Current Journal of Applied Science and Technology

37(6): 1-6, 2019; Article no.CJAST.52060
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Impact of Conservation Tillage with Residue Retention on Soil Physico-Properties and Yield of Rice and Wheat under Rice-wheat Cropping System

Seema[1*], S. R. Choudhury[1], Shambhu Prasad[1] and S. K. Pathak[1]

[1]Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur-813210, Bihar, India.

Authors' contributions

The two year of experiment have been completed by the author Seema as well as have first draft the manuscript. Author SRC have contributed in the analysis of the data. Authors SP and SKP have helped regarding the management of the text and literature etc. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2019/v37i630319
Reviewers and Editors: This manuscript was reviewed and approved by ICCRM-2019* Organising committee.

Original Research Article

Received 23 September 2019
Accepted 02 October 2019
Published 15 October 2019

ABSTRACT

A field experiment entitled "Impact of conservation tillage with residue retention on soil physico-properties and yield of rice and wheat under rice-wheat cropping system" was conducted at Norman E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar during *kharif* and *rabi* of 2012-13 and 2013-14 to observe the effect of conservation tillage and recycling of left over previous year crop residue as mulch in spite of burning on crop yield and on soil health under intensive rice-wheat cropping system. The data obtained from two years of experimentation revealed that higher grain yield of rice (5.23 t/ha) was recorded under conventional direct seeding while in case of wheat maximum grain yield (4.25 t/ha) was observed under zero tillage along with retention of residues than other tillage practices. Similarly in case of soil properties, crop residue retention on surface during winter modified the temperature of soil favourable for wheat root growth. Conservation tillage along with residue also improved the soil nutrient status like soil carbon nitrogen ratio (12.9) well as micronutrient status during the course of investigation.

Keywords: Conservation tillage; residue retention; C: N ratio of soil; soil temperature.

**Corresponding author: E-mail: seemaprjpt.1@gmail.com;*
** Note: This paper was presented in International Conference on Crop Residue Management (ICCRM-2019), October 14-15, 2019, Patna, Organised by Bihar Agricultural University, Sabour, Bhagalpur - 813210 (Bihar), India. Conference organising committee completed peer-review of this manuscript.*

1. INTRODUCTION

Rice-wheat is one of the major cropping systems which play a significant role in food security of India. This system is labour, water, capital and energy intensive and becoming less profitable as all these resources are becoming limited as well soil health is getting deteriorated with the passage of time. Rice cultivation involves ploughing the soil when wet, puddling it and keeping the area for the duration of the rice crop. Repeated puddling adversely affects soil physical properties by dismantling soil aggregates, reducing permeability in subsurface layers, and forming hardpans at shallow depths [1] all of which can negatively affect the following crop in rotation [2]. Excessive pumping of water for puddling in peak summers in north west Indo-gangetic plains (IGP) causes problems of declining water table and poor quality water for irrigation on one hand, whereas, in eastern IGP, rice transplanting depends mainly on monsoon rains. Under present situation of water and labour scarcity, farmers are changing either their rice establishment methods only (from transplanting to direct seeding in puddle soil i.e. Wet-DSR) or both tillage and rice establishment methods (puddle transplanting to dry direct seeding in unpuddled soil i.e. Dry-DSR). Rice grown with conservation tillage can produce similar yield to that under conventional puddling with minimized expenses on field preparation [3]. An extreme tillage requirement with no return of crop residue and other organic materials in loss of soil organic matter and is not sustainable [4]. For getting rice-wheat system sustained, reducing the intensity of tillage is must in an era of intensive agriculture. The recycling of crop residues has the advantage of converting the surplus farm waste into useful product for meeting nutrient requirement of crop. It also maintains the soil physical and chemical condition. A rice-wheat sequence that yields 7 t ha^{-1} of rice and 4 t ha^{-1} of wheat remove more than N 300, P 30 and K 300 kg ha^{-1} from the soil. Mulching/ retention of residue may affect soil fertility, physico-chemical properties and yield of the crop. About 25% of N and P, 50% of S and 75% of K uptake by cereal crops are retained in crop residues, making them viable nutrient sources. There is a need for retaining residue in-situ by surface mulching or by incorporating it in to soil. An experiment was there for conducted to evaluate the yield of rice and wheat under conservation tillage and its influence on soil physic-chemical properties.

2. METHODS AND MATERIALS

The field experiment was conducted during *Kharif* and *Rab*i season of 2012-13 to 2013-14 at Crop Research Centre of G. B. Pant University of Agriculture and Technology, Pantnagar. the soil of the experimental site was silty clay loam with pH 7.95, organic matter 0.926%, and the available N 175.3kg/ha, P 17.2kg/ha and K 210.5 kg/ha. There were total 12 treatments replicated three times in Split-Split Plot Design. Tillage practices (zero tillage, minimum tillage and conventional tillage) were kept in main plots while rice varieties (hybrid rice and HYV) in sub plots and in last residue in sub-sub plots. In residue retention plots residue of rice crop in wheat and of wheat in rice was applied @ of 4 t/ha after sowing of the crop. Two type of rice varieties i.e. Hybrid rice (Pant Sankar Dhan 3) and High Yielding Variety (Pant Dhan 16) and one wheat variety UP 2565 were used as test crop. The recommended dose of fertilizers 120 kg N, 60 kg P and 40 kg K /ha were used for both the crops. Half dose of nitrogen and full dose of P and K was mixed in soil before sowing. Rice was sown in dry condition *i.e*. aerobic rice cultivation. All the agronomic practices and plant protection measures were followed as per the recommendations. Rice crop was harvested on last week of October and wheat crop was harvested on first fortnight of April. After threshing grain yield was measured and after drying yield obtained from each plot were converted in tonnes per hectare. Soil samples were collected with the help of core sampler from after completion of one rice-wheat cropping system and analyzed for soil carbon nitrogen ratio and micronutrient status. Maximum and Minimum Soil temperature were measured during morning and evening hours with the help of soil thermometers at 10 cm of soil depth during the winter wheat crop to observe the impact of residue retention on soil temperature. Temperature was recorded during the growth period of the wheat crop and graphically presented at main growth stages i.e. tillering, heading and at grain filling stage.

3. RESULT AND DISCUSSION

3.1 Rice Yield

Tillage based crop establishment and residue retention did not influence the rice yield strongly as it was the initial phase of the conservation tillage. However, significant effect of different conservation tillage practices on grain yield was

observed after two years of experimentation where higher grain yield was recorded under conventional tillage (5.44 t/ha) followed by minimum tillage (5.39 t/ha) which were significantly higher than grain yield obtained under zero tillage practice (4.62 t/ha). In case of rice varieties, higher grain yield was obtained by HYV (5.23 t/ha) than hybrid rice. Higher yield produced by HYV under conservation tillage indicates its potential to perform better under direct dry sowing condition than the hybrid rice. Similar performance of HYV under aerobic condition was reported others also [5]. The effect of residue retention on rice grain yield was non-significant at the end of the experimentation though little bit higher yield was observed with application of residue along with conservation tillage (Fig. 1).

3.2 Wheat Yield

Similar to rice, different conservation tillage practices influenced the grain yield of wheat at the end of the cropping system. Under zero tillage, significantly higher yield (4.25 t/ha) was observed over minimum and conventional tillage. Wheat grain yield did not influenced by rice varieties during both the years of study. In case of residue retention significantly higher grain yield of wheat (4.31 t/ha) was recorded with the application of residue on surface than no residue retention. The higher response of wheat to residue retention along with conservation tillage or zero tillage might be associated with higher conservation of soil moisture, improved physical condition of the soil due to avoidance of puddling in rice during kharif season, minimum fluctuation in the soil temperature etc. Also higher grain yield in residue retained treatment was due the reason that the nutrient in crop residue and soil could be improved through the adjustment of abundant microorganism after straw residue returning to the field [6]. Likewise, few other researchers observed 9–10% higher yield under ZT combined with residue mulch compared to the conventional tillage and ZT without crop residue [7].

4. SOIL PHYSICO-CHEMICAL PROPERTIES

4.1 Soil Temperature

Tillage can also affect soil temperature through changing soil surface micro topography. Crop residue left on the soil surface as mulch, as compared to incorporation, removal or burning are known to be beneficial for crop production. Crop residue remaining on the soil surface in conservation tillage systems can decrease the rate of soil temperature change because surface residue both increases the reflection of incident solar radiation and acts as an insulating barrier

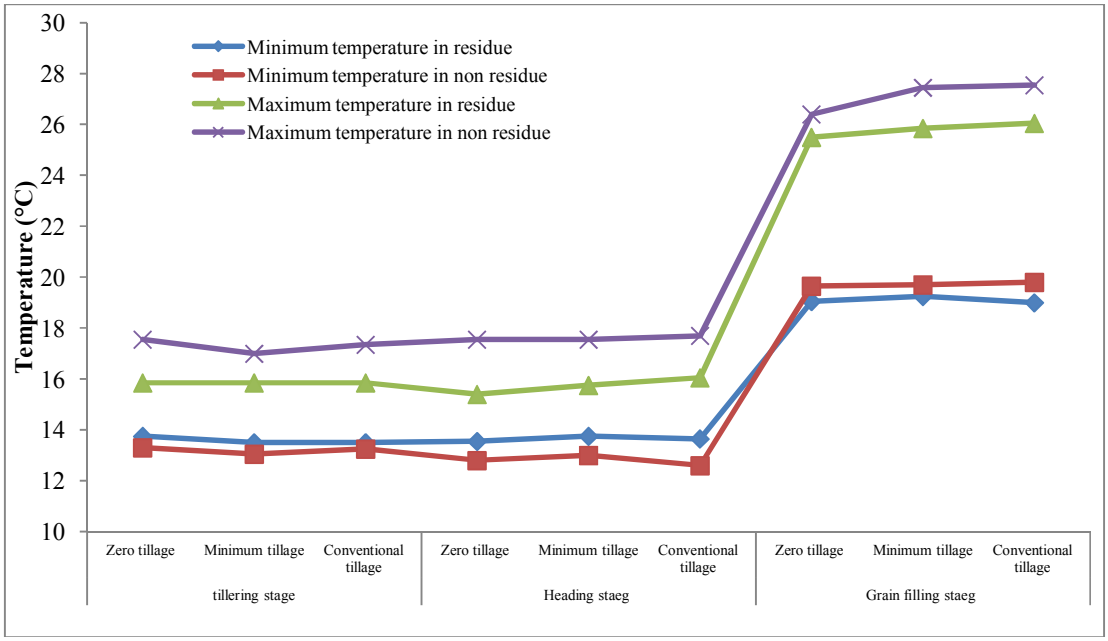

Fig. 1. Effect of tillage and residue management practices on soil temperature during wheat growth stages

between the soil surface and the warmer (or colder) atmospheric air above [8]. It provides the favourable soil temperature for better root growth of wheat crop as compare to the residue removal or burning. Soil temperature was recorded during the wheat crop in both the years at tillering, heading and grain maturity stage. At tillering stage of wheat crop, temperature recorded during morning and evening showed greater variation during the first year of wheat crop than second year. In case of morning hours higher soil temperature was recorded under residue retention as compare to non-residue retention. The variation between residue and non-residue was found more in case of minimum tillage and lower in case of conventional tillage. Opposite result was observed in case of maximum soil temperature.

During heading stage of wheat crop, temperature was higher than those recorded during tillering stage and more increment in soil temperature was recorded during first year than the second year. Similar trend was observed under residue and non-residue as during tillering stage. At grain maturity stage, the variation in morning hour's soil temperature was less as compared to evening hour's temperature during both the years. Residue retention resulted lower soil temperature than non-residue in morning hours. Similarly at evening hours lower soil temperature was recorded under residue retention than non-residue during both the years. The tillage practices did not resulted variation significantly in soil temperature. Crop residue left on the soil surface as mulch as compared to incorporation, removal or burning are known to be beneficial for crop production. Similar results were reported by many others [9] and [10].

4.2 Soil Chemical Properties

Conservation tillage systems can enhance sustainability of soil productivity by reducing soil erosion and increasing soil organic matter. A major factor contributing to changes in SOC and total nitrogen is the amount of carbon and nitrogen return to the soil through crop residue and roots each year. Higher C: N ratio recorded under zero tillage (12.9) than MT and CT. In case of residue management higher ratio was observed under application of residue (12.8) as compare to no-residue at the end of the cropping system Table 1. It has been reported that when residue with wide C: N ratio is added in the soil, a large proportion of the N required by the rapidly increasing microbial population comes directly from the straw. Thus it is expected that with time, the crop residue mulching will reduce the C: N ratio of the microbial biomass [11].

Table 1. impact of conservation tillage on grain yield of rice and wheat and on soil chemical properties

Treatments	Grain yield (t ha^{-1})		C: N ratio of soil	Micronutrient status (mg kg^{-1})			
	Rice	Wheat		Zn	Fe	Cu	Mn
Conservation Tillage practices							
Zero tillage	4.62	4.25	12.9	0.57	12.1	1.83	5.58
Minimum tillage	5.39	4.07	12.6	0.59	11.5	1.90	5.72
Conventional tillage	5.44	4.15	12.4	0.61	11.1	1.80	5.54
S.Em.±	0.04	0.01	0.25	0.008	0.08	0.013	0.09
C.D. (5%)	0.17	0.05	NS	0.03	0.32	0.05	NS
Rice variety							
Pant Sankar Dhan 3	5.08	4.14	12.7	0.60	11.6	1.82	5.48
Pant Dhan 16	5.23	4.17	12.5	0.58	11.5	1.85	5.75
S.Em.±	0.09	0.05	0.14	0.008	0.15	0.015	0.08
C.D. (5%)	NS	NS	NS	NS	NS	NS	NS
Residue management							
Residue mulch @ 4 t/ha	5.14	4.31	12.8	0.60	11.7	1.87	5.72
No-residue	5.17	3.98	12.5	0.59	11.4	1.81	5.51
S.Em.±	0.07	0.06	0.19	0.013	0.14	0.026	0.10
C.D. (5%)	NS	0.20	NS	NS	NS	NS	NS

Under rice-wheat cropping system, the concentration of Fe and Mn was higher in soil which may be attributed to the effect of submergence during rice season. During rice growth period, micronutrient especially Fe and Mn get reduced to their respective Fe^{+2} and Mn^{+2} forms which enhanced their concentration in soil but under aerobic condition reverse result may be observed. Similar result was reported [12]. In another report [13], it has been reported that the continuous practicing of rice-wheat cropping system reduced the micronutrient cations which further resulted in the build up of DTPA-extractable Zn, Cu, Mn, and Fe in soil.

5. CONCLUSION AND RECOMMENDATION

Residue mulching of wheat in rice crop did not found beneficial in terms of rice productivity. However, wheat performed better under rice residue. Conservation tillage improved the soil chemical and physical properties and also found remunerative. So, it can be recommended that DSR in conventional tillage and wheat in zero or minimum tillage with residue mulching may be adopted.

ACKNOWLEDGEMENT

I would like to acknowledge to G.B. Pant University for providing me the opportunity to do this research work. I am also grateful to Bihar Agricultural University to facilitate me with library during the drafting of my manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sharma PK, Ladha JK, Bhushan L. Soil physical effects of puddling in rice-wheat cropping systems. In “Improving the Productivity and Sustainability of RiceWheat Systems: Issues and Impacts” Ladha JK, Hill JE, Duxbury JM, Gupta RK, Buresh RJ (eds.)ASA, CSSA, SSSA, Madison, WI, ASA Special Publication. 2003;65:97-113.
2. Tripathi RP, Sharma P, Singh S. Tillage index: An approach to optimize tillage in rice-wheat system. Soil Till Res. 2005;80: 125-137.
3. Sharma PK, De Datta SK. Physical properties and process of puddle rice soils. Adv. Soil Sci. 1986;5:139-178.
4. Singh G, Jalota SK, Singh Y. Manuring and residue management effects on physical properties of soil under the rice-wheat system in Punjab, India. Soil Till. Res. 2007;94:229-38.
5. Patel DP, Das Anup, Munda GC, Ghosh PK, Bordoloi, Juri Sandhya, Kumar Manoj. Evaluation of yield and physiological attributes of high-yielding rice varieties under aerobic and flood- irrigated management practices in mid-hills ecosystem. Agricultural Water Management. 2010;4:124-132.
6. Xu GW, Tan GL, Wang ZQ, Liu LJ, Yang JC. Effect of wheat residue application and site specific nitrogen management on growth and development in direct-seeding rice. Acta Agronomica Sinica. 2009;35: 685-694.
7. 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 Sci. Soc. Am. J. 2011;75:1851-1862.
8. Yan Shen, Neil McLaughlin, Xiaoping Zhang, Minggang Xu, Aizhen Liang. Effect of tillage and crop residue on soil temperature following planting for a Black soil in Northeast China, Sci Rep. 2018;8: 4500.
9. Fengyun Zhang, Pute Wu, Xining Zhao, Xuefeng Cheng. The effect of no-tillage practices on soil physical properties. African Journal of Biotechnology. 2011;10 (77): 17645-17650.
10. Singh A, Kaur J. Impact of conservation tillage soil properties in rice-wheat cropping system. Agricultural Science Research Journal. 2012;2(1):30-41.
11. Kushwaha CP, Tripathi SK, Singh KP. Variations in soil microbial biomass and N availability due to residue and tillage management in a dry land rice agroecosystem. Soil & Tillage Research. 2000;56:153-166.
12. Singh Gurpreet, Dhaliwal SS, Sadana US, Waila SS. Influencing of cropping systems on micronutrient availability in typic

ustochrept soils of Punjab. J.Res.Punjab agric.Univ. 2011;48(3&4):128-135.

13. Balloli SS, Rattan RK, Garg RN, Singh G, Krishnakumari M. Soil physical and chemical environment as influenced by duration of rice-wheat cropping system. J. Indian Soc. Sci. 2000;48:75-78.

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