ISBN: 978-81-19149-15-5

14. Conservation Agriculture in Drylands of World and India

Shruti Grace George, Prateek Kumar

Ph. D. Research Scholar,
Department of Agronomy,
Sam Higginbottom University of Agriculture,
Technology and Sciences,
Prayagraj, U. P.

Shalini Roy, Doppalapudi Vijaya Rani

Ph. D. Research Scholar,
Department of Agronomy,
Sardar Vallabhbhai Patel University of Agriculture and Technology,
Meerut, U. P.

Abstract:

The empirical evidence at a global level demonstrates that the implementation of Conservation Agriculture (CA) principles, led by farmers, is increasingly gaining momentum and transforming agricultural production systems, representing a new paradigm for the 21st century. Information provided here is a comprehensive overview of the adoption and spread of CA by country and continent.

The global evidence indicates that the shift from tillage-based to CA-based production systems is now a worldwide phenomenon, gaining even more momentum in recent years as a sustainable intensification method and as an example of climate-smart agriculture. CA systems, which involve minimal mechanical soil disturbance, organic mulch soil cover, crop diversification, and good crop and production management practices, are currently practiced on approximately 157 million hectares worldwide, accounting for around 11% of field cropland in all continents and most land-based agricultural ecologies, including various temperate environments.

This represents a 47% increase globally since 2008/09 when the spread was recorded as 106 million hectares. No-tillage CA is practiced on all farm sizes, ranging from less than half a hectare to thousands of hectares, with all crops being able to grow adequately in CA systems. The authors have not yet identified a crop that would not grow and produce under this system, including root and tuber crops.

Keywords:

Conservation Agriculture, Tillage, Climate-Smart Agriculture, Crop Diversification, Sustainable.

14.1 Introduction:

Conservation Agriculture (CA) is a method of managing soil and water resources to ensure sustainable agricultural production systems that are environmentally, socially, and economically sound. It consists of three interconnected principles: minimizing mechanical soildisturbance throughout the entire crop rotation, maintaining permanent soil cover, and using diversified crop rotations or plant associations. Only when all three principles are strictly followed can CA be considered truly practiced. CA, when combined with other best practices,such as using quality seeds, integrated pest and nutrient management, and weed and water management, serves as the foundation for sustainable agricultural production. It also providesopportunities for integrating various enterprises such as crop and livestock, as well as trees andpastures, into agricultural landscapes.

Conservation Agriculture (CA) is a promising approach to sustainable and productive agriculture that involves a combination of reduced soil disturbance, cover crop management, crop rotation, and improved management practices. In dryland areas, such as arid and semi-arid regions, where water and nutrients are often limited, implementing CA practices can help improve soil health, crop yields, and mitigate environmental impacts. Drylands comprise 41% of the world's land surface, and they face numerous challenges to traditional agriculture production. In this context, CA practices can help address soil degradation, water erosion, and low productivity, improving farmers' livelihoods by increasing yields and reducing input costs. This chapter provides insights into the principles, benefits, and challenges of implementing CA practices in dryland areas, both globally and in India.

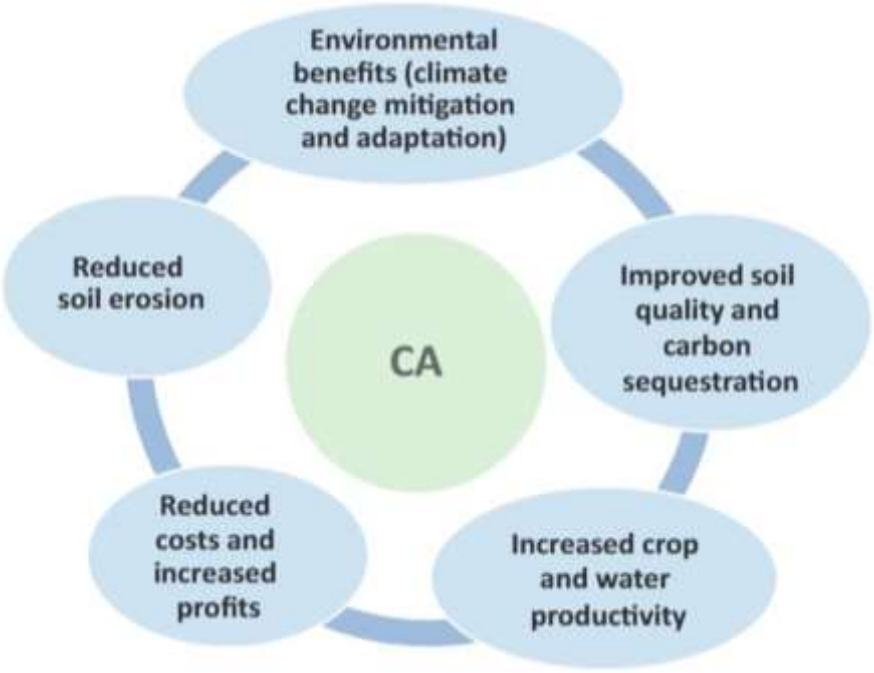

Figure 14.1: Multi-Dimensional Benefits of Adopting CA

10.2 Need for Conservation Agriculture in Drylands

Conservation Agriculture (CA) is a sustainable and productive approach to agriculture that involves the implementation of various practices, including minimal soil disturbance, soil cover, crop diversification, and good management practices. In dryland areas, where water and nutrients are scarce, implementing CA practices can help improve soil health and crop yields while mitigating the environmental impact of agriculture. Drylands cover 41% of the world's land surface and face numerous challenges related to traditional agriculture, including soil degradation, water erosion, and low productivity. CA practices can help address many of these challenges, improving the livelihoods of farmers by increasing crop yields and reducing input costs. Reduced soil disturbance, or no-till, is an essential aspect of CA that helps maintain soil structure and minimizes soil erosion. Cover crop management plays a crucial role in maintaining soil cover and protecting soil moisture

The importance of Conservation Agriculture (CA) in drylands lies in its ability to address the various challenges faced by farmers in these regions. Some of the critical benefits of CA in dryland areas include:

- **Improving soil health:** Drylands have low nutrient levels, poor soil structure, and low water-holding capacity, making it challenging to sustain agricultural productivity. CA practices such as cover crop management and crop diversification enhance soil health and organic matter, leading to improved soil fertility, water-holding capacity, and reduced erosion.
- **Enhancing crop yields:** By improving soil health and reducing soil erosion, CA practices can lead to better crop yields, even in areas with limited water and nutrient resources. In this way, CA can improve food security for farmers in dryland areas.
- **Mitigating environmental impacts:** Tillage-based agricultural practices have significant environmental impacts, such as contributing to climate change, reducing soil quality, and reducing biodiversity. CA practices lead to improved soil health, reduced erosion, and decreased greenhouse gas emissions, mitigating these impacts.
- **Reducing input costs:** CA practices such as crop rotation, use of organic fertilizers, and reduced tillage help to reduce input costs, such as fuel, fertilizer, and labor. This reduction in expenses has the potential to improve the economic well-being of farmers.

14.2 An Overview of Global Perspectives on Conservation Agriculture in Drylands:

Globally, Conservation Agriculture (CA) practices have been recognized as a promising approach to promote sustainable and productive farming in drylands. Many countries worldwide are adopting CA practices as a strategy to mitigate the challenges faced by farmers in dryland areas. These challenges include poor soil health, low crop yields, soil erosion, and water scarcity. CA practices are gaining popularity in arid and semi-arid regions, and they are recognized as a solution to increase productivity and reduce the impact of agriculture on the environment. According to a report by the Food and Agriculture Organization of the United Nations (FAO), CA is currently being practiced on approximately 157 million hectares worldwide, representing around 11% of field cropland.

In recent years, the adoption of CA practices has gained momentum globally due to several factors, including the need to reduce carbon emissions, mitigate climate change, and improve food security. Additionally, several multinational organizations and agencies have recognized the importance of adopting sustainable farming practices and have supported CA initiatives across the world. However, despite the increasing popularity of CA practices, there are still challenges to their widespread adoption. These challenges include high initial costs for equipment, limited access to extension services, lack of knowledge, and technological barriers. Overall, the global perspective on Conservation Agriculture in drylands is positive, and there is growing recognition of its potential to address the challenges faced by farmers in dryland areas. By improving soil health, increasing crop yields, reducing carbon emissions, and preventing soil erosion, CA practices have the potential to transform agricultural production systems, increase long-term sustainability and protect productive natural resources. The adoption of CA practices in drylands can also create socio-economic benefits for farmers, particularly in developing countries where farming is a primary source of livelihood. In this context, CA practices can lead to better market access, higher incomes, and improved living conditions. Moreover, the spread and innovation of CA practices are facilitated by cooperation among different stakeholders, including governments, research organizations, farmers, civil society organizations, and the private sector. The dissemination of innovative approaches to CA such as precision agriculture and digital farming, can enable farmers to adopt efficient and more sustainable farming practices.

In the 1970s, no-tillage technology was introduced to Brazil, where it was developed into the Conservation Agriculture (CA) system by farmers and scientists. However, it was not until the1990s that CA began to be widely adopted in southern Brazil, Argentina, and Paraguay. This growth in adoption caught the attention of development and research organizations such as FAO, World Bank, GIZ, CIRAD, and CGIAR, leading to study tours, workshops, and development and research projects being organized in various parts of the world. As a result, CA has gained increased awareness and adoption in African countries like Zambia, Zimbabwe,Mozambique, Tanzania, and Kenya, as well as in Asia, particularly in Kazakhstan and China. The success of CA in improving conservation and no-tillage practices within an integrated farming concept has led to increased adoption in industrialized countries such as Canada, USA,Australia, Spain, Italy, Finland, Ukraine, and Russia. Currently, CA crop production systems are of interest to most countries around the world, with only a few exceptions where CA is notpracticed by any farmers and there are no local research results available on CA (Jat et al., 2014).

Table 14.1: Area under conservation agriculture in different regions

Continent	Cropland under CA (MA ha)	Per cent of global CA area	Per cent of cropland
South America	66.4	42.3	60.0
North America	54.0	34.4	24.0
Australia & NZ	17.9	11.4	35.9
Asia	10.3	6.6	3.0
Russia & Ukraine	5.2	3.3	3.3

Continent	Cropland under CA (MA ha)	Per cent of global CA area	Per cent of cropland
Europe	2.0	1.3	2.8
Africa	1.2	0.8	0.9

14.3 An overview of Indian Perspectives on Conservation Agriculture in Drylands:

In India, the importance of Conservation Agriculture (CA) in drylands has gained significant attention as its adoption has grown. Dryland areas in India comprise about 70% of the country's total net-cropped area, and farmers in these areas struggle with low yields and poor soil fertility due to harsh environmental conditions like soil degradation, water scarcity, and high temperatures. The Indian Council of Agricultural Research (ICAR) has led efforts to promote CA practices through research, capacity building, and extension activities. The ICAR has developed several new technologies, including zero-tillage seed drills, promotion of organic farming practices, and use of new cropping systems, to enhance transferability of the technology from the researcher's lab to the farmer's field. The government of India has also launched various schemes and programs, such as the National Mission for Sustainable Agriculture (NMSA) and the Pradhan Mantri Fasal Bima Yojana, to encourage farmers to adopt CA practices. These programs provide financial support for farmers to purchase CA equipment and promote the uptake of sustainable agricultural practices. Due to these efforts, the adoption of CA practices in India has increased significantly in recent years. For instance, the area under zero-tillage farming increased from 2.3 million hectares to 3.4 million hectares between 2017 and 2020, representing a 45% growth. Despite these encouraging developments, there are still challenges to the adoption of CA practices in India. For example, farmers may face financial constraints when investing in CA equipment and may lack access to extension services. Moreover, some farmers may resist changes in traditional farming practices that they have been using for generations. Overall, the perspective on CA in drylands in India is generally positive, with efforts made by the government and the ICAR to promote the uptake of sustainable farming practices. However, continued support for research and development is needed to address challenges, promote awareness, and build capacity among farmers to effectively utilize CA practices in dryland areas. Such support is essential to encourage widespread adoption of CA and promote sustainable and productive agriculture systems to meet the food needs of a growing population while also mitigating adverse environmental impacts.

In Punjab, the practice of burning crop residue has led to environmental pollution and loss of nutrients. The adoption of CA practices in the region has been facilitated by the introduction of direct seeding of wheat in the 1980s and later the CA program by CYMMYT in the 1990s. The rice-wheat consortium (RWC) was established by CGIAR in 1994to focus on the rice-wheat farming systems widely practiced in the Indo-Gangetic plains and Himalayan mid-hills region. Today, CA-based technologies are being practiced on nearly 1.5 million hectares of irrigated land in India, particularly in the Indo-Gangetic plains. This is a significant achievement and shows the potential for the wider adoption of CA practices in theregion. This history of research on CA technologies was from irrigated cropping systems particularly in rice–wheat system.

The research on typical CA involving tillage levels, crop– residue retention on soil surface and N management under rainfed conditions with sorghum–castor (Ricinus communis L.) rotation was initiated in 1995 at the ICAR–CRIDA farm.Subsequently several experiments on typical CA with anchored crop–residues involving zero till planters under major rainfed crop rotations were started from 2005 onwards at CRIDA, Hyderabad. Under Consortium Research Platform on CA(CRP–CA), CA experiments were extended to selected centres of All India Coordinated Research Project on Dry-land Agriculture (AICRPDA) and farmers' fields in 2012–13. The research work done in India on CA in rainfed and dryland ecosystems is reviewed critically here, to identify suitable CA practices, prospects and potential benefits of CA, and issues and opportunities for adoption ofCA practices in rainfed areas over large scale. In 7–8–year–old experiment with maize (Zea mays L.)– pigeonpea [Cajanus cajan (L.) Millsp.] and maize–horse gram [*Marcrotyloma uniflorum* (Lam.)Verdc.] sequences on Alfisol showed that, the ZT resulted in about 28%, 16– 26% and 40% higher pigeonpea[Cajanus cajan (L.) Millsp.], maize and horse gram yields respectively, over the CT. At Benguluru, zero tillage and reduced tillage gave 29 and 4.6% lowerfinger millet yields, respectively, as compared to CT on Alfisols soil during the third year of experimentation. Vertisols at Akola, Maharashtra, ZT resulted in 9% and14% lower yields of soybean and chickpea (*Cicer arietinum* L.), respectively, compared with CT.

14.4 Conservation Agricultural Practices in World & India:

Conservation Agriculture (CA) practices are gaining popularity as a sustainable and productive approach to agriculture globally and in India. In the world, CA practices are being adopted on about 157 million hectares of land, accounting for around 11% of field croplands. These practices promote minimal soil disturbance, plant residue retention, and crop rotation schemes. The United States of America (USA), Brazil, Argentina, Canada, and Australia are some of the countries that have adopted CA practices, primarily in the context of large-scale agriculture. In India, studies report that several states in India including Punjab, Haryana, Gujarat, and Rajasthan have adopted CA practices. Punjab and Haryana have increased the area under zero-tillage farming to reduce tillage-based agriculture and maintain soil health. In Gujarat, the government has promoted the Ragi-Indian bean cropping system to build soil fertility. The state of Rajasthan has focused on rainwater harvesting and the development of soil-conservation structures. To support the widespread adoption of CA practices in India, the government and research organizations have launched several programs and initiatives. For instance, the National Mission for Sustainable Agriculture (NMSA) and the Rashtriya Krishi Vikas Yojana (RKVY) are two examples of flagship programs that aim at promoting sustainable agriculture practices in India. The Indian Council of Agricultural Research (ICAR) has been supporting CA practices through research, extension, and capacity building activities, such as developing new crop varieties and agronomic practices, improving cropping models, and promoting innovative technologies.

14.5 Conclusion

In conclusion, conservation agriculture is a sustainable and effective approach for farming in drylands, both in India and across the world. By adopting practices such as minimum tillage, crop rotations, and cover cropping, farmers can conserve soil moisture, reduce

erosion, and improve soil health. This, in turn, leads to higher yields and more resilient crops, which are especially important in regions with limited water resources and unpredictable weather patterns. In India, where dryland farming accounts for a significant portion of agricultural production, conservation agriculture has been increasingly adopted by farmers in recent years. The Indian government has also promoted this approach through various schemes and programs aimed at improving soil health and water conservation. Despite the many benefits of conservation agriculture, its widespread adoption still faces several challenges, including lack of awareness and knowledge among farmers, lack of access to inputs such as seeds and fertilizers, and limited infrastructure for marketing and distribution of produce. Addressing these challenges will require concerted efforts from governments, civil society, and the private sector.

Overall, conservation agriculture holds great promise for improving the sustainability and resilience of agriculture in drylands, and its continued promotion and adoption should be a priority for policymakers, farmers, and other stakeholders in India and around the world.

14.6 References:

1. Bucchignani, E., Mercogliano, P., Panitz, H.-J., Montesarchio, M., 2018. Climate change projections for the Middle East–North Africa domain with COSMO-CLM at different spatial resolutions. Adv. Clim. Chang. Res. 9, 66–80
2. Choudhary, M., Ghasal, P.C., Kumar, S., Yadav, R.P., Singh, S., Meena, V.S., Bisht, J.K., 2016. Conservation agriculture and climate change: an overview. In: Conservation Agriculture. Springer, pp. 1–37.
3. Derpsch, R., Franzluebbers, A.J., Duiker, S.W., Reicosky, D.C., Koeller, K., Friedrich, T., Sturny, W.G., Sa´, J.C.M., Weiss, K., 2014. Why do we need to standardize no-tillage research? Soil Tillage Res. 137, 16– 22.
4. EL Gharras, O., EL Mourid, M., Boulal, H., 2017. Conservation agriculture in North Africa: Experiences, achievements and challenges. In: Conservation Agriculture for Africa: Building Resilient Farming Systems in a Changing Climate, pp. 127–138.
5. FAO, 2014. What is Conservation Agriculture? FAO CA website.
6. FAO, 2016. Food and Agriculture Organization of the United Nations, Conservation agriculture.
7. FAOSTAT, 2020. United Nations Food and Agricultural Organisation. Statistics on Crop Production.
8. Farooq, M., Flower, K.C., Jabran, K., Wahid, A., Siddique, K.H.M., 2011. Crop yield and weed management in rainfed conservation agriculture. Soil Tillage Res. 117, 172–183
9. Gathala, M. K., Kumar, V., Sharma, P. C., Saharawat, Y. S., Jat, M. L., Singh, R. G., ... & Kumar, A. (2014). Optimizing intensive cereal-based cropping systems addressing current and future drivers of agricultural change in the northwestern Indo-Gangetic Plains of India. Agriculture, Ecosystems & Environment, 196, 1-12.
10. Gupta, A., & Singh, G. (2020). Conservation Agriculture in India: Progress, Problems, and Prospects. Agrotechnology, 9(2), 235.
11. Gopinath, K. A., Raju, R. V. S., & Vijaya Kumar, K. A. (2019). Adoption and Determinants of Conservation Agriculture Practices in Drylands: Evidence from a Baseline Study in South India. Journal of Agricultural Education and Extension, 25(3), 215-229.

12. Hussein, M.A., 2008. Costs of environmental degradation. Manag. Environ. Qual. 1477-7835
13. Jat, M. L., Kassie, G. T., Prasad, P. V. V., Ali, M., Chamane, B., & McDonald, A. (2021). Adoption and impact of conservation agriculture in India's drylands: A review. Land Use Policy, 103, 105267.
14. Kapoor, V., & Singh, G. (2019). Adoption of conservation agriculture practices by farmers in North-West India—an overview. Agricultural Reviews, 40(4), 229-239.
15. Kumar, S., Jakhar, R. K., Kalra, N., Singh, R., & Kamboj, M. (2021). Adoption and determinants of conservation agriculture in dryland regions of India: a systematic review. Environmental Science and Pollution Research, 28(21), 27040-27060.
16. Loss, S., Haddad, A., Desbiolles, J., Cicek, H., Khalil, Y., Piggin, C.M., 2015a. The Practical Implementation of Conservation Agriculture in the Middle East. International Center for Agricultural Research in the Dry Areas (ICARDA).
17. Murendo, C., & De Fraiture, C. (2019). Reaping benefits: The adoption of conservation agriculture in Zambia. Land Use Policy, 82, 656-669.
18. Paroda, R. S., & Arora, V. K. (2018). Conservation agriculture in rainfed agro-ecological zones of India: a review. Journal of Applied and Natural Science, 10(1), 230-237.
19. Petrović, M., Ronchi, L., & Batte, M. T. (2016). Profitability of Conservation Agriculture in developing countries: A review of evidence. Agricultural Systems, 146, 129-135.
20. Singh, R. P. (2017). Conservation agriculture in India: An Overview and Strategies for Dissemination. International Journal of Current Microbiology and Applied Sciences, 6(8), 1672-1686.
21. Tiwari, P., Neelima, R., & Sheetal, D. (2017). Adoption and impact of Conservation Agriculture practices in India: Evidence from literature. Science International, 29(4), 775-778.
22. Vanlauwe, B., Wendt, J., Giller, K. E., Corbeels, M., & Gerard, B. (2014). A fourth principle is required to define Conservation Agriculture in sub-Saharan Africa: the appropriate use of fertilizer to enhance crop productivity. Field Crops Research, 155, 10-13.