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Conservation Agriculture: Principles, Advantages and Challenges

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SUMMARY

Conservation agriculture is defined as a recent agricultural management system involving minimal soil disturbance and permanent soil cover combined with crop rotations which is gaining popularity in many parts of the world. Conservation agriculture does not just mean not tilling the soil and then doing everything else the same. It is a holistic system with interactions between households, crops and livestock since rotations and residues also have other uses within households; the result is a sustainable agriculture system that meets the needs of farmers. To be widely adopted, all new technologies have to prove their advantages to a broad group of farmers to understand the differences between what is being practiced and what needs to change. CA aids the cultivators to maintain and elevate productivity levels, boost monetary profits, reverse land degradation, protect environment and respond to rising consequences of rapid climate change.

INTRODUCTION

Conservation agriculture is a production system involving minimum soil disturbance, soil cover through crop residues or other cover crops and crop rotations for achieving high productivity with most efficient resource use. Conservation agriculture conserves natural resources, biodiversity and labour and increases available soil water, reduces heat and drought stress, and builds up soil health in the longer term. It is designated as a sustainable production system constituting a set of farming techniques convenient to the crop requirements and local growing situations of a particular region, where different management practices would protect the soil from severe erosion and degradation, improve its quality, maintain biodiversity, as well as contribute to conservation of natural resources like water and air, besides optimizing production levels. It is a conception of resource preserving crop production technique striving to obtain adequate profits along with sustained productivity while simultaneously preserving the environment. The term 'conservation agriculture' was first coined in 1990s, but the concept to reduce soil disturbance was originated in 1930s, during the Dust Bowl in the United States of America. CIMMYT began working on this new concept in Latin America and South Asian countries in 1990s and in Africa in early 2000s; nevertheless, farmers worldwide are exceedingly adopting CA now-a-days. In the cropping season of 2015-16, conservation agriculture was practiced on approximately 180 mega hectares of cropland globally which was about 12.5 per cent of cumulative croplands on global basis and 69% more than in the 2008-09. One of the options available to ensure sustainable production system is conservation agriculture. It is of particular relevance in rice-wheat cropping system in the NW-IGPs where soil and water health is under stress. Crop residue management is very much essential for maintaining long term sustainability of Indian agriculture; hence, burning of stubbles should be discouraged and residues must be utilized advantageously to improve soil health and reduce environmental pollution. Both in-situ (incorporation into the soil) and ex-situ (composting) methods of residue management are useful; moreover, in the areas where crop residues are generally utilized for animal feed and other beneficial purposes, some of the residues should be recycled into the soil.

Benefits of conservation agriculture

While considering conservation agriculture, the advantages should be classified into economic benefits for improving production efficiency; agronomic benefits to improve soil productivity and environmental and social benefits that protect the soil and make agriculture more sustainable.

Economic benefits:

- Time saving
- Reduction in labour requirement
- Reduction of costs, e.g. fuel, machinery operating costs and maintenance, as well as reduced labour cost
- Higher efficiency by way of more output for a lower input
- The positive impact of CA on distribution of labour during production cycle and even more important, the reduction in labour requirement is the main reasons for farmers to adopt CA.

Agronomic benefits:

- Adoption of conservation agriculture causes improved soil productivity by the means of organic matter increase, in-situ soil water conservation, improvement of soil structure as well as rhizospheric region.
- The continuous addition of crop residues to soil results in an increase of soil organic matter content.
- Primarily the effect was limited to the top layer of soil, but with progress in time it would extend to deeper soil layers.
- Organic matter plays an important role in the soil by improving fertilizer use efficiency, water holding capacity, soil aggregation, rooting environment and nutrient retention.
- Crop residues retained on the soil surface with no or minimum tillage enhances soil quality through improvement in soil organic carbon content and other soil parameters.
- Reduction in tillage provides enough turnover time to form stable soil aggregates, which in turn provide protection of soil organic matter.
- Mineralization of soil organic carbon to CO_2 is moderated, paving way for stable humus formation.
- Improved aggregation leads to improvement in total soil porosity, continuity of soil pores and pore size distribution, thus facilitating water infiltration.
- Improved aggregation and less traffic under conservation agriculture reduce surface and subsurface soil compaction.
- Permanent organic soil cover protects the soil from erosive forces *i.e.* wind and rainfall, shields soil surface from direct exposure to sun, minimizes extremes of soil temperature, and reduces soil water evaporation.
- Nutrient cycling is enhanced due to nutrients drawn from stubble and other residues from the previous crops.
- Slower decomposition or breakdown of surface placed residues can prevent rapid nutrient leaching through soil profile.
- Improved soil organic matter status and greater aggregation result in congenial microclimate for improved microbial activity.
- Diversified rooting depth of crops explore different soil layers for nutrients ensuring better nutrient recycling within soil profile and increased nutrient use efficiency.
- Zero tillage farming with residue cover saves irrigation water and suppresses weeds.
- Leaving the soil undisturbed increases water infiltration, holds soil moisture and helps to prevent topsoil erosion.
- Conservation agriculture enhances water intake that allows for more stable yields in the midst of weather extremes exacerbated by climate change.

Environmental benefits:

- Conservation agriculture reduces soil erosion, improves water and air quality, and increases bio-diversity and carbon sequestration.
- Residues present on the soil surface can reduce the splash effect of raindrops and the drops can proceed to the soil without any harmful effect when energy of the raindrops has dissipated resulting in higher infiltration rate and reduced runoff, ultimately leading to less soil erosion.
- Crop residues can also act as a physical barrier which can reduce the speed of water and wind over the surface.
- Wind speed reduction also reduces evaporation of soil moisture.

Principles of conservation agriculture

Conservation agriculture practices perused in many parts of the world are built on ecological principles making land use more sustainable (Behera *et al*., 2010 and Lal, 2013). The fundamental or core pillars of conservation agriculture are soil disturbance regulation or minimal mechanical soil disturbance, surface residue management or permanent soil cover with living or dead plant material and crop rotation or crop diversification through rotation or intercropping. Following are the core principles of sustainable intensification.

Soil disturbance regulation or minimum soil disturbance

- Controlled traffic, zero or reduced tillage can cause minimum physical soil disturbance on cropland that enhances soil natural processes and recycling by permitting direct planting through surface residues of the previous crop without ploughing or preparation of soil.
- Minimum soil disturbance helps to preserve soil life, aggregates and structural quality and stability.
- This promotes the sustainability of ecosystems.

Permanent soil cover

- Permanent crop cover with recycling of crop residues is a pre-requisite and an integral part of conservation agriculture.
- This principle regulates soil erosion and temperature effect on surface soil, provides substrate for microorganism existence.
- Soils under diverse cropping systems have a higher SOC pool than monocultures.
- Exclusion of summer fallow and growing a winter cover crop augments soil quality through carbon sequestration.
- Crop diversification through rotations, cover and intercrops contributes to recycling of nutrients.
- It also helps to disrupt weeds, pests and disease cycles; can enhance biological nitrogen fixation when legumes are included and also ensure diversification of diets.

Crop rotation

- The sustainability of agro-ecosystems can be enhanced by changing from monoculture to crop rotation.
- Zero tillage is often combined with intercropping and crop rotation.

The principles of conservation agriculture integrated with best management practices have several advantages which are stated below:

- Can give higher yield
- Lower irrigation use
- Increase irrigation water productivity
- Reduction in energy use than conventional tillage
- Net returns can be increased with reduction in production cost
- Conservation agriculture can be amalgamated into majority of the rainfed and irrigated production systems, involving horticulture, agro-forestry, organic farming, rotational farming and integrated farming systems in order to strengthen ecological endurance or sustainability.

Challenges of conservation agriculture

The constraints of conservation agriculture faced by the farmers for adoption are discussed below:

- Wetlands or soils with poor drainage can make its adoption quite challenging.
- In case of limited crop residues, farmers usually utilize the residues for fodder purpose first; therefore, enough residues for soil cover are not left.
- An important hindrance of CA adoption is purchasing of new equipments. Farmers must buy new implements like planters or drills to produce effectively in CA.
- Appropriate seeders are essential which may not be accessible and affordable to small and marginal farmers.
- CA is knowledge intensive practice; all farmers may not have the access to proper knowledge and training required to practice conservation agriculture on their farms.
- CA can increase productivity levels in the long run but cultivators cannot see these advantages immediately.
- But the modern innovations, research and technologies are always trying to help the producers to overcome those issues and facilitate the adoption of CA.
- On the other hand, sowing of a crop in presence of surface residues of preceding crop is a huge menace but new alternatives of zero-till seed-cum-fertilizer drill/planters *viz.* Happy seeder, Turbo seeder and Rotary disc drill have been developed for direct drilling of seeds even in the presence of surface residues as these machineries

are very much useful to manage crop residues with an objective to conserve soil moisture and nutrients along with the management of weeds including moderation of soil temperature; however, these equipments are not in reach for most of the small and marginal poor farmers.

- It is urgently required to develop and fine tune proper farm machineries to facilitate collection, volume reduction, transportation and application of residues and sowing of succeeding crop under a layer of residues on soil surface.
- The process of conservation agriculture takes time; when a farmer tries to become a conservationist, the outcome may be a considerable financial loss to them.
- Conservation agriculture is dependent upon the establishment of an organic layer and production of own fertilizer which is also time consuming.
- While considering the tropical regions, more pressure is actually faced to transform from conventional to conservation agriculture due to the limited available resources.
- According to the Population Reference Bureau, there were around 6.08 billion people on earth in the year 2000 whereas by the end of 2050 there will be an estimated 9.1 billion people throughout the globe. With the burgeoning population pressure, the responsibility of the farmers also increases as there is a huge need to enhance food supply using the same or less land than we use today.
- Problems arise if conservation agriculture cannot produce as much as conventional farms and this may leave the world with less food for more people.

CONCLUSION

Conservation agriculture offers a new paradigm for agricultural research and development which aimed at achieving specific food grain production targets in India. A shift in paradigm has become a necessity in view of widespread problems of resource degradation, accompanied by the past strategies to enhance production with little concern for resource integrity. Integrating concerns of productivity, resource conservation and soil quality and the environment is now fundamental to sustained productivity growth. Conservation agriculture offers an opportunity for arresting and reversing the downward spiral of resource degradation, decreasing cultivation costs and making agriculture more resource use efficient, competitive and sustainable. "Conserving resources – enhancing productivity" has to be the new mission.

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