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SOIL SCIENCE

Effect of Nutrient Management on Soil Health and Wheat (*Triticum aestivum L.*) Production in Degraded land of Chambal Ravine

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Abstract

A field experiment was conducted on a degraded ravine land to evaluate the influence of inorganic and organic sources of nutrients practices on soil health and crop performance of wheat of (*Triticum aestivum* L.). The crop cultivar MP-1203 of wheat was grown with 120:60:60 kg ha^{-1} (NPK) recommended dose of fertilizers under nutrient management practices viz., seven treatments Farmer Practices (T_1), 100% RDF (T_2), 150% RDF (T_3), STCR Based NPK Application (T_4), 50% RDF + 5 tone FYM + PSB+ all deficient Micro Nutrient (T_5), 75% RDF + 2.5 ton FYM/ha + PSB + $ZnSO_4$@25 kg ha^{-1} (T_6), Organics Practices FYM @10 tone ha^{-1} + PSB + Azotobactor (T_7), in randomized block design, replicated three times. Soil reaction, organic carbon, electrical conductivity, BD, MWD, MC, straw and seed yield were analyzed during the study. It was observed that soil reaction pH -1:2.5 (8.48), electrical conductivity (0.37 dSm^{-1}) and organic carbon (0.19%), Bulk density (1.52 Mg M^{-3}), found significantly higher in the 150% RDF followed by 100% RDF and mean weight diameter (0.50 mm), moisture content (18.24 %), were found significantly higher in the 75% RDF + 2.5 ton FYM/ha + PSB + $ZnSO_4$@25 kg ha^{-1} (T_6) followed by 150% RDF and soil biological properties viz., Microbial Biomass Carbon (SMBC) (66.05 µgC g^{-1}), dehydrogenase activity (DHA) (59.46 µg g^{-1} TPF g^{-1} h^{-1}), and fluorescin diacitate (FDA) (11.24 µg g^{-1} h^{-1}) were found significantly higher in the Organics Practices FYM @10tone ha^{-1}+PSB+Azotobactor (T_7) followed by 75% RDF +2 .5 ton FYM/ha + PSB + $ZnSO_4$@25 kg ha^{-1} (T_6) and 150% RDF (T_3),. Very poor microbial activities were observed in farmer practices. The straw yield (4454.27 kg ha^{-1}) and seed yield (3984.45 kg ha^{-1}) of wheat was found highest in 75% RDF+2.5 ton FYM/ha+ PSB+ $ZnSO_4$@ 25 kg ha^{-1} (T_6) practices followed by 150% RDF and STCR Based NPK Application (T_4), Thus, the study demonstrated that the 75% RDF + 2.5 ton FYM ha^{-1} + PSB+ $ZnSO_4$@ 25 kg ha^{-1} (T_6) practice improved soil health and performance of wheat crop.

Highlights

- Basic parameters which influence nutrient management mediated by organic and inorganic sources of plant nutrient for wheat crop have been validated in Ravine land

Keywords: Degraded land, chambal ravine, soil health, wheat, nutrient management

Wheat (*Triticum aestivum*) is is the world's leading cereal crop cultivated over an area of about 651 million tons making it the third most-produced cereal after maize and rice. India achieved remarkable progress in wheat production during the last four decades. India production of wheat estimated is 88.94 million tons) during 2014-15. Defining soil quality/soil health (which we consider to be interchangeable terms), characterizing healthy soil resources, and relating the significance of soil health to agro-ecosystems and their functions. We examine how soil biology influences soil health and how biological properties and processes contribute to sustainability of agriculture and ecosystem services finding of Michael Lehman, *et al*. (2015). Nutrient management, tillage practices, mulching, addition of clay, surface compaction, conservation tillage, use of polymers, etc. can favorably modify the soil physical properties like bulk density, porosity, aeration, soil moisture, soil aggregation, water retention and transmission properties, and soil processes like evaporation, infiltration, run-off and soil loss for better crop growth and yield. We suggest that if appropriate soil management technologies are adopted in rainfed areas for the improvement of soil physical health, the productivity of rainfed crops can be significantly improved by Indoria, *et al.* (2016). Maji, A.K. *et al.* (2010) The earliest assessment of the area affected by the land degradation was made by the National Commission on Agriculture at 148 M ha, followed by 175 M ha by the Ministry of Agriculture (Soil and Water Conservation Division).

One of the major negative onsite effects of soil erosion is the loss of soil fertility status leading to decline in productivity. It is estimated that India suffers an annual loss of 13.4 million tons in the production of major cereal, oilseeds and pulse crop due to water erosion equivalalent to about 2.51 billion Indian rupees (Sharda *et al.*, 2010). Addition of Integrated Plant Nutrition System (IPNS) to this concept ensures balanced fertilization by application of inorganic and organic sources of nutrients. Use of moong straw to improve nutrient status and soil properties in rice-wheat cropping system (Gangola *et al.*, 2012), farmyard manure to enhance nutrient recovery and productivity of wheat (Bhaduri and Gautam, 2012) and higher rice productivity and optimum biological activities (Bhatt *et al.*, 2012) has been successfully demonstrated in recent literature.

Such recommendations are helpful in maintenance and enhancing soil fertility simultaneously with improving crop production and nutrient use efficiencies. Greatest challenge in 21st century is to feed the ever increasing population along with the improvement and maintenance of soil health and environmental quality. The present experiment was conducted with an objective to evaluate the influence of organic and inorganic practices on soil health and performance of Wheat (*Triticum aestivum*) crop.

MATERIALS AND METHODS

The field experiment was conducted during two consecutive *rabi* seasons of 2013-14 and 2014-15 at Aisah (Ambah Tehsil, district Morena), on Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya farm situated in the ravines of Chambal river situated in Grid zone lying in between 26^{o} 41′ 02.60″ N latitude and 78° 06′ 30.20″ E longitude with an altitude of 163 meters from mean sea level (MSL). The region experiences subtropical climate where hot winds during summer flow for a greater part of the day and night temperatures remain high. The hottest months are May and June (mercury touches 48°C), and the temperature drops considerably in last week of June. The winter commences in October and the months of December and January is the coldest, the minimum temperature some time touches to the freezing point at night. Winter rains are erratic and irregular. The average annual rainfall of the Chambal division is 891.4 mm and a major portion is received in July, August and September.

The weather remains sultry and humid in most of the months during the year. The soil of experimental site is sandy loam in texture (inceptisols), low in organic carbon, highly alkaline and saline with low available nitrogen (N), medium phosphorous (P) and high potassium (K) contents (Table 1). The experiment consists of seven treatments viz., Farmer Practices T_1, 100% RDF T_2, 150% RDF T_3, STCR Based NPK Application T_4, INM 1-50% RDF+5 tone FYM + PSB+ all deficient Micro Nutrient T_5, INM 2-75% RDF+2.5 tone FYM + PSB+ all deficient Micro Nutrient T_6, Organics Practices FYM @10 tone/ ha + PSB+ Azotobactor.) T_7 in randomized block design, replicated three times. The crop cultivar MP-1203 of wheat was grown with 120:60:40 kg ha^{-1} (NPK) recommended dose of fertilizers. The recommended fertilizer dose for wheat as per the treatments were applied (120:60:40 N, P_2O_5 and K_2O kg ha^{-1}, respectively) in the form of urea, single superphosphate and muriate of potash, 5cm away from the seed line and 5 cm deep in the soil. In all, 50 percent of nitrogen and entire dose of P_2O_5 and K_2O was applied at the time of sowing and remaining 50 per cent of nitrogen was top dressed in the form of urea in two splits for wheat at 30 and 50 days after sowing. Wheat was sown at a spacing of 22.5X5 cm in the second week of November and harvested in the second week of March.

The data was analyzed statistically and treatment means were compared using LSD techniques at 5% probability appropriate for RBD (Gomez and Gomez, 1984). Soil samples were collected at harvest

Table 1: Effect of nutrient management on changes of physico chemical properties in ravine soil during 2013-2014 and 2014-15

Tr. No.	Physico chemical properties of soil								
	2013-14			2014-15			Pooled		
	pH (1:2.5)	EC (dSm^{-1})	O.C. (%)	pH (1:2.5)	EC (dSm^{-1})	O.C. (%)	pH (1:2.5)	EC (dSm^{-1})	OC (%)
T_1	8.05	0.13	0.11	8.42	0.52	0.15	8.40	0.33	0.13
T_2	8.22	0.25	0.13	8.42	0.49	0.17	8.48	0.37	0.15
T_3	8.07	0.22	0.16	8.35	0.43	0.12	8.10	0.32	0.14
T_4	8.12	0.27	0.18	8.31	0.47	0.18	8.16	0.37	0.18
T_5	8.18	0.19	0.19	8.48	0.49	0.17	8.14	0.34	0.18
T_6	8.26	0.29	0.20	8.44	0.38	0.18	8.09	0.33	0.19
T_7	8.44	0.28	0.17	8.29	0.51	0.16	8.24	0.39	0.16
SEm±	0.20	0.08	0.02	0.08	0.09	0.02	0.21	0.05	0.02
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

(October 2013 and 2014) from soil 0-15 cm from three spots in each plot. Composite soil samples of each replication from the experimental site were collected, processed to pass through 2 mm sieve and preserved for further analysis.

Similarly, representative soil samples from each plot were collected after the harvest of previous crop under the experimental period November 2013 to March 2014. The soil samples were dried in shade, processed to pass through 2 mm sieve and used for further analysis. pH of soil suspension (1: 2.5 soil : water) was determined by a glass electrode pH meter after equilibrating the soil with water for 30 minutes with occasional stirring (Jackson, 1973). The clear supernatant extract obtained from the suspension used for pH (soil : water, 1:2.5) was utilized for EC measurement by conductivity bridge (Richards, 1954). The oxidizable soil organic carbon (SOC) was determined by wet oxidation (Walkley and Black, 1934). The bulk density was determined by method using core sampler by known volume at field moisture. The bulk density was computed by dividing the oven dry weight of soil core by the volume of the core (Richards, 1954). The aggregate analysis was carried out by using Yoder's apparatus (1936), The moisture release pattern was computed by gravimetric method (Klute, *et al.*, 1986) using pressure plate technique.Soil enzyme activity viz., Total microbial content in soil at most active stage (45 DAS) of crop was estimated as described by Dennis and Eldore, 1982. Dehydrogenase assay content in soil was estimated as described by Lenhard, 1956. dehydrogenase (Casida *et al.*, 1964) and Fluorescein diacetate content in soil was estimated as described by Adam and Duncan, 2001.Were estimated to find out the biological activity of the soil.

RESULTS AND DISCUSSION

Crop Yield affected by nutrient management

Grain Yield

The grains yield (kg ha^{-1}) were recorded treatment wise and the data after statistical analysis have been presented in table 4 The different inorganic and organic practices were found to exert significant impact upon grains yield (kg ha^{-1}) during both the years as well as on pooled basis. Significantly higher 4224.90 kg ha^{-1} grain yield in 2013 - 14 and 3744.00 kg ha-^{1} in 2014 - 15 were recorded under application of 75% RDF + 2.5 ton FYM ha^{-1} + PSB+ $ZnSO_4$@ 25 kg ha^{-1} (T_6), which was statistically identical to (T_3) 150% RDF (3427.31 to 3343.33 kg ha^{-1}) in 2013-14 and 2014-15, respectively) and superior over other inorganic and organic treatments during both the years.

However, treatment (T_2) 100% RDF, (T_4) NPK application on the basis of STCR equations (developed at IARI), (T_5) 50% RDF+5 ton FYM + PSB + $ZnSO_4$ 25 kg ha^{-1} and (T_7) FYM @10 ton/ha+ PSB+ Azotobacter conjoint application of inorganic with organic were at par but were Superior over control during both the years. The lowest value of this parameter 1940.41 kg ha^{-1} in 2013-14 and 1888.90 kg ha^{-1} in 2014-15 were noted under farmer practices plot. In case of pooled data, maximum grain yield (3984.45 kg ha^{-1}) was also noted in 75% RDF+2.5 ton FYM ha^{-1} + PSB + $ZnSO_4$@ 25 kg ha^{-1} (T_6), which was statistically at par with T_3 and significantly higher over rest of the remaining treatments. The minimum grain yield (1914.66 kg ha^{-1}) was observed in farmer practices. The result clearly suggests that the inorganic sources of nutrients are better than organic source as far as crop yield is concerned.

Straw Yield

The observations on straw yield (kg ha^{-1}) were recorded treatment wise and the data after statistical analysis have been presented in table 4 The different inorganic and organic practices were found exert significant impact upon straw yield kg/ha during both the years as well as on pooled basis. Result reveals that inorganic and organic practices significantly increased straw yield over farmer practices during both the years. Significantly higher 4561.27 kg ha^{-1} straw yield in 2013 - 14 and 4347.27 kg ha^{-1} in 2014 - 15 were recorded under application of 75% RDF + 2.5 ton FYM ha^{-1} + PSB+ $ZnSO_4$@ 25 kg ha^{-1} (T_6), which was statistically identical to 150% RDF (4012.12 to 3991.37 kg ha^{-1}) in 2013 - 14 and 2014 - 15, respectively) and superior over other inorganic and organic treatments during both the years.

However, treatment (T_2) 100% RDF, (T_4) NPK application on the basis of STCR equations (developed IARI), (T_5) 50% RDF+5 ton FYM + PSB +Zn SO_4 25 kg ha^{-1}, and (T_7) FYM @10 ton/ha+ PSB + Azotobactor conjoint application of inorganic with organic were at par but were Superior over control during both the years. The lowest value of this parameter 2243.79 kg ha^{-1} in 2013 - 14 and 2245.33 kg ha^{-1} in 2014 - 15 were noted under farmer practices plot. In case of pooled data, maximum straw yield (4454.27 kg ha^{-1}) was also noted in 75% RDF+2.5 ton FYM ha^{-1} + PSB + $ZnSO_4$@ 25 kg ha^{-1} (T_6), which was statistically at par with T_3 and significantly higher over rest of the remaining treatments. The minimum straw yield (2244.56 kg ha^{-1}) was observed in farmer practices.

The residual soil fertility improved considerably with the combined application of inorganic fertilizer and organics. It was concluded that integration of organics Rhizobium, PSB & FYM) with inorganics led to 50% saving of inorganic fertilizer without scarifying the yield of sunnhemp-rice cropping sequence and improved soil fertility status. Tripathi *et al.* (2013), Effect of nutrient management in wheat on yield of and nutrient uptake by wheat and soil properties. After three years conjoint use of 10 t FYM ha^{-1} with 100% NPK significantly improved the organic carbon and available N, P and K contents over the chemical fertilizers alone. Integrated nutrient management (100% NPK + 10 t FYM ha^{-1}) maximized yields of wheat crop and improved the soil fertility in the intermediate zone of Jammu and Kashmir. Chesti, *et al.* (2013) (Mauriya; *et al.*, 2013).

Similarly, recommended dose of inorganic fertilizer (F_{100}) gave significantly higher yield of wheat grain and straw by Naik; *et al.* (2013), Ripudaman Singh, *et al.* (2015) Application of organic manure (FYM) integrated with recommended dose of fertilizers and biofertilizers (PSB + BGA/*Azotobacter*) further increased the yield and yield attributing characters of rice and wheat which was similar to 125% recommended dose of fertilizers by Lal Bahadur; *et al.* (2013), Fertilizers constitute an integral part of improved crop production technology. Proper amount of fertilizer application is considered a key to the higher crop production, Mathura Yadav; *et al.* (2013), Over-application of nitrogen (N) in North Central China is primary reasons for yield restriction and low nutrient use efficiencies by Mathura He; *et al.* (2013), The effect of fertilizers indicated that grain and straw yields of wheat were increased more prominently with the addition of 150 kg N, 60 kg P_2O_5, 50 kg K_2O and 5 t of FYM ha^{-1}. By Debarati Bhaduri and Poonam Gautam (2012b), Mubarak and Singh (2011), Integrated nutrient management system for maize-wheat cropping system in an Alfisol. Grain yield of maize, wheat and the system under 50% N through FYM + 50% through chemical fertilizers was significantly higher than that under 100% chemical fertilizers applied to both the crops and was on par with 25% N through FYM and 75% through inorganic source by Prasad; *et al.* (2010) Effect of nutrient management practices (NM) on growth and yield of wheat (*Triticum aestivum* L.)

The experiment consists of eleven treatments viz., T_I-100% recommended dose of fertilizer (RDF) i.e. 120 : 26.4 : 50 N : P : K kg ha^{-1}, T2- 100%

Table 2: Bulk Density (Mg m^{-3}); Mean Weight Diameter (MWD in mm) and Moisture Content (%) as affected by integrated nutrient management after two year study (2014-15)

Treatments	Bulk Density (Mg m^{-3})	MWD(mm)	Moisture Content (%)
T_1	1.34	0.31	12.60
T_2	1.47	0.42	14.74
T_3	1.52	0.48	15.76
T_4	1.47	0.43	14.72
T_5	1.42	0.33	14.16
T_6	1.42	0.50	18.24
T_7	1.39	0.48	15.69
SEm±	0.04	0.02	0.64
CD(0.05)	NS	0.07	1.96

RDF + Vermicompost @ It ha^{-1}, T3-100% RDF + Vermicompost @ It ha^{-1} + Phosphate Solubilizing bacteria (PSB), T4-100% RDF + PSB, T5-75% RDF+ vermicompost @ 1t ha^{-1}, T6- 75% RDF + vermicompost @ 1t ha^{-1} + PSB, T7-50% RDF + Vermicompost @ 1t ha^{-1}; T8-50% RDF + Vermicompost @ 1t ha^{-1}; + PSB, T9-Vermicompost @ 1t ha^{-1}; + PSB, T10-Vermicompo@st 1t ha^{-1} and T11-absolute control. The results revealed that the application of 100% recommended dose of fertilizers (RDF) i.e. 120:26:4:50 N:P:K kg ha^{-1}+ vermicompost @ 1t ha^{-1} + phosphate solubilizing bacteria (PSB) and 75% RDF + vermicompost @1t ha^{-1}+ PSB produced higher yield attributes and grain yield than the other treatments. The higher yield led to higher NPK uptake by wheat. Further, the available NPK content of soil also increased in above NM treatment over control. The highest benefit: cost ratio (2.73) was obtained from the application of 75% RDF + vermicompost @1t hd1+ PSB. by Devi, *et al.* (2011).

Physico-Chemical Properties of Chambal ravine

The effect of organic and inorganic application on physico chemical properties of ravine land viz., pH, electrical conductivity (dSm^{-1}) and organic carbon was studies in the during 2013-14 and 2014-15 are presented in table 4. The treatments showed higher variation in soil pH and ranged between 8.05 to 8.44 and 8.31 to 8.44 (1.25), 2013-14 and 2014-15, respectively. The EC ranges between 0.13 to 0.29 (dSm^{-1}) and 0.43 to 0.52 (dSm^{-1}) both the study period 2013-14 and 2014-15, respectively. The organic carbon values from 0.11 to 0.20 (%) in 2013-14 and 0.12 to 0.18% in 2014-15 study period, respectively. The regular increase in organic carbon at the both year study period was observed in fertility treatments 75% RDF+2.5 ton FYM ha^{-1}+PSB+$ZnSO_4$@ 25 kg ha^{-1} (T_6) and/or treatment (T_3), (T_4), (T_5), (T_6), (T_7) and super-optimal dose fertility treatment (T_2) as compared to farmer practices. In case of pH, the of highest pH value (8.48) was recorded under (T_2) 100% RDF, electrical conductivity 0.39 (dSm^{-1}), in application FYM @10 ton ha^{-1}+PSB + Azotobactor (T_7), and organic carbon varied in range from 0.13 to 0.19% in pooled basis, respectively. Lowest value was recorded with treatment T_1 (farmer practices).

Improvement in soil properties (pH, EC, OC) and soil fertility status (NPK and Zn) was recorded when chemical fertilizers were integrated with organic manures. By Lal Bahadur; *et al.* (2013) the chemical and biological soil characteristics were studied. Significantly highest increase in soil organic carbon and total nitrogen were recorded with 100% NPK + FYM @10 tonnes/ha. The availability of N, P, K, S, soil microbial biomass carbon and nitrogen, dehydrogenase assay and productivity of sorghum and wheat were significantly increased with the integrated application of organic manure (FYM @ 10 tonnes/ha) and mineral fertilizer (100% NPK) over control and other fertilizer treatments after 20 years of experimentation by Katkar *et al*. (2011), The improvement of soil fertility observed with respect to organic carbon, available N, P, K, Fe, Mn, Cu and Zn was prominent with the application of 50% N through FYM and 50% RDF in maize and 100% RDF in wheat in maize-wheat system. The organic carbon, available N, P, K, Fe, Mn and Pb increased with increasing level of fertilizer whereas, pH, available Cu, Zn and Ni decreased.

In general, availability of heavy metals in soil was noted in the order: Pb>Co>Ni>Cd. Fresh crop residue incorporation or green leaf application were less effective than well decomposed organic matter (FYM) in enhancing crop yield and soil fertility by Prasad; *et al.* (2010)

Physical Properties

Soil bulk density (Mg m^{-3})

The continuous application of organic material in the form of farmyard manure and vermicompost may lower the bulk density of soil. The results showed that (Table 2) continuous application of FYM @10 ton ha^{-1} +PSB + Azotobactor (T_7) and 50% RDF+5 ton FYM/ha + PSB+ $ZnSO_4$ 25 kg ha^{-1} (T_5) lowered down the bulk density of soil from 1.39 and 1.42 Mg m^{-3} in final stage of study period, respectively. With increased doses of RDF (50 to 75, 100%) the bulk density of treatments (T_5> T_6 >T_2 > T_4) increased over the organic manure treatments (T_1 and T_7). The highest bulk density 1.52 Mg m^{-3} was recorded under the treatment 150% RDF (T_3), which remained unchanged at the end of study period.

Application of organic manures resulted in higher soil organic carbon, available N, P and K than the chemical fertilizers. Maximum beneficial micro-organisms were recorded under organic nutrient management (ONM) after completion of 5 crop cycles and the bulk density of soil was also lowered significantly in ONM. The B:C ratio was higher for chemical fertilizers in case of rice-durum wheat-green manuring (3.6) and rice-potato-okra (3.1) due to lesser cost of cultivation. Upadhyay *et al.* (2011), The combined use of inorganic fertilizers (100% NPK) along with FYM @ 10 t ha^{-1} significantly improved the bulk density, hydraulic conductivity, available water capacity, water stable aggregates and coefficient of linear extensibility of soil and yield of crops. Total productivity (sorghum + wheat) was found to be positively correlated with these properties Nandapure, *et al.* (2011).

In this article we review how different management technologies like integrated nutrient management, tillage practices, mulching, addition of clay, surface compaction, conservation tillage, use of polymers, etc. can favorably modify the soil physical properties like bulk density, porosity, aeration, soil moisture, soil aggregation, water retention and transmission properties, and soil processes like evaporation, infiltration, run-off and soil loss for better crop growth and yield. We suggest that if appropriate soil management technologies are adopted in rainfed areas for the improvement of soil physical health, the productivity of rainfed crops can be significantly improved, Indoria, *et al.* (2016), R. Lalith Kannan, *et al*. (2013) Ma Aariff Khan and J Kamalakar (2012) Maurice Kodiwo; Boniface Oindo; and Francis Angawa (2014).

Mean Weight Diameter (mm): MWD of the surface layer were highest in the plots where 75% RDF + 2.5 ton FYM ha^{-1} + PSB + $ZnSO_4$@ 25 kg ha^{-1} (T_6) were applied 0.50 mm and were significantly higher than those of the 150% RDF (T_3) and farmer practices (T_1) treatment (Table 2). Different management practices has a great potential to increase aggregate

Table 3: Soil Microbial Biomass Carbon (SMBC), Dehydrogenase activities (DHA) and Fluorescine Diacetate (FDA) after harvest wheat crop during (2014-15)

Treatments	SMBC (μgC g^{-1})	FDA (μg g^{-1} h^{-1})	DHA (μg g^{-1} TPF g^{-1} h^{-1})
T_1	51.71	5.83	12.43
T_2	54.85	6.09	26.83
T_3	63.79	8.59	36.29
T_4	56.27	7.22	28.73
T_5	62.92	8.93	45.49
T_6	65.46	7.26	47.03
T_7	66.05	11.24	59.46
SEm±	1.84	0.31	1.03
CD(0.05)	5.67	0.94	3.19

stability and improve soil quality. The results of our study showed that MWD had positive correlation with organic carbon, $CaCO_3$ and soil acidity values finding of Solaimani Sardo, *et al.* (2013).

Soil Moisture Content : SMC of the surface layer were highest in the plots where 75% RDF+2.5 ton FYM ha^{-1} + PSB + $ZnSO_4$@ 25 kg ha^{-1} (T_6) were applied (18.24) and were significantly higher than those of the 150% RDF (T_3) and farmer practices (T_1) treatment (Table 2). Nutrient management, tillage practices, mulching, addition of clay, surface compaction, conservation tillage, use of polymers, etc. can favorably modify the soil physical properties like bulk density, porosity, aeration, soil moisture, soil aggregation, water retention and transmission properties changed finding of Indoria, *et al.* (2016), M.A. Aariff Khan and J. Kamalakar (2012).

Biological Properties of soil

Soil microbial biomass carbon (μgC g^{-1}): The study of the data Soil microbial biomass carbon (Table 3) revealed that the Soil microbial biomass carbon (SMBC) affected significantly due to different fertility levels after two year study. Soil microbial biomass carbon (SMBC) highest level of (66.05 μg g^{-1}) in treatments FYM @10 ton ha^{-1} + PSB + Azotobactor (T_7) and over treatments lowest value of (51.71 μg g^{-1}) farmer practices (T_1). Soil microbial biomass carbon was enhanced as both a direct and residual effect with the addition of farmyard manure followed by vermicompost and fertilizer treatments, and also by combined addition of manure with either vermicompost or mineral fertilizer by Dharmsinh D Rathod; *et al.* (2013), Lal Bahadur, *et al.* (2013), Lagomarsino; *et al.* (2009) The chemical and biological soil characteristics were studied. Significantly highest increase in soil organic carbon and total nitrogen were recorded with 100% NPK + FYM @10 tonnes/ha. The availability of N, P, K, S, soil microbial biomass carbon and nitrogen, dehydrogenase assay and productivity of sorghum and wheat were significantly increased with the integrated application of organic manure (FYM @ 10 tonnes/ha) and mineral fertilizer (100% NPK) over control and other fertilizer treatments after 20 years of experimentation. By Katkar *et al.* (2011), S. B. Aher, *et al.* (2015), Land degradation causes great changes in the soil biological properties. It may promote short and long-term increases in soil microbial biomass by J.S. Nunes, *et.al.* (2012).

Fluorescine Diacetate (μg g^{-1} h^{-1}): It is obvious from table 3 & Fg.2, that FDA was significantly better by (T_7) FYM @10 ton ha^{-1} +PSB + Azotobactor and 50% RDF + 5 ton FYM ha^{-1}+ PSB+ $ZnSO_4$ 25 kg ha^{-1} (T_5) over farmer practices while other treatments were statistically at par to (T_3) 150 % RDF. FYM @10 ton ha^{-1} + PSB + Azotobactor maintained its superiority among all the treatments.

Dehydrogenase activity (μg g^{-1} TPF g^{-1} h^{-1}): It is obvious from table-3 & fig.3 that dehydrogenase activity was significantly better by FYM @10 ton ha^{-1} +PSB + Azotobactor (T_7) and 50% RDF+5 ton FYM ha^{-1} + PSB+ $ZnSO_4$ 25 kg ha^{-1} (T_5) over farmer practices while other treatments were statistically at par to (T_3) 150 % RDF. FYM @10 ton ha^{-1} + PSB + Azotobactor maintained its superiority among all

Table 4: Effect of different treatment on grain and straw yield (kg ha-^{1}) of wheat during the two years of study

Treatments	Grain Yield (kg ha-^{1})			Straw Yield (kg ha-^{1})		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_1	1940	1889	1915	2243.8	2245.33	2244.56
T_2	3424	3188	3306	3478.8	3643.50	3561.17
T_3	3427	3343	3385	4012.1	3991.37	4001.74
T_4	2934	2910	2922	2973.8	2910.87	2942.33
T_5	2951	2921	2936	3045.3	2980.73	3013.02
T_6	4225	3744	3984	4561.3	4347.27	4454.27
T_7	2429	2310	2369	2448.9	2377.20	2413.06
SEm±	16.47	26.78	16.1	43.83	53.73	43.71
C.D. (p=0.05)	50.74	82.52	49.6	135.05	165.58	134.71

the treatments. The study of four sites of land under native vegetation (NV), moderately degraded land (LDL), highly degraded land (HDL) and land under restoration for four years (RL) to evaluate changes in soil microbial biomass and activity in lands with different degradation levels in comparison with both land under native vegetation and land under restoration in Northeast Brazil.

Soil samples were collected at 0–10 cm depth. Soil organic carbon (SOC), soil microbial biomass C (MBC) and N (MBN), soil respiration (SR), and hydrolysis of fluorescein diacetate (FDA) and dehydrogenase (DHA) activities were analyzed. After two years of evaluation, soil MBC, MBN, FDA and DHA had higher values in the NV, followed by the RL by J.S. Nunes, *et al.* (2012), the effects of plant nutrient recycling through crop residue management, green manuring, and fertility levels on yield attributes, crop productivity, nutrient uptake, and biofertility indicators of soil health in a rice–wheat cropping system. The study revealed that soil microbial biomass carbon (SMBC) and carbon dioxide (CO_2) evolution were significantly greatest under crop residue incorporation (CRI). Sesbania green manuring (SGM) treatment and were found at levels of 364 $\mu g\ g^{-1}$ soil and 1.75 $\mu g\ g^{-1}$ soil h^{-1}, respectively; these were increased significantly by recycling of organic residues. Activities of dehydrogenase and phosphatase enzymes increased significantly after 3 years, with maximum activity under CRI + SGM treatment. by Paul Jai, *et. al.* (2014) Significantly highest increase in soil organic carbon and total nitrogen were recorded with 100% NPK + FYM @10 tonnes/ha. The availability of N, P, K, S, soil microbial biomass carbon and nitrogen, dehydrogenase assay and productivity of sorghum and wheat were significantly increased with the integrated application of organic manure (FYM @ 10 tonnes/ha) and mineral fertilizer (100% NPK) over control and other fertilizer treatments after 20 years of experimentation, by Katkar, *et al*. (2011), S.B. Aher, *et al.* (2015), Ryoichi Doi & Senaratne Leelananda Ranamukhaarachchi (2009).

CONCLUSION

Nutrient management which has greater influence on soil fertility, soil biology, physical and chemical properties of soil which in turn reflects in to crop yield and soil fertility. In present investigation, besides the superior performance of rain-fed wheat crop, 75% RDF + 2.5 ton FYM/ha + PSB + $ZnSO_4$@ 25 kg ha^{-1} practice reported significantly higher chemical, physical, and biological activities were significantly better by FYM @10 ton ha^{-1} +PSB + Azotobacter (T_7) treatments.

REFERENCES

Adam, G. and Duncan, H. 2001. Development of a sensitive and rapid method for the measurement of total microbial activity using fluorescein diacetate (FDA) in a range of soils. *Soil Biology and Biochemistry* **33**: 943–951. DOI: 10.1016/ s0038-0717(00)00244-3

Aher, S.B., Lakaria, B.L., Swami Kaleshananda, Singh, A.B., Ramana, Ramesh S.K and Thakur J.K. 2015. Effect of organic farming practices on soil and performance of soybean (*Glycine max*) under semi-arid tropical conditions in Central India. *J. Appl. and Natural Sci.,* **7** (1): 67– 71.

Bhaduri, D. and Gautam, P. 2012. Balanced use of fertilizers and FYM to enhance nutrient recovery and productivity of wheat (*Triticum aestivum* cv UP-2832) in Mollisol of Uttarakhand. *Int. J. Agri. Environ. Biotech.,* **5**: 435-439.

Bhatt, B., Chandra, R. and Shri Ram 2012. Long-term application of fertilizer and manure on rice productivity and soil biological properties. *Int. J. Agri. Environ. Biotech.,* **5:** 429-433.

Blake, G.R. and Hartge, K.H. 1986. Bulk density, In A. Klute, Ed. Methods of Soil Analysis. Part 1, Physical and Mineralogical Methods 2nd ed. American Society of Agronomy, Madison, Madison, Wisconsin, USA. No. 9.364-367pp.

Casida, L.E., Klein, D.A. and Santoro, T. 1964. Soil dehydrogenase activity. *Soil Sci.,* **98**: 371-376. http:// dx. DOI. org/10.1097/00010694-196412000-00004

Chesti, M.H., Anshuman Kohli, and Sharma, A.K. 2013. Effect of Integrated Nutrient Management on Yield of and Nutrient Uptake by Wheat (*Triticum aestivum*) and Soil Properties under Intermediate Zone of Jammu and Kashmir, *J. Indian Soci. Soil Sci.,* **61**(1): 1-6.

Debarati Bhaduri and Poonam Gautam 2012. Balanced Use of Fertilizers and FYM to Enhance Nutrient Recovery and Productivity of Wheat (Triticum aestivum Cv up-2382) in a Mollisol of Uttarakhand. *Int. J. Agri. Environ. Biotech.,* **5**(4): 435.

Dennis Parkinson and Eldora Paul., 1982. Microbial Biomass, In A.L. Page, Ed. Methods of Soil Analysis, Part 2, Chemical and microbiological properties Amer. Soc. Agron. Inc., Madison, USA. No. **9.** 821-824 pp

Devi, K.N., Singh, M.S., Singh, N.G. and Thokpam, S.A. 2011. Effect of integrated nutrient management on growth and yield of wheat *(Triticum aestivum* L.) *J. Crop and Weed* **7**(2): 23-27.

Dharmsinh D Rathod, Paresh H Rathod, Kishorbhai P Patel and Khushvadan C Patel, 2013. Integrated Use of Organic and Inorganic Inputs in Wheat-Fodder Maize Cropping

Sequence to Improve Crop Yields and Soil Properties. *Archives of Agronomy and Soil Sci.*, **59**(11): 1439-1455.

Gangola, P., Singh, R., Bhardwaj, A.K. and Gautam, P. 2012. Effect of moog straw on soil properties under INM in long-term rice wheat cropping system in a Mollisol. *Int. J. Agri. Environ. Biotech.*, **5**: 281-186.

Gomez, K.A. and Gomez, A.A. 1984. Statistical procedure for agricultural research. 2nd ed. Singapore: John Wiley and Sons.

Indoria, A.K, Sharma K.L., Sammi Reddy K and Ch. Srinivasa Rao 2016. Role of soil physical properties in soil health management and crop productivity in rainfed systems–II. Management technologies and crop productivity. *Curr. Sci.*, **110**(3): 322.

Indoria, A.K, Sharma K.L., Sammi Reddy, K. and Ch. Srinivasa Rao 2016. Role of soil physical properties in soil health management and crop productivity in rainfed systems–II. Management technologies and crop productivity. *Curr. Sci.*, **110**(3): 322.

Katkar, R.N., Sonune, B.A. and Kadu, P.R. 2011. Long-term effect of fertilization on soil chemical and biological characteristics and productivity under sorghum (Sorghum bicolor)–wheat (*Triticum aestivum*) system in Vertisol. *Indian J. Agri. Scii.*, **81**(8): 734–9.

Lagomarsino, Grego, Marhan, Moscatelli and Kandeler 2009. Soil Management Modifies micro-scale Abundance and Function of Soil Microorganisms in a Mediterranean Ecosystem, *European J. Soil Sci.*, **60**(1): 2-12.

Lal Bahadur, Tiwari, D.D., Mishra, J. and Gupta, B.R. 2013. Evaluation of Integrated Nutrient Management Options in Rice (*Oryza Sativa*)– **Wheat (***Triticum Aestivum*) Cropping System in Reclaimed Sodic Land. *Indian J. Agro.*, **58**(2): 137-145.

Lalith Kannan, R. Dhivya, M. Abinaya, D. Lekshmi Krishna R. and Krishnakumar S. 2013. Effect of Integrated Nutrient Management on Soil Fertility and Productivity in Maize, *Bulletin of Environment, Pharmacology and Life Sciences.*, **2**(8): 61-67.

Lenhard, G. 1956. The dehydrogenage activity in soil as a measure of soil microorganisms. Z.Pflanzenernaehr, Dueng, *Bodenkd.* **73**: 1-11.

Ma Aariff Khan and Kamalakar, J. 2012 Physical, physico-chemical and chemical properties of soils of newly established Agro-biodiversity Park of Acharya NG Ranga Agricultural University, Hyderabad, Andhra Pradesh *Int. J. Farm Sci.*, **2**(2): 102-116.

Maji, A.K., Obi Reddy, G.P. and Sarkar and Dipak 2010. Degraded and Wastelands of India. Status and Spatial Distribution. Published by Dr T.P. Trivedi, Project Director, Directorate of Information and Publications of Agriculture, Indian Council of Agricultural Research, Krishi Anusandhan Bhavan I, Pusa, New Delhi.

Mathura Yadav, Praveen Rao, V. and Suresh, K. 2013. Nutrient Uptake of Microsprinkler Irrigated Wheat Cultivars under Varying Nitrogen Levels. *J. Res. ANGRAU*, **41**(2): 131.

Mauriya, A.K., Maurya, V.K., Tripathi, H.P., Verma, R.K. and Radhey Shyam 2013. Effect of site-specific nutrient management on productivity and economics of rice (Oryza sativa)–wheat (*Tritucum aestivum*) system. *Indian J. Agro.*, **58**(3): 282.

Michael Lehman, R. Cynthia, Cambardella, A. Diane, Stott, E. Veronica Acosta-Martinez, Daniel Manter, K. Jeffrey, Buyer, S. Jude, Maul, E. Jeffrey, Smith, L. Harold, Collins, P. Jonathan, Halvorson, J. Robert, Kremer, J. Jonathan, Lundgren, G. Tom, Ducey, F. Virginia, Jin, L. and Douglas Karlen, L. 2015. Understanding and Enhancing Soil Biological Health: The Solution for Reversing Soil Degradation, *Sustainability*, **7:** 988-1027.

Mr. Maurice Kodiwo, Prof. Boniface Oindo, and Prof. Francis Ang'awa 2014. Intensity of Farmland Cultivated and Soil Bulk Density in Different Physiographic Units In Nyakach District *J. Humanities And Social Science (IOSR-JHSS)* 1**9**(1): 86-91.

Mubarak, T. and Singh, K.N. 2011. Nutrient Management and Productivity of Wheat (*triticum Aestivum*)– based Cropping Systems in Temperate Zone. *Indian J. Agronomy*, **56**(3).

Naik, V.R. Patel, P.B. Patel, B.K. Barvalia, V.D. and Patil, R.G. 2013. Integrated Nutrient Management in Wheat Grown on Coastal Areas of Gujarat. *Bioinfolet*, **10**(4B).

Nandapure, S.P. Sonune, B.A. Gabhane, V.V. Katkar, R.N. and Patil, R.T. 2011. Long Term Effects of Integrated Nutrient Management on Soil Physical Properties and Crop Productivity in Sorghum-Wheat Cropping Sequence in a Vertisol. *Indian J. Agri. Res.*, **45**(4).

Nunes, J.S., Araujo, A.S.F., Nunes, L.A.P.L., Lima, L.M., Carneiro, R.F.V., Salviano, A.A.C. and Tsai, S.M. 2012. Impact of Land Degradation on Soil Microbial Biomass and Activity in Northeast Brazil, *Pedosphere*, **22**(1): 88–95.

Paul Jai, Anil Kumar Choudhary, Suri, V.K., Sharma, A.K., Vinod Kumar and Shobhna, 2014. Bioresource Nutrient Recycling and its Relationship with Biofertility Indicators of Soil Health and Nutrient Dynamics in Rice–Wheat Cropping System. *Communications in Soil Science and Plant Analysis*, **45**(7): 912-924.

Ping He, Zhimin Sha, Dongwei Yao, Suli Xing and Wei Zhou 2013. Effect of Nitrogen Management on Productivity, Nitrogen Use Efficiency and Nitrogen Balance for a Wheat-Maize System. *J. Plant Nutrition*, **36**(8): 1258-1274.

Prasad, J., Karmakar, S., Kumar, R. and Mishra, B. 2010. Influence of Integrated Nutrient Management on Yield and Soil Properties in Maize-Wheat Cropping System in an Alfisol of Jharkhand. *J. Indian Soc. Soil Sci.*, **58**(2).

Richards, L.A. 1954. Ed. The diagnosis and improvement of saline and alkali soils. U.S.D.A. Handbook 60.

Ripudaman Singh, Hemant Kumar, Sanjiv Kumar and Shweta 2015. Moisture use, productivity and economics of late sown wheat (*Triticum aestivum*) under limited moisture regimes and integrated nutrient management, *Research. Environ. Life Sci.*, **8**(2): 278-280.

Ryoichi Doi and Senaratne Leelananda Ranamukhaarachchi 2009. Soil dehydrogenase in a land degradation-rehabilitation gradient: observations from a savanna site with a wet/dry seasonal cycle, *Int. J. Tropropical Biology.* **57**(1-2): 223-234.

Sharda, V.N., Dogra, P. and Prakash, C. 2010. Assessment of production losses due to water erosioninrainfed areas of India. *J. Soil Water Conservation*, **65**: 79-91.

Solaimani Sardo, M., Asgari, H.R., Kiani, F. and Heshmati Gh. A. 2013. Effects of Biological Practices on Soil Stability in a Desertified Area of Iran, *Int. J. Environ. Resources Res.*, **1**: 1.

Tripathi, M.K., Majumdar, B., Bhandari, H.R., Babita Chaudhary, Saha, A.R. and Mahapatra, B.S. 2013. Integrated Nutrient Management in Sunnhemp (Crotalaria juncea)-Rice Cropping Sequence in Eastern Uttar Pradesh, *Indian J. Agri. Res.*, **47**(3).

Upadhyay, V.B., Vikas Jain, Vishwakarma, S.K. and Kumhar, A.K. 2011. Production Potential, Soil Health, Water Productivity and Economics of Rice (*Oryza sativa*)-based Cropping Systems under Different Nutrient Sources. *Indian J. Agronomy,* **56**(4).

Walkley, A. and Black, I.A. 1934. An examination of the digestion method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science*, **37**: 29-33.

Yoder, R.E. 1936. A direct method of aggregate analysis of soil and a study of the physical nature of erosion losses. *J. American Society of Agronomy* **28**: 337-351.