

Original Research Article

<https://doi.org/10.20546/ijcmas.2020.910.111>

Soil Physical and Biological Conditions as Influenced by Resource Conservation Practices under Cotton Based Soybean Rotation in Vertisols

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ABSTRACT

The present study was undertaken during 2016-17 at Research farm, Dr. PDKV, Akola. The experiment was laid out in Randomized Block Design with nine treatments replicated three times in Vertisols. The objective of the present experiment was to evaluate the effect of different resource conservation practices on soil physical and biological condition under cotton based soybean rotation in Vertisols. The cotton based soybean rotation was followed since 2011-12. The present experiment was superimposed on soybean during 2016-17. The treatments comprised for soybean crop was recommended dose of fertilizer (RDF) alone and their compensation with organics viz., FYM, phosphocompost, neemcake, bio mulch (farm waste) and green leaf manuring. The results of the present experiment indicated that, the organic carbon was improved with the application of RDF + PC to soybean and 100 % N (FYM) + compensation of P (phosphocompost) to preceding cotton crop resulted improvement in physical conditions of soils i.e. bulk density (1.33 Mg m^{-3}), hydraulic conductivity (0.75 cm hr^{-1}) and AWC (21.80%). The biological properties viz; dehydrogenase activity (DHA) ($56.8 \mu\text{g TPF g}^{-1} \text{ soil } 24 \text{ hr}^{-1}$) and CO_2 evolution ($37.7 \text{ mg CO}_2 \text{ evolved } 100^{-1} \text{ g soil}$) was improved with the application of RDF + PC to soybean and 100 % N (FYM) + compensation of P (phosphocompost) to preceding cotton crop. The seed and straw yield of soybean was noticed with RDF to soybean and 25 % N through Neemcake + RDF compensation to preceding cotton crop under cotton-soybean rotation. Thus, it can be inferred that, the management intervention comprising use of RDF along with phosphocompost to soybean and RDF through FYM + remaining P through phosphocompost to cotton crop helps to improve soil physical and biological properties of soil under cotton based soybean rotation in Vertisols.

Keywords

Conservation Practices, Soybean, Dehydrogenase activity, Bulk density, CO_2 evolution

Article Info

Accepted:
10 September 2020
Available Online:
10 October 2020

Introduction

The enhanced carbon status helps to improve physical and biological properties of soil like bulk density, mean weight diameter, soil

microbial biomass carbon, soil microbial biomass nitrogen and other enzymatic activities. The organic carbon is the key parameter in soil which influences all the physical, chemical and biological properties

of soil. In recent days the content of organic carbon in the soils of semi arid areas is seriously declining.

Soil micro-organisms play a vital role in soil health but are often forgotten in farming systems. There is a growing interest in their beneficial effects, their role as soil health indicators and factors that influence their abundance and diversity. As soil micro-organisms decompose the organic matter and assimilate a portion of the nutrients in soils to build their body. The nutrients in soil microbial biomass are mineralized from the dead micro-organisms. Therefore, soil microbial biomass is considered as a source and sinks for nutrients and is an active pool of organic matter in the soil.

The integrated nutrient management envisages the use of chemical fertilizers in conjunction with organic manures, biofertilizers and other locally available nutrient sources for sustaining soil health and productivity. The combined application of organic manures and chemical fertilizers produces higher crop yield than when each is applied alone. This increase in crop productivity may be due to the combined effect of nutrient supply, synergism and improvement in soil physical and biological properties.

Soil physical conditions, no doubt are slow to respond for their improvement but are essential to maintain the health of soils. Soil physical properties have profound influence on nutrient availability which is important attributes of soil quality. Most physical properties of soil are largely influenced by management and the change in physical properties of soil is exhibited only under long-term adoption of management measures. The important physical properties of soil viz., bulk density, hydraulic conductivity, water retention, available water capacity and mean

weight diameter are generally considered as soil quality indicators. The basic concept underlying the principles of Integrated Nutrient Management (INM) is the maintenance and possibly improvement of soil fertility for sustaining crop productivity on long-term basis. This may be achieved through combined use of all possible sources of nutrients and their scientific management for optimum growth, yield and quality of different crops and cropping systems.

The favorable effects of FYM on physical properties of soil and also as a source of plant nutrients, which are released on its mineralization and become available to plants is well known. Incorporation of organic manures alone and in combination with inorganic fertilizers resulted into decrease in the pH, bulk density and penetration resistance and increased organic carbon content, porosity, infiltration rate, hydraulic conductivity and water stable aggregates (Chalwade *et al.*, 2006). Managing organic source of plant nutrients with mineral fertilizer and their incorporation into the soil in a cropping system has certain favorable and augmenting effects on soil physical properties for sustainability and high productivity of crop.

In view of the above, the experiment was conducted to assess the effect of Resource Consequence Practices on Soil Physical and Biological Conditions under Cotton based soybean rotation in Vertisols.

Materials and Methods

The present experiment was carried out during 2016 -17 on cotton based soybean rotation at Research Farm, Department of Soil Science and Agriculture Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The experiment was laid out in Randomized Block Design with nine

treatments replicated three times located at between on 22°42' N latitude and 77°02'E longitude at an altitude of 307.42 m above MSL and has a subtropical climate. The soil of the experimental site was clayey in nature, Bulk density 1.41 Mg m⁻³ with pH 8.33 (1:2 soil: water) (Piper, 1966), low in EC (Piper, 1966), low in organic matter content of 5.4 g kg⁻¹ (Jackson, 1967), low in available N (Kjeldahl's method) (Subbiah and Asija, 1956), medium in available P (Jackson, 1967) and high in available K (Jackson, 1967) at the start of experiment.

The experiment was laid out in Randomized Block Design with nine treatments replicated three times. The treatments for cotton based soybean rotation are given below (Table 1).

The RDF of soybean was 30:75: kg N, P and K ha⁻¹. The N, P and K were applied through fertilizers viz. urea, single super phosphate (SSP) and muriate of potash containing 46, 16.0 and 60 per cent N, P₂O₅ and K₂O, respectively. Soil samples were collected at 0-15 cm depth from nine treatment plots of all the three replications before sowing in kharif and after harvest of soybean crop during 2016-17 and used for analysis of physical and biological properties. In brief, bulk density was determined by clod coating technique as described by Blake and Hartge (1986). Hydraulic conductivity of soil was determined by Constant head method by Black (1965).

Available water capacity of soil was determined by Pressure plate membrane apparatus method as per Klute (1986). Dehydrogenase activity determined by Assay method as described by Klein *et al.*, (1971). CO₂ evolution was determined by Alkali trap method as described by Anderson (1982).

The plant biomass dry matter of each net plot were threshed, cleaned and weighed. Net plot yield and yield per hectare was calculated

separately. The data on different parameters were tabulated and analyzed statistically by the methods described by Panse and Sukhatme (1971).

Results and Discussion

Soil physical properties

Bulk density is of greater significance in governing the physical condition of soils, generally soils having low and high bulk densities exhibit favorable and poor physical conditions, respectively.

The effect of different resource conservation practices on bulk density of soil was found to be significant. Numerically lower values of bulk density (1.33 Mg m⁻³) were recorded in treatment receiving RDF through FYM + remaining P through phosphocompost (100% N through FYM + compensation of P through phosphocompost to previous cotton) and was found beneficial in improving soil physical condition.

Lowering the bulk density in organic manure applied may be due to higher organic matter, more pore space and good soil aggregation. Mosavi *et al.*, (2010) showed that the application of green manure effects was significantly improved aggregate stability, soil bulk density and available water capacity (AWC). Sharma *et al.*, (2007) observed that the highest bulk density in the control and it decreased modestly with increasing level of NPK from 50 to 150% of the recommended dose.

Bulk density in 100% NPK + FYM was significantly lower than all other treatments. Selvi *et al.*, (2003) revealed that the application of FYM @ 10 t ha⁻¹ along with 100 % NPK recorded significantly lower bulk density.

Table.1 Treatment details under cotton based soybean rotation

Tr.	Rotation	
	Cotton	Soybean
T ₁	100% RDF(50:25:00 kg NPK ha ⁻¹)	RDF
T ₂	<i>Sesbania aculeata</i> 25% N + compensation of RDF	RDF
T ₃	Cotton stalk 25% N composted with <i>trichoderma viride</i> + compensation of RDF	RDF
T ₄	Wheat straw 25% N + compensation of RDF	RDF
T ₅	Bio mulch (farm waste) 25% N + compensation of RDF	RDF
T ₆	Conc. organics (Neemcake) 25% N + compensation of RDF	RDF
T ₇	100% N through FYM+ compensation of P through phosphocompost	RDF through FYM + remaining P through phosphocompost
T ₈	50% N through FYM + compensation of P through phosphocompost & remaining N through urea	RDF through FYM + remaining P through phospho- compost
T ₉	<i>Leucaena loppings</i> 50% N + compensation of P through phosphocompost & remaining N through urea	RDF through FYM + remaining P through phospho compost

Table.2 Effect of different resource conservation practices on physical properties of soil after harvest of soybean

Tr.	Treatment details		BD (Mg m ⁻³)	Hydraulic conductivity (cm hr ⁻¹)
	Cotton	Soybean		
T ₁	RDF	RDF	1.41	0.65
T ₂	25 % N (Dhaincha loppings) + RDF compensation	RDF	1.38	0.74
T ₃	25 % N (Cotton stalk) composted + RDF compensation	RDF	1.40	0.67
T ₄	25 % N (Wheat straw) + RDF compensation	RDF	1.36	0.66
T ₅	25 % N (Bio mulch)+ RDF compensation	RDF	1.39	0.69
T ₆	25 % N (Neemcake) + RDF compensation	RDF	1.39	0.68
T ₇	100 % N (FYM) + compensation of P (phosphocompost)	RDF+PC	1.33	0.75
T ₈	50 % N (FYM) +P compensation (phosphocompost)+N compensation (Urea)	RDF+PC	1.35	0.72
T ₉	50% N (Leucaena loppings) + P compensation (phosphocompost)+N compensation (Urea)	RDF+PC	1.36	0.71
	SE (m) ±		0.02	0.02
	CD at 5 %		0.05	0.06
	Initial value		1.41	

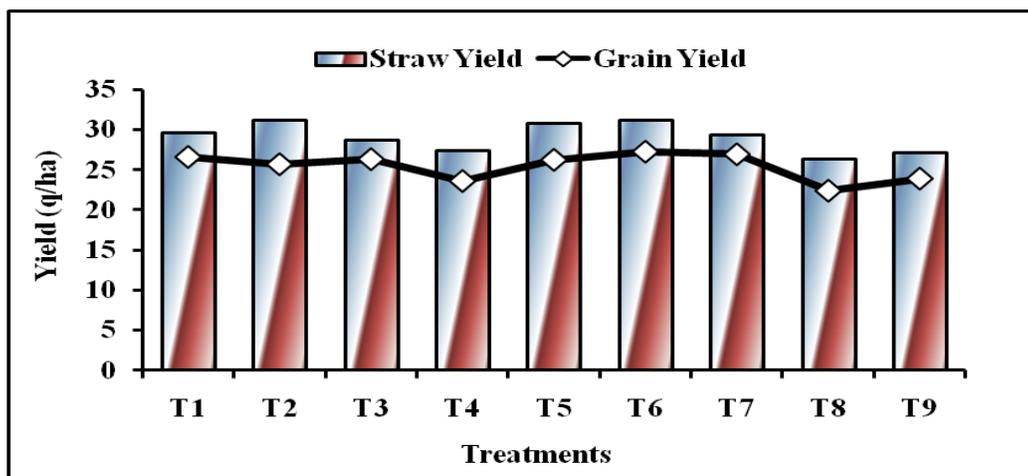
Table.3 Effect of different resource conservation practices on physical properties of soil after harvest of soybean

Tr.	Treatment details		33 kPa	1500 kPa	AWC (%)
	Cotton	Soybean			
T ₁	RDF	RDF	39.52	19.87	19.65
T ₂	25 % N (Dhaincha loppings) + RDF compensation	RDF	41.49	20.29	21.20
T ₃	25 % N (Cotton stalk) composted + RDF compensation	RDF	40.29	19.55	20.74
T ₄	25 % N (Wheat straw) + RDF compensation	RDF	40.72	19.86	20.86
T ₅	25 % N (Bio mulch)+ RDF compensation	RDF	39.38	19.27	20.11
T ₆	25 % N (Neemcake) + RDF compensation	RDF	40.26	19.48	20.78
T ₇	100 % N (FYM) + compensation of P (phosphocompost)	RDF+PC	44.15	22.35	21.80
T ₈	50 % N (FYM) + P compensation (PC) + N compensation (Urea)	RDF+PC	41.62	20.43	21.22
T ₉	50% N (Leucaena loppings) + P compensation (PC) + N compensation (Urea)	RDF+PC	41.60	20.20	21.40
	SE (m) ±		0.45	0.56	0.40
	CD at 5 %		1.34	1.68	1.21

Table.4 Effect of different resource conservation practices on biological properties of soil

Tr.	Treatment details		DHA ($\mu\text{g TPF g}^{-1}$ soil 24 hr ⁻¹)	CO ₂ evolution (mg CO ₂ evolved 100 ⁻¹ g soil)
	Cotton	Soybean		
T ₁	RDF	RDF	36.98	22.08
T ₂	25 % N (Dhaincha loppings) + RDF compensation	RDF	49.94	31.42
T ₃	25 % N (Cotton stalk) composted + RDF compensation	RDF	39.85	27.94
T ₄	25 % N (Wheat straw) + RDF compensation	RDF	38.88	25.57
T ₅	25 % N (Bio mulch)+ RDF compensation	RDF	35.96	28.91
T ₆	25 % N (Neemcake) + RDF compensation	RDF	40.78	22.83
T ₇	100 % N (FYM) + compensation of P (phosphocompost)	RDF+PC	56.80	37.67
T ₈	50 % N (FYM) + P compensation (phosphocompost) + N compensation (Urea)	RDF+PC	52.99	33.39
T ₉	50% N (Leucaena loppings) + P compensation (phosphocompost) + N compensation (Urea)	RDF+PC	46.61	35.10
	SE (m) ±		3.84	3.24
	CD at 5%		11.51	9.71

Fig.1 Seed and straw yield as influenced by resource conservation practices



The hydraulic conductivity was higher (0.75 cm hr^{-1}) with the RDF through FYM + remaining P through phosphocompost + (100% N through FYM + compensation of P through phosphocompost) followed by RDF + (Cotton stalk 25% N composted with trichoderma viride + compensation of RDF) (0.74 cm hr^{-1}), RDF through FYM + remaining P through phosphocompost+ (50% N through FYM + compensation of P through phosphocompost and remaining N through urea) (0.72 cm hr^{-1}) and RDF through FYM + remaining P through phosphocompost + (*Leucaena loppings* 50% N + compensation of P through phosphocompost and remaining N through urea) (0.71 cm hr^{-1}) showing the significant value. Application of RDF + (25% N through wheat straw + compensation of RDF) showing the lower value (0.65 cm / hr) of hydraulic conductivity. Similar results were found by Tiwari *et al.*, (2000). They reported that an application of FYM @ $15 \text{ t ha}^{-1} \text{ yr}^{-1}$ along with recommended NPK dose improved all the physical properties of soil. Selvi *et al.*, (2003) reported that the bulk and particle density of the soil have decreased as compared to control. The water holding capacity, pore space, hydraulic conductivity and permeability were found increased considerably.

The water retention at 33 kPa and 1500 kPa varied significantly under study in Table 2. The

significantly highest water retention at 33 kPa (44.15 percent) and at 1500 kPa (22.35 percent) was recorded in with the use of RDF through FYM and remaining P through phosphocompost (100% N through FYM + compensation of P through phosphocompost to previous cotton). The lower water retention was 39.38 percent at 33 kPa and 19.27 at 1500 kPa was recorded with the use of RDF (25 % N (Bio mulch) + RDF compensation previous cotton crop). It was observed that water retention increased slightly under the FYM and phosphocompost treatments.

The available water capacity was higher (21.80 %) with the RDF through FYM + remaining P through phosphocompost (100% N through FYM + compensation of P through phosphocompost to previous cotton) followed by (21.40%) RDF through FYM + remaining P through phosphocompost (50% N through leucaena loppings and P compensation of PC + N compensation through urea to previous crop), (20.74) RDF (25 % N (cotton stalk) + RDF compensation to previous crop cotton), (20.86) RDF (25 % N RDF (wheat straw) + RDF compensation to previous cotton crop), (20.78) RDF (25 % N through Neemcake + RDF Compensation to previous crop cotton). However, these treatments were found at par with each other (Fig. 1).

Application of recommended dose of fertilizer to both the crop resulted substantial decline in available water capacity (19.65%). Similar results were found by Hati *et al.*, (2007) and Mosavi *et.al.* (2010).

Soil biological properties

Data presenting as regard to dehydrogenase activity (DHA) influenced by different treatments is presented in Table 3. The significantly highest dehydrogenase activity ($56.80 \mu\text{g TPF g}^{-1} \text{ soil } 24 \text{ hr}^{-1}$) was recorded with the application of RDF through FYM + remaining P through phosphocompost (100% N through FYM and compensation of PC to previous crop) followed by RDF through FYM + remaining P through phosphocompost (50% N through FYM + compensation of P through phosphocompost and remaining N through urea) ($52.99 \mu\text{g TPF g}^{-1} \text{ soil } 24 \text{ hr}^{-1}$). The lowest soil microbial biomass carbon was observed under the application of RDF (Bio mulch (farm waste) 25% N + compensation of RDF) ($35.96 \mu\text{g TPF g}^{-1} \text{ soil } 24 \text{ hr}^{-1}$). Similar observations were recorded by Mali *et al.*, (2015).

Significantly highest CO_2 evolution ($37.67 \text{ Mg CO}_2 \text{ evolved } 100^{-1} \text{ g soil}$) was recorded with the application of RDF through FYM + remaining P through phosphocompost (100% N through FYM and compensation of PC to previous crop) followed by RDF through FYM + remaining P through phosphocompost (*Leucaena loppings* 50% N + compensation of P through phosphocompost & remaining N through urea) i.e. ($35.10 \text{ Mg CO}_2 \text{ evolved } 100^{-1} \text{ g soil}$) showing the at par value. The lowest CO_2 evolution was observed under the application of RDF (100% RDF of previous crop) ($22.08 \text{ Mg CO}_2 \text{ evolved } 100^{-1} \text{ g soil}$).

The CO_2 evolution was markedly decreased under RDF. Application of organics materials (FYM, phosphocompost) resulted improvement in CO_2 evolution as compared to rest of the treatments. Biomass addition through root, leaf,

litter and stubble and additional supply of nitrogen through FYM to the microorganisms, might be the reason for improving CO_2 evolution. The results are in close agreement with earlier finding of Ingle *et al.*, (2014) and Jadhao *et al.*, (2014) (Table 4).

Yield of soybean

The seed and straw yield of soybean was increased significantly with the application of RDF to soybean and 25 % N through neemcake + RDF compensation through chemical fertilizers. The application of RDF + PC to soybean and 100 % N through FYM + compensation of P through phosphocompost and RDF alone to both soybean and cotton found equally beneficial for getting higher seed and stalk yield of soybean.

It can be concluded that, the application of RDF + phosphocompost to soybean and 100 % N through FYM + compensation of P through phosphocompost to cotton resulted improvement in physical (bulk density, hydraulic conductivity and AWC) and biological properties (dehydrogenase activity CO_2 evolution) of soil. The seed and straw yield of soybean was increased with the conjoint use of manures and fertilizers.

References

- Chalwade, P.B., V. K. Kulkarni and M. B. Lakade. 2006. Effect of inorganic and organic fertilization on physical properties of Vertisols. *Soils and crops* 16(1): 148-152.
- Ingle, S. S., S. D. Jadhao, V. K. Kharche, B. A. Sonune and D. V. Mali. 2014. Soil biological properties as influenced by long term manuring and fertilization under sorghum (*Sorghum bicolor*)-wheat (*Triticum aestivum*) sequence in Vertisols. *Indian Journal of Agricultural Sciences*, 84 (4): 452-457.
- Jadhao, S. D., A. B. Lokhande, V.K. Kharche, R.D. Chaudhari, D.V. Mali, P. R. Damre.

2014. Effect of different levels of sulphur and zinc on fertility status and microbial ecology under soybean grown in Vertisols. *Journal of Soils and Crops*, 24 (1): 57-62.
- Piper, C. S. 1966. Soil and plant analysis. Asian Reprint, Hans Publication Bombay, India.
- Jackson, M. L., 1973. Soil chemical analysis, Prentice Hall of India Pvt. Ltd., New Delhi.
- Subbiah, B.V and G. L. Asija, 1956. A rapid procedure for the determination of available nitrogen in soil. *Curr. Sci.* 25:259-260.
- Blake, G. R. and K. H. Hartge, 1986. Bulk density. In: *Methods of Soil Analysis, Part-I*, Klute, A. (Ed.). American Society of Agronomy Inc. and Soil Science Society of America Inc. Madison, Wisconsin, USA, pp. 371-373.
- Black, C. A., D. D. Evans, J. L. White, L. K. Ensingager and F. E. Clark (1965). *Method of soil analysis part – II*, Amer. Soc. Agron. Inc. No. 9 Madison USA, pp. 770.
- Klute, A. 1986. Water retention. *Laboratory Method*. In A Klute (Ed) *Method of soil Analysis Part 1*. 2nd ed. Agron. Monograph 9. Madison, Wisconsin. pp 635-662.
- Klein, D. A., T. C. Loh and R. L. Goulding. 1971. A rapid procedure to evaluate the dehydrogenase activity of soil low in organic matter. *Soil Bio and Biochem.* 3: 385-387.
- Anderson, J.P.E. (1982) Soil respiration. In A.L.Page, R.H.Miller, and D.R. Keeney (ed.) *Method of soil analysis, part 2. Chemical and microbiological properties*, Agronomy Monograph No. 9, ASA-SSSA Publisher, Madison, Wisconsin, USA, pp. 831-871.
- Panase, V. G. and P. V. Sukhatme, 1971. *Statistical Methods for Agricultural Workers*. ICAR, New Delhi.
- Mosavi, S. B., A. A. Jafarzadeh, M. R. Nishabouri, Sh. Ostan, V. Feiziasl and E. Karimi, 2010. The effect of different green manure application in dry land condition on some soil physical properties. *Int. J. Agri. Crop. Sci.* 4 (17):1233-1239.
- Sharma, M. B., S. V. Mishra and R. Singh, 2007. Long term effect of fertilizers and manures on physical and chemical properties of Mollisol. *J. Indian Soc. Soil Sci.* 55(4): 523-524.
- Selvi, D. P., P. Santhy and M. Dhakshinamoorthy, 2003. Efficiency of long term integrated plant nutrient management on important soil properties of an Inceptisol. *Madras Agric. J.* 90(10-12): 656-660.
- Tiwari, A., H. R. Nema, B. R. Tembhare and S. K. Sharma, 2000. Soil physical environment in long-term fertilizer experiment on Typic Haplusterts. *JNKVV Res. J.* 34(1& 2): 29-33.
- Hati, K. M., A. Swarup, A. K. Dwivedi, A. K. Mishra and K. K. Bandyopadhyay, 2007. Changes in soil physical properties and organic carbon status at the topsoil horizon of a Vertisol of central India after 28 years of continuous cropping, fertilization and manuring. *Agric. Ecosyst. Environ.* 119(2): 127-134.
- Mali, D. V., V. K. Kharche, S. D. Jadhao, S. M. Jadhao, B. V. Saoji, P. A. Gite, A.B. Age, 2015. Soil biological health under long – term fertilization sorghum – wheat sequence on swell – shrink soil of central Asia. *J. Indian Soc. Soil Sci.* 63(4): 423-428.

How to cite this article:

Mali, D. V., S. D. Jadhao, V. K. Kharche, P. R. Kadu, P. W. Deshmukh, G. S. Laharia, B. A. Sonune, Nilam Kanase and Raut, N. W. 2020. Soil Physical and Biological Conditions as Influenced by Resource Conservation Practices under Cotton Based Soybean Rotation in Vertisols *Int.J.Curr.Microbiol.App.Sci.* 9(10): 929-936.
doi: <https://doi.org/10.20546/ijcmas.2020.910.111>