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Conservation Agriculture: A Resource Saving Option in Modern Economy

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Conservation agriculture (CA) is a farming method that can restore degraded lands while preventing the loss of arable land. It encourages the preservation of a stable soil layer, little soil disturbance and the diversification of plant species. It improves biodiversity and natural biological processes above and below the ground, which helps to boost the efficiency with which water and nutrients are used, as well as to improve and sustain crop yield. All agricultural landscapes and land uses with locally customized practices can benefit from CA principles. External inputs like agrochemicals and plant nutrients of mineral or organic origin are applied optimally and in ways and quantities that do not disrupt or interfere with the biological processes. Soil interventions, such as mechanical soil disturbance, are minimized to an absolute minimum or avoided.

A good agronomic practice, such as timely operations, is made easier by CA, which also enhances overall land management for rain fed and irrigated crops. CA is a foundation for sustainable agricultural output intensification. It is complemented by other well-known good practices such the use of high-quality seeds and integrated pest, fertilizer, weed, and water management, among others. It expands the possibilities for integrating different production sectors, such as integrating crops and animals or incorporating trees and meadows into agricultural landscapes.

Principles of Conservation Agriculture

Conservation agriculture is based on three main aspects that have been modified to account for local conditions and needs:

Minimum mechanical soil disturbance

Permanent soil organic cover

Species diversification

1. **Minimum mechanical soil disturbance:** Direct seeding or planting: Direct seeding refers to the practice of planting crops with little to no soil disturbance following the harvest of the preceding crop and without mechanically preparing the seedbed. In CA systems, the terms "direct seeding" and "no-tillage farming," "zero tillage," "no-tillage," "direct drilling," etc. are interchangeable. While seeding typically refers to a continuous flow of seed, as in the case of little cereals, planting refers to the exact placement of large

seeds (such as corn and beans). The machinery breaks through the soil layer, creates a seeding slot, and drops the seed into it. The size of the seed slot and the accompanying soil movement should be limited to an absolute minimum. After sowing, the seed slot should ideally be entirely covered by mulch once more, and no loose soil should be exposed at the surface. In order to prepare the ground for no-tillage seeding or planting, weeds, agricultural residues, or cover crops are either slashed or rolled; herbicides are sprayed for weed control; or the mulch is seeded directly through. To ensure thorough soil coverage, crop residues are either totally removed or retained in an appropriate amount. Fertilizer and amendments are either broadcast on the soil surface or applied during seeding.

2. **Soil organic cover:** One of the cornerstones of CA is keeping the soil covered. Crop residues are typically left on the soil's surface, but if there is too much time between harvesting one crop and planting the next, cover crops may be necessary. In addition to improving soil qualities, cover crops also have the ability to encourage greater biodiversity in the agro-ecosystem, which increases the stability of the CA system**.** Cover crops are primarily planted for their impact on soil fertility or as livestock fodder, whereas commercial crops are grown for their market worth. Cover crops are advantageous in locations with lower biomass production, such as semi-arid regions or areas with eroded and damaged soils, as they:
   - When the land is fallow, guard the soil.
   - Recycle and mobilize nutrients.
   - Break up hard pans and compacted layers to improve soil structure.
   - Allow a monoculture to rotate.
   - Can be applied to manage pests and weeds.

   Utilizing the remaining soil moisture, cover crops are cultivated during fallow times between harvest and the planting of commercial crops. Before the next crop is sown or after it has been sown but before the competition between the two crops begins, their growth is stopped. Although they boost crop output, cover crops also come with some difficulties.

   Uses for cover crops include:
   - Defending the soil while there is no crop present.
   - Provide an extra source of organic matter to strengthen the soil's structure.
   - Reusing nutrients, particularly P_2O_5 and K_2 and mobilizing them in the soil profile to increase their availability to subsequent crops
   - Give the soil "biological tillage"; certain crops' roots, particularly those of cruciferous plants like oil radish, are important and able to pierce compacted or extremely dense layers, boosting the soil's capacity to absorb water.
   - Using nutrients that are quickly leached (especially N).
3. **Species diversification: Crop rotation**: Crop rotation is essential to provide the soil microorganisms with a varied "diet," as they can explore different soil layers for nutrients because they can root at various soil levels. The crops in the rotation can "recycle" nutrients that have been leached to deeper levels and are no longer available for the main crop. The crops in the rotation act as biological pumps in this way. Additionally, a variety of crops in rotation create a diversified soil flora and fauna because the roots produce various organic chemicals that draw various bacteria and fungus, which are crucial for the conversion of these substances into nutrients that plants can use. Crop rotation also serves an important phytosanitary purpose by preventing the spread of pests and diseases that are peculiar to a given crop from one crop to the next.

Effects of crop rotation include:

- Increased diversity in plant production and, consequently, in the sustenance of people and animals.
- Reduction of weed and pest infestations, as well as their risk.
- Increased dispersion of bio pores or channels produced by different roots (various forms, sizes and depths).
- Improved water and nutrient distribution throughout the soil profile.
- Roots of numerous different plant species explore different strata of the soil profile for nutrients and water, which leads to a higher utilisation of the nutrients and water that are already accessible.
- Enhanced balance of N, P, and K from both organic and mineral sources, as well as increased nitrogen fixation through specific plant-soil biota symbionts.

Methods and techniques:

- Crop rotations are planned and put into action to achieve a variety of goals, including the production of food and fodder (grain, leaves, and stalks), residue production, insect and weed control, nutrient uptake, and biological subsurface mixing and cultivation.
- Given the soil and climate conditions, choose suitable or upgraded seeds to produce large yields as well as high residue production of above-ground and below-ground portions.

The advantages of conservation agriculture

A. Economic advantages that boost production effectiveness.

Three major economic benefits can result from CA adoption:

- Time saving and thus reduction in labour requirement.
- Reduction of costs, e.g. fuel, machinery operating costs and maintenance, as well as a reduced labour cost.
- Higher efficiency in the sense of more output for a lower input.

B. Agronomic benefits that improve soil productivity.

Adopting conservation agriculture leads to improvement of soil productivity:

- Organic matter increase.
- In-soil water conservation.
- Improvement of soil structure, and thus rooting zone.

C. Environmental benefits that protect the soil and make agriculture more sustainable:

- Reduction in soil erosion, and thus of road, dam and hydroelectric power plant maintenance costs.
- Improvement of water quality.
- Improvement of air quality.
- Biodiversity increase.
- Carbon sequestration.