...n and Principles

...on Agriculture (CA) is a win-win system based on the ... management of soil, water and agricultural resources. Its ... is economically, ecologically and socially sustainable ... the land being degraded and soil

CA relies on three principles, which must be considered together for appropriate design and application:

Permanent soil cover

Minimal soil disturbance

Crop rotations

The Benefits

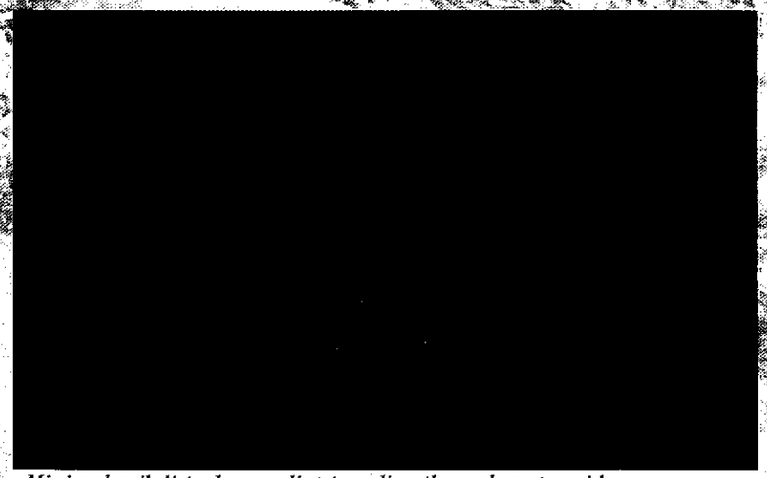
To Farmers

- Savings on fuel, maintenance and replacement of implements
- Increased and more stable yields, resilience of crops to drought and climate hazards, increased and more stable benefits
- Saving time for other activities
- Less heavy work and drudgery, especially for women or weak people
- Diversification in crops and activities: less risks, increased income, improved diet, better livelihood of the farmer

To Communities and the Environment

- Food security and diet improvement for people and livestock, reduced out-migration
- Water resources: improved quality, quantity and availability throughout the year
- Land resources: increased soil fertility, soil regeneration, no erosion, no need to clear new land
- Air quality and climate change: less fuel used, no burning of crop residues or forest, carbon sequestration
- Biodiversity: agro-biodiversity through crop rotations, enhancement of soil biodiversity, less pressure on marginal lands, forests and natural reserves

Crop rotation and permanent soil cover: soybean (crop) after black oat (cover crop and residue cover)



Minimal soil disturbance: direct seeding through crop residues

Direct seeding through crop residues: example of a hand tool

Technologies

Many technologies, including traditional ones, can be adapted to CA principles.

Maintenance of a Permanent Soil Cover

The design of crop rotations and the choice and management of cover crops must ensure that the biomass production is sufficient to satisfy all the needs (food and other crops, livestock feed and residue cover on the soil) and that soil, water and nutrient resources are adequate for the crop. This implies that cover crops have multiple purposes.

Planting through the Soil Cover

This can be done through direct seeding, direct planting or broadcasting into the soil cover, depending on the specific conditions (soil, climate, seeds and cover properties). Suitable machinery and implements are available for manual, animal-drawn or mechanised agriculture.

Crop Residue Management and Weed Control

Crop residue management stimulates soil structure formation by soil fauna, improves soil fertility and helps to control weeds with less dependence on herbicides. Weed control in CA is based on an integrated set of techniques:

- agronomic (mulch cover, crop rotation and appropriate sowing date),
- mechanical (hand weeding, slashing and the use of knife rollers),
- chemical (use of desiccants or other rapidly decomposing herbicides only where needed, mainly during the transition to CA).

Pest and Disease Control

Pest and disease control are based on Integrated Pest Management (IPM) technologies.

Mechanical cover crop management

Implementation

Conditions of Application and Constraints

Factors limiting agricultural production should be rectified before the full benefits from implementation of CA can be realized. This might refer to technical factors, such as soil compaction, insufficient drainage, soil chemical properties, as well as socio-economic factors such as availability of adequate technology, investment capital, land use rights, livestock pressure, customary practices or access to markets. These will have to be addressed in order to establish CA sustainably.

Transforming the Agricultural System

The transition phase usually takes about two years; however, the full benefits of the system often become visible only after five years. In CA, mechanical tillage is replaced by biological tillage (by crop roots and soil fauna) and soil fertility (nutrients and water) is essentially managed through soil cover management, crop rotations and weed management. Fertilizers, water harvesting technologies and irrigation can complement CA, and minimum tillage might be necessary in some cases particularly during the transition.

Biological tillage and soil fertility management through Conservation Agriculture

Changing mentalities

- The soil is a habitat for roots and soil organisms.
- Any damage to this habitat endangers soil fertility and leads to land degradation.
- The soil fauna creates a stable soil structure.
- Tillage creates a temporary soil structure but damages the stable habitat of soil life.

Promotion, Support and Capacity Building

Promotion of CA should be done simultaneously through policies, education Research, and extension institutions in the field. Adoption by farmers is supported most effectively through farmers' groups, study tours, networks and NGOs. Research and extension institutions and the private sector have a major role in providing farmers with appropriate and affordable technologies.

Policies and Incentives

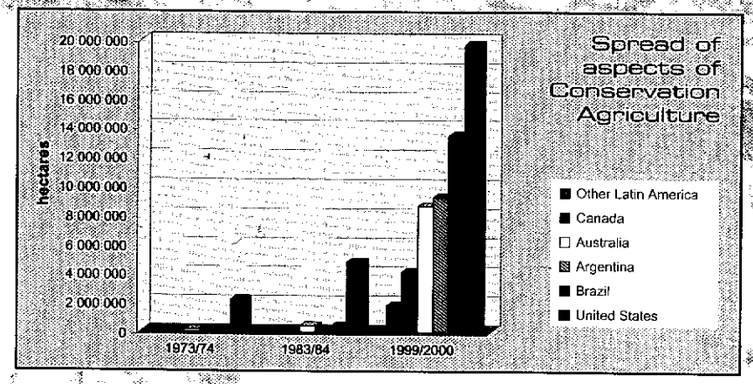
Policies should focus on access to market, credit and input supplies, and rural infrastructures. Policies should support the development of farmers' groups. Incentives should encourage diversification and CA practices, especially during the transition phase.
Inadequate policies and subsidies that support conventional practices might constrain CA adoption. Land use and customary rights must also be taken into account and eventually adapted to favour CA adoption by farmers and rural communities.

FAO and other International Support

FAO is promoting the adoption of the CA concept at policy level as well as stimulating farmer-based movements and collaboration between the research sector and farmer groups. Due to its positive effects on food security, biodiversity, land and water resources, carbon sequestration and sustainable development, CA is a major opportunity to implement the International Conventions on combating desertification, on biodiversity and on climate change (UNCCD, UNCBD and UNFCCC).

Adoption of Conservation Agriculture around the World

CA is being practised in many agro-ecological zones and socio-economic contexts worldwide, such as commercial and small farms in tropical and subtropical areas of Latin America and Africa, commercial farms in the United States and Australia, the rice-wheat belt in Asia, the steppes of Kazakhstan.



For more information

FAO – Workgroup on CA:
www.fao.org/ag/ags/AGSE/Main.htm
This website provides information, references and links to many other Web sites, publications and databases on CA.

ECAF – European Conservation Agriculture Federation:
www.ecaf.org/

RELACO – Latin American Conservation Agriculture Network:
www.fao.org/ag/ags/AGSE/agse_e/6to/rel_pre.htm

ACT – African Conservation Tillage Network:
www.fao.org/act-network/

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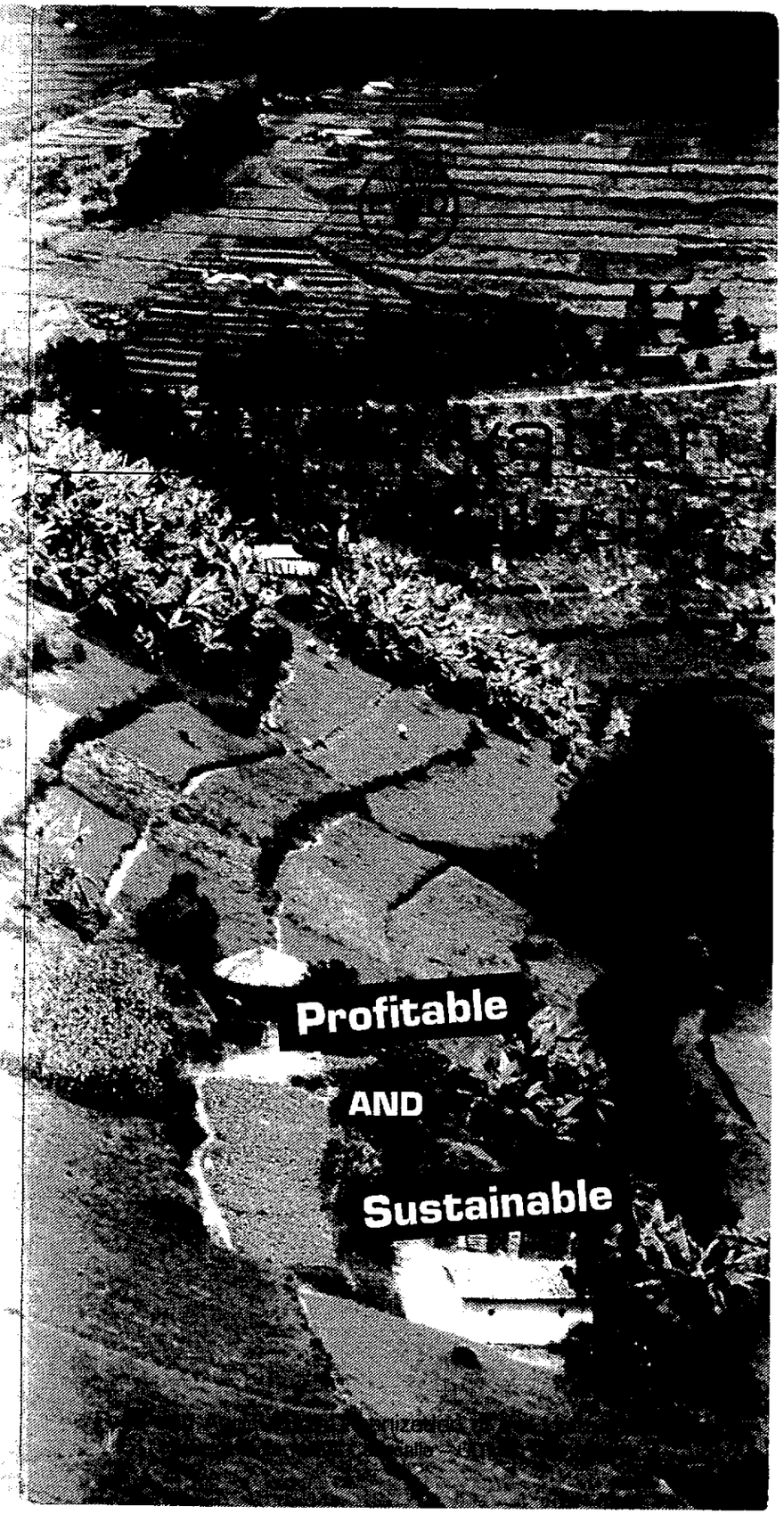

What is the goal of Conservation Agriculture?

What are the characteristics of CA?

CA maintains a permanent or semi-permanent organic soil cover. This can be a growing crop or a dead mulch. Its function is to protect the soil physically from sun, rain and wind and to feed soil biota. The soil micro-organisms and soil fauna take over the tillage function and soil nutrient balancing. Mechanical tillage disturbs this process. Therefore, zero or minimum tillage and direct seeding are important elements of CA. A varied crop rotation is also important to avoid disease and pest problems.

Rather than incorporating biomass such as green manure crops, cover crops or crop residues in CA this is left on the soil surface. The dead biomass serves as physical protection of the soil surface and as substrate for the soil fauna. In this way mineralization is reduced and suitable levels of soil organic matter are built up and maintained.

What are the elements of CA?

Residue management: crop and weed residue management is an essential element of CA. For example, slashing a cover crop or weed cover before flowering or seed set, or rolling to flatten crop residues, reduces weed pressure, increases infiltration of rainwater and protects the soil water against evaporation. The residue cover also protects and feeds the soil fauna that produces and maintains an open pore system in the soil.

Crop rotations: crop rotation is necessary in CA in order to avoid the built-up of pest, weed or disease pressure, and to ensure that root systems explore the soil to different depths. It also entails a more balanced extraction of plan nutrients from the soil.

Zero tillage: zero tillage is a technical component used in CA but not everyone carrying out zero tillage is practising CA. CA not only avoids tillage by placing the seed into the soil with direct drills, it also improves the structure of the soil by maintaining a soil cover. This facilitates direct planting. CA uses biological tillage. Zero tillage can also be applied as a stand-alone technique in conventional agriculture under certain circumstances.

[illegible] are used in [illegible] to reduce soil erosion on bare soils. However, [illegible] tillage practices such as zero tillage can be elements of CA.

Direct planting/seeding: this is a technique of seeding or planting without prior cultivation to prepare a seedbed. Equipment or tools that place the seed in the soil through a mulch or residue cover are used in CA. However, the term direct seeding can also refer to implements used in conventional agriculture that combine primary and secondary tillage and seeding in one machine/tractor operation.

Organic farming: organic farming practices can be elements of CA, but organic farming still relies on tillage in many cases. Conversely, CA is not necessarily organic farming, although it is based on natural processes. CA does not prohibit the use of farm chemical inputs. For example, herbicides are an important component in CA, particularly in the transition phase, until the new balance of weed populations is managed. However, in view of the importance of the soil life for the system, farm chemicals, including fertilizer, are carefully applied and, over the years, quantities applied tend to decline.

What is wrong with tillage?

1. Regarding the overall fertility, including soil structure, virgin soils are usually more fertile than soils following decades of cultivation.
2. Nature shows that plant growth is possible without any soil tillage; otherwise all virgin lands would be deserts.
3. There is scientific evidence that water infiltration is highest on non-tilled soils with a continuous cover of vegetal material.

Explanation:
The accumulation of a mulch cover on an undisturbed soil protects and feeds intensive soil life, which then provides a stable and favourable soil structure and sufficient continuous deep macropores for improved water infiltration. This process of biological tillage is building up in the absence of mechanical tillage and it is reduced or inhibited by mechanical tillage.

Why did humankind till in the first place?
The first agricultural intervention was a kind of no-till within a slash-and-burn agriculture, using a planting stick to make a hole for the seed.

As agriculture became more intensive the technologies available for weed control at that time allowed only a clean tillage approach to large scale farming.

In temperate climates the detrimental effects of tillage are not as [illegible].

Tillage produces an aeration and thus rapid mineralization of organic matter in virgin soils. This mining of soil organic matter makes available plant nutrients for the next crop, albeit only for a limited number of years. This is the origin of the misconception that tillage increases soil fertility.

Once the fertilizing function of soil organic matter had been taken over by mineral fertilizer, the achievement of soil structure had to be taken over by more intensive tillage. This mechanical soil structure formation does not last very long and calls for ever-increasing tillage efforts. Over the years these reduce the content of soil organic matter, which aggravates the problem. Tractor power required for conventional tillage has been steadily rising.

Consequences:
- ❑ On most agricultural soils it is impossible to grow a crop without tillage because of a general soil degradation process.
- ❑ Soil tillage is understood as a purely mechanical problem.
- ❑ Many farmers and the general public cannot imagine how a crop can be grown without tillage.

Is CA compatible with IPM?

CA is compatible and actually works on Integrated Pest Management (IPM) principles. CA, like IPM, enhances biological processes. It expands the IPM practices from crop and pest management to land husbandry. Without the use of IPM practices the build up of soil biota and the consequent biological tillage would not be possible.

What is the role of animal husbandry in CA?

Livestock production can be fully integrated within CA, by making use of the recycling of nutrients. This reduces the environmental problems caused by concentrated intensive livestock production. Integration of livestock into CA enables the farmer to introduce forage crops into the crop rotation, thus widening it and reducing pest problems. Forage crops can often be used as dual-purpose crops, for fodder and soil cover. However, in arid areas with low production of biomass, the conflict between the use of organic matter to feed the animals or to cover the soil still remains to be resolved.

What are common prejudices?

"It only works for grain crops" - The system has been adapted for vegetables and root crops. Now, not only grain crops and pulses but also a wide range of other crops such as sugar cane, vegetables, potatoes, beets and cassava can be grown. Perennial crops such as fruit and vines can also be grown using CA techniques.

"It only works in certain climates or on certain soils" - CA is practised in many agro-ecological zones, from the humid tropics to cold temperate climates, and on all kinds of soils. So far the only areas where the concept has not been successfully adopted are arid zones with extreme water shortages and low production of biomass. In these areas both humans and animals compete with the soil for crop residues.

What are the downsides of CA?

CA is generally a win-win situation. That does not mean that there are no problems. CA may require the application of herbicides in the case of heavy weed infestation, particularly in the transition phase from conventional agriculture.

During the transition phase certain soil-borne pests or pathogens might create new problems because of the changing biological equilibrium. Once the CA environment has stabilized it tends to be more stable than conventional agriculture. So far there has been no pest problem that could not be overcome in CA.

Why can't we do CA without soil cover?

Only in very few soil and climatic conditions is the soil able to maintain its structure on its own. No-till systems such as CA rely on soil life to build and maintain an open pore structure in the soil. This biological tillage replaces mechanical tillage in CA. The soil life consists of macro- and micro-fauna and flora such as earthworms, insects, bacteria, fungi and plant roots. These have to be fed and protected. Soil cover provides protection for the living environment of soil life and the substrate to feed it. In addition the soil cover plays an important role for weed control. No-till agriculture without soil cover is only successful in a few cases and invariably runs into weed problems requiring large amounts of herbicides.

Why can't we carry out CA without crop rotation?

[redacted]

What are the attractions of CA?

CA attracts different people for different reasons:

Farmers:

Reduction in labour, time, farm power.

Reduction in cost.

In the case of mechanized farmers: longer lifetime and less repair of tractors, less power and fewer passes, hence much lower fuel consumption.

Better trafficability in the field.

More stable yields, particularly in dry years.

Gradually increasing yields with reduced inputs.

Increased profit, in some cases from the beginning, in all cases after a few years.

Communities/Environment/Watersbed:

More constant water flows in the rivers, re-activation of wells.

Cleaner water due to less erosion.

Less flooding.

Less impact of extreme climatic situations (hurricanes, drought, etc.).

Less costs for road and waterway maintenance.

Better food security.

At global level:

Carbon sequestration (reduction of greenhouse effect): in some places CA farmers start to receive carbon-grant payments; the global potential of CA in carbon sequestration and reduced energy (fuel) use could equal the human-induced increase in CO_2 in the atmosphere.

Less leaching of plant nutrients and less pollution of surface water and groundwater.

Practically no erosion (erosion is less than soil build-up).

Recharge of aquifers through better infiltration.

Can CA be used to recover degraded soils?

[redacted]

Is CA real?

Elements of CA are being practised on about 45 million ha, mostly in North and South America. CA is growing exponentially on small and large farms in South America, due to economic and environmental pressures. Farmers practising CA in South America are highly organized in regional, national and local farmers' organizations, and are supported by institutions in North and South America. In Europe the European Conservation Agriculture Federation (ECAF), a regional lobby group, has been founded. This body unites national CA associations in the United Kingdom, France, Germany, Italy, Portugal and Spain.

No-tillage in different countries (hectares)

COUNTRY	1999/2000
United States[1]	19 750 000
Brazil[2]	13 470 000
Argentina[3]	9 250 000
Australia[4]	8 640 000
Canada[5]	4 080 000
Paraguay[6]	800 000
Mexico[7]	650 000
Bolivia[8]	200 000
Chile[9]	96 000
Colombia[10]	70 000
Uruguay[11]	50 000
Venezuela[12]	50 000
Others[12]	1 000 000
Total	58 106 000

What are the issues?

[redacted]

CA has great potential in Africa owing to its ability to control erosion, give more stable yields and reduce labour. There are a number of ongoing initiatives promoting different practices, from conservation tillage up to CA. However, the are still some significant problems.

Another vast area where the adoption of CA would be extremely beneficial is Central Asia. In the countries of the former Soviet Union conventional agriculture is in great difficulties because of environmental problems and because of a lack of farm machinery, which has to be replaced. Unless CA is adopted, the investment in new machinery will have to be very high.

Converting to CA needs higher management skills. The first years might be very difficult for the farmers, therefore they might need moral support – from other farmers or from extension services – and perhaps even financial support to invest in new machinery such as zero-tillage planters.

Necessary technologies are often unavailable: in order to try CA, the minimum a farmer needs is a zero-tillage planter, which might not be locally available. Few farmers take the risk of buying new machinery without knowing the system or even having seen it. Machinery dealers might not wish to promote CA as long as it is not supported by extension, since the widespread adoption of CA will reduce machinery sales, particularly of large tractors and tillage equipment.

Why is CA not yet widely recognized and applied?

There is no simple answer to this question; it depends on the specific circumstances. In many cases the system and its benefits are not well known and the culture of tilling the soil or even ploughing is so deeply rooted that people have difficulties in taking CA seriously as long as they do not see successful examples. In temperate zones the climatic conditions allow conventional farming without producing disasters in terms of erosion that are known in tropical climates. The environmental pressure is not yet high enough for farmers to reconsider their production systems, and national and

What is the role of GMOs in CA?

The possible merits or dangers of genetically modified organisms (GMOs) are a distinct issue, without direct relation to CA. As in conventional agriculture, some CA farmers use them; others not. Some people believe that CA would depend on herbicide-resistant varieties. This is not true. Most instances of CA are carried out without herbicide-resistant varieties. In fact, if the weed situation is managed through an adequate crop rotation and cover crop management, herbicide-resistant varieties do not provide any advantage over other varieties. Many farmers therefore consider them as superfluous and even potentially dangerous in a properly established CA system, as they might induce an overuse of herbicides, with consequent damage to the soil life and the possible creation of herbicide-resistant weeds.

What is FAO doing on CA?

Because of its close links with food security, biodiversity, land and water resources, carbon sequestration and sustainable development, CA is a major opportunity to implement the international conventions such as Convention on Sustainable Development (CSD), U.N. Convention to Combat Desertification (UNCCD), U.N. Convention on Bio-diversity (UNCBD) and U.N. Framework Convention on Climate Change (UNFCCC).

FAO has been promoting the CA concept for more than ten years, particularly in Latin America. As it is becoming a success story in Latin America, FAO has been expanding the programme to other regions, such as Africa and Central Asia. An interdisciplinary project on CA has been formulated within the Agriculture Department of FAO.

More information can be found on the following Web site: www.fao.org/ag/ags/AGSE/Main.htm

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