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Assessment of biological indicators of soil quality to enhance productivity of pulse crops

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Abstract
An assessment of biological indicators of soil quality was conducted in three blocks of pulse growing zones of Virudhunagar district *viz*., Sattur, Aruppukottai and Tiruchuli which were classified into three categories *viz*., low yielding (less than 400 kg ha^{-1}), medium (400 to 700 kg ha^{-1}) and high yielding (more than 700 kg ha^{-1}) zones. The biological indicators *viz*., soil organic carbon content, microbial respiration rate and dehydrogenase enzyme activity of soil were assessed for each zone. The low organic carbon content (1.74 g kg^{-1}) in the low yielding zone reflected in the low mean soil respiration rate of 2.34 mg CO_2 $kg^{-1}d^{-1}$. In the high yielding zones, the respiration rate ranged from 2.45 to 7.45 mg CO_2 $kg^{-1}d^{-1}$ with a mean value of 4.48 mg CO_2 $kg^{-1}d^{-1}$. About 70 percent soil samples from high yielding zone recorded high soil respiration rate. The average values of dehydrogenase enzyme activity was higher in 82% of high quality soils where the farmers have practised proper nutrient management practices indicating that regular application of enriched FYM, Azospirillum and pulse wonder along with TNAU recommended dosage of fertilizers enhanced the yield and productivity of pulses.

Keywords: Soil quality, biological indicators, dehydrogenase, respiration rate, pulses

Introduction
Pulses are the important sources of proteins, vitamins and minerals, popularly known as “poor man’s meat” and “rich man’s vegetable” that contribute significantly to the nutritional security of the country. India is the largest producer of pulses with 29 per cent of global area contributing to 19 per cent of the world’s pulse production (Singh *et al*., 2015) [1]. Normally, at the world level pulses are grown in an area of 78 million hectares with an annual production of 70 million tonnes (MT) and productivity of 908 kg ha^{-1}. In India pulses are grown in 23.85 million hectares with an annual production of 14.60 million tonnes (MT) and productivity of 843 kg ha^{-1}.In Tamil Nadu, the total area under pulses is around 9.5 lakh ha with a production of 6.5 lakh tonnes. The average productivity of pulses in the state is around 712 kg ha^{-1} which is far below the average productivity of the country as well as that of the global productivity (Anonymous, 2016) [2]. Virudhunagar district lying at the foot of Western ghats of Tamilnadu, is a predominant pulse growing region, where the average yield of 600 kg ha^{-1} is far below the state average yield of 712 kg ha^{-1}. A thematic session on strategies to increase productivity of pulses in India towards the celebration of International year of pulses clearly highlighted the soil related constraints as one of the major contributing factors for low yield in pulses. In order to restore the quality of degraded soils and to prevent them from further degradation, it is of paramount importance to evaluate the soil quality characteristics in terms of soil quality indicators and to standardize a set of soil quality criteria for improving the productivity of pulses. (Sharma and Mandal, 2009) [3]. Hence, the present study was undertaken to take up an assessment of soil in the low, medium and high yielding zones of Virudhunagar district to characterise the biological health of soil interms of organic carbon content, microbial respiration rate, dehydrogenase enzyme activity and propose yield zone specific suitable nutrient management packages to maximize the productivity of pulse crops.

Materials and methods
Geographically the study area is located in Virudhunagar district lying at the foot of Western Ghats between 90º 20’ and 90º72’ North latitude and 77º20’ and 78º70’ East longitude. The sampling area for soil quality assessment was divided into three categories *viz*.

low yielding (less than 400 kg ha^{-1}), medium yielding (400 to700 kg ha^{-1}) and high yielding (more than 700 kg ha^{-1}) which are also indicated as low, medium and high soil quality categories. About 50 surface samples (0-15 cm) from each zone @ 50 samples per block in two replications were collected covering the low, medium and high yielding zones amounting to 300 number of soil samples. The organic carbon content as the basis for soil biological properties was determined by chromic acid wet digestion method as prescribed by Walkely and Black (1934) [4]. The microbial respiration rate was determined by CO_2 evolution method (Anderson, 1982) [5]. The activity of dehydrogenase enzyme in soils was assayed according to the method prescribed by Cassida *et al*. (1964) [6]. The analytical data on soil quality parameters were processed with statistical parameters *viz*., range, mean, minimum, and maximum following the methods suggested by Gomez and Gomez (1984) [7]. Simple correlation co-efficient were worked out between certain inter related pairs of parameters to observe their degree of dependance as suggested by Snedecor and Cochran (1967) [8]. Principal Component Analysis (PCA) with eigen values ≥ 1 and those that explain at least 5% of the variation in the data were examined by using SPSS software (Andrews and Carroll, 2001) [9].

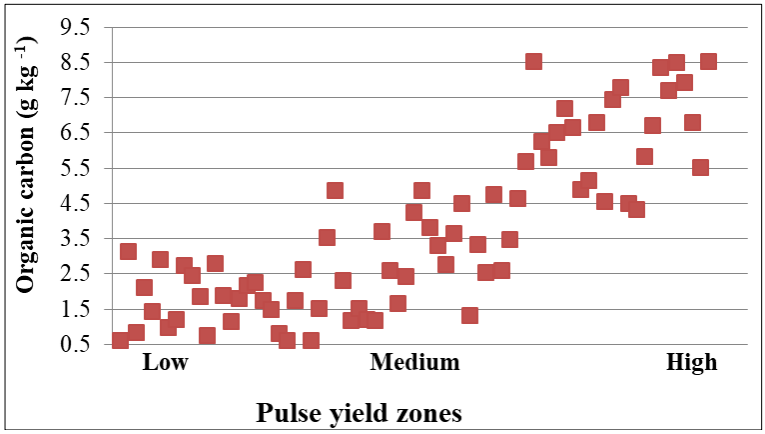

Fig 1: Variation in soil organic carbon content in various yield zones of pulses

Results and discussion

Soil organic carbon content

The organic carbon content of the soil ranged from 0.62 to 3.14 g kg^{-1}, 1.18 to 4.87 g kg^{-1}, 4.33 to 8.55 g kg^{-1} in low, medium and high yielding zones respectively as represented in Fig 1. Among the 300 samples collected and analysed, 100 percent soil samples from the low quality zone recorded low organic carbon as against that of only 20 percent in high yielding zone. The inherently low organic matter content in the tropical soils of Virudhunagar district, the depletion of organic matter under continuous crop cultivation, insufficient and irregular addition of organic sources to the soil by the resource poor farmers of this region might have contributed to the low mean values of organic carbon content in the low yielding zones. This observation corroborated with the findings of Bouajila and Sana (2011) [10].

Soil respiration rate and enzyme activity

The microbial respiration rate and dehydrogenase enzyme activity in the soil samples of low, medium and high yielding pulse growing soils of Virudhunagar district are presented in Table 2.The respiration rate in the soils ranged between 1.45 and 3.24 mg CO_2 $kg^{-1}d^{-1}$ with a mean value of 2.34 mg CO_2 kg^{-1} d^{-1}, 2.08 and 4.33 with a mean value of 3.21 mg CO_2 $kg^{-1}d^{-1}$, 2.45 to 7.45 with a mean value of 4.48 mg CO_2 $kg^{-1}d^{-1}$ in low, medium and high soil quality zones. About 70 percent soil samples from high yielding zone recorded high soil respiration rate. Thus, it can be inferred that the application of farmyard manure and enriched farmyard manure that increase soil organic matter usually enhances soil respiration which can also be related to the response of the farmers in the high soil quality zone towards regular application of organic inputs. Similar findings have been revealed by Bastida *et al*. (2008) [11].

The enzyme activity in the soils of low yielding zone ranged between 17 to 47 TPF with a mean value of 32 TPF µg $g^{-1}$of dry soil hr^{-1}. The average range of dehydrogenase enzyme activity in any fertile soil varied from 80 to 95 TPF µg $g^{-1}$of dry soil hr^{-1}. The soil samples of medium yielding zones recorded an enzyme activity between 45 and 92 with a mean value of 64 TPF µg $g^{-1}$of dry soil hr^{-1}.In the high yielding zone, the respiration rate ranged from 53 to 130 TPF µg $g^{-1}$of dry soil hr^{-1} with a mean value of 83 TPF µg $g^{-1}$of dry soil hr^{-1}. The average values of dehydrogenase enzyme activity was higher in 82 percent of high quality soils where the farmers have practised continuous application of organic manures and regular usage of biofertilizers which also indicated that soil enzymatic activity is strongly connected with soil organic matter content and microbial respiration rate.

Table 2: Soil respiration rate (mg CO_2 kg^{-1} d^{-1}) and Dehydrogenase enzyme activity (TPF µg $g^{-1}$of dry soil hr^{-1}) of various Soil Quality (SQ) categories under pulses

Sample No.	Soil respiration rate (mg CO_2 kg^{-1} d^{-1})			Dehydrogenase enzyme activity (TPF µg $g^{-1}$of dry soil h^{-1})		
	Low	Medium	High	Low	Medium	High
1	3.21	2.13	3.88	24	63	65
2	2.82	3.67	2.45	33	57	88
3	1.45	2.76	3.45	22	72	90
4	1.46	2.56	4.87	26	66	98
5	2.22	3.78	5.43	42	55	90
6	3.15	3.89	4.32	37	64	92

7	3.24	3.56	2.78	32	65	87
8	3.09	2.54	6.02	42	75	67
9	2.21	2.78	3.08	25	70	67
10	3.02	4.02	4.24	28	73	78
11	2.44	2.87	6.04	37	87	81
12	1.66	2.79	2.67	27	60	85
13	1.78	3.67	3.09	17	77	81
14	2.44	4.33	7.32	21	64	79
15	1.63	2.87	4.25	47	53	82
16	2.22	2.66	4.32	41	61	112
17	3.02	3.86	6.08	29	53	130
18	2.14	2.76	3.78	19	52	53
19	2.22	4.08	4.21	35	58	61
20	3.12	3.48	2.89	23	45	53
21	1.77	2.08	7.45	37	72	97
22	1.65	2.68	5.66	28	64	99
23	1.89	2.46	3.11	46	92	101
24	2.11	4.00	5.78	34	56	93
25	2.08	3.92	3.88	46	49	56
Max	3.24	4.33	7.45	47	92	130
Min	1.45	2.08	2.45	17	45	53
Mean	2.34	3.21	4.48	32	64	83
SED	0.63	0.68	1.44	8.89	11.33	18.56
CV	21.78	28.18	32.14	27.85	22.66	17.25

Conclusion

The results of the assessment of the biological soil quality indicators in major pulse growing blocks of Virudhunagar district showed that 100 per cent soil samples from the low soil quality zone recorded low organic carbon content and only 20 per cent of the soils in high yielding zone had a lower organic carbon content. The medium and high soil quality zones recorded higher values of, soil respiration rate and dehydrogenase enzyme activity compared to the zone of low soil quality. The findings of the study emphasized that improved soil quality is indicated by soil organic matter content which needs top most priority for enhancing pulse productivity in low soil quality zone. Application of any of the organic manures *viz*., P enriched FYM, vermicompost along with regular usage of biofertilizers like Azospirillum, Phosphate solubilizing bacteria and resorting to recommended application of DAP/ TNAU pulse wonder in low soil quality category for reducing the flower shed and improving the drought tolerance are essential for enhancing the yield of pulse crops.

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