Conservation Agriculture to Sustainable Farming: A Case Study from Asia

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Abstract

This study delves into conservation agriculture (CA), a farming approach characterized by minimal soil disturbance (known as no-till or NT) and permanent soil cover through mulching, complemented by crop rotations, as a more sustainable method for future cultivations. It briefly explores the significance of tillage in agriculture, which emerged in response to the devastating American Dust Bowl of the 1930s. Subsequently, it introduces CA as advancement over CT. This study emphasizes CA's role in promoting sustainable and environmentally friendly crop cultivation practices. It draws a case study of Asia to illustrate the successful implementation of CA practices, resulting in improved production sustainability and profitability. Additionally, the study examines the implications of CA on greenhouse gas emissions and its contribution to mitigating global warming. Ultimately, it underscores the imperative for agriculture to adopt more resource-efficient and environmentally conscious practices to meet the growing demands of a burgeoning global population. Encouraging the adoption of CA management systems emerges as a key strategy for achieving this objective.

Keywords: Sustainable Farming, Agriculture, Sustainable Development, Asia

Introduction

Conservation agriculture (CA) is a contemporary farming approach with minimal soil disturbance (referred to as no-till or NT) and preserving a permanent layer of soil through mulching, alongside crop rotations. This method is gaining traction globally as a sustainable agricultural management system. Cultivation refers to the process of preparing land for planting or growing crops using tillage methods, which is synonymous with plowing or tillage. Moreover, the concept of "sustainable" has been extensively discussed and delineated in various scholarly works. Sustainability entails the capability of being borne or endured, maintained without interruption or decline over an extended period. In today's agricultural context, sustainability is crucial as it ensures the preservation of natural resources for future generations to meet their food needs. The objective of this chapter is to present and promote CA as a contemporary agricultural methodology that can empower farmers globally to attain objectives of sustainable agricultural production. Before exploring CA, the chapter examines several aspects concerning cultivation.

Cultivation Techniques

Undoubtedly, tillage's advantages listed were advantageous to farmers, yet they came at a cost to the farmers themselves and the environment, as well as the natural resources vital to farming. Edward H. Faulkner, an innovative agronomist in the 1930s, challenged the efficacy of plowing in his manuscript 'Ploughman's Folly' (Faulkner 1943). Paul Sears acknowledges Faulkner's astuteness in challenging "plow". Faulkner recognized latest design plow's mold board, which was in a curved shape, did not facilitate the incorporation of organic matter. Rather, it buried this valuable material deep beneath the soil, akin to undigested food from a hearty meal within the human stomach.

Conservation Tillage (CT)

From 1930- 2005, individuals within the agricultural sector have promoted the adoption of reduced tillage methods, aiming to reduce reliance on fossil fuels, mitigate soil runoff and erosion, and enhance soil organic matter. The first five decades witnessed the emergence of CT, and presently, a considerable portion of the agricultural area is cultivated with the help of these methods. However, in the 'No-tillage seeding' book by Baker et al. (2002), it was elucidated that "As soon as the modern concept of reduced tillage was recognized, everyone, it seems, invented a new name to describe the process." The book delineates 14 distinct names for reduced tillage methods, each with its rationale. Furthermore, it provides extensive examination techniques for no-tillage practices.

Conservation Agriculture (CA)

Conservation Agriculture entails maintaining a consistent organic soil cover, which may comprise either a live-growing crop or a layer of decomposed mulch. The primary purpose of this cover is to provide physical protection to the soil against the adverse effects of sun, rain, and wind, while also serving as a source of nourishment for soil organisms. Soil microorganisms and fauna play a crucial role in soil tillage and nutrient regulation, a process disrupted by mechanical tillage. Hence, the adoption of zero or minimal tillage and direct seeding practices are integral components of CA. Additionally, implementing a diverse crop rotation is essential to mitigate disease and pest-related issues.

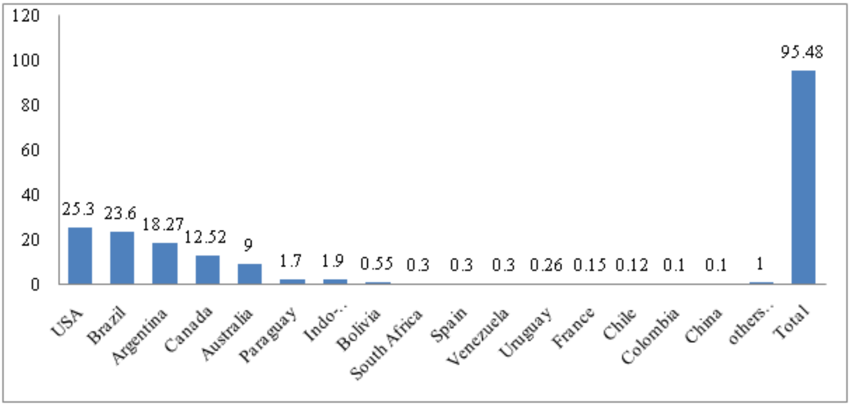
However, the recent introduction of the term 'conservation agriculture' (CA) by organizations like the FAO further complicates matters. CA aims to conserve, enhance, and optimize natural resources through integrated management approaches. CA contributes to environmental conservation and enhances agricultural production sustainability, aligning with the overarching objective of achieving sustainable agricultural production. However, this term is often not differentiated from CT, further contributing to confusion within the agricultural community.

Table 1.1
NT Adoption Worldwide

Country	**Area Under NT (Mha) 2004-2005**
USA	25.300
Brazil	23.601
Argentina	18.271
Canada	12.520
Australia	9.001
Paraguay	1.701
Indo-Gangetic Plains*	1.901
Bolivia	0.550
South Africa	0.301
Spain	0.301
Venezuela	0.301
Uruguay	0.260
France	0.151
Chile	0.120
Colombia	0.101
China	0.101
others (estimate)	1.001
Total	95.480
Source: FAO website, *Derpsch (2005)	

According to Derpsch (2005), global adoption of no-tillage practices amounts to approximately 95 million hectares (Mha), serving as a rough indicator for CA, although recognizing that not all of this land is uniformly under no-tillage or maintains perpetual ground cover. Table 1.1 offers a detailed overview of global no-tillage adoption by various nations, indicating that 6 nations have reported more than 1 Mha each. South America exhibits the maximum rates of adoption, marked by a notable prevalence of permanent no-tillage and soil cover. Argentina and Brazil encountered considerable delays in surpassing the 1 Mha milestones during the early 1990s, followed by rapid expansion to current values of 18.3 Mha and 23.6 Mha, respectively. The study made by Derpsch (2005) estimated that Brazil's adoption of no-tillage contributed to a 67.2 million ton increase in grain production over 15 years, generating additional revenue of $10 billion. Furthermore, it is estimated that the Republic of Brazil segregated 12 million tons annually on 23.6 Mha of no-tillage area, with an average rate of 0.51 tons per hectare per year. The adoption of no-tillage practices also significantly reduces tractor usage, resulting in substantial fuel savings.

Figure 1.1
The Scope of NT Adoption on a Global Scale



Source: Based on Table 1.1

The data provided in Figure 1.1 illustrates the extensive global adoption of no-tillage practices in agriculture as of 2004-2005. Leading the trend, the United States boasts the largest area under NT, followed closely by Brazil and Argentina. Canada and Australia also contribute significantly to this practice, with substantial land areas adopting no-tillage methods. Notably, countries across various regions, including Paraguay, the Indo-Gangetic Plains, and South Africa, have embraced no-tillage on a considerable scale. While some nations like Bolivia, Spain, and Venezuela exhibit moderate adoption rates, others such as Uruguay, France, Chile, Colombia, and China have comparatively smaller areas under no-tillage cultivation. Additionally, an estimated 1 million hectares spread across various countries contribute to the overall global adoption of no-tillage. Collectively, these efforts result in a total of 95.48 million hectares worldwide practicing no-tillage, emphasizing its significance in enhancing soil health, conserving moisture, and promoting sustainable agricultural practices.

Equipment for Conservation Agriculture

Before delving into case studies from Asia, it is imperative to underscore the crucial role of equipment in the success of CA; without suitable equipment, zero-till and CA practices are destined to falter. Equipment for CA must be not only developed and refined but also swiftly made accessible and embraced to effectively support this advancing farming system. Several comprehensive reviews on equipment requirements for zero-tillage systems are available. The fundamental equipment requirements in a CA system encompass handling loose straw, precise placement of seeds and fertilizer, efficient furrow closing, and compaction of seed/soil.

Rice-Wheat Systems: An Asian Case Study

Traditionally, rice cultivation in the Indo-Gangetic Plains, as well as in many other rice-producing areas in Asia, involves dripping soil plowing in the primary rice fields (known as puddling), succeeded by Resettling rice seedlings grown in distinct seedbeds. Remarkably, this method of rice cultivation has been purportedly utilized for centuries without a notable decline in productivity, albeit yielding at relatively low subsistence levels. Many comprehensive reviews have analyzed numerous long-term experiments conducted across various Asian regions, focusing on modern varieties. These experiments encompass rice-wheat and rice-rice cropping systems, indicating declines in yields over time while others do not exhibit such trends.

Farmers have historically practiced puddling for specific reasons, primarily to manage weeds effectively. They observed that maintaining soils in an anaerobic and flooded state minimized weed issues and facilitated easier hand weeding due to the softening of soils. Puddling led to diminished water percolation and infiltration, resulting in water accumulation on the surface of the soil. While there is limited literature on the impact of puddling on soil biological properties, some research conducted at the International Rice Research Institute (IRRI) in the 1990s sheds light on this aspect (Reichardt et al. 2001).

During the 1960s, With the advent of modern wheat and rice varieties in South Asia, farmers of the Northwest part of the Indian Territory and Pakistani territory integrated rice into their wheat cultivation methods, while counterparts of the eastern regions of South Asia integrated wheat into their rice cultivation methods. This approach facilitated wheat cultivation in the cool, dry season and rice cultivation during the warm, wet monsoon months, thereby intensifying the system, which has expanded to encompass 13.5 million hectares (Mha) since the 1960s. Presently, it represents one of the most crucial cropping systems for ensuring food security in South Asia, alongside rice-rice systems. Nonetheless, farmers encountered a significant challenge upon adopting this new system: the degradation of soil's physical properties after the cutting of a puddled and replanting rice crop. Intensive puddling also resulted in increased soil cracking. In contrast, unpuddled direct-seeded rice helped maintain better soil physical conditions, although yields were lower in areas where weed control was insufficient. To prepare suitable seedbeds for wheat planting, farmers resorted to multiple plowing operations, which consumed time and often led to delayed planting, reduced wheat yield potential, and various other detrimental effects.

To tackle the issues arising from delayed planting and the late transition from rice harvesting to wheat planting, the area saw the inception of no-tilled wheat amidst rice peg around 1985, providing a feasible remedy. Initiatives to adjust and advocate for resource-preserving methodologies (RPMs), encompassing NT, in the Indo-Gangetic Plains (IGP) have persisted for almost 30 years. Nonetheless, last 4-5 years these methodologies have garnered swifter acknowledgment among agriculturalists. While the adoption of NT is progressing in irrigated Rice-Wheat (RW) regions, its penetration into rain-fed agro-eco-regions is still limited. In the 2004-2005 wheat seasons, approximately 2 million hectares of no-till wheat were farmed by 425,000 cultivators across four South Asian nations. Both extensive and small peasants embraced this innovation, with smaller-scale agriculturalists accessing no-till drill services from providers. The primary catalyst for the swift uptake of NT in recent times has been the adoption of participatory methodologies, enabling farmers to trial the technology autonomously in their fields. Additionally, the endorsement of indigenous equipment manufacturers as collaborators in the initiative has been pivotal. The availability of affordable, effective drills, utilizing inverted T coulter technology introduced from New Zealand, has further facilitated widespread adoption.

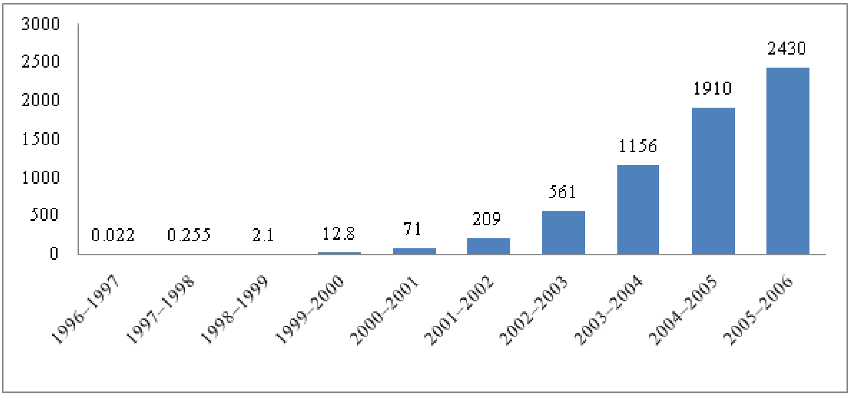
An essential requirement of this agricultural system is the development and accessibility of equipment capable of facilitating optimal germination of rice and wheat seeds. The Rice-Wheat Consortium (RWC) members are actively partnering with local manufacturers and farmers to guarantee the accessibility of novel equipment for trial at reasonable costs, along with post-sales support and the provision of essential spare parts to ensure the effectiveness of this approach. Recently, versatile zero-till fertile-seed exercises furnished with reverse T openers, disc planters, punch planters, trash movers, or roto-disc openers have been devised for sowing into scattered residues.

Numerous advantages have been attributed to this innovation, including significant savings of US$145 million in fuel costs (based on 2004 costs), as well as the associated benefits of reduced greenhouse gas emissions, decreased weed prevalence, enhanced beneficial insect activity and notably, higher yields at reduced costs. Furthermore, the advancement results in enhanced revenues from wheat farming and time savings, allowing for redirection towards alternative productive endeavors. Foreseen is the expansion of this innovation's adoption as equipment manufacturers meet rising drill demands and awareness regarding the advantages of zero-till wheat reaches the maximum peasant. Concurrently, as attitudes toward tillage necessity among farmers evolve, it is expected that the majority of wheat cultivation following rice harvesting in South Asia will transition to this innovative approach.

Nonetheless, the quest for agricultural sustainability persists. To realize the full benefits of zero-tilled wheat throughout the system and to enhance soil quality and biological health, changes in rice cultivation practices are imperative. These aerobic systems involve the cultivation of rice directly seeded onto flat or raised beds, with or without tillage, and with or without transplanting. The primary goal is to empower farmers to grow rice without tilling the soil, and subsequently, to cultivate wheat without tilling as well. Studies suggest that wheat yields are highest when grown after direct-seeded rice without soil puddling (Tripathi et al., 2005).

Figure 1.2 presents a decade-long snapshot of the global adoption of NT practices from 1996-1997 to 2005-2006, measured in millions of hectares.

Figure 1.2
Estimated NT Wheat Area in Asia



Source: http://www.rwc.cgiar.org

Beginning with a modest 0.022 million hectares in 1996-1997, the area under no-tillage cultivation witnessed steady growth until 1999-2000, reaching 12.8 million hectares. Subsequently, a notable surge in adoption occurred, with the area expanding rapidly from 71 Mha in 2000-2001 to 1910 Mha in 2004-2005, reflecting a significant global embrace of conservation agriculture. Despite a slight slowdown in growth, the trend continued upwards, with 2430 Mha under no-tillage by 2005-2006. This data underscores a widespread recognition of the benefits of no-tillage practices, such as improved soil health and sustainability, driving their increasing integration into agricultural systems worldwide

Conclusion

Over the next decade, crop production will face the daunting task of increasing food output while utilizing less land, optimizing natural resources, and minimizing environmental impact. Achieving this objective is crucial to meeting rising food demand while preserving land productivity for future generations. Agricultural scientists, extension personnel, and farmers will be challenged to meet these demands. However, adopting productive yet sustainable management practices outlined in this chapter can play a crucial role in addressing this challenge. The advancement of suitable equipment to facilitate the adoption of these systems by farmers is a prerequisite for success. Promoting farmer engagement in experimenting with these technologies through participatory approaches can expedite their adoption by addressing entrenched attitudes toward tillage. Additionally, securing ongoing, sustainable funding from donors to sustain long-term applied research in this domain is of paramount importance.

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