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Physico-chemical Soil Quality Indicators as Influenced by Different Soil Management Practices in Central India

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Abstract -The concepts of soil quality and health imply an assessment to how well soil functions in improving the crop production and environment. The present research brought out the effect of different soil management practices on soil physical and chemical parameters and help in improving quality of Vertisols. The study was conducted in Central India covering regions of Madhya Pradesh, Maharashtra, Rajasthan and Andhra Pradesh and the management history of traditionally followed cropping systems under tillage practices (Conservation and conventional), with nutrient management through inorganic and integrated management practices. The soil quality indicators such as bulk density, water holding capacity, soil pH, EC, organic carbon and available N, P, K, S were analyzed in the rhizosphere surface (0-15 cm) soil samples from stated regions. Conservation tillage practices decreased the soil bulk density (1.07±0.06g/cc) and improved the total water holding capacity (56.06±5.73%) of soil as compared to conventional tillage (1.38±0.12g/cc and 48.36±6.59 %, respectively). The integrated use of fertilizers and manures (either poultry manure or FYM) helped in elevating these two parameters (1.21±0.14 g/cc and 50.42±4.22%, respectively) as compared to inorganic fertilization alone (1.55±10 g/cc and 32.74±3.45% respectively). Integrated use of FYM/ poultry manure with fertilizers was also found to be influential in raising the organic carbon storage of soil (11.53±1.22-18.50±9.82Mgha^{-1}) under conservation tillage as compared to inorganic fertilization with either conservation or conventional tillage (8.38±0.93-13.34±3.60Mgha^{-1}). The practice of integrated nutrient management with conservation tillage in different traditionally followed cropping systems as well increased the contents of available N (137±15.28 µg g^{-1} soil), P (16.7±3.12 µg g^{-1} soil), K (251±107.39 µg g^{-1} soil), and S (13.0±8.35 µg g^{-1} soil) in soils. Our results indicated that integrated nutrient management (inorganic fertilization with FYM or poultry manure) of these cropping systems under conservation tillage and integrated nutrient management enhances the soil physico-chemical quality indicators.

Keywords- Soil Physico-Chemical Quality Indicators, Inorganic Fertilization with FYM

INTRODUCTION

The aim of the agriculture research is to raise crop productivity and production with minimal impairment or possible improvement of the basic soil resources and the surrounding environment. Sustainability of agricultural systems has become an important issue in developing countries, including India. Over-exploitation of soils over many decades has resulted in exhaustion of the intensive agricultural production systems and steadily declining productivity has been noticed in long-term experiments in Asia (Bhandari *et al*., 2002; Ladha *et al*., 2003; Manna *et al*., 2005). Many of the issues of sustainability are related to soil quality, assessment of soil quality and the direction of change with time is a primary indicator of whether agriculture is sustainable (Karlen *et al*., 1997). The response of soils to management and inputs also depends on soil quality. It is, therefore, important to identify the soil characteristics responsible for changes in soil quality, which may eventually be considered as soil quality indicators for assessing agricultural sustainability.

Soil quality consists of three main aspects of physical, chemical, and biological quality, with the first affecting soil physical processes in the soil, such as water movement and aeration, as well as chemical and biological processes. Therefore it plays a central role in controlling soil quality (Dexter, 2004). Soil quality is the outcome of interactions among physical, chemical and biological characteristics, and its proper assessment requires the determination of a large number of parameters (Bloem *et al*., 2006a; Marzaioli *et al*., 2010). To evaluate effects of management on soil physical quality, aggregate-size distribution, water stability of those aggregates, compaction, water retention and porosity have been widely used as soil

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quality indicators and are often referred to as dynamic physical quality indicators. Collectively assessing multiple indicators such as these, along with those reflecting biological and chemical properties and processes can be useful for quantifying changes in soil quality due to various management practices (Karlen, 2004).

Several studies have shown the positive effect of no-till on improving soil physical and chemical (Melero *et al*., 2009a, b) compared to traditional tillage. A wide range of special tillage operations involving soil inversion, chiseling, sub soiling or deep tillage (for soils with an impending layer within rooting depth) have been found to be beneficial by minimizing soil hardening or bulk density, improving soil porosity, infiltration, soil water storage, and root development (Lal, 1984;). Soil tillage (seedbed preparation) methods in addition to manure use are basic practices involved in crop production. These practices are known to influence soil physical conditions, nutrient availability, growth and yield of crops (Ojeniyi and Agboola, 1995). Tillage operation tends to modify soil bulk density and pore size distribution, loosens, granulates, crushes and even compacts soil particles (Klute, 1982). In addition to the provision of essential plant nutrients to soils, organic manure improves soil structure through enhanced soil water holding capacity, aeration and drainage which encourage good root formation and plant growth (Cooke, 1975).

The aim of this work is to determine the influence of different soil management on some physico-chemical properties of Vertisols under soybean [Glycine max (L.) Merrill] based cropping system of central India.

MATERIALS AND METHOD

The present study was confined to the major command area of soybean in the states of Madhya Pradesh, Maharashtra, Rajasthan and Andhra Pradesh, which falls under semi-arid tropics and receives an average annual rainfall between 800 to 1000 mm; the bulk of which is received in the months from June to October. Maximum temperature in April and May ranges from 38°C to 44°C and the minimum temperature during December and January from 7^{o}C to 13°C. Most of the soybean command area is covered with Vertisols and associated soils. Since soybean-wheat (irrigated regime), soybean-chickpea (rainfed regime) and soybean-potato or garlic or onion (irrigated regime) constituted major cropping systems of Central India, were included in the study.

A total of 213 surface (0-15 cm) soil samples from the rhizosphere of soybean at flowering (R2–stage) from farmers' field covering contrasting agro-management systems were collected from major soybean growing regions of Madhya Pradesh, Maharashtra, Rajasthan and Andhra Pradesh. The contrasting management practices included either reduced (two passes of cultivators followed by planking) or conventional tillage (deep tillage once in 3-4 years followed by two passes of cultivator and planking), nutrient management through integrated approach or inorganics in 14 cropping systems encompassing soybean-wheat, soybean-chickpea, soybean-potato/garlic/onion (Table 1). These management systems were followed by the farmers for at least minimum of 10 years. In case of integrated nutrient management, the farmers used organic manures once in 3 years. These soil samples were collected during the *kharif* of 2009 and 2010 and refrigerated at 4^{o}C and subsequently analyzed for bulk density (Piper, 1966), water holding capacity (Piper, 1966), soil reaction (Jackson, 1967). The organic carbon in soil was analyzed using Walkley and Black method as described by Yeomans and Bremner (1988). The soil available nitrogen in soil was determined by the alkaline permanganate method (Subbiah and Asija, 1956), available phosphorous by Olsen *et al*. (1954), available nitrogen by Hanway and Heidel (1952) and available sulphur by turbidimetric method (Chesnin and Yien, 1950).

Table 1. Treatment description of the different agricultural management systems

Management System	Treatment description		
	Cropping system	**Tillage**	**Nutrient management**
ConsT, SFYM – WF	Soybean-wheat	Conservation	FYM to soybean and fertilizer to Wheat
ConsT, SFYM + F– WF	Soybean-wheat	Conservation	FYM and fertilizer to soybean, and fertilizer to wheat
ConsT, SPM – WF	Soybean-wheat	Conservation	Poultry manure to soybean and fertilizer to wheat
ConsT, S – WF	Soybean-wheat	Conservation	No fertilization to soybean and fertilizer to Wheat
ConsT, SF – WF	Soybean-wheat	Conservation	Fertilizer to soybean, fertilizer to wheat
ConsT, SFYM +F – CF	Soybean – chick pea	Conservation	FYM and fertilizer to soybean, and fertilizer to chickpea

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ConsT, SFYM – P/Ga/OF	Soybean-potato or garlic or onion	Conservation	FYM to soybean and fertilizer to potato/garlic/onion
ConsT, SPM – P/Ga/OF	Soybean-potato or garlic or onion	Conservation	Poultry manure to soybean and fertilizer to potato/garlic/onion
ConvT, SFYM – WF	Soybean-wheat	Conventional	FYM to soybean and fertilizer to wheat
ConvT, SFYM +F – WF	Soybean-wheat	Conventional	FYM and fertilizer to soybean and fertilizer to wheat
ConvT, SF – WF	Soybean-wheat	Conventional	Fertilizer to soybean and fertilizer to wheat
ConvT, S FYM +F – CF	Soybean – chick pea	Conventional	FYM and fertilizer to soybean, and fertilizer to chickpea
ConvT, SF – CF	Soybean – chick pea	Conventional	Fertilizer to soybean and fertilizer to chickpea
ConvT, SFYM +F – P/GA/OF	Soybean-potato or garlic or onion	Conventional	FYM and fertilizer tp soybean, and fertlizer to potato/garlic/onion

The analytical results were analyzed by using SAS statistical software (ver.9.2; SAS Institute, Cary, NC). One way analysis of variance (ANOVA) was carried out with the ANOVA procedure in SAS enterprise guide4.2 and the Fisher least significant differences (LSD).

RESULTS AND DISCUSSION

Effect of different soil management practices on bulk density and water holding capacity

Considerable variation in dynamic properties like bulk density (1.07 to 1.55 g cc^{-1}) and water holding capacity (32.74 to 56.06 %) was observed. The variation in values for bulk density and water holding capacity under conservation tillage (1.07 to 1.55 g cc^{-1} and 32.74 to 56.06 %) and conventional tillage (1.43 to 1.50 g cc^{-1} and 40.28 to 48.36 %) observed were on account of different cropping system and nutrient management, wherein addition of organic manures alone and in combination with fertilizers has played a role. It can be noted that the integration of poultry manure with fertilizers irrespective of cropping systems showed comparatively lower bulk density (1.07 and 1.21 g cc^{-1}) and higher water holding capacity (50.42 and 56.06 %). In general, integrating FYM with fertilizers in different cropping systems as well led to lower bulk density and higher water holding capacity as compared to cropping systems receiving only fertilizers for nutrient management.

A reduction in bulk density is very commonly observed on incorporation of crop residues organic amendments as compared to fertilizers alone (Herrick and Lal, 1995; Sharma *et al.,* 2000;). Acharya *et al.* (1988) and Sharma *et al.*, (2000) observed improvement in water holding capacity of soil due to addition of organic manures compared to only inorganic fertilizer application. In general, irrespective of cropping systems and nutrient management, the average bulk density was lower by 10 per cent indicating better soil physical conditions in conservation tillage over conventional tillage. Irrespective of cropping system and tillage, the integrated nutrient management revealed lower values of bulk density by 9 per cent (Table 2). The water holding capacity in integrated nutrient management was also higher by 16 per cent when looked into irrespective of cropping systems and tillage types (Table 2). This brought out that the reduction in extent of tillage as well integrated use of organics and inorganics in long-term reduces the bulk density of soil and increases water holding capacity. Reduction in BD in soils amended with organic or organic–inorganic amendments has also been reported in earlier studies (Abbasi and Tahir, 2012; Abbasi *et al.*, 2010; Bandyopadhyay *et al*., 2010). Bandyopadhyay *et al.* (2010) reported that the BD under NPK + FYM was 5.6 % lower than NPK and 9.3 % lower than the control treatment after 4th year crop cycle.

Conservation tillage has numerous positive effects on soil, such as improvement of water-holding capacity, and reduction of soil erosion (Lindwall and Anderson, 1981). Organic amendment increased the soil WHC, which reflected that the rate of moisture loss during the dry period was lower in amended than in unamended soil (Hueso *et al*., 2011). Bhatia and Shukla (1982) reported that use of FYM either alone or in combination with fertilizers increased significantly the water holding capacity and retention of moisture at field capacity. Whereas, regular application of only chemical fertilizers had an adverse effect on the retention of soil moisture. Bhriguvanshi (1988) observed that application of FYM either alone or in combination with nitrogenous fertilizers under conservation tillage played a definite role in improving water holding capacity of soil which was attributed to the improvement in structural condition of the soil.

Table 2. Effect of different soil management practices on basic physical properties

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Treatment	Bulk density (g/cc)	Water holding capacity (%)
ConsT, SFYM – WF	1.46 ± 0.13^{ab}	48.52 ± 8.84^{abc}
ConsT, SFYM + F– WF	$1.44\ 0.07^{ab}$	42.46 ± 7.09^{bcd}
ConsT, SPM – WF	1.21 ± 0.14^{c}	50.42 ± 4.22^{ab}
ConsT, S – WF	1.55 ± 10^{a}	32.74 ± 3.45^{e}
ConsT, SF – WF	1.49 ± 0.13^{ab}	38.36 ± 9.10^{de}
ConsT, SFYM +F – CF	1.48 ± 0.19^{ab}	49.62 ± 3.40^{ab}
ConsT, SFYM – P/Ga/OF	1.15 ± 0.06^{cd}	41.87 ± 14.78^{bcd}
ConsT, SPM – P/Ga/OF	**1.07 ± 0.06^{d}**	**56.06 ± 5.73^{a}**
ConvT, SFYM – WF	1.43 ± 0.07^{ab}	47.21 ± 7.41^{bc}
ConvT,SFYM +F – WF	1.48 ± 0.11^{ab}	41.88 ± 8.50^{bcd}
ConvT, SF – WF	1.48 ± 0.13^{ab}	41.79 ± 6.47^{bcd}
ConvT, S FYM +F – CF	1.38 ± 0.12^{b}	48.36 ± 6.59^{abc}
ConvT, SF – CF	1.42 ± 0.04^{b}	47.81 ± 3.94^{abc}
ConvT, SFYM +F – P/GA/OF	1.50 ± 0.11^{ab}	40.28 ± 8.61^{de}
SEm (±)	0.01	58.81
LSD	**0.13**	**8.83**

Data are mean values of six replicates± SD; means with different letters in the same column differ significantly at P=0.05 according to Fisher LSD

Effect of different soil management practices on Soil pH, EC and Organic Carbon

As regards pH and EC, although the agricultural management practices showed significant differences, soils are mildly alkaline and salt content is also not a limitation for crop production. The pH values ranged from 7.32 (conservation tillage in soybean - wheat fertilized) to 7.89 (conventional tillage in soybean FYM – wheat fertilized) and electrical conductivity from 0.13 (conservation tillage in soybean FYM plus fertilizer – chickpea fertilized) to 0.49 dSm^{-1} (conservation tillage in soybean fertilizer - wheat fertilized). Although, soil reaction and electronic conductivity are inherent properties of soil, the variation might be the combined effect of varying management continuous for a longer duration. However, the lowest value of pH (7.32) was associated with soybean- wheat system with conservation tillage, wherein no organics were used and wheat received only fertilizers (Table 3). The use of nitrogenous fertilization for extended period may bring decline in soil pH (Soumare et al., 2003).

Cropping systems under contrasting management showed significant variation in organic carbon content (0.36-0.95 %). In general, irrespective of nutrient management followed, the organic carbon content was higher in soils under conservation tillage (0.54 to 0.95 %) as compared to conventional tillage (0.41 to 0.84 %). The variation in organic carbon content with in systems under conventional or conservation tillage might be on account of nutrient management systems indicating the role of organic matter recycling in use of organics in conjunction with inorganics (Table 3). The maximum build up of organic carbon (0.95 %) was noticed in soybean-wheat cropping system under conservation tillage wherein soybean received poultry manure followed by wheat receiving fertilizers only. In case of conventional tillage as well soybean receiving FYM plus fertilizers followed by wheat fertilized showed maximum value of organic carbon (0.84 %). Comparison of high intensity cropping system soybean followed by potato/onion/garlic under different tillage system revealed that soybean receiving FYM followed by fertilized subsequent crops had higher contents of organic carbon (0.74 %) than the same system under conventional tillage wherein soybean receiving FYM plus fertilizer followed by fertilized subsequent crops (0.55 %) indicating the importance of conservation tillage in building up of organic carbon in soil. On an average basis, irrespective of cropping systems and nutrient management practices, organic carbon content was 19.64 per cent higher in conservation tillage over conventional tillage. Similarly integrated nutrient management over cropping systems and tillage systems revealed higher organic content by 41 per cent.

Table 3. Effect of different soil management practices on basic chemical properties

Treatment	pH	EC (dSm^{-1})	Organic Carbon (%)
ConsT, SFYM – WF	7.51 ± 0.26^{bc}	0.35 ± 0.15^{ab}	0.87 ± 0.55^{ab}
ConsT, SFYM + F– WF	7.67 ± 0.09^{ab}	0.47 ± 0.29^{a}	0.59 ± 0.13^{cd}
ConsT, SPM – WF	7.70 ± 0.27^{ab}	0.22 ± 0.06^{bc}	**0.95 ± 0.12^{a}**
ConsT, S – WF	7.32 ± 0.27^{c}	0.18 ± 0.20^{bc}	0.36 ± 0.05^{cd}
ConsT, SF – WF	7.66 ± 0.21^{ab}	**0.49 ± 0.24^{a}**	0.59 ± 0.13^{cde}
ConsT, SFYM +F – CF	7.76 ± 0.09^{ab}	0.13 ± 0.13^{c}	0.54 ± 0.08^{abc}
ConsT, SFYM – P/Ga/OF	7.81 ± 0.43^{a}	0.34 ± 0.15^{ab}	0.74 ± 0.08^{abc}
ConsT, SPM – P/Ga/OF	7.67 ± 0.34^{ab}	0.23 ± 0.12^{bc}	0.73 ± 0.13^{abc}
ConvT, SFYM – WF	**7.89 ± 0.20^{a}**	0.14 ± 0.04^{c}	0.53 ± 0.09^{cde}
ConvT,SFYM +F – WF	7.71 ± 0.24^{ab}	0.25 ± 0.19^{bc}	0.84 ± 0.27^{ab}
ConvT, SF – WF	7.70 ± 0.21^{ab}	0.35 ± 0.23^{ab}	0.41 ± 0.13^{de}
ConvT, S FYM +F – CF	7.67 ± 0.13^{ab}	0.16 ± 0.07^{bc}	0.49 ± 0.10^{de}
ConvT, SF – CF	7.75 ± 0.25^{ab}	0.27 ± 0.24^{bc}	0.54 ± 0.62^{cde}
ConvT, SFYM +F – P/GA/OF	7.74 ± 0.14^{ab}	0.13 ± 0.01^{c}	0.55 ± 0.05^{cde}
SEm (±)	0.06	0.03	0.04
LSD	**0.28**	**0.20**	**0.22**

Data are mean values of six replicates± SD; means with different letters in the same column differ significantly at P=0.05 according to Fisher LSD

The two agricultural management systems under conservation tillage were soybean receiving FYM followed by potato/garlic/onion and soybean receiving poultry manure followed by potato/garlic/onion. In this case as well the organic source influenced the organic carbon content. Replacement of FYM with poultry manure reduced bulk density and increased the organic carbon remained comparable (Table 3). In case of soybean–chickpea system under conventional tillage, soybean receiving FYM with

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fertilizer followed by chickpea fertilized showed slight improvement in bulk density but there was reduction in content of organic carbon (Table 3).

Effect of different soil management practices on Macro-nutrients (Available N, P, K, S)

The change in available nutrient content in soil is the dynamic property which is dependent of types of agricultural management practices followed in that area. The values of available N, P, K and S for conservation tillage were 85 - 137 µg g-1 soil, 6.55 -16.7 µg g-1 soil, 115 - 251 µg g-1 soil and 5.2 – 13.0 µg g-1 soil, respectively, barring conservation tillage, soybean followed by wheat fertilized were higher than that of conventional tillage possessing corresponding values 77-115 µg g-1 soil, 5.2 - 13.5 µg g-1 soil, 68 - 196 µg g-1 soil and 4.9 - 13.4 µg g-1 soil, respectively, with exception of conventional tillage, soybean with FYM plus fertilizer followed by chickpea fertilized (289 µg g-1 soil K) and conventional tillage, soybean with FYM followed by potato/garlic/onion with fertilizer (22.1 µg g-1 soil S). The system conservation tillage, soybean-wheat fertilized exhibited lowest values for available N (46 µg g-1 soil), available P (3.2 µg g-1 soil), available K (84 µg g-1 soil) and available S (2.0 µg g^{-1} soil), obviously because other management practices were with better nutrient management or/and integration of organic as well as inorganic nutrient management. In general, the N, P, K and S contents were better maintained in the practices with integrated nutrient management than practices with inorganic management. Incorporation of poultry manure in practices invariably led to higher availability of these four nutrients (Table 4). Irrespective of tillage type and cropping systems, the integrated nutrient management maintained higher contents of available N, P, and S contents.

Table 4. Effect of different soil management practices on available macro-nutrients

Treatment	Available Nutrients (µg g^{-1} soil) N	P	K	S
ConsT, SFYM – WF	102±9.64^{bcd}	12.8±11.56^{abc}	115±56.81^{cde}	11.7±4.01^{ab}
ConsT, SFYM + F– WF	111±35.31^{abc}	10.6.15±6.14^{bcde}	170±168.49^{bcd}	13.0±8.35^{ab}
ConsT, SPM – WF	**137±15.28^{a}**	**16.7±3.12^{a}**	193±31.31^{abc}	12.3±1.66^{ab}
ConsT, S – WF	46±6.28^{e}	3.2±0.65^{f}	84±13.51^{de}	2.0±0.97^{b}
ConsT, SF – WF	95±20.94^{bcd}	9.7±4.10^{bcde}	179±143.21^{bcd}	9.6±3.87^{b}
ConsT, SFYM +F – CF	109±3.78^{bc}	6.55±2.48^{def}	251±107.39^{ab}	5.2±0.88^{b}
ConsT, SFYM – P/Ga/OF	85±36.53^{cd}	13.2±7.10^{abc}	157±88.88^{bcde}	8.3±2.49^{b}
ConsT, SPM – P/Ga/OF	110±14.41^{abc}	14.3±2.27^{ab}	170±29.48^{bcd}	11.4±2.08^{ab}
ConvT, SFYM – WF	77±17.43^{d}	5.12±3.61^{ef}	191±106.59^{abc}	4.9±3.31^{b}
ConvT,SFYM +F – WF	115±33.16^{ab}	9.8±2.79^{bcde}	126±83.36^{cde}	13.4±11.24^{ab}
ConvT, SF – WF	89±27.70^{bcd}	5.4±3.48^{ef}	123±84.39^{cde}	7.3±3.15^{b}
ConvT, S FYM +F – CF	115±28.24^{ab}	13.5±7.71^{ab}	**289±77.46^{abc}**	8.6±2.57^{b}
ConvT, SF – CF	102±20.73^{bcd}	7.3±2.35^{cdef}	196±30.23^{abc}	9.3±6.01^{b}
ConvT, SFYM +F – P/GA/OF	103±38.25^{bcd}	11.3±2.13^{abcd}	68±39.92^{e}	**22.1±33.12^{a}**
SEm (±)	605.02	25.89	7680.68	100.18
LSD	**28**	**5.89**	**101**	**11.52**

Data are mean values of six replicates± SD; means with different letters in the same column differ significantly at P=0.05 according to Fisher LSD

Conservation tillage provides better opportunities to build up soil carbon/carbon fractions status thereby promoting the nutrient dynamics (Lal, 2007; Mirsky *et al.,* 2008; Sombrero and de Benito, 2010) mediated by increased soil microbial activity. Raveendran *et al*. (1994) reported that cow and chicken manure contained 0.46 % and 1.78 % total P and 0.69 % and 2.66 % total K, respectively. Steward *et al*. (2000) reported an increase in soil N, P and K from manure application, while high amounts of, P, and K may be tied up in the organic form, the availability of P and K in animal manure often approaches 90 or 100 % (Azevedo and Stout, 1974). Eghball *et al*. (2004) found that organic amendments accumulated a substantial quantity of P in soil that can contribute to crop P uptake for up to 10 years without any additional P. Several studies have demonstrated the benefits of NT over CT, including improvements in physical, chemical and biological properties of the soil (Boddey *et al*., 2010).

CONCLUSION

The study conducted on the effect of different soil management practices on soil physical and chemical parameters brought out that different management histories encompassing varied cropping systems in the same region had a remarkable impact on the soil properties. Long-term application of poultry manure or FYM and adoption of conservation tillage increased the water holding capacity, organic carbon content, available macronutrients (N,P,K and S) and reduced the bulk density as compared to inorganic fertilization/no fertilization. The result indicated that conservation tillage irrespective of cropping systems and nutrient management systems led to betterment of soil physico-chemical indicators, which offers better option to sustain productivity of soybean-based cropping systems in Vertisols and associated soils of central India.

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REFERENCES

[1]. Abbasi, M.K., Tahir, M.M., 2012. Economizing nitrogen fertilizer in wheat through combinations with organic manures in Kashmir, Pakistan. *Agron. J.* 104, 169–177.

[2]. Abbasi, M.K., Khaliq, A., Shafiq, M., Kazmi, M., Ali, I., 2010. Comparative effectiveness of urea N, poultry manure and their combination in changing soil properties and maize productivity under rainfed conditions in Northeast Pakistan. *Exp. Agric.* 46, 211–230.

[3]. Acharya, C. L., Bishnoi, S. K. and Aduvanshi, H. S. 1988. Effect of long-term application of fertilizers and organic and inorganic amendments under continuous cropping on soil physical and chemical properties in an Alfisol. *Indian Journal of Agricultural Sciences* **58**: 509-516.

[4]. Agele SO (2007). Efficacy of organic amendments on the establishment and biomass yield of grass species on adegarded alfisol. *J. Plant Interactions*, 2(3): 195-201

[5]. Bandyopadhyay, K.K., Misra, A.K., Ghosh, P.K., Hati, K.M., 2010. Effect of integrated use of Farmyard manure and chemical fertilizers on soil physical properties and productivity of soybean. *Soil Tillage Res.* 110, 115–125.

[6]. Bhandari AL, Ladha JK, Pathaka H, Padre AT, Dawe D, Gupta RK (2002). Yield and soil nutrient changes in long-term Rice-Wheat Rotation in India. *Soil Sci Soc Am J*. 66:162 – 170.

[7]. Bhatia K. S. and K. K. Shukla, 1982. Effect of continuous application of fertilizers and manures on some physical properties of alluvialsoil. *J. Indian Soc. Soil Sci*., 30: 33-36.

[8]. Bhriguvanshi, S.R. 1988. Long-term effect of high doses of farmyard manure on soil properties and crop yield. *Journal of the Indian Society of Soil Science* 36: 784-786.

[9]. Blevins, R.L., Thomas, G.W., Smith, M.S., Frye, W.W., 1983. Changes in soil properties after 10 years of no-tillage and conventionally tilled corn. *Soil Tillage Res*. 3, 135–146.

[10]. Bloem,J.,Hopkins,D.W.,Benedetti,A.,2006a. Microbiological Methods for Assessing Soil Quality. CABI Publishing, Oxfordshire, UK

[11]. Brady NC (1990). Soil organic matter and organic soils. The nature and properties of soils. Macmillan Publishing Co. New York, p. 279-313.

[12]. Bennie ATP, Botha FJP, (1986). Effect of deep tillage and controlled traffic on root growth, water use efficiency, and yield of irrigated wheat and maize. *Soil Till. Res*. 17: 85-95.

[13]. Boddey, R.M.; Jantalia, C.P.; Conceição, P.C.; Zanatta, J.A.; Bayer, C.; Mielniczuk, J.;Dieckow, J.; Santos, H.P.; Denardin, J.E.; Aita, C.; Giacomini, S.J.; Alves, B.J.R.; Urquiaga, S. 2010. Carbon accumulation at depth in Ferralsols under zero-till subtropical agriculture. *Global Change Biology* 16:784-795.

[14]. Chesnin, L. and Yien, C. N. 1950. Turbidimetric determination of available sulphur in soil. *Soil Science Society of America Proceedings* **15**: 149-151.

[15]. Cooke, 1975 Cook, R.J., L.S. Thomashow, D.M. Weller, D. Fujimoto and M. Mazzola. 1995.Molecular mechanisms of defense by rhizobacteria against root disease. *Proc.Natl. Acad. Sci.* USA. 92:4197-4201.

[16]. Craswell, E.T. and Lefroy, R.D.B. 2001. The role and function of organic matter in tropical soils. *Nutrient Cycling Agroecosystems*. 61: 7-18.

[17]. Dexter, A. R. 2004. Soil physical quality - Preface. *Soil and Tillage Researh* **79**: 129-130.

[18]. Dick, W.A., 1983. Organic carbon, nitrogen, and phosphorus concentration and pH in the soil profiles as affected by tillage intensity. *Soil Sci. Soc. Am. J*. 47, 102–107.

[19]. Eghball, B., Ginting, D., Gilley, J.E., 2004. Residual effect of manure and compost applications on corn production and soil properties. *Agron. J*. 96, 442–447.

[20]. Ferris, H., Venette, R.C., Scow, K.M., 2004. Soil management to enhance bacterivore and fungivore nematode populations and their nitrogen mineralisation function. *Applied Soil Ecology* 25, 19–35.

[21]. Fox, R.H., Hoffman, L.D., 1981. The effect of N fertilizer source on grain yield, N uptake, soil pH, and lime requirement in no-till corn. *Agron. J*. 73, 891–895.

[22]. Hanway, J. J. and H. Heidel, 1952. Soil analysis method as used in Iowa State College. *Agric. Bull.*, 57: 1-13.

[23]. J. E. Herrick, R. Lal 1995. Soil Physical Property Changes during Dung Decomposition in a Tropical Pasture. *Soil Science Society of America Journal* - SSSAJ , 59, 3.

[24]. Hueso S, Hernández T, García C 2011. Resistance and resilence of the soil microbial biomass to severe drought in semiarid soils: The importance of organic amendments. *Appl Soil Ecol* 50:27–36

[25]. Ismail, L., Blevins, R.L., Frye, W.W., 1994. Long-term no-tillage effects on soil properties and continuous corn yields. *Soil Sci. Soc. Am. J*. 58, 193–198.

[26]. Jackson, M. L. 1967. Soil Chemical Analysis, 498 pp. Prentice Hall of Index Pvt. Ltd, New Delhi, India

[27]. Kanamori T, Yasuda T (1979). Immobilisation, mineralisation and the availability of the fertilizer nitrogen during the decomposition of organic matter applied to soil. *Plant Soil,* 52: 215-229.

[28]. Karlen, D. L., Mausbach, M. J., Doran, J. W., Cline, R. G., Harris, R. F. and Schuman, G. E.1997. Soil Quality: concept, rationale, and research needs. *Soil Science Society of America Journal* **60**: 4-10.

[29]. Karlen, D. L. 2004. Liquid swine manure management challenges on tile-drained soils. *Applied Engineering in Agriculture* **20**(5): 693-699.

[30]. Klute, A., 1982. Tillage effects on hydraulic properties of soil. A review. In: Predicting Tillage Effects on Soil Physical Properties and Processes. P.W. Unger and Van

© 2015, IJSRBS All Rights Reserved

Doren, D.M. (eds.) ASA Special Publication No.44:29-43.

[31]. Ladha, J.K., H. Pathak, A. Tirol-Padre, D. Dawe, and R.K. Gupta. 2003. In Improving the productivity and sustainability of rice-wheat systems: Issues and Impacts. Ed. J.K. Ladha et al. pp. 45-76. *Am. Soc. Agron., Spl.* Publ. 65, Madison, Wisconsin

[32]. Lal R (1984). Mechanized tillage system effects on soil erosion from an Alfisol in water sheds cropped to maize. *Soil Till. Res*., 4:349-360.

[33]. Lal R (1976). No-tillage effect on soil properties under different crops in western Nigeria. *Soil Sci. Soc. Am. Proc.*, 40: 762-768.

[34]. Lal, R. 2007. *Carbon Management in Agricultural Soils: Mitigation and Adaption Strategies for Global Change*. Springer, Vol. 12(2), pp. 303-322.

[35]. Liebig, M.A., Tanaka, D.L., Wienhold, B.J., 2004. Tillage and cropping effects on soil quality indicators in the northern Great Plains. *Soil & Tillage Research* 78, 131–141.

[36]. Lindwall C.W., Anderson, D.T., 1981. Agronomic evaluation of minimum tillage systems for summer fallow in southern Alberta. *Can. J. Plant Sci.* 61, 247-353.

[37]. Marzaioli, R.; D'ascoli, R.; Pascale, R.D. & Rutigliano, F. 2010. Soil quality in a Mediterranean area of Southern Italy as related to different land use types. *Appl. Soil Ecol*., 44:205-212.

[38]. Manna, M.C., Swarup, A., Wanjari, R.H., Ravankar, H.N., Mishra, B., Saha, M.N., Singh, Y.V., Sahid, D.K. and Sarap, P.A. 2005. Long-term effect of fertilizer and manure application on soil organic carbon storage, soil quality and yield sustainability under sub-humid and semi-arid tropical India. *Field Crops Res*., 93, 264-280.

[39]. Melero, S., L´opez-Garrido, R., Murillo, J. M. and Moreno, F. 2009. Conservation tillage: Short- and long-term effects on soil carbon fractions and enzymatic activities under Mediterranean conditions. *Soil and Tillage Research* **104**: 292–298.

[40]. Minoshima, H., Jackson, L.E., Cavagnaro, T.R., Sanchez-Moreno, S., Ferris, H., Temple, S.R., Goyal, S., Mitchell, J.P., 2007. Soil food web and carbon dynamics in response to conservation tillage in California. *Soil Science Society of America Journal* 71, 952–963.

[41]. Mirsky, S. B., Lanyon, L. E. and Needelman, B. A. 2008. Evaluating soil management using particulate and chemically labile soil organic matter fractions. *Soil Science Society of America Journal* **72**: 180–185.

[42]. Ojeniyi SO, Agboola AA (1995). A review of tillage requirement of crops in Africa Soils 28, 259-266.

[43]. Olsen, S. R., Cole, C. V., Watanabe, F. S. and Dean, L. A**.** 1954. Estimation of available P in soils by extraction with sodium bicarbonates. *Circular U.S. Department of agriculture* **939**: 1-19.

[44]. Piper, C. S. 1966. *Soil and Plant Analysis*. Hans publishing house, Bombay, India

[45]. Ravindran, V., G. Ravindran and S. Sivalogan. 1994. Total and phytate phosphorus contents of various foods and feedstuffs of plant origin. *Food Chem*. 50:133-136.

[46]. Raymond WM, Roy LD (1992). Organic Matter and Container Media Soils: An Introduction to soils and Plant Growth, 6th edn. (Delhi: Prentice Hall), pp. 181-224.

[47]. Reeves, D.W. 1997. The role of soil organic matter in maintaining soil quality in continuous cropping systems. *Soil Tillage Research*. 43: 131-167.

[48]. Sharma *et al.*, (2000) Sharma B.D., Mukhopadhyay S.S., Sidhu P.S., Katyal J.C. 2000. Pedospheric attributes in distribution of total and DTPAextractable Zn, Cu, Mn and Fe in Indo-Gangetic plains. *Geoderma*, 96: 131–151.

[49]. Schwab, A.P., Ransom, M.D., Owensby, C.E., 1989. Exchange properties of an Agriustoll: effects of long-term ammonium nitrate fertilization. *Soil Sci. Soc. Am. J*. 53, 1412–1417.

[50]. Sobulo, R.A., Osiname, O.A. 1986. Soil properties and Crop yields under continuous cultivation with different management system. In: R. Lal,P.A. Sanchez and R. W. Cunnings (eds). Land clearing and development in the tropics. A. A. Balkama, Rotterdam, Boston, pp. 363-370.

[51]. Sombrero, A. and Benito, A. 2010. Carbon accumulation in soil: Ten-year study of conservation tillage and crop rotation in a semi-arid area of Castile-Leon, Spain. *Soil and Tillage Research* 107(2): 64-70.

[52]. Soumare, M., Tack, F., Verloo, M.G., 2003. Effects of a municipal solid waste compost and mineral fertilization on plant growth in two tropical agricultural soils of Mali.*Bioresour.Technol.* 86, 15–20.

[53]. Subbiah, B. V. and Asija, G. C. 1956. A rapid procedure for determination of available nitrogen in soil. *Current Science* **25**: 259-260.

[54]. Wong MH, Wong JWC (1989). Germination and seedling growth of vegetable crops in fly ash amended soil. *Agric. Ecosyst. Environ*., **26**: 232-235.

[55]. Yeomans, J. C. and Bremner, J. M. 1988. A rapid and precise method for routine determination of organic carbon in soils. *Communication in Soil science and Plant Analysis* **19**: 1467-1476.

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