ECHO® Best Practices Note

No. 6

Conservation Agriculture
Best Practices for Resource-Limited Smallholder Farms

Relay cropping of rice bean and maize in Thailand

INTRODUCTION

Much of the content below is drawn from previous ECHO publications available online at www.ECHOcommunity.org. References to these are abbreviated as AN (Asia Notes), EAN (East Africa Notes), EDN (ECHO Development Notes) and TN (Technical Notes). Where possible, website links as of this writing (2016), are provided for references cited.

What is conservation agriculture?

Conservation agriculture (CA) is a resource-saving land management approach that optimizes and sustains the capacity of soils to produce food. In CA, sustainability is linked to the ecological preservation of agricultural landscapes. This is achieved through 1) minimal soil disturbance, 2) keeping soils covered, and 3) crop diversification. Implementing these three elements requires a combination of practices, for which there are many options. Thinking of CA as an overall system, rather than a fixed set of techniques, gives farmers and practitioners the freedom to evaluate and adopt a set of CA-related practices appropriate to local needs.

What problems does conservation agriculture address?

Farmers in many parts of the world, because of human population growth, have little choice but to crop their land continuously, with scarce resources to replace nutrients withdrawn by each successive crop. Crop residues are often lost as a source of organic matter and mulch, usually through burning or by removal for animal feed or cooking fuel. Especially where nutrient reserves are already low, and topsoil is exposed to erosion (Figure 1), soils lose their capacity to sustain adequate crop yields. Additionally, extreme weather events, adverse changes in climate, human conflict, and sickness can all work against smallholder farmers' abilities to sustain the productive capacity of their soils.

Figure 1. An example of soil erosion seen in Tanzania. *Source: Stacy Reader*

What's Inside:

by ECHO staff

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Conservation agriculture is a means by which the cycle of land degradation can be reversed. Minimizing soil tillage, keeping soils covered, and diversifying crops all help to preserve soil structure and biology, retain moisture and nutrients, guard against soil erosion, and maintain organic reserves of soil fertility. Farmers are most likely to benefit from CA when all three of its elements are implemented together (Corbeels *et al.* 2014). As growing constraints vary with location (EAN 1), an understanding of underlying principles is key to selecting best-fit CA practices for each local context.

Soil Tillage\ Principles

Agricultural uses

On previously uncultivated land, tillage creates the conditions in which planted seeds have good contact with the soil and can grow without competition from weeds. With technology ranging from a simple hoe to tractor-drawn implements, tillage has also been used to break up compacted layers of soil, control soil-borne pests by exposing them to sunlight, incorporate cover crops and fertilizer into the soil, and to uproot and bury weeds.

Soil structure

Frequent soil disturbance, however, can negatively impact soil structure. Excessive tillage–particularly when the soil is repeatedly inverted and left bare–also adversely affects soil microbial life and organic matter (Kushwaha *et al.* 2001), both of which help soil particles to “aggregate” (stick together). Soil aggregates become smaller each time they are broken apart. As soil porosity (open space between soil particles) declines, more and more rainfall runs off the soil surface instead of being retained in the field. Loss of topsoil to erosion, in turn, accelerates the depletion of nutrients and land degradation.

Weed management

While cultivation kills many weeds, it can increase proliferation of others. Tillage cuts weeds into pieces, spreading those that propagate via underground stems. Also, tilled seedbeds favor germination of weed seeds in addition to crop seeds. Weed seeds buried by a plow can lie dormant in the soil and then germinate when brought closer to the soil surface through subsequent tillage.

Weed seeds on the soil surface lose viability more quickly than buried seeds (Anderson 2005). Consequently, with no additional weed seeds added to the soil, the emergence of weeds declines more rapidly in non-tilled than tilled soil (Mohler 1993). To keep from adding new weed seeds to the soil, minimum tillage needs to be combined with a strategy for weed management.

Soil Tillage\ Practices

Keep tillage to a minimum

Some form of tillage, or herbicides, may be needed the first time a plot of ground is cropped. Thereafter, strategies can be implemented to avoid further disturbance of the soil.

“No-till” or “zero-till” methods involve no mechanical tillage. Seeding is done by pushing the seeds into the soil surface, as done with dibble sticks, or with equipment that creates a narrow slot into which seeds are placed.

Alternatively, various forms of “minimum tillage” can be used. Where the hoe is already relied upon for weeding, minimum tillage would require less behavioral change than going to complete no-till. In the Foundations for Farming and Farming God’s Way systems (EDN 98; TN 71), planting basins are dug with hoes. Hoes are also used to remove weeds when they are small, avoiding deep disturbance of the soil. The zai pit system, developed in West Africa, also makes use of planting basins; though they are labor-intensive to dig, they make it possible to produce a crop on ground that would otherwise be too hard/encrusted for plants for grow (TN 78).

Where flooding occurs, CA can be practiced utilizing permanent raised beds or ridges (EDN 127). Such an approach keeps crop roots above the water table while also avoiding the digging of new ridges each year. On steep slopes, these ridges are established along the contour to minimize erosion. Seeds are sown on top or on the sides of the ridges.

Combine minimal tillage with weed management practices

As mentioned earlier, weed control is important in systems with no or minimal tillage. One way to keep weeds in check is through judicious use of herbicides. Though controversial, their use enables weed management without disturbing the soil. Herbicides also reduce labor associated with weeding, making it easier to scale up CA (Nyamangara *et al.* 2014). Challenges and concerns to be aware of include cost, availability, negative impact on soil microorganisms, and resistance of weeds to herbicides. Where herbicides are accessible, training will likely be needed on safe and proper use. To minimize the environmental impact of herbicides, Bajwa (2014) suggests combining chemical weed control with approaches such as hand-weeding, mulching, optimal crop spacing (to shade weeds), and cover crops.

Some methods of hand-weeding involve less work than deep hoeing. At ECHO, we have found "scuffle hoes" (Figure 2) to be less laborious than conventional hoes for removing small weeds. Scuffle hoes cut weeds just below the soil surface, disturbing only a very shallow layer of soil. They also provide an easy way to weed underneath a layer of vegetative mulch. Such tools could be fabricated by local metal workers. Larger weeds can be cut off near the soil with a more traditional hoe, or chopped with a machete.


Figure 2. Push/pull scuffle hoes used for cutting off weeds just below the soil surface. *Source: Tim Motis*

Soil Coverage\ Principles

Mulch can be any material that covers and protects the soil. The type of mulch most applicable to smallholder agriculture is plant-based material, which can be living (as with cover crops) or dead (stalk and leaf residue that remains after crop harvest). Because of competing uses for crop residues, mulch is the most difficult component of CA to implement. Without it, yield gains are still possible if the other two elements of CA are combined with fertilizer and good pest management. Yet, mulch is critical to the success of CA, benefitting farmers and their soils in important ways.

Figure 3. Note the absence of weeds under a dense pigeon pea canopy. *Source: Tim Motis*

Weed suppression

Crop residues, if left on the soil surface, serve as a barrier that impedes light and the emergence of weeds. The leaf canopy of living mulch also deprives weeds of light (Figure 3). Weeding is laborious and costly, so eliminating one or more weeding operations is significant. This is particularly true in the context of small-scale agriculture, where 50 to 70 percent of farmers' labor time is spent hand weeding, and where most of the weeding is done by women and children (Gianessi and Williams 2011).

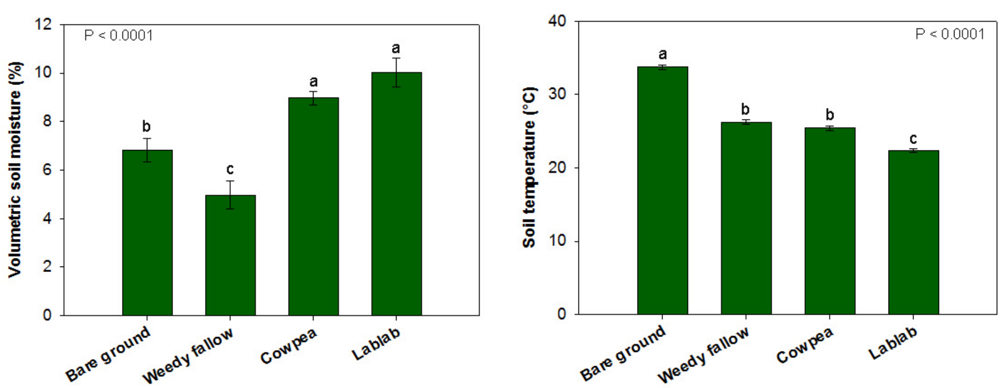
Soil erosion

Mulch protects soils from wind and water erosion, preserving valuable topsoil.

Soil temperature and moisture

Mulch also protects soils from the drying and heating effects of the sun. Unlike non-living crop residue, an actively growing cover crop withdraws moisture from the soil (Frye and Blevins 1989) as water is taken up by the roots and evaporated through the leaves into the air. At the same time, the canopy of live mulch conserves soil moisture by reducing evaporation of water from the soil surface. In an ECHO field trial in South Africa, dense cowpea (*Vigna unguiculata*) and lablab (*Lablab purpureus*) cover preserved soil moisture and cooled the ground (Figure 4).

Figure 4. Influence of living legume canopy on soil moisture and temperature in South Africa.



Soil moisture (20 weeks after seeding; with probe rods inserted to a depth of 20 cm) and temperature (18 weeks after seeding; 10 cm deep) in a legume screening trial by ECHO in South Africa. Data were taken from four plots per treatment (bare ground, weedy fallow, cowpea and lablab). Legumes were spaced 50 X 50 cm. Bars with differing letters are statistically dissimilar.

Nutrient release

Plants take up minerals from the soil over the course of their life cycle. Those minerals can be returned to the soil. As CA entails no or minimum tillage, above-ground biomass retained in farmers' fields remains on the soil surface. Above- and below-ground biomass (leaves/stems and roots, respectively) eventually decomposes, enriching the soil (Figure 5). Nutrient release rate depends on a number of factors, including how woody the tissue is. (This relates to carbon:nitrogen ratios; woody tissue contains more cellulose/lignin and, hence, more carbon than softer leaf tissue.) Thin-leaved legumes like velvet bean (*Mucuna pruriens*), typically degrade more rapidly than maize (*Zea mays*) stalks. Rates of decomposition and nutrient release also increase with increasing temperature, moisture and microbial activity.

Figure 5. Leaf litter under legume vines, illustrating the potential of mulch to enrich the soil. *Source: Tim Motis*

Soil ecology and organic matter

By protecting against erosion, moderating against temperature extremes, and by providing a food source for macro and microorganisms (e.g. earthworms and bacteria), vegetative ground cover contributes to a healthy soil ecology. As organic material is broken down by soil life, nutrients are released to the plants. Because organic matter decomposes quickly under high heat and rainfall, continuous ground coverage with plant-based mulch may be needed to maintain adequate soil organic matter in many tropical and subtropical areas.

Soil Coverage\ Practices

Grow a healthy crop

More biomass will be created if a farmer can use quality seed, manage pests and supply the nutrients needed for a healthy crop. Inputs are often scarce or expensive, making it necessary to maximize efficiency. Instead of amending an entire field, fertilizers can be used more efficiently by concentrating them in smaller amounts near crop roots. This is done through micro dosing (EDN 84) and the placement of inputs in planting basins or furrows/bands.

Figure 6. A field in Tanzania where farmers left the bottom third of the maize plants in the field. The top two thirds of each plant was removed for livestock feed. Note the small dust tornado in the background. Mulch reduces topsoil losses due to wind/water erosion. *Source: Stacy Reader's photo and personal communication with Neil Miller*

Leave residues in the field

Some crop residue may be needed for livestock feed, but as much as possible should be kept in the field. Figure 6 explains an approach that allows farmers to feed their animals while also leaving some soil cover.

Do not burn residues

Crop residues are sometimes burned to remove debris for ease of planting, and to kill crop pests. However, burning leaves the soil unprotected and kills beneficial organisms. Most nutrients are lost to the air. Those that are released to the soil are quickly lost due to leaching and erosion. In fields where trees are grown with annual crops, farmers have a strong reason not to burn crop residues.

Keep crop residues on the soil surface

In cooler climates, legume and crop residues are often incorporated into the soil, for several reasons. Less nitrogen is lost to the air (as ammonia [NH_3] gas) than with exposed mulch. Also, burying mulch makes its nutrients more accessible to plant roots and microbes. Incorporating residues, though, requires tillage. Also, in the warm tropics, ground coverage is necessary to protect the soil from erosion and from the heat of the sun. When combined with no- or minimum-tillage, surface mulch still contributes to soil fertility, as soil microbes are able to access surface residues through channels preserved in undisturbed soil.

Grow leguminous cover crops

Residues of staple crops are often insufficient to supply the amount of organic material needed to sustain crops and livestock over time. Manure is often in short supply or difficult to transport. Legumes are an excellent option for producing organic matter right in farmers' fields (TN 10). Choose legumes that benefit both the farmer (through weed suppression and possibly food/fodder options) and the soil (by protecting the soil from erosion and building soil organic matter). See Box 1 for other factors to consider. A booklet titled Restoring the Soil by Roland Bunch is an excellent resource for exploring cereal/legume systems that farmers have used in different parts of the world.

Box 1. Legume selection factors

Climate: Legumes for warm areas include cowpea (*Vigna unguiculata*), jack bean (*Canavalia ensiformis*), lablab (*Lablab purpureus*), pigeon pea (*Cajanus cajan*), rice bean (*Vigna umbellata*), tephrosia (*Tephrosia vogelli* or *T. candida*) and velvet bean (*Mucuna pruriens*). Of these, jack bean, lablab, pigeon pea and tephrosia are the most drought tolerant. For cooler areas, consider faba bean (*Vicia faba*), runner bean (*Phaseolus coccineus*) or hairy vetch (*Vicia villosa*).

Growth habit: Bushy, upright legumes (e.g. pigeon pea and bush types of cowpea, rice bean and velvet bean) are easier to manage and harvest than vining types. They are often preferred for more mechanized agriculture. Vining types cover the ground and produce plenty of biomass, but they climb the stalks of cereal grain crops.

Time to maturity: There are pros and cons for each legume. Cowpea, for instance, is capable of producing edible, dry beans well before the maize harvest. Lablab is slower to establish but produces a late-season harvest of edible beans on vines that persist longer into the dry season than cowpea. Long-duration pigeon pea varieties tend to produce more biomass than shorter-duration types.

Crop Diversity\ Principles

Soil health

Plant species differ in the mix of minerals they contain, and in the organic substances excreted from their roots. Consequently, diverse plantings are more likely to nourish a broad range of soil organisms–with increased nutrient cycling–than a single crop planted year after year on the same land.

Efficiency

Crops vary with respect to nutrient demand and rooting traits. Farmers can use these differences to their advantage in maximizing the efficiency of fertility resources.

- More nutrient-demanding crops like maize can benefit from soil-enriching legumes.
- Deep-rooted plants (Box 2) take up nutrients from deeper soil layers and make them available to more shallow-rooted crops.
- Shallow-rootedness can be advantageous in phosphorous-deficient soils. Phosphorus does not leach as readily as other nutrients and is often most concentrated near the soil surface where it can be accessed by lateral roots (Lynch 2011).

Box 2. Examples of deep- and shallow-rooted crops.

Deep-rooted plants include tall cereal crops such as maize; tap-rooted annual legumes such as alfalfa (*Medicago sativa*), lablab, and pigeon pea; and many perennials (e.g. nitrogen-fixing agroforestry trees).

Shallow-rooted crops include many grasses, most vegetables and annual legumes such as peanuts (*Arachis hypogaea*) and common beans (*Phaseolus vulgaris*).

As a general rule, trees produce the deepest roots, followed by shrubs and then herbaceous (non-woody) plants (Canadell *et al.* 1996; Maeght *et al.* 2013).

Resilience

Crops can be selected for tolerance to poor soils, periods of drought and salinity (TN 84). Diverse plantings minimize the risk of crop failure caused by a plant pest or disease or adverse climate shifts. Resilience to economic downturns, is strengthened through a range of products that can be harvested for family consumption or income generation. An ideal mix of crops provides options for economic gain while also sustaining the soil.

Scalability

Diverse plantings are often thought of as being most applicable to smaller, intensively-managed gardens. There are ways, though, to integrate multiple crops into field-scale plantings. A few such approaches are presented in the next section.

Crop Diversity\ Practices

Integrate legumes into field cropping systems

Intercropping

Intercropping entails growing two or more crops simultaneously, in the same field. Intercropping may be the best approach for areas with short rainy seasons. Spatial arrangement of the crops should make maximum use of the land. Some kind of row configuration is usually best for ease of management. Figure 7a depicts a row of legumes alternated with a row of maize. In Figure 7b, the grain and legume are grown in alternate 'strips,' with each strip consisting of more than one row. Strip cropping reduces crop competition, but legume vines may not cover all of the ground underneath the cereal crop.

Figure 7. Intercropping of maize with cowpea in alternate rows (in South Africa; A) or in strips (ECHO Florida; B). The strip cropping photo (right) illustrates a system, developed in Nigeria by the International Institute of Tropical Agriculture, in which four rows of cowpea are alternated with two rows of maize; farmers were willing to devote fewer rows to maize because of the high value of cowpea grain. *Source: Tim Motis*

Figure 8. An example of relay cropping in Thailand, with rice bean planted into maize near the end of the maize growing season. *Source: Rick Burnette*

Relay cropping is a form of intercropping in which the legume is planted into a cereal crop shortly before the cereal crop is harvested (Figure 8; AN 10). Sometimes the legume is planted only a few weeks after a main crop. However long, a delay gives farmers a way to integrate fast-growing, competitive legumes with staple grain crops. For relay cropping to work, the rainy season must be long enough to establish a delayed legume planting.

Rotation

A grain and legume crop can also be grown on the same field–or portion of a field–during alternate seasons. This approach minimizes competition and the possibility of pests moving from the legume to a main crop. Crops can be rotated between blocks of space within a field to allow the farmer to grow a staple grain crop every year. Within each of these scenarios, including that of intercropping, rotation can be used to break weed and pest cycles. For example, legumes can be planted into rows that had been devoted to a cereal crop during a previous season; likewise, a cereal crop can be planted into rows previously planted to a legume.

Integrate trees

The use of trees in CA is a form of "EverGreen Agriculture," a concept in which trees are grown for fuel, fertilizer, food (TN 69), fiber, and fodder. Trees can be integrated into the planting system in a number of ways:

Around the edges of a field

Planted around the border of a field, trees such as *Gliricidia sepium* can be used for live fencing (EDN 116; TN 23).

Dispersed in fields at wide spacing

In lowland regions of the tropics, annual crop plants have been shown to benefit from 10 to 15 percent shade, achieved by planting trees 10 to 15 m apart (EDN 89). In upland areas in Southeast Asia, fruit trees such as mango are sometimes dispersed in field cropping areas, which increases the diversity of farm products (Figure 9).

Figure 9. Widely-spaced mango trees in a rice bean field in Thailand. *Source: Rick Burnette*

In parts of Africa, Faidherbia (*Faidherbia albida*) trees are grown in association with annual cereal crops and/or legumes (World Agroforestry Centre; EDN 107). Faidherbia produces its leaves during the dry season, providing shade and a source of feed for animals during times of drought (Heuzé and Tran 2016). It then goes dormant during the rainy season, depositing an abundance of organic fertilizer (through leaves and pods that fall to the ground) and allowing light to reach the crops beneath the trees. This may not hold true in areas with both a short and long rainy season.

Farmer Managed Natural Regeneration (FMNR; TN 65), a system developed in West Africa, takes advantage of an "underground forest" of already-existing stumps (from previously-cleared trees). These stumps are allowed to regrow, with the regrowth managed to facilitate annual crop growth and to supply firewood and/or timber. A similar approach, built on FMNR but with more intentional planting of edible acacias, is the Farmer Managed Agroforestry System (FMAFS; TN 60).

In rows along the contours of hillsides

Tree rows can be planted along the contours of hillsides, with annual and/or perennial crops planted in the space between tree rows. This is done in a system called SALT (Sloping Agricultural Land Technology; TN 72; EAN 2), developed in the Philippines to reduce erosion on steep slopes. It incorporates crop diversification and mulch (tree prunings), and can be practiced using reduced tillage (Figure 10).

Figure 10. A form of SALT in northeast India, in which perennial crops such as betel nut palm (*Areca catechu*) are grown between rows of *Tephrosia candida*. Perennials require less weeding than annual crops. *Source: Rick Burnette*

Incorporate plants with varying root traits

The mix of plant species, whether grown together or in sequence, should be selected with root traits—and related soil/microbial interactions—in mind.

Implement a disease and pest management strategy

Crop diversification can reduce incidence of pests. Legumes, for example, have reduced incidence of the plant parasite striga in cereal grains (Gworgwor 2002; Kureh *et al.* 2006). A good mix of crops, grown together or in sequence, fosters beneficial organisms yet minimizes the harboring of plant pests and diseases. Consider adopting an approach called Integrated Pest Management (IPM) to reduce the risk of a plant pest or pathogen spreading from one crop to another. IPM involves monitoring pests for timely intervention, growing healthy crops in conjunction with natural pest control, and limited use of pesticides. In a two-part IPM approach called "Push-Pull" (EDN 77 and 116), border plants attract (pull) insect pests to the edges of the field and intercropped plants repel (push) insects away from the main crop.

Promotion of CA\ Principles

While CA has much to offer, care needs to be taken in how farmers are encouraged to adopt it. Remember that CA as a flexible system rather than a fixed set of prescribed technologies. This mindset, combined with a willingness to listen to farmer concerns, will foster mutual learning and discovery of effective context-specific CA practices. A few commonly mentioned CA-related concerns include:

- Scarcity of mulch to keep the soil covered.
- Limited access to manure or mineral fertilizers to augment essential plant nutrients; crop residues and nitrogen-fixing legumes do not always supply enough fertility to the soil.
- Labor involved in weeding, if no-till is practiced without effective weed control methods.
- Labor involved in digging planting basins that are often associated with the concept of CA.
- Flooding of planting basins that can occur in low-lying areas with high rainfall.
- Issues around land tenure, local culture and/or gender that impact receptivity to CA.

Once constraints are identified, farmers can help test and modify practices accordingly. For example, where manure is lacking, the community could explore ways to increase the number of animals, collect more of the manure from existing animals, and/or use existing supplies as efficiently as possible. Where mulch is lacking, assessment of competing uses for crop residues could lead to ideas that could be tested on small plots before large-scale promotion and implementation. Cultural and social issues can be dealt with, at least in part, by learning about and working in harmony with indigenous systems of innovation (see EDN 130 [end of article] for insight by Joel Matthews).

Promotion of CA\ Practices

Involve farmers in adapting CA to the local context

Learn as much as possible about authority structures, roles of men and women on the farm, and land ownership. Talk with farmers to find out what has worked or failed, what resources are available, what constraints they face, and what ideas they have for moving forward. Create opportunities for farmers to learn from each other.

Test potential components of CA in small plots, with input and participation from farmers. From 2010 to 2015, when ECHO staff members studied tropical legume intercropping strategies in South Africa, we found that a simple legume screening trial, designed to identify top-performing legumes, was also useful as a training tool. Farmers and scientists alike could walk the plots, observe the legumes first hand, and exchange ideas.

Consider costs and benefits

Take time to document short- and long-term costs and net returns of implementing CA technologies–both financial and in terms of labor. An FAO document (IIRR and ACT 2005) lists the following economic requirements:

- [CA] must bring the farmer a visible and immediate benefit, economic or otherwise.
- The benefit must be substantial enough to convince farmers to change their ongoing practices.
- Farmers must be able to cover the costs that are incurred.

Figure 11. A type of scuffle hoe called a "stirrup" or "push and pull" hoe, this one made in Tanzania. *Source: Stacy Reader*

Build capacity to support extension efforts

Invest in a project design with the structure (e.g. for management and reporting) and human capacity (e.g. farmers who have succeeded with CA) needed to build farmer knowledge. A focus on learning will more likely lead to lasting impact than subsidized inputs (Miller *et al.* 2014). Encourage and equip trainers to articulate a broad range of options that farmers can evaluate for themselves, rather than promoting a fixed package of practices. Concerning extension, key Modernizing Extension and Advisory Services (MEAS) insights were summarized by ECHO and are available online as ECHO Summaries.

Figure 12. Jab planter used at ECHO's demonstration farm in Florida (left) and a jab planter used in East Africa (right). *Source: Tim Motis (left) and Stacy Reader (right)*

Pay attention to gender issues

On smallholder farms, the roles of both men and women are vital. Seek to understand those roles, and involve women as well as men in developing technologies and making decisions.

Facilitate the creation of appropriate farm tools

Weeding and planting through surface mulch are typically the two main sources of extra labor with CA. Working with engineers and local blacksmiths to design and create CA-related tools could be extremely beneficial to farmers. Tools most likely to be used are those that meet a felt need (e.g. make planting or weeding less laborious), are affordable and that can be constructed with local materials. Figure 11 shows a variation of the earlier-mentioned scuffle hoe that was made in Tanzania. Jab planters (Figure 12) enable placement of seeds at a consistent depth with very little disturbance to the soil. The oxen-drawn ripper (Figure 13) has gained wide acceptance in Africa as a way to mechanize CA (Nyathi and Miller 2016). It opens up a narrow planting furrow with minimal soil disturbance. Not all farmers will be able to own such equipment; however, they may be able to hire the services of those who do.

Figure 13. Oxen-drawn ripper in use in Kitui, Kenya. *Source: Neil Miller*

CONCLUSION

With its emphasis on sustainable crop production through preservation of the environment, CA is very much relevant to resource-limited farmers who want to grow food while restoring marginal soils and protecting the long-term health and productivity of their land. It works best if all three elements of CA–minimal soil disturbance, continuous mulch, and crop diversification–are practiced at the same time. Each of these components can be implemented in different ways. Understanding the principles behind them is helpful in tailoring practices to local settings. Farmers should be equipped with knowledge necessary to effectively evaluate and select a set of CA-related practices that best meets their needs.

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ECHO DOCUMENTS

Access to ECHO Documents may require log-in information through ECHOCommunity. Please sign-in or register to take advantage of free membership.

A Combination of Approaches to Conserve Soil and Water (EAN 2)

Bottle-cap fertilizer (EDN 84)

Conservation Agriculture in East Africa: An Update (EAN 1)

Conservation agriculture in areas with high rainfall (EDN 127)

Dispersed Shade (in EDN 89 Vegetative and agronomic technologies for land husbandry)

Faidherbia, an important 'fertilizer tree' (EDN 107)

Farmer Managed Agroforestry System (TN 60)

Farmer Managed Natural Regeneration (TN 65)

Foundations for Farming/Farming God's Way (EDN 98; TN 71)

Green Manure Crops (TN 10)

Indigenous Systems of Innovation (in EDN 130 Effective use of workshops in agriculture extension)

Intercropping for Pest Control: The Push-Pull Approach (EDN 116) and EDN 77 [page 4 article titled Protecting Maize with "Weeds"])

Living Fences (EDN 116, TN 23)

Modernizing Extension and Advisory Services (ECHO Summaries)

Sloping Agricultural Land Technology (TN 72)

The Use of Green/Manure Cover Crops for Relay Cropping in Northern Thailand (AN 10)

Tree Gardening (TN 69)

Understanding Salt-Affected Soils (TN 84)

Zai Pit System (TN 78)

FOR FURTHER READING

General information

African Conservation Tillage Network, on conservation agriculture principles and practices in Africa.

Conservation Agriculture Newsletter: subscribe at https://vr2.verticalresponse.com/s/canewsletter to receive practical information, based on field work being done in Tanzania, sent out by Putso Nyathi and Neil Miller (Technical Officers with Canadian Foodgrains Bank).

Cornell University website, Conservation agriculture: global research and resources.

Farooq, M. and K.Siddique (Editors). 2015. Conservation Agriculture. Springer International Publishing Switzerland.

Save and Grow, a book (available as a PDF download) on an ecosystem approach to sustainable agricultural intensification that encompasses CA.

Crop sequencing

Gomez I. Crop planning and management in organic agriculture. FAO (compiled by I. Gomez as part of a Training manual on organic agriculture).

Matusso, J.M.M., J.N. Mugwe, and M. Mucheru-Mana. 2012. Potential role of cereal-legume intercropping systems in integrated soil fertility management in smallholder farming systems of sub-Saharan Africa. Third RUFORUM Biennial Meeting, Entebbe, Uganda.

Economic aspects

Food and Agriculture Organization. 2001. The economics of conservation agriculture. Rome, Italy.

Francis R., P. Weston and J. Birch. 2015. The social, environmental and economic benefits of Farmer Managed Natural Regeneration (FMNR). World Vision Australia.

Legumes

Bunch, R. Restoring the soil: A guide for using green manure/cover crops to improve the food security of smallholder farmers. Canadian Foodgrains Bank.

Fact sheets on many legume species available online through Grassland Species Profiles, Tropical Forages, and Winrock (nitrogen-fixing trees).

Odunze, A. C., E. N. O. Iwuafor, and V. O. Chude. 2002. Maize/herbaceous legume inter-crops and soil properties in the northern Guinea savanna zone, Nigeria. *Journal of Sustainable Agriculture* 20 (1): 15–25.

Odunze, A. C., S. A. Tarawali, N. C. de Haan, E. Akoueguon, A. F. Amadji, R. Schultze-Kraft, and G. S. Bawa. 2004. Forage legumes for soil productivity enhancement and quality fodder production. *Journal of Food 2* (2): 201–209.

Promotion

Modernizing Extension and Advisory Services.

Farmer Field Schools: an internet search will yield multiple documents/case studies.

Tillage practices

Friedrich, T and A. Kassam. 2012. No-till farming and the environment: Do no-till systems require more chemicals? *Outlooks on Pest Management* 23:153-157.

Hoorman, J.J. and R. Islam. 2016. Understanding soil microbes and nutrient cycling. Ohioline (Ohio State University Extension).

Foundations for Farming and Farming God's Way: systems that teach CA through a hoe-based approach that incorporates small basins as permanent planting stations.

Pest Management

FAO website on Integrated Pest Management.

Push-Pull, an Integrated Pest Management strategy that controls stemborers and striga weeds while also improving soils.

Trees in conservation agriculture

EverGreen Agriculture: a website on the integration of trees with food crops and livestock.

World Agroforestry Centre (ICRAF): the 'Resources' section of this website has abstracts and links to many publications related to trees in smallholder agricultural landscapes.

Farmer Managed Natural Regeneration (FMNR): this website is a gateway to FMNR training and informational resources.