Theme 1: Climate-smart agricultural practices

CONSERVATION AGRICULTURE

A publication sponsored by the ICSIAPL project

What you will learn

- What is conservation agriculture?
- Difference between conservation agriculture and conventional agriculture.
- Main three principles of conservation agriculture.
- Other principles of conservation agriculture
- What is climate smart agriculture
- Practices of climate smart agriculture
- Importance of conservation agriculture

History of conservation agriculture ?

"Dust Bowl" is a period in US history in the 1930s when soil organic matter levels reached their lowest point in the American prairie lands after years of agriculture-induced soil degradation. Research indicated that the return of crop residues to the soil was a successful strategy for increasing levels of soil organic matter and soil microbes, effectively reversing soil fertility declines.

In the 1970s, Conservation Agriculture introduced soil health care practices like no-tillage, cover cropping, and crop rotation that are aimed to conserve the long-term fertility and productivity of the soil.

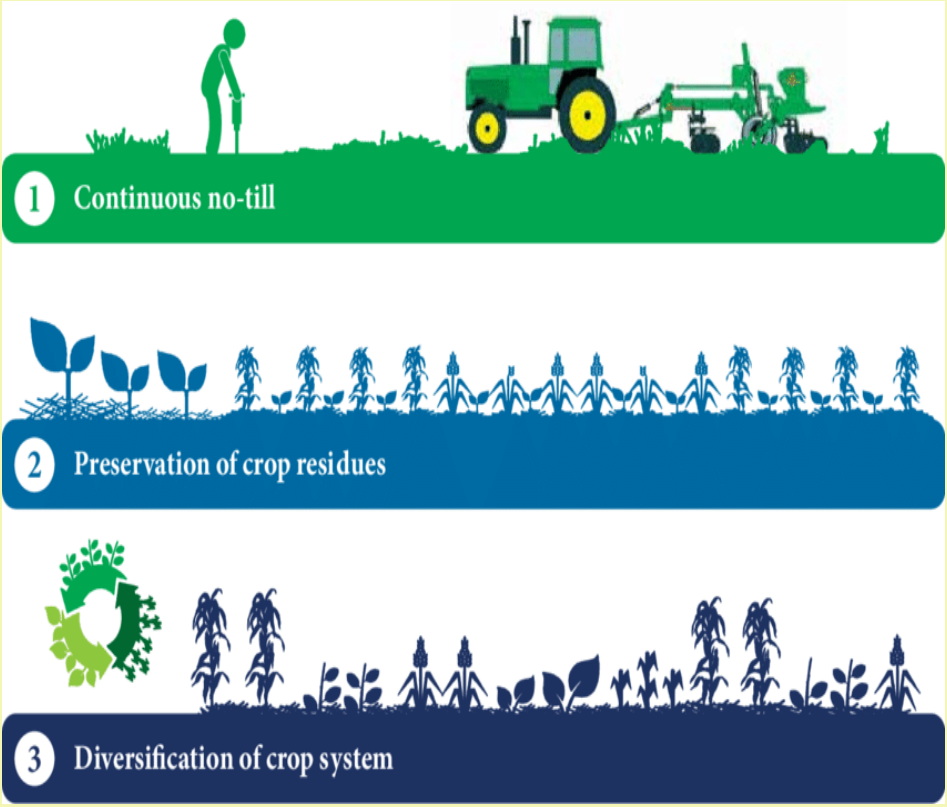
In the 1990s South American countries like Brazil, Argentina, Peru & Paraguay made large-scale adoptions of Conservation Agriculture practices which have been successful in addressing soil fertility problems and increasing crop productivity.

What is Conservation Agriculture ?

Conservation agriculture refers to a farming system that conserves, improves and uses natural resources (biodiversity and ecosystems) more efficiently through sustainable intensification and integration of locally available resources.

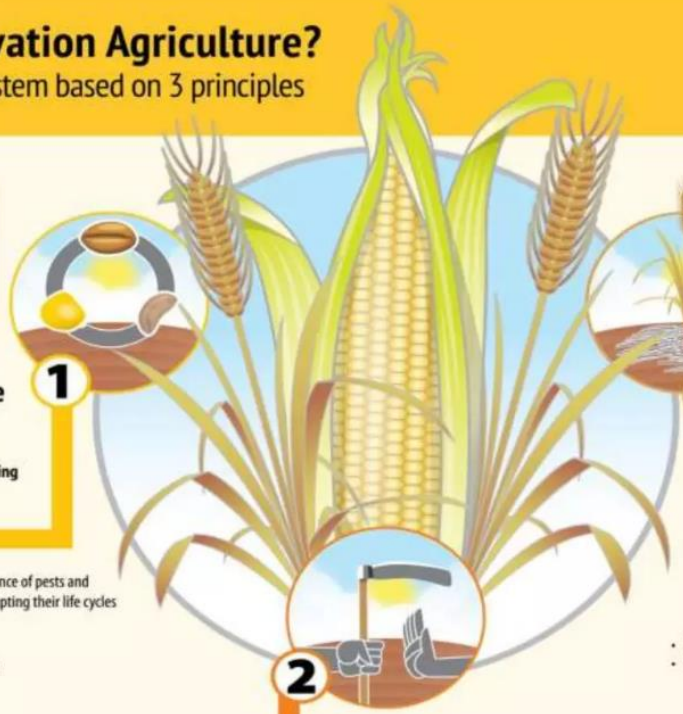
Conservation agriculture practices can also contribute to making agricultural systems more resilient to climate change. In many cases, conservation agriculture has been proven to reduce farming systems' greenhouse gas emissions and enhance their role as carbon sinks.

This farming system prevents degeneration of arable land while regenerating degraded land.



What is Conservation Agriculture?

Sustainable farming system based on 3 principles



What is crop diversification?

Intercropping is growing two or more crops at the time time on the same piece of land. Crop rotation is growing two different crops on the same land in a sequential manner

1 Crop diversification decreases pest, disease and weed pressure

Benefits of crop rotation or intercropping

- Reduces the ocurrence of pests and diseases, by interrupting their life cycles
- Weed control
- Adequately distributes nutrients in soil profile
- Allows to balance residue production: some crops leave more residue than others
- Reduces economic risk, in case of an event negatively affecting certain crops
- Reduces climatic risks

2 Minimal soil movement

Benefits of reduced tillage

- Avoids compactation and soil surface sealing
- Reduces erosion
- Reduces greenhouse gases

What is crop residue?

Crop residue or stubble is the accumulation of dried up plant parts left on the field, including cover crops or green manure

3 Soil coverage with residue of the previous crop, cover crop, or both

Benefits of soil cover

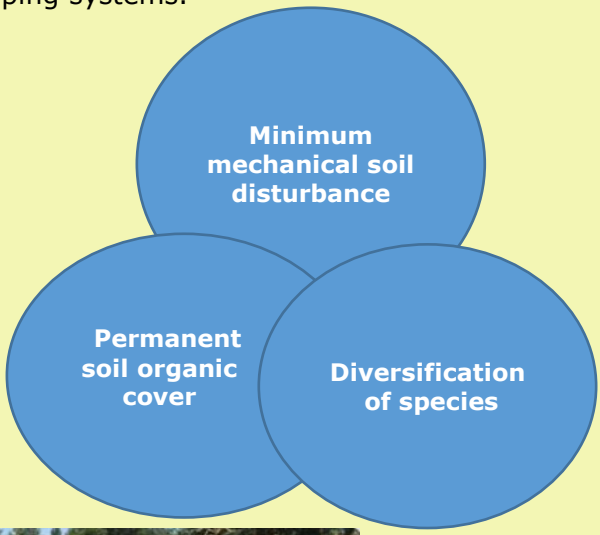
- Higher water infiltration andavailable soil water content
- Less evaporation
- Less water and wind erosion
- Soil temperature is buffered
- Increases biological activity and soil organic matter
- Improves soil fertility and structure

CIMMYT

Principles of Conservation agriculture

The main three principles

Minimum mechanical soil disturbance (least disturbance)
Permanent soil organic cover
Diversification of crops for example encouraging crop rotation and intercropping systems.



Tillage agriculture

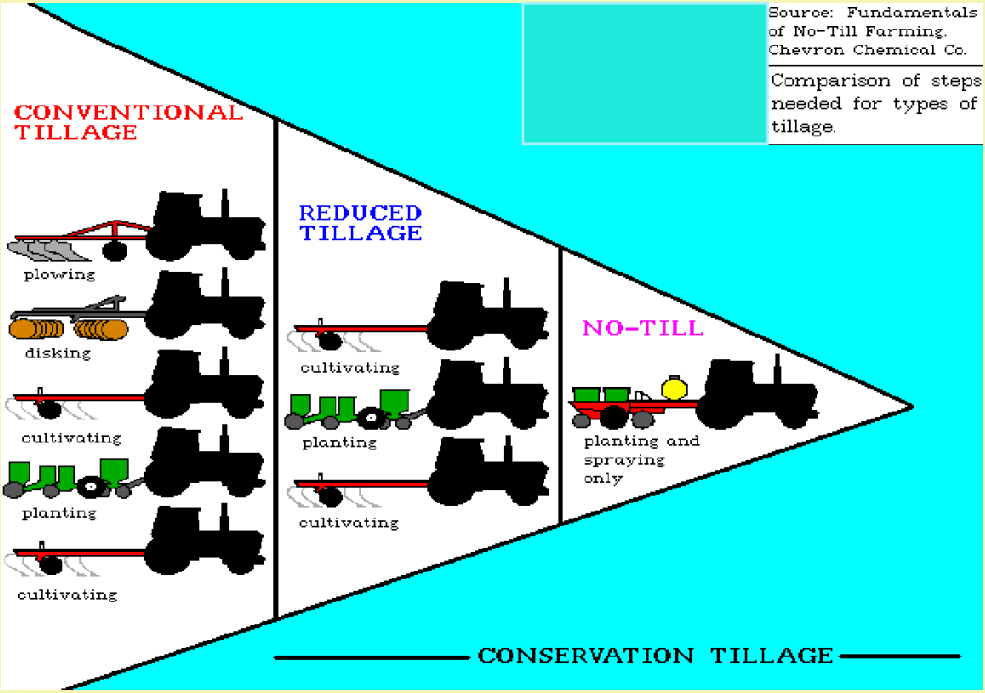
Conventional agriculture uses method of land tillage which disturb the soil severally before planting

Conventional agriculture refers to a farming system that is based on intensive use of agrochemicals e.g. synthetic fertilizers , herbicides, insecticides and fungicides to maximize agricultural output.

In conventional farming land preparation is generally done with a disc plough. This practice of land tillage disturbs the soil intensively and requires several repetitions before the land is ready for planting.

Conventional tillage practices versus conservation tillage

Comparison of steps needed for type of tillage as depicted in the image on the right



Source: Fundamentals of no-till farming Chevron Chemical Co.

Type of machinery

Conservation agriculture promotes minimum soil disturbance.

In the picture on the right a disc plough (intensive soil disturbance) is used in conventional farming versus a chisel plough in a conservation farming system.

VERSUS

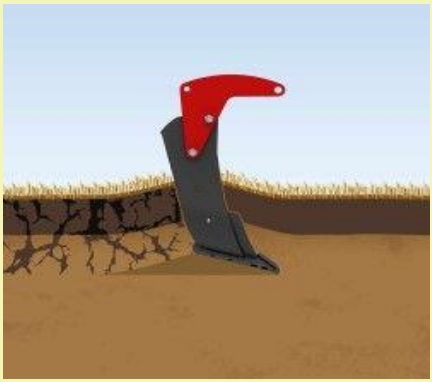
Land preparation

Deep restructuring

The chisel provides soil restructuring to 45 cm. It eliminates the results of extreme climate conditions as well as ground compaction resulting from grazing. It allows air and water to circulate again to bring life back into the soil. Living soil is essential to cultivation.

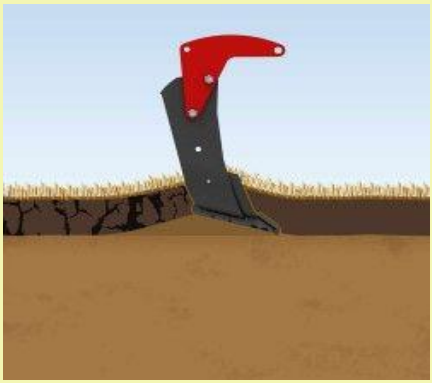
Intermediate loosening

From 25 to 35 cm deep, it eliminates poor soil preparation due to the same tool being used too often at the same depth (base effect).
Plots where tubers are intensively grown can be very uneven in terms of compaction. They are made worse by areas of grubbing-up. The chisel plough recovers these areas.



On the surface

At less than 25 cm of depth, the Helios prepares for root establishment.
The Michel blade performs this task without disrupting the surface and without pushing fine soil down. On the other hand, the Cracker tine vigorously mixes the surface horizon.



Mechanisation of conservation agriculture

Sub-soiler (for deep land cultivation, improving water infiltration)
Chisel tine cultivator (for land preparation)
Seed-bed, spring tine (for fine tilth)seed bed preparation
Leveling blade (for drain canals and road maintenance

Minimum tillage (soil disturbance) small holder farming systems

Farmers are encouraged to till the land as little as possible.

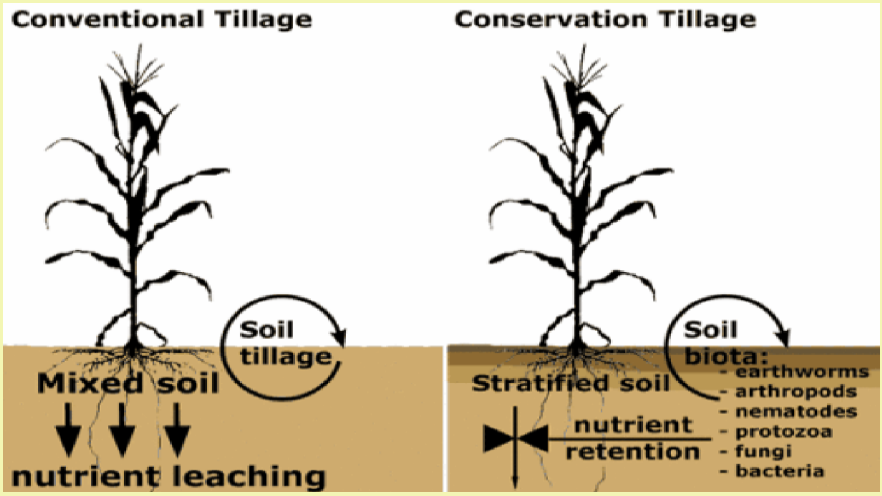
One of the methods is preparation of planting basins based on crop spacing recommendations, this helps farmers dig soil only where seeds or fertilizer are to be placed.

When farmers go back to using the planting basins season after season they become permanent.

Plant basins

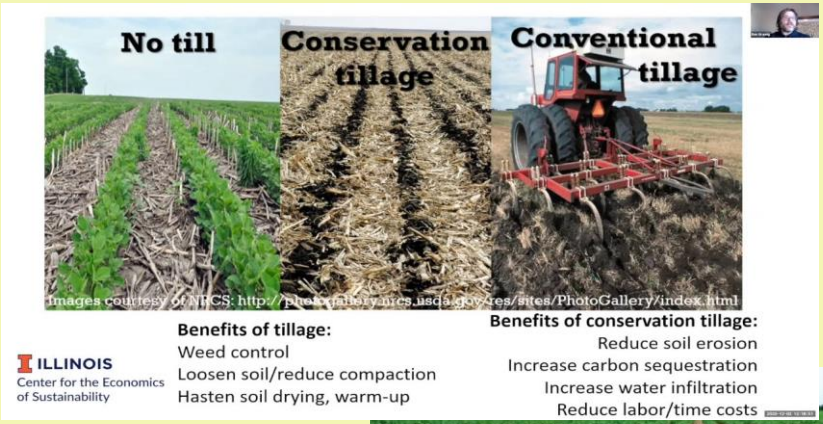
Effect of tillage on soil structure, health and fertility

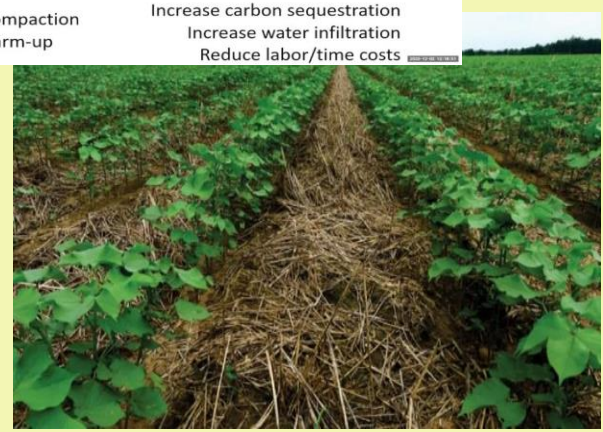
Better water infiltration and retention
Reduction on cost of machinery
Better soil management, soil health, soil structure, no compaction.
Better retention of plant nutrients
In future better yield (soil investment)



Advantages of minimum tillage and soil disturbance

Protects the soil against erosion by water and wind
Cost savings: fuel, time and labour costs in the long term
Improves infiltration and Improves soil organic matter conserves soil moisture (Changes in soil quality , see image on the right , A - baseline B- Improved)
Improves soil organic matter
Increases yield per unit of fertilizer or manure applied. Long-term decreases the amount of fertilizer per hectare.





Permanent soil organic cover

Soil cover is any living vegetation such as crops/trees, crop residues or mulching on the surface of the soil.

Farmers are encouraged to cover the soil and keep the soil covered as much as possible since it's a method of improving soil fertility management.

In nurseries for tree or vegetable seedlings farmers practice mulching to protect young , emerging plants

Incorporating crop residues from the previous season in the soil when cultivation the land is also a form of organic cover.

Advantage of permanent soil organic cover

Planting cover crops intercropped with the main crop protects evaporation of water found in the soil and protects the soil from being eroded by wind or water. (e.g. desmodium in between a maize crop, oats planting at the same time as Boma Rhodes grass and harvesting when the Rhodes grass is established)

Helps reduce the impact of direct , intense rainfall hence reduce soil erosion.

Soil cover suppresses the growth of weed, thereby avoiding competition with main crop (e.g. Desodium in combination with Maize or Lablab in combination with maize).

Soil cover reduces water runoff while encouraging water seepage into the soil.

Evaporation is reduced ensuring soil moisture is conserved for the current crop or the next crop.

Soil cover provides beneficial environment for soil organisms such as worms that perform important biological tillage.

Crop residues when used regulate soil temperature hence acts as heat insulators. This reduces volatilization of mineral compounds from the soil and promotes biological activities in the soil.

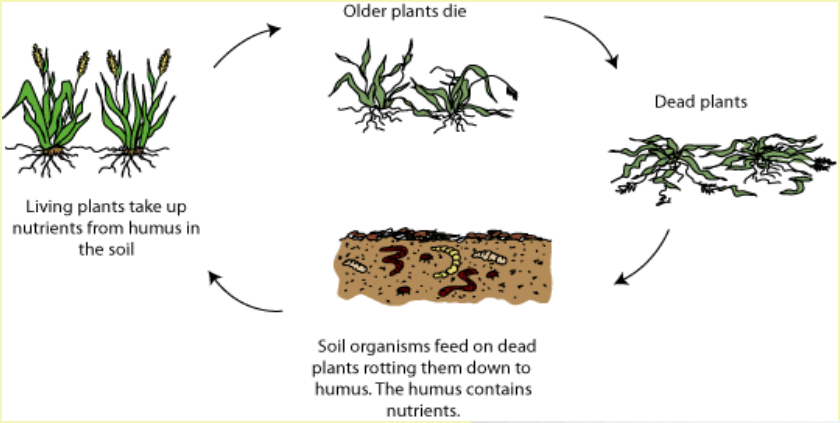
Crop residues also release trapped mineral nutrients in the stalk to the soil to be used by roots of main crop.

Promotes better environment for root and seedling growth.

Increases soil porosity and soil aggregate stability.

Permanent soil cover with crop residues and live mulches

Protects the soil against erosion by water and wind
Improves recycling of nutrients
Suppresses weed germination and growth
Improves organic matter accumulation and carbon sequestration.



Diversification of crops

Crop diversification is a farming system that incorporates growing of several crops of different species, example are

- crop rotation
- intercropping systems

Crop rotation involves planting of different, preferably not related, crops on the same piece of land in a sequence. (e.g beans following after maize, peas following after wheat etc)

This avoids over utilization of soil nutrients by a particular crop.

Crop rotation

Intercropping is a system where two or more (multiple) crops are grown in the same farm and season.

Intercropping also encourages increased yield especially when intercropping with leguminous crop since they fix nitrogen in the soil.
The pull and push system is another good example of intercropping

Intercropping

Soil fertility replenishment:

When nitrogen-fixing legumes (cow peas) are rotated.
Rotating deep rooted crops 'pump up' leached nutrients to the upper soil zones to be used by shallow rooted crops. This improves soil quality through better nutrient distribution in the soil profile.

Reduced pest/diseases:

Crop rotation breaks cycle of dominant pest and diseases
If cover crops are used in the crop rotation cycle weeds are smothered.

Provision of crop residues:

Crop rotation also provides crop residue for the next season by balancing production of residue by crops with short-lived residue and crops with durable residue.

Other examples of intercropping systems

Mixed swards: Refers to planting of multiple species (two or more) on a piece of land. This can be herbs and legumes in a mixture with grasses for grazing.

Agroforestry systems: Trees in agroforestry systems can be incorporated with crops, pasture and animals like the systems below;

- Silvipastoral systems
- Agrosilvocultural system
- Agrosilvipastoral system

Agroforestry systems

i. Silvipastoral systems

Is the incorporation of trees and pasture/animals. Grasses or legumes are grown in the inter-space of trees.
This method improves fodder productivity; and is mostly practised in the arid and semi-arid areas

ii. Agrosilvocultural systems

Is the combination of crops and trees similar to alley cropping systems

iii. Agrosilvipastoral systems

Involves trees, crops and pastures/animals

Advantage of intercropping

Variety:

Mixed swards provide a variety of nutritional feeds for livestock to enjoy from.

Multipurpose benefits:

Trees have multipurpose benefits to both land and livestock, for example;
Shade for animals
Source of green manure to soil
Provides soil cover
Some trees have medicinal element in them apart from being a source of feeds to livestock (fodder trees)

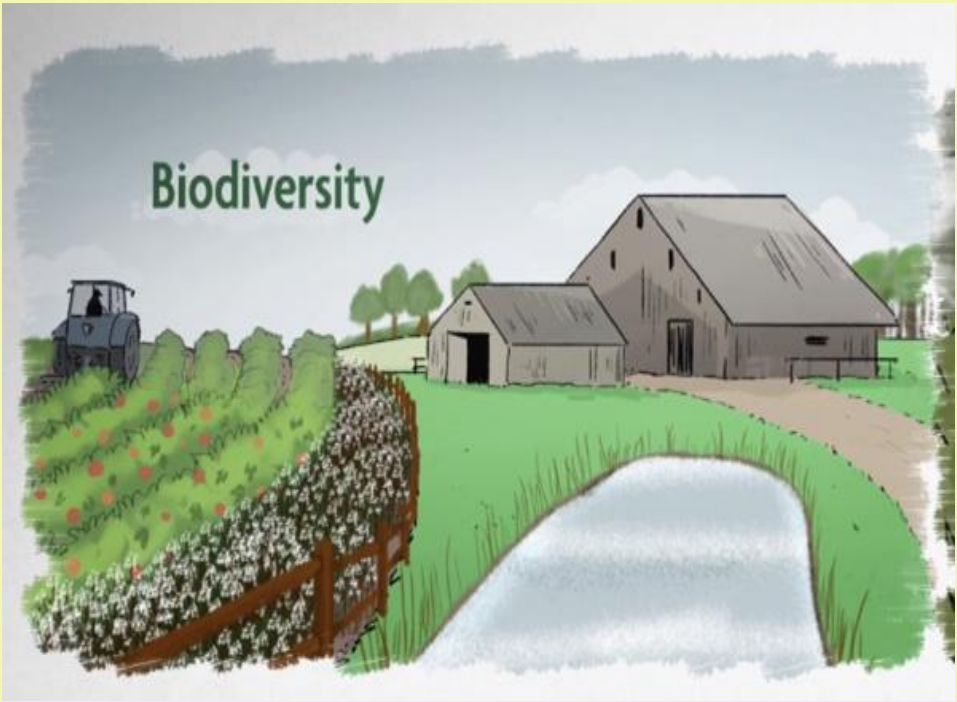
Summary of Crop rotation and intercropping

Improvement of water use: crops with different rooting systems also utilize soil water at different soil depths.

Improve fertility and production: crops have different rooting patterns which take up nutrients at different soil depths.

Rotations help to utilize soil nutrients more efficiently. In addition, legumes fix nitrogen in the soil for the benefit of successive cereal crops in a rotation.

Reduction of pests and diseases: different crops are susceptible to different disease and pest agents. Therefor, growing such crops in rotation will reduce the incidence of diseases and pests with no cost.



Other principles of conservation agriculture

Integrated pest management (IPM)

Integrated Soil fertility management (ISFM)

Direct planting

Precision irrigation

1.

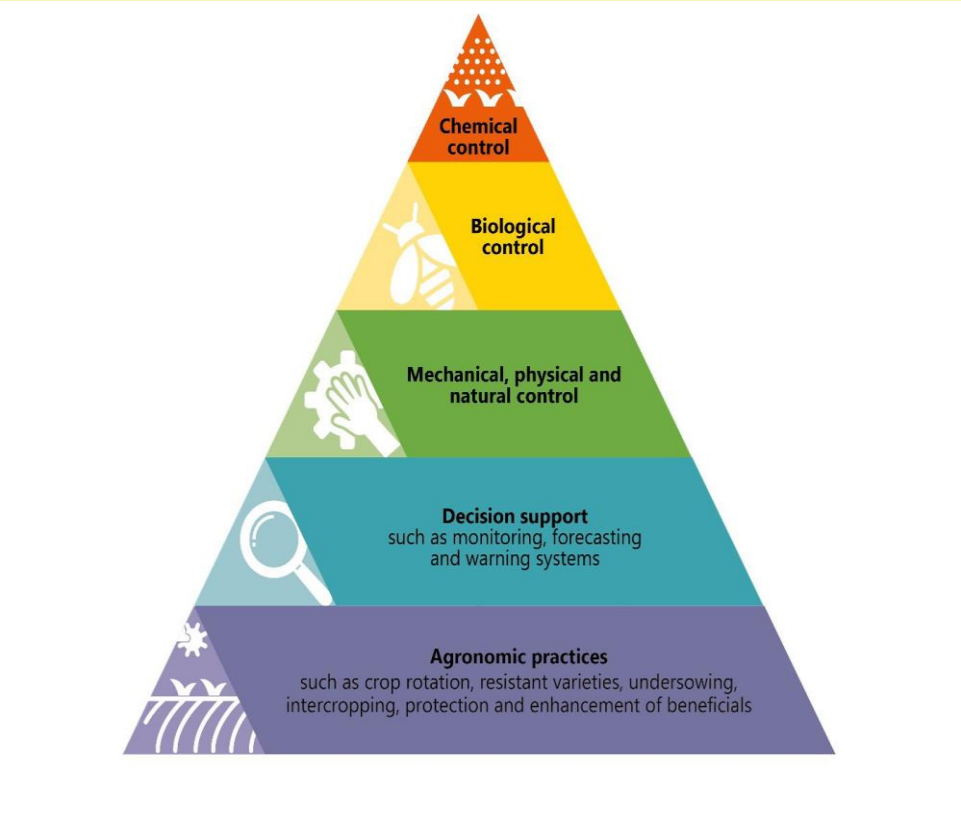
2.

4.

3.

Integrated pest management (IPM)

Integrated pest management is a practice that encourages the growth of healthy crops with the least disruption to agro- ecosystems and encourages natural pest control by considering all available plant protection methods.



Integrated pest management combines a number of approaches for carefully combining cultural, mechanical, biological and chemical methods.

The principle of IPM are; prevention, avoidance, monitoring and suppression.

Steps to follow when applying the IPM process are as listed below (depicted in the image on the right)

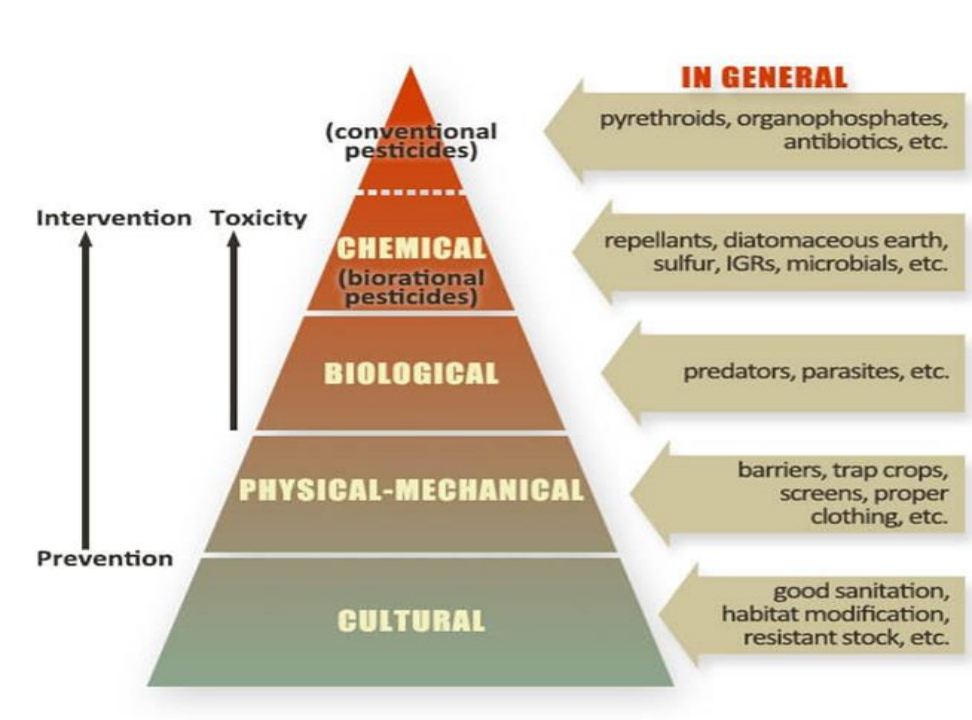
- The first approach is to identify the crop and related pests.
- Secondly, monitor that is looking at symptoms and signs on crops.
- Thirdly, decide based on the information and severity.
- Fourthly control/intervene using the appropriate approach then record.

Integrated Pest Management – Biological Control

https://youtu.be/OrMKHhb6jgs

Pyramid of Integrated pest management (IPM) tactics

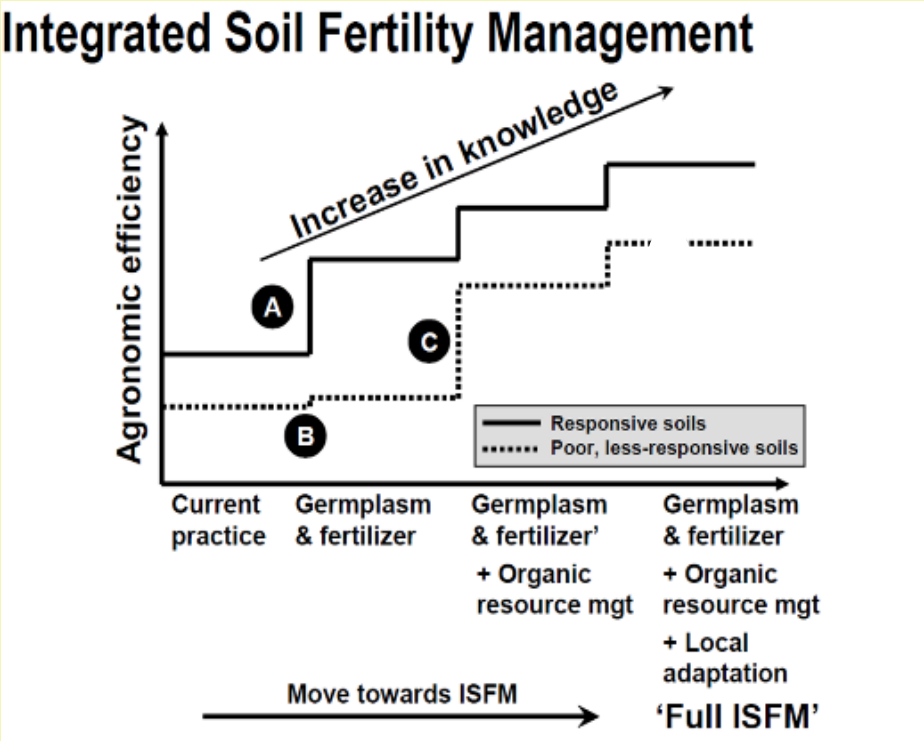
When intervening the first consideration is using mechanical control, biological control then lastly chemical control.



Conservation agriculture practices

Another technologies that farmers can take up is Integrated Soil fertility management (ISFM)

- This is a set of soil fertility management practices that includes use of :
  - improved germplasm,
  - organic inputs (manure, compost etc) and
  - inorganic/synthetic fertilizer combined with
  - knowledge how to adapt these practices to local conditions.



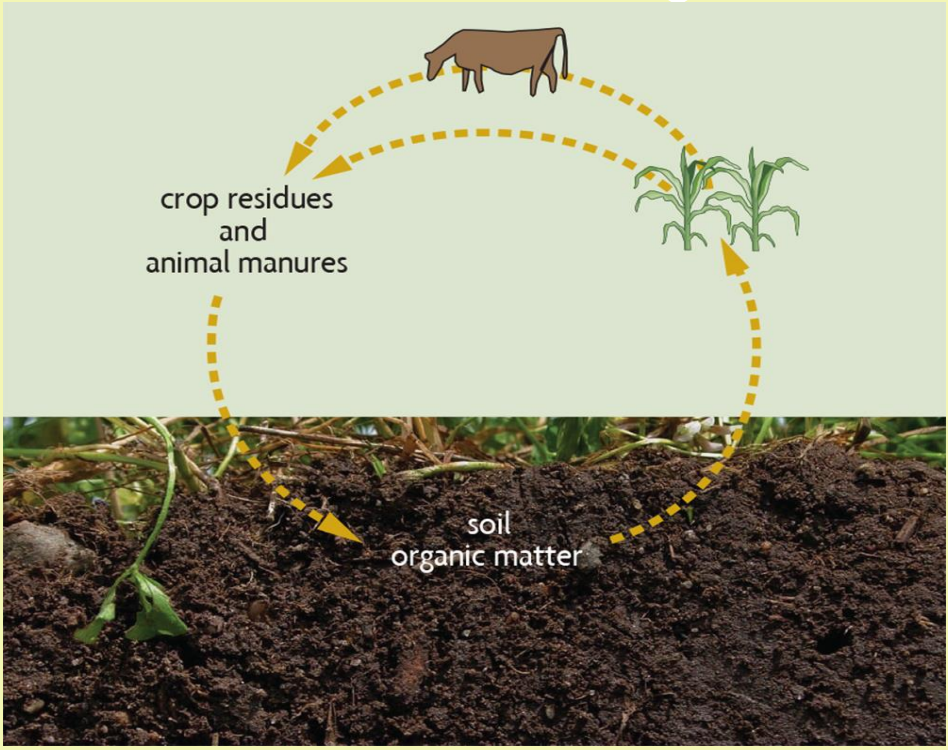
Fertilizer efficiency in conservation agriculture

Fertilizer use efficiency is high due to better soil structure encouraged in conservation agriculture practices. The high levels of crop residues that are integrated back into the soil encourages the build-up of high levels of soil organic matter which is associated with improved soil structure.

The final result of soils with high organic matter content is increased fertilizer nutrient use efficiency (with an estimated 2 times more nutrient uptake in high organic matter soils).

Increased water holding capacity (an estimated 4 times more water holding capacity and crop sustenance during periods of drought stress).

Decreased water pollution (increased soil water retention curbs fertilizer nutrient losses due to leaching and runoff into waterways).



Direct planting

Direct planting involves growing crops with minimum soil disturbance after the harvest of the previous crop. (see image on the right. Peas are planted in the residue of the wheat stubble). Direct planting can be used with all annual and perennial crops and vegetables.

Direct planting can be done manually (see picture top right) or mechanically i.e. animal or tractors drawn conservation agriculture planters.

Hand push seeder

Precision irrigation

Precision irrigation is a sustainable approach that allows application of water and nutrients to the crop at the right time, quantity, place so that it can meet with the plants needs.

Drip irrigation system (see image on the right) is an innovative way that brings water to the plant roots, this way you do not loose a single drop of water while maximizing on savings and yields.

By watering only where crops are planted, we reduce water wastage, discourage growth of weeds, increase yields while protecting soils and increasing soil fertility.

Precision irrigation systems do not just water plants, they fertilize and protect soils and crops.

Advantage of precision irrigation

Precision delivery of water/nutrients to roots reduces spray losses on surrounding soils reducing weed emergence, for example; drip system reduces wastage by 40-70%.

Precision irrigation is suitable to variety of soils and different land size.

Precision irrigation allows even distribution of water throughout the land.

Use of automated precision irrigation systems reduces need for additional labor/workforce.

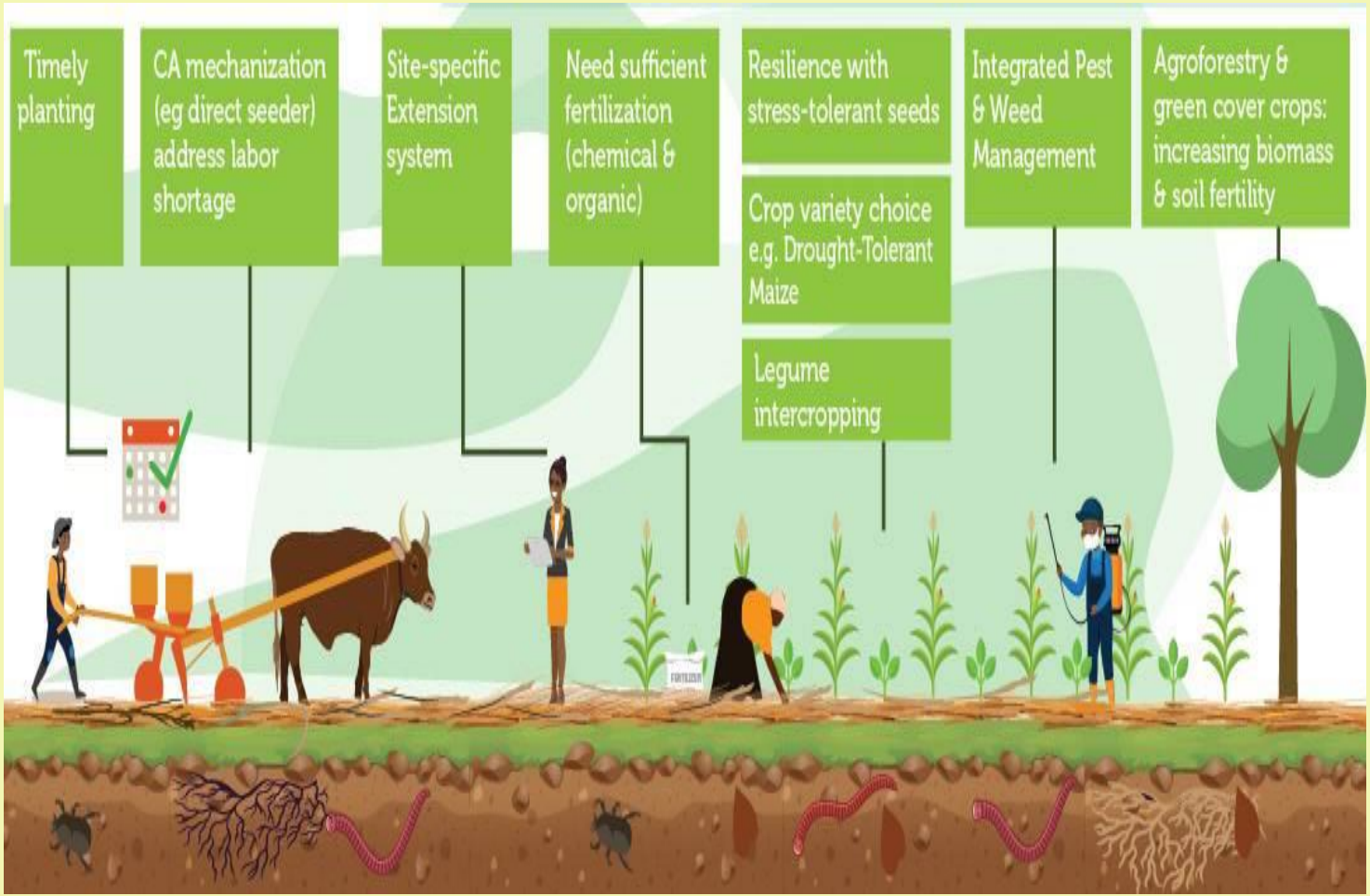
Precision irrigation systems are easy to set up

Climate Smart Agriculture (CSA)

Climate smart agriculture is an integrated way of managing landscapes, cropland, livestock, forests and fisheries in farming systems with an aim to contribute to issues of food security and climate change.

Advantages of Climate Smart Agricultural practices

- Sustainably increases productivity
- Encourages resilience (adaptation)
- Reduces/remove emissions by greenhouse gases (GHGs)


Timely planting
CA mechanization (eg direct seeder) address labor shortage
Site-specific Extension system
Need sufficient fertilization (chemical & organic)
Resilience with stress-tolerant seeds
Crop variety choice e.g. Drought-Tolerant Maize
Legume intercropping
Integrated Pest & Weed Management
Agroforestry & green cover crops: increasing biomass & soil fertility

Examples of climate smart agricultural practices

Integrated manure management.

Use of quality (certified) seeds of improved high yielding forage varieties.

Rainfall and run-off water harvesting.

Soil organic matter management e.g. Minimum tillage, incorporation of crop residues in the soil.

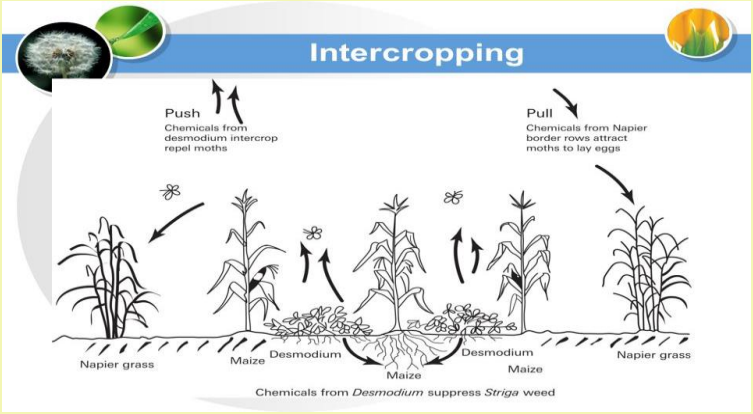
Integrated soil fertility management.

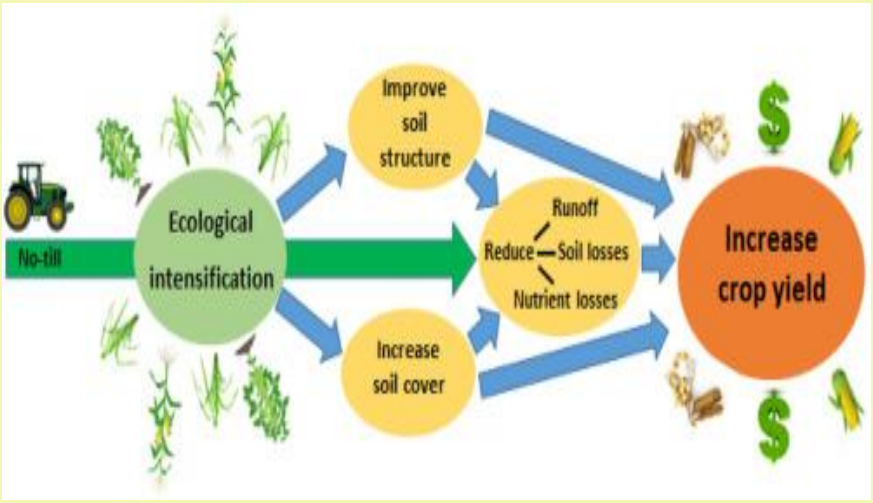
Biodiversity management e.g. crop rotation and intercropping.

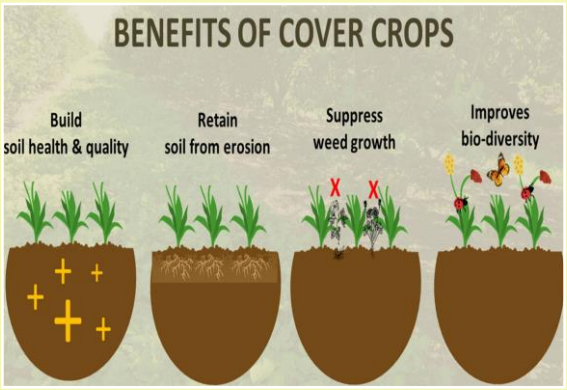
Integrated pest management (IPM)

In conclusion: conservation agricultural practices contribute to climate smart agriculture.

Good principles of Conservation Agricultures







GOOD PRINCIPLES

PRACTICED WITHIN REGENERATIVE CONSERVATION AGRICULTURE

HOW:
(No / minimum tillage)

Increased water holding capacity

OUTCOME:
Increased soil health

Minimum mechanical soil disturbance

HOW:
Leaving crop residues on he soil surface & growing cover crops in rotation

Increased infiltration rates, duced evaporation & runoff

OUTCOME:
linimal risk of soil erosion loss of valuable nutrients

Permanent organic soil cover

CA/RA PRINCIPLES

Diversification of crops

HOW:
Crop rotations (intercropping & mixed cover cropping)

Prolonged growth cycle

OUTCOME
Protected soil against th negative impacts of climate change

Integration of livestock

HOW:
Introducing animals for grazing on cover crops

Reduction of pests, diseases, & weed pressur

OUTCOME:
Increases in soil health and incomes

The simultaneous application of all these principles - practiced within regenerative conservation agriculture - help farmers to implement more resilient crop management strategies, reducing chances of crop and farm

Good principals of Conservation Agricultures

Ministry of Foreign Affairs of the Netherlands

About the ICSIAPL Project

The Integrated & Climate Smart Innovations for Agro-Pastoralist Economies and Landscapes in Kenya's Arid and Semi-arid Lands is (ICSIAPL) is athree-year (2021 –2023) project funded by the European Union (EU) and the Ministry of Foreign Affairs of the Kingdom of the Netherlands (DGIS). It is managed through a delegated cooperation with the Embassy of the Kingdom of the Netherlands (EKN) in Nairobi.

The EU fund is attached to the DeSIRA Initiative(Development Smart Innovation through Research in Agriculture).

The project is implemented by SNV Netherlands Development Organisation, SNV,(lead partner) and the Kenya Agriculture Livestock Research Organization, KALRO (research partner).

KALRO
Kenya Agricultural & Livestock Research Organization

SNV