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CONSERVATION AGRICULTURE: AN APPROACH FOR SUSTAINABLE AGRICULTURE

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ABSTRACT

Conservation agriculture (CA) is now considered as a new way ahead for the conservation of resources and also improves the productivity for accomplish the goals of sustainable agriculture. In latest past, progressive and considerable efforts are made to expand, filter and spread conservation-based agricultural technologies across the world. Remarkable efforts on surface management with crop residues and zero-till practices for crop production were reviewed. Conservation Agriculture (CA) comprising the minimum mechanical soil disturbance, covering the soil with cover crops or plant biomass and diversifying crop rotations or associations which is feasible and considered as a more sustainable cultivation system than that currently done. Many challenges are faced by the world and one of it is to fulfill the demand of growing population on the scenario of climate change with reduction in external inputs. The surface of the soil is kept covered by residues of crop, biomass or cover crops to provide the physical protection to the soil from the soil degradation agents and most importantly provide nourishment for the life of the soil. In the paper discussion has been done about the rising concerns of conventional agriculture systems with regard to its adoption, positives and negatives of conservation agriculture in promoting conservation agriculture.

***Keywords*:** Cover crops, zero-till, crop rotations, soil degradation

Introduction

Achieving the security of food for the ever increasing population, especially in the nations which is less developed nations and developing the production system of agriculture which is sustainable are one of the major challenges before the globe in this century. Fulfilling the requirement of food for the people is not only the challenge but eggs, fruits and vegetables demand by the rapidly expanding middle class population in developing nations. The challenges become more complex because of forthcoming climate change-related risks, already there is start of experiencing the adverse effects in one or other form in agricultural production systems in many parts of the world. As more and more diversion of agricultural land towards the use of residential and industrial throughout the globe, there is requirement of more and more production of food from the rapidly less cultivated land. This will additionally hurt the already delicate natural resource base, especially water and land, making it more difficult to meet the food requirements of the world. So, there is urgent requirement for the conservation or even the natural resources improvement from the degradation by water as well as by wind erosion, which accelerates many times because of activities of human beings.

Conservation Agriculture (CA) comprising the minimum mechanical soil disturbance, covering the soil with cover crops or plant biomass and diversifying crop rotations or associations which is feasible and considered as a more sustainable cultivation system than that currently done. Many challenges are faced by the world and one of it is to fulfill the demand of growing population on the scenario of climate change with reduction in external inputs (Pittelkow *et al.*, 2015).

The behind approach for the management of agro-ecosystem for the improved and sustained productivity, increment in profits and security of food while preserve and enhance the resource base and the environment (Friedrich *et al.*, 2012). The introduction of Conservation Agriculture (CA) approach was made for the improvement of sustainability and productivity as well as improves the farmers profit while maintaining the natural resources. This includes the management of natural resources at the village, farm and landscape scales to enhance the synergies between the ecosystem conservation and food production. Due to minimum soil disturbance in conservation agriculture, the life and biological processes in soil are not disturbed which is important for getting the fertile soil which supports the healthy plant development and growth The surface of the soil is kept covered by residues of crop, biomass or cover crops to provide the physical protection to the soil from the soil degradation agents and most importantly provide nourishment for the life of the soil. The crop residue burning is strictly prohibited in CA. The diversified crop rotation by the inclusion of legumes in CA helps to manage the infestation of disease and pest problems and also improves the quality of soil through the organic matter addition and biological nitrogen fixation (Baudron *et al.*, 2009).

Components of Conservation Agriculture

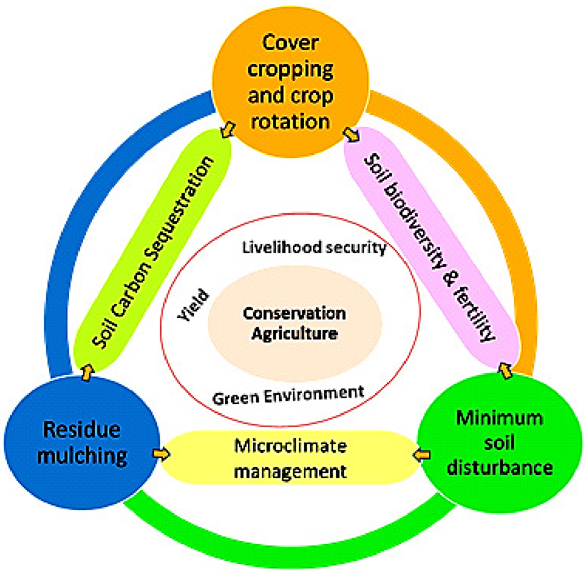

Fig. 1 : Components of conservation agriculture and their positive interaction with the environment. (Swaminathan *et al.*, 2022)

CA-based technologies/practices

(1) Crop rotation

Kumar *et al.*, 2018 found that CA-based based on rice-wheat-mungbean systems improves the productivity of system by 11 per cent, profit by 24 per cent and lessen the use of irrigation water by 28 per cent and requirement of energy input lessen by 25 per cent as compared to conventional RW system or practice of farmers (12.3 Mg ha^{-1}; 2650 mmha^{-1}; INR 85,800 ha^{-1}; 79.2 GJ ha^{-1}) also reduces the global warming potential by 23 per cent (1.5 Mg CO_2 eqyr^{-1}). Similarly the reporting was done by Jat *et al.* (2019c, 2020a, 2020b) with the integration of mungbean in to RW/MW system. The broader choice in the agriculture system of production is proposed by the Crop diversification to offer in the RW domain especially in an area to expand production- related activities of diversified crops and also reduction in yield. On average, the inclusion of leguminous crops in cereal systems (RW/MW) contributes an increase of 18 per cent in system productivity and 15 per cent in net returns (Choudhary *et al.*, 2018a).

There are some challenges in adapting the crop rotation that crop rotation are lack of reliable markets for m many leguminous crops and limitation in the improvement of legume seeds (Baudron *et al.*, 2007; Haggblade and Tembo, 2003). Farmers are forced not to choose the plant legumes in permanent planting basins due to crop geometry (Baudron *et al.*, 2007).

(2) Residue management

Out of the total crop residue burning in India, RW system contributes 84 per cent and the 16 per cent from other types of rotations of crop (Singh & Panigrahy, 2011). The distruction of beneficial microflora of the soil with major implications nutrient use efficiency and soil health is also done by the in-situ burning (Lohan *et al.*, 2018). Farmer friendly and cost valuable options for the crop residue management provides intense effect of water conservation by the reduction of losses due to evaporation and run-off reduction (Singh *et al.*, 2010). The temperature of canopy also lowers down in wheat by 1–4°C during the grain filling period. Similarly, they also lowered the canopy temperature in wheat by 1–4°C at the grain filling period. The reduction in the population of *Phalaris minor* is noticed by 45-75 per cent, when a load of >6.0t ha^{-1}residue maintained over the surface of the soil in the RW system of India (Sharma *et al.*, 2015; Sidhu *et al.*, 2007). The latest version of the Turbo seeder (Sidhu *et al.*, 2015) has been identified as one of the technological innovation Key which is developed and validated under the different farmer situation. The new approach is initiated by Turbo seeder for sorting out the shortcomings of direct drilling of wheat into heavy rice residue load as surface mulch in a single operational pass (Sidhu *et al.*, 2007, 2015). It also facilitates timely planting with higher crop productivity (Aryal *et al.*, 2020).

(3) Zero-till (ZT) Technology

Conservation Agriculture comprises manly three principles: minimum soil disturbance (including ZT), crop rotation, and residue retention/permanent soil cover (FAO, 2011). The chemical, physical and biological properties of the soil affected by the ZT and its pattern are entirely different from the conventional tillage affect. No-tilsoill in the perspective of CA can also cause the improvements in the quality of the through the soil structure improvement and with the enhancement of biological activity of soil, cycling of nutrients, water infiltration capacity, water holding capacity of soil and water use efficiency (Hobbs *et al.*, 2008). Mineralization of organic nutrients viz. sulfur, nitrogen and phosphorus might be a major source of available nutrients near the ZT soil surface. Larger exchangeable potassium found in ZT experimental plots at 0-5 cm. The reason behind the accumulation of potash in the deeper layer of soil depending on plowing depth in CT is due to mechanical mixing of soil (Blevins and Frye, 1993). More nitrogen gets mineralized in CT system at the surface of the soil due the disturbance of soil (Halvorson *et al.,* 2001).

The change on the soil C and N cycles are found due to Paddy-wheat rotation and makes the chemical specifications and biological effectiveness of nutrients diverse with seasons, soil biomass and make more complicated soil physical changes (Fig. 1). Tillage practices causes the band breakdown of the soil aggregates and also oxidizes the once hidden organic matter into the atmosphere which on longer duration use deteriorates the soil quality. Tillage affect on the atmosphere occurs as radioactive gases emitted from the earth surface to the atmosphere (Lal *et al.*, 2007). Approx one-third of the global greenhouse gas emission is recognized to changes in tillage scenarios (Gattinger *et al.*, 2014). 10-12 per cent of global green house gas emissions is contribution of direct emissions from agriculture in 2010 (Tubiello *et al.,* 2013). Further, UNEP (2013) emission gap recognized agriculture as first of the four sectors that contributes and have confirmed to be efficient in lessening the greenhouse gas emissions. The report gives emphasis on the adoption of the zero-tillage practice to reduce the adverse effects of global warming. The shift from CT to ZT had been reported to yielda carbon sequestration rate of 367-3667 kg CO_2 $ha^{-1}year^{-1}$ (Tebrügge and Epperlein, 2011) as oxidation of CO_2 into the atmosphere has been checked to the marked extent.

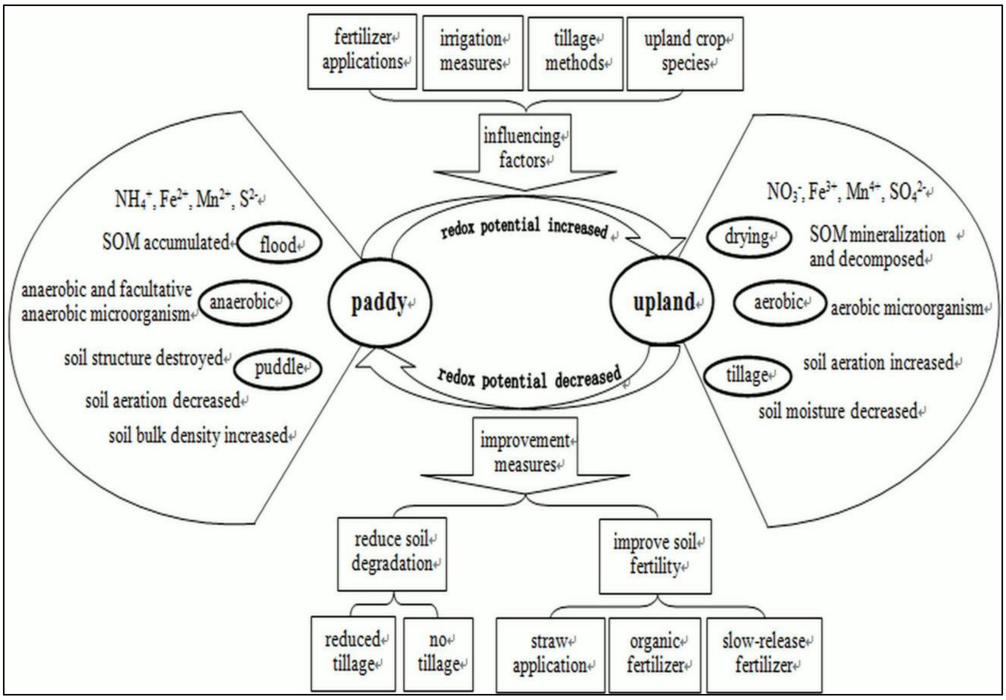

Fig. 2 : Characteristics of Paddy-upland rotation and its improvement measures: Soil organic matter (Bhatt *et al.,* 2017)

Factors affecting the adoption of conservation agriculture

(1) Biotic and abiotic stress-

Green Revolution changed the scenario of agriculture in the IGP of India; it improved the productivity of cereal crops but at the same time, biotic stresses like weeds, insects, pests, and diseases also intensified due to changed cropping systems and resource requirements. A weed called *Phalaris minor* in the wheat crop was introduced at the same time and shift in weed flora due to increased fertilizer dose, irrigation facilities, and dwarf varieties in rice and wheat crops. With time it has developed a strong resistance to the commonly used herbicides and farmers have to find out new and effective herbicides every 3 years (Sharma *et al.*, 2015).

(2) Natural resource degradation

The intensive tillage which is based upon the RW system in western has arisen the problems of natural resource (soil, water and diversity) degradation. About 50 and 75 per cent overexploitation of ground water in Haryana and Punjab respectively cause by the extreme pumping of groundwater for irrigating the crops (Humphreys *et al.*, 2010). The groundwater table in this region during one decade (1993–2003) has gone down by approximately 0.50 m yr^{-1} due to monotonous RW system, repeated RW cultivation favours the loss of organic matter, mining of excessive soil nutrients, nutrients imbalance and also affects the flora diversity and fauna in the region which are crucial for ecosystem strength (Choudhary *et al.*, 2018b).

(3) Climate change

Agriculture and other production systems are immensely affected by the climate change in the Indian subcontinent through variability in weather, precipitation patterns and alterations in temperature causing shift in crop season. The different aspects of crop production, nutrient cycling, agricultural ecosystem and ultimately food security are affected by such aspects (Sharma *et al.*, 2015).

Advantages of conservation agriculture

Several benefits of CA are shown in Fig 2. CA ensures provides physical protection against weather (raindrops, wind, dry or wet periods), better soil structure of soil as well as cohesion protection of soil erosion and transportation of nutrients and lastly saves energy, money and time. CA has the huge potential for diverse agro-ecological system and soil. It is neutral for farm-holding size but small holder farmers required CA to reduce the production cost, resource saving and profitability increase (Derpsch, 2008). Most of the time conservation agriculture is misunderstood as organic farming. There are some little differences between two. Although both having the same objective of improvement in the health of soil through natural resources, organic farming avoids the chemical inputs application while CA permits. CA is seen as a solution for the problems of food security and productivity (Hobbs, 2007) and has the capability to reduce the need of labour for preparation of land and soil fertility improvement as well as reduction in water stress in crops (IIRR, 2005). The objectives of conservation agriculture is year round cropping, mulching may be live or residue, crop rotation and reducing tillage. The reduction in mechanical tillage increases the activity of macro and micro flora activity duo which biological activity of soil get improved, that in turn improves structure of the soil and enhances the growth of the plant (Selvakumar and Sivakumar, 2021).

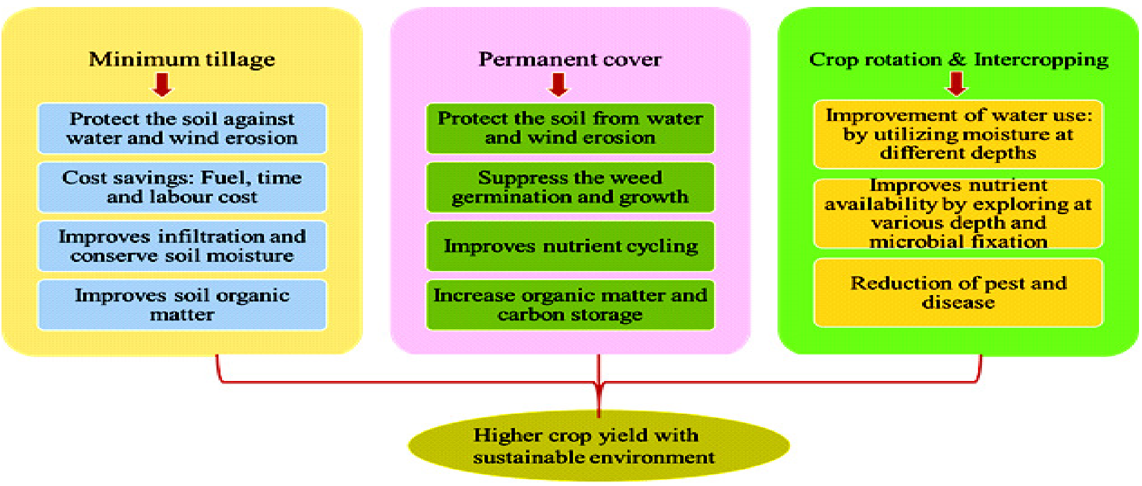

Fig. 3: Conservation agriculture component wise soil, environment and yield benefits. (Swaminathan *et al.*, 2022)

Conclusion

Over the past three decades or so, there is significant progress has been made worldwide to build up and spread the technologies for the resource conservation such as zero and reduced tillage systems, better crop residues management and planting systems that improvise the conservation of water and nutrient. Conservation Agriculture, which is based in the fundamental principles of providing permanent soil cover (through crop residues, cover crops), minimum soil disturbance and crop rotation is now considered to be the most important for sustainable agriculture. It is thus a means of achieving higher production goals by protecting natural resources and the environment.

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