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Effect of Tillage on Nutrient Dynamics and Physical Condition of Soil under Rainfed Rice Chick Pea Based Cropping System of Bastar, Chhattisgarh

Jitendra Kumar[1], Nirmal De[1*], A Pradhan[2], Pallab Sharma[3] and G. Ravindra Charry[4]

[1]*Institute of agricultural Science, Banaras Hindu University, India*
[2]*College of Agriculture, Jagdalpur, Indira Gandhi Krishi Vishwavidhalaya, India*
[3]*Bishwanth College of Agriculture, Assam Agriculture University, India*
[4]*Project coordinator AICRPDA, CRIDA, Hyderabad, India*

**Corresponding author*

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A B S T R A C T

The present study evaluated the effects of long-term tillage operation on soil physical properties and nutrient dynamics on surface soil. The soil samples were collected at 0 to 15cm soil depth profiles in the year of 2016 and 2017 from following treatment (T1) Conventional tillage, (T2) Conventional tillage with seeding by bullock drawn, (T3) Zero till seeding with bullock drawn, (T4) Conservation tillage seeding with country plough and (T5) Utera cropping (T5). The samples were analyzed for physical properties, Soil organic carbon and macronutrient. The statistical analysis was made in SAS 9.3 DMRT test was employed to compare the mean of estimated soil nutrient dynamics. Coupled with other physic chemical parameters of soil affected by different tillage treatment. The effect of tillage management was found significant on most of soil physic chemical parameters Zero tillage had highest amount of available N, P, K and S over other tillage treatments. The highest SOC was found in conservation tillage at par Zero tillage. The lowest SOC was recorded in Utera cropping. This study showed that zero tillage enhances physical environment of soil as well as availability of nutrients that may result sustainable soil health and crop yield.

Introduction

A number of ploughless tillage systems have been developed in the last decades with less tillage intensity and or a reduced depth of tillage. They result in an accumulation of crop residue at the surface and to a reduced fertilizer distribution in the soil. As a consequence an alteration of soil conditions occurs. Most important is an increase in soil organic carbon (SOC) in the top soil and effects on the stratification of nutrients (Salinasgarcia *et al.*, 2002; Zibilske *et al.*, 2002). Soil organic carbon is regarded as an eminent indicator of soil quality (Diaz-Zorita and Grove, 2002) and influences soil chemical, physical and biological properties. Less intensive tillage with plants covering the soil almost throughout the whole year helps to decrease the danger of N-losses to the ground water (Spiegel *et al.*, 2002). Several authors have reported that different tillage systems heavily affect potential nitrogen mineralization due to surface accumulation of crop residues (Salinas-Garcia *et al.*, 2002, Franzluebbers *et al.*, 1994). Therefore, a further study is warented to elucidate the effects of long-term tillage management practices that trigger the changes in soil properties in under continuous rice chick pea cropping system under rainfed condition of Bastar region of Chattisgarh.

Materials and Methods

Description of the experiment

Field experiments were conducted at the Research Farm of S G. College of Agriculture and Research Station Kumhrawand, Jagdalpur, Indira Gandhi Krishi vishwavidyalaya, Raipur (C.G.) during *Kharif and Rabi* season 2016 and 2017 under AICRP on Dry Land Agriculture the soil order of the site is alfisol. Jagdalpur is situated in between 19.0741° N, 82.0080° E with altitude ranging from 550-760m above mean sea level. The experiment followed the randomized block design (RBD) with five treatments *i.e* (T1) Conventional tillage, (T2) Conventional tillage with Seeding by bullock drawn, (T3) Zero till seeding with bullock drawn, (T4) Conservation tillage seeding with country plough and (T5) Utera cropping.

Soil sampling and chemical analyses

Soil samples were collected from the top soil layer (0–15 cm) after harvest of the rice crop, and then were air dried and subsequently grounded to pass a 0.25 mm sieve. Soil organic carbon was determined by a standard potassium dichromate digestion method Walkley and Black 1934, Available nitrogen content of soil was determined by alkaline permanganate method (Subbia and Asija, 1956). Available phosphorus (Olsen's method) by extraction with $NaHCO_3$ 0.5 mol L^{-1}at pH 8.5 and spectrophotometric determination. Available potassium by extraction with ammonium acetate 1N L^{-1} at pH 7 and determination by flame photometer. Available sulphur content was determined by Turbidi metrically (Chesnin and Yien, 1951)**.**

Statistical analysis

All ANOVA, regression, and multivariate analyses were conducted in SAS 9.3. Treatments were analyzed by one-way ANOVA and significant differences between means were judged by Turkey's post-hoc tests.

Results and Discussion

Macronutrient dynamics

Available N was significantly (Table 1) influenced ($P \leq 0.05$) by tillage management practices. The highest availability of N (282.24 kg ha^{-1}) was recorded in the Zero tillage whereas lowest (240.33 kg ha^{-1}) was found in utera cropping. The reduced disturbances in soil prohibiting redistribution of soil nutrient resulting the more nutrient accumulation on soil surface that was available for crop.

Significant effect of tillage was also recorded in the potassium availability, it was followed the similar trend (Fig. 1) that was observed in the available Nitrogen.

Zero tillage showed the highest amount of available phosphorous (20.40 kg ha^{-1}) and significantly different from all the treatment. Lowest phosphorus content was recorded in Utera cropping (11.21 kg ha^{-1}), in conventional tillage there was gradual decreased availability of macronutrient with increasing the tillage operations. pH also play very important role in availability of phosphorous and our finding was in zero tillage the highest pH (Fig. 2) was recorded that also resulted into increased in the availability of phosphorous. The increased of phosphorous in zero till might be due increased gradual reduce in disturbances reflected in gradual increase in available P content.

The available sulphur content was significantly influenced by tillage, It was recorded that the Zero tillage and minimum tillage had more available S content compare to conventional tillage over other treatment. The less no of tillage operation resulted into accumulation of root stubble within the soil which decompose in time domain and add the Sulphur and Soil Organic Carbon too (Table 1 and Fig. 3).

Soil reaction (pH) and electrical conductivity (EC)

The effect of tillage was significant and the highest pH was recorded in Zero till vis-a-vis minimum tillage system (Table 1) this is might be due do the experiment was continuing from several year as a part of long term on dry land agriculture. The effect of tillage was not significant moreover the highest EC was recorded in Zero till with seeding by bullock drawn and lowest was conventional tillage vis-a-vis Utera cropping. The decrease of EC in conventional tillage agrees with the findings of Qian *et al.,* (1994b) who reported that the opening and aeration of the top soil layers allowed increased leaching to occur in the surface soil.

Physical properties of soil

Bulk density

Bulk density was significantly influenced ($P \leq 0.05$) by the different tillage practice. The effect of tillage management was significant on the bulk density and it was found that the zero tillage vis-s-vis minimum tillage had lowest bulk density and they are significantly different from remaining treatment the BD was respectively 1.36 and 1.39Mgm^{-3} (Table 2) where was highest was recorded in the Utera cropping (1.41Mgm^{-3}). In conventional tillage the bilk density was 1.39Mgm^{-3} was recorded the BD was further increased with from 1.38 to 1.39 Mgm^{-3} by adding a plough with nari. This increase was the result of natural reconsolidation of soil particles because of subsequent irrigation and summer drying. The results are in line with the finding of Jat *et al.,* 2006. Therefore our finding reinforcing the fact that the gradual increase the disturbances in the soil by increased no of tillage and intercultural operations resulting more compaction of soil that leads to increase bulk density. The decrease in bulk density under tilled plots may be due to increase in non-capillary porosity and low soil mass per unit volume. Owing to the progressive increase in bulk density after tillage, the difference between the tilled and no tilled treatments becomes smaller and smaller with the time since tillage progresses. The results are in line with the finding of Lower BD under No Tillage than conventional tillage has also been reported by Green *et al.,* (2005) The No Tillage system maintained a significantly greater amount of residue on the soil surface increase soil organic carbon and biotic activity (Lal, 1989; Karlen *et al.,* 1994), thereby decreasing bulk density, particularly near the soil surface.

Porosity

Porosity was significantly influenced ($P \leq 0.05$) by the different tillage practice. The highest porosity was recorded in zero tillage system (48.20%) followed by conventional tillage with nari seed drill (47.92%) and lowest was found in Utera cropping (Table 2) and conventional tillage these both treatment slightly different values but statistically at par.

Table.1 Effect of different tillage management on pH, EC, Soil organic carbon and nutrient dynamics of soil

Treatments	pH	EC (dSm^{-1})	SOC ($g\ kg^{-1}$)	AN ($Kg\ ha^{-1}$)	AK ($Kg\ ha^{-1}$)	AP (Kg ha-1)	AS ($Kg\ ha^{-1}$)
Conventional tillage	6.63	0.11	4.27	252.06	175.95	16.95	18.69
Conventional tillage with Nari seed drill	6.62	0.12	3.90	250.97	189.62	16.81	19.12
Zero till by bullock drawn seed drill	7.01	0.14	4.83	282.24	203.29	20.40	22.71
Minimum tillage plough with nari	6.97	0.12	4.80	255.88	203.29	16.38	19.26
Utera Cropping	6.31	0.11	2.90	240.43	150.13	11.21	17.51
LSD	0.4	0.07	1.65	10.11	16.32	2.64	4.94
CV	3.2	31.88	17.98	2.09	4.70	8.56	10.87
Mean	6.71	0.11	4.89	256.32	184.46	16.35	18.66

Table.2 Effect of different tillage management on soil physical properties of soil

Treatments	BD (Mgm^{-3})	Porosity (%)	AWC (%)	WSA (%)	Sand (%)	SE(±)	Clay (%)	SE(±)	Silt (%)	SE(±)
Conventional tillage	1.39	46.89	38.08	56.02	60.32	0.07	27.47	0.31	12.22	0.47
Conventional tillage with Nari seed drill	1.41	47.92	41.40	59-00	59.91	0.60	27.33	0.59	12.63	0.44
Zero till by bullock drawn seed drill	1.38	48.20	44.43	59.32	58.87	0.93	28.87	0.43	13.80	0.34
Minimum tillage plough with nari	1.37	47.69	41.45	59.22	58.43	0.19	24.67	0.70	12.70	0.45
Utera Cropping	1.41	46.54	41.50	53.66	61.89	0.26	25.28	0.33	13.44	0.44
LSD	0.04	1.34	3.86	4.56						
Mean	1.38	47.85	41.37	57.44						

Fig.1 Influence of tillage management on available nitrogen and potassium

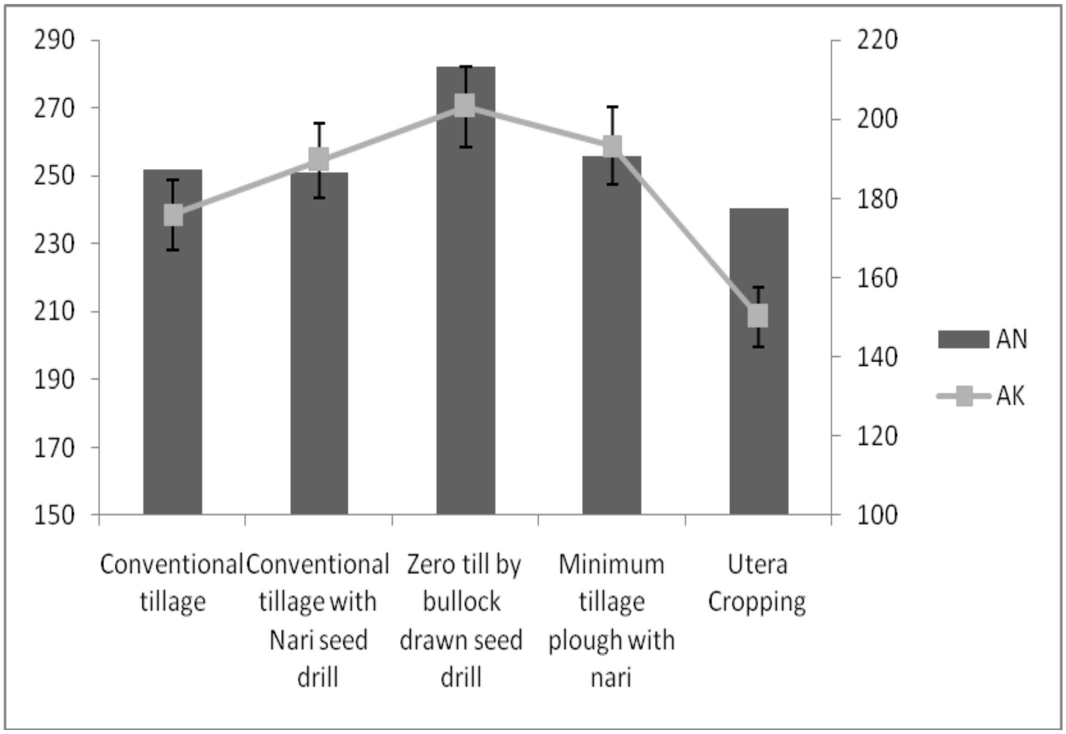


Fig.2 Influence of tillage management on available Phosphorous and pH

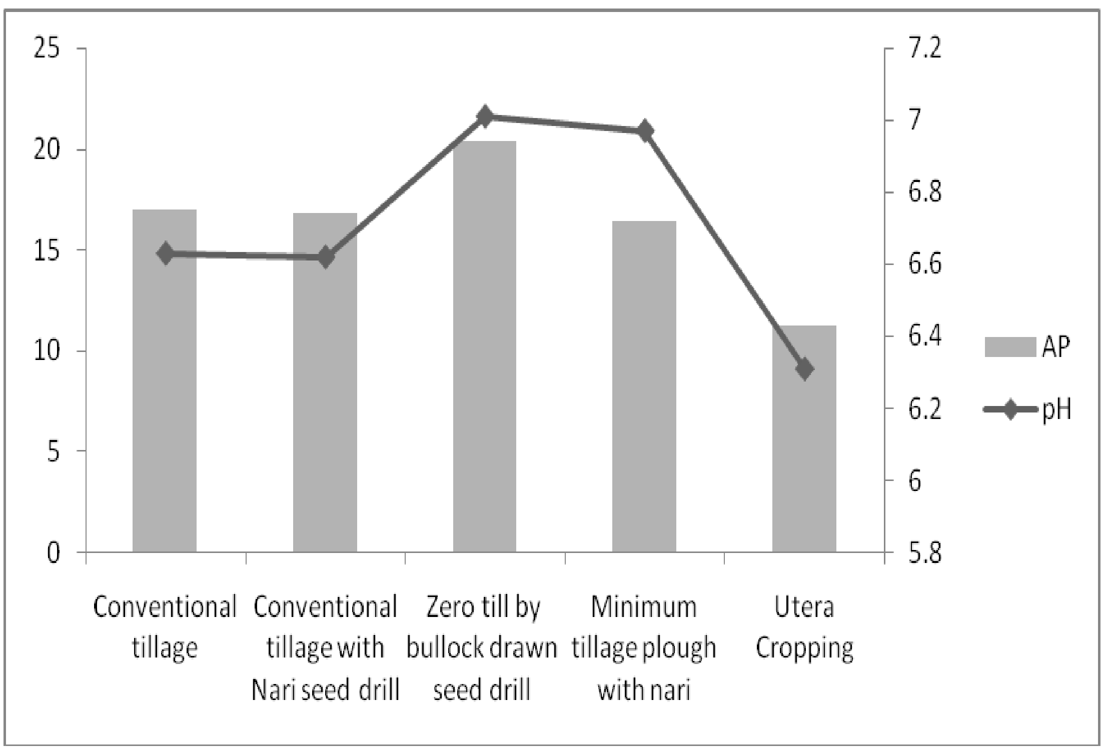


Fig.3 Influence of tillage management on soil organic carbon and available sulphur

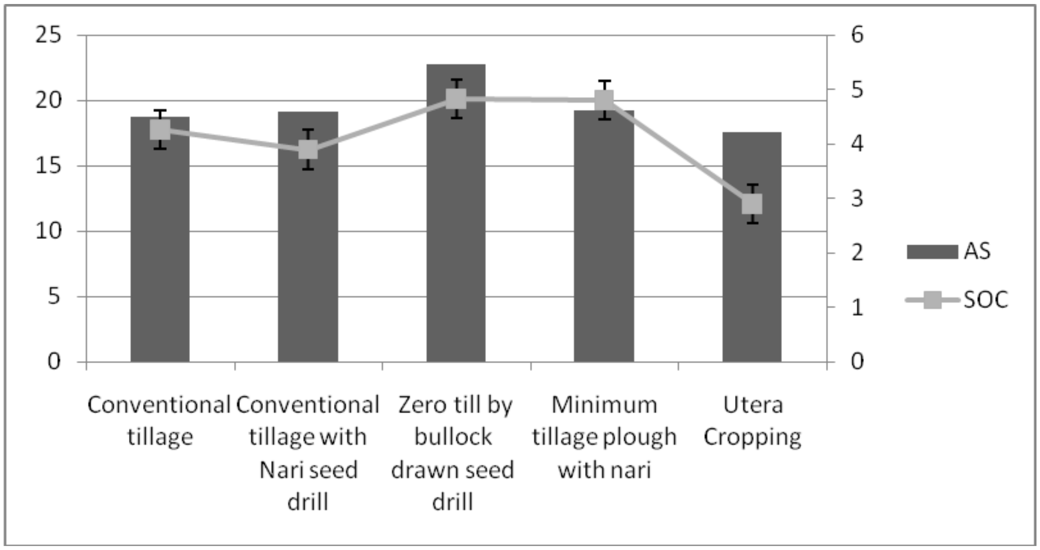
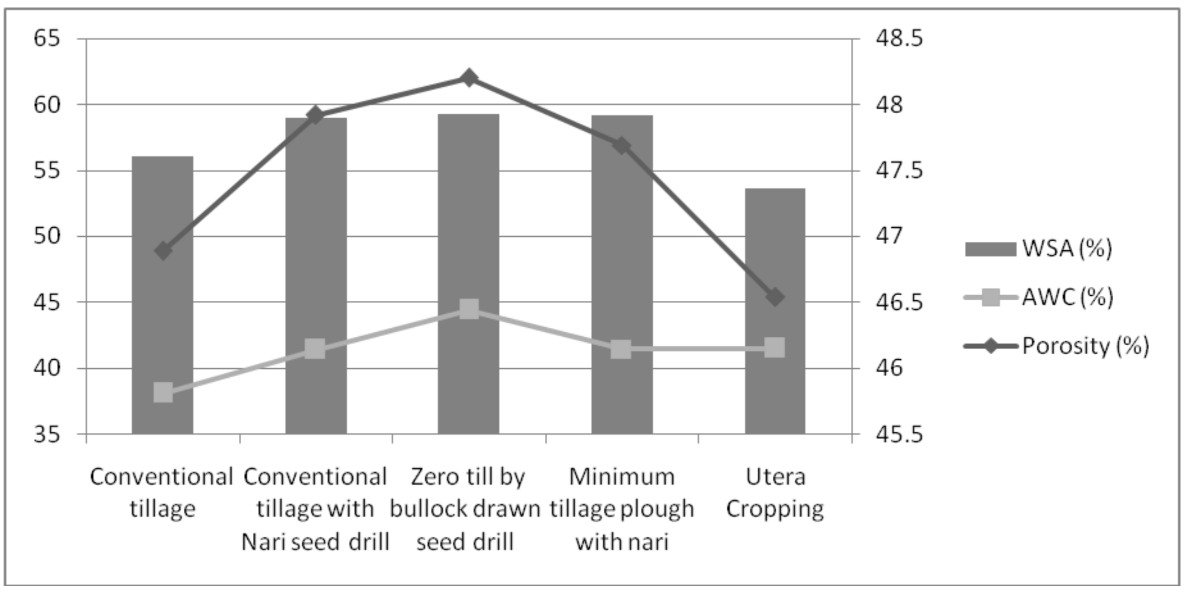


Fig.4 Influence of tillage management on porosity, water stable aggregate and available water content of Soil



It had been also reported that minimal and no tillage would decrease the soil porosity for aeration, but increase the capillary porosity; as a result, it enhances the water holding capacity (Fig. 4) of soil along with bad aeration of soil (Glab and Kulig, 2008). They reported that the porosity of soil with conventional tillage was significantly higher in comparison with reduced tillage.

Available water content

Available water capacity was significantly (Table 2) influenced ($P \leq 0.05$) The highest AWC was recorded in zero tillage system (44.43%) and lowest was recorded in conventional tillage system, moreover all the treatment were statistically at par. Our result was in agreement with (Gregorich *et al.*, 2005), who was reported that increases of soil water content, had been observed under zero-till system.

Water Stable Aggregate (WSA)

Reduced tillage practices showing the higher WSA compare with the intensive tillage and more intercultural operations. The highest WSA was recorded in Zero tillage (59.32%) followed by minimum tillage (59.22%) recorded utrea cropping system.

The same results were obtained by Hůla *et al.*, (2010), who found that, after three years, the ploughing variant showed worsened soil structure in comparison to reduced tillage. Soil tillage based on ploughing can result in faster deterioration of soil structure compared to shallower tillage less disturbing the soil.

According to various authors (Daraghmeh *et al.*, 2009; Bogužas *et al.*, 2010), site adaptable tillage, in comparison to conventional methods, increases the amount of water stable aggregates and improves (soil) structure due to a combination of greater amounts of organic matter, reduced bulk weight of soil, and a greater share of larger aggregates.

In conclusion, based on the investigated soil parameters, an assessment of soil macronutrient and physical parameters leads to the following findings: After long term tillage management years in the zero tillage and minimum tillage treatment a showed improve in accumulation of organic carbon content and plant available N, P and K near the soil surface have occurred.

Further it was also found that the enhancing in physical parameters of soil resulting in increased porosity and water stable aggregate hence more available water content which remarkable finding in agriculture and particularly in rainfed ecosystem.

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