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Traffic and tillage effects on wheat production on the Loess Plateau of China: 2. Soil physical properties

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Abstract. Controlled traffic zero and minimum tillage management with residue cover has been proposed as a solution to erosion and other soil degradation challenges to the sustainability of dryland farming on the Loess Plateau of China. This was assessed between 1998 and 2007 in a field experiment involving a conventional tillage treatment, and 2 controlled traffic treatments, no tillage and shallow tillage, with full straw cover in both cases. This paper reports the soil physical properties after 9 years of dryland wheat production under these treatments, and the substantial improvements seen in soils under controlled traffic. Compared with conventional tillage, controlled traffic significantly reduced soil bulk density in the 0–0.15 m soil layer, and increased total porosity in the 0–0.60 m soil layer, where macroporosity (>60 μm) and mesoporosity (0.2–60 μm) increased at the expense of microporosity (<0.2 μm). Readily available water content and saturated hydraulic conductivity were greater in controlled traffic treatments. Controlled traffic farming appears to be an improvement on current farming systems on the Loess Plateau, and valuable for the sustainable development agriculture in this region.

Additional keywords: controlled traffic, soil physical properties.

Introduction

Bulk density, porosity, and water retention capacity are usually recognised as important indicators of soil quality, but farming methods can influence these by altering soil physical properties. Tillage and wheel traffic can affect soil structure by fragmentation and compaction (Lamande *et al*. 2003; Pagliai *et al*. 2004), and create heterogeneity in tilled soil between compacted and uncompacted zones. Compaction induced by vehicle traffic has adverse effects on several key soil properties such as bulk density, porosity, and hydraulic conductivity (Radford *et al*. 2000; Green *et al*. 2003). McGarry (2001) identified this as the most serious environmental problem caused by conventional agriculture.

The dryland region of the Loess Plateau of China has soil that is easily eroded and is intensively cropped with dryland winter wheat, which occupies 56% of the arable land (Zhu 1989). Soil erosion and limited crop-available water are the major factors constraining agricultural production on the Loess Plateau, and severe erosion has resulted in degradation of soil physical properties, such as bulk density and water retention (Zha and Tang 2003). Traditional farming practices which include intensive ploughing and the routine removal of crop residues were identified as the major cause of this degradation (Wang *et al*. 2006). These practices exacerbate soil, water, and nutrient loss, decrease water availability and fertility, and contribute to land degradation (Jin *et al*. 2007). For sustainable productivity, farmers need to manage their resources and adopt farm practices which will control soil erosion and land degradation.

All heavy equipment wheels are confined to permanent traffic lanes in the controlled traffic system, which could be an effective way to prevent soil structural degradation (and perhaps allow amelioration) when it is combined with minimum or zero tillage and residue retention. Controlled traffic farming has been shown to reduce soil compaction and improve soil physical and biological properties in Australia (Tullberg *et al*. 2007). Soil infiltration properties, plant-available water capacity, and crop yields improved significantly even when 15% of land area was used for permanent traffic lanes (Radford *et al*. 2000). Studies conducted in China have also confirmed the positive effects of controlled traffic in arid environments. Over 5 years monitoring on the Loess Plateau, for instance, Wang *et al*. (2003) showed that controlled traffic with zero tillage reduced runoff and soil water erosion by 41% and 81%, respectively, compared with conventional traffic and tillage. Zhang (2002) found that random field traffic can increase draft and fuel consumption of trailed tillage implements by 26–30%, and Li *et al*. (2000) demonstrated that non-trafficked soil under no-tillage management conserved 5.2% more water in the top 0.50 m

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soil layer, due to decreased bulk density and improved water infiltration.

There is still comparatively little information available on the changes in soil properties and crop production after long-term tillage and traffic treatments on the Chinese Loess Plateau, but a field trial to investigate this was started in 1998. This paper reports tillage and traffic treatment effects on soil physical properties after 9 years of controlled traffic in terms of density, soil porosity, soil water retention curves, and saturated hydraulic conductivity. Treatment effects on soil organic matter, nitrogen fertiliser availability, and crop yields are discussed in the accompanying paper by Chen *et al*. (2008).

Materials and methods

Site

The experiment was conducted at Chenghuang village (37°32′–38°6′N, 112°4′–113°26′E), near the city of Linfen, located in south-central Shanxi province. Linfen is located in a semi-arid region, 360–500 m above sea level on the Loess Plateau. Average annual temperature is 10–12°C, with maximum and minimum recorded values of 42.0°C in July and 25.6°C in January. Accumulated degree-days $\geq$10°C is approximately 3600 in an average of 130 frost-free days per year. Annual rainfall is about 500 mm, but highly variable, with >60% usually occurring between June and September. Annual pan evaporation is 1800 mm, nearly 4 times greater than annual rainfall. The most common cropping system is a winter wheat monoculture with fallow from the middle of June to the middle of September.

The soil is Cinnamon Loess soil, low in organic matter (<1%) and slightly alkaline (pH 7.9). Under the USDA Texture Classification System, the soils are defined as silt loams, and according to the FAO-UNESCO soil map (FAO-UNESCO 1974) the soil type is a Chromic Cambisol. It has been intensively cultivated for many centuries. The soils of the Loess Plateau are generally described as porous and homogenous to considerable depth with limited variability within fields (He *et al*. 2007).

The effect of controlled traffic with and without surface tillage was compared with traditional tillage production of winter wheat from 1998 to 2007. Before the treatments were arranged, the experimental area was ploughed (0.30 m depth) to improve uniformity. Seed and fertiliser are commonly applied at very high rates by farmers of the Chinese Loess Plateau, to maximise the chance of good yields. In this study, seed and fertiliser were applied at the district recommended rates (per ha) of 225 kg wheat seed, 150 kg N, 140 kg P, and 62 kg K (He *et al*. 2007). Wheat was planted in the last 10 days of September and machine-harvested in the first 10 days of June each year.

Experimental design

The experimental design used 3 treatments in 5 randomised blocks. Each plot was 4.5 m wide and 30 m long. The treatments included 2 controlled traffic treatments, no tillage (NT) and shallow tillage (ST), with full straw cover in each case. One conventional (mouldboard plough) tillage treatment (CT) followed the traditional practice in that area.

The NT system included no-tillage planting and fertilising between 20 and 30 September, and harvesting between 1 and 10 June by combine harvester. Standing stubble of 0.30 m height was retained with all wheat straw left as mulch cover (about 3.8 t/ha). A fallow period followed harvest until mid-September, with herbicide applied for weed control.

The ST treatment also applied the same no-tillage planting and fertilising unit between 20 and 30 September, and harvest by combine harvester between 1 and 10 June, leaving 0.3-m-high standing stubble and all wheat straw cover (about 3.8 t/ha). A fallow period followed harvest until mid-September, with non-inverting, shallow tillage (0.05–0.08 m depth), using 0.6-m-wide sweeps for initial fallow weed control, but herbicide was used for subsequent weed control.

The control (CT) treatment was applied as follows: spreading of fertiliser, mouldboard ploughing to 0.20 m depth and tillage (harrowing and levelling) for seeded preparation, planting between 20 and 30 September, and manual harvesting between 1 and 10 June. While the majority of wheat straw was removed, a small amount of standing stubble 0.05–0.06 m high (~0.5 t/ha) remained after the harvest. The soil was ploughed again to 0.20 m after the first summer rain, and weeds were controlled by shallow tillage (0.05–0.08 m) in the fallow period (mid-June to mid-September).

The layout of crop rows and permanent traffic lanes was designed to accommodate the characteristics of the local tractors and planters. Six rows of winter wheat (*Triticum aestivum* Linfen 225) at 0.20 m row spacing were planted in beds 1.5 m wide between wheel track centre lines. The width of each wheel track was 0.30 m, so the land use efficiency was about 80% in the controlled traffic system.

Measurements

Soil sampling and analysis

Soil samples were taken in March 2007. Three sampling points approximately 3 m apart were chosen in each subplot. Undisturbed soil cores for bulk density, soil porosity, saturated hydraulic conductivity, and soil water characteristics curve were obtained from depths of 0–0.15, 0.15–0.40, and 0.40–0.60 m from the crop zone of each treatment and from an unplanted wheel track.

Bulk density

In each plot, 9 random soil samples were taken using a 50.4-mm-diameter, 50-mm length of steel core sampling tube, then weighed wet, dried at 105°C for 48 h, and weighed again to determine bulk density.

Soil cores for soil water retention curve

Three undisturbed soil cores were taken from each treatment to determine the soil water retention curve. Following the procedure of Klute (1986), these cores were wetted to saturation by capillary action in a sand and kaolin box before using a laboratory pressure plate extractor to drain them to matric potentials of 0, –5, –10, –30, –50, –80, –100, –300, –500, –1000, and –1500 kPa. Finally, they were oven-dried at 105°C for 24 h. The weight of each sample was recorded at each matric potential and after oven drying. Available water content (AWC) was taken as the difference between water retention at 30 and 1500 kPa soil suction, and water retention at 0 kPa matric potential was taken as the best estimate of total porosity. Readily available water content (RAW) was determined by the difference between water retention at 10 and 100 kPa soil suction (Vidhana Arachchi 1998).

Soil porosity

Soil porosity was classified as macroporosity (consisting of pores with equivalent radius >60 μm), mesoporosity (0.2–60 μm), and microporosity (<0.2 μm). Macroporosity was taken as the volumetric water content difference between 0 kPa and –5 kPa matric potential. Mesoporosity was taken as the volumetric water content difference between –5 kPa and –1500 kPa matric potential. Microporosity was determined by the volumetric water content at –1500 kPa matric potential.

Saturated hydraulic conductivity

Saturated hydraulic conductivity (Ks) was determined by the constant-head method (Klute and Dirksen 1986). For each treatment, 3 intact saturated soil cores of 61.8 mm diameter and 40 mm height were fixed within a flexible-wall permeameter (controlling side-wall flow) and supplied with water at the top, using a Marriot bottle to maintain a stable hydraulic head of 0.03 m.

Statistical analysis

The SPSS analytical software package was used for all statistical analyses. Mean values were calculated for each of the measurements, and ANOVA was used to assess the effects of conservation tillage on the measured variables. When this indicated a significant *F*-value ($P < 0.05$), multiple comparisons of mean values were made on the basis of the least significant difference (l.s.d.).

Results

Bulk density

The effects of traffic and tillage practices on bulk density were significant in the surface soil layer, but less pronounced in the deeper layers (Table 1). In the 0–0.15 m soil layer, mean bulk density of controlled traffic treatments (NT and ST) was 11.2% less ($P < 0.05$) than that of CT soil, but the value in wheel tracks was 10.2% greater. In 0.15–0.40 and 0.40–0.60 soil layers, the bulk density differences of controlled traffic treatments were smaller and only significant ($P < 0.05$) in the case of the 0.40–0.60 m soil layer in ST, where mean bulk density was 8.1% less than that in CT.

Porosity

In general, macro and mesoporosity were greater in controlled traffic treatments but microporosity was less than that in CT (Fig. 1). In the 0–0.15 m soil layer, controlled traffic (NT and ST) was associated with a significant increase in total porosity ($P < 0.05$) with mean values of 205% more macroporosity

Table 1. Mean soil bulk density (Mg/m^3) of the 3 treatments (NT, no tillage; ST, shallow tillage; CT, conventional tillage) and wheel track in 0–0.60 m soil profile

Means within the same column followed by the same letter are not significantly different at $P = 0.05$ by the *F*-test in the analysis of variance; $^{\dagger}P < 0.1$

Treatment	Soil depth (m)		
	0–0.15	0.15–0.40	0.40–0.60
NT	1.36a	1.46a†	1.45ab
ST	1.25a	1.48a†	1.37a
CT	1.47b	1.52a†	1.49b
Track	1.62c	1.51a†	1.43ab

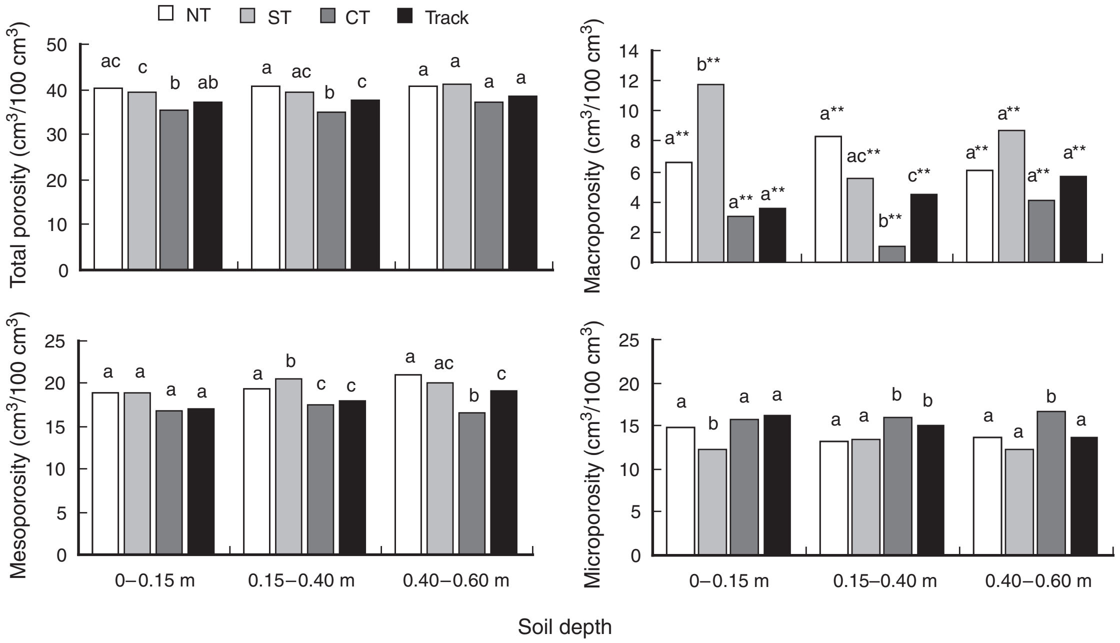

Fig. 1. Mean soil porosity of the 3 treatments and wheel track in 0–0.60 m soil profile. Means in the same soil profile followed by same letters are not significantly different at $P = 0.05$ (**$P < 0.01$).

($P < 0.01$), but 14% less microporosity, than the CT treatment. In deeper soil layers, controlled traffic treatments also had significantly ($P < 0.01$) greater (537%) macroporosity in the 0.15–0.40 m soil layer, and significantly ($P < 0.05$) greater (19%) mesoporosity in the 0.15–0.60 m soil layer, but mean microporosity in 0.15–0.40 m soil layer was 17% less ($P < 0.05$).

Among controlled traffic treatments, mean macroporosity of ST was 77% greater ($P < 0.01$) in the 0–0.15 m layer and mesoporosity was greater by 8.0% in the 0.15–0.40 m layer ($P < 0.05$), but mean microporosity decreased by 17% ($P < 0.05$) in the 0–0.15 m soil layer, compared with the NT treatment. In the wheel tracks, mean macro- and mesoporosity values increased with soil depth, but microporosity decreased. The soil pore size distribution in CT treatments and the wheel tracks were similar, and significant differences were only found in total porosity and macroporosity in the 0.15–0.40 m soil layer, and in mesoporosity in the 0.40–0.60 m soil layer.

Soil water retention curve

Mean soil water retention curves for the 3 treatments are shown in Fig. 2. Compared with CT, the mean water retention capacity of NT and ST was greater at low soil suction (<5 kPa), and smaller at high soil suctions (>5 kPa), but treatment differences were not significant ($P > 0.05$). In controlled traffic treatments, mean values for NT were greater than those for ST in 0–0.15 and 0.40–0.60 m soil layers, but differences were negligible in the 0.15–0.40 m soil layer. Wheel tracks showed the greatest water retention in the 0–0.15 m soil layer, but the 0.15–0.60 m soil layer was quite similar to controlled traffic. At greater depth (0.15–0.60 m), CT appeared to retain more water than both controlled traffic treatments and wheel tracks.

Mean AWC of controlled traffic treatments appeared to be greater throughout the profile, but this effect approached statistical significance ($P < 0.1$) only in the 0.40–0.60 m soil layer (Fig. 3). Controlled traffic NT and wheel tracks, respectively, appeared to have the greatest and least available water in 0–0.60 m soil layer.

Mean RAW of controlled traffic treatments was 20%, 18%, and 51% greater than that of CT in 0–0.15, 0.15–0.40, and 0.40–0.60 m, respectively (Fig. 4), and this difference was significant ($P < 0.01$) in 0.40–0.60 m layer. In controlled traffic treatments, the values of RAW in NT and ST treatments were similar in 0–0.60 m soil layer, but the RAW of wheel tracks was significantly ($P < 0.05$) less than that of controlled traffic treatments in the 0.15–0.40 m soil layer, and significantly ($P < 0.01$) greater than that of CT in 0.40–0.60 m layer.

Saturated hydraulic conductivity

The mean Ks for the 3 treatments and wheel tracks is illustrated in Fig. 5, but differences were significant ($P < 0.01$) only in the surface layer, where the value for tilled controlled traffic soil was much greater than that for any other treatment. Generally, the Ks values for non-tilled controlled traffic soil declined with depth, while the values for CT and wheel track soils increased with depth. Among the controlled traffic treatments, mean saturated hydraulic conductivity of ST was 133% greater than NT in the 0–0.15 m soil layers, but only 63.0% greater in

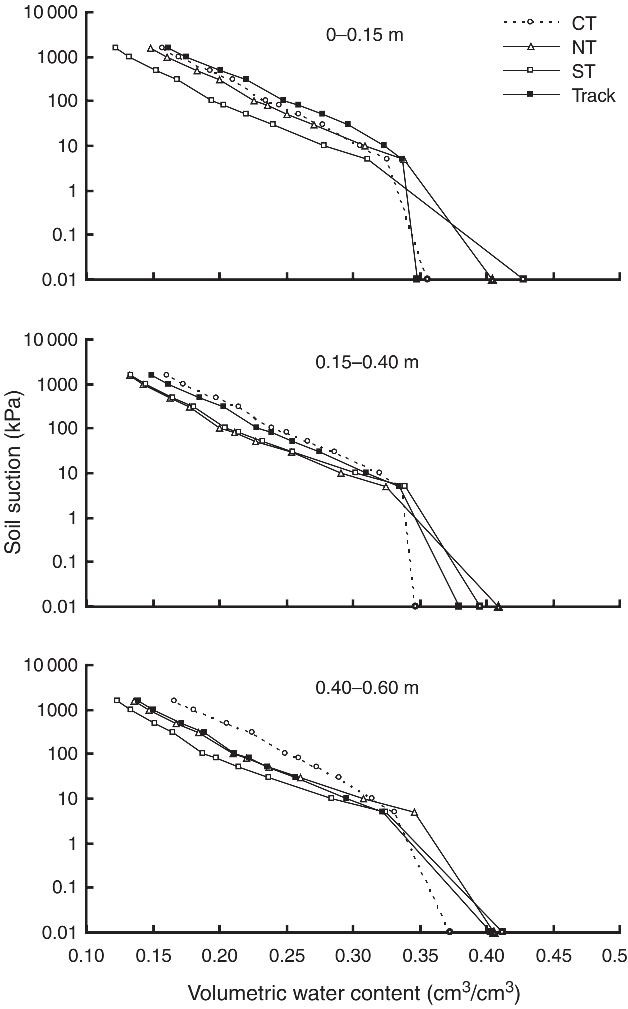

Fig. 2. Soil water retention curves from the 3 treatments at depths of 0–0.15, 0.15–0.40, and 0.40–0.60 m. For clarity of this graph, error bars are not given.

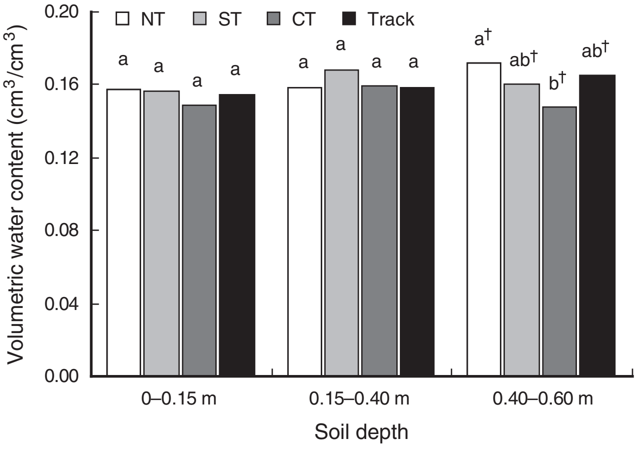

Fig. 3. Mean available soil water content of the 3 treatments and wheel track in 0–0.60 m soil profile. Means in the same soil profile followed by same letters are not significantly different at $P = 0.05$ ($^{\dagger}P < 0.1$).

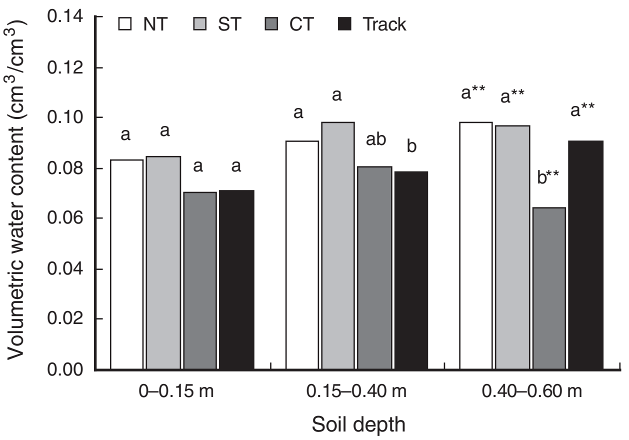

Fig. 4. Mean readily available soil water content of the 3 treatments and wheel track in 0–0.60 m soil profile. Means followed by same letters are not significantly different at $P = 0.05$ (**$P < 0.01$).

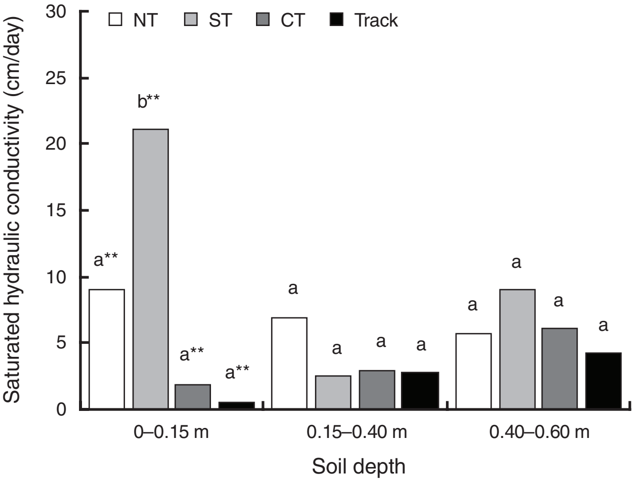

Fig. 5. Mean soil saturated hydraulic conductivity of the 3 treatments in 0–0.60 m soil profile. Means in the same soil profile followed by same letters are not significantly different at $P = 0.05$ (**$P < 0.01$).

the 0.15–0.40 m layer. Mean Ks values for wheel tracks were smaller in most cases.

Discussion

Long-term (9 years) controlled traffic practices resulted in a significant ($P < 0.05$) decrease in soil bulk density in the surface 0.15 m, but this effect was not significant in the 0.15–0.40 m layer. In this experiment, the shallow tilled controlled traffic treatment appeared to also have significant ($P < 0.05$) influences on bulk density in 0.40–0.60 m layer relative to the conventional treatment. This is surprising at a depth 0.30 m beneath that of the annual shallow tillage, and 0.10 m deeper than the overall tillage applied 9 years earlier. Bulk density reduction at this depth can be produced only by natural amelioration (soil biota, roots, or shrink–swell), although bulk density can be increased by vertical loads (usually those of machinery), so this result must be seen as an aberration. Other data are consistent with the results of Horn *et al.* (1998), demonstrating the effect of repeated wheeling on conventionally tilled soil.

Results presented here illustrate the positive effects of controlled traffic treatments on mean macroporosity (>60 μm) in the top 0–0.60 m, compared with CT soil. Mean effects on mesoporosity (0.2–60 μm) are smaller, but consistently positive and statistically significant ($P < 0.05$) at 0.15–0.60 m depth. Mean levels of microporosity of controlled traffic treatments are consistently smaller than that of CT soil, with significant differences again in the 0.15–0.40 m depth profile. These results are consistent with those of Benjamin (1993) and Braunack *et al.* (1995) in demonstrating the negative effects of wheel traffic and tillage on macro- and mesopore formation.

Within the controlled traffic treatments, ST produced significantly more macroporosity, and significantly less microporosity, than NT in 0–0.15 m soil layer, but the effect on macroporosity appeared to be reversed in 0.15–0.40 m layer, and mesoporosity of the tilled treatment was greater in the 0.15–0.40 m soil layer. The significant improvement in macropore volume in ST treatments at shallow tillage depth is consistent with the bulk density results at that depth, illustrating the effect of annual shallow tillage, compared with no-tillage.

Studies by Rasmussen and Arshad (1999) have demonstrated that repeated compaction of CT soil by traffic wheels will reduce porosity and particularly the number of larger pores, and this effect can be seen in the similar porosity of the wheel track and CT soil at 0–0.15 m. Interestingly, at greater depth 0.15–0.60 m, the wheel track has greater macro- and mesoporosity, but less microporosity at 0.40–0.60 m, compared with CT soil. The relatively light tractor units (<3 t) used on this experimental site appeared to have little significant impact at greater depth, even in wheel tracks, allowing a better soil pore distribution to develop at greater depth, compared with CT. Similar effects have been observed by McHugh *et al.* (2004), who speculated that the surface compaction in a wheel track might have provided some protection to deeper layers.

Soil water retention is an important property that governs plant-available water capacity, its ability to grow crops on stored water, and other ecosystem function. This work has demonstrated that traffic and tillage management can alter soil porosity and pore-size distribution, and hence water-retention characteristics. Soil water retention curves presented here are consistent with those of Yang *et al.* (2006), who showed that soil water retention increased with wheel traffic induced soil compaction, largely as consequence of the increasing proportion of micropores. The effect was greatest in the 0–0.15 m soil layer, and appeared to become smaller at depth, but no significant ($P > 0.05$) differences were observed.

While there were few significant differences in AWC (–30 to –1500 kPa), significant treatment differences did occur within the smaller range of soil moisture tension which corresponds to the RAW for wheat (–10 to –100 kPa). It is interesting to note the marked reduction in RAW of CT and wheel track treatments between 0.15 and 0.60 m (compared with controlled traffic) and the greater RAW in wheel tracks (compared with CT) soil at 0.40–0.60 m depth. This is consistent with the suggestion that surface compaction has protected soil further down the profile.

Mean values of saturated hydraulic conductivity were usually greater in controlled traffic treatments and this result is of considerable importance for the weakly structured, easily erodible soils of the Loess Plateau. The only significant ($P < 0.01$) difference occurred between NT and ST controlled traffic in the surface 0.15 m, but this effect appeared to reverse in the 0.15–0.40 m layer. The lowest values of Ks occurred in the wheel track, corresponding to the greatest bulk density values, but Ks generally improved with depth.

These results are consistent with the generally accepted idea that more rapid movement of soil water (infiltration and drainage) occurs via macropores (Cameira *et al.* 2003), storage of plant-available water occurs largely in mesopores, while water in micropores is essentially unavailable to plants (Sillon *et al.* 2003). The CT treatment was subject to both traffic and tillage, resulting in the smallest values of macroporosity and mesoporosity across all depths, and greatest values of microporosity except in the surface layer. Despite the loosening effects of tillage, the hydraulic conductivity of the surface layer of tilled soil was close to that of the wheel track. Previous studies on the Loess Plateau by Luo *et al.* (2005) have also shown that CT resulted in less macropores and hydraulic conductivity than zero or minimum tillage, and observations from this work are generally consistent with those from rainfall simulation and field plots studies such as Li *et al.* (2001) and Wang *et al.* (2003).

Controlled traffic was associated with greater mean macroporosity and mesoporosity, and less microporosity, than other treatments, thus improving internal drainage and readily available water. Shallow tillage with full residue cover provided a consistent effect in increasing macroporosity, RWC, and Ks in the surface layer, but produced the reverse effect (compared with no-tillage with residue cover) in the deeper soil layer of ST plots, probably due to the disruption of pore continuity by shallow sweep tillage.

The data reported here show that soil effect at depths greater than 0.40 m was relatively small, at least compared with results reported by McHugh *et al.* (2004) and Tullberg *et al.* (2007) from work in Queensland. The total mass of the tractor units used to impose traffic and tillage treatments in China was approximately 3 t. This is much smaller than the values of 7–8 t for tractor units used in the Queensland work, although tyre inflation pressures were approximately 100 kPa in both cases. This is consistent with the generalisation that tyre pressure is the major determinant of surface soil damage, while total mass determines the depth to which this damage penetrates (Soane and van Ouwerkerk 1994).

The accompanying paper (Chen *et al.* 2008) reported the positive impact of controlled traffic management (NT and ST) on soil organic matter and nitrogen. Soil physical data reported here provide supporting evidence for this proposition, because soil texture is unchanged by traffic and tillage. Indications of structural change, such as an increase in mesopore volume, must occur as a result of some realignment of soil particles, which might well be a function of increased soil organic matter. These results are also consistent with those of McHugh *et al.* (2004), who demonstrated the damaging effects of heavy tractor and machinery wheels on soil physical properties such as pore size distribution, and its impact on water availability to plant roots.

Table 2. Output and input for winter wheat production under 3 treatments (NT, no tillage; ST, shallow tillage; CT, conventional tillage)
Mean yield: the data are the average values of yields from 1999 to 2006.
Output = yield × price (grain price = 1 yuan/kg, AU$1 ~6 yuan)

Treatment	Mean yield (t/ha)	Output	Input	Economic benefit
		(yuan/ha)		
NT	3.40	3400	2205	1195
ST	3.49	3490	2325	1165
CT	3.11	3110	2565	545

Chen *et al.* (2008) demonstrated that even with 20% of land used for permanent traffic lanes, overall mean wheat yield in controlled traffic (NT and ST) treatments was 10% higher than that in CT treatment, and the differences were significant ($P < 0.05$) in 4 of 8 years between 1999 and 2006. Controlled traffic treatments were also associated with increased soil organic matter and nitrogen levels in addition to the improved soil physical properties reported here. The economic benefit of controlled traffic treatments was 635 yuan/ha (~AU$118/ha) greater than that of CT (Table 2), before accounting for any reduction in machinery inputs. In controlled traffic treatments, ST was associated with a greater mean yield than NT, whereas tilled controlled traffic treatments produced a significant yield loss of 5% under controlled traffic in Queensland over a 6-year period (Tullberg *et al.* 2007). This difference is probably a result of the greater soil disturbance and moisture loss associated with 3 chisel tillage operations in Australia (compared with the single, non-inverting operation reported here).

Several authors (Li *et al.* 2000; He *et al.* 2007) have commented on the remarkable uniformity soils of the Chinese loess plateau, where these tests were carried out. Soils within these treatments have also been subject to consistent and uniform management for a period of 9 years. Replication in this experimental design was based on past experience of biological variability within cropping plots, but was clearly insufficient to provide statistically satisfactory evidence of some treatment effects. Greater replication is recommended for future research to elucidate the impact of tillage and traffic on soil structure, and its physical and biological properties.

Conclusions

Data presented here show several significant changes in the physical properties of soil after 9 years controlled traffic management of dryland wheat production on the Loess Plateau of northern China. These included significant increases in macroporosity, mesoporosity, and readily available water, together with reductions in soil bulk density and microporosity in different layers under controlled traffic, compared with the traditional mouldboard tillage treatment currently used in this region. Although the data include many instances where means failed to meet the criterion for significance, they were generally consistent with other results within this dataset, and the literature on traffic effects.

This study demonstrates that controlled traffic management offers a significant improvement for the current farming systems on the Chinese Loess Plateau, and these improvements in the physical condition of soils under controlled traffic are generally in agreement with those reported for similar treatments in Australia. The absence of suitable machinery and the perception of yield loss from non-productive traffic lanes are likely to be adoption problems. More research on the relationships between controlled traffic, tillage, residue, productivity, and environmental conditions is required on the Loess Plateau of China.

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