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STEP UP IN PROPERTIES OF MEDIUM LAND SOIL THROUGH TILLAGE AND NUTRIENT MANAGEMENT UNDER OAT-RICE CROPPING SYSTEM

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Abstract: A field experiment was conducted at forage field situated at College of Veterinary Science and Animal Husbandry, campus of BAU Ranchi (Jharkhand) to study the effect of tillage and nutrient management on oat- paddy cropping system during 2011 and 2012. Results revealed that bulk density, aggregates and available moisture content of soil were marginally improved under zero tillage compared to conventional tillage under oat–rice system whereas, nutrient levels had no effect on soil physical properties. Organic carbon (3.87 g/kg) and available N (249.47 kg/ha) were higher under zero tillage compared to conventional tillage whereas, an opposite trend was noted in case of available P_2O_5 (31.76 kg ha^{-1}) and K_2O (163.02 kg ha^{-1}) in soil. With regards to nutrient levels, 125 % RDF recorded maximum available nutrients except available phosphorus where 75% RDF + Bio-fertilizers was at par with 125 % RDF. Biological properties of soil in terms of microbial populations (*Azotobacter* and *Actinomycets*) and CO_2 evolution were higher under zero tillage (7.87 x 10^4cells g^{-1} of soil, 30.87 x 10^6cells g^{-1} of soil and 378 mg kg^{-1} soil day^{-1}) respectively and negative response in biological properties specially the microbial population was noted with increased nutrient level. Interaction effect of the treatment was not observed on the properties of soil.

Keywords: Tillage, Nutrient management, Bio-fertilizer, Aggregates and Available soil moisture.

Introduction

India with 2.4 per cent of world geographical area constitutes about 16 per cent of human and 15 per cent of livestock population. The increasing population pressure on land has posed a major challenge before the agricultural scientist to produce more and more food and forage from limited physical and shrinking land resources. Jharkhand is a state with limited irrigation facility and rice-fallow is prevalent cropping system. Most of the farmers (about 86 %) are small and marginal having limited resources and they usually grow rice during rainy season and leave the land fallow during winter and summer, mainly due to deficit in soil moisture and lack of irrigation. Due to heavy pressure on soil and wrong method of tillage

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operation and injudicious use of fertilizer, deteriorating the soil quality and further resulted into poor fertility of soil.

Jharkhand soils are generally acidic in nature which causes fixation of mainly P and Ca leading to poor availability of major and micro nutrients (Singh and Sarkar, 1998). Use of bio-fertilizers are generally advocated under prevailing situation as they play an important role in improving N and P status of soil. Among the different sources of bio-fertilizer, phosphate solublizing bacteria (PSB) and *Azotobactor* can be applied along with lower levels of nutrient as alternate source to meet the high requirement of nutrient in multi-cut forage oat. *Azotobactor,* free living nitrogen fixing bacterium lives in association with plant roots and fixes atmospheric nitrogen in readily available form to plants. *Azotobactor* is also high respiring organism and hence works well in the soils having sufficient organic matter.

The use of PSB as inoculants simultaneously increases P uptake by the plant and crop yield. Strains from the genera *Pseudomonas* and *Bacillus* are among the most powerful phosphate solubilizers. Bio-fertilizer improves the N and P status of soil through fixation of nitrogen and release of fixed P and Ca which have positive correlation with soil health. Further, residual effect of tillage and nutrient applied to any crop may be evaluated in succeeding crop with regards to growth, yield and quality of the produce. Keeping in view the entire facts an experiment was conducted to assess the effect of tillage and nutrient management practices on changes in physical and chemical properties of soil under oat-rice cropping system.

Materials and methods

A trial was carried out during *Rabi* and *Kharif* season of 2011 and 2012 at the forage field situated at College of Veterinary Science and Animal Husbandry, campus Kanke under Birsa Agricultural University, Ranchi. Composite soil samples from the experimental plot before the experiment and individual soil sample from different plots after two year experimentation were taken. Soil samples were tested as per the standard methods of analysis on physical, chemical and biological properties. The soil of field was sandy loam in texture having sand (56.8%, silt (28.0%), clay (15.2%) and water holding capacity (38.68 %) with pH (6.2). The initial organic carbon (3.8 g kg^{-1}) with available nitrogen (232 kg ha^{-1}), available phosphorus (23.25 kg ha^{-1}) and available potassium (156.41 kg ha^{-1}). Further, available Ca (151.4 mg kg^{-1}), available Fe (55.0 mg/ kg), available Zn (1.13 mg kg^{-1}) available B (0.63 mg kg^{-1}), while in terms of biological character the population of Azotobactor (3.2 x 10^4 cells g^{-1} soil) *Actinomycetes* (12 x 10^6 cells g^{-1} soil) and CO2 evolution (107 mg kg $soil^{-1}$ day^{-1}) was present before the experimentation. The experiment was laid out in Split- plot Design (SPD) with three tillage management, Zero tillage, Minimal tillage and Conventional tillage under main plot and four nutrient management, 125 % RDF, 100 % RDF, 75 % RDF and 75% RDF+ Bio-fertilizer (PSB+ *Azotobactor*) in sub plot treatment and replicated thrice which were applied in oat. The fodder oat (Cultivar : Kent) was sown in the second week of November, keeping row to row distance 25 cm with recommended seed rate 100 kg/ha in 5 m X 4 m plot area under medium land condition. Fertilizers were applied at the time of sowing through urea, DAP and MOP as basal application. Bio-fertilizer was applied as seed inoculating material in the form of PSB @ 500 g/ha and *Azotobactor* @ 500 g/ha and further top dressing were carried through urea. Paddy was transplanted during *Kharif* after harvest of oat in the same laid out field at same levels of tillage and uniform fertilizer dose @100:50:25, NPK kg ha^{-1} (just 25% less than RDF). Paddy was grown at normal agronomical practice. The data on soil after two years of experimentations; yield and economics involved in oat and paddy recorded separately and later on same was calculated for the system. Data recorded were properly analyzed in standard format of Split- plot Design and presented below in tabular form.

Results and discussion

Soil Study

It is evident from the experimental data that tillage and nutrient management affected the organic carbon, bulk density, available N, P_2O_5, K_2O and population of *Azotobactor, Actinomycetes* and amount of CO_2 evolution while interaction of tillage and nutrient management have no affect on soil properties.

Physical properties

Bulk density of soil under zero tillage slightly improved. However, the effect of tillage and nutrient management on bulk density was not significant. Higher bulk density was obtained with the higher degree of compaction under different tillage systems (Table 1).

Soil aggregates in terms of Geometric Mean Diameter (GMD) was affected significantly by tillage management carried during the oat cultivation and it was significantly higher in zero tillage (0.70 mm) than minimal (0.68 mm) and conventional tillage (0.66 mm). Nutrient management and it's interaction with tillage management had no significant effect on soil aggregate. Field capacity of soil was not affected significantly due to different tillage and nutrient management. However some improvement was observed within the tillage treatments. Field capacity at 125 % RDF (20.93 %) was slightly higher over 75 % RDF and at par with rest of the levels. Permanent wilting point also followed the trend of field capacity. Tillage as well as nutrient management and its interaction have no significant effect on permanent wilting point of soil.

Tillage management significantly affected the available soil moisture. Its value was (10.70 %) under zero tillage which was significantly more than minimal tillage (9.54 %) as well as conventional tillage (8.74 %). Further, same under minimal tillage was higher than conventional tillage. As, the above character of soil is directly and indirectly influenced by the crop residue left in the field differently due to adoption of different tillage practices. As total biomass left in the field from forage oat crop residue and rice residue varied in amount differently and its total biomass in year in the field was affected by tillage as well as nutrient levels. Zero tillage (20.19 q ha^{-1}) received significantly more biomass over other tillage management. Similarly 125 % RDF also had higher biomass incorporation than other nutrient levels (Table 1). Organic carbon under zero tillage was significantly higher compared to minimal and conventional tillage, while bulk density under conventional tillage was maximum. This might be due to higher crop residues present under zero tillage over the other tillage and under this condition addition of organic matter led to improve the organic carbon content and accordingly reduced the compactness of soil resulted in less bulk density. Zero tilled plots received about 20.19 q ha^{-1} crop residues per annum which was about 90.83 per cent more than conventional and about 23.94 per cent more the minimal tillage which supplied nutrients through decomposition. Besides, a left over residual nutrients which was not fully utilized by oat also added the advantage to increase rice yield. Pierce *et al*. (1994) reported that minimal tillage reduced soil compaction as compared to conventional tillage and tillage had variable effects on bulk density. Soil aggregate in terms of geometric mean diameter (GMD) was highest under zero tillage while available soil moisture was higher under conventional tillage (Table 1). Marginal improvement in bulk density, aggregate and field capacity of soil was recorded at higher level of nutrients due to increase in decomposition of organic residues.

Chemical properties

Soil pH presented in table 4.13, showed that tillage as well as nutrient management and its interaction had no significant effect on soil pH. However, Organic carbon under zero tillage (3.95 g kg^{-1}) was significantly superior over minimal tillage (3.87 g kg^{-1}) and conventional tillage (3.80 g kg^{-1}) and similarly minimal tillage was significantly superior over conventional tillage. In other hand, nutrient management and it's interaction with tillage management had no affect on organic carbon (Table 2).

Availability of different nutrients (N, P_2O_5 and K_2O) after two years of experimentations was evaluated and found that the higher available N was in minimal tillage (252.08 kg ha^{-1}), while P_2O_5 (31.76 kg ha^{-1}) and K_2O (163.0 kg ha^{-1}) were recorded under conventional tillage compared to the rest of tillage managements. However, tillage management had no significant effect on available nitrogen in the soil. Among the different nutrient levels the highest available N (256.67 kg ha^{-1}) and K_2O (167.9 kg ha^{-1}) at 125 % RDF were significantly superior over other levels. Available N (249.95 kg ha^{-1}) and K_2O (156.30 kg ha^{-1}) at 100 % RDF were at par with 75% RDF + Bio-fertilizer while, P_2O_5 at 75% RDF + Bio-fertilizer (31.43 kg ha^{-1}) and at 125 % RDF (31.82 kg ha^{-1}) were at par to each other which were significantly superior over other levels of nutrient. Further 100 % RDF (27.31 kg ha^{-1}) and 75% RDF (27.78 kg ha^{-1}) were at par to each other. Interaction effect was not significant on availability of N, P_2O_5 and K_2O. Available nitrogen status of soil was influenced by different tillage and nutrient management. Maximum available nitrogen was recorded under minimal tillage as well as fewer than 125 % RDF. This may be pointed out that the biomass added due to incorporation of crop residue in different tillage and less utilization of nitrogen which reflected to forage and grain yield. As different amount of crop residue under different tillage management practices were remained in the soil and inoculation of bio-fertilizers (*Azotobacter* + PSB) improved the availability of nitrogen and phosphorus in the soil. Higher crop residues with chemical fertilizer maintained the soil fertility status. Similar findings were obtained under different cropping sequences in different soil types of India (Behra and Ram, 2004; Bajpai *et al.* 2006 and Laxminarayana, 2006). Organic matter on decomposition solubalized soil nutrient thus, resulted in significant improvement in available nutrient status of soil (Dahma, 2003).

Biological properties

Levels of tillage and nutrient management significantly influenced the population of *Azotobacter*, *Actinomycetes* and CO_2 evolution. *Azotobacter,* and *Actinomycetes* under minimal tillage (7.69 x 10^4 cells g^{-1}, and 30.52 x 10^6 cells g^{-1}) and under zero tillage (7.87 x 10^4 cells g^{-1}, and 30.87 x 10^6 cells g^{-1}) respectively were at par with each other and were significantly superior over conventional tillage (5.72 x 10^4 cells g^{-1} and 28.54 x 10^6 cells g^{-1}). Whereas, CO_2 evolution under zero tillage (378 mg kg^{-1} soil day^{-1}) was significantly superior over conventional and minimal tillage. *Azotobacter* and *Actinomycetes* population and CO_2 evolution decreased with the increased dose of fertilizer and same at 75% RDF + Bio-fertilizer (8.01 x 10^4 cells g^{-1}, 38.33 x 10^6 cells g^{-1} and 376 mg kg^{-1} soil day^{-1}) respectively were significantly higher over other levels of nutrient management. Interaction effect of treatments was not significant (Table 2). Biological properties in terms of microbial population density (*Azotobacter* and *Actinimycetes*) and CO_2 evolution were improved under zero tillage compared to conventional tillage and minimal tillage. Among the nutrient levels, population of microbes and CO_2 evolution remained higher under 75 per cent recommended dose of fertilizer along with biofertilizers compared higher levels of nutrient. This might be due to inoculation of microbes like *Azotobacter* and phosphate solublalizing bacteria. This was due to fact that at higher levels of nutrient, crop met up nutrient requirement from inorganic sources resulted in reduction of microbial activity (Devi *et al.* 2009). They also reported the efficiency of microbes increased at lower dose of nutrient. Continuous cropping exhausted the native pool of nutrient which caused reduction in total microbial population. Soil enzymes were largely a function of microbial activities and influenced by agronomic practices that enhanced microbial numbers and biomass present in soil.

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Table 1: Effect of tillage and nutrient management on organic matter incorporation and physical properties of soil under oat –paddy cropping system.

Treatments	Biomass left per year in the soil	Physical properties				
		Bulk density (Mg m^{-3})	Aggregate GMD (mm)	Field capacity (%)	Permanent wilting point (%)	Available soil moisture (%)
Tillage Management (T)						
Zero tillage	20.19	1.58	0.70	20.35	10.98	10.70
Minimal tillage	16.29	1.56	0.68	20.52	11.41	9.54
Conventional tillage	10.58	1.56	0.66	20.38	11.06	8.74
S.Em ±	0.42	0.01	0.003	0.36	0.24	0.17
CD at 5%	1.64	NS	0.01	NS	NS	0.67
Nutrient Management (N)						
125 % RDF	17.73	1.56	0.68	20.93	11.36	9.56
100 % RDF	15.51	1.55	0.68	20.53	11.22	9.46
75 % RDF	14.09	1.54	0.68	19.71	10.95	9.44
75 % RDF +Bio-fertilizers	15.44	1.54	0.69	20.48	11.07	10.25
S. Em ±	0.57	0.03	0.01	0.47	0.27	0.24
CD at 5%	1.69	NS	NS	NS	NS	0.69
CV %	10.89	5.79	6.56	6.91	7.26	7.44
Interaction(TXN)	NS	NS	NS	NS	NS	NS

Table 2: Effect of tillage and nutrient management on chemical and biological properties of soil under oat –rice cropping system.

Treatments	Chemical Properties					Biological properties		
	pH	Organic carbon (g kg^{-1})	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})	*Azotobactor* (x 10^4 cells g^{-1})	*Actinomycete* (x 10^6cells g^{-1})	CO_2 evolution (mg kg^{-1} soil day^{-1})
Tillage Management (T)								
Zero tillage	6.21	3.95	249.41	28.82	154.52	7.87	30.87	378
Minimal tillage	6.21	3.87	252.08	28.17	159.82	7.69	30.52	359
Conventional tillage	6.20	3.80	246.74	31.76	163.02	5.72	28.54	353
S.Em ±	0.09	0.01	2.10	0.05	0.08	0.04	0.33	1.99
CD at 5%	NS	0.04	NS	0.20	0.32	0.15	1.29	7.80
Nutrient Management (N)								
125% RDF	6.22	3.93	256.67	31.82	167.9	6.16	24.89	347.
100% RDF	6.21	3.88	249.95	27.78	159.3	6.84	27.02	362.
75% RDF	6.20	3.85	241.84	27.31	150.4	7.37	29.67	368
75% RDF+-Bio-fertilizer	6.20	3.86	249.18	31.43	158.9	8.01	38.33	376
S.Em ±	0.07	0.09	4.32	0.87	2.76	0.12	0.75	6.45
CD at 5%	NS	NS	12.83	2.58	8.19	0.35	2.22	19.15
CV %	3.40	6.95	5.19	8.82	5.20	5.07	7.50	5.32
Interaction(TXN)	NS	NS	NS	NS	NS	NS	NS	NS