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Effect of Long Term Application of Fertilizer and Manure on Establish Relationship between Soil Organic Carbon Fractions with Yield of Maize and Wheat Crops under Maize-Wheat Sequence in *Heplustepts*

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A B S T R A C T

A field study entitled "Effect of long term application of fertilizer and manure on Establish Relationship Between soil Organic Carbon Fractions with yield of maize and wheat crops 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 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}. The application of farm yard manure also increased the passive and active soil organic carbon like humin, humic acid, fulvic acid, soil microbial carbon, water soluble carbon, water soluble carbohydrate and carbon mineralization. The significant positive correlation was found of organic carbon fraction with yield of maize and wheat crops. The regression of maize grain and stover yield, wheat grain and straw yield with its forms explains the variation in forms up to 92%, 99%, 99% and 98%, respectively.

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). 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). 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).

The role of microorganisms in P turnover and P availability was found to be more important in the organic system (Fliessbach *et al.,* 1998). 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 *i.e.,* the application of N, P, K and FYM increasing of soil microbial-biomass C and dehydrogenase activity (He *et al.,* 1998). 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). 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 (Manjhi *et al.,* 2014). The major constraint affecting the soil fertility is the adequate availability of suitable fertilizer and organic manures. 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 as certain initial fertility status and physico-chemical properties of the experimental soil. 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 correlation, regression analysis (Steel and Torrie, 1980). Pooled analysis of the data for two year was carried out using standard analysis of variance suggested by Gomez and Gomez (1984).

Results and Discussion

The soil microbial biomass carbon fraction ascribed highly significant positive relationship only with wheat grain yield (r= 0.488**) and significantly positive relationship with maize grain yield (r=0.421*), maize stover yield (0.384*) and wheat straw yield (0.390**). The soil microbial biomass nitrogen fraction ascribed highly significant positive relationship with wheat grain yield (r= 0.608**), maize grain yield (0.520**), maize stover yield (0.491**) and wheat straw yield (0.511**).

The SMBP fraction ascribed significant positive relationship with maize grain yield (r=0.430*), maize stover yield (0.331*) and significant positive relationship with wheat grain yield (r=0.310*).The water soluble carbon fraction ascribed significant positive relationship with maize grain yield (r=0.425*), maize stover yield (r=0.424*), wheat grain yield (r=0.426*) and wheat straw yield (0.336*).

The water soluble carbohydrates fraction ascribed highly significant positive relationship with maize grain yield (r= 0.507**), maize stover yield, wheat grain yield (r=0.637**) and wheat straw yield (r=0.612**). The soil dehydrogenase activity fraction ascribed significant positive

relationship with maize grain yield (r=0.360*), maize stover yield (r=0.364*) and wheat grain yield (0.314*). The carbon mineralization fraction ascribed highly significant positive relationship with maize grain yield (0.557**). maize stover yield (r=0.636**), wheat grain yield (r=0.577**) and wheat straw yield (r=0.554**).

The humic acid fraction ascribed significant p ositive relationship with only wheat grain yield (r=0.321*), In case of humic acid fraction non significant positive re lationship with maize grain yield, maize stover yield and wheat straw yield. The fulvic acid fraction ascribed all maize grain and stover yield and wheat grain and straw yield observed non-significant. The humin fraction ascribed highly significant positive relationship with maize grain yield (r=0.605**), maize stover yield (r=0.613**), wheat grain yield (r=0.632**) and wheat straw yield (r=0.600**).

The soil microbial biomass carbon highly significantly correlated with soil microbial biomass nitrogen (r=0.829**), water soluble carbon (r=0.776**), humic acid (r=0.727**), Humin (r=0.729**) and significant positive relationship with soil microbial biomass phosphorus (r=0.608*) and fulvic acid (r=0.701*).

The soil microbial biomass nitrogen highly significantly correlated with SMBP (r=0.813**), DHA (r=0.751**), carbon mineralization (r=0.825**), humic acid (r=0.779**), humin (r=0.827**) and significant positive relationship with water soluble carbohydrates (r=0.637*) and fulvic acid (r=0.653*). The soil microbial biomass phosphorus found highly significantly correlated with DHA (r=0.810**), carbon mineralization (r=0.809**) and humin (r=0.739**). The water soluble carbon found highly significantly correlated with DHA

(r=0.892**), humic acid (r=0.710**) and significant positive relationship with WSCO (r=0.631*), carbon mineralization (r=0.619*), fulvic acid (r=0.695*) and humin (r=0.606*).

The water soluble carbohydrate significantly correlated with DHA (r=0.594*), carbon mineralization (r=0.633*) and humin (r=0.666*).

The soil dehydrogenase activity found highly significantly correlated with carbon mineralization (r=0.744**) and significant positive relationship with humic acid (r=0.631*), fulvic acid (r=0.582*) and humin (r=0.600*). The carbon mineralization highly significantly correlated only with humin (r=0.893**) and significant positive relationship with humic acid (r=0.674*).The humic acid highly significantly correlated with fulvic acid (r=0.952**) and humin (r=0.776**). The fulvic acid significant correlated with humin (r=0.634*).

Pooled stepwise regression

The regression of maize grain and stover yield, wheat grain and straw yield with its forms explains the variation in forms up to 92%, 99%, 99% and 98% respectively. soil microbial biomass carbon followed by Soil microbial biomass nitrogen, soil microbial biomass phosphorus, water soluble carbon, water soluble carbohydrates, soil dehydrogenase activity, humic acid, fulvic acid and humin to the maximum extent. The soil microbial biomass carbon fraction ascribed highly significant positive relationship with wheat grain yield, maize grain yield, soil microbial biomass nitrogen, water soluble carbon, humic acid, Humin and significant positive relationship with soil microbial biomass phosphorus and fulvic acid. The results of present investigation are in line with the finding of Thakre and Ravankar (2004) and Santhy (1999).

Table.1 Correlation co-efficient between different forms of active fraction and maize & wheat yield of LTFE soils in 2013-14 and 2014-15

Sr. no.	Correlation between	
	Active pools forms to crop yield	
1	Soil Microbial Biomass Carbon **v/s** Maize grain Yield	0.421*
2	Soil Microbial Biomass Carbon **v/s** Maize stover Yield	0.384*
3	Soil Microbial Biomass Carbon **v/s** Wheat Grain Yield	0.488**
4	Soil Microbial Biomass Carbon **v/s** Wheat Straw Yield	0.390*
5	Soil Microbial Biomass Nitrogen **v/s** Maize grain Yield	0.520**
6	Soil Microbial Biomass Nitrogen **v/s** Maize stover Yield	0.491**
7	Soil Microbial Biomass Nitrogen **v/s** Wheat Grain Yield	0.608**
8	Soil Microbial Biomass Nitrogen **v/s** Wheat Straw Yield	0.511**
9	Soil Microbial Biomass Phosphorus **v/s** Maize grain Yield	0.430*
10	Soil Microbial Biomass Phosphorus **v/s** Maize stover Yield	0.331*
11	Soil Microbial Biomass Phosphorus **v/s** Wheat Grain Yield	0.310*
12	Soil Microbial Biomass Phosphorus **v/s** Wheat Straw Yield	0.294
13	Water Soluble Carbon **v/s** Maize grain Yield	0.425*
14	Water Soluble Carbon **v/s** Maize stover Yield	0.424*
15	Water Soluble Carbon **v/s** Wheat Grain Yield	0.426*
16	Water Soluble Carbon **v/s** Wheat Straw Yield	0.336*
17	Water Soluble Carbohydrates **v/s** Maize grain Yield	0.507**
18	Water Soluble Carbohydrates **v/s** Maize stover Yield	0.471**
19	Water Soluble Carbohydrates **v/s** Wheat Grain Yield	0.637**
20	Water Soluble Carbohydrates **v/s** Wheat Straw Yield	0.612**
21	Soil Dehydrogenous Activity **v/s** Maize grain Yield	0.360*
22	Soil Dehydrogenous Activity **v/s** Maize stover Yield	0.364*
23	Soil Dehydrogenous Activity **v/s** Wheat Grain Yield	0.314*
24	Soil Dehydrogenous Activity **v/s** Wheat Straw Yield	0.255
25	Carbon Mineralization **v/s** Maize grain Yield	0.557**
26	Carbon Mineralization **v/s** Maize stover Yield	0.636**
27	Carbon Mineralization **v/s** Wheat Grain Yield	0.577**
28	Carbon Mineralization **v/s** Wheat Straw Yield	0.554**

Table.2 Correlation co-efficient between different forms of passive fraction and maize & wheat yield of LTFE soils in 2013-14 and 2014-15 year

Sr. no.	Correlation between	
	Passive pools forms to crop yield	
1	Humic Acid **v/s** Maize grain Yield	0.191
2	Humic Acid **v/s** Maize stover Yield	0.273
3	Humic Acid **v/s** Wheat Grain Yield	0.321*
4	Humic Acid **v/s** Wheat Straw Yield	0.196
5	Fulvic Acid**v/s** Maize grain Yield	0.088
6	Fulvic Acid**v/s** Maize stover Yield	0.166
7	Fulvic Acid**v/s** Wheat Grain Yield	0.201
8	Fulvic Acid**v/s** Wheat Straw Yield	0.075
9	Humin **v/s** Maize grain Yield	0.605**
10	Humin **v/s** Maize stover Yield	0.613**
11	Humin **v/s** Wheat Grain Yield	0.632**
12	Humin**v/s** Wheat Straw Yield	0.600**

* Significant, ** highly significant

Table.3 Correlation coefficient between forms of active and passive pools fraction to among forms of LTFE soils in 2013-14 and 2014-15 year

Sr. no.	Correlation between Active to Among forms & Passive Forms		Sr. no.	Correlation between Active to Among forms & Passive Forms	
1	SMBC **v/s** SMBN	0.829**	24	SMBP **v/s** HUMIN	0.739**
2	SMBC **v/s** SMBP	0.608*	25	WSC **v/s** WSCO	0.631*
3	SMBC **v/s** WSC	0.776**	26	WSC **v/s** DHA	0.892**
4	SMBC **v/s** WSCO	0.568	27	WSC **v/s** CAR. MIN.	0.619*
5	SMBC **v/s** DHA	0.552	28	WSC **v/s** H.A.	0.710**
6	SMBC **v/s** CAR. MIN.	0.554	29	WSC **v/s** F.A	0.695*
7	SMBC **v/s** H.A.	0.727**	30	WSC **v/s** HUMIN	0.606*
8	SMBC **v/s** F.A.	0.701*	31	WSCO **v/s** DHA	0.594*
9	SMBC **v/s** HUMIN	0.729**	32	WSCO **v/s** CAR. MIN.	0.633*
10	SMBN **v/s** SMBP	0.813**	33	WSCO **v/s** H.A.	0.498
11	SMBN **v/s** WSC	0.790**	34	WSCO **v/s** F.A	0.402
12	SMBN **v/s** WSCO	0.637*	35	WSCO **v/s** HUMIN	0.666*
13	SMBN **v/s** DHA	0.751**	36	DHA **v/s** CAR.MIN.	0.744**
14	SMBN **v/s** CAR. MIN.	0.825**	37	DHA **v/s** H.A.	0.631*
15	SMBN **v/s** H.A.	0.779**	38	DHA **v/s** F.A	0.582*
16	SMBN **v/s** F.A.	0.653*	39	DHA **v/s** HUMIN	0.600*
17	SMBN **v/s** HUMIN	0.827**	40	CAR.MIN. **v/s** H.A.	0.674*
18	SMBP **v/s** WSC	0.695*	41	CAR.MIN. **v/s** F.A	0.494
19	SMBP **v/s** WSCO	0.456	42	CAR.MIN. **v/s** HUMIN	0.893**
20	SMBP **v/s** DHA	0.810**	43	H.A. **v/s** F.A	0.952**
21	SMBP **v/s** CAR.MIN.	0.809**	44	H.A. **v/s** HUMIN	0.776**
22	SMBP **v/s** H.A.	0.541	45	F.A. **v/s** HUMIN	0.634*
23	SMBP **v/s** F.A.	0.407			

* Significant, ** highly significant

Table.4 Regression equation between crop yield to active and passive forms in LTFE

Dependent variables	Regression equation	R^2
MGY	Y= -1027 - 0.787(SMBC) + 34.83(SMBN) - 34.44(SMBP) + 8.96(WSC) - 4.35(WSCO) - 0.10(DHA) - 5.15(CAR.MIN) - 3.03(HA) + 0.89(FA) + 80.46(HUMIN)	0.926
MSY	Y= 2270 - 1.15(SMBC) + 53.51(SMBN) - 111.99(SMBP) + 22.33(WSC) - 13.69(WSCO) - 0.823(DHA) + 11.17(CAR.MIN) - 6.125(HA) + 1.159(FA) +144.8(HUMIN)	0.996
WGY	Y= 2403 - 4.378(SMBC) + 299.4(SMBN) - 298.5(SMBP) + 43.82(WSC) -16.15(WSCO) + 0.423(DHA) – 22.59(CAR.MIN) -14.29(HA) – 3.556(FA) + 418.7(HUMIN)	0.984
WSY	Y= 2374 – 6.630(SMBC) + 332.2(SMBN) – 308.8(SMBP) + 65.64(WSC) – 13.61(WSCO) – 21.83(DHA) – 11.04(CAR.MIN) – 25.13(HA) + 17.59(FA) + 534.7(HUMIN)	0.978

The soil microbial biomass nitrogen fraction ascribed highly significant positive relationship with wheat grain yield, wheat straw yield, maize grain yield, soil microbial biomass phosphorus, dehydrogenase activity, carbon mineralization, humic acid, humin and significant positive relationship with water soluble carbohydrates and fulvic acid. These observations are in close conformity to those obtained by Vance *et al.,* (1987).

The soil microbial biomass phosphorus fraction ascribed highly significant positive relationship with maize grain yield and significant positive relationship with wheat grain yield, dehydrogenase activity, carbon mineralization and humin.

The water soluble carbon fraction ascribed significant positive relationship with maize grain yield, maize stover yield and wheat grain yield. The water soluble carbon highly significantly correlated with dehydrogenase activity and humic acid, while it shows significant positive relationship with WSCO, carbon mineralization, fulvic acid and humin. The Water Soluble Carbohydrates fraction ascribed highly significant positive relationship with maize grain yield, wheat grain yield, wheat straw yield. The water soluble carbohydrate significantly correlated with dehydrogenase activity, carbon mineralization and humin. The dehydrogenase activity fraction ascribed significant positive relationship with maize grain yield, maize stover yield, carbon mineralization and significant positive relationship with humic acid, fulvic acid and humin (Tables 1–4).

The carbon mineralization fraction ascribed highly significant positive relationship with maize stover yield, wheat grain yield, humin and significant positive relationship with maize grain yield, wheat straw yield and humic acid. Verma and Mathur (2007) show relationship among active pools of soil

organic matter and C/N, SMBC, SMBN, SMBP. The C/N ratio was highly and significantly correlated with soil microbial biomass carbon (SMBC), soil microbial biomass nitrogen (SMBN), water soluble carbon (WSC), water soluble carbohydrates (WS-CHO)and dehydrogenase activity (DHA) under maize crop. The humic acid fraction ascribed highly significant positive relationship with maize grain and stover yield and wheat straw yield, fulvic acid and humin and significant positive relationship with wheat grain yield. The fulvic acid fraction maize grain and stover yield, wheat grain and straw yield observed non-significant. The fulvic acid significant correlated with humin. The humin fraction ascribed highly significant positive relationship with maize grain and stover yield, wheat grain yield and straw yield.

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