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Effect of Conservation Tillage on Soil Respiration, Organic Carbon, Moisture and Yield of Wheat /Maize System on North China Plain

Albert Houssou[1], Guopeng Liang[2], Lili Gao[3], Xueping Wu[4], Huijun Wu[5], Xiaobin Wang[6], Dianxiong Cai[7]

[1234567]National Engineering Laboratory for Improving Quality of Arable Land, Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, China

Abstract: ***Conservation tillage management can improve soil properties and reduces soil CO_2 emission. We determined soil CO_2 flux rate, soil moisture, crop yield, soil organic carbon (SOC) and total nitrogen (TN), on North China Plain throughout a 3-year period. Tillage systems were: rotary tillage without crop residues (CT), rotary tillage with straw incorporated into the soil (RS), and no-tillage with crop residues used as mulch (NTS). Soil respiration was measured with a LI-8100. Soil samples were collected at 0-20cm to determine SOC and TN. Dichromate oxidation and Kjeldahl methods were used to determine SOC and TN, respectively; and the gravimetric method was used to identify soil water content. The crops were winter wheat (Triticumaestivum L.) and summer maize (Zea mays L.).During the wheat and maize growing period, NTS reduced $C0_2$ compared with CT and RS.At 0-20cm depth, NTS increased SOC stock by 17.077 and 3.82 % compared with CT and RS, respectively.NTS maintained higher TN and compared with CT and RS. At soil surface layers NTS had higher soil moisture compared with CT and RS. However the crop yields under NTS were less than those recorded under RS, but were higher than what recorded under CT. Thus, this study suggests that NTS is suitable for North China plain farmers in the short term, but further research is needed on its long term effects on soil properties, respiration, and yield.***

Keywords: crop residue - no-tillage, CO_2-soil carbon sequestration, TN, water content, yield

1. Introduction

SOC, nutrient uptake by plants, and crop yields can be improved by agricultural management practices such as utilization of crop residues and no-tillage. Impacts of conservation tillage on soil fertility, organic matter, respiration, and crop yield have been well investigated, but the findings vary by location due to difference in climate, crop residue management, cropping system, and soil type [1]. Wheat and maize residues are easily incorporated into the soil, used as mulch, and are good sources of crop nutrients, enhancing soil fertility, and increasing yield [2]

On the basis of previous research, many authors reported that tillage with crop residue incorporation improved SOC levels and soil nutrients in the subsurface relative to no-tillage because of lower organic matter decomposition rates under no-tillage systems [3] while others reported that residue incorporation reduced SOC [4] because of close contact between soil microbes and crop residues. There is no consensus regarding differences in SOC sequestration between residue incorporation and residues used as mulch under no-tillage systems. Over 5-10 years, conversion from conventional tillage to either no tillage with crop residues used as mulch or tillage with crop residues incorporated into the soil can sequester 0.57 Mg C ha-1 yr-1 [5]. In some cases, no-tillage and tillage with crop residue incorporated into the soil may have similar effects on soil carbon levels [6]. Thus, additional research is important to understand the mechanisms and dynamics of SOC change under no-tillage and tillage with residue incorporation into the soil [7]. Furthermore, in North China, agricultural practices are characterized by clean plowing with all crop residues removed from the topsoil, usually by burning or use as animal fodder, leaving soil bare and unprotected by vegetation cover [8]. However, crop residues contain high quantities of crop nutrients, and have high levels of organic matter rich in micronutrients [9]. Several previous studies reported that crop residues contribute to soil nutrients and organic material [10]; therefore, the use of crop residues can improve soil properties and productivity [11]

Tillage has important implication for CO_2 emissions. Deep tillage increases CO_2 emissions from the soil to the atmosphere [12]. This indicates that the implementation of no-tillage practices can reduce soil CO_2 emission. However, there is no consensus on differences in soil CO_2 emission rates among no-tillage with crop residue as mulch, tillage without residue incorporation, and tillage with residue incorporation. Some authors reported similar soil CO_2 emission rates from no-tillage and conventional tillage [13], whereas [14] observed large CO_2 emissions under no-tillage. The differences in soil CO_2 emissions among tillage practices may depend on the type and position of crop residue, soil, climate, crop and short –and long-term tillage practices [14].

Water is also one of the main factors for agricultural production in the North China, and thus storing water in the soil profile is essential for crops to survive during the periods without rainfall. However, intensive tillage systems are contributing to declining soil moisture in the North China Plain. Furthermore, soil water conservation is critical to winter wheat production, which depends on soil water because in winter, rainfall is limited and irregular [15]. Storing soil water for improving crop yield has been supported by many studies including those conducted in the North China Plain [16]. Conventional tillage leads to serious loss of water through evaporation and percolation, and therefore decreases crop yields. Thus, improving soil structure and water storage are extremely necessary in the

North China Plain. No-tillage with crop residues practice is considered helpful because it is one of the effective ways to improve soil structure and soil water storage, especially in an arid region like the North China Plain [17]

Generally, soils with low bulk density have better physical condition for growing crops, improving plant root density and nutrient uptake. In the North China Plain, no-tillage significantly increased the topsoil bulk density compared to tillage [18, 19]. This suggests that tillage with crop residue incorporation can effectively decrease soil bulk density. However, little information is available on the effect of conservation tillage on soil nitrogen.

A better understanding of the short-term effects of tillage systems and straw management practices on SOC, soil nutrients and water, soil respiration, is necessary forfurther development of conservation tillage in North China Plain. Since 2002, the Chinese government has issued a series of policies to promote the application of conservation tillage because many researchers reported that conservation tillage improves soil fertility water and SOC, reduces soil respiration, and promotes sustainability. The area under conservation tillage expanded from 0.13 million hectares in 2003, and projected to 10 million hectares in 2015. However, China still accounts for only 0.2% no-tillage or conservation tillage area worldwide [20]. In addition, due to the conflicting results of previous studies , and the specificity of results to soil type and climate, more work is required to understand how tillage and crop management residues affects soil properties. We hypothesized that no-tillage with crop residues used as mulch would be optimal compared with tillage with crop residue incorporated into the soil and tillage without crop residue. Thus, the objectives of this study were to determine the impacts of conservation tillage on soil respiration rate, total nitrogen (TN)), cumulative soil water content (CSWC), organic carbon (SOC) in North China.

2. Materials and methods

2.1 Site Description

The experimental site, managed by the Chinese Academy of Agricultural Sciences (CAAS), is located in Langfang in Hebei Province. In this province, a rotation of winter wheat and summer maize accounts for 80% of agricultural land. The winter wheat was planted in October after harvesting summer maize sown in June. The weather in spring is dry and windy; it is hot and rainy in summer. Autumn is cold, while winter is chilly. January is the coldest month with an average temperature of 4.7 °C, and July the hottest with an average temperature of 26.2 °C. Annual precipitation is concentrated during the summer (from June to September). About 70-80% of annual precipitation occurs from June to September growing period of maize, and 20-30 % occurs from October to June during the growing period of wheat. The amount and distribution of rainfall changes widely from year to year due to the continental monsoon climate. The soil texture is silt loam according to the FAO soil classification and the soil properties before the experiment are presented in Table 1

Table 1: The basic soil properties before experimental design

Property	Value
Soil organic carbon (g kg-1)	6.38
Total Nitrogen (g kg-1)	0.85
Available Phosphorus(mg kg-1)	12.75
Available potassium (mg kg-1)	93.7
pH	8.0

2.2 Experimental Design

This experiment started from October 2012 to June 2015 and randomized block design was used. The size of each plot was 66.56m^2; wheat and maize were grown in alternation. Three treatments were conducted in this experiment, and each treatment was repeated three times (Table 2): Rotary tillage without crop residues was conventional tillage (CT), but rotary tillage with straw incorporated into the soil (RS), and no-tillage with crop residues used as mulch (NTS) were conservation tillage. Fertilizers for winter wheat were applied at the rate of N: P_2O_5:K_2O = 90: 150: 75 kgha^{-1} during sowing period and another 90:00: 00 during jointing period kgha^{-1}. Fertilizers for maize were applied at the rate of N: P_2O_5:K_2O 180:150:74 kgha^{-1}during sowing period and another 60:00:00 kgha^{-1}during heading period.

Table: Description of experimental design

Treatments	Treatment details	
	Winter	summer
CT	Rotary tillage	Rotary tillage
RS	Rotary tillage	Rotary tillage
NTS	No –tillage	No-tillage
Crop residue management		
CT	Remove	Remove
RS	Incorporation into soil	Incorporation into soil
NTS	Use as mulch	Use as mulch

On no-tillage plots (NTS):All crop residues were removed before the wheat or maize was sown. After seedling emergence, all residues from the wheat/maize were cut, flattened and left on the soil surface at the rate of 6164.60 and 4408.8 kg ha^{-1} of maize and wheat residues, respectively. The crop residues were returned to the plot from which they originated. On the plots which were under tillage with crop residues, rotary tillage was practiced a depth of 25cm, and all residues were mixed or incorporated into the soil at the rate of 6164.60 and 4408.8 kg ha^{-1}of maize and wheat straw, respectively. On the plots under rotary tillage without crop residues, all above-ground maize residues were removed. 10–16 cm high wheat stubble that corresponded to 110.25 kg ha^{-1} was left in the field before tillage, but the maize straw was at the rate of zero per hectare.

2.3 Measurement

Soil bulk density (BD, gcm^{-3}) was determined by using of the cutting ring core method at the depth of 0-20cm. Three cores were collected at random in each plot in June 2013 and 2015 during the maize and wheatharvest period, respectively. Soil samples in the rings were dried in the laboratory at 105°C for 24h

To measure soil respiration, a PVC tube with an inner diameter of 20 cm and a height of 13 cm, was inserted into the soil to a depth of 9cm at the center of each plot. Before practicing tillage, the PVC was removed and reinserted at the same position after crop emergence. One day before measurement, all living plants inside and adjacent to the PVC were removed by hand to avoid above-ground plant respiration. Soil respiration was measured for up to 180 seconds between 8 and 11 am. Soil respiration was measured directly by using an automated soil CO_2 flux system analyzer (LI-8100, LI-COR, Inc., Lincoln, NE, USA) in units of µmolCO2 m^{-2} s^{-1} in the field.Cumulative CO_2 was computed as follows:

CCO2 (kg ha^{-1}) = sum of R_i *38016 (1)

withR_i(µmolCO_2 m^{-2} s^{-1}) = average soil respiration, n = number of times the data on soil respiration rate were collected during wheat or maize growing period, 38016= a converting factor. We hypothesized that there was no large variation of soil respiration rate during the measurement day.

To determine SOC and TN, soil samples during the harvest periods of wheat and maize were collected at the depths of 0-20cm depth in 2015. Soil samples were obtained from the central area of each plot to avoid edge effects. For each depth, soil samples were air-dried, homogenized and divided into two equal parts after removal of visible undecomposed plant residues. One part was filtered using a 0.25mm sieve to determine SOC. Dichromate oxidation method was used to determine SOC [21]. The second part of soil was passed through a 1mm sieve to determine TN. For TN, the Kjeldahl method was used. TN or SOC was calculated as follows:

Total nitrogen (kgha^{-1}) = TN (mg ha^{-1}) * A, and SOC = SOC (mg ha^{-1}) * A,with A = bulk density (g/cm^3)*test depth(cm)/10 (2)

2.4 Statistical analysis

Mean values were calculated for each of the variables, and ANOVA was used to assess the effects of conservation and straw on soil properties, soil respiration and yield. SAS 9.2 and 5% significance level were used for all statistical analyses.

3. Results and discussion

3.1 Bulk Density

The effects of tillage practices on BD were observed in 2013 and 2015 at maize and wheat harvest time, respectively. The tillage practices significantly influenced the BD at the 0-20 cm soil depth (Table 3). In 2013, the soil BD under NTS at 0-20 cm soil depth was significantly higher than that of CT. Lower BD recorded under RS and CT compared with NTS may in part be attributed to disturbance of soil surface during the tillage operation, and lowest BD under RS compared with CT was attributed to crop residue incorporated into the soil during tillage practice. Higher BD under NTS attributed to lack of tillage operation was consistent with other reports and finding [22]. In 2015, significant differences were observed among treatments.CT had the highest BD, this suggests that conservation tillage improves BD. This result is similar to [23] when they compared conventional tillage with no-tillage. Paired comparison between 2013 and 2015 showed that only tillage with crop residues used as mulch significantly reduced bulk density from 1.699 to 1.506 g cm^{-3}, but CT increased it from 1.45 to 1.646 g cm^{-3}. An increase in BD recorded under CT system through time could be caused by the settling of soil surface layer after tillage breaking up of the aggregates under the influence of rainfall, therefore soil was compacted. [24] reportedthe similar result.

Table 3: Effect of tillage on BD at 0-20 cm soil depth (g cm-3)

Years	2013	2015
Treatments	0-20cm	0-20cm
CT	1.45b **	1.646a **
RS	1.383c ns	1.388c ns
NTS	1.699a *	1.506b *

The numbers followed by the same letters down a column are not significantly different at $p < 0.05$; *, **down the same row, indicates significant differences for paired comparison between 2013 and 2015 BD $P< 0.05$, $p< 0.01$, respectively; ns: indicates no significant differences for paired comparison between 2013 and 2014 BD.CT: rotary tillage without crop residues in winter and summer; RS: rotary tillage with crop residue incorporation into soil in winter and summer; NTS: no- tillage with crop residues use as mulch in winter and summer.

3.2 Soil respiration rate and cumulative carbon emission

The rate of CO_2 flux is one of the important parameters that can describe CO_2 emission from soil. Soil respiration rate varied over the growing periods of wheat and maize (see Figure 1a-b -c). Among treatments for both wheat growing seasons (Figure 1a, b), p-values ranged from less than 0.0001 to 0.23. In October, RSemitted CO_2 at the highest rate of 4.593 and 4.3433µmol$m^{-2}s^{-1}$ in 2013 and 2014, respectively. Compared with CT and NTS systems, RS increased CO_2 by 107.53 and 106.287; and 128.998 and 123.50%, respectively in October 2013 and 2014. This implies that incorporating crop residues into the soil increased soil respiration compared with using crop residues used as mulch or practicing tillage without crop residues. From October to March, all treatments decreased CO_2 flux. That could be attributed to soil temperature. Indeed, from October to March soil temperature decreased. From March to May, all treatments increased CO_2 flux and reached their maximum rate in May. That could be attributed to not only the soil temperature but also root respiration and microbial activities. From May to June, CO_2 decreased under all treatments and reached their lowest rate of CO_2 emission in June. Average soil respiration ranked from the highest to the lowest in µmolCO_2 m^2s^{-1} wasRS(3.785 and 3.62), NTS(2.919 and 2.72) and CT(2.956 and 2.78), and no significant differences were observed between CT and NTS for average soil respiration rate. This suggests that the most disruptive tillage practices with maize residue incorporation released CO_2 at a higher rate.

During the growing period of maize (Figure 1c), significant differences were observed among treatments except in October, the maturity stage, and p-values ranged from less than 0.0001 to 0.574. On 12, July, 2014, CT (5.11 μmolCO_2 m^2s^{-1}) and RS (5.45μmolCO_2 m^2s^{-1}) significantly emitted high rates of CO_2 because they were tilled at the beginning of the maize growing period and crop residues were incorporated into the soil. For those treatments, the highest CO_2 rate was recorded during early period and then, the CO_2 rate declined steadily. CT significantly emitted CO_2 less than RS because there was lack of crop residues under CT. NTS decreased CO_2 flux rate by 46 and 55.7% compared with CT and RS respectively. From 12 to 28 July 2014, the effects of tillage decreased, but those of microbes increased. Indeed, from that period, the CO_2rate decreased under RS and CT from 5.11 and 5.45 to 4.88 and 5.37μmolCO_2 m^2s^{-1}, respectively.However, under NTS, the CO_2 flux rate reached its maximum value (5.28 μmolCO_2 m^2s^{-1}) on 28 of July before decreasing. Furthermore, from August to September, RS still significantly had the highest CO_2 flux rate and at the maturity stage, in October, no significant differences were observed among treatments. The average soil respiration ranked from the highest to the lowest was RS(3.976), CT (3.626), and NTS(3.472) μmolCO_2 m^2s^1. In addition, during this study (6 days for each growing period of wheat and 5 days for maize), the cumulative CO_2 emitted by hectare was 674.277 and 634.867 (CT), 863.343 and 826.341 (RS) and 665.914 and 622.685 kg (NTS), respectively in 2013-2014 and 2014-2015 during wheat growing period. During maize growing period, cumulative CO_2 emitted by hectare was 627.076 (CT), 906.909 (RS) and 791.949 kg. Previous studies showed that no-tillage with residue cover reduced CO_2 emission by reducing soil disturbance [25]. These results suggest that crop residues incorporated into the soil by tillage significantly increased CO_2 emissionswhich may resultefrom the abundance of carbon in maize and wheat straw, and close contact between residues and micro-organisms when residues are incorporated into the soil[26]releasing carbon to the atmosphere during straw decomposition. In contrast, when the residues were left as mulch on the soil surface the contact between residue and soil organisms was restricted. This study also suggests that crop residue incorporation is not the best way to reduce CO_2 emissions because no-tillage could reduce the crop residuedecomposition rate [27]. Our results were different from what [28] reported. They reported that seasonal emission patterns were not much influenced by tillage; however, the results of this study corroborated with[25]who reported that no tillage practice with straw used as mulch decreased CO_2emission by reducing soil disturbance. Thus, no-tillage with straw used as mulch can be used to reduce air pollution in an agriculture system.

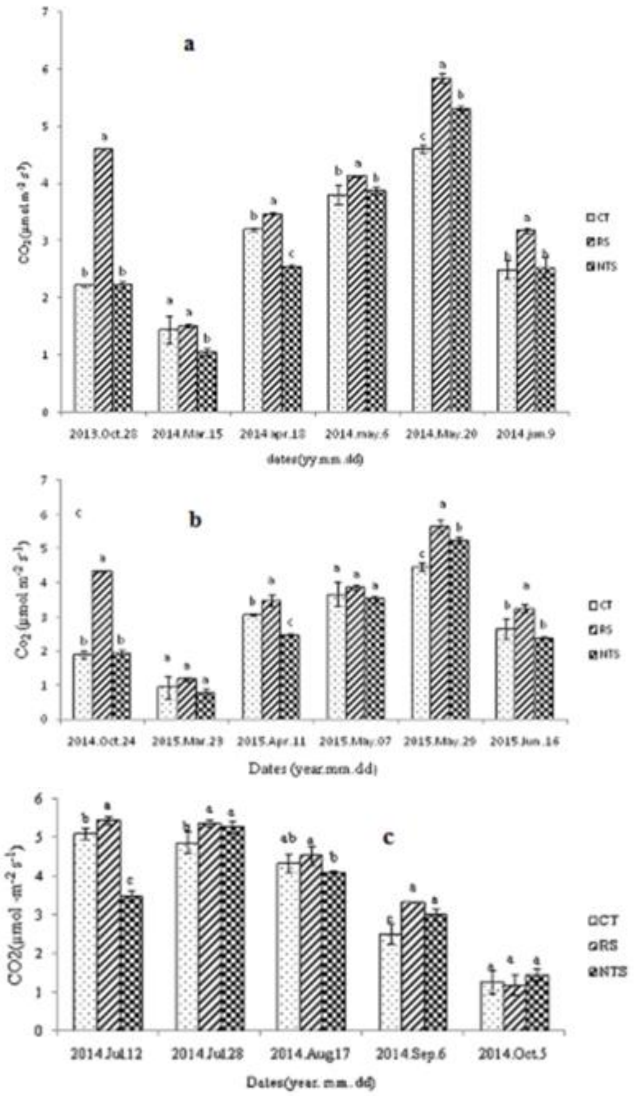

Figure 1 (a, b and c): rate of carbon dioxide emission

Rate of soil carbon dioxide emission during the growing periods of wheat (μmol m-2 s-1).The mean followed by the same letters are not significantly different at $p < 0.05$, CT: rotary tillage without crop residues in winter and summer; RS: rotary tillage with crop residue incorporation into soil in winter and summer; NTS: no-tillage with crop residues use as mulch in winter and summer

3.3 SOC Concentration and Stock

All treatments increased SOC concentration at different rates with significant differences among treatments when compared with 2012 SOC concentration (Table 4). Comparison between SOC concentration of 2012 and 2015 showed that CT, RS and NTS increased SOC concentration by 38.5, 85.17 and 77.147 %, respectively. This suggests that crop residues increased SOC concentration. In 2015, CT significantly had the lowest SOC concentration; however no significant difference were observed between RS and NTS. SOC concentration under different treatments was 11.815 (RS), 11.302 (NTS) and 8.836 g kg^{-1}(CT). In addition, NTS significantly increased SOC stock by 17.077 and 3.82 %, compared with CT and RS, respectively. This suggests that crop residues with no tillage improve SOC at soil surface. CT, RS and NTS produced higher levels of SOC at the surface layer.Higher SOC concentration and stock under RS and NTS than CT system can be attributed to surface residues. This finding is consistent with many other studies[6].Our finding is not consistent with [29] whoreported that SOC change was zero or negative after conversion from CT to NTS in short-term studies, but SOC increased after 6 or 8 years at 0-30cm dept. From the current study, it is evident that no-tillage with crop residues is a good carbon tool sequestration in North China Plain.

Table 4: SOC concentration and stock in 2015 at 0-20cm, SOC concentration in 2012: 6.38g kg-1 at 0-20cmdepth

	SOC Concentration(g kg^{-1})	SOC Stock (kg ha^{-1})
	0-20cm	0-20cm
TC	8.836b	29097.89b
RS	11.814a	32807.85a
NTS	11.302a	34061.33a

The numbers followed by the same letters down a column are not significantly different at $p < 0.05$ CT: rotary tillage without crop residues in winter and summer; RS: rotary tillage with crop residue incorporation into soil in winter and summer; NTS: no- tillage with crop residues use as mulch in winter and summer

3.4 TN concentration and stock, and ratio C:N

The tillage systems significantly affected TN concentration and stock (Table 5). At 0-20 cm, comparison between TN concentration of 2012 and 2015 showed that CT, RS and NTS lost TN concentration by 56.82, 33.02 and 7.86%, respectively. This suggests that NTS reduces the TNloss.In 2015, NTS significantly reduced TN concentration loss by 45.387 and 23.19 % compared with CT and RS, respectively ($p < 0.001$). Significant differences were observed among treatments ($p= 0.0009$). This finding is not consistent with [30] because they noted that tillage effects on TN were negligible at the end of 3 years of tillage practices. Higher TNunder RS and NTS than CT can be attributed to the surface placement of residues [6].Furthermore, [31]reported that NTS significantly increased NT in both short-term and long-term treatments. In addition, [32] reported that CT increased TN, but the present study showed a decreased under TN. These differences among nitrogen rates can be explained not only by soil properties, but also by the fertilizer applied, weather conditions, management, and history tillage history type.

Tillage practices affected theC:N ratio. Before the experimental design the C:N ratio was 7.505, however in 2015 the ratio was18.474, 16.312 and 14.362 under RS, CT and NTS, respectively; thus whatever the type of tillage, it accelerated crop residue decomposition. The decomposition rate was significantly lower under NTS followed by CT and RS. In 2015, compared with CT and RS, NTS significantly reduced the ratio ($P = 0.0012$). The lowest ratio under NTS could be attributed to the low crop residue decomposition rate. Hou et al. (2012) reported similar finding in North China, however [33]reported that the ratioC:N ratio greater under NTS compared with CT and RS.

Table 5: TN concentration and stock in 2015 at 0-20cm,TN concentration in 2012: 0.85 g kg-1 at 0-20 cm depth

Treatments	TN concentration (g kg^{-1})	NT stock (kg ha^{-1})	C:N ratio
	0-20cm	0-20cm	0-20cm
CT	0.542c	1784.02b	16.311b
RS	0.639b	1776.377b	18.473a
NTS	0.788a	2376.528a	14.3622c

The numbers followed by the same letters down a column are not significantly different at $p < 0.05$ CT: rotary tillage without crop residues in winter and summer; RS: rotary tillage with crop residue incorporation into soil in winter and summer; NTS: no- tillage with crop residues use as mulch in winter and summer

3.5 Cumulative soil water content and crop yield

Figures 3 a and bshow the average of CSWC at 0-200cm depth during the wheat (2013-2014) and maize (2014) growing period, respectively. While figure 3 c shows the average of CSWC at 0-120cm depth during wheat growing period in 2014-2015. During the first wheat growing period (Figure 3a), CSWC was significantly greater under NTS than CT and RS at 0-100 cm depth, but at 100-180 cm depth, no significant differences were observed. At 0-100cm depth, NTS significantly increased CSWC by 4.73 and 16% compared with CT and RS, respectively. This suggests that during dry period no-tillage had high moisture at the surface layers. At 180-200 cm depth, CSWC was significantly greater under RS. In 2015, CSWC was significantly greater under NTS than CT and RS at 0-20cm depth ($p <0.05$) (Figure, 3c). However no significant differences were observed at 20-40cm depth. At 40-120cm depth, CT significantly had the highest soil moisture ($p<0.05$). This suggests that at the top soil layers (0-40 cm) there was soil water evaporation and in the deep layers there was soil water depletion under CT

During maize growing period (Figure 3b), CSWC was significantly higher under NTS at 0-20cm of soil depth. At 20-80cm depth, no significant differences were recorded. At 100-200cm, CSWC was significantly higher under CT, and P-value ranged from 0.0013 to 0.0488. This suggests that during wet period, water percolation occurred under CT.

Differences in CSWC were related to soil water infiltration and water evaporation. The NTS system had crop residues on the soil surface, which obviously prevented soil water from evaporation during dry period, while enhancing rainfall infiltration into the soil. This finding is consistent with [34; 35]. However, our finding was consistent with [36] who reported that conventional tillage had higher moisture than no-tillage. The highest CSWC recorded under CT during the summer can be explained by higher precipitation.

Table 7 shows the winter wheat and summer maize yields. RS significantly had the highest yield whereas CT the lowest one. This study demonstrated that tillage systems affected yield. This result was consistent with what [37] reported. In this study, NTS had lower yield compared with RS. This finding is consistent with [37]who reported that NTS yields were lower in the early years of their study, but improved with the passage of time. Furthermore there were no significant differences between CT and NTS except in 2014 for maize. Some previous short-term studies had reported this similar result.However, theresult is not consistent with [38].Although during the short-term experiment there were no significant differences between CT and NTS, NTS improved crop yield more than CT. These improvements were consistent with [39; 40]. The improvements under RS and NTS were attributed to enhanced soil nutrients, soil water, and SOC.

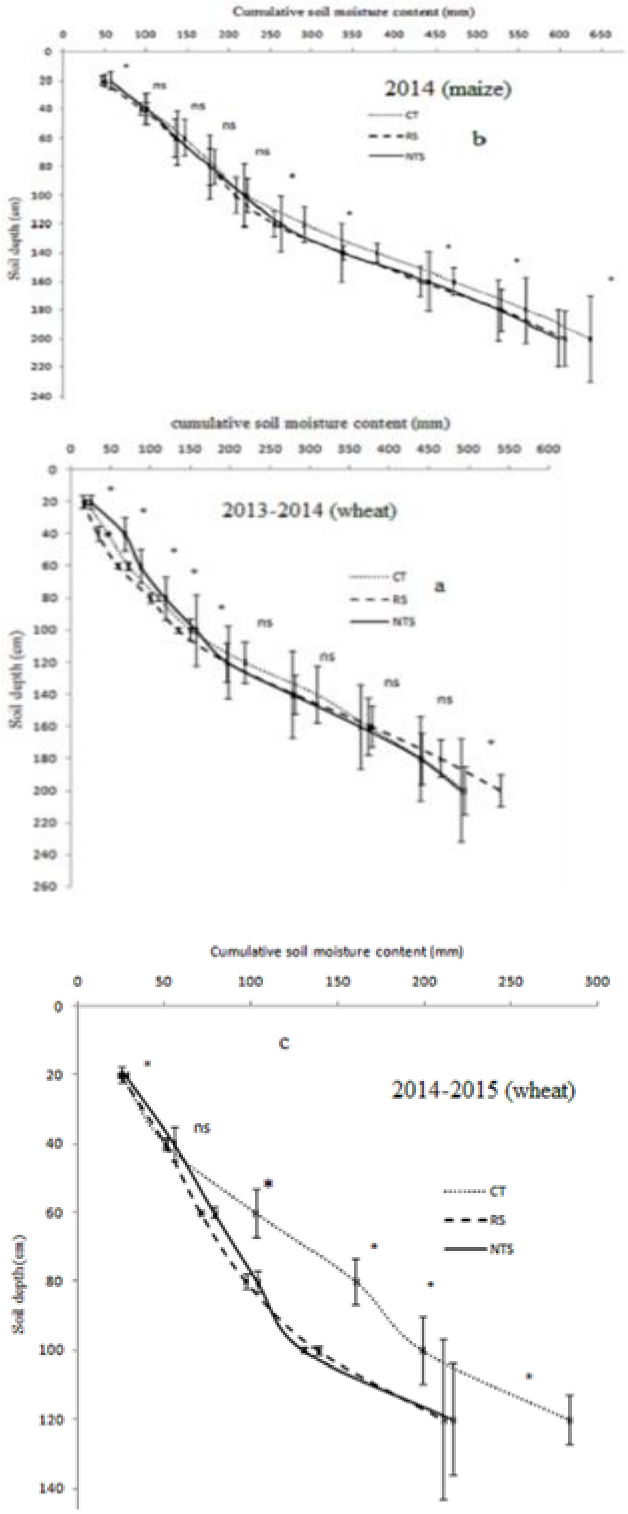

Figure 3(a, b, c): Cumulative soil water content during wheat and maize growing period (n = 6 for wheat and 5 for maize)

Table 7: Wheat and maize yield

Treatments	Wheat (Mgha^{-1})			maize (Mgha^{-1})	
Years	2013	2014	2015	2013	2014
CT	5.551b	5.603b	6.122b	4.18c	4.201c
RS	6.185a	6.235a	7.530a	4.88a	4.681a
NTS	5.735b	5.785b	6.44b	4.54c	4.424b

The numbers followed by the same letters down a column are not significantly different at $p < 0.05$

CT: rotary tillage without crop residues in winter and summer; RS: rotary tillage with crop residue incorporation into soil in winter and summer; NTS: no- tillage with crop residues use as mulch in winter and summer

4. Conclusion

In this study, the CT, RS, and NTS practices were found to have different effects on BD, SOC, CO_2 rate, TN, and AP, as well as soil CSWC. Short-term NTS practice significantly increased SOC stock, soil TN, AP at 0-40cm depth. NTS improved CSWC The adoption of conservation tillage, particularly NTS, potentially sequesters carbon in North China. The potential effects of NTS on soil quality were more apparent at 0–20 than 20-40 cm depth. The short-term effect of NTS on yield was lower than RS. This study shows that using NTS management is beneficial in North China and enhances soil quality, and the environment by reducing CO2 emissions compared with RS. However, longer-term study of the relationship between conservation tillage, soil properties, yield, and environmental conditions is needed in North China.Hence, it is better to collect more data on soil respiration that will help to identify the maximum cumulative CO_2 emitted by each treatment.

5. Acknowledgements

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References

[1] P. I.Moraru , T. Rusu. Effect of Tillage Systems on soil moisture, soil temperature, soil respiration and production of wheat, maze and soybean crops s and Production on Wheat, Maize and Soybean Crop. J. Food Agri. Environ., 10(2), pp. 445-448, 2012.

[2] M. C. R. Alberto, H. U. Neue, A. B. CApati, R. U. Castro. Effect of different straw management practices on soil fertility, rice yield and the environment.Proc.of the Int'ISimp.On Maximising Rice Yield through improved Soil and Environment, pp11-17, 1996.

[3] C. Piovanelli, C. Gamba G. Brandi, S. Simonini, E. Batistoni.Tillage choices affect biochemical properties in soil profile. Soil Till.Res, 90(1-2), pp. 84-92, 2006.

[4] P. P. Chivenge, H. H. Murwira, K. E. Giller, P. Mapfumo, J. Six. Long term impact of reduced tillage and residue management on soil carbon stabilization: implications for conservation agriculture on contrasting soils. Soil Till.Res., 94 (2), pp328 -337, 2007.
[5] West, T. O., Post, W.M. Soil organic carbon sequestration rates by tillage and crop ro- tation: a global data analysis. Soil Science Society of America Journal, 66 (6).pp. 1930–1946, 2002.
[6] H. Blanco-Canqui, R. Lal. No-tillage and soil profile carbon sequestration: an on-farm assessment. Soil Sci. Soc. Am. J. 72(3), pp. 693–701, 2008.
[7] S. F. Christopher, R. Lal, U. Mishra.Regional study of no-till effects on carbon sequestration in the midwestern United States. Soil Sci. Soc. Am. J, 73 (1), pp. 207–216, 2009.
[8] Wang, X. B., Cai, D. X., Perdok, U. D., Hoogmoed, W. B., Oenema, O. Development in conservation tillage in rainfed regions of North China. Soil Till.Res., 93(2), pp. 239–250, 2007.
[9] J. Lee. Effect of application methods of organic fertilizer on growth, soil chemical properties and microbial densities in organic bulb onion production.SciHortic.124(3), pp.299–305, 2010.
[10] G. Saro, R. Lal. Soil restorative effects of mulching on aggregation and carbon sequestration in a Miamian soil in central Ohio. Land Degrad Dev. 14(5), pp. 481–493, 2003.
[11] L. N. Mulumba, R. Lal. Mulching effects on selected soil physical properties. Soil Till Res. 98(1), pp. 106-111, 2008.
[12] D. C. Reicosky, D. W. Archer. Moldboard plow tillage depth and short-term carbon dioxide release. Soil Till.Res, 94 (1), pp. 109–121, 2007.
[13] J. W. Elder, R. Lal. Tillage effects on gaseous emissions from an intensively farmed organic soil in North Central Ohio. Soil Till.Res, 98 (1), pp.45–55, 2008.
[14] K. Oorts, R. Merckx, E. Gréhan, J., Labreuche, B. Nicolardot. Determinants of annual fluxes of CO2 and N2O in long-term no-tillage and conventional tillage systems in northern France.Soil Till.Res, 95(1-2),pp.133–148,2007.
[15] Z. K. Xie, Y. J. Wang., F. M. Li. Effect of plastic mulching on soil water use and spring wheat yield in arid region of northwest China. Agricult Water Manage, 75(1), pp. 71-83, 2005.
[16] Q. J. Wang, H. Chen, H. W. Li, W. Y. Li, X. Y. Wang, A. D. Mchugh, H. He,et al. Controlled traffic farming with no-tillage for improved fallow water storage and crop yield on the Chinese Loess plateau. Soil Till. Res. 104 (1), pp. 341-350, 2009.
[17] P. Gicheru, C. Gachence, J. Mbuvi, E. Mare. Effects of management practices and tillage systems on surface water conservation and crust formation on a sandy loam in semi-arid Kenya.Soil Till.Res, 75(2), pp. 173-184, 2004.
[18] M. Zhang, F. Wang, F. Chen, M. P. Malemela H. Zhang. Comparison of three tillage systems in the wheat-maize system on carbon sequestration in the North China Plain. J. Clean Prod., 54(1), pp. 101–107, 2013.
[19] S. B. Dikgwatlhe, Z. Chen, R. Lal, H. Zhang, F. Chen. Changes in soil organic carbon and nitrogen as affected by tillage and residue management under wheat–maize cropping system in the North China Plain.Soil Till. Res, 144(1), pp. 110–118, 2014.
[20] J. Bruinsma. World Agriculture: Towards 2015/2030- An FAO Perspective. Earthscan Publications. Ltd., London, PP. 297 – 330, 2013
[21] A. Walkley, A. I. Black. Estimation of soil organic carbon by the chromic acid titration method.Soil Sci., 37, pp. 29–38, 1934.
[22] I. Jemai, N. B. Aissa, S. B. Guirat, M. B. Hammouda, T. Gallali. On farm assessment of tillage impact on vertical distribution of soil organic carbon and structural soil properties in a semiarid region in Tunisia. J. Environ. Manage.113(30), pp. 488–494, 2012.
[23] R. Roscoe, P. Buurman. Tillage effects on soil organic matter in density fractions of a CerradoOxisol. Soil Till.Res., 70(2), pp.107-119, 2003.
[24] D. Janušauskaite, G. Kadžienė, O. Auškalnienė. The Effect of Tillage System on Soil MicrobiotainRelation to Soil Structure. Pol. J. Environ. Stud. 22(5), pp. 1387-1391, 2013.
[25] S. A. Prior, R. L. Raper, G. B. Runion.Effect of implement on soil CO2 efflux: Fall vs. spring tillage. Trans. ASAE, 47(2), pp. 367–373, 2004.
[26] S. Fu, D. C. Coleman, R. Schartz, R. Potter, P. F. Hendrix, D. A. Jr. ^{14}C distribution in soil organism and respiration after the decomposition of crop residue in conventional tillage and no-tillage agroecosystems at Georgia Pieddimont.Soil Till. Res., 57(1-2), pp. 31-41, 2000.
[27] C. Li, Z. Kou, J. Yang, M. Cai, J. Wang, C. Cao. Soil CO2 fluxes from direct seeding rice fields under two tillage practices in central china. Atmos. Environ., 44 (23), pp.2696-2704, 2010.
[28] J. Lee, J. W. Hopman, C. V. Kessel, A. P. King, K. J. Evatt, D. Louie, D. E. Rolston,, J. Six. Tillage and seasonal emissions of CO2, N2O and NO across a seed bed and at the field scale in a Mediterranean climate. Agr. Ecosyt. Environ, 129(4), pp. 378–390, 2009.
[29] J. Six, C. Feller, K. Denef, S.Ogle, J. C. D. Sa, A. Albrech. Soil organic matter, biota and aggregation in temperate and tropical soils-Effects of no-tillage.Agronomie, 22(7-8), pp. 755–775, 2002.
[30] M. M. Al-Kaisi, X. Yin, M. A. Licht. Soil carbon and nitrogen changes as influenced by tillage and cropping systems in some Iowa soils. Soil Till. Res., 105(4), pp. 635–647, 2005.
[31] H. Cai-Bian, Z. Fan-Jiang, L. Jia-Qiang. Cultivation effects on the carbon an nitrogen dynamics at depth in oasis farmlands of the southern Tarim Basin, China. Soil Scie.plantnutr, 61(2), pp. 287-294, 2014.
[32] R. Hou,, Z. O. Y. Li, D. D. Tyler, F. Li, G. V. Wilson. Effects of tillage and residue management on soil organic carbon and total nitrogen in North China Plain. Soil Sci. Soc. Am. J,76(1), pp. 230-240, 2012.
[33] A. Gál, T. J. Vyn, E. Michéli, E. J. Kladivko, W. W. McFee,.Soil carbon and nitrogen accumulation with long-term no-till versus moldboard plowing overestimated with tilled-zone sampling depths. Soil Tillage Res. 96(1-2), pp. 42–51, 2007.
[34] L. L. Li, G. B. Huang, R. Z. Zhang, B. Bill, G. D. Li, K. Y. Chan. Benefits of conservation agriculture on soil and water conservation and its progress in

China.Agricultural Sciences in China, 10(6), pp. 850-859, 2011.

[35] D. C. Nielsen, P. Uger, P. R. Miller. Efficient water use in dryland cropping system in the Great Plains.Agron.J. .97(2), pp. 364-372, 2005.

[36] M. Rashidi, F. Keshavarzpour. Efffect of different tillage methods on soil physical properties and crop yield of watermelon (Citrullus Vulgaris). Journal of agricultural and Biological Science, 2(6), pp. 1-6,,2007.

[37] K..R. Olson, S. A. Ebelhar, J. M. Lang. Effects off 24 years of conservation tillage systems on soil organic carbon and soil productivity. Appl. Environ. Soil Sci., 2013 (617504), pp.1-10, 2013.

[38] G. Huang., Q. Chai, F. Feng, A. Yu. Effects of Different Tillage Systems on Soil Properties, Root Growth, Grain Yield, and Water Use Efficiency of Winter Wheat (Triticumaestivum L.) in Arid Northwest China. J. Integr. Agr, 11(8), pp. 1286–1296, 2012.

[39] J. He, H. W. Li, X. Y. Wang, A. D.McHugh, W. Y. Li, H. W. Gao, N. J. Kuhn. The adoption of annual subsoiling as conservation tillage in dryland maize and wheat cultivation in northern China.Soil Till. Res. 94 (2),pp. 493–502 (2007).

[40] Z. Su, J. Zhang, W. Wua, D. Cai, J. Lv, G. Jiang, J. Huang, J. Gao, R. Hartmann, D. Gabriels,. Effects of conservation tillage practices on winter wheat water-use efficiency and crop yield on the Loess Plateau, China. Agricultural Water Management, 873(3), pp. 307–314, 2007.