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Prolificity achieved through sustainability of agriculture

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Abstract
One of the long-term remedy in view of the natural resources depletion in agricultural means and degradation of the environment has been identified as conservation of agricultural systems with proper crop and soil management packages. In this paper the significance of agricultural conservation and its connection to environmental changes worldwide are considered. Growing interest in sustainable agriculture has been viewed as a constructive reaction in terms of both intensive contemporary agriculture, which depends on large inputs for crop production, and low-input, conventional agriculture. Conservation agriculture (CA) strives to increase crop productivity and sustainability by reestablishing soil fertility, utilizing the three principles of crop namely rotation, minimal soil disturbance, and surface crop residue retention. With the help of these technologies, agricultural systems may sustain high productivity as well as biodiversity conservation which in turn leads environmental protection. The physical health of the soil must be maintained at its highest level in order to grow crops sustainably and utilize natural resources without degrading their quality.CA methods may improve soil WHC by modifying the pore size distribution (PSD) and increasing the amount of soil organic carbon (SOC).Conservation agriculture (CA), that is considered as a sustainable strategy, can improve ecosystem services and environmental quality while preserving or increasing agricultural output. Individuals involved in the agricultural production and supply chain must be empowered and involved for sustainable agricultural development (SAD). Hence CA can be considered to be more environmentally responsible and sustainable method of crop management.

Keywords: conservation agriculture, crop production, soil fertility, conservation tillage, soil physical health, soil organic carbon, water holding capacity

Introduction

Conservation agriculture (CA), an agro-ecological strategy, seeks to encourage the profitable and sustainable intensification of agricultural systems by putting into practice three interconnected principles based on locally developed methods: minimal soil disturbance, permanent soil cover, and crop rotations (Dang,2019).Conservation agriculture (CA) techniques have the capacity to change the soil's physical, chemical, and biological soil quality indicators in comparison to conventional tillage (CT) techniques (Basavanneppa *et al*., 2017; Yadav *et al*., 2017). Moreover, CA might have an impact on the functional diversity of soil microorganisms, which is crucial for better soil quality, crop output, and other ecosystem services (Yadav *et al*., 2017). In comparison to conventional tillage systems, that often increase soil organic matter content, plant accessible water capacity, soil aggregation, soil water transfer capacity, infiltration properties, and saturated hydraulic conductivity (Bhattacharyya *et al*., 2008). The conventional tillage system and the depth of the soil sample are the main factors that affect the soil's ability to hold water. More and more people are endorsing CA as Climate Smart Agriculture, which helps in both aspects of climate change mitigation and adaptation (Pretty and Bharucha,2014).CA is a method of managing agro ecosystems that increases the sustains production, earnings, and food security while protecting and enriching the environment and the base of available resources (Karkiand Shrestha, 2015).Successful results on crop yield and soil fertility augmentation on wheat and maize crops, with CA have been documented. However, there weren't many literature on other crops. Therefore, the purpose of this study is to thoroughly lay out the concepts of conservation agriculture, including its scope, advantages, challenges, and study within the context of agricultural production. A significant problem is finding sustainable and ecologically acceptable ways to balance food production with the rapidly increasing population [1, 2, 3, 4, 5, 6].

For the upcoming decades, water scarcity is going to be a big problem [7, 8, 9, 10]. More extreme heat waves, frequent and intense bouts of drought, and intense rainfall are all predicted by climate change models. CA is commonly touted as a sustainable farming method that can increase agricultural output, environmental quality, and ecosystem services (ES) like carbon storage [2, 3, 4, 5, 6].

Agriculture for conservation and its components

CA deals with the concept of resource-saving agricultural, crop production that attempts to generate acceptable earnings coupled with high and sustained production levels [11] while concurrently safeguarding the environment, in accordance with the FAO of the United Nations. Three main elements make up CA: (i) minimal or no soil disturbance through tillage; (ii) permanent soil-surface cover through organic wastes; and nil or minimal weeding. (iii) acceptable crop rotations by crop diversification in the annual crops, by incorporating pulses into crop rotations or employing shallow- and deep-rooted crops, and suitable plant species in perennial farming systems. The terms zero tillage, no tillage, reduced tillage, and minimum tillage for conservation tillage as a part of CA is considered in the analysis of this study.

1. Land cover and conservation farming

In California, crop residue on the soil surface improves the physical health of the soil and the associated processes because it reduces the striking effect of raindrops on soil particles, acts as a soil insulator to reduce evaporation loss, minimal impact on wind erosion, increases water productivity, reduces soil loss, water run-off, thereby regulating the hydrothermal regime. In California, agricultural residue on the soil tends to boosts long-term productivity [12]. Moreover, a variety of chemical components, such as organic mucilages, polysaccharides, humic acids, and aromatic compounds, are released during the decomposition of agricultural residue. These substances serve as binders for various soil particles, converting them into durable soil aggregates. Crop residues also boost a variety of soil macro- and microorganisms' activity, which further aids in the formation of sturdy soil aggregates. A region's ability to benefit from crop residue cover depends on a variety of biophysical characteristics, including the soil type, topography, amount and intensity of rainfall, wind speed, macro-pores or channels that make it easier for water, nutrients, and air that could reach out the soil, which aids in the formation of successive crop root growth. Thus, including crop leftovers from tillage techniques into crop rotation in California may benefit the soil's physical health. However, crop rotations' positive effects on improving the physical health of the soil rely on a variety of variables, including the kind of legume used in the cropping system, crop intensification the amount of fallow land, and the type of tillage, temperature, and the quantity and size of crop residues covering the soil surface [13]. The degree to which the physical qualities of soil are shielded from both natural and artificial perturbations, however, is clearly correlated with the amount of land surface cover [14, 15]. Crop residue land cover improves soil health and reduces the negative effects of conventional tillage, but it is expensive, challenging to manage, and difficult to incorporate with other conservation agricultural methods.

2. Conservation and tillage agriculture

The farmers claim that the main purpose of tillage operations is to provide an ideal soil surface condition for seedbed preparation and to prepare the soil for sowing, planting, inter-culture operations, irrigation, drainage, weed control, harvesting operations, etc.According to the type of soil, amount of soil moisture present at the time of tillage, kind of tillage tools were employed, and based on the number of tillage operations, frequently causes soil loosening[16,17].The loss of soil organic matter and, subsequently, the physical health of the soil are both primarily caused by over tillage, which is also one of the major contributing causes. In this regard, conservation tillage techniques have shown to be quite successful in reducing soil erosion, increasing soil moisture retention, recharging water from the profile by increasing water infiltration and conductivity, improving soil organic matter and soil biological properties, and finally enhancing the overall physical health of the soil for optimal crop growth conditions.

3. Conservation agriculture and crop rotation

Crop rotation is the third crucial element of CA after tillage and land cover. The type and character of crops used in crop rotation affect the scope and amplitude of potential changes to the physical health of the soil [18, 19]. In California, crop rotation, which involves growing leguminous crops and both shallow- and deep-rooted plants alternately, enhances soil structure, organic matter content, water infiltration and retention, as well as other related soil qualities.

Effects of Conservation Agriculture on Soil Water Retention

Soil water holding capacity (WHC the total amount of water that a soil can store after the excess water has been drained off) is an essential aspect of crop production that helps to reduce the consequences of climate change by preserving yields from weather unpredictability [20]. The agro-ability ecosystem's to adapt to extreme occurrences, such as intense rain and drought waves, is also aided by improvements in soil WHC [21, 22]. These improvements increase soil resilience to the growing climate variability.

1. Conceptual Framework and Review Objectives

Agronomic management has an impact on soil WHC, the study involved the assessment of primary CA-practice that includes minimal soil disturbance, crop diversity, and CRR that resulted in improved soil WHC and AWHC. Reviewing the impact of CA-based management strategies on soil WHC, AWHC, and water conservation was the goal. It was postulated that CA-based management techniques might raise SOC, which in turn might raise soil WHC and AWHC. It was noted that CA-based management techniques can also change the soil's WHC by affecting the PSD and pore continuity [23, 24].

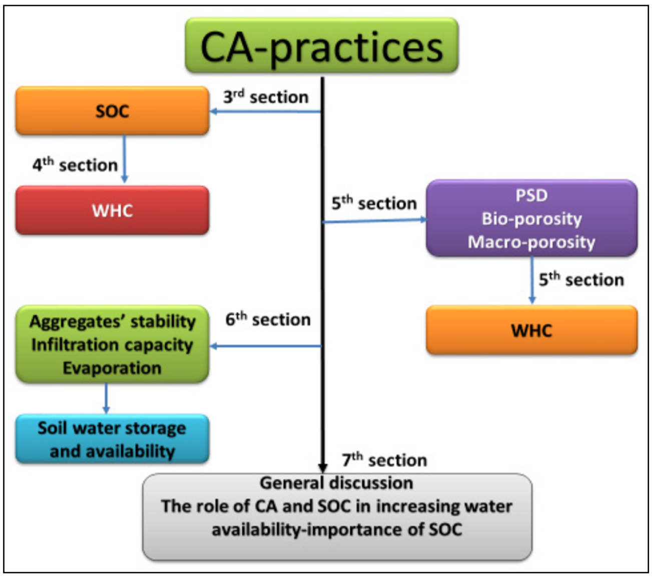

Fig 1: Diagrammatic representation of the review structure SOC, WHC, and PSD stand for soil organic carbon, water holding capacity, and, respectively, pore size distribution

First, as shown in Figure 1, it was noted whether CA-based management techniques increased SOC (Section 3), which in turn directly influenced soil WHC (Section 4).The potential for CA-based management techniques to modify PSD, porosity, and bio-porosity (and hence indirectly soil WHC) was then examined (Section 5).The change in soil water content (SWC) as a result of variations in soil infiltration capacity and soil surface evaporation rate under CA-based management strategies (Section 6) was then examined[25,26]. As a result of their impact on some soil physical qualities, it was finally explored (in Section 7) that the function of CA-based management methods and SOC resulted in boosting water availability (e.g., aggregate stability, infiltration capacity, and evaporation from the soil surface). Also covered were the significance of SOM and comprehending the quantitative impact of SOC on soil WHC and water availability.

Participatory framework for sustainable agricultural development (PSAD).

Sustainable developmentis termed as "development that not only addresses current needs, but also a sustainable future for people and the planet" [27] (Brundtland, 1987). Environmental, economic, and social factors are frequently categorized into three categories. These categories of variables are also recognized in the agricultural industry. Economic factors include productivity, profitability, stability, and viability; social factors cover local context, actor involvement, and benefit distribution; and environmental factors include the quality of agricultural inputs and farming practices. In addition to these classifications of determinants, some literature also divides governance-related factors into groups that take into account the various SAD factors' governing bodies, protocols, and legal frameworks [28, 29]. The scope of current frameworks is widened by PSAD, which contains components that would make it possible for all parties involved in the agricultural production and supply chains to cooperate and engage in SAD [30] in order to achieve benefits parity**.** Environmental, economic, social, and governance-related issues are the four categories of factors.

1. Environmental Factors

There are three categories of environmental factors namely water, land, and air, biodiversity and food safety. Water, land, and air is considered for safeguarding the resources from any activity that can cause harm (directly or indirectly) [31]. Biodiversity are the elements preventing extinction of vital anthropods (non-enemy necessary species) and other important organisms (plants and animals) for ecosystems. Food safety is an aspects that ensure that there is no risk of food-borne illness that can damage consumers in any activity throughout the food supply chain, from farm to consumer [32].

2. Economic Factors

Economic factors are often related to the production, market, logistics, finance, and capacity development aspects of agricultural supply chains. The process of converting or enhancing raw materials into desired products involves many different areas of manufacturing, including planning, execution, control, and coordination across chain players [33]. Market are the components of a network of interdependent people that collaborate to produce value through the exchange of resources like materials, cash, and information. Financial infrastructures components that facilitate the movement of materials along the supply chain [34]. Capacity development are the elements that affect how well individuals, groups, and communities perform, including opportunities and access to resources, as well as knowledge and abilities to raise one's socioeconomic standing.

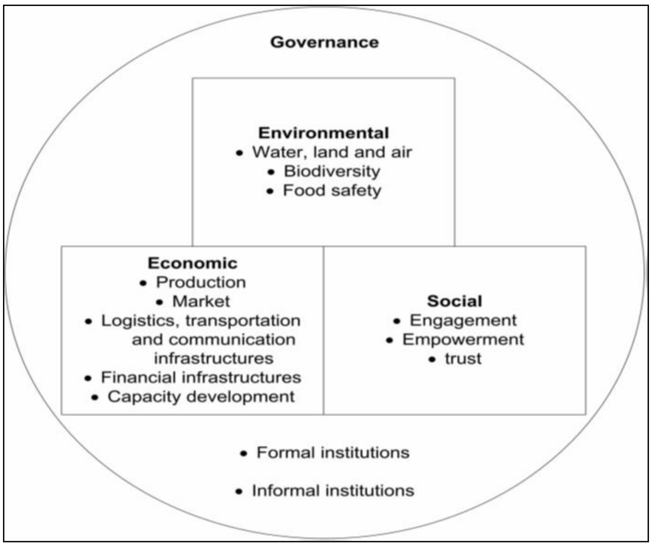

Fig 2: Framework for self-organized agricultural development

3. Social Factor

Empowerment, participation, and trust are three participatory system values that are vital to sustainable development. These principles—trust, mutual understanding, learning, and self-organization—are consistent with the notion of the social elements of sustainability advanced by Missimer, Robert, and Broman (2017). Empowerment are the elements associated with capability awareness, decision-making, action- and responsibility-taking capacity, and capacity for self-organization [35]. Engagement is defined as the degree to which actors are connected and interact with one another in order to communicate, comprehend one another's points of view, come to a consensus, make decisions together, and work toward a common goal. Trust Elements that affect how well system actors connect with one another, particularly in terms of dependability. As a result of actors interacting face-to-face or through ICT, trust gradually grows over time (in either a favorable or bad way) [36].

Conservation Agriculture to Improve Ecosystem Services

Ecosystem also provides advantages to people either directly and indirectly to quote a few provisioning (such as the provision of food and fibre), regulating (such as the regulation of air quality, flood control, and crop pollination), supporting (such as the provision of living space for plants and animals and the maintenance of biodiversity), and cultural services (such as the non-material benefits from ecosystems like cultural identity and spiritual well-being) [37, 38]. At the expense of environmental deterioration and the loss of biodiversity, humans have generally profited from this transformation. Figure 3 depicts the pictorial representation of ecosystem services.

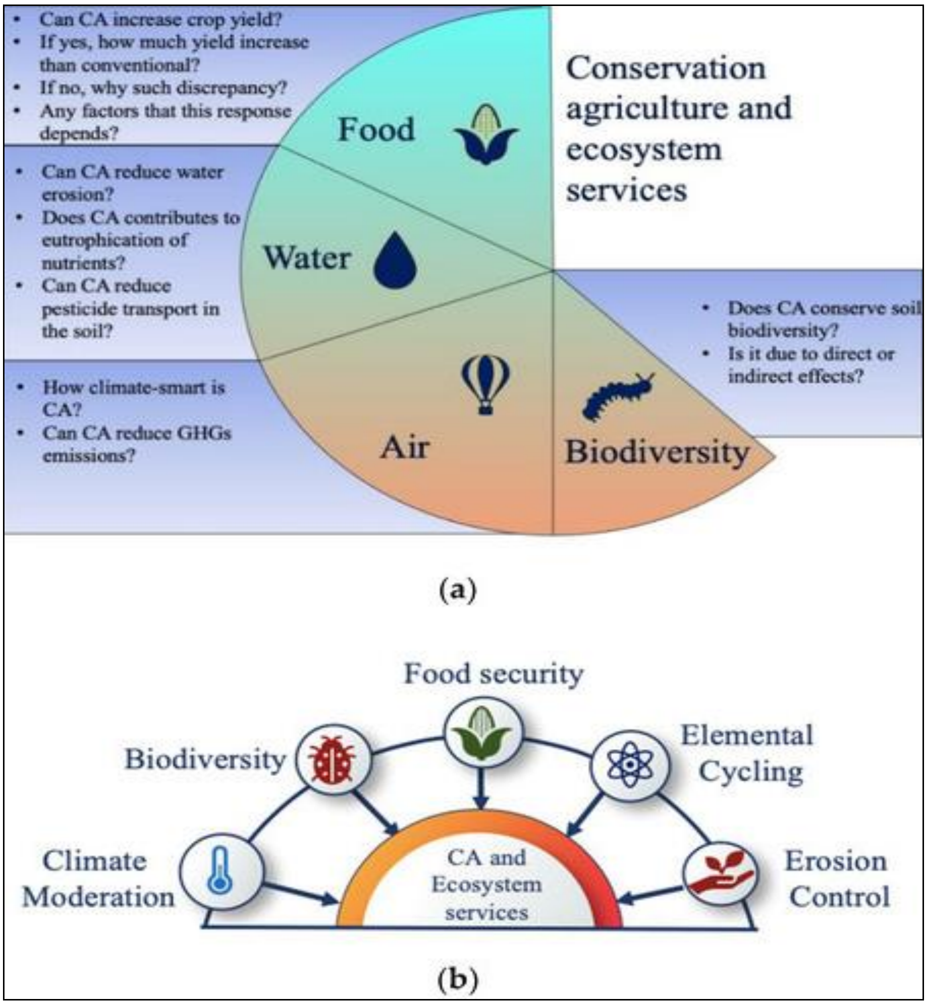

Fig 3: Ecosystem services provided by conservation agriculture (top); and (b) a schematic diagram showing the primary ecosystem services provided by conservation agriculture

1. Means to increase crop productivity through Conservation Agriculture

1.1 Water Storage

The potential of CA systems to increase soil water storage is one of its most well-known advantages. Increases in SOC at the soil surface in CA systems are primarily brought on by decreased soil disturbance along with enhanced residue retention [39]. This improves water penetration rate and, as a result, the ability to capture rainwater for use by crops is achieved [40]. In addition, it aids in maintaining microspores that can quickly transport water into the soil surface. Additionally, keeping crop remains on the soil's surface reduces the pace at which soil water evaporates, thereby increasing soil water storage.

1.2 Yield and Productivity

It has been proved that CA systems can increase [41], reduce, or have no effect on yield [42]. Whether CA has been fully or partially adopted, the climatic condition, the type of cropping systems used, and the management strategies plays a significant role in increase or decreases of crop output after the adoption of CA [43, 44].

1.3 Weather conditions

Retaining crop residue can reduce soil temperatures in cooler areas, delay in plant maturity these factors have a detrimental impact on yield [45].CA systems can result in water logging and yield loss in regions with poor soil drainage, CA can also increase yield in wet climates in areas with well drained soils.

1.4 Techniques for yield management

Various weeds, pests, and illnesses are managed by cultivation in traditional methods. Infestations and production losses may increase if CA is implemented without modifying tillage, weed, pest, and disease management techniques [46]. Similar to this; agricultural residue stored in CA systems has a high carbon: nitrogen ratio, which can immobilize nitrogen and result in a deficiency. Reduced yields could also occur if fertilizers or crop rotations containing legumes are not used to retain the available N.

Water conservation and agriculture: From eutrophication to erosion

In conventional agricultural system, greater soil disturbance and the absence of site-specific soil and water conservation techniques are the main contributors to soil erosion. Residue retention in CA has the potential to increase surface roughness while reducing runoff and soil losses [47]. The enhancements made by CA to the stability of the soil aggregate and water storage have a direct or indirect impact on runoff and soil losses. The loss of nitrogen and phosphorus (N and P) from agricultural regions into streams can cause eutrophication, and N and P are recognized as two of the most significant water pollutants in the world [48]. CA has a number of advantages over traditional tillage in terms of preserving soil and water, hence it is also anticipated to have an impact on N and P export [49]**.** Due to enhanced rates of water infiltration, greater surface stability, and decreased soil disturbance, CA can reduce soil loss and runoff. Pesticides can be transported to water bodies differently under conservation agriculture. Pesticides, particularly polar or low polarity pesticides, can be intercepted by crop residues [50]. Soil surface crop residue retention under CA may impact the effectiveness of pesticide interception. By increasing the organic matter content of soil, especially in the top surface layers, pesticide retention can be improved and susceptibility to microbial degradation can be reduced.

Gaining Knowledge on Conservation Agriculture's Challenges and Greenhouse Gas Emissions

The emission of greenhouse gases (GHGs) from the soil to the atmosphere as well as their collection and vice versa are impacted by crop and soil management methods [51]. As a result, agriculture has been recognized as one of the four crucial industries that could help cut down on world GHG emissions .It is well known that the fewer tillage operations required by CA will result in a reduction in fuel use and GHG emissions**.**CA can alter the flux of other GHGs, such as nitrous oxide and methane (CH_4), in addition to the amount of CO_2 that is released into the atmosphere (N_2O).For instance, CA may increase the rates of nitrification and denitrification and, as a result, N2O emission in areas where soil moisture, microbial biomass, and labile carbon are improved.

Sustainable agricultural production with conservation agriculture

Plowing and minimal organic material recycling are characteristics of conventional agriculture. While conservation agriculture is distinguished by minimal tillage, the use of mulch, and crop rotations, organic agriculture does not utilize pesticides or mineral fertilizer. In spite of many advantages of CA few crop productions are affected as listed below.

1. Rice

Conservation agriculture can result in increased yields and possibly higher stable revenues. With the right fertilizer management, conservation agriculture may help boost crop output, enhance soil health, and generate revenue. Bell *et al*. (2019) discovered that the longer-term application of conservation agriculture enhanced rice grain output (by up to 12 percent) [52]. According to Calcante and Oberti (2019), the total cost of production for rice was 1334.74 rupees per hectare for conventional tillage, 1125.79 rupees per hectare for minimum tillage, and 1078.75 rupees per hectare for no-tillage.

2. Wheat

Wheat crop yield is significantly impacted by conservation agriculture. According to Khorami *et al*. (2018), conservation agriculture, includes less tillage, enhanced agronomy, and better varieties, has produced good results, including an increase in wheat yield and maize biomass (2009) Govaerts *et al*.In the field of wheat farming, zero tillage was reported to result in a 4–10% improvement in crop output [53]. Additionally, CA improved nutrient usage effectiveness (Jat *et al*., 2012;Saharawat *et al*., 2012; Shrestha *et al*., 2018). When compared to traditional agriculture, which produced 950 kg/ha of wheat grain, the program's application of conservation agriculture increased wheat grain yield by 79% (1700 kg/ha) (Ghosh *et al*. 2015). According to Hunag *et al*. (2008), crops produced with no-tillage and mulched stubble performed better in terms of nutrients, which improved the flow of water to the plants and increased crop output. Similarly, Baumhardt *et al*. (2013) found that fields that were mulched with straw, whether they were irrigated or supplied by rain, produced more water.

3. Potato

CA is essential to the growth of potatoes. In potato-based systems, reduced tillage and cover crops increased the soil's organic matter and carbon content over a 7-year period (Quintero and Comerford, 2013). According to Barrera Mosquera *et al*. (2019), implementing a workable conservation agriculture system instead of conventional methods boosted crop productivity [54] increases the net (of the cost of production) advantages of the system by 25 and 24%, respectively. The carbon content was greater by 33 percent and the soil carbon concentration was 29 percent higher under conservation tillage than under conventional tillage sites, according to improved CA practices in potato-based systems during a 7-year period (Quintero and Comerford, 2013).

4. Barley

CA techniques, also results in increase of barley yields**.** Buschiazzo *et al*. (1999) analysed the effect of tillage practices on sorghum production at six experimental locations in the subhumid and semiarid Pampas region and discovered that average yields with no-till and reduced-till were higher than with conventional tillage (mouldboard-till). The research initiatives carried out between 2011 and 2014 used conservation agriculture.

5. Cotton

Less tillage and better residue preservation improves the physical qualities of the soil in addition to promoting water conservation, reducing soil erosion, and increasing the quantity of organic matter in the soil (Blanco and Lal, 2008; Patel *et al*.,2019). Naveen Kumar and Babalad's (2017) discovery of no-tillage with crop residue retention on the surface was shown to be more successful and lucrative [55]. The farmers in India and other nations have a large opportunity to implement the CA packages in the cotton-wheat system, which increases net financial savings (Blaise, 2015). CA techniques leave a field residue that keeps the soil moister and inhibits weed growth (Bilalis *et al*., 2003). This study demonstrates that less tillage used in conservation agriculture results in higher yields and lower production costs. In addition to the decreased weediness, enhanced soil structure and moisture content may also contribute to yield benefits.

6. Soybean

Thiagalingam *et al*. (1991) examined the impacts of no-till and conventional tillage practices in a maize-soybean rotation on a clay loam soil. They came to the conclusion that no-till produced on average of 20 percent higher soybean yields than conventional tillage, and that no-till also improved soybean germination. According to Dibert *et al*.

(1989), the no till method may result in a greater yield of soybean types when the soil moisture content is raised. Wilhelm and Wortman (2004) found that the no-till approach produced the same amount of soybeans as the traditional tillage method.

The contribution of conservation agriculture to sustainable agriculture

A relatively new agricultural management technique that is gaining favour worldwide is conservation agriculture (CA), which is characterized by low soil disturbance (no-till, NT) and permanent soil cover (mulch). According to the definition of cultivation, it is "the tilling of land," "the raising of a crop via tillage," or "to loosen or break up soil" [56]. The goal of sustainable agricultural production can be attained by farmers in many regions of the world through CA, a modern agricultural practice.

1. Culturing techniques or tillage

In the nineteenth century, the introduction of the industrial revolution made tractors and mechanical power available for tillage operations. Today, there is a wide range of machinery for agricultural production and tillage. The reasons for using tillage are it softens the soil and made it easier to put seeds into damp soil using hand tools or seed drills at the proper depth thereby resulting in good and uniform seed germination. Moreover wherever crops are present, weeds coexist peacefully with them and compete with them for nutrients, light, and water. Farmers were able to swap the advantage from the weed to the crop by tilling their fields, allowing the crop to grow more abundantly and without competition early in its life. Tillage promoted mineralization and oxidation of soil organic matter, which led to the release of soil nutrients essential for crop growth [57]. While many soil additives and their nutrients are more easily accessible to roots when they are blended into the soil, several nitrogenous fertilizers are also lost to the atmosphere if they are not. While certain nitrogenous fertilizers lose their nitrogen to the atmosphere if they aren't mixed in, many soil additions and their nutrients are more readily available to roots if they are cycle.

2. Equipment for agriculture conservation

The techniques for handling loose straw (cutting or moving it aside), planting seeds and fertilizer, sealing the furrow, compacting the soil and seeds, and planting and applying fertilizer are the most essential instruments needed for a CA system. Small-scale farmers still use rental and service companies even if they don't own tractors or seeders. Direct-drill seeding machinery must be adjusted to function with human, animal, or small tractor power sources, though, in order for small-scale farmers to buy the equipment (lower weight and draught requirements). An easy, three-row, compact grain seeder has been created for Bolivia's small-scale farmers who depend on animals for power (Wall *et al*. 2003). Instead of a disc opener, this equipment uses a shovel to minimize weight. Straw wheels are attached to the coulter to aid in debris removal and reduce clogging [58, 59]. It also benefits from working in both ploughed and unplugged terrain. Farmers claimed time savings as the drill's main benefit; with this equipment, a hectare could be planted in 10 hours rather than 12 days with the TT and seeding methods. To aid in clearing debris from the coulter and lessen clogging, straw wheels are mounted to it. It also has the advantage of working in both ploughed and unploughed land. Farmers cited time savings as the key advantage of this drill; using this equipment, a hectare may be planted in 10 hours as opposed to 12 days using the TT and seeding techniques.

Benefits of agriculture for conservation

At the farm, regional, and national levels, conservation agriculture has advantages. The advantages can be divided into three major groups: (i) agronomic advantages that increase soil productivity; (ii) economic advantages that increase production effectiveness and profitability; and (iii) environmental and social advantages that safeguard the environment and promote sustainable agriculture [60]. Conservation agriculture finds advantages such as to enhance the viability of various manufacturing systems, enhances ground water recharge by increasing water infiltration, which lowers surface and ground water runoff, promotes better habitat for species, from larger insects to soil-borne fungus and bacteria, which enhances the biological, physical, and chemical characteristics of the soil and increases crop output, raise agricultural revenue by reducing production costs (15–16%) through energy, labour, and water savings, promote biodiversity while increasing the worth of environmental services, decrease in food prices and an increase in food and nutritional security as a result of better, more constant yields, increased incomes in rural areas are preventing rural-urban migration and lower food prices and reliable harvests.

Future of Agriculture

The future of sustainable agriculture is conservation agriculture. The advantages are applicable to all varieties of agro-ecosystems. In addition to enhancing soil health and maximizing the use of natural resources, it also lowers production costs boosts farm income, and—most importantly—abates global warming by sequestering carbon in the soil. Contrary to conventional agriculture, which degrades soil through heavy tillage, burning of straw and external inputs, CA does not employ any of these practices. The benefits of CA technology are simple to use, but action must be taken to set up some aggressive demonstration and information-dissemination programmes that are well supported by farmer skill development [61]. To improve the state of agriculture in the future, there has to be a global movement to support conservation agriculture.

Conclusion

Over the past 30 years, there has been substantial advancement in the development and application of technology for resource conservation, including zero and reduced tillage systems, improved crop residue management, and planting techniques that boost water and nutrient saving. Lesssoil erosion and surface runoff often come from improving soil structure through conservation agriculture. It is particularly beneficial in arid regions where it keeps agricultural output higher and increases soil water storage. CA generally enhances the soil's capacity to store organic carbon, particularly in the topsoil. This can help to mitigate climate change through the storage of carbon, a reduction in greenhouse gas emissions (CO_2, CH_4, N_2O), and water control. An innovative paradigm for PSAD is based on four categories of factors: governance-related, environmental, economic, and social. Recent technologies for conservation agriculture have paved a way to sustainable agriculture in the mere future. The advantages of span multiple scales, including nano-level (improving soil qualities), micro-level (saving inputs, lowering cost of production, boosting farm revenue), and macro-level (reducing poverty, enhancing food security, and reducing global warming). The conservation agriculture may be vigorously promoted in light of the enormous benefits that might be predicted, as was the case during the green revolution time. Crop cultivation will have to boost food production on less land during the next ten years while reducing environmental harm. There is no alternative method to ensure that there is enough food to meet demand and that the land's productivity is maintained for future generations.

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