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REVOLUTIONIZING FARMING: THE RISE OF CONSERVATION AGRICULTURE

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Introduction

Conservation agriculture (CA) is a sustainable farming approach that aims to safeguard and enhance the environment while ensuring long-term agricultural productivity. It emphasizes the three key principles of minimal soil disturbance, permanent soil cover, and crop diversification. By decreasing soil erosion, preserving water, and improving soil health by regenerating degraded lands, conservation agriculture promotes long-term sustainability and resilience in agricultural systems. It enhances biodiversity and natural biological processes above and below the ground surface, which contribute to improved nutrient, water use-efficiency & to improved and sustained crop production. It encourages producers to adopt practices such as no-till or reduced tillage, cover cropping, & crop rotation. Conservation agriculture reduces the reliance on synthetic inputs, minimizes GHG, and enhances biodiversity (Bhan and Behera, 2014). This approach helps to maintain soil fertility, preserve natural resources, & alleviate climate change impacts. Conservation agriculture is gaining recognition worldwide as a promising solution for sustainable food production and environmental conservation (Pasricha, 2013). Its implementation requires knowledge sharing, training, and supportive policies to enable farmers to transition to these practices successfully.

Current Status of Global and Regional Adoption trends of CA

The worldwide area under CA has proficient growth over the years (Fig. 1). It started with 2.8 million hectares (Mha) in 1973 and gradually increased to 6.2 Mha by 1983.

However, the adoption of CA gained significant momentum in the late 1990s, with the area expanding to 38 Mha in 1996 and further to 45 Mha in 1999. The growth continued in the early 2000s, reaching 72 Mha in 2003. The adoption of CA has seen a substantial acceleration since then, with the global area reaching 125 Mha in 2011, 180 Mha in 2016, and reaching 205.4 Mha in 2022 (contributes 12.5% of global crop land area). This growth indicates a growing recognition and acceptance of CA as a sustainable farming practice worldwide (Kassam *et al.*, 2022).

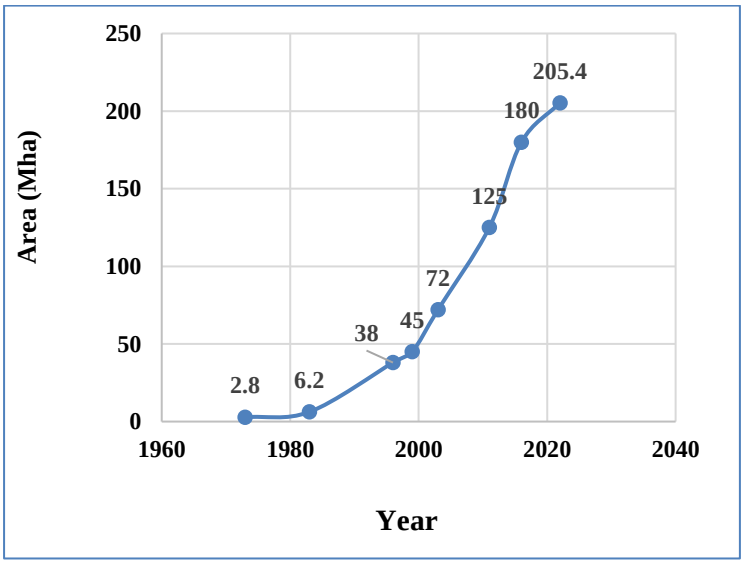

Fig. 1: World wide area under CA

The current status of Conservation Agriculture (CA) globally showcases significant adoption and recognition of sustainable farming practices. In countries such as the USA, Brazil, and Argentina, CA has gained substantial traction, with CA areas of 45.2 M ha, 32 M ha, and 31 M ha, respectively. Australia and Canada also exhibit significant CA areas of 22 M ha and 19 M ha, respectively. The combined CA area in other countries stands at 56.2 M ha. In Asia, China leads with 9 M ha, followed by Kazakhistan, India, and other Asian countries contributing to a total CA cropland area of 13.93 M ha. This data reflects the global commitment to sustainable farming methods, emphasizing environmental conservation and agricultural productivity through CA practices (Kassam *et al.*, 2022).

Principles of Conservation Agriculture

Through following the three principles of CA, farmers seek to implement sustainable and environment-friendly agricultural practices that simultaneously protect soil health, conserve water, enhance biodiversity, improve agricultural productivity & contribute to the regeneration of ecosystems.

1. Minimum soil disturbance or direct seeding/planting

CA promotes reduced or minimal soil disturbance by minimizing or eliminating tillage operations. This helps to preserve soil structure, organic matter, and beneficial soil organisms, while reducing soil erosion and compaction.

- Techniques for reducing soil disturbance (e.g., no-till, reduced tillage)
- Benefits of minimal soil disturbance (e.g., improved soil structure, reduced erosion)

2. Soil Organic Cover

CA emphasizes the conservation of a permanent cover of crop residues or cover crops on the soil surface. This helps to protect the soil from erosion, retain moisture, reduce weed growth, and improve soil fertility & health.

- Methods for maintaining soil cover (e.g., crop residues, cover crops)
- Benefits of permanent soil cover (e.g., moisture conservation, weed suppression)

3. Species Diversification

CA encourages crop diversification through practices such as crop rotation or intercropping. This helps to break pest & disease cycles, improve nutrient cycling, enhance soil biodiversity, and increase overall resilience and sustainability of the farming system.

- Practices for crop diversification (e.g., crop rotation, intercropping)
- Benefits of crop diversification (e.g., pest control, nutrient cycling)

Policy Issues

- Emphasis on Livelihood Security
- Diversified Cropping Systems in different agro-ecoregions
- Significant impact on plant growing micro-environment
- Policy Support for Capacity Building by organizing trainings needed
- Scaling Up CA Practices
- Payments for Environmental Services (PES) and Fines
- Development and Availability of CA Equipment
- Adaptation and Validation of CA Technologies

Benefits of Conservation Agriculture (CA)

For any new technology to gain widespread adoption, it must offer compelling benefits and advantages that appeal to a diverse range of farmers who comprehend the distinctions between their current practices and the potential benefits of adopting the new approach. In the context of conservation agriculture, these advantages primarily fall into the category of economic benefits, enhancing overall production efficiency.

The adoption of Computer Automation (CA) can yield three significant economic advantages:

- Enhanced time efficiency leading to reduced labor demands.
- Decreased expenses, such as fuel, machinery operating costs, maintenance, and lower labor expenses.
- Improved overall efficiency, resulting in increased output with minimal input.

Enhancing soil productivity offers a range of agronomic advantages:

- Efficient in-soil water conservation.
- Promotion of organic matter, bolstering soil fertility.
- Enhancement of soil structure, providing an optimal rooting zone for plants.

Environmental benefits that safeguard the soil and foster sustainable agriculture:

- Mitigation of soil erosion, resulting in reduced maintenance costs for infrastructure like roads, dams, and hydroelectric power plants.
- Improved water and air quality.
- Increased biodiversity.
- Carbon sequestration, aiding in the fight against climate change**.**

Future Directions and Emerging Trends in CA

1. Adoption of regenerative practices: CA will increasingly focus on regenerative practices that aim to restore soil health and biodiversity while improving productivity.
2. Emphasis on carbon sequestration: CA will prioritize tactics that enhance carbon-sequestration in agricultural soils, contributing to climate-change mitigation.
3. Integration of agroforestry systems: Agroforestry will be integrated into conservation agriculture systems, providing multiple benefits such as increased biodiversity, improved soil fertility, and enhanced water management.

4. Utilization of digital technologies: CA will leverage digital technologies, like sensors, drones, and machine learning, to optimize resource use, monitor soil conditions, and facilitate precision farming practices.
5. Promotion of farmer-led initiatives: There will be a greater emphasis on farmer-led initiatives and participatory approaches, empowering farmers to be active contributors and decision-makers in implementing conservation agriculture practices.

Conclusion

Conservation agriculture shifts the focus from production targets to sustainable resource management in Indian agriculture. It aims to integrate productivity, resource conservation, soil quality, and environmental concerns for long-term growth. Developing and promoting conservation agriculture requires expanding scientific knowledge and collaboration with farmers and stakeholders. By adopting a holistic systems perspective, it offers the potential to reverse resource degradation and decrease cultivation costs. Ultimately, conservation agriculture aims to create a more sustainable, efficient, and competitive agricultural sector in India and globally.

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