EFFECT OF COMBINED USE OF ORGANIC MANURES AND INORGANIC FERTILIZERS ON THE CARBON DIOXIDE FLUXES IN SUNFLOWER (*Helianthus annuus* L.)

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ABSTRACT

Field experiments were conducted to study the effect of combined use of organic manures and inorganic fertilizers on carbon dioxide fluxes and yield of sunflower production during the year 2016 and 2017. The experiments were conducted in RBD with the following treatments *viz.*, **T_1**- Control (No fertilizer), **T_2**- RDF alone, **T_3** - Farmyard manure @ 12.5 t ha^{-1} + 100 % RDF + SSP @ 40 kg ha^{-1}, **T_4** - Vermicompost @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1}, **T_5** - Pressmud @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1}, **T6** - Poultry waste manure @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1} , **T_7**- Composted coir pith @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1}. The results recorded that the application of 100% RDF alone or different organics integrates with 100% RDF treatments significantly influenced the seed and stover yield during the year 2016 and 2017. The higher seed yield of 2218 and 2295 kg ha^{-1} and stover yield of 2894 and 2942 kg ha^{-1} were recorded in the treatment supplemented with Farmyard manure @ 12.5 t ha^{-1} + 100 % RDF + SSP @ 40 kg ha^{-1} + Azospirillum and phosphobacteria as soil application (**T_3**) during the year 2016 and 2017 respectively. Pertaining to the soil organic carbon of 8.10 and 8.26 g kg^{-1}, soil organic matter content of 1.39 and 1.40 %, a higher total carbon of 13.87 and 14.21 g kg^{-1} and carbon stock of 15.43 and 15.96 t ha^{-1} recorded in the treatment supplemented with Farmyard manure @ 12.5 t ha^{-1} + 100 % RDF + SSP @ 40 kg ha^{-1} + Azospirillum and Phosphobacteria (**T_3**) during the year 2016 and 2017 respectively and the same was superior over all other treatments. With regards to CO_2 emission pattern, the combined application of organic manures and inorganic fertilizers recorded a higher value over control (No fertilizer) and 100% RDF alone applied treatments. A consistent increased pattern of CO_2 emission was noticed from vegetative to reproductive stage and there after CO_2 emission declined at harvest stage of the crop during the first and second year of the crop. FYM @ 12.5 t ha^{-1} + 100 RDF% + SSP @ 40 kg ha^{-1} + Azospirillum and phosphobacteria (T_3) recorded the least value of 0.08 and 0.07, 0.14 and 0.14 and 0.11 and 0.07 m mol m^{-2} s^{-1} at 40, 80 DAS and at harvest stages respectively during both the years 2016 and 2017 respectively. Apparently a higher value of CO_2 emission of 0.13 and 0.13, 0.17 and 0.21 and 0.16 and 0.13 m mol m^{-2} s^{-1} were recorded with the treatment supplemented with pressmud @ 5 t ha^{-1} + 100 RDF% + SSP @ 40 kg ha^{-1} + Azospirillum and phosphobacteria as soil application at 40, 80 DAS and at harvest respectively during the year 2016 and 2017 respectively.

Key words: Inorganic fertilizers, Organic manure, SOC, soil organic matter, sunflower and Total carbon.

INTRODUCTION

The concentration of tropospheric CO_2 have been progressively increasing from about 280 µmol mol^{-1} at the beginning of the industrial revolution to 379 µmol mol^{-1} at present (IPCC 2007). Moreover, it will be reaches its peak digit of 410 during, 2020 (IPCC). The CO_2 increase is accelerating — while it averaged about 1.6 ppm per year in the 1980's and 1.5 ppm per year in the 1990's and has increased to 2.2 ppm per year during the last decade (2008-2017). Agricultural ecosystems represent an estimated 11% of the earth's land surface which include some of the most productive and carbon rich soils (Subhadip et al., 2012). Attention is drawn on the carbon fluxes from the field cultivation and to assess the potentiality of the agricultural soil and the atmospheric storage capacity through adoption of well managed practices like application of nutrients is one way to trap the high degree of possible carbon and yield of the cultivated crops the other way. It is widely accepted that the organic matter in these soils have a positive influence on physiochemical and biological processes and especially soil organic carbon (SOC) is one of the most remarkable indicator of the soil quality and health. Pertaining to the soil organic matter, it is very decisive in increasing or maintaining, an order to achieve optimum soil functions and therefore sustaining the fertility and crop production. As a component of terrestrial carbon (C) cycle, soil can be either source or sink of atmospheric carbon dioxide (Lal, 2007). Soil carbon pool comprises of two components: Soil organic carbon (SOC) and soil inorganic carbon (SIC). The SOC pool includes highly active humus to relatively inert charcoal C. The SIC pool includes the elemental C and carbonate minerals (eg: gypsum, calcite, dolomite, aragonite and siderite) (Sahrawat, 2003). The high temperature coupled with high degree of diurnal variation hastened the organic matter decomposition in the soil and quit possible to an increased emission of CO_2 to the atmosphere when it accompanied with frequent disturbance of top soil by way of tillage operations. Intensive cultivation naturally resulting in soil carbon depletion which leads to reduced productivity. The average SOC content of the soils in the region is however, low due to intensive cultivation along with the prevailing high temperature and humidity (Nambiar, 2002). Soil organic carbon which is very reactive, ubiquitous component in soil, is an important soil quality indicator that influence the productivity and physical well being of soils (Konatsuzuki and Ohta, 2007). As improved SOC density can enhance the productivity of agricultural crops (Nieder *et al*., 2003). Furthermore, lack of assured moisture could not support higher cropping intensity in the arid, semi arid and sub humid climate, due to the contribution of root biomass towards organic C is miserably low. In semi arid tropical regions farmers do not use adequate and need based balanced nutrients due to uncertainty of rainfall, likely risk of crop failure paired with poor economical status of the farmers which resulted in poor organic status in those soils (Sharma *et al.*, 2009).

An estimated potential of agricultural intensification on SOC sequestration in soils of India ranges from 12.7 to 16.5 $Tg^{-1}Y^{-1}$ (Lal, 2003). The SOC concentration of most soils in India is less than 5 g kg^{-1}. To sustain or improve the SOC status of the soils with the addition of organic amendments likely to be an organic wastes, might be a viable option in tropical areas where the inorganic fertilizers cost are high, at the same time organic wastes are plentiful for increase the SOC content in soils. Investigations regarding the efficacy of applying recycled organic wastes on SOC and soil quality are however, limited in these regions (Sharma *et al*., 2005). Long term studies have shown that practices like, improved fertilizer management, manures as compost application, residue incorporation enhanced the soil carbon build up and storage (Kimble *et al*., 2002). Addition of various organic manures integrated with inorganic fertilizers in rice-wheat system enhanced the aggregation eminence of the soil which paves way for higher storage of SOC content Singh *et al.*, (2007). In addition to that, the application of inorganic fertilizers with organic manure (NPK+FYM) recorded higher SOC concentration comparatively than inorganic fertilizers (NPK) alone in all the long time experiments Pathak *et al.* (2011). The combined use of organic manures and inorganic fertilizers not only improve the soil fertility through sustain the SOC content but also mitigate the impact of climate change through carbon accumulation in the soil. Only a few researches have been carried out on SOM dynamics and yield of crops on management practices (Rudrappa *et al.*, 2006). Hence, the present investigation was carried out to evaluate the effect of combined use of organic manures and inorganic fertilizers on carbon dioxide emission and crop yield of sunflower.

MATERIALS AND METHODS

Field experiments were conducted at Ayan Athur Village, Ariyalur District, Tamil Nadu, India, during the months of January 2016 to May 2017 in sandy clay loam. The field is geographically situated at 11°23'N latitude, 79°29'E longitude and an altitude of +26 m MSL. The experimental soil had a pH of 7.89, EC- 0.46 dSm^{-1}, organic carbon – 0.46%, total carbon- 0.80%, $kMnO_4$-N – 117 kg ha^{-1}, Olsen- P- 12.9 kg ha^{-1}, NH_4OAc- K- 143 kg ha^{-1}. The treatments consist of 7 treatments *viz.*, **T_1**- Control (No fertilizer), **T_2**- RDF alone, **T_3** - Farmyard manure @ 12.5 t ha^{-1} + 100 % RDF + SSP @ 40 kg ha^{-1}, **T_4** - Vermicompost @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1}, **T_5** - Pressmud @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1}, **T_6** -

Poultry waste manure @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1} , **T$_7$**- Composted coir pith @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1}. The treatments were imposed during the month of January to May of 2016 and 2017. The experiments were conducted in RBD. The hybrid sunflower Sunbred275 was chosen for the study. The treatment schedule consisted of organic manures *viz.*, FYM @ 12.5 t ha^{-1}, vermicompost @ 5 t ha^{-1}, poultry waste manure @ 5 t ha^{-1}, pressmud 5 t ha^{-1} and composted coirpith @ 5 t ha^{-1} applied as basally and incorporated with Azospirillum and phosphobacteria @ 2 kg ha^{-1} as a soil application. A nutrient schedule of 60:90:60 Kg N, P and K ha^{-1} was followed during the period of study. Half the recommended doses of nitrogen and potash and the entire dose of phosphorus were applied basally as per the treatment schedule. The remaining dose of nitrogen and potash were applied at the pre flowering stage. The S was supplied through Single Super Phosphate (16% P_2O_5 and 12% S) for both the years of crop. At the time of harvest seed and stover yield were recorded. Post harvest soils after each crop were analyzed for soil organic matter as %, soil organic carbon as %, total carbon expressed as g kg^{-1} (Walkey and Black, 1973) and soil organic carbon expressed as g kg^{-1}. After harvest of each crop, soil organic carbon stock was worked out with the following formula proposed by (Majumdar *et al.*, 2007).

SOC stock = ∑ Profile volume bulk density x SOC content

MEASUREMENT OF CO_2 FLUXES IN SUNFLOWER FIELD

CO_2

The experiments were conducted at Ayan Athur village, Ariyalur distirct, in Tamil Nadu. CO_2 fluxes measured in sunflower crop during the vegetative, flowering and maturity stages. The LI-7500A is a high performance, non-dispersive, open path infrared CO_2 and H_2O Analyzer designed for use in eddy covariance flux measurement systems. Three components of wind velocity (U, V, and W) and temperature were measured with a sonic anemometer (Hs, Gill) while the densities of CO_2 and water vapour were measured with an open-path CO_2/H_2O Analyzer (LI-7500A). The sensor heads of the sonic anemometer and the IRGA were mounted all most at a height of 3.0 m above the ground, where the direction of the sonic anemometer was 180±1°. The horizontal distance between two sensor heads was 0.16 m, the data from the sonic anemometer and the IRGA were sampled at 10 Hz stored in CR 100 data logger (CR 100, Campbell, S/N1396) which was retrieved using compact flash card. For calculating the covariance, wind velocity components were rotated because the accurate direction of the sonic anemometer was not known and also because relatively large numbers of wind data were had flagged. Frequency losses due to path length, averaging and the separation between the anemometer and the IRGA were corrected following a procedure proposed by researchers, but crosswind correction to SHF was not applied because the cross wind effect was corrected automatically in internal processing of Gill`s Sonic anemometer.

STATISTICAL ANALYSIS

The experimental data were statistically analyzed as suggested by Gomez and Gomez (1976). For significant results the critical difference was worked out at 5 per cent level.

RESULTS

Sunflower yield attributes Seed and stover yield

The results revealed that the treatment nourished with a judicious combination of different organic manures with inorganic fertilizers positively influenced all yield components *viz.*, total number seeds capitulum $^{-1}$ and number of filled seeds capitulum^{-1}, seed and stalk yield of sunflower over control. The results pertaining to seed and stover yield presented in Table-1. The grain yield ranged from 976 to 2218 kg ha^{-1} and 991 to 2295 kg ha^{-1} during the first and second year crop period. Among the treatments, the higher seed yield of 2218 and 2295 kg ha^{-1} were recorded in FYM@ 12.5 t ha^{-1} + 100% RDF + SSP @ 40 Kg ha^{-1}+ Azospirillum and Phophobacteria @ 2 kg ha^{-1}(T_3). This was significantly followed by vermicompost @ 5 t ha^{-1} + 100% RDF + SSP @ 40 Kg ha^{-1} + Azospirillum and Phophobacteria @ 2 kg ha^{-1} (T_4) treatment with a seed yield of 2120 and 2212 kg ha^{-1} during in the first and second year respectively. The decreasing trend in seed yield was observed in the treatment as follows $T_6 > T_5 > T_7 = T_2 > T_1$ during both the crop period. Among the organic manures + inorganic fertilizers treated plots, composted coirpith @ 5 t ha^{-1} + 100% RDF + SSP @ 40 Kg ha^{-1}+ Azospirillum and Phophobacteria @ 2 kg ha^{-1}(T_7) registered a lower value of 1836 and 1895 kg ha^{-1} seed yield and it was on par with RDF alone (T_2) during both the years. Control plot (No fertilizer) recorded the least seed yield of 976 and 991 kg ha^{-1} compared to all other treatments, during both the years.

Pertaining to the stover yield, the value ranged from 1703 to 2894 and 1781 to 2942 kg ha^{-1} during the first and second year of sunflower crop respectively. Among the treatments, a higher stover yield of 2894 and 2942 kg ha^{-1} recorded with FYM@ 12.5 t ha^{-1} + 100% RDF + SSP @ 40 Kg ha^{-1}+ Azospirillum and Phophobacteria @ 2 kg ha^{-1}(T_3). This was significantly followed by vermicompost @ 5 t ha^{-1} + 100% RDF + SSP @ 40 Kg ha^{-1}+ Azospirillum and Phophobacteria @ 2 kg ha^{-1} (T_4) with a stover yield value of 2802 and 2836 kg ha^{-1} during the first and second year respectively. The decreasing trend in stover yield were observed in the treatment as follows, $T_6 > T_5 > T_7 = T_2 > T_1$ during the year 2016 and 2017. Among the organic manures + inorganic fertilizers treated plots, composted coirpith @ 5 t ha^{-1} + 100% RDF +SSP @ 40 Kg ha^{-1} + Azospirillum and Phophobacteria @ 2 kg ha^{-1} (T_7) registered lower value of strover yield 2532 and 2625 kg ha^{-1} and it was on par with RDF alone (T_2) imposed treatment in both the years of sunflower. Control plot (No fertilizer) recorded the least strover yield of 1703 and 1781 kg ha^{-1} which was inferior to all other treatments imposed with organics + 100% RDF+ SSP during the first and second year sunflower crop.

Higher values were recorded for all the yield attributes *viz.*, total number seeds capitulum^{-1} and number of filled seeds capitulum^{-1}, seed yield and stover yield in both the first and second year of the crop period for the treatment (T_3).

Table-1 Effect of combined use of organic manures and inorganic fertilizers on seed and stover yield of sunflower (2016 and 2017)

Experimental year	I year		II year	
Treatments	Seed Yield kg ha^{-1}	Stover Yield Kg ha^{-1}	Seed Yield kg ha^{-1}	Stover Yield Kg ha^{-1}
T1	976	1703	991	1781
T2	1815	2501	1822	2532
T3	2218	2894	2295	2964
T4	2120	2802	2212	2836
T5	1911	2625	1981	2687
T6	1996	2710	2092	2740
T7	1836	2532	1895	2625
S.E(M)	**28.96**	**22.11**	**30.02**	**23.62**
CD(P=0.05)	**61.73**	**47.14**	**64.24**	**50.54**

Treatment Details

T_1 - Ref – No fertilizers

T_2 - 100% RDF alone

T_3 - FYM @ 12.5 t ha^{-1} + 100 % RDF + SSP @ 40 kg ha^{-1}

T_4 - Vermicompost @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1}

T_5 - Pressmud @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1}

T_6 - Poultry waste manure @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1}

T_7 - Composted coirpith @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1}

EFFECT OF INM ON SOM AND SOC CONTENT IN SUNFLOWER PRODUCTION

The observations recorded on the soil organic matter, soil organic carbon and total carbon on the sunflower crop in the first and second year crop are presented in the Table-2. Addition of organic manures along with 100% inorganic fertilizers, SSP @ 40 kg ha^{-1} and Azospirillum and phosphobacteria @ 2 kg ha^{-1} showed positive influence on SOM over other treatments. The higher SOM content values ranged from 0.78 to 1.39 and 0.91 to 1.40 % during the first and second year of the crop respectively. A higher SOM value of 1.39 and 1.40 % were recorded in FYM @ 12.5 t ha^{-1} + 100% RDF + SSP @ 40 Kg ha^{-1}+ Azospirillum and Phophobacteria @ 2 kg ha^{-1}(T_3) in 2016 and 2017 respectively. This was significantly followed by the treatment nourished with vermicompost @ 5 t ha^{-1} + 100% RDF + SSP @ 40 Kg ha^{-1}+ Azospirillum and Phophobacteria @ 2 kg ha^{-1} (T_4) plot. The decreasing trend in SOM were observed in the treatment as follows, $T_6 > T_5 > T_7 > T_2 > T_1$ during the first and second year of crop. The least value of SOM (0.78 and 0.91%) was noticed with the control (No fertilizer) treatment during the year 2016 and 2017 respectively.

Addition of organic manures with 100% inorganic fertilizers, SSP @ 40 kg ha^{-1} and Azospirillum and phosphobacteria @ 2 kg ha^{-1} confirmed positive influence on soil organic carbon (SOC) over other treatments during both the years of sunflower crop. A higher soil organic carbon with the value of 8.10 and 8.26 g kg^{-1} recorded in FYM @ 12.5 t ha^{-1} + 100% RDF + SSP @ 40 Kg ha^{-1} + Azospirillum and Phosphobacteria @ 2 kg ha^{-1} (T_3), the first and second year crop respectively. This was significantly followed by the treatment nurtured with vermicompost @ 5 t ha^{-1} + 100% RDF + SSP @ 40 Kg ha^{-1}+ Azospirillum and Phosphobacteria @ 2 kg ha^{-1} as soil application (T_4) supplemented plot. The decreasing trend in soil organic carbon were observed in the treatment as follows; $T_6 > T_5 > T_7 = T_2 > T_1$ during the first and second year of crop.

Pertaining to the total carbon content, treatments supplemented through organic manures + 100% RDF + SSP @ 40 kg ha^{-1}+ Azospirillum and phosphobacteria @ 2 kg ha^{-1} exerted a significant influence during both the years of crop. Among the treatments, FYM @ 12.5 t ha^{-1} + 100% RDF + SSP @ 40 Kg ha^{-1} + Azospirillum and Phosphobacteria @ 2 kg ha^{-1}(T_3) recorded a higher total carbon with the value of 13.87 and 14.21 g kg^{-1}during the first and second year of the crop respectively. Whereas, a lower value of 12.29 and 12.59 g kg^{-1} total carbon registered with pressmud @ 5 t ha^{-1} + 100% RDF + SSP @ 40 Kg ha^{-1} + Azospirillum and Phosphobacteria @ 2 kg ha^{-1}(T_3) during the year 2016 and 2017 respectively. The least value of total carbon 11.67 and 11.26 g kg^{-1} were noticed with control (No fertilizer) treatment during both the years of sunflower crop.

Table-2 Effect of combined use of organic manure and inorganic fertilizers on SOM and SOC of sunflower (2016 and 2017)

Experimental year	I Year			II Year		
Treatments	**SOM (%)**	**Soil organic carbon (g kg^{-1})**	**Total carbon (g kg^{-1})**	**SOM (%)**	**Soil organic carbon (g kg^{-1})**	**Total carbon (g kg^{-1})**
T1	0.78	4.50	11.67	0.91	5.30	11.26
T2	0.96	5.60	12.10	1.05	6.10	11.92
T3	1.39	8.10	13.87	1.42	8.26	14.21
T4	1.32	7.74	13.52	1.35	7.91	13.92
T5	1.18	7.12	13.12	1.20	7.46	13.68
T6	1.24	6.71	12.29	1.27	6.87	12.59
T7	1.13	6.89	12.72	1.14	7.09	13.11
S.E(M)	**0.023**	**0.14**	**0.11**	**0.018**	**0.12**	**0.03**
CD(P=0.05)	**0.05**	**0.31**	**0.24**	**0.04**	**0.26**	**0.07**

Treatment Details

T_1 - Ref – No fertilizers

T_2 - 100% RDF alone

T_3 - FYM @ 12.5 t ha^{-1} + 100 % RDF + SSP @ 40 kg ha^{-1}

T_4 - Vermicompost @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1}

T_5 - Pressmud @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1}

T_6 - Poultry waste manure @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1}

T_7 - Composted coirpith @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1}

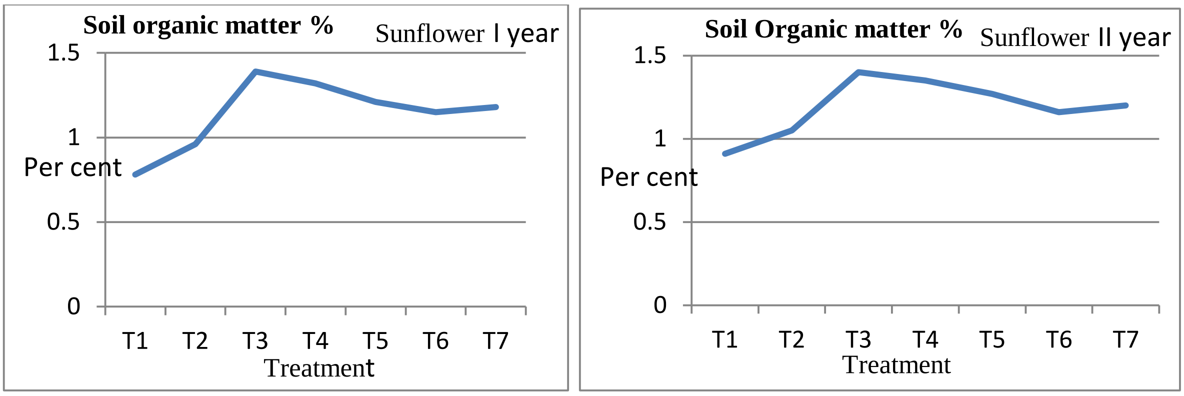

Figure.1

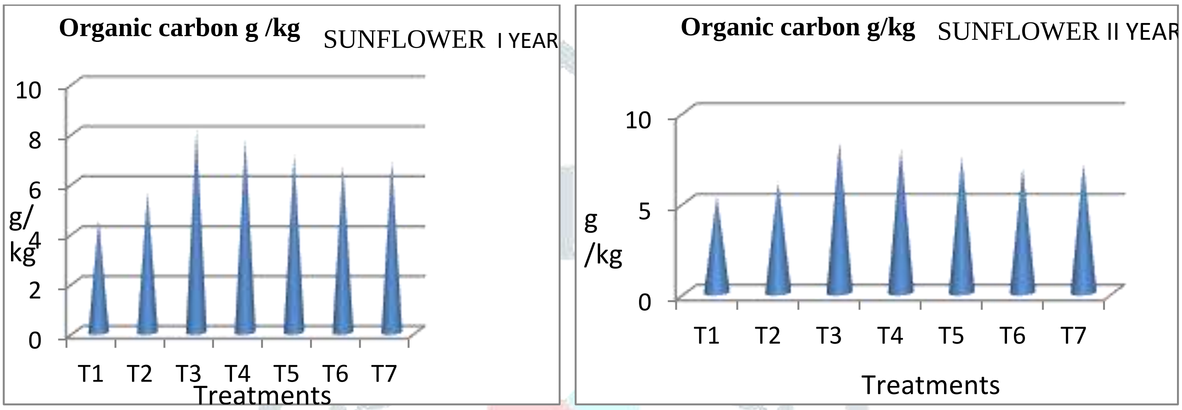

Figure.2

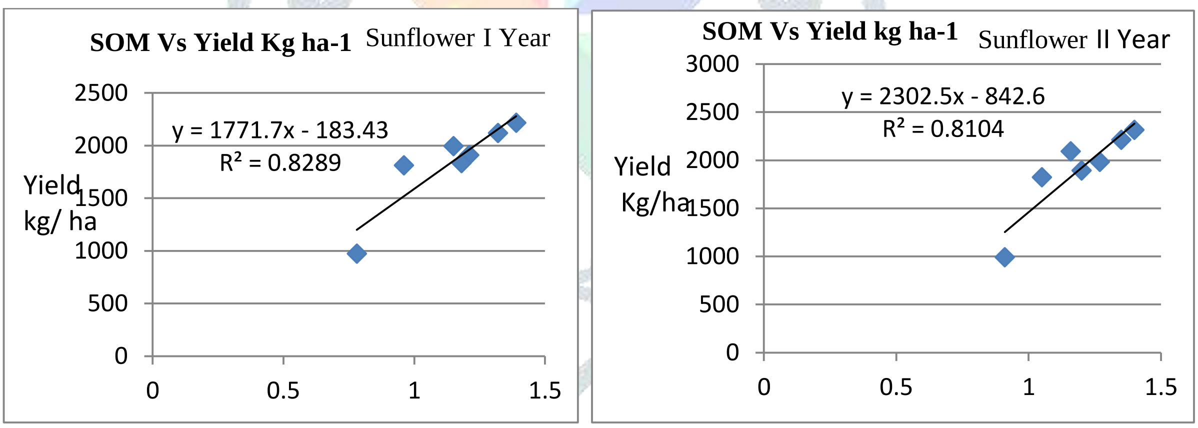

Figure.3

Relationship between SOM and System yield.

EFFECT OF ORGANIC MANURES AND FERTILIZERS ON CO_2 FLUXES IN SUNFLOWER PRODUCTION

The observations recorded on the carbon dioxide emission on 40 DAS, 80 DAS and at harvest stages of the first and second year crops were presented in the Table 3.

The carbon dioxide fluxes from the plot nurtured through different organic manures combined with 100% inorganic fertilizers revealed that the carbon dioxide emission depends upon the season, diurnal variation and different growth phases of the crop. The data on CO_2 emission revealed that the diurnal variation with the need based irrigation had a marked influence on CO_2 ecosystem exchange at all growth stages during, the year 2016 and 2017. All the treatments exhibit their affirmative pattern of CO_2 ecosystem emission during their growth period especially at day time even though fulfill the requirement for uptake of

CO_2 by the crops for their photosynthetic assimilation and also exerted increased pattern on CO_2 emission due to the release of carbon dioxide as a result of respiration at night.

A higher value of total CO_2 emission per day 0.13 and 0.13, 0.18 and 0.21 and 0.16 and 0.13 m mol m^{-2} s^{-1} were recorded at 40, 80 DAS and at harvest stages respectively with the application of pressmud @ 5 t ha^{-1} with 100% RDF (T_5) during both the years of the sunflower crop. Among the different organic manures tried in this study, Pressmud @ 5 t ha^{-1} with 100% RDF (T_5) received plots exhibit their high potential in the amount of carbon dioxide exchange to the ecosystem than other organic manures *viz.*, FYM, vermicmpost, poultry waste manure and composted coir pith. Apparently, the treatment nourished with FYM @ 12.5 t ha^{-1} + 100% RDF recorded the least total CO_2 emission per day value of 0.08 and 0.07, 0.14and 0.14 and 0.11and 0.07 m mol $m^{-2}s^{-1}$at 40, 80 DAS and at harvest respectively during both the years of the crop.

Table-3 Effect of INM on CO_2 emission (m mol m^{-2} s^{-1}) in sunflower I Year

Treatments	CO_2 emission (mmol m^{-2} s^{-1})					
	40DAS		80DAS		At Harvest	
	Day	Night	Day	Night	Day	Night
T_1	0.006	0.04	0.021	0.03	0.02	0.02
T_2	0.008	0.05	0.039	0.07	0.04	0.05
T_3	0.020	0.06	0.050	0.09	0.05	0.06
T_4	0.030	0.07	0.060	0.10	0.06	0.08
T_5	0.050	0.08	0.070	0.11	0.07	0.09
T_6	0.030	0.08	0.060	0.10	0.06	0.09
T_7	0.040	0.08	0.070	0.11	0.06	0.09

Treatment Details

T_1 - Ref – No fertilizers

T_2 - 100% RDF alone

T_3 - FYM @ 12.5 t ha^{-1} + 100 % RDF + SSP @ 40 kg ha^{-1}

T_4 - Vermicompost @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1}

T_5 - Pressmud @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1}

T_6 - Poultry waste manure @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1}

T_7 - Composted coirpith @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1}

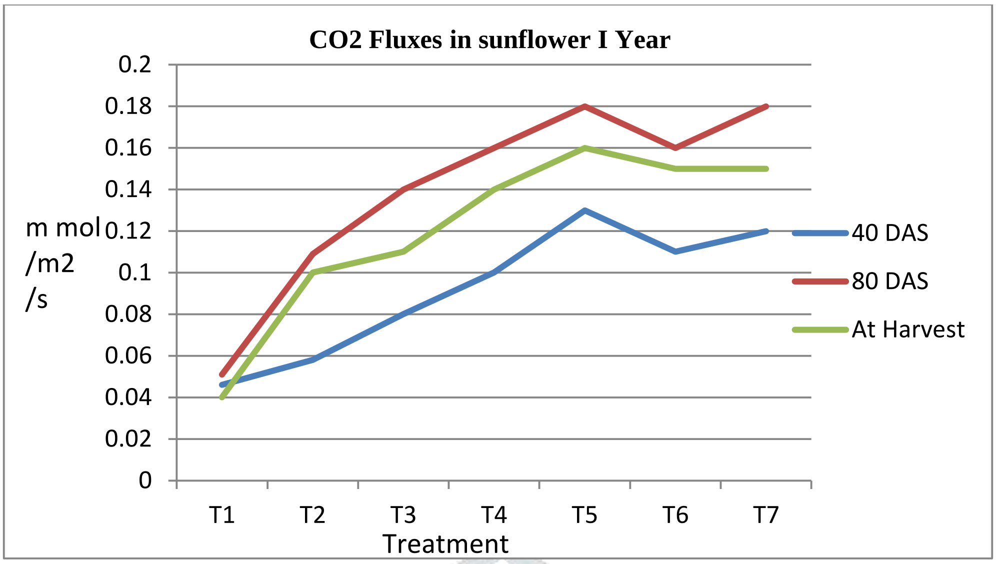

Figure.4

Table-4 Effect of INM on CO_2 emission (m mol m^{-2} s^{-1}) in sunflower II Year

Treatments	CO_2 emission (m mol m^{-2} s^{-1})					
	40DAS		80DAS		At Harvest	
	Day	Night	Day	Night	Day	Night
T_1	0.008	0.03	0.010	0.03	0.007	0.03
T_2	0.009	0.04	0.017	0.06	0.011	0.02
T_3	0.020	0.05	0.040	0.10	0.030	0.04
T_4	0.030	0.06	0.060	0.11	0.040	0.05
T_5	0.050	0.08	0.080	0.13	0.072	0.06
T_6	0.040	0.07	0.060	0.11	0.050	0.05
T_7	0.050	0.07	0.070	0.12	0.065	0.05

Treatment Details

T_1 - Ref – No fertilizers

T_2 - 100% RDF alone

T_3 - FYM @ 12.5 t ha^{-1} + 100 % RDF + SSP @ 40 kg ha^{-1}

T_4 - Vermicompost @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1}

T_5 - Pressmud @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1}

T_6 - Poultry waste manure @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1}

T_7 - Composted coirpith @ 5 t ha^{-1} + 100% RDF + SSP @ 40 kg ha^{-1}

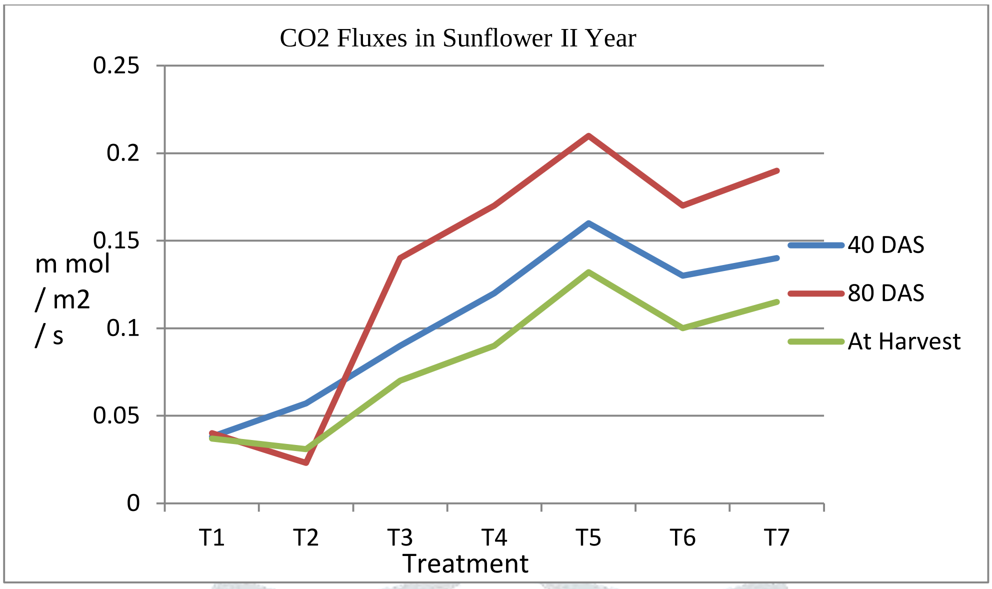

Figure.5

DISCUSSION

EFFECT OF INM ON YIELD ATTRIBUTES, SEED AND STOVER YIELD OF SUNFLOWER

From the study the results evidenced (Tab.1) an increased seed and stover yield were recorded in FYM @ 12.5 t ha^{-1} + 100% inorganic fertilizers + SSP @ 40 kg ha^{-1} + Azospirillum and Phosphobacteria which could be ascribed due to higher mineralization of nutrients because of improved physical and chemical conditions of the soil, resulting in creating a favourable environment in the soil, which helped the nutrients to be more in the availability form, which results in better plant growth. Besides, FYM might have triggered the activity of microorganisms which in turn resulting the synthesis of phytin (Isoinsitolhexa phosphate) *i.e.,* a complex of nutrient like Ca, Mg P containing salt plays a key role in the production of larger seeds and improve the filling percentage reported by Krishnamurthi and Madan (1996 a) and Manjunatha *et al*., 2009. Furthermore, the N nutrient plays a key role in keeping alive the photosynthesis even at critical stages like seed setting, seed filling by way of facilitating the translocation of metabolites to the sink, which results in better filling of late formed florets. The reciprocation of the overall improvement reflected into better source- sink relationship, tissue differentiation from somatic to reproductive and meristematic activity (Baldev and Pareek, 1999) and increased rate of photosynthesis and stomatal conductance which can be due to more absorption of nutrients and ultimately resulted in increased seed and stalk yield and yield attributes in sunflower (Tahereh Vaseghmanesh *et al.*, 2013 and Naser Hajiketabi *et al.*, 2014). These results were concomitant with the findings of Nanjundappa et al. (2001) and Syed et al. (2006).

EFFECT OF ORGANIC MANURE AND FERTILIZERS ON SOM, SOC AND TOTAL CARBON CONTENT IN SUNFLOWER PRODUCTION

Soil organic matter is known as revolving nutrient fund that supplies mainly carbon, nitrogen, phosphorus and sulphur. Therefore decline in soil carbon generally decreases crop productivity (Selva Anbarasu *et al.*, 2016). The increased soil organic carbon recorded (Tab.2) in the treatment (T3) FYM @ 12.5 t ha^{-1} + 100% inorganic fertilizers + SSP @ 40 kg ha^{-1} + Azospirillum and Phosphobacteria, was due to the addition of organic manures which improved the physio chemical properties of the soil especially in sandy clay loam soil, which in turn paves way for increased root biomass. Root derived materials are an important DOC source in the soil (Lu et al, 2005). Furthermore about 30 to 60 % of photosynthesized C is allocated to the below ground parts, and as much as 40 to 90% of this substrates enter into the soil in the forms of root exudates, mucilage, sloughed – off cells and decaying roots (Lynch and Whipps, 1990). A positive linear relationship of (R^2= 0.810 and 0.828) soil organic matter and system yield during the first and second year crop. A positive interaction between the organic manures with inorganic NPK eventually increased the all growth components. This is attributed due to internal – physiological process and external- phenophase of the crop which in turn leads to accumulation of more photosynthates. This positive sign in the microbial activity is from a diversified nourishment substrate. The photosynthesized C input into the soil differed among the plant species and the maximum proportion was up to 20%, 64-86% of which was rapidly respired by soil microorganisms and only 2-5% of which incorporated into SOC (Hutsch *et al*., 2002). A significant positive linear relationship (R^2= 0.935 and 0.832) between soil organic carbon and system yield (Fig3 and 4) were registered in the first and second year of the study respectively.

Effect of organic manure and fertilizers on Carbon dioxide fluxes in Sunflower production

The carbon dioxide fluxes from the plot nurtured through different organic manures combined with 100% inorganic fertilizers revealed that the differences in the carbon dioxide emission depends upon the season, diurnal variation and different growth phases of the crop. All the treatments (Tab.3 and 4) exhibit increased CO_2 emission (Fig.4 and 5) during growth stages of the crop especially at day time even though fulfill the requirement for uptake of CO_2 by the crops for their photosynthetic assimilation and also exerted its cumulative increased value of CO_2 emission due to the release of carbon dioxide as a result of respiration at night. Elevated CO_2 compounded by associated rise in ambient temperature and less water availability (Aranjuelo *et al.,* 2007). Addition of organic manures with inorganic fertilizers proved their positive interaction which resulting in enhancement of microbial activity, furthermore when it coupled with proper moisture regime and sufficient soil temperature showed its magnitude of CO_2 release from the soil most probably in the day time. As soil microbial biomass considered to be responsible for regulating nutrient cycling (Marumoto, 1984) and is closely related to the primary productivity of an ecosystem (Marcel *et al.,* 2008). CO_2 evolution resulting from degradation of organic materials is a good indicator to measure the organic compound decomposition rate and also is a good index to determine the nutrient release pattern and the optimum time for organic matter application (Ahmad et al., 2007). In addition to that dehydrogenase enzymes play a vital role in the biological oxidation of soil organic matter by transferring protons and electrons from substrate to acceptors (Selva Anbarasu *et al.,* 2016). CO_2 flux was more in Pressmud + RDF treated plots during both day and night time due to more availability of dehydrogenase enzymes in organic manures paves way for more activity of microorganisms to decompose the organic matter. The favorable effect of organic manure on the activity of dehydrogenase in soil and it was more pronounced due to combined application of organic manure with NPK which was attributed to increase the mineralization of nutrients from microbial decomposition of organic matter (Singaram and Kamalakumari, 1995). However, under high intensive cropping system recommended doses of NP and manures maintained soil quality parameters which in turn support better crop productivity Kumara et al. (2014).

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