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Conservation Agriculture and Climate Change

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Annotation: Due to salinization, scarcity of fresh surface and groundwater resources, and climate changes that negatively affect the stability of agricultural production (both plant and animal), including declining rainfall rates and their poor distribution during the agricultural season, high temperatures, and desertification, the agricultural sector is one of the sectors most affected by climate change. It has become necessary for those interested in the agricultural sector, including researchers and farmers, to search for sustainable, productive, and profitable agricultural production methods that are less depleting of agricultural natural resources, such as soil and water. Applying climate-smart agricultural technologies that ensure increased agricultural production while maintaining the sustainability of agricultural natural resources is crucial. The basic solution is to apply the Conservation Agriculture (CA) system, which contributes to increasing the efficiency of using limited water resources and stopping the deterioration of agricultural lands, effectively achieving food security.

Keywords: Conservation agriculture, organic cover, crop rotation.

Introduction

Conservation Agriculture (CA) is the practice of farming, the methods and techniques of which try to preserve or conserve the ecosystem, to minimize the effects of environmental degradation, to improve soil, water and air quality, and to make possible the production of good quality and productive crops. Conservation agriculture commonly includes the basic practices such as

recycling and reusing organic matter, extraction of maximum value, leaving the environment in its natural state and ensuring a conservation of biodiversity, which plays a role to offer health as well as diversity in agricultural systems. For instance, it is an agricultural system which can preserve the arable land from loss, while can restore the degraded lands. It also fosters more efficient use of water and nutrients, and increased crop production and sustainability through the enhancement of natural biological processes above and below ground and it also increases biodiversity. (FAO, 2019).

Conservation agriculture is such a strategy: less environmental and climate change impacts, lower costs for farmers. It is the most successful agricultural pattern in areas which are arid and semi-arid or where water sources are scarce or limited or are dependent to a major extent on rainfall. It is even more relevant because less rainfall is occurring and conservation agriculture starts providing its benefits after two years as they are cumulative (Adonadaga et al., 2022; Linderhof et al., 2022). On the other hand, conservation agriculture, for example, is the combination of cultivation of field crops on soil not prepared in advance by making any trench or stripe of sufficient width and depth to put fertilizer and subsequently seed; and finally with the soil covered by the residues of the previous crop. It is therefore seen as one of the methods of managing agricultural ecosystems for the purpose of raising the productivity and sustainability, attaining food security and conserving the natural resources. (Friedrich et al., 2012; Mwangi et al., 2015).

Conservation agriculture system has the potential to raise up the ability of agricultural ecosystems to face up climate change which is derived from improvement in soil organic carbon content and decrease in fuel consumption because of no tillage so that greenhouse gas emissions will be reduced and consequently, its exacerbating of the globe warming, will be restricted (Bista et al., 2017; Kumar et al., 2017). Conservation agriculture consists of three principles adopted by the farmers, which are also consistent with requirements of sustainable agriculture, as envisaged by the FAO (2011) i.e. (1) minimum soil disturbance; (2) maintaining permanent soil cover; and (3) introduction of crop rotation. The major pillars upon which the conservation agriculture system depends on include reduction of soil disturbance or doing minimal or no tillage, use of the land permanently covered with the plant residues, crop rotation including the use of legumes to add nitrogen to the soil for biomass production and weed control. (Stanojevic, 2021).

Other known good practices such as use of high-quality seeds, integrated pest, nutrient, weed, and water management, etc. complement conservation agriculture to provide the basis for sustainable agricultural production intensification and an opening up of increasing options for integrating production sectors as crop & livestock integration, tree & pasture integration in agricultural areas. (Bista et al., 2017).

The area of land that has applied conservation agriculture technology is estimated at 205.4 million hectares in the world, and the application of this technology has increased by 59% since 1987 in Latin America. In the Arab world, Sudan has begun to apply it and the cultivated area within the conservation agriculture system reached 10,000 hectares in 2019, while the cultivated area in Iraq reached 12,000 hectares (FAO, 2019).

The aim of the study: Due to the climate changes that the world is witnessing, especially in Iraq, we have been thinking about new practices that we can apply to agriculture to preserve it, including conservation agriculture, in which the productivity of field crops is improved. Main, including wheat and barley, and farmers should be encouraged to implement climate-smart agricultural interventions to adapt to climate changes that prevent this, including the use of conservation agriculture technology in field agriculture. The article also aims to encourage farmers to use the conservation agriculture system because it increases productivity, improves soil, reduces costs, does not use pesticides, and enriches the soil with organic matter, thus increasing soil fertility, increasing soil biodiversity, increasing the rate of reproduction of living organisms, reducing pollution, improving its composition, as well as the rate of water filtration

and storage in the root zone, preventing wind and water erosion of the soil, and reducing the amounts of fuel, fertilizers and pesticides.

Principles of Conservation Agriculture

Conservation agriculture is based on the principles of minimizing soil disturbance and maintaining permanent soil organic cover by conserving previous crop residues and applying crop rotation. The principles of conservation agriculture apply globally to all agricultural areas and land uses with locally adapted practices. Mechanical disturbances to the soil are minimized or avoided and external inputs such as fertilizers and plant nutrients of mineral or organic origin are optimally applied in ways and amounts that do not interfere with biological processes occurring in the soil (Figure 1).

The first principle: minimum soil disturbance

It is a traditional agricultural practice (Zero-tillage) i.e. no annual tillage of crops, which is usually known as cultivation without disturbing the soil and is done by plowing at a depth of less than 30 cm and the area must be left covered with plant residues directly and the seeds are planted using a machine capable of placing seeds through plant residues. This practice is one of the most important ways to protect the soil from erosion and drift. It is also necessary to preserve nutrients in the soil and prevent water loss (Grassini et al., 2011).

The first principle of the conservation agriculture system is based mainly on practicing minimum soil disturbance, which is important in preserving nutrients in the soil and preventing water loss. In the past, farmers believed that plowing the soil would increase soil fertility through the mineralization process that occurs in the soil and the introduction of new crops into agriculture, especially in dry and semi-dry areas. Today, plowing is seen as a process that destroys organic materials that may be present in the soil cover, so no-till agriculture has spread as a process that can Maintaining soil organic matter levels for a longer period with the possibility of making the soil productive for longer periods. Minimal tillage also reduces the destruction of soil microorganism colonies, which is common in conventional tillage practices (FAO, 2008 & FAO, 2019).

The second principle: Organic Soil Cover

The process of covering the soil surface with a layer of plant residues is one of the basic pillars in the application of the conservation agriculture system and its success, as plant residues are left on the soil surface after harvesting. The application of the conservation agriculture system is one of the promising agricultural systems (no tillage or minimal tillage and covering the soil surface with the remains of the previous crop and applying the appropriate agricultural cycle) where the remains of the previous crop are used to improve the chemical, physical and biological properties of the soil, increase crop productivity, reduce pollution of the soil and the atmosphere, and preserve natural agricultural resources represented by soil and water (Panettieri et al., 2020).

The second principle of the conservation agriculture system integrates a permanent organic soil cover through which a nearly unlimited habitat for living organisms in the soil can be activated, creating a great opportunity for biological diversity in the soil. It will result to break down of plant residues in the soil surface by decomposition leading to high amount of soil organic matter that will serve as fertilizer to the soil. Additionally, this layer will prevent soil erosion, mostly in sandy and dry soils it will allow drift or prevent it from being blown or exposed to erosion by water or through wind. Plant residues on the soil surface also reduce the speed of surface runoff and the effect of raindrops (Farooq and Nawaz, 2014 and Liu et al., 2019). Green cover crops are mainly planted to improve soil fertility. Cover crops are of great importance in areas that produce small amounts of plant residues, such as dry and semi-dry areas, because they protect the soil during fallow periods, improve soil structure, and can be used to control weeds and agricultural pests. Plant residues also improve the soil's organic matter content, which leads to an increase in the size and stability of soil masses, limits soil erosion, and helps the soil to restore its

biological activity, it increases its fertility after the decomposition of organic matter into mineral elements, which greatly reduces the costs of adding fertilizers to the soil (Becker et al., 2022) and (Chen et al., 2018).

Figure 1: Principles of conservation agriculture.

The third principle: the diversity of agricultural systems (crop rotation)

The third principle of the conservation agriculture system is to practice different crop rotations that act as natural insecticides and herbicides against certain crops, this process will not allow pests such as insects and weeds to grow with certain crops, and the application of the appropriate long-term agricultural rotation works to reduce the density of harmful weeds (Farooq and Nawaz., 2014).

Crops rotation aims to diversify plant production and reduce the risk of the spread of pests and harmful weeds and a greater distribution of vital channels and pores resulting from diverse roots according to the diversity of crops, which helps in better distribution of water and nutrients in building the soil and increasing nitrogen fixation through the equivalence between microorganisms in the soil and plants and improving the balance of nitrogen, phosphorus and potassium from organic and mineral sources in addition to increasing the formation of humus in the soil (Hobbs et al., 2008).

The process of changing the host within the agricultural cycle (crop rotation) plays the role of a natural insecticide and also a biological herbicide, as it prevents agricultural pests and harmful weeds from settling in the field, which prevents a decrease in agricultural production and prevents the spread of agricultural pests in the fields, which greatly reduces the use of chemical pesticides, and the agricultural cycle is an effective means of reducing the spread of harmful weeds (Mashavakure et al., 2020).

The role of conservation agriculture in improving soil properties

The Food and Agriculture Organization believes that conservation agriculture has three main benefits, which are that in fields that adopt the conservation agriculture system, farmers and growers will see a significant increase in organic matter levels and an increase in water conservation due to the vegetation cover and organic matter layer, as well as improving soil structure and the root zone (FAO, 2019) (Figure 2).

The application of the conservation agriculture system helps increase the efficiency of using available water resources in limited quantities, especially in dry and semi-dry areas under dry farming systems. Many international and Arab studies have indicated the importance of applying the conservation agriculture system in improving soil and crop management factors and improving water productivity and quality. This ultimately helps improve crop productivity, increase farmer income, and improve his standard of living, in addition to improving environmental factors (Bista et al., 2017 and Telkar et al., 2017).

Many studies have shown that leaving 6-10 tons of plant residues per hectare helps the soil maintain its water content by reducing the area of the soil surface directly exposed to sunlight, which prevents water loss through evaporation. Leaving the remains of the previous crop on the soil surface also reduces the scattered effect of raindrops. The conservation agriculture system is one of the most important agricultural systems that adapt to the effects of rainfall by increasing the rate of infiltration due to the decrease in the rate of water loss through surface runoff and soil erosion, increasing the soil's ability to retain water, and increasing the apparent density and porosity of the soil by changing the soil structure and the stability of soil aggregates (Figure 2) Li Peng, Z. et al., 2019) and Peng et al., 2019 and Khodadali et al.,2021 and (Becker et al.,2022

The conservation agriculture system is one of the modern and pioneering technologies that aim to preserve the soil from wind and water erosion processes, as it works to improve the efficiency of water use by preserving the soil's water stock, benefiting from rainwater, and improving soil fertility and its productive capacity, as the conservation agriculture system depends mainly on reducing soil movement before planting by following the no-tillage agriculture system and sowing directly over the residues of the previous crop, covering with crop residues, and applying agricultural rotations (Zhang et al.,2022).

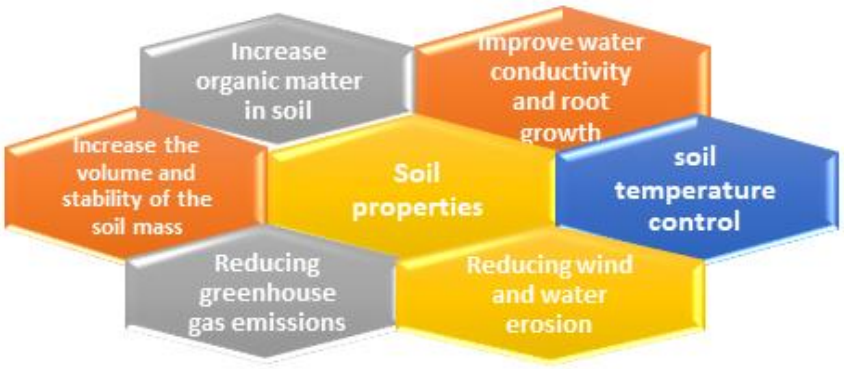

Figure 2: Improvement of some soil properties under conservation agriculture system.

Leaving a sufficient amount of crop residues above the soil surface helps improve the soil's organic matter content and improves the soil's biological activity, which contributes to improving all physical and chemical soil properties. The application of the conservation agriculture system leads to an increase in the soil's organic matter content as a result of leaving crop residues above the soil surface and plant roots, in addition to protecting the humus from the effects of sunlight and reducing the rate of decomposition of organic matter as a result of the decrease in soil temperature (Yadav et al., 2018 and da Silva et al., 2021). Increasing the soil's organic matter content during the application of the conservation agriculture system will improve the soil texture and increase the soil's ability to retain water, which reduces the rate of water loss and leads to the slow release of nutrients, which ensures their availability during the different stages of plant growth. Organic matter also increases the size of the blocks Soil stability and

increasing the number of microorganisms in the soil because it represents a source of food for living organisms and inhibits the development of pathogens, which improves soil fertility and productivity (Debele, 2019). The process of covering the soil surface with crop residues used in the conservation agriculture system acts as a protective umbrella that reflects the sun's rays reaching the soil surface, which prevents the soil temperature from rising by shading the soil surface, as leaving the remains of the previous crop in sufficient quantities above the soil surface allows for a reduction in the soil temperature between the planted rows, which slows down the speed of germination of weed seeds and delays their emergence above the soil surface (Salem et al., 2020).

Plant residues left on the soil surface are the main food for earthworms, which leads to their reproduction and increase in numbers. They dig tunnels in the soil, in addition to the tunnels left by plant roots after their decomposition, which improves soil aeration and water seepage into the soil (S ale et al., 2015). Plant residues left on the soil surface in the conservation agriculture system are a storehouse of nutrients in the soil, which prevents their loss through washing, increases the cation exchange capacity, provides a suitable environment for bacteria that fix atmospheric nitrogen, and increases the number of microorganisms in the soil and thus increase the biological activity, which leads to the slow decomposition of organic matter and the provision of mineral nutrients in sufficient quantities during the stages of plant growth and reduce the requirements of subsequent crop plants for fertilizers (Minsy and McBratney, 2018) and Peng et al., 2019 and Ramoneda et al., 2021).

Not tilling the soil or tilling it to the minimum prevents the compaction of the subsurface soil layers and the formation of the impermeable surface crust, thus reducing soil erosion by wind or water and reducing water loss by surface runoff and evaporation and reducing fuel consumption by reducing the number of agricultural operations and improving soil fertility and increasing biological activity in it due to the increase in its organic matter content (Das et al., 2020) The number of earthworms, microorganisms, bacteria, and fungi is greater in soils that rely on the application of the conservation agriculture system, which plays an important role in increasing soil fertility. The spread of living organisms and the increase in their activity are attributed to In the soil, to maintain soil moisture and increase its organic matter content as a result of covering the soil surface with the remains of the previous crop and increasing the diversity of essential microorganisms as a result of the diversity of agricultural cycles in the application of the conservation agriculture system (Jalli et al., 2021)

The role of conservation agriculture in improving the productivity of agricultural crops

At present, those interested in the agricultural sector must realize that the goal of agriculture is not only to obtain a high economic yield, but rather the increase in yield must be on sustainable foundations that ensure the preservation of agricultural natural resources available in limited quantities and reduce dependence on external chemical agricultural production inputs to preserve soil quality, groundwater quality and the environment (Adonadaga et al., 2022).

Conservation agriculture aims to reduce production costs and increase productivity per unit area by increasing the soil content of organic matter and microorganisms, thus increasing soil fertility by improving the rate of infiltration and storing it in the root zone and reducing the effects of climate change, erosion risks, and global warming by reducing repeated tillage operations (Amadu, 2020). Many studies have shown that the use of the conservation and climate-smart agriculture system is one of the most successful solutions that can reduce the loss in agricultural production resulting from climate changes such as drought and high temperatures, as the application of this system works to increase productivity by reducing agricultural production costs, increasing farmers' income, improving their standard of living, and increasing the ability of crops to withstand drought and heat while maintaining their production efficiency by improving the adaptive capacity of agricultural ecosystems (Lottering et al., 2021) (Figure 3).

Figure 3: Roles played by climate-smart agriculture

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