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LBNF Practices Combined with Crop Diversification Achieves Soil Organic Carbon Principle '4p1000' under Tropical Conditions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Three separate field experiments were carried out at the Agricultural College and Research Institute, TNAU, Madurai, India during 2019-22 with the aim of assessing the possibility of achieving soil organic carbon principle '4p1000' a recent initiative in restoring soil health, through a novel farming system of Low Budget Naturalway Farming by cultivating millets and pulse crops,. The experiments focused on monocropping of millets, sequential multiple cropping and intercropping of millets, and pulses. The studies continuously assessed soil organic carbon status of the cultivated fields to see whether 4p1000 is feasible under tropical conditions. The results of the trials revealed that, despite the LBNF practice of using tree leaf biomass as a source of

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nutrients, monocropping failed to realize the principle. However, it was feasible to accomplish this when a millet-pulse system was employed and a black gram pulse crop was introduced to the system. The intercropping of pulses and millets would contribute further to the accumulation of soil organic carbon in the cultivated fields. The study proved that the 4p1000 principle is achievable in the tropics.

Keywords: 4p1000; soil organic carbon; LBNF practice; trees.

1. INTRODUCTION

Low Budget Naturalway Farming (LBNF) has been defined as a scientific reorientation of the eco-friendly system of Indian agriculture by utilizing the traditional and natural ways of food production and adopting those indigenous practices for the cultivation of crops by utilizing trees, plants, and animal products, with the objective of enhancing product quality. Only trees and their parts are used in this novel farming method. It is a Veganic approach. Though trees have an essential part in human life, they are so far viewed as a material for providing shade, construction, and furniture making. In any case, the neglected circuitous commitments of tree species in food production have been examined. It has three principles viz., Biomass transfer technique, Leaf Tea Spray and Tree Botanicals and Extracts for plant protection and, four strategies 4p1000; feed the soil, not the crop; Soil – Soul of Infinite Life and Tree Leaves- a Natural Game-Changer in Crop Production. The first principle of the biomass transfer technique claims that leguminous trees are capable of fixing atmospheric nitrogen [1,2]. Besides, tree leaves also contain high nitrogen and other major nutrients. These leaves decompose faster in the soil and release nutrients.

1.1 4 per 1000

The Lima-Paris Plan of Action's "4 per 1000" Initiative was unveiled in 2015 at the UNFCCC CoP 21. Since its inception, it has expanded to include more than 550 members and Partners, making it genuinely international. The Initiative is a true multi-stakeholder initiative made up of a variety of groups, including Signatory Countries, International & Regional Organisations, Research & Education, Farmer's Organisations, NGOs & Civil Society, Business & Private Sector, and finally. Farmers [local family farms and farmer organizations] and foresters are our beneficiaries. The "4 per 1000" Initiative's vision for the year 2050 is "worldwide healthy and carbon-rich soils to combat climate change and end hunger," which means that, in accordance with various agro-pedo-climatic regions, the initiative's stated goal is to achieve and implement that vision in every region of the world, for every category of beneficiaries. The Initiative engages in extensive advocacy work to persuade decision-makers, the public, scientists, institutions, and private sector businesses to take incremental steps towards this objective each year while always keeping in mind that farmers and foresters are the Initiative's key stakeholders. It is obviously clear that our social, natural, and economic environments are degrading continuously and virtually erroneously everywhere. It is necessary to switch the development paradigm from sustainable development to regenerative development. The word "regeneration" will be used frequently in the next years to describe efforts to improve the soils, which are the source of life on Earth for humans, animals, and plants. Either our century is regenerative, or it isn't! The "4 per 1000" Initiative's efforts focus on improving soil health through soil regeneration, especially as a result of carbon that plants have taken from the atmosphere and returned to the soil in the form of organic plant matter or animal origin [3].

This study investigated the likelihood of achieving 4p1000 under tropical conditions through field experiments with millets and pulses as target crops and different legume tree species as tests crops. Millets were grown severally and also conjointly with pulses as intercrop and also as sequential crop. The total duration of the experiment was almost four years (2019- 2022) and soil organic carbon (SOC) status was analyzed periodically and the methodologies and findings discussed in this paper. For SOC, the units (%) and (g kg^{-1}) were used. The conversion factor for % into g kg^{-1} is multiplication by 10.

2. MATERIALS AND METHODS

Three separate field research experiments were conducted from 2019 to 2022 as detailed below.

Experiment I- Monocropping of prosomillet and kodomillet was followed and they were cultivated sequentially on the same field in the order of prosomillet – prosomillet-kodomillet for 64 weeks. Experiment 1I – Multiple cropping of growing little millet and black gram was followed. They were grown in the order of little millet- little millet- black gram in a year and repeated the next year also. Experiment 1II – Intercropping of millet with pulses was followed in the same field after the completion of experiment II. For Comparison, crops were cultivated under a conventional crop production guide (CPG) and Zero Input practice simultaneously in all the experiments.

a) Study location

The trials were conducted at the central farm of the Agricultural College and Research Institute, TNAU, Madurai, India. Geographically, the experimental fields were located at 9^0 54' N latitude, 78^0 5' E longitude, and at an altitude of 147 m above sea level. The field topography was medium; the soil was sandy clay loam. The site selected for study was kept fallow during last season.

b) Climate and weather

The mean weather at the site over the past 30 years has been as follows: an average annual rainfall of 846 mm received over 43 rainy days, average maximum and minimum temperatures of 33.7°C and 23.8°C, respectively, mean daily pan evaporation of 6.2 mm and average relative humidity of 80% at 07.14 hours and 60% at 14.14 hours.

c) Cropping systems

Two cropping systems, namely Monocropping and diversified cropping, have been investigated for varying lengths of time on the same field for each system in order to continuously track soil organic carbon change through time. Small millets were grown as a monoculture for 64 weeks in a separate field while diversified cropping was represented by two methods: a millet-pulse cropping system for 92 weeks, followed by a millet + pulse intercropping system for 60 weeks in another field. To measure SOC flow, both forms of cropping were continuously monitored for soil organic carbon contents

d) Source of Biomass

Leguminous trees rich in leaf nitrogen content were used as a source to supply nitrogen to the crops. The leaves were harvested and applied into the field after seedbed preparation. Then the leaf biomass was incorporated into the soil using a tiller and allowed to decompose for 6 weeks time. The tree species evaluated and the quantity of leaf biomass used are given in treatment under each experiment.

EXPERIMENT I- MONOCROPPING

Three consecutive field trials were laid out from February 2021 to May 2022 to investigate the influence of tree leaf biomass incorporation to supply the N requirement of small millets along with the conventional practice and zero input practice. The rainfall received during the leaf litter decomposition period was given below. Because, soil moisture is a key factor in decomposition and hence, we have used fresh leaf biomass by calculating leaf moisture content and applied, but the recommendations are given only on dry weight basis.

Treatments

To supply the Nitrogen requirement (40 kg ha^{-1}) of prosomillet and kodomillet, the following Tree leaf biomass were incorporated at N equivalence on a dry weight basis six weeks before sowing the crop. The period of six weeks is allowed for the decomposition of the applied leaf litter [4,5] as found and published (http://www.envirobiotechjournals.com/article_abstract.php?aid=12491&iid=350&jid=3). For the first crop and third crops, the field was wet once during the decomposition period to ensure the required soil moisture as it was raised during summer. For the second crop, decomposition occurred naturally due to monsoon rains.

List 1. Quantum of rainfall received during litter decomposition period (6 weeks)

Crop	Period	Rainfall (mm)
First	February to March, 2021	5
Second	July to November, 2021	903
Third	December, 2021 to January, 2022	28

M_1 - *Albizia lebbek* (L.) Benth (1.38 t ha^{-1})
M_2 - *Delonix regia* Boj.ex Hook (1.42 t ha^{-1})
M_3 - *Gliricidia sepium* (jacq.) Steud (1.46 t ha^{-1})
M_4 - *Peltophorum ferrugineum* (Decne.) Benth (1.37 t ha^{-1})
M_5 – *Millettia pinnata* syn. *Pongamia pinnata* (L.) Pierre (1.67 t ha^{-1})

The Soil samples were periodically withdrawn at 15 cm depth from the start of the experiments till the harvest of the crops and analyzed for soil organic carbon by Chromic acid wet digestion method after Walkley and Black (1935).

EXPERIMENT II- MULTIPLE CROPPING

A cropping system of little millet - little millet-black gram was followed for two years and the crops rose sequentially and the experiment was conducted for two years from 2019 to 2021.

Treatments

To supply the nitrogen requirement (44 kg ha^{-1}) of little millet, the following Tree leaf biomass were incorporated at N equivalence on dry weight basis six weeks before sowing the crop. A period of six weeks is allowed for decomposition of applied leaf biomass (http://www.envirobiotechjournals.com/article_abstract.php?aid=12491&iid=350&jid=3).

M1- *Leucaena leucocephala* (Lam.) de Wit (1.70 t ha^{-1})
M2- *Millettia pinnata* syn. *Pongamia pinnata* (L.) Pierre (2.00 t ha^{-1})
M3 - *Gliricidia sepium* (Jacq.) Walp. (1.50 t ha^{-1})
M4 - *Delonix regia* (Hook.) Raf. (1.45 t ha^{-1})

EXPERIMENT III - INTERCROPPING

Two field experiments were carried out at the Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai during 2021-22 and 2022. The field experiment was set up in a split plot design with the incorporation of five distinct types of leguminous tree leaves and eight intercropping systems were replicated twice. The treatments were allotted randomly to each replicated block to lessen the experimental error and also to provide an equal chance of experiencing diverse variations for all the treatment combinations. In total, two experiments were carried out during the late *rabi* season of 2021 and the summer of 2022. First trail (Late rabi season): August 2021 (09.08.2021) – January 2022 (03.01.2022) and second trial (Summer season): January (12.01.2022) – July 2022 (11.07.2022).

The tree leaf biomass were incorporated to supply 40 to 60 kg of nitrogen as per requirement of millet crops

M1: *Peltophorum ferrugineum* (Decne.) at the rate of 2.01 to 3.0 t ha^{-1}
M2: *Albizia lebbek* (L.) at the rate of 1.66 to 2.45 t ha^{-1}
M3: *Gliricidia sepium* (Jacq.) at the rate of 1.84 to 2.78 t ha^{-1}
M4: *Delonix regia* (Boj.) at the rate of 1.74 to 2.62 t ha^{-1}
M5: *Millettia pinnata* syn.*Pongamia pinnata* (L.) Pierre at the rate of 1.68 to 2.52 t ha^{-1}

The millets grown were barnyard millet, foxtail millet, kodomillet and finger millet and intercropped with black gram and cowpea at 3:1 ratio.

3. RESULTS

3.1 Results of Monocropping Study

The incorporation of tree leaf biomass had a significant impact on soil organic carbon status. The time zero value of SOC was 4.0 g kg^{-1}. The incorporation of green manures into the soil organic carbon status showed a significant trend and it rose up to a mean value of 5.3 g kg^{-1} six weeks after incorporation of leaf biomass and progressed further and ended at 7.0 g kg^{-1} at the harvest of the second crops *i.e*., in 37 weeks it rose by 1.75 folds (Fig. 1). Later the mean SOC value reached to a maximum of 6.8 g kg^{-1} while it was 5.4 CPG practice and 4.3 g kg^{-1} in zero input plot at the end of 64 weeks.

3.2 Achievements

In this experiment, a mean annual addition of SOC of only 3.0 g kg^{-1} (3p1000) was reached against the target of 4p1000.

3.3 Results of Multiple Cropping

During the first-year, little millet-little millet-black gram were raised and the data are presented in Table 1 and Fig. 2. The time zero value for SOC at the beginning of the experimentation was 2.2 g kg^{-1} (i.e. 0.22 %). The incorporation of green leaf manures showed a significant trend on soil organic carbon status in the whole cropping system. After 6 weeks of GLM incorporation, the

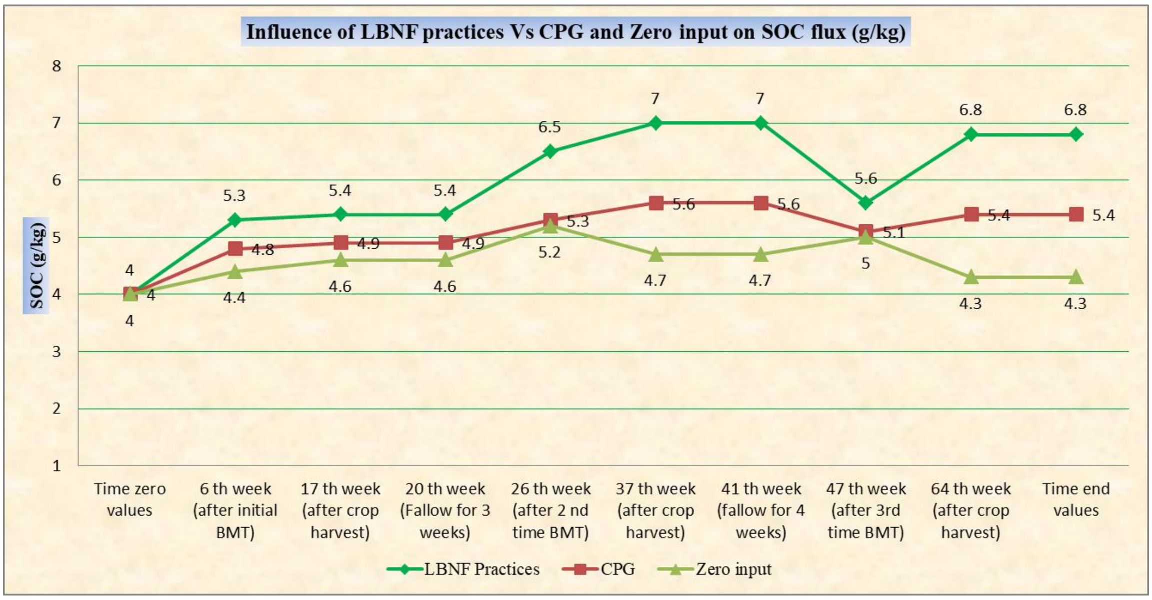

Fig. 1. Influence of systems on SOC trend over period of time

soil organic carbon (5.6 g kg^{-1}) was higher in *Delonix regia* and lower (3.7 g kg^{-1} i.e. 0.37%) in *Leucaena leucocephla* and which rose to 5.7 g kg $^{-1}$ (i.e. 0.57 %) in *Delonix regia* and (4.0 g kg $^{-1}$) in *Leucaena leucocephla* after the harvest of the first crop of little millet. Later, after the incorporation of GLM before raising the second crop, SOC was 6.0 g kg $^{-1}$in *Delonix regia* and 4.3 g kg $^{-1}$) in *Leucaena leucocephla*, but after harvest of the second crop of little millet, the SOC was high 7.0 g kg $^{-1}$) in *Gliricidia sepium* while *Leucaena leucocephla* contained the lowest SOC of 4.8 g kg $^{-1}$.

The reach of 4p1000 was observed in the study at the end of the first year (52 weeks). The mean SOC of LBNF practices started at 2.2 g kg $^{-1}$ at the beginning and reached 6.6 g kg $^{-1}$ after one year. It increased beyond and reached 7.1 g kg $^{-1}$ at the end of 92 weeks.

After the harvest of the third crop, black gram, the SOC was maximum (0.71 % i.e. 7.1 g kg^{-1}) in *Gliricidia sepium* and minimum (0.58%) in *Leucaena leucocephla*. In the case of CPG practice and zero input plots, SOC increased from 0.22% to 0.66% at the end of the first year, yet it showed lower than LBNF and the zero-input plot recorded SOC (0.38%) at the end of the first year. During the second year, before the start of the second-year experiments, the mean SOC was (0.66 %). After 6 weeks of leaf biomass incorporation, though SOC showed non-significance, the values ranged from 0.68% to 0.72%. After the harvest of the first crop of little millet in the second year, the highest SOC (0.73%) was discerned in *Delonix regia* and *Pongamia pinnata* recorded the lowest (0.67%) SOC. This trend continued even after the harvest of black gram, with a higher SOC (0.74%) in *Delonix regia* and a lower SOC (0.68%) in *Pongamia pinnata*. Regarding CPG practice and zero input plots, the final values of SOC at the end of experimentation was 0.53% in CPG practice and 0.43% in zero input plots.

3.4 Achievements

In this experiment, a mean annual addition of SOC of 4.4 g kg^{-1} (4p1000) was achieved and reached 7p1000 after 92 weeks.

3.5 Results of Intercropping Study

The effect of LBNF practices on SOC in the millet-pulse intercropping system is depicted in Table 2. The incorporation of green leaf manures had a significant impact on soil organic carbon status in the millet-pulse intercropping system. The time-zero value of SOC at the beginning of the experimentation was 7.1g kg $^{-1}$. The incorporation of green manures into the soil organic carbon status showed a significant trend in the whole cropping system. The results presented in the table showed that, after six weeks of tree leaf biomass incorporation, the soil organic carbon (7.6 g kg $^{-1}$ and 8.1 g kg $^{-1}$) was higher in *D. regia* in both years and lower values of 6.8 g kg $^{-1}$ and 7.4 g kg $^{-1}$ were noted in

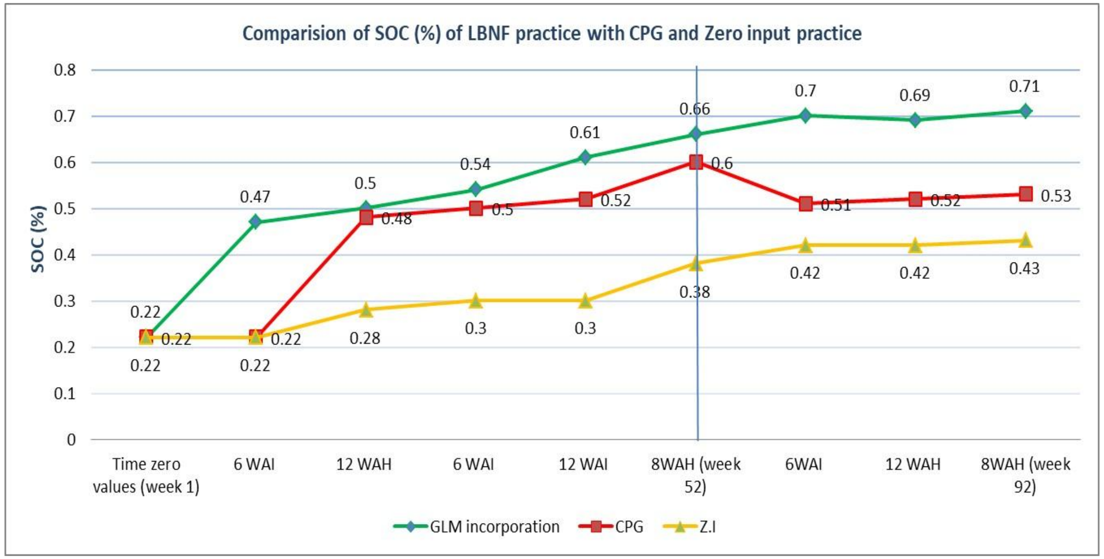

Fig. 2. SOC (%) trend under multiple cropping with LBNF practices

Table 1. Effect of LBNF on Soil Organic Carbon (SOC) status in little millet based cropping system (2019 – 2021)

Treatment	Time zero values (15.08.2019)	Little millet – little millet – Black gram (2019 -2020)					Little millet –black gram (2020 -2021)			
		6 weeks after leaf biomass incorporation	After harvest of 1st millet	6 weeks after incorporation	After harvest of 2nd millet	After 1st Black gram harvest	6 weeks after leaf biomass incorporation	After harvest of 3rd millet	After harvest of 2nd black gram	End values (16.07.202)
M_1	0.22	0.37^{c}	0.40^{c}	0.43^{c}	0.48^{c}	0.58^{c}	0.69	0.69^{c}	0.70^{b}	0.70
M_2		0.46^{b}	0.52^{b}	0.55^{b}	0.59^{b}	0.64^{b}	0.68	0.67^{bc}	0.68^{b}	0.68
M_3		0.49^{b}	0.50^{b}	0.59^{a}	0.70^{a}	0.71^{a}	0.72	0.71^{ab}	0.73^{a}	0.73
M_4		0.56^{a}	0.57^{a}	0.60^{a}	0.69^{a}	0.70^{a}	0.72	0.73^{a}	0.74^{a}	0.74
Mean		**0.47**	**0.5**	**0.54**	**0.61**	**0.66**	**0.70**	**0.69**	**0.71**	**0.71**
S.Ed	-	**0.019**	**0.017**	**0.014**	**0.012**	**0.014**	**0.009**	**0.013**	**0.013**	**-**
C.D ($P < 0.05$)	-	**0.042**	**0.036**	**0.029**	**0.027**	**0.030**	**NS**	**0.028**	**0.028**	**-**
CPG	0.22	0.22	0.48	0.50	0.52	0.60	0.51	0.52	0.53	0.53
Zero input		0.22	0.28	0.30	0.30	0.38	0.42	0.42	0.43	0.43

M_1 – Leucaena leucocephala, M_2 – Pongamia pinnata, M_3 – Gliricidia sepium, M_4 – Delonix regia
CPG – Crop production guide (44:22:0) NPK kg ha^{-1}, Zero input – no inputs from external source except seeds

Table 2. Effect of LBNF practices on soil organic carbon (SOC) (g kg -1) in millet-pulses intercropping systems

LBNF practice	Time zero value	6 weeks after incorporation of tree leaf biomass	After harvest of first crop	6 weeks after incorporation of tree leaf biomass	After harvest of second crop
M1	7.1	6.8	7.1	7.4	7.2
M2	7.1	7.5	7.7	7.9	7.5
M3	7.1	7.2	7.4	7.6	7.4
M4	7.1	7.6	7.9	8.1	7.8
M5	7.1	7.1	7.2	7.4	7.3
Mean	7.1	7.2	7.5	7.7	7.4
SE(d)	-	0.20	0.19	0.21	0.09
CD (< 0.05)	-	0.46	0.45	0.48	0.20
CPG	5.3	5.3	5.6	5.3	5.5
ZI	4.4	4.4	3.6	3.4	3.2

M1: Peltophorum ferrugineum, M2: Albizia lebbek (L.), M3: Gliricidia sepium (Jacq.), M4: Delonix regia (Boj.), M5: Millettia pinnata syn. Pongamia pinnata (L.), CPG- Crop production guide and ZI-Zero Input.

P. ferrugenium. After the harvest of the first and second year crops, the SOC status was higher (7.9 g kg -1 and 7.8 g kg -1) in *D. regia*, whereas a lower (7.1 g kg $^{-1}$ and 7.2 g kg $^{-1}$) SOC was documented in *P. ferrugenium*. In the case of CPG practice and zero input practice, values of SOC at the end of experimentation were 5.5 g kg $^{-1}$ in CPG practice and 3.2 g kg $^{-1}$ in zero input practice.

In this study (2021-22) after practicing LBNF practices SOC remarkably increased to 7.5 g kg $^{-1}$ at the end of the first year (21 weeks), which was 25.33% more than CPG practice and maintained at the same level (7.4 g kg $^{-1}$) till the end of the study. Among the practices, the incorporation, and decomposition of *D. regia* increased the SOC to 7.9 g kg $^{-1}$ during the first year and 7.8 g kg $^{-1}$ after 48 weeks. *D. regia* LBNF has increased nearly 8.0 g kg $^{-1}$ SOC stocks within 48 weeks. This results clearly proved that SOC status was increased from medium (5.0 to 7.5 g kg $^{-1}$) to a high level (more than 7.5 g kg $^{-1}$). The conventional CPG practice had just added 0.2 g kg $^{-1}$ to the SOC at the end of the study. The incorporation of leaf biomass and allowing for decomposition of six weeks favourably and significantly altered the soil organic carbon (SOC) status.

3.6 Results on Soil Organic Carbon 3-Year Trends

One of the major strategies of LBNF is achieving 4p1000 which is adding 4g kg^{-1} SOC annually. The experiment field has been under LBNF practices since 2019. The earlier research on LBNF based cropping system was carried out for two years in the same field (experiment II) and found that the SOC level at the start of studies, i.e. during August 2019 was just 2.2 g kg $^{-1}$, and it ended at 7.1 g kg $^{-1}$ in August 2021. This might be due to the continuous application of inorganic fertilizers alone, supported by Hemalatha et al, [6] in the finger millet-maize cropping sequence. In the case of ZI practice also, SOC was reduced from a beginning value of 4.4 to a value of 3.2 g kg -1 due to no addition of organic matter in the soil. An active and diverse soil microbial population is the key to growing healthy, high-yielding organic crops. Successful organic fertility management should primarily feed the soil microbial life in a long-term manner rather than simply feeding the plants. Three years of observations indicated that it is possible to achieve 4p1000 in one year under tropical conditions and also able to sustain it by adopting theses techniques.

4. DISCUSSION

Soil organic carbon is an important aspect to maintain soil health and to promote sustainable agriculture in the tropics. International Year of Soils 2015 has announced SOC is the critical link for land restoration and agriculture solutions to climate change adaptation and mitigation. This was promoted by the 4 per 1000 initiative introduced at COP 21 by France and its main goal is to increase SOC stocks at 0.4% (4 per 1000/year) through agro ecological and sustainable practices like the addition of organic matter [7]. SOC is dictated by carbon inputs and outputs, and the 4P 1000 initiative primarily focuses on agricultural soils with low SOC levels due to unsustainable crop intensification techniques [8] to be built up with carbon.

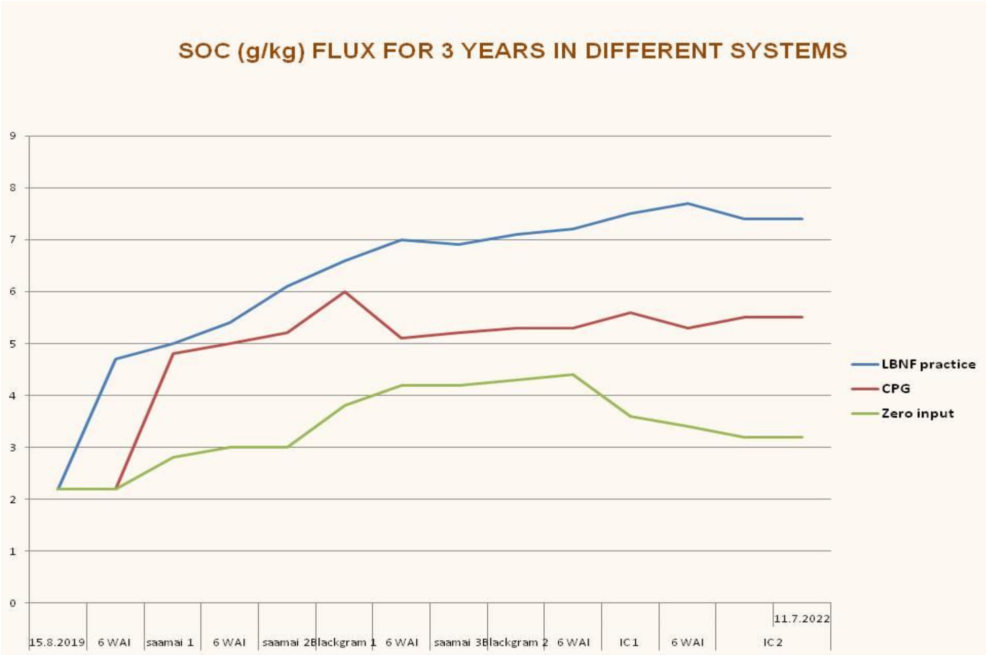

Fig. 3. Soil organic carbon flux for 3 years

This investigation fulfilled one of the strategies of LBNF, enhancing SOC through 4p1000. The results clearly support this. The time zero value of SOC before scheduling of LBNF was 0.22% in August, 2019 in the experimental field. After practicing LBNF aka *Vrikshayurvedic farming* by addition of organic matter through green leaf manures as basal nutrients in the soil prior to sowing of three little millet crops and two residual legume crops, SOC remarkably increased to 0.66% at the end of the first year, which was 9.0% more than CPG practice. The present study achieved the 4P1000 objective by increasing SOC by 0.44% within one year itself, and it was further increased to 0.71 % within the next 40 weeks i.e. within 92 weeks, LBNF has increased nearly 0.5% SOC stocks and it will continue to increase if the practice is adopted continuously on a long term basis.

Even though the conventional practice had reached a SOC of 6.0 g kg $^{-1}$ in the first year from 2.2, but it declined to 5.3 g kg $^{-1}$ at the end of the study. This might be due to the continuous application of inorganic fertilizers alone supported by Hemalatha and Chellamuthu, [6] in finger millet-maize cropping sequence. In the case of zero input practice, SOC climbed from beginning values of 2.2 to 4.3 g kg $^{-1}$, but remained static after that as there was no addition of organic matter in the soil. An active and diverse soil microbial population is the key to growing healthy, high-yielding organic crops. Successful organic fertility management should primarily feed the soil microbial life in a long-term manner, rather than simply feeding the plants. For the active proliferation of microorganisms in soil and increasing nutritional availability to crops, soil organic carbon stocks act as an energy source.

An active and diverse soil microbial population is the key to growing healthy, high-yielding organic crops. Successful organic fertility management should primarily feed the soil microbial life in a long-term manner rather than simply feeding the plants. Soil organic carbon stocks act as an energy source [9]. SOC and soil enzymes are the two significant aspects that play a vital role in increasing soil microbial load in soil. Both the factors were increased through the addition of organic matter to the soil. In the present study, it was achieved through the incorporation of tree leaf biomass. The increased microbial load was observed when LBNF was practiced, and it might be due to better decomposition of green leaf manures through micro-organisms that resulted in the transformation of organic bounded nutrients to inorganic form for the plant; resulting in an increase in SOC stocks and also, thereby, increasing soil microbial load. This theory supported the findings of [10], who reported that the highest microbial load was observed when soil was bounded with organics rather than inorganics. Under conventional practice due to continuous application of intensive inorganic fertilisers alone in the soil, this can cause degradation of the environment through nutrient runoff and biodiversity loss. The zero-input practice also had less microbial load due to the absence of external inputs.

5. CONCLUSION

Monocropping of millets did not succeed in reaching 4p1000, despite the LBNF practice of utilizing tree leaf biomass as a source of nutrients. But when blackgram pulse crop was added to the cropping system and a millet-pulse system strategy was used, it was possible to achieve the principle of 4p1000 under tropical conditions. The accumulation of soil organic carbon in the cultivated field would be further aided by intercropping pulses and millets. Thus, crop diversity and the inclusion of a legume crop in the annual rotation are necessary for increasing the amount of organic carbon in the soil, together with the use of the appropriate source of biomass, such as the leaves of legume trees, to deliver nutrients through the soil. The incorporation of legume tree leaf biomass as a source of nutrients and allowing it to decompose help to build and maintain soil organic carbon status in the cultivated soils.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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