Conservation Agriculture: A Way for Soil Water Conservation

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ABSTRACT

World population is going on increasing, it may be 2.4 billion by 2050, but stabilizing the yield of crop is questionable in Indian agriculture due to improper management of agricultural land. Excess tillage accelerate the organic matter oxidation present on the top soil, soil erosion and creates subsurface hard pan. This makes the field unsuitable for cultivation of crops in future. Climate change is worsening the situation by imposing water scarcity in India. So to evade these problems, conservation agriculture is the only way. Main objectives of conservation agriculture is reducing tillage, year round cropping, crop rotation, mulching may be live or residue. Due to reduced mechanical tillage, activity of micro flora and macro flora get increases that improves biological tillage of soil, that in turn improves soil structure and enhances the plant growth. Most of the studies showed that the cost of wheat production and CO₂ emission from the field is reduced when conservation agriculture was followed in rice-wheat cropping system. Crop rotation and also mixed cropping improves soil fertility and also it reduces soil erosion. It can be a part of climate smart agriculture. It reduces greenhouse gas emission and also it can improve carbon sequestration. Considerably it can save 20-30% of water.

Key words: Conservation agriculture, Effect on soil, Principles.

Tillage is the important age old practice, which improves the soil structure, thereby it improves quality of soil like more soil water retention, aeration, root growth etc., but due to introduction of heavy weight tillage implements to plough the soil, occurrence of subsurface soil layer compaction, vulnerable to erosion and faster degradation of organic matter on the surface soil occurs (Wolff and Stein, 1998). Due to increased fuel cost, tillage operation become costlier. So to reduce the ill effects of conventional tillage, modern tillage practices came to play. Main aim of the conservation agriculture is to reduce the tillage operation and also addition of previous crop residue to the soil. It improves the health of soil ecosystem by improving the biological activity. In conservation agriculture, mono cropping is completely avoided.

Conservation agriculture (CA) is a concept evolved as a response to concerns towards sustainability in agriculture, which has recorded steady increase in worldwide to cover about ~8% of the world arable land (FAO, 2012) and now it reached 180 Mha (Kassam et al., 2019). Moreover as organic matter is lesser in most of the Indian soils, conservation agriculture plays a vital role in soil and water conservation compared to zero tillage. Mostly farmers are not aware of this technology due to lesser level of communication through extension activities (Podder et al., 2017). This review mainly focuses on the effect of conservation agriculture on soil and water conservation.

Minimizing tillage or conservation tillage and its desired effect

In minimum tillage, primary tillage is like conventional tillage, whereas secondary tillage activities are be minimized. In the case of zero tillage, tillage operations are restricted with sowing area. Due to reduced tillage activity, soil compaction get decrease, soil micro flora activity get increase. It is helpful for the higher nutrient availability and improves soil structure by secreting sticky organic substances. So soil aeration, moisture retention capacity also improve. It improved root growth and re exposure of weed seeds due to reduced soil turning (Kassam and Friedrich, 2009). Due to reduced tillage activity, organic matter decomposition get decreased, which intern maintained the organic layer horizon of the soil in temperate region (Ghosh et al., 2019). In India direct drilling of seeds extensively followed in rice-wheat cropping system. Most of the studies showed that the cost of wheat production was reduced by Rs. 2,000 to 3,000 ($ 33 to 50) per hectare (Malik et al., 2005). It also reduced the CO₂ emission from the field not less than 25%. So it was helpful to control climate change. Deep carbon accumulation with compact layer was observed in No-till soil (Soane et al., 2012). 10 years of study on minimum tillage with rice-maize cropping system recorded higher nutrient use efficacy and water use efficiency in eastern indo gangetic plains (Jat et al., 2018). Practicing zero tillage combined with balanced nutrient enhanced the yield of crop in wheat based cropping system (Parihar et al., 2019).
Residue addition and its effect
30% of the previous crop residue should be applied. It acts as a mulch, suppress weed population may be due to shading or allelopathic effect, reduces the soil water evaporation and also it adds nutrient to the soil. It improved soil organic carbon (Blanco-Canqui & Ruis, 2018). In temperate region it is highly helpful to retain the temperature of the soil. In sloppy areas it will reduce the erosion of soil (Fischer and Hobbs, 2019). But residue application in cool and moist region caused water logging, which ultimately affected the initial growth of crop and final yield (Blanco-Canqui & Ruis, 2018).

Crop rotation and its feasibility
Crop rotation has to be followed in conservation agriculture like cereals followed by pulses or deep root followed by shallow rooted crops etc. It helped to avoid the depletion of single nutrient from the same depth of soil and also it was highly helpful for the restoration of nutrient in case of growing legume crop in rotation (Negi and Rana, 2016). It also reduced the pest, disease and nematode problem compared to mono cropped areas (Kassam and Friedrich, 2009; Dumanski et al., 2006). Rotating erosion permitting crop to erosion resisting crop resulted in reduced the soil erosion. But it is not possible in dry farming. Because in that mostly mono cropping is practiced by using received rainfall (>750 mm). But during offseason green manure can be cultivated with lesser rainfall and incorporation can be done into the soil.

Effect of conservation agriculture on soil physical properties
Conventional method of tillage reduced the soil’s infiltration, sorptivity, steady state flow, hydraulic conductivity and infiltration. It was mainly due to compaction formed in the subsurface layer of the soil. Excessive tillage improved the soil erosion (Penning de Vries et al., 2008) and generally organic matter addition was not there. This hinder the growth and development of microbes present in the soil that ultimately decreased the quality of soil and increases erosion. It also increases the cost of cultivation due to increased fuel prices. But when the minimum or zero tillage is followed, cultivation cost can be minimized due to reduction in tillage or avoiding tillage operations. In conservation agriculture generally 30% of the previous crop’s residue is added as a mulch on soil surface. It safeguarded the soil from weather abnormalities and residue addition also enhanced the biological activity of the soil. Increased concentrations of SOC and N within the aggregates was observed in the upper 5-8 cm of soil depth after 37-40 years of conservation agriculture treatments (Jacobs et al., 2009). Minimum tillage improved the soil pore size of 0.5-50 mm (Pagliai et al., 2004). This improved the water holding capacity of the soil. Water holding capacity of the soil was high in unploughed soil than ploughed due to increased micro pores at top 0-10 cm of the soil (McVay et al., 2006). So water content available in this pores will be highly available to plants. Some of the studies indicated that addition of organic matter improved the structure of the soil and aggregate formation (Shukla et al., 2003), which in turn improved the earth worm and other microbial content of the soil (Subbulakshmi et al., 2009). It also increases the interconnected soil pores and the infiltration capacity of the soil. Mulching also reduces the evaporation of soil moisture. So it will be conserved for the future crop utilization.

Effect of conservation agriculture on soil chemical properties
There are slight pH difference between conventional tillage, Minimum tillage and zero tillage soil. Zero tilled soil recorded higher organic matter level compared to conventional tillage, because in zero tilled soil oxidation of organic matter is much slower. Reduced soil N loss was recorded with minimum tillage and zero tillage soil (Dalal, 1992). Higher mineralization and/or leaching rate could be implicated for reduction in organic C and total N under tilled plot due to soil structure deterioration following tillage. The effective cation exchange capacity (ECEC) were significantly higher at ZT compared to CT. The study reported that less soil disturbance is beneficial to soil chemical quality improvement (Busari et al., 2015).

Effect of conservation agriculture on organic matter content of the soil
Soil hold three times more carbon than atmosphere (Sanderman et al., 2017). When the forest or grass land is converted into agricultural land, soil organic matter decomposition will be rapid, it could deplete 50% of the soil organic carbon in 10-15 years (Diels et al., 2004; Zingore et al., 2005). Residue addition in conservation agriculture declined the rate of organic matter decomposition and leads to accumulation of higher soil organic matter (Corbeels et al., 2006). It enhanced the soil organic carbon status and it also provide an opportunity for climate change mitigation (Smith et al., 2019). CENTURY and RothC models stimulation suggested that conversion to no-tillage in the West African dryland sandy soils resulted in small increases in soil C contents (0.1-0.2 t ha$^{-1}$ year$^{-1}$) (Farage et al., 2007). Chivenge et al. (2007) found that in fine textured soil, reduced tillage could have a strong positive effect with soil organic matter. This was mainly due week physical and structural protection of soil organic matter in sandy soils, in that the organic matter of the soil strongly depend on quantity of crop residues added repeatedly to the soil. Increasing organic matter content of the soil improves the quality of the soil and nutrient content of the soil that ultimately increase the yield of cultivated crop (Schjonning et al., 2018), but some of the study results revealed that even though conservation agriculture increased organic matter content yield of the crop remain unchanged (Sun et al., 2020).

Trend in conservation agriculture
Globally, CA is practiced in 180 M ha. In In India, CA adoption is still in the initial phases. Zero tillage and CA has expanded
about 1.5 million hectares over the past few year (Jat et al., 2012). In rice-wheat (RW) system of the Indo-Gangetic plains (IGP) adopted zero tillage practices, due to improvement in seed drill, which help the farmers to sow the seeds in zero tillage condition. In other crops and cropping systems, reduced/zero-tillage operations are slowly getting introduced. In addition to ZT, other concept of CA need to be further improved and it should sustain the productivity. The CA adoption also offers diversification through crop intensification. Zero tillage technology farmers could able to save on land preparation costs by about Rs. 2,500 ($41.7) per ha and reduced diesel consumption by 50 - 60 litres per ha (Sharma et al., 2005). Zero tillage allows timely sowing of wheat, enables uniform drilling of seeds, improves fertilizer use-efficiency, saves water and increases yield up to 20%. Success has also been achieved in bed planting of wheat, cotton and rice. This has resulted in savings of irrigation water, improved fertilizer use and reduced soil crusting.

**CONCLUSION**

Due to conventional agriculture, all the natural resources has been exploited. So sustainability of food production will become a questionable one in future. Conservation agriculture can be a solution for sustaining the production. To mitigate the climate change, carbon sequestration should be more, carbon-di-oxide release should be less. Conventional tillage encourage the release of carbon-di-oxide from the stored soil carbon pool. This can be avoided through conservation agriculture. It also include residue mulching. This reduces evaporation of water from soil surface, adds food to microbes and also reduce erosion. Diversified cropping reduce the depletion of single nutrient from the soil. As an overall view, conservation agriculture conserve soil and water. India is having diversified cropping and diversified soil types. So conservation agricultural practices has to be standardized for diversified cropping and soils through experiments.

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