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Long-term effect of organic and inorganic fertilization on labile carbon fractions under maize-wheat cropping system in typic *haplustepts* soil of southern Rajasthan (India)

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Abstract
The effect of organic and inorganic fertilization on labile carbon fraction in an typic Haplustepts soil of Southern Rajasthan (India) was studied in a long-term field experiment initiated during 1996-97 at Instructional farm, Rajasthan College of Agriculture, Udaipur (India). Labile organic matter fraction (i.e WS-OC, WS-CHO, $KMnO_4$, POC and LFOC) were significantly influenced by organic and inorganic fertilization. Significantly highest value of all labile matter fraction were recorded under FYM @ 20 t ha^{-1} treatment followed by 100% NPK + FYM 10 t ha^{-1} treatment. Balance use of fertilizers alone or in combination with organic manure resulted in significant build up of available N and P.

Keywords: Labile carbon fraction, long-term experiment, farm yard manure, soil organic carbon

Introduction
Soil quality does not depend just on the physical and chemical properties of the soil but also on the biological properties. The soil organic carbon exists in two pools *viz.*, active pool and passive pool. The active pool generally contributes about 10-20% towards total soil organic matter, where as stable or passive pools have 50-60% contribution towards total soil organic matter. Labile or active C pools fuel soil food web and hence influence nutrient cycling and many other biologically related soil properties. Labile organic carbon is sensitive to soil management practices and thus provides a better measurement of carbon dynamics in short-term to medium-term effect than the total carbon alone (Ding *et al.*, 2006) [9]. Some of the important labile pools of SOC currently used as indicators of soil quality are microbial biomass carbon (MBC), water soluble carbon, water soluble carbohydrates particulate organic carbon (POC) and $KMnO_4$-oxidizable labile organic carbon (LOC). For many centuries manure application to the soil was the common practice, but this traditional management practice changed since the 1980s due to increasing affordability of chemical fertilizers. More chemical and less organic fertilizers are now used in the area (Gong *et al*., 2009) [12]. So, a long-term experiment was established in 1996-97 to study the effects of the organic and inorganic fertilization on soil properties. We hypothesized that changes in the fertilization system have considerable effects on soil microbial activity which are known to be susceptible to the input of organic material. To prove these hypotheses we measured SOC and labile organic carbon in soil with 21 years' application of organic manure and inorganic fertilizer under a maize-wheat cropping system in the southern Rajasthan of India.

Materials and Methods
The present investigation was carried out in the ongoing long-term fertilizer experiment initiated during 1996 at the Instructional farm, Rajasthan College of Agriculture, Udaipur during 2016-17 and 2017-18. The experimental site is a permanent manurial trial and its layout is on fixed site, at block B_2, situated at 24°34N' latitude, 73°42E' longitude and 582.17 m about mean sea level. The area comes under sub-humid southern plain (Zone-IVa) of Rajasthan.
The climate of the region is subtropical, characterized by mild winters and distinct summers associated with high relative humidity particularly during the months of July to September. The mean annual rainfall of the region varies from 650 to 750 mm, most of which is received in rainy season from July to September. The mean maximum and minimum temperature are 35.45 °C and 17.41 °C, respectively.

The soil of the experimental field was sandy clay loam in texture, non-saline and slightly alkaline in reaction and classified taxonomically as "typic *Haplustepts*". At the initiation of the experiment, soil of the experimental field was having pH 8.20, EC 0.48 dSm^{-1}, Organic carbon 6.80 g kg^{-1}, 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 12 treatments with four replications in a randomized block design with 152 m^2 plot for each treatment were as follows: T_1-control; T_2-100% N; T_3-100% NP; T_4-100% NPK; T_5- 100% NPK + Zn; T_6-100% NPK + S; T_7- 100% NPK + Zn + S; T_8-100% NPK + Azotobacter; T_9-NPK 100% NPK + FYM 10 t ha^{-1}; T_{10}- FYM 10 t ha^{-1} + 100% NPK (-NPK of FYM); T_{11}-150%; T_{12}-FYM 20 t ha^{-1}. Soil samples collected from a depth of 0-0.15 m after the harvest of maize (2016-17 and 2017-18) were used for determination of various chemical parameters.

The sources used for applying N, P and K were urea, di-ammonium phosphate (adjusted for its N content) and muriate of potash, respectively. Gypsum and zinc sulphate ($ZnSO_4.7H_2O$) were used to supply S and Zn respectively. The other sources of nutrients were FYM (farm yard manure) and bio fertilizer (*Azotobacter* sp.). Nitrogen, Phosphorus and Potash was applied @ 100:26:25 kg ha^{-1}. The sulphur and zinc were applied @ 40 kg S ha^{-1} and 5 kg Zn ha^{-1} respectively while FYM was applied as per the treatments. The sulphur, zinc and FYM were applied once in a year to the maize crop. The bio fertilizer for seed inoculation was used at 600 g ha^{-1} during both seasons.

Fertilizer application in both wheat and maize crops was made as per the treatment. Full dose of phosphorus and potash and half dose of nitrogen were applied at sowing time by drilling in crop rows. The remaining dose of nitrogen was top dressed in two equal split doses at 25-30 DAS and 45-50 DAS depending upon the occurrence of rains to maize and top dressed just before 1^{st} irrigation applied at CRI stage to wheat crop. Farm yard manure was thoroughly mixed in soil as per the treatment allocation one month before sowing of maize. The seeds were treated with *Azotobacter* inoculants as per the treatment. The seeds were thoroughly mixed with biofertilizer slurry in such a way that all the seeds were uniformly coated with *Azotobacter* and then allowed to dry in the shade before the sowing of crop.

Soil samples collected from a depth of 0-0.15 m after the harvest of maize (2017-2018) were used for determination of various chemical parameters. The other lot was passed through 100-mesh screen and was stored in polythene bags for determining different fractions of SOM. Four composite soil samples from 0-0.15 m were also drawn from adjacent fallow plots. The processed soil samples were analyzed for active pools of SOM *viz*., Water-soluble organic carbon (WS-OC), Water soluble carbohydrates (WS-CHO), Soil microbial biomass carbon (SMBC), Permanganate oxidizable soil carbon ($KMnO_4$-C), Particulate organic carbon (POC) and Light fraction organic carbon (LFOC).

Permanganate oxidizable soil carbon (Labile carbon) was determined as per the procedure outlined by Weil *et al.*, (2003) [33], a modified method from Blair *et al.*, (1995) [5]. Took 3 gram of air-dried soil (<2 mm) in 50 ml centrifuge tube. Added 30 ml of 20 mM $KMnO_4$ to soil in centrifuge tube and run a blank without taking soil. Shook the content for 15 minutes and centrifuge for 5 minutes at 2000 rpm. Transferred 2 ml aliquot of supernatant in to 50 ml volumetric flask. Read the absorbance at 560-565 nm and determined concentration of $KMnO_4$ from standard calibration curve (plot of concentration Vs absorbance)

$$\text{POSC (mg kg}^{-1}) = (B - S) \text{ x } \frac{50}{2} \text{ x } \frac{\text{(Volume of KMnO}_4\text{ (ml)}}{1000} \text{ x } \frac{1000}{\text{Weight of soil (g)}} \text{ x } 9$$

Where

B = concentration (m molar) of $KMnO_4$ in blank

S = Concentration (m molar) of $KMnO_4$ in sample

50/2 = Dilution factor

POC (53-2000 µm) was separated from 2 mm soil following the procedure of Camberdella and Elliott (1992) [7]. Portions (10 g) of air-dried soil were dispersed in 30 ml of sodium hexametaphosphate, $(Na)_6(PO_3)_6$ (5g l^{-1}), with shaking on a reciprocating shaker for 18 h.

The resulting soil suspension was poured over a 53-µm screen under a flow of distilled water to ensure separation. All material remaining on the screen was washed into a dry dish, oven-dried at 60 °C for 48 h, and ground to determine the C content. The LFOC was determined using the method described by Gregorich and Ellert (1993) [14]. Portions (10 g) of air-dried soil were each placed in a centrifuge tube with 20 ml NaI solution (specific gravity ca. 1.7 g cm^{-3}). The tubes were shaken on a reciprocating shaker for 60 min, and then centrifuged at 1000×g for 15 min. The floating material was poured into a vacuum filter unit with Whatman GF/D filter paper, and the material retained by the filter paper was washed with 0.01M $CaCl_2$ and distilled water, dried at 60 °C for 48 h, weighed, and analyzed for C content.

Results and Discussion

Effect of organic and inorganic fertilization on SOC and labile carbon fractions

Soil organic carbon (SOC)

Data revealed that the SOC contents in 100% NPK treated plot was statistically at par with T_5, T_6, T_7, and T_8. The highest soil organic carbon 9.70 g kg^{-1} was obtained with application of FYM 20 t ha^{-1} (Table 1). This treatment was significantly superior then all other treatments. Other treatments also influenced organic carbon content significantly as compared to control plot. Higher values of soil organic carbon (SOC) content of the soil were found in the treatments receiving farmyard manure alone or in combination with chemical fertilizers as compared to those treatments receiving chemical fertilizers alone. Reason attributed is the direct incorporation of organic matter, better root growth and more plant residues addition after harvest of crops. These findings are in agreement with the observations of Katyal *et al.* (2003) [18], Kannan *et al.* (2013) [17] and Brar *et al.* (2015) [6]. The increase in SOC of all the fertilizer treatments might be due to the continuous addition of root biomass, root exudates and plant biomass in soil with time. These results show that the application of inorganic fertilizers over the last two decades on regular basis leads to increase in soil organic carbon. Similar results were also reported by Choudhary *et al.* (2017), Tripura *et al.* (2018) [31] and Meena *et al.* (2018) [24].

Water soluble organic carbon (WS-OC)

Application of FYM 20 t ha^{-1} gave 174.42 and 87.99 per cent higher WS-OC content as compare to control and recommended dose of fertilizer (Table 1). Highest water soluble organic carbon was observed in treatment receiving

FYM alone followed by treatment with continuous addition of FYM in association with 100% NPK fertilizers whereas the lowest content was found in controlled treatment. The newly humified organic carbon through FYM addition might have sustained higher amount of WS-OC in sole FYM treatment whereas higher amount of water soluble carbon in the 100% NPK + FYM @ 10 t ha^{-1} might be due to its origin and root exudates and lysates and its presence in soil solution. These results were confirmed by Verma and Mathur (2009) [21], Meena and Sharma (2016) [23], Choudhary *et al.* (2017), Singh and Bembi (2018). WS-OC content in 100% NPK being 254.0 mg kg^{-1} was found to be significantly higher than treatment receiving 100% NP (217.5 mg kg^{-1}) and 100% N (188.5 mg kg^{-1}). The WS-OC content in 100% N, 100% NP and 100% NPK treatments was higher by 8.33, 25.0 and 45.97 per cent, respectively over the control.

Water soluble carbohydrate (WS-CHO)

The application of balanced fertilizers showed marked increase in the WS-CHO content of the soil over unfertilized plots which might be due to better establishment of root system of plants and also increased microbial activity in soil (Banwasi and Bajpai, 2001) [3]. Application of optimal and super optimal dose of NPK *viz;* 100 and 150% NPK increased the WS-CHO by 32.65 and 95.80 per cent, respectively over the control. WS-CHO content in 100% NPK being 585 mg kg^{-1} was found to be significantly higher than treatment receiving 100% NP (536.5 mg kg^{-1}) and 100% N (472.5 mg kg^{-1}) (Table 1). The lower WS-CHO content in 100% N alone and 100% NP treated plots as compared to balanced nutrition might be due to adverse effect of imbalanced application of fertilizers on WS-CHO content of soil. Application of 100% NPK + FYM and 100% NPK (-NPK of FYM, T_{10}) showed significant increase in the content of WS-CHO by 93.67 and 89.40 per cent, respectively over 100% NPK alone. The maximum content of WS-CHO content under integrated use of FYM and 100% NPK which might be due to improvement in physical, chemical and biological properties of soil which might have resulted in higher root biomass and crop residues and increased microbial activity as has been reported by Izquierdo *et al.* (2005) [16]; Kaur *et al.* (2008) [19], Meena and Sharma (2016) [23], Tripura *et al.* (2018) [31].

Soil microbial biomass carbon (SMBC)

The highest content of SMBC was recorded under FYM 20 t ha^{-1} (392.5 mg kg^{-1}) which was significantly superior to rest of the treatments (Table 2). Application of FYM 20 t ha^{-1} gave 156.53 and 49.23 per cent higher SMBC as compare to control (153.0 mg kg^{-1}) and recommended dose of fertilizer (263.5 mg kg^{-1}). Application of optimal and super optimal dose of NPK *viz;* 100 and 150% NPK increased the SMBC by 72.22 and 98.36 per cent, respectively over the control. SMBC in 100% NPK being 263.5 mg kg^{-1} was found to be significantly higher than treatment receiving 100% NP (205.0 mg kg^{-1}) and 100% N (194.0 mg kg^{-1}). Application of 100% NPK + FYM and 100% NPK (-NPK of FYM, T_{10}) showed significant increase in the content of SMBC by 34.91 and 32.63 per cent, respectively over 100% NPK alone. Use of FYM alone or in combination with chemical fertilizers significantly increased soil microbial biomass carbon (SMBC). The supply of additional mineralizable and readily hydrolysable carbon due to organic manure application might have resulted in higher microbial activity in return higher soil microbial biomass carbon. Many other workers (Tamilselvi *et al.*, 2015; Meena and Sharma., 2016; Kundu *et al.*, 2016 and Khan *et al*., 2017) [29, 23, 22, 20] have also shown marked build up in microbial biomass carbon in soil receiving manure.

Potassium permagnate oxidizable carbon ($KMnO_4$-C)

Highest $KMnO_4$-C was observed in treatment receiving FYM alone followed by treatment with continuous addition of FYM in association with 100% NPK fertilizers whereas the lowest content was found in controlled treatment. The newly humified organic carbon through FYM addition might have sustained higher amount of $KMnO_4$-C in sole FYM treatment whereas higher amount of $KMnO_4$-C in the 100% NPK + FYM @ 10 t ha^{-1} might be due to its origin and root exudates and lysates and its presence in soil solution. A marked increase in labile carbon under 100% NPK + FYM indicated that this pool of soil organic C is more sensitive to changes due to manuring and fertilization. Higher addition of root biomass under integrated nutrient management (NPK + FYM) might have attributed to the increase in this pool as compared to other treatments. These results corroborate the findings of other researchers (Rudrappa *et al.* 2006) [27]. The $KMnO_4$-C content in 100% N, 100% NP and 100% NPK treatments was higher by 29.18, 42.32 and 70.95 per cent, respectively over the control (Table 2). Application of 100% NPK + FYM and 100% NPK (-NPK of FYM, T_{10}) showed significant increase in the content of $KMnO_4$-C by 30.17 and 29.36 per cent, respectively over 100% NPK alone. Purakayastha *et al.* (2008) [26] and Gong *et al.* (2009) [12] also reported that application of FYM along with NPK resulted in the highest accumulation of labile carbon than in the inorganic N application alone.

Particulate organic carbon (POC)

Application of balanced dose of chemical fertilizers (100% NPK) either alone or combination with FYM resulted in significantly increased POC content as compared to the control. Application of 100% NPK + FYM and 100% NPK (-NPK of FYM, T_{10}) showed significant increase in the content of POC by 29.68 and 25.0 per cent, respectively over 100% NPK alone. Highest POC was observed in treatment receiving FYM alone followed by treatment with continuous addition of FYM in association with 100% NPK fertilizers whereas the lowest content was found in controlled treatment. Manuring enhanced POC content in soils due to the presence of higher root exudates, which contained lingo-cellulose residues (Arshad *et al.*, 1990; Bhattacharyya *et al.*, 2012) [2, 4]. The increase in POC in fertilized plot was mainly being due to increased yield trend in this treatment over past years. The additional amounts of organic C input from organics in the treatments received NPK along with organics further enhanced the POC contents in these treatments. The main source of POC in this study was mainly the left over root biomass and increased microbial biomass debris. Our results corroborate the findings reported by Nayak *et al.* (2012) [25], Khan *et al.* (2017) [20], Ghosh *et al.* (2018) [11], Goutami *et al.* (2018) [13].

Light fraction organic carbon (LFOC)

The pooled analysis reveals that FYM 20 t ha^{-1} gave 156.53 and 48.95 per cent higher LFOC content as compare to control (153.0 mg kg^{-1}) and recommended dose of fertilizer (263.5 mg kg^{-1}) (Table 2). Application of optimal and super optimal dose of NPK *viz;* 100 and 150% NPK increased the LFOC by 46.1 and 54.7 per cent, respectively over the control. Similarly, application of 100% NPK + FYM and 100% NPK (-NPK of FYM, T_{10}) showed significant increase in the content of LFOC over 100% NPK alone. Highest LFOC was observed in treatment receiving FYM alone followed by treatment with continuous addition of FYM in association with 100% NPK fertilizers whereas the lowest content was found in controlled treatment. Higher addition of root biomass under integrated nutrient management (NPK + FYM) might have attributed to the increase in this pool as compared to other treatments. Han *et al.* (2006) [15] also reported the LFOC concentration was considerably greater in soils receiving farmyard manure along with NPK fertilizer in a long-term experiment. LFOC in 100% NPK being 263.50 mg kg^{-1} was found to be significantly higher than treatment receiving 100% NP (205.0 mg kg^{-1}) and 100% N (194.0 mg kg^{-1}).

Effect of organic and inorganic fertilization on nutrient balance in soil

Nitrogen balance

Available nitrogen varies from 250 to 405 kg N ha^{-1} in different plots as compared to initial nitrogen of 370 kg N ha^{-1} at initiation of experiment during *kharif* -1997. The available nitrogen content decreased as compared to initial value in all treatments except in 100% NPK +10 t ha^{-1} FYM, FYM 10 t ha^{-1} + 100% NPK (-NPK of FYM) and 150% NPK treatments. The maximum depletion 120 kg in 21 years of continues cropping without NPK (Control) was observed which accounts to 5.71 kg ha^{-1} year^{-1}. Application of 150% NPK and 100% NPK +10 t ha^{-1} FYM resulted in significantly higher N build up *i.e.* 1.67 kg and 1.05 kg N ha^{-1} year^{-1}, respectively. It is interesting to note that alone application of FYM @ 20 t ha^{-1} was not reached to the level of significance and depletion of 2.05 kg N ha^{-1} year^{-1} was observed under this treatment. Total nitrogen addition and uptake by both crops during experimentation presented in the table indicates that except in control and FYM @ 20 t ha^{-1} treatments, all other treatments apparently increased available nitrogen from 159.51 to 329.31 Kg N ha^{-1} during twenty one years of experiment. However, the actual built up of nitrogen (Table 3) during 21 years is less than it. It is due to loss of nitrogen though leaching volatilization or transformation in the soil.

Phosphorus balance

Available phosphorus status improved or remain maintained in combination treatments except in control or alone application of nitrogen. The nutrient depletion of 6.84 kg ha^{-1} was obtained under control followed by 6.30 kg ha^{-1} under alone application of nitrogen in 21 years of experiment, which resulted in 0.33 and 0.30 kg P_2O_5 ha^{-1} yr^{-1} depletion under wheat- maize cropping sequence (Table 3). Among combined nutrient treatments 100% NPK + FYM 10 t ha^{-1} results in buildup of 9.5 kg P_2O_5 ha^{-1} and 12.26 kg P_2O_5 ha^{-1} under 150% NPK application. These treatment resulted 0.45 and 0.58 kg P_2O_5 ha^{-1}yr^{-1} build up in available phosphorus after completion of 21 rotation of wheat-maize cropping sequence. Total phosphorus added in the different treatments varied from 72 to 156 kg P_2O_5 ha^{-1} in two years of experiment. Total phosphorus uptake by wheat-maize rotation during 2016-17 and 2017-18 varied from 20.51 to 91.60 kg P_2O_5 ha^{-1}. Control and 100% N application shows negative balance of 20.51 and 39.17 kg P_2O_5 ha^{-1}, respectively. However, in other treatments apparent balance was positive and varied from 25.64 to 64.40 kg P_2O_5 ha^{-1}. The maximum available phosphorus 64.4 kg ha^{-1} was recorded in 150% NPK treatment during two years of experimentation.

Potassium balance

Available potassium content decreased significantly in all treatments. The maximum depletion of 200 kg K_2O ha^{-1} was observed under control followed by application of N alone (T_2) 195 kg ha^{-1} after completion of 21 years. The depletion varies from 63 to 200 kg ha^{-1} under different treatment combination, which results in 3.00 to 9.52 K_2O ha^{-1} yr^{-1} in different treatments. The maximum 9.52 kg K_2O ha^{-1} yr^{-1} and minimum 3.00 kg K_2O ha^{-1} yr^{-1} was estimated under control and 150% NPK application, respectively. Thus, result indicated to relook in the recombination of potassium for this cropping sequence. It was evident from the data presented in Table 4 that available potassium content decreased as compared to the quantity added in two year experiment. It was due to over mining of potassium as the recommended dose was less than the uptake by the sequence. It was also shown by data pertaining to the uptake of potassium exceeds to the uptake of nitrogen in all the treatment combinations.

Balance use of fertilizers alone or in combination with organic manure resulted in significant build up of available N and P. P is immobile in soil as compared to N and K. The negative P balance is obviously due to absence of P in fertilization schedule whereas positive P balance was due to addition of P in excess of its uptake by the crop. These findings are in confirmation with findings of Dwivedi *et al.* (2007) [10]. A declining trend of available K from its initial status was noticed as a result of continuous cropping, which indicated considerable mining of available K. This was in confirmation with findings of Thakur *et al.* (2011) [30], Kumar *et al.* (2013) [21] and Agarwal *et al.* (2014) [1].

Table 1: Effect of organic and inorganic fertilization on SOC and labile carbon fraction of soil after harvest of maize under wheat-maize cropping sequence

Treatments	SOC (g kg^{-1})			WS-OC(mg kg^{-1})			WS-CHO(mg kg^{-1})		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T_1 = Control	5.40	5.10	5.25	180.00	168.00	174.00	450.00	432.00	441.00
T2 = 100% N	6.60	6.50	6.55	192.00	185.00	188.50	480.00	465.00	472.50
T3 = 100% NP	6.90	7.00	6.95	210.00	225.00	217.50	525.00	548.00	536.50
T4 = 100% NPK	7.40	7.60	7.50	230.00	278.00	254.00	575.00	595.00	585.00
T5 = 100% NPK + Zn	7.50	7.70	7.60	237.00	281.99	259.49	591.99	609.99	600.99
T6 = 100% NPK+ S	7.40	7.60	7.50	239.00	287.00	263.00	597.00	617.00	607.00
T7 = 100% NPK+ Zn + S	7.60	7.70	7.65	235.00	279.00	257.00	587.00	607.00	597.00
T8 = 100% NPK + *Azotobactor*	7.50	7.80	7.65	238.00	281.00	259.50	596.00	615.00	605.50

T9 = 100% NPK + FYM 10 t ha^{-1}	8.90	9.40	9.15	438.00	492.00	465.00	1096.00	1170.00	1133.00
T10 = FYM 10 t ha^{-1} + 100% NPK (-NPK of FYM)	8.80	9.20	9.00	430.00	482.00	456.00	1076.00	1140.00	1108.00
T11 = 150% NPK	7.80	8.10	7.95	335.00	352.00	343.50	837.01	890.01	863.51
T12 = FYM 20 t ha^{-1}	9.50	9.90	9.70	460.00	495.00	477.50	1152.00	1260.00	1206.00
S.Em.±	0.18	0.19	0.13	7.90	8.69	11.49	19.76	20.81	14.35

Table 2: Effect of organic and inorganic fertilization on labile carbon fraction of soil after harvest of maize under wheat-maize cropping sequence

Treatments	SMBC (mg kg^{-1})			$KMnO_4$-C (g kg^{-1})			POC (g kg^{-1})			LFOC (mg kg^{-1})		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T_1 = Control	156.00	150.00	153.00	0.725	0.721	0.723	1.370	1.350	1.360	156.00	150.00	153.00
T2 = 100% N	195.00	193.00	194.00	0.931	0.937	0.934	1.420	1.410	1.415	195.00	193.00	194.00
T3 = 100% NP	204.00	206.00	205.00	0.991	1.067	1.029	1.450	1.470	1.460	204.00	206.00	205.00
T4 = 100% NPK	259.00	268.00	263.50	1.225	1.247	1.236	1.900	1.940	1.920	259.00	268.00	263.50
T5 = 100% NPK + Zn	261.99	270.99	266.49	1.229	1.252	1.240	1.940	1.990	1.965	261.99	270.99	266.49
T6 = 100% NPK+ S	260.00	269.00	264.50	1.224	1.246	1.235	1.930	1.950	1.940	260.00	269.00	264.50
T7 = 100% NPK+ Zn + S	264.00	273.00	268.50	1.231	1.249	1.240	1.920	1.960	1.940	264.00	273.00	268.50
T8 = 100% NPK + *Azotobacter*	261.00	271.00	266.00	1.228	1.248	1.238	1.940	1.980	1.960	261.00	271.00	266.00
T9 = 100% NPK + FYM 10 t ha^{-1}	346.00	365.00	355.50	1.583	1.635	1.609	2.460	2.520	2.490	346.00	365.00	355.50
T10 = FYM 10 t ha^{-1} + 100% NPK (-NPK of FYM)	340.00	359.00	349.50	1.574	1.624	1.599	2.350	2.450	2.400	340.00	359.00	349.50
T11 = 150% NPK	290.00	317.00	303.50	1.240	1.246	1.243	2.140	2.170	2.155	290.00	317.00	303.50
T12 = FYM 20 t ha^{-1}	380.00	405.00	392.50	1.792	1.890	1.841	2.820	2.950	2.885	380.00	405.00	392.50
S.Em.±	6.57	6.85	4.75	0.030	0.031	0.022	0.048	0.049	0.034	6.57	6.85	4.75
C.D. (P = 0.05)	18.90	19.73	13.41	0.088	0.090	0.062	0.137	0.141	0.097	18.90	19.73	13.41

Table 3: Effect of organic and inorganic fertilization on nutrient balance in soil after completion of twenty one cycles of wheat-maize sequence

Treatments	Status of nutrients (2017-18) (kg ha^{-1})			Nutrient change (kg ha^{-1})			Nutrients balance (kg ha^{-1} yr^{-1})		
	N	P	K	N	P	K	N	P	K
T_1 = Control	250	15.76	465	-120	-6.84	-200	-5.71	-0.33	-9.52
T2 = 100% N	298	16.3	470	-72	-6.3	-195	-3.43	-0.30	-9.29
T3 = 100% NP	317	25.45	480	-53	2.85	-185	-2.52	0.14	-8.81
T4 = 100% NPK	358	25.95	560	-12	3.35	-105	-0.57	0.16	-5.00
T5 = 100% NPK + Zn	352	28	562	-18	5.57	-103	-0.86	0.27	-4.91
T6 = 100% NPK+ S	355	26.76	557	-15	4.16	-108	-0.71	0.20	-5.14
T7 = 100% NPK+ Zn + S	353	26.8	567	-17	4.2	-98	-0.81	0.20	-4.67
T8 = 100% NPK + *Azotobacter*	363	25.7	566	-7	3.1	-99	-0.33	0.15	-4.71
T9 = 100% NPK + FYM 10 t ha^{-1}	392	32.1	589	22	9.5	-76	1.05	0.45	-3.62
T10 = FYM 10 t ha^{-1} + 100% NPK (-NPK of FYM)	384	28.05	582	14	5.45	-83	0.67	0.26	-3.95
T11 = 150% NPK	405	34.86	602	35	12.26	-63	1.67	0.58	-3.00
T12 = FYM 20 t ha^{-1}	327	23.38	551	-43	0.78	-114	-2.05	0.04	-5.43
Initial value (1997)	360	22.5	665						

Table 4: Effect of organic and inorganic fertilization on nutrient balance in soil during experimentation (2016-17 and 2017-18)

Treatments	Nutrients addition (kg ha^{-1})			Total nutrients uptake (kg ha^{-1})			Nutrients balance (kg ha^{-1})		
	N	P	K	N	P	K	N	P	K
T_1 = Control	0	0	0	97.88	20.51	114.05	-97.88	-20.51	-114.05
T2 = 100% N	480	0	0	193.4	39.17	217.14	286.6	-39.17	-217.14
T3 = 100% NP	480	104	0	252.83	58.55	268.88	227.17	45.45	-268.88
T4 = 100% NPK	480	104	100	320.49	71.2	325.52	159.51	32.8	-225.52
T5 = 100% NPK + Zn	480	104	100	336.05	72.91	335.23	143.95	31.09	-235.23
T6 = 100% NPK+ S	480	104	100	337.9	71.04	333.07	142.1	32.96	-233.07
T7 = 100% NPK+ Zn + S	480	104	100	351.71	76.08	346.29	128.29	27.92	-246.29
T8 = 100% NPK + *Azotobacter*	480	104	100	347.82	75.67	347.65	132.18	28.33	-247.65
T9 = 100% NPK + FYM 10 t ha^{-1}	576	140	190	408.01	90.08	440.75	167.99	49.92	-250.75
T10 = FYM 10 t ha^{-1} + 100% NPK (-NPK of FYM)	480	104	100	356.53	78.36	380.12	123.47	25.64	-280.12
T11 = 150% NPK	720	156	150	390.69	91.6	437.05	329.31	64.4	-287.05
T12 = FYM 20 t ha^{-1}	192	72	180	213.58	50.31	220.21	-21.58	21.69	-40.21

Conclusion

Based on the results, it can be inferred that labile organic matter fraction (i.e WS-OC, WS-CHO, $KMnO_4$, POC and LFOC) were significantly influenced by organic and inorganic fertilization. However, significantly highest value of all labile matter fraction were recorded under FYM @ 20 t ha-

[1] treatment followed by 100% NPK + FYM 10 t ha^{-1} treatment. Application of balanced inorganic fertilization alone also significantly increased the all labile matter fraction as compared to control and 100% N treatment.

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