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Effect of Conservation Agriculture on Different Crops: A Review

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ABSTRACT

The production of crops through conventional method has high impact on food security and economic purpose. As productivity of the soils and wider environmental effects of conventional agricultural techniques, particularly the ploughing, disking, and hoeing of soils, are causing significant concern. Thus, Conservation agriculture a holistic approach with adequate crop and soil management packages, is one of prolonged techniques towards diminishment in depletion of the natural resources with ecological viability in agriculture. As conservation agriculture helps in better soil structure and stability of soil aggregates, increase in nutrients stored, less investment and reduced use of machinery and animals in crop production etc. However, Conservation agriculture systems are much more complex than conventional systems. Site specific knowledge has been the main limitation to the spread of the system. Also, strengthened knowledge and information sharing mechanisms should be needed to accomplish such project. Assisting farmers and researchers in reorienting their agricultural practices towards cost-effective, sustainable solutions that utilize less vulnerable choices and pathways is crucial. In most ecological and socio-economic settings, conservation agriculture-based crop management solutions that are adapted to local needs will play a critical role in achieving this goal.

Key words*: Conservation agriculture, Sustainability, No-till, Agriculture, Conventional agriculture*

Introduction

The world's increasing population has led to a growing demand for food, making agriculture a vital component of our lives. Agriculture plays a strategic role in enhancing food availability and achieving food security, although there is uncertainty surrounding its ability to meet the rising global demand (Pawlak and Kolodziejczak, 2020). To satisfy these demands, conventional agriculture has become more prevalent over time. The objective of conventional agriculture is to maximize crop yield potential, achieved through the use of synthetic chemicals, genetically modified organisms, and other industrial products. While conventional agriculture benefits food security and the economy, it also compromises biodiversity, soil fertility, and ecosystem health (Gangrude *et al.,* 2016).

Conservation agriculture in lieu of conventional farming

In recent years, the elevation in the cost of production of food, climate variability, scarcity of water, deterioration of natural ecosystems and bio - diversity, and the economic crisis have clearly made an intensive challenge of agricultural sustainable development. The productivity of soils and wider environmental effects of conventional agricultural techniques, particularly the ploughing, disking, and hoeing of soils, are causing significant concern. Govern-

ments and farmers have been actively exploring new production techniques that sustain soil productivity and structure (FAO, 2015). Thus, Conservation agriculture a holistic approach with adequate crop and soil management packages, is one of the long-term techniques towards the reduction in the depletion of natural resources and ecological sustainability in agriculture. Conservation agriculture is increasingly being promoted as a set of concepts and practises that can contribute to long-term productivity intensification. It is a sustainable agricultural strategy that intends to meet the following goals: everlasting and profitable expansion of agricultural operations through the application of three interdependent principles i.e., Minimal soil disturbance, permanent soil cover, and crop rotations. The overall objective of conservation agriculture is to make better use of agricultural resources (than conventional agriculture) by integrated management of available soil, water, and biological resources, while minimising external inputs. It boots up the microbial activity which in turn soil quality, crop production, and many ecosystem services.

Conservation tillage has been found to have positive impacts on soil organic matter content, plant surface and groundwater capacity, soil aggregation, and soil water transmission capacity, as well as infiltration parameters and saturated hydraulic conductivity, as reported by Pretty and Bharucha (2014). As a result, conservation agriculture is increasingly being promoted as a Climate Smart Agriculture practice, aiding in both adaptation and mitigation of climate change. This approach is gaining popularity as an alternative to both conventional and organic agriculture. The use of conservation agriculture may help to mitigate the harmful effects of indiscriminate use of chemical fertilizers, pesticides, and herbicides, which have negatively impacted soil health, according to research by Shrestha *et al.* (2020).

Why Conservation agriculture/ Necessity of conservation agriculture

As the world's population grows every day, it is predicted to go from 7.7 billion in 2019 to 9.7 billion in 2050. (United Nations, 2019). Increasing global food production will be essential to feed these more people, especially in emerging nations where population growth is now occurring at the highest rates (United Nations, 2019). This is necessary in a world where there are few opportunities to increase the amount of land used for agriculture, and where land degradation, the scarcity of freshwater resources, an increase in the variability of the climate, and extreme weather events brought on by climate change make it difficult to increase production on already-existing agricultural land. Therefore, global agricultural systems must develop to produce more food with higher sustainability in order to fulfil the world's growing food demand. Due to intensive agriculture's conventional methods, second-generation issues with soil degradation, soil organic matter depletion, and deficiencies of several macro and micronutrients, including N, P, K, S, Zn, Fe, and Mn, have emerged. These issues may be related to excessive nutrient removal from soils (Ladha *et al.*, 2000; Tiwari, 2002), a decline in the groundwater table and deterioration of groundwater quality (Humphreyse (Hobbs *et al.*, 1997). But ongoing soil disturbance from farming, notably from soil inversion, has resulted in soil compaction, deterioration of soil structure, and a decline in the amount of organic matter in the soil. Due to the employment of high energy-consuming machinery, this has led to a variety of environmental effects, including soil deterioration, water and wind erosion, eutrophication, increased carbon emissions emitted from the soil, and a general decline in beneficial soil organisms and animals. Over the ages, earth built up and offered a growing environment for plants. Plants in turn served to prevent soil erosion. Humans' agricultural endeavours have been upsetting this connection. Degradation and variability issues have been made worse by climate change as a result of increasingly irregular rainfall events and frequent storms (Osborn *et al.*, 2000). Since practising conservation can also aid in lowering CO_2 emissions.

Principles of conservation agriculture

Many regions of the world practise conservation agriculture, which is based on ecological principles and increases the sustainability of land usage (Wassmann, 2009; Behera *et al.*, 2010; Lal, 2013). As a potent instrument for managing natural resources and achieving sustainability in agriculture, adoption of Conservation agriculture to improve Resource use efficiency (RUE) and crop yield is urgently needed. Three fundamental principles—which are interconnected and must be taken into account as a whole for effective design, planning, and implementation processes—underlie conservation agriculture. Which are:

Least amount of mechanical soil disturbance

The biological activity of the soil creates extremely solid soil aggregates and holes of different sizes that enable the penetration of air and water. This method, which is sometimes referred to as "biological tillage," is incompatible with mechanical tillage. The biological soil structuring mechanisms will cease to exist with mechanical soil disturbance. A little amount of soil disturbance promotes/maintains ideal levels of respiration gases in the rooting zone, moderate organic matter oxidation, porosity for water transport, retention, and release, and restricts re-exposure of weed seeds and their germination (Kassam and Friedrich, 2009). The notable agronomic practice of no-tillage (NT) or minimum tillage is Minimum soil disturbance standards must be met in order for seed and fertiliser to be applied to the soil without negatively affecting its structure, aggregation, aggregate stability, or porosity. In the past, soil tillage helped with the mineralization of nutrients, which increased soil fertility to a little amount (Dumanski *et al.,* 2006), however extensive tillage on a long-term basis causes soil erosion and deterioration (Donovan and Casey, 1998). Thus, it was discovered that ZT, or minimal soil disturbance, was beneficial in reducing the detrimental effects of both excessive tillage and soil erosion (Li *et al.,* 2007). Therefore, by minimising subsurface compaction, low or no tillage associated with conservation agriculture not only enhances soil aeration and water permeability yet, it also offers a niche for a variety of microbial communities (Sayre and Hobbs, 2004).

A constant organic soil layer

A permanent soil cover is necessary to prevent the soil from being harmed by exposure to rain and sunlight, to give soil micro- and microorganism's a steady supply of "food," and to change the soil's microclimate for the best growth and development of soil organisms, including plant roots. According to Ghosh *et al.* (2010), this enhances soil aggregation, soil biological activity, soil biodiversity, and carbon sequestration. Agricultural residues on the soil's surface keep it from being eroded and washed away by runoff (Boual *et al.,* 2011; Brouder and Gomez-Macpherson, 2014). (Thomas *et al.,* 2007). The amount of soil cover lowers soil evaporation from the surface, enhances water infiltration, and modifies soil temperature. If potential evapotranspiration was high and water-holding capacity was low, keeping crop residue and avoiding tillage increased infiltration and soil moisture content (Ter Avest *et al.,* 2015).

Crop rotations with more variety

Undoubtedly, crop rotations are the best method for weed control. Every crop place different biotic and abiotic restrictions on the weed population; as a result, some weeds will develop more quickly than others while others will be stunted. This makes it possible to imagine any individual crop as a filter that only allows specific weeds to pass through its management strategy (Booth and Swanton, 2002). Crop rotation is essential to provide the soil microorganisms with a variety "diet," as well as to search through the various soil layers for nutrients that have leached to deeper levels and may be "recycled" by the crops in rotation. A diversified crop rotation also results in a diverse soil flora and fauna. Legumes play a key role in crop rotations and sequences because they interrupt Pest species' life cycles, fix nitrogen biologically, reduce off-site pollution, and increase biodiversity (Dumanski *et al.,* 2006; Kassam and Friedrich, 2009).

Effect of Conservation agriculture on Different Crops

Rice

Conservation agriculture has the potential to increase crop yield and bring stable incomes. Proper nutrient management in conservation agriculture practices can improve soil health and lead to economic benefits.

Bell *et al.* (2019) found that the longer-term practice of conservation agriculture led to an increase in rice grain yield of up to 12%. In terms of cost of production, conventional tillage had a total cost of 1334.74/ha for rice production, while minimum tillage had a cost of NRs.1125.79/ha, and no-tillage had a cost of NRs.1078.75/ha. Furthermore, Calcante and Oberti (2019) reported that minimum tillage had 16% more savings compared to conventional tillage, and no-tillage had 19% more savings compared to conventional tillage. The results of various studies indicate that conservation agriculture practices have the potential to not only increase crop yields but also decrease production costs, which can lead to higher profits for farmers. Furthermore, by improving soil health, conservation agriculture practices can promote the long-term sustainability of

agricultural systems, providing benefits for both farmers and the environment.

Wheat

Several studies have demonstrated the benefits of conservation agriculture practices in enhancing crop yield and nutrient use efficiency in various crop systems, including wheat and maize-wheat rotations. Huang *et al.* (2008) found that no-tillage and stubble mulching increased nutrient performance, resulting in improved water flow in plants and increased crop yield. Gathala *et al.* (2011) reported a 4-10% increase in wheat crop yield due to zero tillage practices, while Jat *et al.* (2011) found that conservation agriculture practices enhanced nutrient use efficiency. Ghosh *et al.* (2010) observed a 79% increase in wheat grain yield due to the use of conservation agriculture practices compared to traditional agriculture practices. Similarly, Bashour *et al.* (2016) found a 27% increase in wheat crop yield with conservation agriculture practices compared to conventional agriculture practices. Additionally, Khorami *et al.* (2018) reported that conservation agriculture practices, including tillage reduction, better agronomy, and improved varieties, led to an increase in wheat yield. Choudhary *et al.* (2018) also showed the benefits of conservation agriculture in a maize-wheat system, demonstrating an improvement in soil quality compared to a rice-wheat system.

Maize

Conservation agriculture practices have shown higher yields and biomass of maize, as reported by Afzalinia *et al.* (2012). Shrestha *et al.* (2020) studied the performance of hybrid and open-pollinated varieties of maize under various conservation agriculture-based practices and found the highest benefit-cost ratio in the plot with no-tillage and residue, followed by no-tillage without residue. Thierfelder *et al.* (2015) found greater corn yields under conservation agriculture compared to conventional tillage in southern Africa.

Cotton

Conservation agriculture practices can benefit crops by leaving crop residue in the field, which helps maintain soil moisture content and reduces weed growth (Bilalis *et al.,* 2003). These practices can also lead to increased net monetary savings and have potential for adoption in various regions, such as the cotton-wheat system in Punjab, India (Blaise, 2015). Research has shown that no-tillage with crop residue retention can result in higher productivity and profitability (Naveen Kumar and Babalad, 2017). Additionally, the use of less tillage with increased residue preservation can contribute to water conservation, decrease soil erosion, and improve soil physical properties, including increased organic matter content (Blanco and Lal, 2008; Patel *et al.,* 2019).

Lentil

Based on the study conducted by Wahbi *et al.* (2014), the adoption of Conservation agriculture practices led to a 20-30% increase in lentil grain yields in comparison to conventional tillage. The increase was particularly noticeable for early and late ripening genotypes. According to Bashour *et al.* (2016), the increase in lentil output under the experiments with conservation agriculture as opposed to traditional methods. According to the same author, conservation agricultural approaches reduced the cost of producing lentils by 17.5% when compared to traditional methods. According to Prasai *et al.* (2018), in far western Nepal, the Khajura lentil variety achieved a grain yield that was 11.96% greater (1.03 t ha-1) than that of traditional farming methods.

Barley

Barley yields have been observed to increase under conservation agriculture techniques. Buschiazzo *et al.* (1998) conducted research at six experimental locations in the subhumid and semi-arid Pampas area and found that average yields with no-till and reduced-till were greater than with conventional tillage (mouldboard-till) for sorghum production. Barrera Mosquera *et al.* (2019) investigated the viability of conservation agricultural strategies for barley (*Hordeum vulgare* L) in the Andean area of Ecuador between 2011 and 2014. The study concluded that less tillage used in conservation agriculture resulted in higher yields and lower production costs.

Potato

Conservation agriculture plays a crucial role in potato cultivation. Quintero and Comerford (2013) reported that reduced tillage and cover crops over a seven-year period in potato-based systems increased the soil's organic matter and carbon content. Conservation tillage sites had 33% greater carbon content and 29% higher soil carbon concentration

than conventional tillage sites, demonstrating the effectiveness of improved conservation agriculture practices in potato-based systems. Barrera Mosquera *et al.* (2019) further support the benefits of conservation agriculture, reporting a 25% increase in crop yield and a 24% increase in net advantages of the system compared to traditional methods.

Sorghum

According to Bayala *et al.* (2012), as for millet, maize, and sorghum, the improvements in yield using Conservation agriculture techniques were greater on low to medium productivity areas. Conservation agriculture may improve the environmentally friendly production of feedstock for biofuels like sweet sorghum. According to Yousif and Babiker (2015), Conservation agriculture might be used to provide a greater and more affordable sorghum yield. They observed that Conservation agriculture is a desirable alternative for farmers because to its increased yield and net return. As stated by Malobane *et al.* (2018), Conservation agriculture increased sorghum yield as a biofuel feedstock in semiarid South Africa.

Soybean

According to Dibert *et al.* (1979), the notill technique may result in a greater yield of soybean types when the soil moisture content is raised. Thiagalingam *et al.* (1991) conducted a four-year study to investigate the effects of no-till and conventional tillage methods on a clay loam soil in a maize-soybean crop rotation. They came to the conclusion that no-till produced on average 20% greater soybean yields than conventional tillage, and that no-till improved soybean germination. Wilhelm and Wortman (2004) found that the no-till approach produced the same number of soybeans as the traditional tillage method.

Conclusion

In conclusion, conservation agriculture is a viable strategy for producing crops sustainably. It has a number of advantages, including improved soil health, crop yield, and farmer livelihoods. Contrary to conventional farming methods, the use of Conservation agriculture on a variety of crops, including wheat, maize, rice, and cotton, has been demonstrated to increase yields, need less water, and have a lower environmental effect. Farmers, governments, and other stakeholders must significantly change their attitudes and behaviours in order to implement Conservation agriculture. In order to expand Conservation agriculture-based farming and assure its long-term viability, more research and funding are required. It is now crucial to integrate concerns of productivity, resource conservation, soil quality, and environmental sustainability for long-term productivity growth. Conservation agriculture presents an opportunity to halt and reverse the decline of natural resources while also reducing cultivation costs, increasing resource efficiency, and promoting sustainable agriculture. As demand for food and energy grows, the need for sustainable agricultural practices becomes even more important for India to address the impacts of climate change and ensure energy security. Adopting no-till conservation agriculture practices can be a valuable step in meeting these challenges, but farmers and researchers will require support in reorienting their practices towards more efficient and sustainable choices. Therefore, conventional agriculture practices are not a sustainable option for long-term gains in food production, and conservation agriculture-based solutions tailored to local needs must play a critical role in ecological and socio-economic settings of agriculture.

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