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Conservation Agriculture: Yesterday, Today and Tomorrow

(*Sanju Kumari Meena[1] and Dr. Deepak S Mohekar[2])
[1]College of Home Science, SKRAU, Bikaner, Rajasthan
[2]Division of RSA, ICAR-NBSS&LUP, Nagpur-440033, Maharashtra
*Corresponding Author's email: meenasanju095@gmail.com

Abstract
Agriculture is challenging especially today with numerous factors such as erratic changes in the climatic factors, degenerating soil fertility, epidemics of evolved pathogens and insects, changed food behavioral patterns of consumers and depleting natural resources of production. On the other hand, exponentially growing human population around the globe is demanding high food and nutritional securities. Sustainable intensification of food production is one of the reliable remedies to overcome these issues. Conservation agriculture is a way farming system which is rooted to principles of reduced environmental depletion and sustainable production of food.

Introduction
The idea of conservation agriculture was formed early in the 1930s in the United States of America, but the term gained popularity only after 1990s. it largely aims to increase the biological diversity of a specific area and thereby reducing the soil and environment degradation to help the soil regenerate. Conservation agriculture relies on three basic principles such as

1. Minimum or no soil mechanical disturbances
2. Year-round permanent soil organic coverage
3. Diversified cropping systems

1. Minimum mechanical soil disturbance: Tillage is the agricultural operation including pulverization, digging, cutting, stirring and turning of soil in order to make good soil bed for the agricultural practices. Human controlled
tools such as spading machines, cage wheels, ploughs, subsoilers and harrows are used to make good tilth and physical conditioning of soil. These practices gradually lead to the disruption of soil structure leading to the increased soil erosion and low fertility.

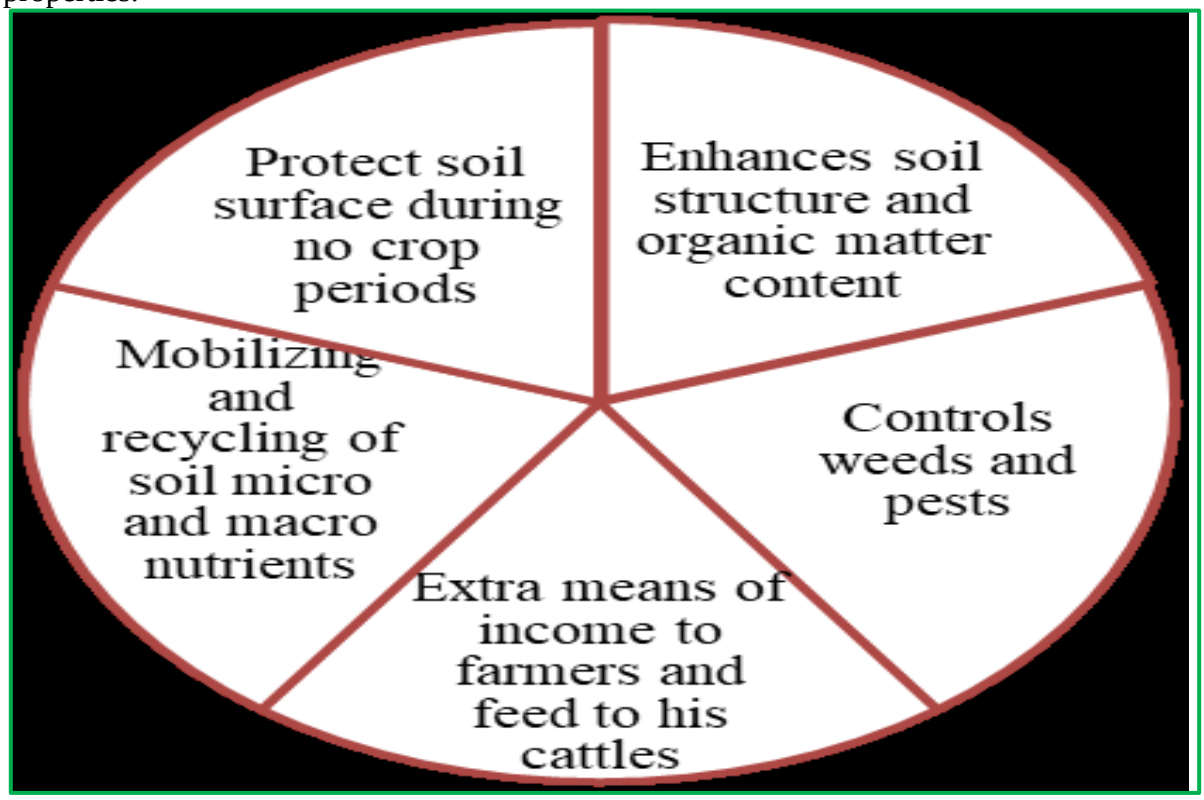
Conservation agriculture put forth the idea of zero tillage, minimum tillage or conservation tillage practices in which the total area of soil disturbed will be either less than 15 cm deep or 25 % of the total area under agriculture. This will enhance the total structure and organic matter content of the soil and thereby reduces the soil runoff. Various other practices recommended by conservation agriculture are direct seeding, direct drilling, and bed planting rice.

i) Direct seeding or planting: The soil is prepared without any mechanical operations and the seeds or the seedlings are directly planted on to the seed bed. A hand tool like a shovel or a machine is used to dig into the soil and precisely place the large seeds or seedlings directly in to the soil.

ii) Conservation tillage: In minimum or conservation tillage, tillage practices are either avoided completely or reduced to essential operations in order to protect the soil. The weeds are either rolled or slashed and removed or herbicides are used to kill. Proper mulching with previous crop residues is practiced to give good cover over the soil and manures, fertilizers and soil amendments are provided adequately. These practices help to maintain at least 30 % of the soil with residue covers. The primary tillage practices such as deep ploughing and power tilling are completely avoided and only finer operations are carried out.

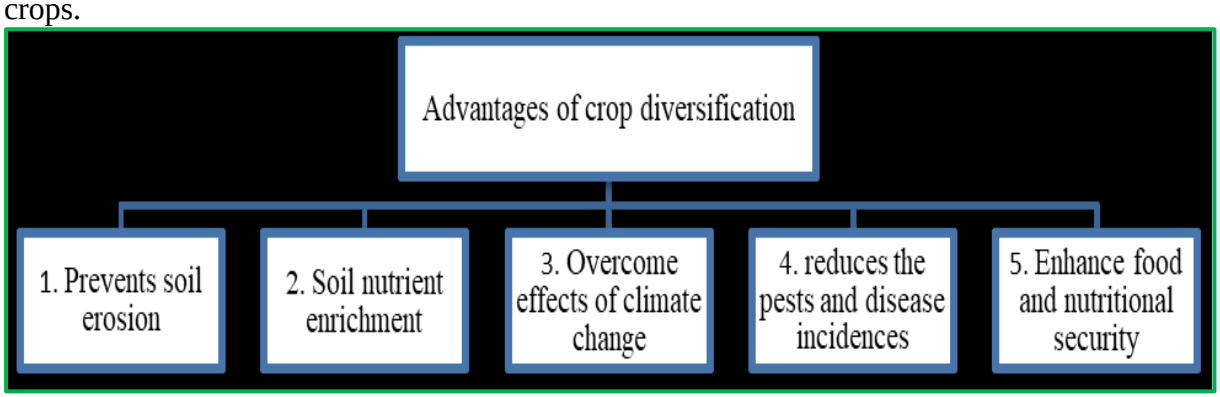
iii) Raised Bed planting: Raised bed planting is particularly followed in rice cultivation in Eastern parts of Gangetic plains and those area which are low lying and water logging is prominent. It is carried out to reduce the soil mechanical operations required for rice transplanting. Beds of 0.6 to 1 meter size are prepared and separated using furrows. One of the other major advantages of these beds are in the conservation of irrigation water up to 30%.

2. Year-round permanent soil organic coverage: Permanent soil coverage using cover crops such as cereals or pulses or previous crop residue can positively impact the soil health and fertility. The cover crops enrich the soil either by nitrogen fixation or decreases the runoff using their deeply seated soil binding fibrous root systems. The soil organic cover has immense contribution towards the maintenance of agroecosystem and soil physical properties.



The cover crops are easily grown on available nutrients previous crop season and stored underground water. There is minimum resource requirement to grow them which can later act as an additional source of income or a feed for the cattle. Some legume cover crops such as sunhemp, black gram, soy bean or cowpea can be grown as green manuring crops which are incorporated in to the soil within 60 days after sowing helps to improve water holding capacity and nitrogen enhancement in soil. These protective plants on the soil surface can act as a barrier to the rain and prevent soil erosion to some extent.

3.Diversified cropping systems: Diversified cropping systems and crop rotations help to bring cultivations of different plant species in a land area over seasons or at same time. It not only financially beneficial to farmers but also helps in maintaining good soil health by nurturing soil micro-organisms. The different root systems of crops can give natural substitute for tillage operations by growing deep in to the soil layers. Leached and unabsorbed soil nutrients can be recycled and regenerated by growing different types of crops.



i) Prevents soil erosion: Crop diversification in the farm lands aims to minimize the agricultural inputs which can negatively affect the soil health coupled with enhancing the soil properties. Following a planned agricultural rotation, the heterogeneity of the crop production system enhances soil performance by boosting soil beneficial microbial activity, increasing soil organic matter, (Studdert and Echeverría, 2000) and water holding capacity. The mixed cropping or intercropping systems are known to boosts soil enzymatic activities, physical and chemical properties, soil water conservation, and wet-soil aggregate equilibrium (Zuber et al., 2018). The increased soil organic matter content and humus enhances soil porosity and infiltration rate which facilitates more water storing capacity of the soil. These factors ultimately lead to decreased surface runoff of the soil and reduces soil erosion.

ii) Soil nutrient enrichment: Every plant is different with respect to their nutritional requirement and microbial preferences. The crop rotation not only enhance the soil nutrients through organic matter but also aids in the development of helpful soil bacteria. Many crops such as chickpea, pea and some vegetables on a rotation can enhance the functionality of the soil micro-organisms. Studies have shown improved performance of wheat and chickpea in a rotation coupled with improved microbial activities. Some crops particularly maize and pulse, can produce root exudates that improve the bacterial activities in the soil (Jin *et al.*, 2019). These increased activities soil microbes mobilize the fixed nutrients and makes it in the available form to the plants.

iii) Overcome the effects of climate change: Crop diversification can greatly help in enhancing soil water and nutrient contents. The reserved soil moisture in different layers of soil can be efficiently utilized by crops with different rooting patterns thereby resisting moisture deficit conditions to an extent. It also increases the water use efficiency of the plants. The different root patterns of crops helps in creating bio poreswithin the deep

compacted soil, helping in enhancing the total porosity and water uptake capacity of the soil. Multistoried cropping systems can effectively beat temperature stress by growing sensitive plants as shady plants.

iv) Reduces pests and disease incidences: One of the serious problems of monoculture is the epidemics of pests and disease incidence. The continuous availability of the target host avails favorable conditions for the insects or pathogens to perpetuates and reproduce. In a mixed cropping system, the life cycle of a pathogen or an insect is discontinued due to lack of available favorable host plant. This cultural practice can also reduce the number of pesticides and fungicides applied to the farm which helps in reducing the soil pollution and total expenditure to the farmers. In a study comparing wheat monoculture and a crop rotation involving wheat- turnip- barley- pea, the incidence of wheat leaf blotch disease severity was found 20% less when wheat was grown every fourth year compared with wheat monoculture (Jalli et al.,2021). Avoiding susceptible host plants and including nonhost plants in to the rotation until the pathogen or insect cycle breaks, can be adopted efficiently to reduce the incidences to protect the crops.

v) Enhance food and nutritional security: According to FAO, the demand for food would rise by 50–70% globally during the next forty years. Despite widespread increases in yields, nearly one-third of the growing area for the key staple crops saw yields that either never increased, stalled, or even decreased. Adopting crop rotations or intercropping systems can create sustainable production of different crops with nutritional values. Crop diversification challenges the risk due to uncertainties arise due to fluctuating climatic conditions as well as provide crop yields. A crop rotation involving cereals, pulses, oilseeds and vegetables can sufficiently feed the family with recommended.

Conclusion

Conservation agriculture practices are globally recognized and have added advantages of limited resources with improved production. It not only enhances the sustainable crop production but helps delineate adverse effects of climate change. Conservation agriculture methodologies serves as the foundation for sustainable agricultural output intensification when combined with other well-known good practices, such as the use of high-quality seeds and integrated pest, fertilizer, weed, and water management. It expands the possibilities for integrating different production sectors, such as the integration of trees and meadows into agricultural landscapes and the integration of crops and cattle.

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