Conservation Agriculture

Research Study

(Planning and Research Department)

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Table of Contents

1. Introduction

Conservation Agriculture (CA) is a set of soil management practices that minimize the disruption of the soil's structure, composition and natural biodiversity. CA has proven potential to improve crop yields, while improving the long-term environmental and financial sustainability of farming.

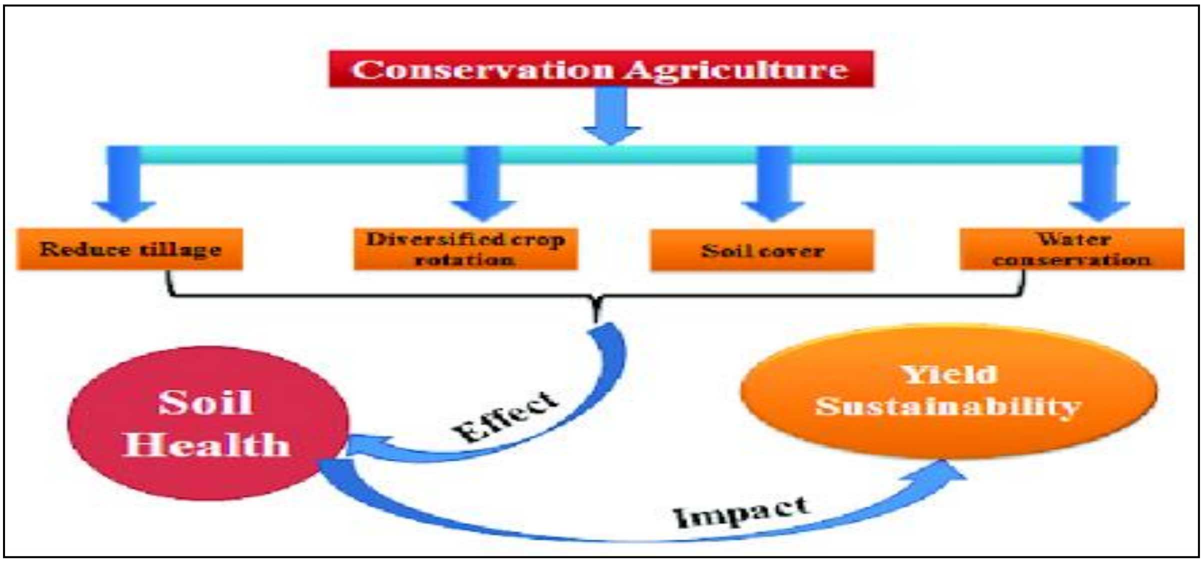
Conservation agriculture (CA) is a way of farming in which producers, as per usual, have to invent, adapt, apply and learn things within the constraints of their own circumstances and situations. Conservation Agriculture strives to minimize soil disturbance. Reducing soil tillage and ensuring that the soil has a vegetative or residue cover has a dramatic impact on reducing soil erosion. Reductions in soil erosion losses of up to 99 percent are possible in this type of farming.

Different conservation agriculture federations & networks have been formed in different regions of the world like Africa, Europe, Canada and America. Food and Agriculture Organizations of the United Nations have a special focus on conservation agriculture since this type of farming helps building resilience against climate change. Conservation agriculture has been identified as one of the 15 strategies by UN's IPCC to mitigate climate change.

Reducing soil erosion has an added benefit of conserving valuable top soil and plant nutrients for the next crop. Over time soil organic matter will increase leading to improvements in soil structure, water holding capacity and nutrient holding capacity. Many modern day ploughing

and tillage techniques alter the natural balance of micro-organisms in the soil. Under Conservation Agriculture the natural balance is restored and the soil is better able to supply plant nutrient and water needs.

Crop rotations are the other corner stone of conservation systems. Rotating between different types of crops helps to reduce the buildup of insect pests and diseases that can build up in the soil if the same crop is grown on the same field year after year.



Proponents of CA have some valid arguments in its favor and different case studies of different countries like Prague, Brazil & Italy have been useful in understanding the better use of conservation agriculture and its benefits. Proponents of traditional tillage system argue that it is not suitable for all agro-ecosystems which is true as well however, it can be used in certain situations and reasons to restore soil fertility.

2. Principles of Conservation Agriculture

The three principles of conservation agriculture include:

1) Direct planting of crop seeds
2) Permanent soil cover, especially by crop residues and cover crops
3) Crop rotation

2.1 Direct Seeding or Planting

Direct seeding involves growing crops without mechanical seedbed preparation and with minimal soil disturbance since the harvest of the previous crop. The term direct seeding is understood in CA systems as synonymous with no-till farming, zero tillage, no-tillage, direct drilling, etc. Planting refers to the precise placing of large seeds (maize and beans for example); whereas seeding usually refers to a continuous flow of seed as in the case of small cereals (wheat and barley for example). The equipment penetrates the soil cover, opens a seeding slot and places the seed into that slot. The size of the seed slot and the associated movement of soil are to be kept at the absolute minimum possible. Ideally the seed slot is completely covered by mulch again after seeding and no loose soil should be visible on the surface. Land preparation for seeding or planting under no-tillage involves slashing or rolling the weeds, previous crop residues or cover crops; or spraying herbicides for weed control, and seeding directly through the mulch.

Crop residues are retained either completely or to a suitable amount to guarantee the complete soil cover, and fertilizer and amendments are either broadcast on the soil surface or applied during seeding. A three-row no-till planter is planted through a cover crop flattened by a knife roller.

2.2 Permanent Soil Cover

A permanent soil cover is important to: protect the soil against the deleterious effects of exposure to rain and sun; to provide the micro and macro organisms in the soil with a constant supply of "food"; and alter the microclimate in the soil for optimal growth and development of soil organisms, including plant roots. Cover crops need to be managed before planting the main crop. This can be done manually or with animal or tractor power. The important point is that the soil is always kept covered.

The Effects of Soil Cover:

- Improved infiltration and retention of soil moisture resulting in less severe, less prolonged crop water stress and increased availability of plant nutrients.
- Source of food and habitat for diverse soil life: creation of channels for air and water, biological tillage and substrate for biological activity through the recycling of organic matter and plant nutrients.
- Increased humus formation.
- Reduction of impact of rain drops on soil surface resulting in reduced crusting and surface sealing.
- Consequential reduction of runoff and erosion.
- Soil regeneration is higher than soil degradation.
- Mitigation of temperature variations on and in the soil.
- Better conditions for the development of roots and seedling growth.

Means and Practices:

- Use of appropriate/improved seeds for high yields as well as high residue production and good root development.
- Integrated management and reduced competition with livestock or other uses e.g. through increased forage and fodder crops in the rotation.

- Use of various cover crops, especially multi-purpose crops, like nitrogen fixing, soil-porosity-restoring, pest repellent, etc.
- Optimization of crop rotations in spatial, timing and economic terms.
- “Targeted" use of herbicides for controlling cover crop and weed development.

2.3 Crop Rotations

The rotation of crops is not only necessary to offer a diverse "diet" to the soil micro organisms, but as they root at different soil depths, they are capable of exploring different soil layers for nutrients. Nutrients that have been leached to deeper layers and that are no longer available for the commercial crop can be "recycled" by the crops in rotation. This way the rotation crops function as biological pumps. Furthermore, a diversity of crops in rotation leads to a diverse soil flora and fauna, as the roots excrete different organic substances that attract different types of bacteria and fungi, which in turn, play an important role in the transformation of these substances into plant available nutrients. Crop rotation also has an important phytosanitary function as it prevents the carry over of crop-specific

pests and diseases from one crop to the next via crop residues an example of crop rotation to maintain soil fertility and break pathogen carry-over.

The Effects of Crop Rotation:

- Higher diversity in plant production and thus in human and livestock nutrition.
- Reduction and reduced risk of pest and weed infestations.
- Greater distribution of channels or biopores created by diverse roots (various forms, sizes and depths).
- Better distribution of water and nutrients through the soil profile.
- Exploration for nutrients and water of diverse strata of the soil profile by roots of many different plant species resulting in a greater use of the available nutrients and water.
- Increased nitrogen fixation through certain plant-soil biota symbionts and improved balance of N/P/K from both organic and mineral sources.
- Increased humus formation.

Means and Practices:

- Design and implementation of crop rotations according to the various objectives: food and fodder production (grain, leaf, stalks); residue production; pest and weed control; nutrient uptake and biological subsurface mixing / cultivation, etc.
- Use of appropriate / improved seeds for high yields as well as high residue production of above-ground and below-ground parts, given the soil and climate conditions.

3. Equipment

Conservation Agriculture can be carried out using a variety of different equipment, enabling it to be done on small or large scales. Various equipments are also used during the growing season and at harvest time. The common types of equipment used are Hand Hoe, Chinese (Li) Planter, Rotary Punch Planter, Animal-drawn Planter, Tractor Drawn Planter, Teren Rope, Sprayers and Roller.

4. Advantages and Disadvantages of Conservative Agriculture

To be widely adopted, all new concepts need to have benefits and advantages that attract a broad group of farmers who understand the differences between what they are doing and what they need. In the case of conservation agriculture these benefits can be grouped as following:

4.1 Economic Benefits

Three major economic benefits can result from CA adoption:

- Time saving and thus reduction in labor requirement.
- Reduction of costs, e.g. fuel, machinery operating costs and maintenance, as well as a reduced labor cost.
- Higher efficiency in the sense of more output for a lower input. The positive impact of conservation agriculture on the distribution of labor during the production cycle and, even more important, the reduction in labor requirement are the main reasons for farmers in Latin America to adopt conservation agriculture, especially for farmers who rely fully on family labor. Manual labor for soil preparation is back-breaking and unnecessary. Should the supply of labor be reduced, through sickness or migration, then the traditional system can quickly become unsustainable.

4.2 Agronomic Benefits

Adopting conservation agriculture leads to improvement of soil productivity:

- Increase in Organic matter.
- In-soil water conservation.
- Improvement of soil structure, and thus rooting zone.
- The constant addition of crop residues leads to an increase in the organic matter content of the soil. In the beginning this is limited to the top layer of the soil, but with time this will extend to deeper soil layers. Organic matter plays an important role in the soil: fertilizer use efficiency, water holding capacity, soil aggregation, rooting environment and nutrient retention, all depend on organic matter. A soya plant with deformed root system due to compaction. The roots show a marked tendency to lateral development with few vertical roots to explore other soil strata.

4.3 Environmental Benefits

- 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.

5. Why Conservation Agriculture?

Residues on the soil surface reduce the splash-effect of the raindrops, and once the energy of the raindrops has dissipated the drops proceed to the soil without any harmful effect. This results in higher infiltration and reduced runoff, leading to less erosion. The residues also form a physical barrier that reduces the speed of water and wind over the surface. Reduction of wind speed reduces evaporation of soil moisture. Soil erosion is reduced close to the regeneration rate of the soil or even adding to the system due to the accumulation of organic matter. Soil erosion fills surface water reservoirs with sediment, reducing water storage capacity. Sediment in surface water increases wear and tear in hydroelectric installations and pumping devices, which result in higher maintenance costs and necessitates earlier replacement. More water infiltrates into the soil with conservation agriculture rather than running off the soil surface. Streams are then fed more by subsurface flow than by surface runoff. Thus, surface water is cleaner and more closely resembles groundwater in conservation agriculture than in areas where intensive tillage and accompanying erosion and runoff predominate. Greater infiltration should reduce flooding, by causing more water storage in soil and slow release to streams. Infiltration also recharges groundwater, and thus increasing well supplies and revitalizing dried up springs. Sediment and dissolved organic matter in surface water must be removed from drinking water supplies. Less sediment loss and less soil particles in suspension, lead to a reduced cost for water treatment. Maintaining soil cover will reduce erosion with the consequent loss of soil fertility, soil compaction, and, eventually, landscape change. One aspect of conventional agriculture is its ability to change the landscape. The destruction of the vegetative cover affects the plants, animals and micro-organisms. Some few profits from the change and turn into pests however, most organisms are negatively affected and either they disappear completely or their numbers are drastically reduced. With the conservation of soil cover in conservation agriculture a habitat is created for a number of species that feed on pests, which in turn attracts more insects, birds and other animals. The rotation of crops and cover crops restrains the loss of genetic biodiversity, which is favored with mono-cropping. Systems, based on high crop residue addition and no tillage, accumulate more carbon in the soil, compared to the loss into the atmosphere resulting from plough based tillage. During the first years of implementing conservation agriculture the organic matter content of the soil is increased through the decomposition of roots and the contribution of vegetative residues on the surface.

This organic material is decomposed slowly, and much of it is incorporated into the soil profile, thus the liberation of carbon to the atmosphere also occurs slowly. In the total balance, carbon is sequestered in the soil, and turns the soil into a net sink of carbon. This could have profound consequences in the fight to reduce green house gas emissions into the atmosphere and thereby help to forestall the calamitous impacts of global warming.

6. Difference between Conservation Agriculture & Conventional Tillage System

The difference between Conservation Agriculture & Conventional Tillage System is that preceding green manure cover crop and weeds are crush bent over with a knife roller, instead of burning and incorporating the residues and weeds into the soil. This provides a mulch layer which protects the soil (against rain, wind & sun), retains soil moisture and provides nutrients for next crop to be sown.CA contrary to CTS has zero tillage thereby creating no disturbance in deep soil.

7. Limitations & Challenges of Conservation Agriculture

The most important limitation in all areas where conservation agriculture is practiced is the initial lack of knowledge. There is no blueprint available for conservation agriculture, as all agro-ecosystems are different. A particularly important gap is the frequent dearth of information on locally adapted cover crops that produce high amounts of biomass under the prevailing conditions.

The success or failure of conservation agriculture depends greatly on the flexibility and creativity of the practitioners and extension and research services of a region. Trial and error, both by official institutes and the farmers themselves, is often the only reliable source of information. However, as conservation agriculture is gaining momentum rapidly in certain regions, there now exist networks of farmer organizations and groups of interested people who exchange information and experiences on cover crops, tools and equipment and other techniques used in conservation agriculture.

Initial nervousness about switching from plough-based farming to CA can be ameliorated by forming farmer groups to exchange ideas and gain knowledge from more experienced practitioners. As conservation agriculture partly relies on the use of herbicides, at least during the initial stage of adoption, some people worry that adoption of conservation agriculture will increase herbicide use and that in turn will lead to increased contamination of water by herbicides. In fact experience has shown that herbicide use tends to decline over time as the soil cover practices prevent weed emergence. Reductions in leaching of pesticides under conservation agriculture might be caused by greater microbial activity degrading pesticides faster or to greater organic matter adsorbing the pesticides.

8. Dilemma of Going Forward or Backward?

Opponents claim that this type of farming is far from modernization and is practiced in remote and underdeveloped regions of the world however their perception is far from reality. It is understandable that those who do not acknowledge Climate Change and its effects on environment usually having vested industrial/commercial interests will also fail to appreciate benefits of CA. One of the misconceptions about CA is that it prohibits use of machinery in reality CA emphasizes minimum tillage and use of machinery that does not disturb soil deeply. Therefore a far as dilemma of going forward or backward is concerned undoubtedly Conservative Agriculture is a step forward towards better soil health ,better crop and better environment for population worldwide and without adopting its basic principles no agriculture would be sustainable in future.

9. Conclusion

Crop production in the next decade will have to produce more food from less land by making more efficient use of natural resources and with minimal impact on the environment. Only by doing this will food production keep pace with demand and the productivity of land be preserved for future generations. This will be a tall order for agricultural scientists, extension personnel and farmers. Use of productive but more sustainable management practices can help resolve this problem. Crop and soil management systems that help improve soil health parameters (physical, biological and chemical) and reduce farmer costs are essential. Development of appropriate equipment to allow these systems to be successfully adopted by farmers is a pre-requisite for success. Overcoming traditional mindsets about tillage by promoting farmer experimentation with this technique in a participatory way will help accelerate adoption. Encouraging donors to support this long-term applied research with sustainable funding is also an urgent requirement. If not all, a few principles of conservation agriculture are still useful for most agriculture regions of the world, since CA is based on Good Agriculture Practices (GAP).In the wake of Climate Change; Conservation Agriculture is the only ray of hope to conserve environment and soil resources.

Critical steps for a successful CA adoption (Derpsch, 2008)

1. Improve your knowledge about the system, especially weed control.
2. Analyse your soil (aim for a balanced nutrient status) and alleviate soil acidity (liming).
3. Avoid soils with bad drainage.
4. Level the soil surface.
5. Eliminate soil compaction by cultivation.
6. Produce the highest amount possible of mulch cover.
7. Buy a no-till planter – only after steps 1 to 6 have been met.
8. Start on 10% of your farm.
9. Use crop rotation and green manure cover crops.
10. Be prepared to learn constantly and be up to date with new developments. Join the nearest CA study group.

10. Sources:

- *http://www.fao.org/ag/ca/1c.html*
- *http://www.growingnations.co.za/conservation-agriculture/*

Research & Editorial Team

Mr. Farhat Karim Hashmi EVP (P, R&T D)

Mr. Muhammad Rashid SVP (P&RD)

Abida Razzaq VP (P&RD)

Aamna Imtiaz OG-III (P&RD)