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Review

A history of tillage in California's Central Valley

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ABSTRACT

The Central Valley (CV) of California is a remarkably productive agricultural region. Much of the productive capacity of the CV stems from the reliable tillage management systems that were developed beginning in the 1930s and that changed very little until the 1990s and even more dramatically in the 2000s. A variety of technologies, people and social networks have contributed to the major transformations in tillage management that have rapidly occurred during this recent time. Factors that influenced the prior slow evolution of tillage systems in the region include the need to find ways to farm with irrigation, cope with a broad range of soils, achieve high crop quality and yields to compete on world markets, expand farming operations to greater acreage, and find ways to farm with ever-increasing costs. The cost increases, recognition of the emerging concepts of conservation agriculture (CA), and the development and broader adoption of advanced irrigation systems are now spurring farmers and research organizations in the CV to overcome problems experienced with conventional tillage practices and to develop new cropping systems in the region including no-tillage and strip-tillage. Ultimately, broader adoption of conservation agriculture principles and practices in this region will stem from a diverse and complex set of motivating factors. The role of global farmer-to-farmer communication has had a major impact on this process. Ongoing targeted problem-solving efforts addressing weed, water and fertility management in conservation agriculture systems will be needed to make them more reliable and widely used.

Contents

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1. Introduction

1.1. Background

Tillage – the physical manipulation or disturbance of the soil for the purpose of crop production (Koller, 2003; Reicosky and Allmaras, 2003) – is an important aspect of agroecosystems that dates back to the very dawn of agriculture (Lal et al., 2007; Huggins and Reganold, 2008). While natural terrestrial ecosystems do not typically involve tillage (Beck, 2014), the majority of agro-ecosystems have been developed to include some measure of tillage or soil manipulation as part of their sustained success in producing crops. Over the ages, farmers have relied on tillage operations in their fields to achieve a variety of functions that contribute to and improve crop productivity (See Box 1). These fundamental and universal goals of tillage have been used around the world across a great range of production scales and have variously employed human, animal or mechanical energy sources depending on a farmer's means and access to technology. Some of these goals of tillage, however, need to be reevaluated as we increase our understanding of agro-ecosystems.

The recorded history of the development of tillage practices used in various regions of the world is both fascinating and complex (Coughenour and Chamala, 2000; Lindwall and Sonntag, 2010; Awada et al., 2014; Duiker and Thomason, 2014; Brock et al., 2000). During the last thirty years of the twentieth century, a number of relatively radical tillage system alternatives including no-tillage and strip-tillage have become common and more widely adopted around the world (Lindwall and Sonntag, 2010; Reicosky and Allamaras, 2003). These systems that are now known as a key component of an expanded system called "conservation agriculture" (see Box 2) have been critical to the agricultural sustainability of several regions including the US Great Plains (Morrison, 2000), the central Canadian plains (Lindwall and Sonntag, 2010; Awada et al., 2014), much of Brazil, Argentina and Paraguay (Derpsch and Friedrich, 2009; Junior et al., 2012), and Western Australia (Crabtree, 2010; Llewellyn et al., 2012). The spiral of soil improvement and water conservation afforded by changes from conventional tillage management approaches to no-tillage, high-residue systems throughout the Dakotas and Nebraska, for instance, are widely credited with reversing the downward economic trend of farms in that region in the 1990s with not only enabling the diversification and intensification of the productive capacity, but also sustaining the economic viability of farming in this part of the country (Anderson, 2005, 2009, 2011). The largely farmer-led innovations that began in the 1970s in South America also involved conversion to no-tillage over the majority of farmland in Brazil, Argentina and Paraguay (Junior et al., 2012; Friedrich and Kassam, 2011). Likewise, the innovations were largely credited with reversing the unsustainable soil losses due to erosion throughout that region and contributing to lowering production costs (de Freitas and Landers, 2014). The simultaneous expansion of no-tillage adoption in Western Australia (Friedrich et al., 2012; Llewellyn et al., 2012) and Canada (Lindwall and Sonntag, 2010; Awada et al., 2014) is another example of local, largely farmer-initiated innovation in tillage management that went far in assuring the sustainability of farming in these regions.

The technologies, people and social networks that have led to each of these major tillage system transformations across these wide-ranging regions have been captured, archived and showcased for various audiences in a variety of historical accounts (Coughenour and Chamala, 2000; Junior et al., 2012; Kassam et al., 2014a, b; Lindwall and Sonntag, 2010; Awada et al., 2014) and formats (http://www.kis.usask.ca/CTConference.html#Dumanski). Tillage innovation is thus an important way in which agriculture improves and becomes more efficient and sustainable. Understanding experiences with tillage system innovation and how mindsets change as new systems are adopted is also important because it provides information of the huge challenges that will be required to achieve further timely transformational changes in agricultural production systems (Lindwall and Sonntag, 2010; Awada et al., 2014). Because no comprehensive historical archiving of tillage system and management changes in California's Central Valley (CV) (Fig. 1) exists and because of the dynamic evolution and

Box 1. Functions of tillage

To create a seedbed
To loosen compacted soil layers
For weed, insect, and pathogen control
For aeration
To incorporate crop and weed residues into the soil
To inject or incorporate fertilizers and pesticides
To facilitate irrigation, water infiltration and soil moisture storage
To stimulate net nitrogen mineralization
To plant a seed/seedling
For rain capture
To control soil temperature
For salinity control
To mix soil layers
To increase rooting