The Pharma Innovation Journal 2021; 10(10): 711-714

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(10): 711-714

www.thepharmajournal.com
Received: 14-08-2021
Accepted: 20-09-2021

Shweta Kumari
Agricultural Technology Management Agency, Nalanda, Bihar, India

Devashish Kumar
Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Sanjay Kumar
Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

SK Dutta
Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Chandini
Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Kajal Verma
Department of Agronomy, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Corresponding Author:
Devashish Kumar
Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Assessing the soil properties under conservation agriculture based tillage practices in cereal based cropping system of Bihar

Shweta Kumari, Devashish Kumar, Sanjay Kumar, SK Dutta, Chandini and Kajal Verma

Abstract
Soil quality degradation associated with resources scarcity is the major concern for the sustainability of conventional rice-wheat system in the Indo Gangetic Plains region of South Asia. Replacement of conventional management practices with conservation agriculture (CA) practices is required to improve soil quality. The present study was a long-term maize-based conservation agriculture field experiment which was established in 2013-14 at experimental farm of Bihar Agricultural University, Sabour, Bhagalpur. It was devised to compare the effect of zero tillage, permanent beds and the conventional tillage on bulk density (BD) and water holding capacity (WHC) after four years. In the split plot design, three tillage practices *viz.* zero tillage (ZT), conventional tillage (CT) and permanent bed (PB) were kept in main plot and four rabi crops *viz.* wheat, rabi maize, mustard and chickpea were kept in sub plot and the treatment combination were replicated thrice. ZT and PB showed significantly lower BD as compared to CT. Among rabi crops the minimum BD was found in wheat followed by maize, mustard and chickpea. WHC for 0-15 and 15-30 cm soil depth was found higher in ZT and PB as compared to CT. Among rabi crops the WHC was found maximum in wheat followed by maize, mustard and chickpea. Therefore CA practices improved soil properties, increases WHC and by lowering the intensity of soil erosion prevents land degradation.

Keywords: Conservation agriculture, bulk density, water holding capacity

Introduction
Rice-wheat cropping system is the major cropping system in the Indo Gangetic Plains and plays a crucial role in food security for the region. At the same time, this cropping system is responsible for poor soil health, low crop yields, multinutrient deficiencies and water resource depletion (Jat *et al.*, 2013, Parihar *et al.*, 2016) [14, 18]. Sandy loam soil is the most dominant soil texture of Indo Gangetic Plains. The main production constraints of this type of soil are higher bulk density, poor water retention capacity, higher hydraulic conductivity, lower soil organic carbon and lower biological activities (Singh *et al.*, 2016) [24]. Conservation agriculture (CA), which has residue cover on the soil surface at least 30%, could be one of the potential practice to improve the soil physical environment (Salem *et al.*, 2015, Singh and Malhi 2006) [20, 23]. The CA practices improve stability of soil aggregates (Sheehy *et al.*, 2015) [22], total porosity and groundwater movement (Jemai *et al.*, 2013, Wang *et al.*, 2009) [15, 26], and plant root growth (Grzesiak *et al.*, 2013) [10]. Tillage is the practice of physical manipulation of soil for the establishment of crops. Optimizing tillage activities results in better soil quality. Tillage practices significantly affect the soil properties; it makes the soil either porous or compact. Soil compaction refers to the packing effect of a mechanical force on the soil. This packing effect decreases the volume occupied by pores and increases the density and strength of the soil mass. Excessive compaction may cause undesirable effects such as decreased infiltration of water, restriction of root growth, and increased runoff. These detrimental effects can increase soil erosion. Under conventional tillage practices such as deep mould board plowing, excessive and indiscriminate tillage may cause loss of soil organic matter, degradation of soil structure, extensive wind and water erosion leading to deterioration of soil quality. Soil with better health and quality will be able to produce higher crop yield under favorable as well as extreme climatic conditions, and soil health acts as a critical component for adaptation and mitigation of climate change effects by the crops (Congreves *et al.*, 2015) [7].
Crop management practices i.e., tillage systems or cropping sequences can affect soil health.

Karlen *et al.*, 2013 [16] observed that deep soil ploughing with mouldboard plow had significant negative impact on soil health and quality parameters. Some studies showed encouraging findings of increasing soil organic matter, soil structure due to maintenance of soil aggregates, reduced oxidation of soil organic matter with minimum tilling of soil compared to conventional tillage (Beare *et al.*, 1994, Halvorson *et al.*, 2002) [2, 13]. Similarly, diversification in crop rotations can also affects soil health by affecting carbon contents, due to the difference in chemical composition of different crop residues that are added to soil (Srinivasarao *et al.*, 2013) [25]. These effects of either tillage or cropping systems on soil physical and chemical properties affect the microbial biomass and their activities and some other important processes such as organic matter decomposition and mediation of plant nutrient availability (Dick, 1992, Balota *et al.*, 2003) [8, 1]. It is hypothesized that conservation agriculture based tillage practices (ZT and PB) and diversified maize based crop rotations improve soil physical, chemical and biological properties and overall soil health, compared to conventional tillage and existing dominant rice-wheat cropping system of the region. Identification of best tillage practice and/or crop rotation to maintain or enhance soil health can help the farmer/grower to plan their crop management strategies. In this backdrop, the objectives of present study were to determine the effects of CA based tillage practices on soil health parameters.

Material and Methods

The present experiment was carried out at research farm of Bihar Agricultural University, Sabour during 2017-18 rabi season, to evaluate the effect of long-term conservation agriculture practices like zero tillage and permanent beds on bulk density and water holding capacity of the fifth year rabi season crops as compared to their performance against the conventional tillage for different rabi crops. The experimental plots had uniform topography. The sequences of crops grown during the preceding four years in the experiment were maize in kharif season followed by wheat, rabi maize, mustard and chickpea in rabi season. The climatic condition of this place is tropical to subtropical and somewhat semi-arid in nature and is characterized by very dry summer, moderate rainfall and very cold winter. During the crop season there was cool and bright climate prevailed throughout the dry season.

The experiment was laid out in split plot design with 12 treatment combinations comprising of three tillage treatments; T_1 -zero tillage (ZT), T_2- conventional tillage (CT) and T_3-permanent bed (PB) in main plot, four rabi crops *viz*. C_1-Wheat (var. HD 2967), C_2- Rabi Maize (var. P 3396), C_3-Mustard (var. Rajendra Suphlam) and C_4-Chickpea (var. JG 14) in sub plots. The fertilizer dose was 120:60:40,150:75:50, 80:40:40, 20:50:0 (N: P_2O_5: K_2O kg ha^{-1}), in wheat, rabi maize, mustard and chickpea respectively. In wheat and rabi maize nitrogen was applied in three splits, half as a basal dose at the time of sowing, one fourth before first irrigation and one fourth before third irrigation while full dose of P_2O_5 and K_2O were applied as basal. In mustard total amount of P_2O_5 and K_2O with 50% of N were applied as a basal, while the left over N was top dressed at the time of first irrigation. In chickpea, total amount of 20:50 kg of N: P_2O_5 ha^{-1} were applied at the time of sowing. After sowing of crops in the plots a uniform application of pre emergence herbicide – Pendimethalin @ 3L a.i. ha^{-1} was sprayed for management of weeds within two days after sowing.

In zero tillage, crops were grown on zero tilled plots without disturbing the soil except for seed or fertilizer placement, with 30 per cent maize residue retained in the plots from the kharif maize crop in rotation. The conventional tilled plots were ploughed with two passes of tractor drawn disc plough followed by two ploughing with cultivator and one planking. The field was uniformly leveled to the specified plot dimension and in permanent bed; crops were grown on permanent bed plots without disturbing the soil except for seed or fertilizer placement, with 30 per cent maize residue retained in the plots from the earlier maize crop in rotation. The width of the beds (mid-furrow to mid-furrow) was 67 cm, with 37 cm wide flat tops, and 30 cm furrow width.

The soil samples were collected with soil auger from different places at random at a depth of 0-15 cm and 15-30 cm from the experimental site before laying out the experiment. The composite soil sample representing the whole field was taken and subjected to mechanical and chemical analysis in laboratory to determine the physico-chemical properties. The bulk density of the soil samples was determined by drawing samples by core sampler (Black and Hartge, 1986) [4]. The samples were oven dried, weighed and the soil bulk density was calculated as given below. Bulk density was expressed in g cm^{-3}.

Bulk density (g cm^{-3}) =Oven dry weight of soil (g) / Volume of soil (cm^3).

The maximum water holding capacity of the soil was determined by using Keen Raczkows Ki brass cup as described by Piper, 1966 [19]. To interpret the effect of different treatments, the data collected in course of experiment were analyzed statistically by applying the analysis of variance techniques laid down by Cochran and Cox, 1967 [6], Panse and Sukhatme, 1978 [17] and Gomez and Gomez, 1984 [11]. Relevant data were statistically analyzed separately to interpret the results. The mean data for each parameter has been presented. For comparison of ‘F’ values and for determination of critical difference at 5% level of significance, Fischer and Yates Table, 1963 [8] were consulted.

Results and Discussion

Effect of conservation agriculture practices on bulk density

The bulk density (BD) of soil which was measured in two depths, i.e. 0-15 cm and 15-30 cm has been presented in Table 1. The data showed that BD increased with depths. The tillage practices had significant effect on BD for the two soil depths measured. In 0-15 cm BD in ZT (1.37 g cm^{-3}) was significantly lower as compared to CT (1.47 g cm^{-3}) and PB (1.40 g cm^{-3}). In 15-30 cm BD in both ZT (1.52 g cm^{-3}) and PB (1.52 g cm^{-3}) was significantly lower as compared to CT (1.56 g cm^{-3}). Cultivation of different Rabi crops had significant influence on BD for 0-15 cm soil depth while it was non-significant for 15-30 depth. In 0-15 cm the BD of wheat plot (1.39 g cm^{-3}) statistically at par with rabi maize (1.41 g cm^{-3}) and mustard plot (1.43 g cm^{-3}) while significantly higher BD was recorded in chickpea plots (1.43 g cm^{-3}). There was no significant influence of interaction of tillage and rabi crops on BD of soil for both the depths measured.

Soil organic carbon (SOC) being foundation to soil quality and also an important indicator of agricultural sustainability. Intensive tillage which is done in CT leads to rapid oxidation of SOC whereas ZT and PB reduce the losses of SOC by reducing their oxidation through minimizing the disturbance of soil. Lesser soil disturbance occurs under ZT and PB practices leads to lower oxidation of SOC and simultaneously residue retention under these practices through crop diversification might further facilitate greater carbon inputs which ultimately resulted into higher SOC under ZT and PB as compared to CT. The lower value of B.D. under ZT and PB might be due to higher SOC under ZT and PB. Moreover, due to retention of residue in the top soil layers under ZT and PB results in prevention of aggregate break down and thereby improving the porosity which results in lower B.D under ZT and PB. Our results corroborate to the findings of Salinas – (Garcia *et al.*, 1997[21] and Gathala *et al.*, 2011) [9]. In CT there is physical compaction of soil caused by heavy tillage implements traffic which leads to higher B.D at lower soil depth. Positive effect of crop residues under ZT and PB on soil B.D at the surface 0-15 cm has been reported previously by many researchers (Bhattacharyya *et al.*, 2008, Govaerts *et al.*, 2009) [3, 12].

Effect of conservation agriculture practices on water holding capacity

The data pertaining to water holding capacity (WHC) of soil which was measured in two depths, i.e. 0-15 cm, and 15-30 cm has been presented in Table 2. In main plot there was significant influence of tillage practices on WHC for two depths. WHC was recorded maximum in ZT (52.58%) which was significantly higher over CT (45.05%) while statistically at par with PB (50.95%) for 0-15 cm soil depth. The similar result was also found in 15-30 cm soil depth, in which the WHC in ZT (45.38%) was significantly higher over CT (40.70%) while statistically at par with PB (43.30%). In sub plot there was significant effect of different rabi crops on WHC of soil. Wheat plot recorded the maximum WHC (53.32%) which was significantly higher over rabi maize (49.31%), mustard (47.97%) and chickpea (47.50%) plots for 0-15 cm soil depth. WHC was recorded maximum for 15-30 cm in wheat plot (45.06%) which was significantly higher over mustard plot (42.01%) and chickpea plot (41.77%) while statistically at par with rabi maize plot (43.68%). There was no significant influence of interaction on WHC.

Water holding capacity was found to be higher under ZT followed by PB as compared to CT. This could be due to residue retention on soil surface which leads to better infiltration and conservation of water as well as reduces the losses through evaporation under ZT and PB as compared to CT. Since organic matter contributes majorly towards soil aggregation and development of soil structure, therefore in the present study tillage practices like ZT and PB which retained previous crop residues supported better soil aggregation and also towards improving the water holding capacity of the soil.

Table 1: Effect of conservation agriculture based tillage practices on bulk density

Treatment	B.D. (g cm^{-3}) 0-15 cm	B.D. (g cm^{-3}) 15-30 cm
Zero Tillage	1.37	1.52
Conventional Tillage	1.47	1.56
Permanent bed	1.4	1.52
S Em (±)	0.004	0.01
C.D at 5%	0.02	0.03
Wheat	1.39	1.52
Rabi Maize	1.41	1.52
Mustard	1.42	1.55
Chickpea	1.43	1.54
S Em (±)	0.01	0.01
C.D at 5%	0.03	NS
ZT-W	1.35	1.51
ZT-M	1.34	1.49
ZT-Mu	1.38	1.54
ZT-C	1.40	1.53
CT-W	1.45	1.56
CT-M	1.49	1.56
CT-Mu	1.46	1.56
CT-C	1.47	1.58
PB-W	1.37	1.50
PB-M	1.41	1.52
PB-Mu	1.41	1.52
PB-C	1.41	1.52
S Em (±)	0.01	0.01
C.D at 5%	NS	NS

ZT-Zero tillage; CT-Conventional tillage; PB-Permanent bed; W-Wheat;
M-Maize-; Mu-Mustard; C-Chickpea.

Table 2: Effect of conservation agriculture based tillage practices on water holding capacity

Treatment	WHC (%) 0-15 cm	WHC (%) 15-30 cm
Zero Tillage	52.58	45.38
Conventional Tillage	45.04	40.7
Permanent bed	50.95	43.3
S Em (±)	0.91	0.66
C.D at 5%	3.59	2.58
Wheat	53.32	45.06
Rabi Maize	49.31	43.68
Mustard	47.97	42.01
Chickpea	47.5	41.77
S Em (±)	0.55	0.69
C.D at 5%	1.62	2.05
ZT-W	57.02	48.13
ZT-M	51.35	46.05
ZT-Mu	51.85	43.43
ZT-C	50.1	43.92
CT-W	47.41	41.09
CT-M	45.17	40.86
CT-Mu	43.57	41.05
CT-C	43.99	39.8
PB-W	55.51	45.94
PB-M	51.4	44.12

PB-Mu	48.49	41.54
PB-C	48.4	41.59
S Em (±)	1.23	1.23
C.D at 5%	NS	NS

ZT-Zero tillage, CT-Conventional tillage, PB-Permanent bed, W-Wheat, M-Maize, Mu-Mustard, C-Chickpea

Conclusion

Based on the result of the experiment, "Assessing soil properties under conservation agriculture based tillage practices in cereal based system of Eastern India" it can be concluded that the conservation agriculture-based zero tillage and permanent bed tillage practices along with residue retention and crop diversification resulted in significant increase in water holding capacity and reduction in bulk density than conventional tillage and traditional rice-wheat based cropping system. CA based tillage practices can improve soil physical structure and water storage, protect moisture, and increase crop yield. Our study suggest that, zero tillage and other conservation agriculture-based tillage practices along with partial residue retention can be adopted for improving soil health.

References

1. Balota EL, Colozzi-Filho A, Andrade DS, Dick RP. Microbial biomass in soils under different tillage and crop rotation systems. Biol. Fert. Soils 2003;38:15-20.
2. Beare MH, Hendrix PF, coleman DC. Water-stable aggregates and organic matter fractions in conventional and no-tillage soils. Soil sci. Soc. Am. J 1994;58:777-786.
3. Bhattacharyya R, Kundu S, Pandey SC, Singh KP, Gupta HS. Tillage and irrigation effects on crop yields and soil properties under the rice–wheat ii system in the Indian Himalayas. Agricultural water management 2008; 95(9):993-1002.
4. Blake GR, Hartge KH. Bulk density 1. Methods of soil analysis: part 1- physical and mineralogical methods, (methods of soilan1) 1986, 363-375.
5. Cochran GW, Cox MG. Experimental Design. John Willey and Sons, Inc. U.S.A. 1967.
6. Congreves KA, Hayes A, verhallen LL, Van Eerd LL. Long term impact of tillage and crop rotation on soil health at four temperate agroecosystems. Soil Tillage Res 2015;152:17-28.
7. Dick RP. A review: long-term effect of agricultural systems on soil biochemical and microbial parameters. Agriculture. Ecosyst. Environ 1992;40:25-36.
8. Fischer RA, Yates F. Statistical Tables for Biological Agricultural and Medical Research (6th Ed.). Oliver and Boyd, Edinburgh, Tweeddale Cowot, London 1963.
9. Gathala MK, Ladha JK, Saharawat YS, Kumar V, Kumar V, Sharma PK. Effect of tillage and crop establishment methods on physical properties of a medium-textured soil under a seven-year rice-wheat rotation. Soil Science Society of America Journal 2011;75(5):1851-1862.
10. Grzesiak S, Grzesiak MT, Hura T, Marcińska I, Rzepka A. Changes in root system structure, leaf water potential and gas exchange of maize and triticale seedlings affected by soil compaction. Environmental and Experimental Botany 2013;88:2-10.
11. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. John Willey and Sons, Inc., New York 1984, 180.
12. Govaerts B, Sayre KD, Goudeseune B, De Corte P, Lichter K, Dendooven L *et al*. Conservation agriculture as a sustainable option for the central Mexican highlands. Soil and Tillage Research 2009;103(2):222-230.
13. Halvorson AD, Brian JW, Alferd LB. Tillage, nitrogen and cropping system effects on soil carbon sequestration. Soil Sci. Soc. Am. J 2002;66:906-912.
14. Jat ML, Gathala MK, Saharawat YS, Tetarwal JP, Gupta R. Double no-till and permanent raised beds in maize–wheat rotation of north-western Indo-Gangetic plains of India: Effects on crop yields, water productivity, profitability and soil physical properties. Field Crops Research 2013;149:291-299.
15. Jemai I, Aissa NB, Guirat SB, Ben-Hammouda M Gallali T. Impact of three and seven years of no-tillage on the soil water storage, in the plant root zone, under a dry subhumid Tunisian climate. Soil and Tillage Research 2013;126:26-33.
16. Karlen DL, Cambardella CA, Kovar JL, Colvin TS. Soil quality response to long-term tillage and crop rotation practices. Soil Tillage Res 2013;133:54-64.
17. Panse V, Sukhatme PV. Statistical Methods for Agricultural Workers (3rd Ed.). ICAR, New Delhi 1978.
18. Parihar CM, Jat SL, Singh AK, Kumar B, Pradhan S, Pooniya V *et al*. Conservation agriculture in irrigated intensive maizebased systems of north-western India: effects on crop yields, water productivity and economic profitability. Field Crops Research 2016;193:104-116.
19. Piper CS. Soil and plant analysis. Hans Publishers: Bombay, India 1966.
20. Salem HM, Valero C, Muñoz MÁ, Rodríguez MG Silva LL. Short-term effects of four tillage practices on soil physical properties, soil water potential, and maize yield. Geoderma 2015;237:60-70.
21. Salinas-Garcia JR, Hons FM, Matocha JE. Long-term effects of tillage and fertilization on soil organic matter dynamics. Soil Science Society of America Journal 1997;61(1):152-159.
22. Sheehy J, Regina K, Alakukku L, Six J. Impact of no-till and reduced tillage on aggregation and aggregate-associated carbon in Northern European agro ecosystems. Soil and Tillage Research 2015;150:107-113
23. Singh B, Malhi SS. Response of soil physical properties to tillage and residue management on two soils in a cool temperate environment. Soil and Tillage Research 2006;85:143-153.
24. Singh VK, Yadvinder-Singh Dwivedi BS, Singh KS, Majimdar K, Jat ML, Mishra RP *et al*. Soil physical properties, yield trends and economics after five years of conservation agriculture based rice-maize system in north-western India. Soil Tillage Res 2016;155:133-148.
25. Srinivasarao C, Venkateswarlu B, Lal R, Singh AK, Kundu S. Sustainable management of soils of dryland ecosystems of India for enhancing agronomic productivity and sequestering carbon. Adv. Agron 2013;121:253-325.
26. Wang Y, Xie Z, Malhi SS, Vera CL, Zhang Y, Wang J. Effects of rainfall harvesting and mulching technologies on water use efficiency and crop yield in the semi-arid Loess Plateau, China. Agricultural Water Management 2009;96:374-382.