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Soil Biological Properties as Influenced by Tillage and IPNS under Soybean-Cotton Rotation in Vertisol

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A B S T R A C T

The present investigation was conducted during kharif 2016-17 with a view to study the effect of various tillage and IPNS practices on soil biological properties under soybean – cotton rotation in Vertisol. The experiment was conducted at Research Farm, Department of Soil Science and Agricultural Chemistry, Dr. PDKV, Akola. The experiment was carried out with main plot comprises two treatments i.e. conservation tillage (CNS) (one harrowing and two weeding) and conventional tillage (CNV) (one ploughing, one harrowing, two hoeing and two hand weeding) and eight sub plot treatments of integrated plant nutrient system consisting of control, 100 per cent RDF and use of chemical fertilizer along with organic source of nutrient in which 50 per cent N applied through organic sources (FYM, wheat straw, Glyricidia leaf manuring (GLM), composted cotton straw, Vermicompost and Phosphocompost) and remaining N was applied through chemical fertilizers. The soybean variety JS-335 was undertaken for the experiment with general recommended dose of fertilizer 30:75:30 N, P_2O_5, K_2O kg ha^{-1}. The experiment was framed in randomized block design (RBD) with three replications. Among the tillage practices, significantly higher soybean seed yield and biological properties viz., SMBC (276 µg g^{-1}), DHA (67.72 µgTPF g^{-1} 24 h^{-1}), CO_2 evolution (68.58 mg 100 g^{-1} soil) and SOC stock (11.85 Mg ha^{-1}) were recorded in conservation tillage as compared to conventional tillage under soybean-cotton rotation. The various integrated plant nutrient supply treatments influenced significantly highest biological properties viz., SMBC (279 µg g^{-1}), DHA (72.25 µgTPF g^{-1} 24 h^{-1}), CO_2 evolution (71.25 mg 100 g^{-1} soil) and SOC stock (12.16 Mg ha^{-1}) were recorded with the application of FYM in conjunction with chemical fertilizers. Whereas, the highest seed yield was recorded with the application of phosphocompost along with chemical fertilizer.

Introduction

Conservation agriculture has emerged as a new paradigm to achieve the goals of sustainable agricultural production. It involves the new and innovative ways of generating and promoting technologies that focus on resource conservation as a way to enhance productivity in a sustainable manner. Conservation agriculture aims at reversing the process of degradation inherent to the conventional agricultural practices like intensive cultivation and burning or removal of crop residues. Aggressive seed bed preparation with heavy machinery lead to declining soil fertility, biodiversity and erosion. The nutrient needs of the Indian agriculture are so large that no single plant nutrient source be it fertilizers, organic manures, green manures or biofertilizers is in position to meet the entire plant nutrient demand. Therefore, resource conservation becomes a top priority and restoration of precious soil resource by way of innovative means of management is the need of the day.

Soil is the only and finite natural resource of the production of different crops. The degradation of soil health has emerged as a major factor responsible for stagnation in agricultural production and is posing a serious threat to our national food security for the last few years. The degradation of soil health in many cultivated areas is manifested in terms of loss of soil organic matter and depletion of native soil fertility due to imbalanced and unscientific use of fertilizer. This has become a major constraint now in improving crop productivity. The escalating population, attenuating good quality land resources for crop production and increasing concern for declining soil quality and environment degradation highlight the urgency for continuously enhancing and sustaining the productivity of land. The high yielding hybrid varieties of many crops are being grown by the farmers in the country which resulted in heavy nutrient mining from the soil. The utility of land to produce yield is limited and limits of production are set by soil and climatic parameters.

Soybean cultivation is continuously increasing due to its dual utility as pulse as well as oil seed crop, besides it has better market price, high protein content (40-42 %) and oil content (20-22 %). It is the cheapest and richest source of high quality protein. It supplies most of the nutritional constituents essential for human health. Hence, soybean is called as “Wonder bean” or “Miracle bean”. Soybean occupies an intermediate position between legumes and oilseed. It is grown in the area which receive 800-1200 mm rainfall and on almost all types of soil. Soybean crop contributes 24-30 q ha^{-1} residues which can be recycled and nutrient content therein be harnessed for the succeeding crop besides improving the soil fertility.

In India, area under soybean cultivation is approximately 9.95 m ha with production of 12.57 MT. Maharashtra ranks 2nd in soybean cultivated area and production in country. The area under soybean crop in Maharashtra is 35.80 lakh ha of total cultivated area of the country with an average productivity of 1102 kg ha^{-1} and production 39.45 lakh MT. (Anonymous, 2016). Out of total soybean cultivated area in Maharashtra 75 to 80% area is in Vidarbha. The area under soybean cultivation in Vidarbha is 25.50 lakh ha with production of 21.62 lakh MT and average productivity is 1050 kg ha^{-1}.

Materials and Methods

The field experiment was conducted on research farm of Department of Soil Science and Agricultural Chemistry. The effect of conventional and conservation tillage was assessed along with different organic and inorganic fertilizers. The study was conducted in Kharif 2016-17. The effect of tillage and organic sources were studied on soil properties under soybean and cotton crop rotation.

The experiment was carried out with main plot comprises two treatments i.e. conservation tillage (CNS) (one harrowing and two weeding) and conventional tillage (CNV) (one ploughing , one harrowing, two hoeing and two hand weeding) and eight sub plot treatments of integrated plant nutrient system consisting of control, 100 per cent RDF and use of chemical fertilizer along with organic source of nutrient in which 50 per cent N applied through organic sources (FYM, wheat straw, Glyricidia leaf manuring (GLM), composted cotton straw, Vermicompost and Phosphocompost) and remaining N was applied through chemical fertilizers. The experiment was framed in randomized block design with three replications. The variety JS-335 was sown in the present investigation. The general recommended dose of fertilisers 30:75:30 N, P_2O_5, K_2O kg ha^{-1} was used. The N, P and K were applied in the form of urea, single super phosphate and muriate of potash. Treatment wise basal doses (half nitrogen and full phosphorus and potassium) of fertilizers were calculated and applied at the time of sowing and remaining half dose of nitrogen was applied at flowering to soybean, thoroughly mixed in the soil. The crop residues were decomposed by PDKV decomposer. FYM, wheat straw, composted cotton stalk, vermicompost, phoshpocompost and glyricidia green leaves were applied as a source of nutrient in soil. The different organics and crop residues were applied based on NPK content. The crop residues and Glyricidia green leaves were applied in between two rows of soybean and thoroughly mixed in the soil. Simultaneously the crop residue samples were collected and analysed for nutrient composition. The plant samples of soybean seed and straw were collected at the time of harvest and analysed for various nutrient content and uptake of nutrients and plot wise soybean and straw yields were recorded.

Results and Discussion

Seed yield of soybean

The various tillage practices significantly influenced on soybean seed and straw yield (Fig. 1). The soybean seed yield was recorded maximum in conservation tillage as compared to conventional tillage. The highest soybean seed yield in conservation tillage might be due to its cumulative effect of soil moisture which ultimately helps in improving nutrient supplying capacity of soil, use efficiency, thus it directly influences on uptake of higher nutrients in conservation tillage than conventional tillage. Similar finding was reported by Khan *et al*.,(2015) and Mehdi *et al*., (2016).

The highest seed yield of soybean was recorded with the application of 100 % N through phoshpocompost + remaining P through chemical fertilizer followed by the use of 50 % N through vermicompost + remaining RD through chemical fertilizer. The increase in yield with IPNS treatments may be due addition of organics which enhances soil fertility and resulted in higher yield. These results are in close conformity with the findings Saini *et al.* (2005) and Kundu *et al.* (2008).

Due to solubilisation of native as well as applied nutrient fertilizers at higher level with crop residues produces complexing agents and nutrients are released after microbial decay of crop residue ultimately increase the grain yield. Similar findings were reported by Deshmukh *et al.* (2010).

The increase in seed yield of soybean with 100 % N through phoshpocompost + remaining P through chemical fertilizer could be attributed to cumulative effect of better growth that produced more number of pods which ultimately increased the seed yield. Similar findings were reported by Singh and Kumar (2012) and Sikka *et al.* (2012),The increased in seed yield due to residual effect of balanced fertilization with secondary nutrients and micronutrients was also recorded by Jadhao *et al.* (2018).

Soil biological properties

Soil microbial biomass carbon

The significantly higher soil microbial biomass carbon was observed in conservation tillage (276 µg g^{-1} soil) as compared to conventional tillage (263 µg g^{-1} soil). The greater amount of crop residue incorporation and burying in plot remaining with conservation tillage might have provided available substrate for maintenance of larger SMB pool and higher C and N mineralization. The results were in consonance with the finding of Gabhane et *al*., *(*2014). Similar observations were recorded by Rao (2007) indicating greater amount of microbial biomass carbon in minimum tillage as compared to conventional tillage.

The sources of organics under study have recorded on par results in soil microbial biomass carbon. However, application of 50 % N through FYM + remaining RD through chemical fertilizer recorded significant improvement in soil microbial biomass carbon (279 µg g^{-1} soil) over all other treatments and application of 100 % N through phoshpocompost + remaining P through chemical fertilizer was found on par with control. The treatment where only organics were added including crop residues, phoshpocompost, vermicompost and glyricidia green leaf manuring with inorganic fertilizers showed increase in soil microbial biomass carbon over 100 % RDF. It might be due to the supply of readily available and mineralizable carbon by the addition of organic matter resulted in higher microbial activity and it turns increased the microbial biomass carbon. This indicated that, systems with high organic matter inputs and easily available soil organic matter compounds tends to have higher microbial biomass contents and activities because they are preferred energy sources for microorganisms. These results are in conformity with Manna *et al.* (2005) and Ingle *et al.* (2014). The Interaction between tillage and IPNS on soil microbial biomass carbon was non significant (Table 1).

Dehydrogenase activity

The higher dehydrogenase activity was observed in conservation tillage (67.72 µg TPF g^{-1} 24 h^{-1}) as compared to conventional tillage (58.08 µg TPF g^{-1} 24 h^{-1}). Similar findings were reported by Nager *et al*., (2017) and Gabhane *et al*., (2014) (Table 2).

The significant improvement of dehydrogenase activity was observed due to 50 % FYM + remaining RD through chemical fertilizer (72.32 µg TPF g^{-1} 24 h^{-1}) followed by (70.44 µg TPF g^{-1} 24 h^{-1}) 100 % N through phoshpocompost + remaining P through chemical fertilizer for soybean and (69.33 µg TPF g^{-1} 24 h^{-1}) 50% N through GLM + remaining RD through chemical fertilizer. The stronger effects of FYM on dehydrogenase activity might be due to the more easily decomposable components of crop residues on the metabolism of soil microorganisms and due to the increase in microbial growth with addition of carbon substrate. Significant increase in dehydrogenase activity with the application of FYM might be due to increase in microbial growth with addition of carbon substrate reported by Kharche *et al*., (2010).

The FYM application was superior in improving DHA as it stratified microbial population. Also, being chief carbon source, it provides energy for soil microorganisms, and increases number of pores, which are considered important in soil-water–plant relationships and maintain good soil structure accompanied by better dehydrogenase activity Marinari *et al.,* (2000). The significantly lower DHA at only chemical fertilizer in comparison with high DHA under crop residues, green manuring indicate the importance of organics for soil biological health. The Interaction between tillage and IPNS on dehydrogenase activity of soil was non significant on biological properties of soil.

CO_2 evolution

The higher CO_2 evolution was noticed in conservation tillage (68.58 mg 100 g^{-1} soil) as compared to conventional tillage (63.53 mg 100 g^{-1} soil). Similar finding were reported by Lal and Jacinthe (2009) (Table 3).

Table.1 Effect of tillage and IPNS on Soil Microbial Biomass Carbon of soil at grand growth stage of soybean under soybean-cotton rotation

	Treatments	**SMBC (µg g^{-1})**
	(a)Tillage	
	Set I-Conservation tillage	276
	Set II -Conventional tillage	263
	SE(m)±	1.99
	CD at 5 %	5.76
	(b) Integrated plant nutrient system	
T_1	Control	248
T_2	100 % RDF	262
T_3	50 % N through FYM + remaining RD through chemical fertilizer	279
T_4	50% N through WS+ remaining RD through chemical fertilizer	269
T_5	50% N through GLM + remaining RD through chemical fertilizer	278
T_6	50 % N through composted cotton stalk+ remaining RD through chemical fertilizer	265
T_7	50 % N through vermicompost+ remaining RD through chemical fertilizer	277
T_8	100 % P through phoshpocompost+ remaining N through chemical fertilizer	279
	SE(m)±	3.99
	CD at 5 %	11.52
	(c) Interaction	NS

Table.2 Effect of tillage and IPNS on Dehydrogenase activity of soil at grand growth period of soybean under soybean-cotton rotation

	Treatments	**DHA (µgTPF g^{-1} 24 h^{-1})**
	(a)Tillage	
	Set I-Conservation tillage	67.72
	Set II -Conventional tillage	58.08
	SE(m)±	0.68
	CD at 5 %	1.95
	(b) Integrated plant nutrient system	
T_1	Control	48.03
T_2	100 % RDF	59.48
T_3	50 % N through FYM + remaining RD through chemical fertilizer	72.32
T_4	50% N through WS+ remaining RD through chemical fertilizer	63.20
T_5	50% N through GLM + remaining RD through chemical fertilizer	69.33
T_6	50 % N through composted cotton stalk+ remaining RD through chemical fertilizer	51.36
T_7	50 % N through vermicompost+ remaining RD through chemical fertilizer	68.91
T_8	100 % P through phoshpocompost+ remaining N through chemical fertilizer	70.44
	SE(m)±	1.35
	CD at 5 %	3.91
	(c) Interaction	NS

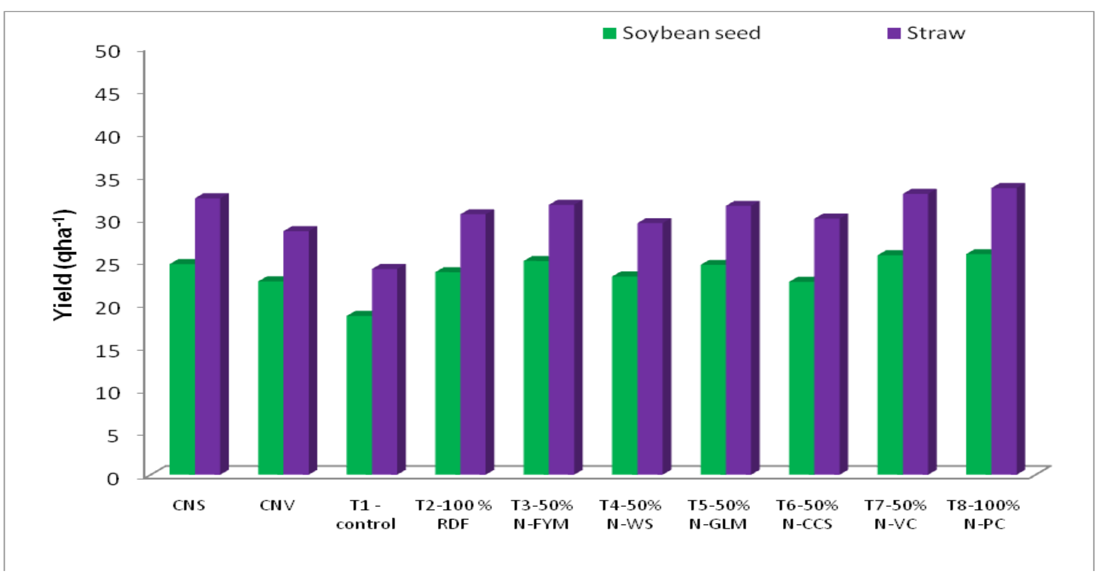
Table.3 Effect of tillage and IPNS on CO_2 evolution of soil of soybean under soybean-cotton rotation

	Treatments	**CO_2 evolution (mg 100 g^{-1} soil)**
	(a)Tillage	
	Set I-Conservation tillage	68.58
	Set II -Conventional tillage	63.53
	SE(m)±	0.50
	CD at 5 %	1.45
	(b) Integrated plant nutrient system	
T_1	Control	53.12
T_2	100 % RDF	61.53
T_3	50 % N through FYM + remaining RD through chemical fertilizer	71.25
T_4	50% N through WS+ remaining RD through chemical fertilizer	68.11
T_5	50% N through GLM + remaining RD through chemical fertilizer	70.22
T_6	50 % N through composted cotton stalk+ remaining RD through chemical fertilizer	69.51
T_7	50 % N through vermicompost+ remaining RD through chemical fertilizer	70.68
T_8	100 % P through phoshpocompost+ remaining N through chemical fertilizer	71.02
	SE(m)±	1.00
	CD at 5 %	2.89
	(c) Interaction	NS

Table.4 Effect of tillage and IPNS on SOC stock in soil after harvest of soybean under soybean-cotton rotation

	Treatments	**SOC Stock ($Mg\ ha^{-1}$)**
	(a)Tillage	
	Set I-Conservation tillage	11.85
	Set II -Conventional tillage	11.66
	SE(m)±	0.10
	CD at 5 %	0.29
	(b) Integrated plant nutrient system	
T_1	Control	11.28
T_2	100 % RDF	11.42
T_3	50 % N through FYM + remaining RD through chemical fertilizer	12.16
T_4	50% N through WS+ remaining RD through chemical fertilizer	11.49
T_5	50% N through GLM + remaining RD through chemical fertilizer	12.13
T_6	50 % N through composted cotton stalk+ remaining RD through chemical fertilizer	11.52
T_7	50 % N through vermicompost+ remaining RD through chemical fertilizer	11.94
T_8	100 % P through phoshpocompost+ remaining N through chemical fertilizer	12.09
	SE(m)±	0.20
	CD at 5 %	0.57
	(c) Interaction	NS

Fig.1 Effect of tillage and IPNS on soybean seed and straw yield under soybean-cotton rotation



SOC Stock

The significantly higher SOC stock was recorded in conservation tillage (11.85 Mg ha^{-1}) as compared to conventional tillage (11.66 Mg ha^{-1}) after harvest of soybean. Similar findings were reported by Liu *et al.*, (2005) (Table 4).

The Significantly higher SOC stock was observed with the addition of 50 % N through FYM + remaining RD through chemical fertilizer (12.16 Mg ha^{-1}) which was significantly superior over all the other treatments and lowest SOC stock was observed under control (11.28 Mg ha^{-1}). Thus results, suggested that the use of FYM, Phosphocompost, crop residues and green manuring with chemical fertilizers help in maintaining SOC Stock of soil over a long term period.

Addition of organic materials might have enhanced the microbial activity in the soil and consequently the release of complex organic substances like humic and fulvic acids acting as chelating agents during the decomposition of organic manure and crop residue. This could have prevented carbon from precipitation, fixation, oxidation, leaching and augmented the solubility, mobility, availability of insoluble micronutrients by Manna *et al*.,(2005). The Interaction between tillage and IPNS on SOC stock was non significant.

In conclusion, among the tillage practices, significantly higher soybean seed yield and biological properties viz., SMBC, DHA, CO_2 evolution and SOC stock were recorded in conservation tillage as compared to conventional tillage under soybean-cotton rotation. The various integrated plant nutrient supply treatments influenced significantly highest soybean seed and biological properties viz., SMBC, DHA,CO_2 evolution and SOC stock were recorded with the application of phosphocompost in conjunction with chemical fertilizers followed by FYM, GLM and vermicompost under conservation tillage.

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