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Short Term Effect of Tillage, Residue and Biofertilizer on Physicochemical Soil Attributes under Teraiagro-ecological Zone of West Bengal, India

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ABSTRACT

Improvement of physicochemical status of soil always should be of major concern before adopting any practices. In the present investigation, we assessed tillage, crop residue and biofertilizer on some physicochemical properties of soil. Results revealed that pH and bulk density both observed to get higher in their level proportionally with depths. Residue and biofertilizers application significantly ($p<0.05$) improved organic carbon content irrespective of the tillage practice. Higher available nitrogen content observed with the application of residue and biofertilizer in both zero-tillage (ZT) and conventional tillage (CT)at surface layer (0-5 cm). ZT with residue application recorded highest phosphorus (P) at 0-5 cm depth. Residue and biofertilizer both increased the P at 0-10 cm layer; however, biofertilizer involving PSB had better effect in CT than the ZT. Residue application increased the K availability in the plough layer but the effect of biofertilizer found to be restricted to top layer.

KEYWORDS
tillage, residue, biofertilizers, West Bengal

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INTRODUCTION

Conservation agriculture techniques are addressing the constraints arising from the rice-wheat cropping systems with underlying principles of reducing the excess exploitation of the soil, water and improving the environmental quality in a manner to enhance the sustainability of the overall production system in agriculture in the context of meagre opportunity to increase the land under agriculture (Erenstein, 2007). Potential solution includes a shift from intensive tillage to 'no or reduced tillage'. Zero tillage (ZT)/reduced tillage (RT) greatly influence the physical, chemical and biological properties of soil as improves aggregation and increases the organic matter content of the soil, which in turn affects the crop production and its sustainability (Kumar *et al*, 2020b) ; (Kumar *et al*, 2020a). Reduced soil tillage has certain advantages, as it prevents soil erosion, reduces water loss and decreases crop cultivation costs in comparison with conventional soil tillage with a plough as it increases the amount of residues in soil. Under no till condition the residues add organic matter which improves aggregation of soil which improves the capacity of the soil to sequester more carbon (Saurabh *et al*, 2021) .

Zero tillage results in improvement of soil chemical properties (Ismail *et al*, 1994) also. The SOM largely contributes to nutrient cycling and thus supply of N, S and other elements as well (Saleque et al.2009).The residue addition also influences the nutrient dynamics in soil, Verma and Bhagat (1992)reported that the incorporation of rice straw in wheat resulted in a slight increase in P, Mn and Zn availability and substantial increase in the availability of K. Due to adoption of the conservation tillage practise these biochemical properties also improve indicating the changes in biochemical processes of soil.

Agriculture in the northern parts of West Bengal especially in Cooch Behar district is different from other advanced Rice-wheat belt. The Rice-wheat cropping system is not very prevalent in those areas although it is gaining importance in a progressive manner. The potentials to improve the production and productivity of agricultural crops in this district are constrained due to soil which is light textured with low indigenous nutrient status; acidic in reaction and excessive rainfall ($\geq$3000 mm) affect the un-exploited vigour adversely. Conservation agriculture is being promulgated by the different agencies to overcome the constraints related to the increased growth of agriculture in this district.

Under the existing situation, zero tillage wheat is gaining popularity with slight increase in area under direct seeded rice production (Kumar *et al*, 2022). In the stage of adoption of new technologies to a particular agro-ecological situation, however, certain un-explained events may come to the fore which needs tackling in a careful way for meaningful diffusion of the technology. Since evaluation of the impacts of

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tillage practices intervened with crop residues and biofertilizer on crop productivity in rice-wheat system as well as on soil properties in high rainfall areas so far are meagre and are not precisely documented. Hence the present study focuses on evaluating the changes in some physicochemical of the soil as influenced by the tillage operations and cultivation management in rice-wheat system.

MATERIALS AND METHODS

Site description

The study area is a terai zone, classified as Typic Fluvaquent of the order Entisol belongs to a long-term agricultural research site (26^0 19″ N, 89^0 23″ E; 43m above MSL) situated at research farm of the University, Cooch Behar district, West Bengal state. The area has a rainfall of more than 350 cm per annum of which around 80% or more is received within the months to June December, the mean annual temperature is used to vary between10 and32°C. Soils at the site are broadly classified with strong to moderately acidic in reaction, medium to high in organic carbon status, loamy sand to sandy loam in texture, high in total N and P, and medium to low in potash (Paul 2010).

EXPERIMENTAL DETAILS AND MANAGEMENT

Field studies were conducted on a long-term experimental field of rice wheat system with undisturbed layout established in the year of 2009.The experiment is laid as factorial RBD with 3 factors and each with two levels such as: (1) tillage practice: (a) zero tillage (ZT) and conventional tillage (CT); (2) crop residue: (a) crop residue addition (R^+) and crop residue removal (R0) and (3) seed inoculated biofertilizer: (a) application of biofertilizer (B+) and (b) no application of biofertilizer(B0).

In conventional tillage two passes of two-wheel tractor followed by two passes of rotavator were applied for each crop. In rice, puddling is done and 21-30 days age seedlings transplanted. In ZT, seed drill was used for sowing wheat and rice both. For residue treatment stubbles of rice and wheat maintained at 12-15 cm height in the experimental plots after the harvest of the crops and rest portion of the straw after threshing were used as sources of residue for in–situ application in respective treatment plots. The amount of residue added along with the stubbles amounted to 4-5 t/ha on sun dried basis was applied in every crop season. In biofertilizer treated plots of rice seed treatment with Azospirillum and phosphate solubilizer @ 5g inoculation per Kg of seed was done. Similarly, for wheat seed dressing with Azotobacter and phosphate solubilizer using talc formulation with gum acacia was done at the same rate. All other management practise with respect to weed management, nutrient management and irrigation management was followed as per the site and crop specific recommendations of the region.

Sampling and analysis

Soil samples were collected from each treatment plot at 0-5, 5-10 and 10-20 cm depths immediately after the harvest of wheat in rice-wheat cropping system after completion of five years of the trial i.e., five crop cycles. After removing all stubbles, residues and unwanted substances, composite soil samples from each treatment plot were homogenized and there after sub-divided into two groups, each of 500 g by weight.

Soil pH was determined with a glass electrode at a soil and water ratio of 1:2.5 (Jackson, 1973). Bulk density was estimated using steel core of $100cm^3$volume. Air dried soil was chemically oxidized with 0.167M $K_2Cr_2O_7$ in the presence of concentrated H_2SO_4 and titrated by $Fe(NH_4)_2SO_4$ (Walkley and Black, 1934). Available N was estimated from soil sample by distilling with 0.32% $KMnO_4$ and 2.5% NaOH as described by Subbiah and Asija (1956). Extractable P was measured by extracting soil samples by Bray's-I reagent at the ratio of soil: extractant (1:10) (Watanbe and Olsen 1965). Exchangeable K extracted with 1N neutral ammonium acetate (NH_4OAC) in 1:5 ratio followed by filtration as described by Hanway and Heidel (1952).

Statistical Analysis

Analysis of variance for each parameter was performed using PROC GLM of Statistical Analysis System (SAS) software (version 9.3). Mean separations for different treatments under different parameters were performed using Least Significant Difference comparison ($P< 0.05$). Normality assumption of residual under analysis of variance was also verified using PROC UNIVARIATE statement in SAS.

RESULTS AND DISCUSSION

Soil pH

The changes in soil pH due to the tillage, residue and biofertilizers were more reflected in surface (0-5cm) than other two layers (5-10 and 10-20 cm) and the effect of tillage and crop residue management on changes in pH were more visible relative to biofertilizer inoculations (Table 1). In the surface layer (0-5cm), soil pH was lower in ZT (5.28) than CT (5.38); similarly, pH in the soil where crop residue was incorporated (5.30) was also lower than where it was removed (5.36); soils receiving seed inoculated biofertilizer (5.31) showed significantly ($P<0.05$) lower pH than that received no biofertilizer inoculation (5.35). Similar results of relatively lower pH in soil at 0-5cm than 5-10 cm depth in a corn-soybean rotation under no tillage treatment over that in the plots under continuous tillage were reported by Houx et al. (2011). The pH in soil cultivated with maize and wheat was significantly affected by type of tillage, residue management and interplay among these factors only in the first 5 cm layer as reported by Fuentes *et al* (2009). The occurrence of lower pH under zero tillage practice as observed in the present study can be explained by the relative increase of acidity in rhizosphere especially in the upper soil layer of zero-tilled plots as a result of increased load of residue and its decomposition. Limousine and Tessier (2007) reported that there was accelerated rate of mineralisation of organic substances in residues subsequent with higher relative oxidation and also release of acidic compounds through root exudation. Combined treatment of crop residue and biofertilizer on soil pH relative to individual treatments within and between tillage practices (ZT and CT) when assessed, it was clearly evident that crop residue along withbiofertilizer was more pro-active in compounding the changes in pH than when applied singly either in ZT or CT practice at 0-5 and 5-10 cm soil depths (Table 1).

Table 1: Effect of tillage, residue and biofertilizer on soil physicochemical properties (pH, BD & OC) of post wheat soil in rice-wheat cropping system

Treatments		pH			Bulk density (Mgm^{-3})			Organic carbon (gkg^{-1})		
		0-5 cm	5-10 cm	10-20 cm	0-5 cm	5-10 cm	10-20 cm	0-5 cm	5-10 cm	10-20 cm
Tillage	ZT	5.28 a	5.49 a	6.05 a	1.43a	1.46a	1.63b	9.59 a	7.69a	4.28a
	CT	5.38 b	5.50 a	6.15 b	1.37b	1.48a	1.66a	9.05 b	7.80a	4.49a
Residue	R+	5.30 b	5.46 b	6.05b	1.39a	1.46a	1.66a	9.35a	7.97a	4.61a
	R0	5.36 a	5.51 a	6.15a	1.41a	1.47a	1.63b	9.29a	7.53a	4.16b
Bio fertilizer	B+	5.31 b	5.49 a	6.11 a	1.38b	1.44b	1.65a	9.49a	7.87a	4.54 a
	B0	5.35 a	5.51 a	6.09 a	1.42a	1.50a	1.64a	9.15b	7.63a	4.23 b
Till * Res (P<0.05)		NS	NS	NS	0.017	0.018	0.003	0.009	NS	NS
Till* Bio fert., (P<0.05)		NS	NS	NS	NS	NS	NS	0.0004	0.04	NS
Res* Bio fert., (P<0.05)		NS	NS	NS	0.004	NS	0.0006	0.007	NS	NS
Till* Res * Bio fert., (P<0.05)		0.0011	<0.0001	NS	0.004	NS	NS	NS	NS	NS

Bulk density

Tillage treatments resulted in significant (P<0.05) increase in BD due to no-tillage (1.43 gcm^{-3}) in comparison to CT (1.37 gcm^{-3}) in the 0-5 cm soil layer but it was reverse in the subsequent depths. At 10-20cm soil depth, the BD was significantly (P<0.05) higher in CT than ZT(Table 1). Jat et al. (2009) Jat *et al* (2009) also observed similar trend in BD where in ZT wheat had significantly higher BD as well as penetration resistance. Increased BD is due to more compactness of soil under zero till at surface soil, while the soil became more friable with the increased intensity of tillage in conventional practice at the surface soil layer (Ram *et al*, 2010).Higher BD in lower layer under CT and relatively higher BD in 10-20cm layer irrespective of tillage treatments were probably due to development of sub-surface compacted layer created where fine soil particles dispersed during tillage settle in to spaces of soil matrix that were previously occupied by air. In the present study, the effect of residue application on the bulk density did not show any variation at 0-10cmdepth. Variations in BD are common and mostly related to management factors such as planting machinery, number of machine passes, as well as the soil water content at which the soil is tilled (Martinez et al.2008). The interplay between tillage and residue showed significant variation (p<0.05) among all the soil depths. Incorporation of residue in CT resulted in reduced BDat 0-10 cm soil depth; however, no variations observed at 10-20 cm soil depth due to same. Biofertilizers improved the crop growth with higher root biomass and subsequent decomposition of the root biomass resulted in increase in the organic matter content results in decrease in BD (1.38gcm^{-3}) in 0-10 cm soil depth.

Organic carbon

Organic Carbon (OC) found to increase significantly in surface layer (0-5cm) in ZT plots than CT. Due to reduction in tillage, the OC increased to the tune of 5.97% in the surface layer. But this trend was reverse in 5-10 cm layer, where there was slightly higher OC was recorded in CT (7.80 gkg^{-1}) than ZT (7.69gkg^{-1}) and in 10-20 cm OC was significantly (P<0.05) higher in CT than the ZT (Table 1). Reduction in tillage improves the SOC content of the soil in long term perspective as reported. However, short term (<10 years) tillage effects on soil carbon dynamics are complex and often variable. Thomas *et al* (2007) found that in the top 10 cm depth, the mean amount of organic C was greater in no-till (NT) than reduce tillage (RT) and greater in RT than in CT. They further reported that there was concentration gradient in organic C with concentration gradient decreasing from 0-2.5 to 5-10 cm depth which was also observed in the present case where OC decreased down the depth in soils irrespective of the treatments. Residue application increased OC content in 0-10 cm but in the 10-20cm soil layer this increment was substantial in comparison to soil where there was no application of the residue (Table 1). Ghimire *et al* (2012) reported that the crop residue applied soils had consistently higher amounts of SOC at all depths than soils without crop residues. Retention of the residue on the surface under ZT generally reduces contact with the soil and variation in moisture and temperature at the surface play significant roles in varying the decomposition rates. Buried residues in CT decomposed at 3-4 times the rate of residues left on the soil surface (Beare *et al*, 1993). As the tillage intensity increases, soil contact of crop residue is increased and crop residues serve as a source of carbon to compensate carbon loss from microbial activity in crop residue treatments especially in conventionally tilled plots. Similar higher content of SOC was observed by Dolan *et al* (2006) at the depth of 20-25 and 25-30 cm under mouldboard ploughing than under no-till. In the 0-5 cm soil layer significant interaction between tillage and residue resulted in higher OC in ZT without residue than where residue was added. Kong and Six (2010) suggested that root C contributes more to overall C stabilisation than C from residues. As much as 7-43% of the total plant biomass C can be contributed by roots (Melero *et al*, 2008). Therefore, the zero till treatments without residue addition in the study may have received more carbon from roots. Biofertilizer inoculation significantly (P<0.05) increased OC in 0-5 and 10-20 cm. Piotrowska *et al* (2012) working with microbial biofertilizer UG Max reported that there was increase in soil carbon content during the entire period of the application compared to the control indicating humification of straw and post-harvest residue by soil microorganisms. The tillage and biofertilizer interplay in 0-5 cm soil layer indicated that there was more OC content in zero tilled plots without biofertilizers than in plots of zero-tillage with biofertilizers.

Mineralizable nitrogen (AN)

AN concentration was significantly higher at 0-5 and 5-10 cm soil layers in ZT than CT and the increase was to the tune of 9.73 and 5.93% respectively at the corresponding soil layers; AN significantly (p<0.05) higher in CT plots at 10-20 cm soil layer (Table 2).

Soil organic carbon and nitrogen are directly influenced by tillage, residue return and N fertilization management practices as reported by Dolan et al. 2006. Soil samples for SOC and N analyses, obtained from a 23-year field experiment, soils near the surface had more SOC and N stored in NT and chisel plough (CH) systems as compared to the mould board plough (MB) system. However, below 20 cm, the MB treatment retained more stored SOC and N than in conservation tillage practices. In a short-term study of 3-year by Mina *et al* (2008) significantly higher AN in 0-5 cm soil layers was reported in zero-tilled plots than in other different tillage practices. Significantly higher (6.25%) AN in the 0-5 cm soil layer was obtained as a result of crop residue incorporation over where it was removed; however, in the subsequent two soil layers (5-10, 10-20 cm.) increases in AN were marginal when compared with those where no crop residue was added. The plots receiving seed-inoculated biofertilizer (88.7 and 79.2 $mgkg^{-1}$, respectively) also showed significant increase in AN status both at 0-5 and 5-10 cm soil layers as against those receiving no biofertilizer treatment (83.0 and 74.5 $mgkg^{-1}$, respectively); Likewise, tillage and crop residue treatments, no significant difference in mean AN at 10-20 cm depth due to biofertilizer inoculation was observed (Table 2).A glance into the depth-wise status and distribution of AN in soils indicated that there was decrease in AN status with increase in the depth of soil irrespective of treatments used.

Table 2: Effect of tillage, residue and biofertilizer on macronutrient status of post wheat soil in a rice-wheat cropping system.

Treatments		Mineralizable nitrogen($mgkg^{-1}$)			Extr. Phosphorus ($mgkg^{-1}$)			Exchangeable potassium($mgkg^{-1}$)		
		0-5 cm	5-10 cm	10-20 cm	0-5 Cm	5-10 cm	10-20 cm	0-5 cm	5-10 cm	10-20 cm
Tillage	ZT	89.8 a	79.1 a	53.6 b	24.9a	13.7a	3.7a	131.5a	85.6a	59.9a
	CT	81.8 b	74.6b	59.3 a	13.7b	7.7b	3.6a	120.5b	80.9b	60.7a
Residue	R+	88.4 a	77.6 a	55.1 a	21.1a	12.7a	3.9a	136.3a	89.7a	61.8a
	R0	83.2 b	76.1 a	51.9 a	17.6b	9.7b	3.5b	115.8b	76.8b	58.8b
Bio fertilizer	B+	88.7 a	79.2 a	54.9 a	20.2a	11.3a	3.8a	129.6a	78.2b	59.5a
	B0	83.0 b	74.5 b	52.0 a	18.4b	11.1a	3.5b	122.4b	88.4a	61.1a
Till * Res (P<0.05)		NS	NS	NS	<.0001	<0.0001	NS	0.0001	NS	<.0001
Till* Bio fert., (P<0.05)		NS	NS	NS	<.0001	<0.0001	0.0027	<0.0001	0.0012	0.005
Res* Bio fert., (P<0.05)		NS	NS	NS	<.0001	0.0002	NS	0.0001	<.0001	0.03
Till* Res * Bio fert., (P<0.05)		NS	NS	NS	0.0001	<0.0001	NS	0.0028	0.0077	0.02

Extractable phosphorus (Extr-P)

Concentration of extr-P found highest in top most layers in ZT than CT (Table 2). The plots under ZT where only residue was applied recorded very high P (35.21 mg kg^{-1}). The higher stratification of P in 0-5cm soil layer under ZT was probably due to P "stratification' 'resulting in accumulation of more extractable P due to fertilizer application and from decomposition of crop residues retained on the soil surface under ZT. Combined application of residue and biofertilizer in both the tillage augmented P content in soil. Biofertilizer involving PSB had better effect in CT than the ZT. Soil disturbance caused by CT improved the intimate contact with soil particles throughout the plough layer rather than accumulating into top layer only which collectively resulted into relatively lower extr.-P at the uppermost depths in the soils (Table 2). Similar results in separate experiments were observed by Malhi *et al* (2011) in respect to the effect of tillage and crop residues on available P in soils. At 5-10 cm layer, ZT practice likewise in the previous layers, resulted into maintaining substantially higher (78.5%) average extr.-P in soils compared to CT; similarly overall effect of crop residue addition on average extr.-P was found significant and positive (30.59%) over that in soils where no crop residue was retained. Significantly higher (11.81 and 7.91% respectively) amounts of extr.-P on an average basis were found to be retained in soils of respective plots receiving crop residues and biofertilizer inoculation as compared to those which received no crop residues and biofertilizer inoculation respectively.

It was further evident that the stratification of extr-P was higher in ZT plots showed highest build-up of available P fraction in terms of both cumulative extr-P in plough layer (0-20cm) and relative amount accumulated up to 10cm depth in post-wheat soils. Malhi *et al* (2011) reported higher amounts of extractable P in soil under ZT compared to CT. Higher P resulted from decomposition of crop residues retained on the soil surface under ZT. The greater concentration of P and organic matter under strip till conditions reduces the P fixing capacity of the soil. They were of the opinion that increased mixing by tillage under CT may have converted fertilizer/available P into less labile forms by increased immobilization of P, thus decreasing extractable P content in soil. Interaction effect of tillage x crop residues, tillage x biofertilizer, crop residue x biofertilizer and even tillage x crop residue x biofertilizer were found significant both at 0-5 and 5-10 soil depths (Table 2).

Exchangeable potassium (Exch-K)

The overall mean effect of different treatment variables on exch-K at soils depths when considered, the responses of treatments more or less restricted to two upper depths (0-5 & 5-10cm), but there was no consistent pattern of change in exch-K due to treatments at 10-20 cm soil depth (Table 2). In the 0-5 cm layer, zero tilled soils observed to maintain significantly higher (9.13%) amount of exch-K on average basis over that in CT soils; a similar but highly significant increase (17.70%) of mean exch-K was recorded in soils from plots receiving crop residues than where it was removed. Mean value of exch-K in soils from seed-inoculated biofertilizer treatment also exhibited a significant increase (5.89%) over that where no bio fertilizer was added . Iii *et al* (2011) reported that extractable K was greatest at the 0-0.05 m depth and less at the 0.05-0.10 m under NT treatment (Table 2).

In 5-10cm layer, significantly higher means of exch-K (5.90 and 16.78% respectively) was observed in ZT with crop residue than in CT without crop residue treatments respectively. However, bio fertilizer inoculation treatment resulted to show significant decrease (13.04%) in average exch –K in soils when compared with no biofertilizer inoculation treatment. In the 10-20cm soil layer, significant and positive change (5.08%) in exch-K due to crop residue addition over that without addition was observed and no significant difference between treatments with respect to tillage and biofertilizer was noted. It has become apparent from these results that crop residue addition had more pronounced effect relative to tillage and biofertilizer in maintaining overall higher exch-K status in post-harvest soils of wheat grown in a rice-wheat cropping sequence. Fernandez *et al* (2010) observed at least two-fold increases in exchangeable K values in the 0-5 cm soil depth. They further reported that K values were not significantly different 5 to 10 and 10 to 20 cm depths. This stratification of potassium in surface layers especially in ZT and CT plots added with residue was due to the accumulated K from crop residues. Most K came from fertilizers and crop residues, the upper layers of no-tilled soil were enriched in K, whereas tilled soil did not exhibit any vertical gradient in a long-term experiment in France as reported by L Limousin and Tessier (2007). The interplay between all the factors (tillage, residue and biofertilizers) was found to significantly increased K content in soil under study (Table 2).

Grain and straw yield

Wheat sown under the ZT (4.19 t ha^{-1}) recorded comparative mean yield advantage of 19.37% in comparison to conventional tillage. Similarly, crop residue addition and biofertilizer seed inoculation at sowing resulted similar increase in mean yield to the tune of 11.23% for each as compared to respective mean yield obtained in the plots receiving no-crop residue and no biofertilizer seed treatment. There were no significant effects of tillage x crop residue, tillage x biofertilizer and crop residue x bio-fertilizer on wheat grain yield. Similar significantly higher (4.6%) yield of wheat was recorded with zero tillage in comparison to conventional tillage as reported by Laik *et al* (2014).

Keeping parity with the trends observed in grain yields of wheat, there was significant ($P<0.05$) increase in straw yield in zero tillage (6.18tha^{-1}) than the conventional tillage (5.26tha^{-1}). The application of residue and bio-fertilizer inoculation also resulted in increase in the straw yield of wheat (Table 3). Meena (2010) also reported that zero tillage recorded significantly higher grain and straw yields of wheat which was higher to the tune of 7.48 and 7.13% and 7.21 and 5.21% over farmers practice and conventional tillage respectively on mean basis.

Table 3: Effect of tillage, residue and bio fertilizer on grain and straw yield of wheat (average of two years)

Treatments		**Wheat Grain yield (t/ha)**	**Wheat Straw yield (t/ha)**
Tillage	Zero Till. (ZT)	4.19a	6.18a
	Conv.Till.(CT)	3.51b	5.26b
LSD (P<0.05), Tillage		0.35	0.46
Residue	Added (R1)	4.06a	5.96a
	Removed (R0)	3.65b	5.48b
LSD (P<0.05), Residue		0.35	0.46
Biofertilizer	Added (B1)	4.06a	6.02a
	Not Added (B0)	3.65b	5.42b
LSD (P<0.05), Bio-fertilizer		0.35	0.46
Interactions (Pr>F)			
Tillage * Residue (P<0.05)		NS	NS
Tillage * Bio fert. (P<0.05)		NS	NS
Residue * Bio fert. (P<0.05)		NS	NS
Tillage * Residue * Bio fert. (P<0.05)		NS	NS

Means with same letter are not significantly different

CONCLUSION

Tillage had a lot to alter the physicochemical and biological properties of soil in the present study. Quite evidently, ZT management had proved to improve the physicochemical status of the soil but better contemplated in 0-10 cm layer only. The combined application of residue and biofertilizer was registered a striking effect in recuperating the physiochemical properties of the soil by sustaining nutrient balance of the system in remarkable approach. Among physicochemical properties, pH and bulk density both were found to be affected by interplay of residue and tillage in comparison to tillage and bio fertilizer. Application of both residue and bio fertilizer significantly had a massive impact over oxidizable C irrespective of the tillage practice. The positive impact to adopt ZT was limited to 0-5 cm, but with better stratification ability CT had shown its role in lower depths. ZT with addition of residue and biofertilizers improved available nitrogen, phosphorus and potassium in the surface layer. Residue application increased the K availability in the plough layer but the effect of biofertilizer found to be restricted in only top most layer.

Improvement of physicochemical and biological status of soil always should be of major concern before adopting any practices. Resource conserve technology (RCT) in all aspect served its purpose. Residue addition on surface in ZT and incorporation under CT had immense potential improve the favourable status of soil physiochemical properties that facilitates a good growth.

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