Increasing crop yields through conservation tillage in dryland areas of China

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Introduction

Conservation tillage (CT) has been globally recognized as an advanced agricultural technology that may reduce the effect of drought and improve the physical condition of soils. In China, CT research started with support from the Ministry of Agriculture (MOA), China and the Australian Centre for International Agricultural Research in 1992 (He et al. 2010). This work has demonstrated significant improvements in productivity over this period, especially in the arid and semi-arid region of China. This paper reports the impacts of CT on crop yields in dryland areas of China including the loess plateau of China, North China plain, Northeast China, Northwest China and the farming–pastoral ecotone of Inner Mongolia.

Materials and Methods

The long-term experiments were conducted at Linfen (1993-2006) on the Loess Plateau one crop/year region, Beijing (2000-2007) and Hebei (1998-2009) of North China Plain (NCP) two crops/year regions, Liaoning and Heilongjiang (2005-2007) of Northeast China one crop/year regions, Gansu (2005-2007) of Northwest China one crop/year region, and Farming pastoral ecotone at Inner Mongolia (1998-2008). In all these experimental sites, two tillage treatments were evaluated: CT and Traditional tillage (TT). Residue was removed from TT before mouldboard ploughing to a depth of 10-18cm, followed by harrowing, hoeing, rolling and levelling.

Results and Discussion

Long-term CT has shown the positive results in terms of providing higher crop yields as compared to TT in the five different areas (Table 1) of the dryland cropping regions of China. The NCP and the Northeast of China has the greatest yield under either treatment, but the largest improvement due to CT occurred in the Loess Plateau region.

At Linfen (1994-2006) on the Loess Plateau, Li et al. (2007) showed that mean yield for CT management (3.6 t/ha) was 19.2% higher than TT treatment, and yield differences between treatments were significant in 6 out of 12 years ($P<0.05$). It is interesting to note that the mean yield advantage of CT was relatively small (8.4%) in the first 3 years of the experiment, but this increased to a mean value of 22.3% in the subsequent 9 years, and yield improvements were greater in drier years. At Beijing (2000-2007) of NCP, Zhang et al. (2009) showed that tillage treatments had little effect on winter wheat yields during the first 3 years or on summer maize yields during the first 2 years, but yields of both crops were significantly ($P < 0.05$) higher under CT in subsequent years. As indicated in Table 1, average winter wheat yields in 2004–07 under CT was 423 kg/ha (7.46%) higher than TT; In summer maize, CT was 138 kg/ha (3.24%) higher. In Hebei, winter wheat and summer maize yields in CT and TT treatments fluctuated widely from year to year. Mean 11 years' winter wheat yield for CT was 3.5% greater than that for TT, and yield differences between treatments were significant in 4 out of 11 years ($P<0.05$). Again, the mean yield advantage of CT was minimal in the first 5 years of the experiment, but improved to 6.2% in the subsequent 6 years, and similar effects in maize. Mean (1999-2009) yield for CT plots was 1.4% higher than that for TT plots, and the yield differences were significant ($P<0.05$) in the years of 2004 and 2009. Again, these significant yield advantages produced by CT were only observed in the last 6 years of the experiment. At both Liaoning and Heilongjiang in Northeast China, He et al. (2010) found a mean yield improvement from CT of 88.3 kg/ha (Liaoning) and 225 kg/ha (Heilongjiang), compared with TT. At Gansu in Northwest China, He et al. (2008) found the mean wheat yields for CT and TT treatments were 6128 kg/ha and 5981 kg/ha, indicating a significant ($P < 0.05$) yield improvement of 0.8% for CT compared with TT treatment. In Inner Mongolia, He et al. (2009) indicated that the yields on CT treatments were greater than those on the TT plot, with significant differences ($P < 0.05$) in 6 of 10 years on average. The mean yield advantage of CT was relatively small (6%) in the first 4 years, but this increased to a mean value of 13% in the subsequent 6 years.

Statistically significant results have not been achieved in all years, or in all trials, but some clear patterns can be seen in the accumulated data and publications from this work. The most important is the substantial improvement in crop yield generally associated with conservation tillage. This yield benefit is much greater in dry years, but often not seen for some years after adoption. Conservation tillage also makes a positive contribution to soil structure and economics. It is clearly an appropriate technology for improving the yields and sustainability of dryland crop production in China.

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Table 1. Crop yields (t/ha) under conservation tillage (CT) and traditional tillage (TT) in Linfen of Loess Plateau (1993-2006), Li et al. (2007); in Beijing (2000-2007) and Hebei (1998-2009) of North China Plain, Zhang et al. (2009); in Liaoning and Heilongjiang (2005-2007) of Northeast China, He et al. (2010); in Gansu (2005-2007) of Northwest China, He et al. 2008; and in Farming pastoral ecotone of Inner Mongolia (1998-2008), He et al. (2009).

Site		**Crop**		**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Loess Plateau	Linfen	Winter wheat	CT	3.2[a]	2.5[a]	3.9[a]	4.1[a]	3.1[a]	2.6[a]	2.6[a]	3.8[a]
			TT	3.0[a]	2.3[a]	3.5[a]	3.9[a]	2.5[b]	2.1[b]	1.7[b]	2.9[b]
North China Plain	Hebei	Winter wheat	CT	–	–	–	–	–	6.1[a]	6.3[a]	5.8[a]
			TT	–	–	–	–	–	6.2[a]	6.2[a]	5.6[a]
		Summer maize	CT	–	–	–	–	–	10.4[a]	9.9[a]	9.5[a]
			TT	–	–	–	–	–	10.2[a]	10.1[a]	9.4[a]
	Beijing	Winter wheat	CT	–	–	–	–	–	–	6.3[a]	5.8[a]
			TT	–	–	–	–	–	–	6.2[a]	5.6[a]
		Summer maize	CT	–	–	–	–	–	–	9.9[a]	9.5[a]
			TT	–	–	–	–	–	–	10.1[a]	9.4[a]
Northeast China	Liaoning	Spring maize	CT	–	–	–	–	–	–	–	–
			TT	–	–	–	–	–	–	–	–
	Heilong-jiang		CT	–	–	–	–	–	–	–	–
			TT	–	–	–	–	–	–	–	–
Northwest China	Gansu	Spring wheat	CT	–	–	–	–	–	–	–	–
			TT	–	–	–	–	–	–	–	–
Farming pastoral ecotone	Inner Mongolia	Spring wheat	CT	–	–	–	–	1.2[a]	1.3[a]	1.4[a]	1.3[a]
			TT	–	–	–	–	1.1[a]	1.1[b]	1.4[a]	1.2[a]

Site		Crop		2002	2003	2004	2005	2006	2007	2008	2009
Loess Plateau	Linfen	Winter wheat	CT	4.2[a]	4.0[a]	5.2[a]	3.8[a]	4.7[a]	−	−	−
			TT	3.0[b]	3.4[a]	4.6[a]	2.7[a]	4.4[a]	−	−	−
North China Plain	Hebei	Winter wheat	CT	6.4[a]	6.5[a]	5.6[a]	6.4[a]	6.1[a]	6.3[a]	6.5[a]	5.7[a]
			TT	6.6[a]	6.4[a]	5.3[b]	6.2[a]	5.8[b]	5.3[b]	6.4[a]	5.4[b]
		Summer maize	CT	10.0[a]	10.7[a]	9.2[a]	9.9[a]	9.5[a]	10.4[a]	10.3[a]	9.6[a]
			TT	10.1[a]	10.5[a]	8.8[b]	9.8[a]	9.2[a]	10.5[a]	10.1[a]	9.2[b]
	Beijing	Winter wheat	CT	6.4[a]	6.5[a]	5.6[a]	6.4[a]	6.1[a]	6.3[a]	−	−
			TT	6.6[a]	6.4[a]	5.3[b]	6.2[a]	5.8[b]	5.3[b]	−	−
		Summer maize	CT	10.0[a]	10.7[a]	9.2[a]	9.9[a]	9.5[a]	10.4[a]	−	−
			TT	10.1[a]	10.5[a]	8.8[b]	9.8[a]	9.2[a]	10.5[a]	−	−
Northeast China	Liaoning	Spring maize	CT	−	−	−	9.4	9.1	10.6	−	−
			TT	−	−	−	9.3	9.0	10.6	−	−
	Heilong-jiang		CT	−	−	−	9.5	9.5	10.9	−	−
			TT	−	−	−	9.6	9.4	10.3	−	−
Northwest China	Gansu	Spring wheat	CT	−	−	−	5.4[a]	6.1[ab]	6.4[a]	−	−
			TT	−	−	−	5.6[a]	6.0[a]	6.2[a]	−	−
Farming pastoral ecotone	Inner Mongolia	Spring wheat	CT	1.5[a]	1.3[a]	1.5[a]	1.5[a]	1.4[a]	1.4[a]	−	−
			TT	1.3[b]	1.1[b]	1.5[a]	1.3[b]	1.1[b]	1.1[b]	−	−

Values within a column in each experimental site followed by the same letters are not significantly different (P>0.05).

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