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Effect of long term application of fertilizer and manure on physico-chemical properties of soil under maize-wheat sequence in *Heplustepts*

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Abstract
A field study entitled "Effect of long term application of fertilizer and manure on physico-chemical properties of soil under maize-wheat sequence in *Heplustepts*" was conducted during *Kharif* 2013-14 and 2014-15 in the Long Term Fertilizer Experiments initiated in *Kharif*, 1997 at the Instructional Farm of the Rajasthan College of Agriculture, Udaipur. The soil of the experimental site was sandy clay loam in texture, slightly alkaline in reaction, medium in available nitrogen and phosphorus, while high in potassium and zinc. The objectives were to assess effect of continuous application of fertilizer and manure on physic-chemical properties of soil. The treatment consisted of control, 100 % N, 100 % NP, 100 % NPK, 100 % NPK + Zn, 100 % NPK + S, 100 % NPK + Zn + S, 150 % NPK, 100 % NPK + *Azotobacter*, FYM 10 t ha^{-1} + 100 % NPK (-NPK of FYM), 100 % NPK + FYM 10 t ha^{-1} and FYM 20 t ha^{-1}. These treatments were evaluated under randomized block design (RBD) with four replications. The results of the present investigation revealed that the highest available nitrogen were obtained in treatment under the application of 100% NPK + FYM 10 t ha^{-1} and the highest available phosphorus was obtained in treatment 100% NPK + Seed treatment with Azotobactor. The highest potassium was obtained in treatment 150% NPK and the highest Organic carbon was obtained in treatment FYM 20 t ha^{-1}. The highest available water content and Soil Aggregate were obtained in treatment FYM 20 t ha^{-1}.

Keywords: Organic manure, bio-fertilizer (*Azotobacter*), organic carbon soil aggregate

Introduction
Sustainable agriculture involves successful management of resources for increase agricultural production to satisfy changing human needs, while maintaining or enhancing the environment and natural resources (FAO, 1989) [2]. Long-term experiments initiated during 1930's and 1940's in India revealed that for sustained crop production adequate P and K fertilization was necessary along with nitrogen (Nambiar and Abrol, 1989) [1]. Many of' these experiments were not followed for detailed monitoring of soil fertility. Phosphorus is the second major nutrient in practical agriculture, being fairly immobile, becomes unavailable for plant uptake through conversion to insoluble form. Under such circumstances, microbial biomass although relatively small, can be an important source of P for microorganisms. Measurement of P content of soil biomass is essential for an accurate assessment of its important in P cycling crop nutrition (Rao and Khera 1995) [17]. The role of microorganisms in P turnover and P availability was found to be more important in the organic system (Fliessbach *et al.*, 1998) [10]. Microbial biomass phosphorus is a significant source of P to plants and its agricultural effectiveness could be modified by the addition of limestone. Fertilizers and organic amendments (He *et al,* 1998). The application of N,P,K and FYM increasing of soil microbial-biomass C and dehydrogenase activity. The mineral-fertilizer recommendations are inadequate, whereas annual application of FYM along with NPK fertilizers sustains yield and soil productivity. Ranjan Bhattacharyya *et al,* (2008) [16]. The application of chemical fertilizer along with organic manure increased soil fertility status in terms of pH, organic carbon, available N, P, K, S and B as compared to its initial values of cropping system. The major constraint affecting the soil fertility is the adequate availability of suitable fertilizer and organic manures. Choosing in cultivation of suitable Biofertilizer and fertilizer that adapts itself under the normal soil condition of the Udaipur region is a necessity for soil fertility sustainability. Concomitantly, adoption of appropriate integrated nutrient management operations may result in acceptable physical characteristics of soil, *viz* soil microbial biomass nitrogen, soil microbial biomass phosphorus, potassium and ultimate enhancement of water holding capacity. One of the feasible solutions for addressing the imbalanced nutrient and related constrains, is the applied of FYM and biofertilizer,

which promote soil fertility and organic carbon in soil. Soils of Udaipur region belongs to different soil groups. It's very difficult task to predict about its fertility make-up. As the soil fertility is decreasing day by day due to low use of farmyard manure and consequently increase in use of chemical fertilizers, our aim is to study the trend of soil status of soil in long run. The organic matter is decreasing in our soil. Therefore such study will generate useful information on managing soil health.

Materials and Methods

At the inception of the experiment, the composite soil samples were drawn from 0-15 cm depth prior to treatment application in order to ascertain initial fertility status and physico-chemical properties of the experimental soil. The soil having pH (8.20), EC 0.48, Organic carbon (g kg^{-1}) 6.80, Available Nitrogen 360 (kg ha^{-1}), Available phosphorus 22.4 (kg ha^{-1}), Available potassium 671 (kg ha^{-1}), Available Zn 3.76 (mg kg^{-1}), Available Fe 2.52 (mg kg^{-1}). The experiment was carried out at the Instructional Farm of the Rajasthan College of Agriculture, Udaipur, in randomized block design (RBD) with four replications The treatment consisted of three sources chemical fertilizers, organic manure and bio-fertilizer (*Azotobacter*) and their combinations, *viz*., control, 100 % N, 100 % NP, 100 % NPK, 100 % NPK + Zn, 100 % NPK + S, 100 % NPK + Zn + S, 150 % NPK, 100 % NPK + *Azotobacter*, FYM 10 t ha^{-1} + 100 % NPK (-NPK of FYM), 100 % NPK + FYM 10 t ha^{-1} and FYM 20 t ha^{-1}. Statistical analysis was done as outlined by Panse and Sukhatme (1985). The data so generated during the course of present investigation were subjected to simple correlations, regression analysis. Pooled analysis of the data for two year was carried out using standard analysis of variance suggested by Gomez and Gomez (1984) [7].

Results and Discussion

There was progressive increase N (kg ha^{-1}) significantly higher values (at 2013-14 (459), at 2014-15 (464) and pooled (461) observed in treatment T_9 (100% NPK + FYM 10 t ha^{-}1), but P (kg ha^{-1}) significantly higher values at 2013-14 (27.54), at 2014-15 (29.97), pooled (28.75) observed in treatment T_8 (100% NPK + Seed treatment with Azotobactor). However P (kg ha^{-1}) treatment T_9 (100% NPK + FYM 10 t ha^{-1}) was found to be statistically at par with treatment T_8 (100% NPK + Seed treatment with Azotobactor). However at 2013-14, 2014-15 and pooled N (kg ha^{-1}) highest (459, 464 and 461 respectively) were observed in treatment T_9 (100% NPK + FYM 10 t ha^{-1}) which was 79.29, 84.12 and 81.49% higher than lowest value (256, 252 and 254 respectively) in treatment T_1 Control, but at 2013-14, 2014-15 and pooled P (kg ha^{-1}) highest (27.54, 29.97 and 28.75 respectively) were observed in treatment T_8 (100% NPK + Seed treatment with Azotobactor) which was 60.49, 98.74 and 89.39% higher than lowest value (15.29, 15.08 and 15.18 respectively) in treatment T_1 Control.

The maximum increase in the microbial biomass, due to these inputs was observed under the manure + fertilizer treatment. Similar findings was reported by Ghoshal and Singh (1995).Soil microbial biomass nitrogen was increased with the integrated application of organic manure (FYM @ 10 tonnes/ha) and mineral fertilizers (100% NPK) over control and other fertilizer treatment. Similar findings was reported by (Katkar *et. al.,* 2011) [13] The greater amount of crop residues and N fertilizers provided substrate for maintenance of the larger soil microbial biomass pool and the higher C and N mineralization in the 0 to 200 mm depth during the growing season similar findings was reported by (Salinas *et al.,* 1997) [18]. Soil microbial biomass nitrogen and carbon play an important role in nutrient cycling in soils Similar findings was reported by (Oliveira *et al.,* 2001) [15]. The amount of microbial biomass P was found to be the highest for the combined application of 100% NPK + farmyard manure (FYM). Similar findings was reported by (Santhy *et al.* 2004) [19].

There was progressive increase K (kg ha^{-1}) significantly higher values (at 2013-14 (614), at 2014-15 (600) and pooled (607) observed in treatment T_{11} (150% NPK), but OC (%) significantly higher values (at 2013-14 (0.896), at 2014-15 (0.902), pooled (0.899) observed in treatment T_{12} (FYM 20 t ha^{-1}). However K (kg ha^{-1}) treatment T_9 (100% NPK + FYM 10 t ha^{-}1), T_{10} (FYM 10 t ha^{-1} + 100% NPK (-NPK of FYM) and T_{12} (FYM 20 t ha^{-1}), were found to be statistically at par with treatment T_{11} (150% NPK). However at 2013-14, 2014-15 and pooled K (kg ha^{-1}) highest (614, 600 and 607 respectively) were observed in treatment T_{11} (150% NPK) which was 24.79, 25.00 and 24.89% higher than lowest value (492, 480 and 486 respectively) in treatment T_2 (100% N). Integrated nutrient management on soil fertility and revealed that application of recommended dose of inorganic fertilizer along with FYM @ 10 tonnes ha^{-1} improved soil fertility in terms of available N, P, K and organic carbon. Similar findings was reported by Kannan *et al.* (2013). Integrated nutrient management on soil fertility status under maize-wheat cropping sequence and reported that application of chemical fertilizer along with organic manure significantly increased soil fertility status in terms of pH, organic carbon, available N, P, K, S and B as compared to its initial values after twenty two years of cropping. Similar findings was reported by.

There was progressive increase available water content and Soil Aggregate after harvest of wheat crop significantly higher values (AWC (%) at 2013-14 (13.10), at 2014-15 (14.27) and pooled (13.69) and (Soil Aggregate (%) at 2013-14 (62.97), at 2014-15 (65.50) and pooled (64.24) observed in treatment T_{12} (FYM 20 t ha^{-1}). However available water content and Soil Aggregate treatment T_9 (100% NPK + FYM 10 t ha^{-}1) was found to be statistically at par with treatment T_{12} (FYM 20 t ha^{-1}). Organic amendments (manure and compost) were mixed with a soil: sand blend at 2 per cent by dry weight and blends were incubated at 12 per cent moisture for 24 weeks at 25°C. Similar findings was reported by (Hartz *et al,* 2000) [12]. Application of organic manures such as Farmyard manure increases the available water content and Soil Aggregate after harvest of wheat crop and promotes the activity of beneficial micro-organism. The long term effect on fertilization on fractionation of organic matter and found that OM, FA, HA content showed positive significant relationship with grain and fodder yield of maize. Similar findings was reported by (Filon and Shelar, 2002) [3]. Thakre and Ravankar (2004) [5]. Humus Conservation in soils is favourably influenced by N fertilization through maintaince of equilibrium between humification and mineralization processes where organo-mineral fertilization of cultivated soils increases the fertility by accumulation of organic matter. Similar findings was reported by (Tianu, 1997) [6].

Table 1: Effect of Manure and Fertilizer on available N and P after harvest of wheat crop in LTFE soil

Treatment	N (kg ha^{-1})			P (kg ha^{-1})		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_1 = Control	256	252	254	15.29	15.08	15.18
T_2 = 100% N	246	265	255	15.83	15.25	15.54
T_3 = 100 NP	273	276	275	21.54	22.44	21.99
T_4 = 100% NPK	341	346	344	22.84	23.26	23.05
T_5 = 100% NPK + Zn	337	339	338	22.72	23.40	23.06
T_6 = 100% NPK+ S	339	341	340	22.93	24.13	23.53
T_7 = 100% NPK+ Zn + S	334	336	335	25.15	26.89	26.02
T_8 = 100% NPK + Seed treatment with Azotobactor	341	345	343	27.54	29.97	28.75
T_9 = 100% NPK + FYM 10 t ha^{-1}	459	464	461	27.52	29.33	28.42
T_{10} = FYM 10 t ha^{-1} + 100% NPK (-NPK of FYM)	396	402	399	23.40	25.76	24.58
T_{11} = 150% NPK	360	367	364	22.34	24.23	23.29
T_{12} = FYM 20 t ha^{-1}	293	302	298	25.94	26.60	26.27
S.Em.±	6	5	4	0.55	0.40	0.49
C.D. at 5 %	17	15	11	1.58	1.15	1.51

Table 2: Effect of Manure and Fertilizer on available K and OC after harvest of wheat crop in LTFE soil

Treatment	K (kg ha^{-1})			OC (%)		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_1 = Control	497	494	496	0.524	0.523	0.524
T_2 = 100% N	492	480	486	0.637	0.632	0.635
T_3 = 100 NP	498	488	493	0.672	0.673	0.673
T_4 = 100% NPK	541	550	545	0.722	0.724	0.723
T_5 = 100% NPK + Zn	588	582	585	0.729	0.733	0.731
T_6 = 100% NPK+ S	569	555	562	0.717	0.722	0.720
T_7 = 100% NPK+ Zn + S	553	564	559	0.738	0.744	0.741
T_8 = 100% NPK + Seed treatment with Azotobactor	563	559	561	0.603	0.594	0.598
T_9 = 100% NPK + FYM 10 t ha^{-1}	590	587	588	0.851	0.865	0.858
T_{10} = FYM 10 t ha^{-1} + 100% NPK (-NPK of FYM)	598	595	597	0.845	0.851	0.848
T_{11} = 150% NPK	614	600	607	0.724	0.721	0.723
T_{12} = FYM 20 t ha^{-1}	599	586	593	0.896	0.902	0.899
S.Em.±	10.60	11.00	7.64	0.017	0.017	0.012
C.D. at 5 %	30.53	31.68	21.58	0.049	0.050	0.034

Table 3: Effect of Manure and Fertilizer on available water content (AWC) and Soil Aggregate after harvest of wheat crop in LTFE soil

Treatment	AWC (%)			Soil Aggregate (%)		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_1 = Control	11.42	11.53	11.48	50.05	50.19	50.12
T_2 = 100% N	10.62	10.99	10.80	51.38	52.88	52.13
T_3 = 100 NP	11.19	11.24	11.21	51.66	53.14	52.40
T_4 = 100% NPK	10.85	11.04	10.95	54.28	55.78	55.03
T_5 = 100% NPK + Zn	11.49	11.79	11.64	54.30	55.80	55.05
T_6 = 100% NPK+ S	11.58	11.63	11.61	55.37	56.87	56.12
T_7 = 100% NPK+ Zn + S	11.64	11.67	11.65	56.10	57.60	56.85
T_8 = 100% NPK + Seed treatment with Azotobactor	11.36	12.34	11.85	56.73	58.23	57.48
T_9 = 100% NPK + FYM 10 t ha^{-1}	12.75	13.78	13.26	60.55	63.07	61.81
T_{10} = FYM 10 t ha^{-1} + 100% NPK (-NPK of FYM)	12.69	13.69	13.19	56.25	58.81	57.53
T_{11} = 150% NPK	10.73	10.85	10.79	55.80	57.33	56.57
T_{12} = FYM 20 t ha^{-1}	13.10	14.27	13.69	62.97	65.50	64.24
S.Em.±	0.26	0.24	0.18	0.85	1.04	0.67
C.D. at 5 %	0.74	0.69	0.49	2.46	2.98	1.90

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