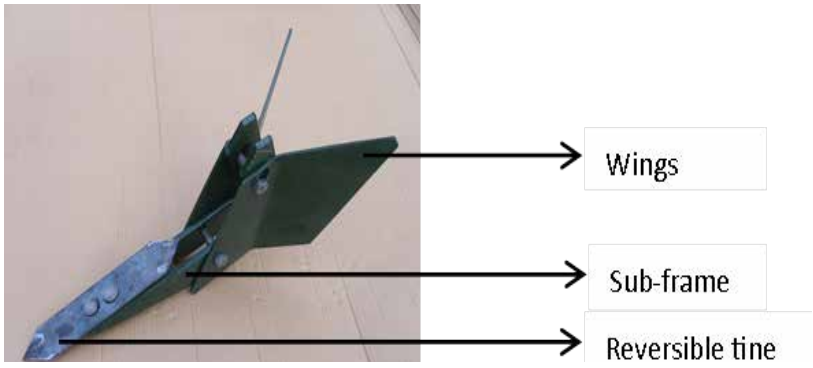
One tool that has been developed specifically for planting in conservation agriculture fields is the jab planter. It can be used to plant and apply fertilizer in one operation through mulch but is yet to gain popularity among farmers due to its cost. It quicker than hand hoe or the dibbler and can achieve better seed and fertilizer placement leading to better germination.



Various parts of a jab planter

b) Animal-powered planting and land preparation

Ripper planting is where by the planting furrows are made using a tool specifically made for that purpose known as a ripper.The ripper can be operated at shallow depths (10-15cm) to open planting furrows. Seed and fertilizer are then placed in the furrow and covered manually. This method of planting is used after land preparation through use of a sub-soiler a tool used to break up the hardpan in soil and is fast, uses less energy and labour than the traditional plough and can be used with single, smaller or weaker animals. However, it does not work well under mulch/residue conditions. In such case, the farmer may opt to use the direct seeding equipments to plant through the mulch.



Various parts of a ripper

Various parts of a sub soiler

c) Direct seeding equipment

Animal-drawn direct seeders/ planters are equipments that are operated using animals. These tools are now available and are capable of planting through surface mulch. Like the jab planter, seeding and fertilizing can be done in one operation. It is fast and causes very little soil disturbance. Germination is good resulting in higher yields than can be achieved with the ripper and hand tool. However these tools are expensive.

d) Tractor-drawn planters

Tractor-drawn planters are equipments operated using tractors and are readily available but are far more expensive than animal-drawn planters. Usually they are multi-row machines and will have typically 3-5 seeding and fertilizer units mounted in across beam and are more suited to planting in large farms in a short period of time.

Management of Agroforestry tree species in CAWT

Management of agroforestry tree species begins with selecting the right tree species for the right place. Tree species grown in different area develop adaptation traits to the areas they grow in and may not perform very well in areas of different climatic conditions. It is therefore recommended that you select the most suitable type (provenance and species) of the tree for the area you would like to plant.

Some of these management practices once you have the species include:

1. **Watering/ irrigating** which is crucial for young seedlings especially those that are newly transplanted.

2. **Fertilizing/manuring** is important for nursery seedlings or if plants are planted in infertile soils.

3. **Controlling weeds** is done to reduce competition between trees and other unwanted plants through activities such as spot weeding, use of herbicides and mulching around the base of each young tree. For trees intercropped with annual crops, weed control is done when weeding the crops.

4. **Mulching** involves placing dry leafy material at the base of the tree to conserve soil moisture by reducing loss of water through evaporation. This is crucial during the first few months after planting the trees in the field before full establishment especially if the rains are inadequate.

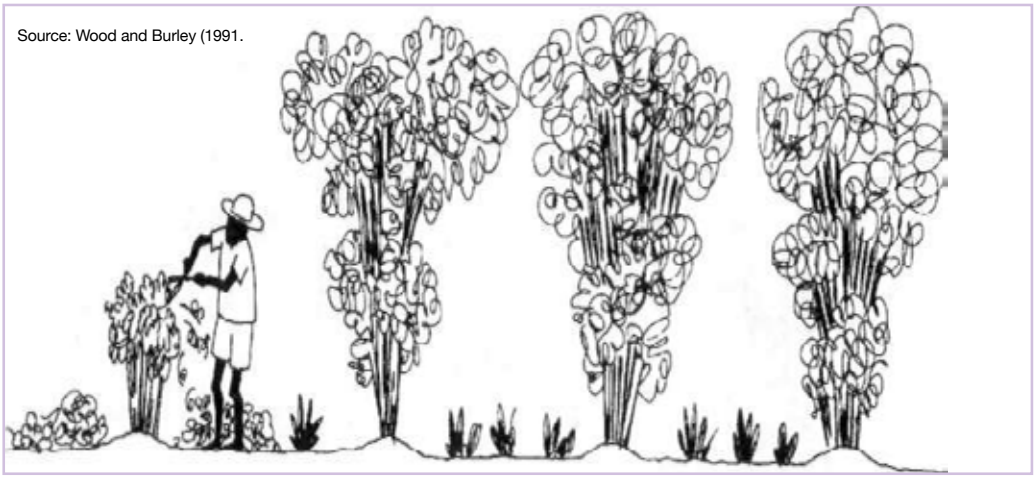
5. **Gapping** involves filling of gaps of trees that do not establish well. This practice ensures that the land is used effectively. You can either add trees of different species if they are superior to those you have (substitution), add more trees of the same species if satisfied with them (addition) or replace the poor variety of the same species with better variety (replacement)

6. **Thinning** happens when the trees grow big in the farm and occupy too much space that they compete among themselves and/or with other farm components. It involves removal of some trees that are too thin for the desired size, economic value and using the wood from the removed trees as building material, firewood or even sale.

7. **Coppicing** is a practice that is desirable when trees are planted in alleys in cropland and competition with crops needs to be minimized. It works best with species that are able to grow back after cutting and involves cutting a tree at or near the base so that it grows new shoots. The practice is also done for trees planted away from crop alleys if the species has ability to restablish after cutting because it substitutes the task of planting a new tree after a mature one is felled. For tree species intercropped with crops as alleys e.g leguminous shrubs, it is suggested that the tree be cut back at 30 cm from the ground.

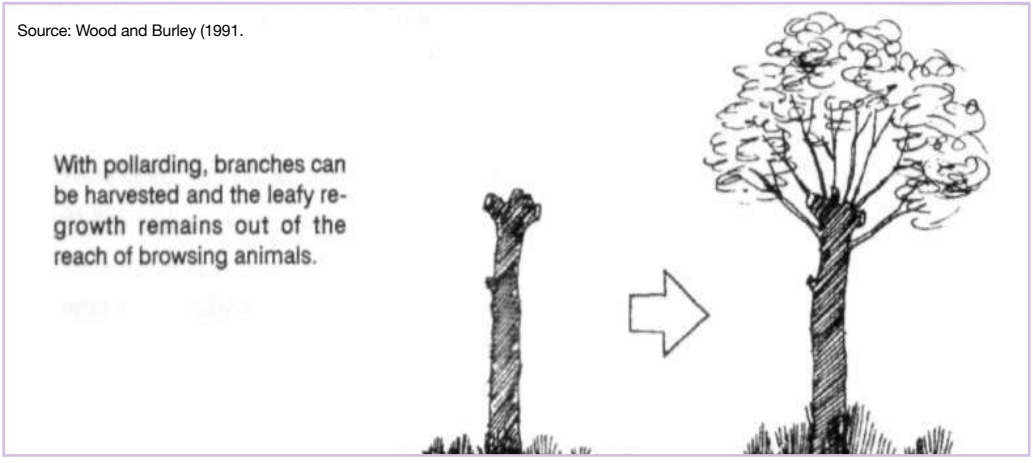
8. **Pruning** is conducted when the tree crowns are too huge and involves removal of branches from the lower part of the crown. In this practice, branches are cut near the stem to reduce shade for intercropped cereals, increase yield because lower branches respire more than they photosynthesize compared to branches in the upper parts of the crown. Pruning can also be conducted if you are interested in getting early harvest for desired product such as fuelwood.

Source: Wood and Burley (1991.



9. **Pollarding** involves cutting the tree at the top to control growth of the shoot tip and encourage lateral or side growth mainly for forage while reducing shading of underneath crops. The practice also works best with species that re-grow easily after cutting.

Source: Wood and Burley (1991.



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World Agroforestry Centre is a
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World Agroforestry Centre, United Nations Avenue , Gigiri
P.O.Box 30677-00100, Nairobi, Kenya
Phone +(254) 20722 4000, Fax + (254)207224001,
Via USA phone (1-650) 833-6645'
Via USA fax (1-650) 833-6646
Email: worldagroforestry@cgiar.org
Website:www.worldagroforestry.org