CONSERVATION AGRICULTURE: A SUSTAINABLE FUTURE OF AGRO-ECOSYSTEM

Abstract

Increase in degradation of soil resource base and escalating soil degradation has been the result of the continuous usage of traditional or conventional practices of farming which involves tillage and burning the crop residues. With time, input costs like fuels, fertilizers, and others will increase which makes it necessary to use the resources effectively in agriculture. Conservation agriculture has emerged as a technological option for the better use and saving of resources available on the basis of its principles, which include giving minimum disturbance to the soil, covering the soil surface with cover crops or crop residues and crop rotation or crop diversification. They are considered as a good option for attaining the sustainability in crop production under varying environmental conditions as they aim to use the resources efficiently without degrading the soil resource base. This chapter gives a brief knowledge about the concept, aims, principles and advantages of adopting the conservation agriculture practices.

Keywords: Zero tillage, conservation agriculture, crop residues, crop rotation, natural resource

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I. INTRODUCTION

Conventional practices in agriculture and green revolution have caused an increase in yield of crops, but has put a question mark on the yield sustainability and soil quality, as they have incurred several environmental problems like soil biodiversity and fertility loss, water scarcity and salinization (McIntyre et al., 2009). The agricultural production system in India is being addressed with severe problems of degradation of soil and water, rising cost of production, decrement in soil organic matter, practising tillage-induced agriculture causing soil compaction and water erosion, drop in ground water table, labour shortages and uncertain rise in price of fuels. As a result, governments and farmers are looking for alternative production practices that preserve soil structure and productivity and thus conserve the natural resources. All these concerns about the sustainability of agricultural system has led to the development of the concept of conservation agriculture (CA) (Figure 1), which has grown steadily to occupy around 11% of the world's arable land (157.8 M ha) (FAO 2016). It is based on three main principles, as given by FAO (http://www.fao.org.ag/ca): minimum soil disturbance, where the disturbed area should cover only less than 15 cm width or 25% of the cropping area, more than 30% ground cover and crop rotation with minimum of three crops. It is described as a scientific agricultural practice which aims to save and preserve the natural resources, increase crop productivity and production, through the use of efficient or resource conservation techniques. Therefore, CA can be a preferable technology for addressing the challenges of food security and environmental problems posed by the conventional practices.

II. CONCEPT AND AIM OF CONSERVATION AGRICULTURE

According to FAO, CA is a concept of agricultural crop production which saves natural resources and focuses on improving natural and biological processes, above and below ground. It is described as a management strategy for agro-ecosystems that aims to boost productivity, profit, and food security while protecting and strengthening the environment and the resource base. A variety of management techniques are used under CA to maintain a soil cover by surface retaining crop residues with zero/no till and minimal tillage, minimising the effect on the soil composition, structure, and natural biodiversity and reduction in soil erosion and degradation. CA is basically interlinked with its three principles, where anyone applied only to the management systems does not qualify the system to be a CA based system. It requires all the three principles to be followed in the management practices. The three basic principles are described as:

1. There should be minimum or no disturbance to the soil, through implementation of broadcasting seeds or no- till seeding, and direct seeding, and allowing minimum soil compaction through minimum traffic.
2. Retaining crop residues, cover crops and any other ex-situ plant materials over the ground surface permanently.
3. Crop rotation should be followed, involving a legume crop once along with non-legume crops.

CA aims to

1. Use natural resources more efficiently by conserving and improving them, and reversing the processes of deterioration induced by conventional agricultural practices.

2. Integrate the soil, water and biological resources available along the external sources.
3. Conserve the environment along with enhancing and sustaining the agricultural production.
4. Lower the cost of production by saving energy, labour and water.

III. TECHNOLOGIES FOR CONSERVATION AGRICULTURE

1. **Zero tillage:** Since conventional practices of tillage allow the soil to get loosened for preparation of good seed bed. uniform germination of seeds and fertilizer, manures and crop residue incorporation into the soil, they provide some quick advantages. But they have proved to be negative in the long run as there have been a decline in the soil organic matter, which is essential for good soil aggregation, infiltration of water, aeration, availability of nutrients and microbial interactions in the soil. Tillage operations in the long term make the soils to form hardpan below the plough layer of soil, which thus restricts the penetration of roots and infiltration of water in the soil.

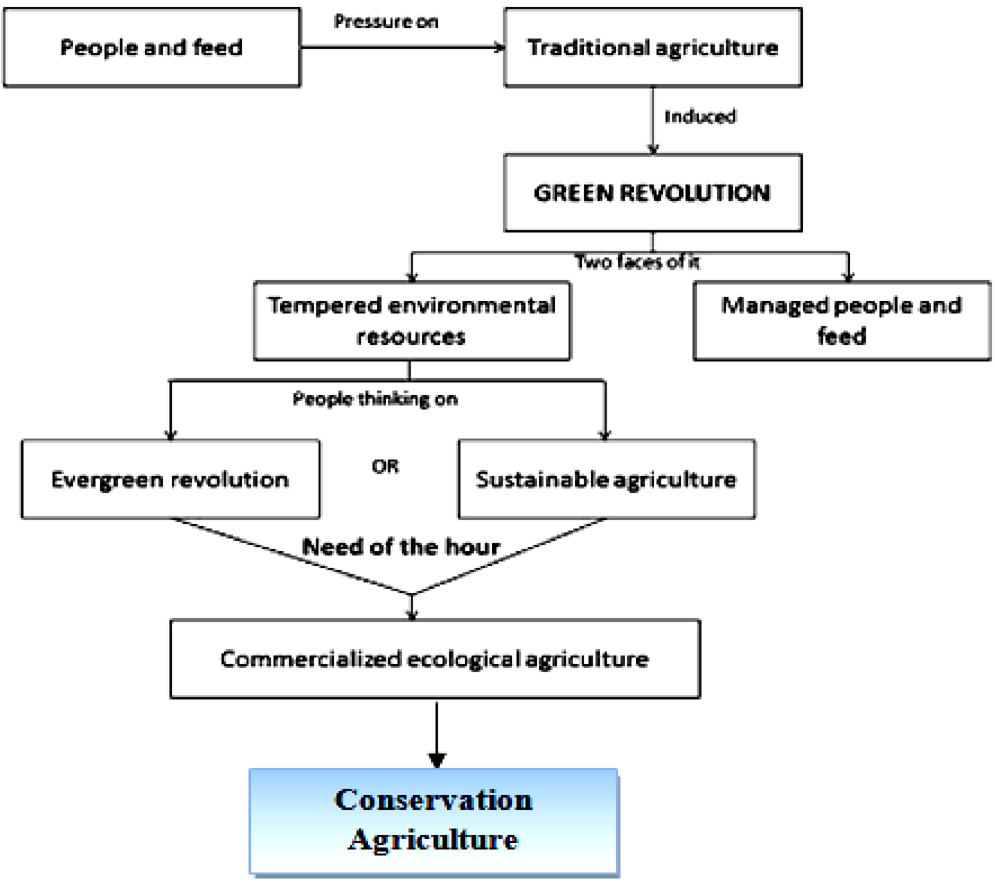

Figure 1: Generalised Flow Diagram Depicting the Change from Traditional Agriculture towards Conservation Agriculture (Srivastava et al. 2016).

Zero tillage or no- tillage practice makes the use of tillage implements which make a channel for dropping the seeds for sowing and does not allow the soil to get turned over. It involves leaping three to four operations of tillage required for ploughing the soil, as it occurs in conventional practices, thus reduces the production costs and the subsequent crop is timely planted, especially in case of wheat. Although there is high variability in the yield benefits of ZT over conventional tillage practice, ZT accompanied by mulching has shown a decline in yield initially but the yield increases subsequently over time (Baudron et al. 2011), causing increased yields over conventional tillage practice (Rusinamhodzi et al. 2011). ZT has proven to improve soil health, soil organic carbon build up, energy savings, mitigation of the effects of climate change by sequestering the soil organic carbon and reduction of GHG emissions.

2. **Surface covering with cover crops and crop residues:** Water erosion has caused soil loss in India by >10 tonnes per hectare per year (Maji et al., 2008), which causes the soil to lose fertile top soil layer and thus, less availability of major nutrients. CA practices emphasize on keeping the surface soil to be covered always, either through the cover crops or through retaining the crop residues in the field. Cover crops are mainly grown for filling the time between harvesting of preceding crop and establishment of the succeeding crop where there is long gap. The biomass provided by cover crops allow protection of the soil surface from impact of raindrops, help in preserving the soil moisture and give shade to the soil surface. Further, when legumes are taken as cover crops, they help increase the mineralization of available nutrients (especially, nitrogen) and thus, make available the nutrients for succeeding crop. They also give extra income to the farmers in the form of fodder or food resources.

   The part of the crop left after harvest in the field or the part which is left aside during processing or which is not used generally or not sold is defined as the crop residues. Rice and wheat contribute a high quantity to the crop residues, produced annually from various crops (Rao, 2014). A major part of Northern India contributes to the increase of GHG emissions due to stubble burning, which has not only resulted in polluting the environment, but has caused a loss of 6 Mt of major nutrients. Crop residues, not only preserve the soil moisture, reduce evaporation, protect the soil from direct impact of raindrops, it helps in improving the soil physical, chemical and biological properties by providing decomposable organic matter. In rice-wheat systems, crop residue recycling has resulted in an increase of rice yield by 13% and wheat yield by 8%, cost effectiveness to decrease by 5 and 3%, and energy efficiency to decrease by 13 and 6%, when compared to residue retrieval, while the advantage in yield was in range of 9 and 3 % as compared with residue burning (PDFSR, 2011).

3. **Crop rotation, cropping systems and crop diversification:** An essential part of CA practices is crop rotation, which provides higher diversity for crop production, feed for humans and livestock, and managing weeds/pests. Legumes, when included in crop rotation provide ample benefits of increased yields of subsequent crop, input costs reduction because of N-fixation and decrease in incidence of crop diseases (Pannell, 1995), diverse and better distribution of nutrients and water throughout soil profile created by channelling of diverse roots. Crop rotation helps in recycling those nutrients which have leached to the lower layers and are not being made available for the main crops. Cropping systems intensification (growing more number of crops per year, double cropping and taking cover crops) helps to increase soil carbon storage under ZT (Luo et al. 2010). Also, a diverse soil flora and fauna is obtained when various crops are taken in rotation, as different organic compounds are released by roots which allow inhabitation of

different types of bacteria and fungi in the soil rhizosphere, which help in the mineralization of major nutrients in the soil. An increase in diversification or intensity of cropping will help in minimising the risks, enhance biodiversity, profit will be obtained from diversified sources and thus help in sustaining the resources.

4. **Direct seeding in rice:** Puddling and transplanting practices under conventional agriculture require much labour and water and there are increasing trends of soil degradation, which needs the change to shift from transplanted and puddled rice to direct seeded rice (DSR). DSR is more favourable where there is low availability of water and high wages, as it was observed in Southeast Asian countries, where there was a shift from transplanting to DSR due to shortages of labor and rise in wages (Pandey and Velasco, 2005). In the Indo-Gangetic plains, direct seeded and transplanted rice which were grown on raise beds, helped in reducing the use of water by 12-60% as compared with the flooded transplanted rice (Gupta et al., 2003).

Other technologies under CA include direct seeding, laser land levelling, bed planting, use of GIS (Geographical Information System) and GPS (Global Positioning System) systems, customised leaf color charts (LCC) for site specific nutrient management, adopting system of rice intensification (SRI), etc. All these technologies under CA help in utilising the resources efficiently, without deterioration.

IV. ADVANTAGES OF CONSERVATION AGRICULTURE

1. Soil quality, soil biota and the system productivity can be improved by following CA-based sustainable intensification as compared to the conventional practices (Choudhary et al. 2018).
2. In cereal based systems CA can help in saving the water, labor and improve the soil health and provide higher production (Gathala et al. 2013; Jat et al. 2015).
3. CA can increase the profit of farmers by integration of legumes in their cropping system (Kumar et al. 2018).
4. They can increase the organic carbon storage in soil through regulation of the rapid decomposition process of soil organic matter (Das et al. 2013).
5. They can provide a low carbon technology, minimise the emissions of greenhouse gases (GHG) from the fields (Dash et al. 2017).
6. They can help in sustaining the yields, especially in tropical lowlands (Dash et al. 2017).
7. CA practices can improve the nutrient and water use efficiency (Jat et al. 2012; Saharawat et al. 2012).
8. CA have proved to improve the efficiency of resources used by decomposition of crop residues, soil structure improvement, improvement in nutrient recycling and availability (Jat et al. 2009a).
9. They have reduced the production costs by Rs 5760 per hectare in the Indo-Gangetic Plains of India (Erenstein and Pandey, 2006).
10. It improves the overall soil physical, chemical and biological properties of soil.
11. They can help in reducing poverty and enhancement of food and nutritional security, because of optimised and higher crop yields and low prices of food.

V. CONCLUSION

Conservation agriculture has proven to be efficient in utilising inputs, saves water, requires less labor, helps in reducing the emission of greenhouse gases, reduces the production costs, improves the soil microbial activity, soil physical and chemical properties and helps in getting sustainable yield. CA provides a new approach for research and development in agriculture as compared to the conventional practices, which aimed mainly at achieving specific targets of food grain production. Therefore, CA can be said as the future of sustainable agriculture.

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