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Comparative Evaluation of different Crop Production Practices on Soil Organic Carbon and Nutrients Status in Arecanut

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ABSTRACT: Knowing the negative impacts of chemicals, we have been exploring for alternative methods in agriculture that can not only result in higher yields but are also environmentally friendly. Apart from modern agricultural approaches, numerous crop production modules are practiced in Indian agriculture, such as Organic farming, Natural farming, Chemical farming etc. Despite the fact that there are many modules, comparative scientific research to evaluate the various modules is limited. In this regard, a field experiment was conducted in the farmer's field at Andagi village of Sirsi taluk to study the effect of different crop production practices (Recommended package of practice (RPP), Organic farming, Natural farming and Chemical farming) on soil fertility status in arecanut. The pooled data (2020 and 2021) depicted that, soil pH and electrical conductivity did not vary significantly due to different farming system. Whereas, significantly highest soil organic carbon content was found in organic farming (0.81%) which was on par with natural farming (0.76%) and least was noticed in chemical farming (0.57%). The highest available nitrogen (329.01 kg ha^{-1}), phosphorus (31.77 kg ha^{-1}) and potassium (216.52 kg ha^{-1}) contents in soil were recorded in RPP. Whereas the highest secondary and micro nutrients content in soil was observed in organic and natural faming. The lowest of all these nutrients were recorded in chemical farming at harvest stage of arecanut.

Keywords: Arecanut, black pepper, soil organic carbon, nutrients status.

INTRODUCTION

India is having the knowledge treasure especially in the field of agriculture, since times immemorial. Traditionally, we are growing the crops to fulfil our day to day needs and as a source of income for leading a healthy, sustainable life. With modernization, agricultural practices in the country also changed to the larger extent with the passing timeline. Green revolution in India lead to an era of intensified agriculture practices, including the use of high yielding varieties/hybrids, chemical fertilizers and plant growth regulators for maximizing the yield levels of the crops (Tilman *et al*., 2002). Domestication, sole cropping/ monocropping and luxuriant crop growth due to fertilizers and growth promoters undoubtedly, increased the yield but, on the other hand it leads to soil deterioration and drastic increase in number of pest and diseases affecting the crop. Further it resulted in increased use of plant protection chemicals for managing the pest and diseases (Tripathi *et al*, 2018). Due to indiscriminate use of the chemicals in agriculture, we are facing the consequences like pollution of soil, water and environment, chemical residues in food leading to the serious problems in human health. In recent years, by knowing the ill effects of chemicals, we are looking for the alternative ways in agriculture which can not only result in better yields but also environmentally safe. Apart from modern agricultural practices, there are many modules of crop production, followed in Indian agriculture *viz*., Organic farming, Natural farming, Low External Input Agriculture (LEISA), Bio-dynamic farming, Zero Budget Natural Farming (ZBNF) *etc*. Though there are many modules, comparative scientific study to evaluate the different modules is very scanty. In this view, a field experiment was conducted in the farmer's field at

Andagi village of Sirsi taluk to study the effect of different crop production practices (Recommended package of practice (RPP), Organic farming, Natural farming and Chemical farming).

MATERIALS AND METHODS

A field demonstration on the use of various farming systems was carried out during 2020 and 2021 on a sandy clay, moderately deep, red soil in arecanut plantation cropping system at farmer's field, Andagi village of Sirsi taluk, Karnataka. The experiment was conducted in the arecanut (Sagara local) plantation of an approximate age of 17 years. The climate of experimental area is warm humid with a mean annual precipitation of 2500 mm and mean minimum and maximum temperature of 19.4°C and 30.3°C, respectively.

The pH (1:2.5) of the soil (0-30 cm depth) was 6.74, electrical conductivity (EC) 0.18 dSm^{-1}, organic carbon 0.68%. Available nitrogen, phosphorus, potassium and sulphur were 325, 19.46, 195 kg ha^{-1} and 14.56 mg kg^{-1}, respectively. The exchangeable calcium and magnesium contents were 5.72 and 2.50 cmol (p^{+}) kg^{-1}, respectively. Whereas, DTPA extractable zinc, copper, iron and manganese were 0.91, 1.40, 8.14 and 14.88 mg kg^{-1}, respectively.

The experiment was laid out with the following treatments in a randomised block design with five replications: T_1: Recommended package of practice, T_2: Organic farming, T_3: Natural farming and T_4: Chemical farming. Lime ($CaCO_3$) was applied uniformly to all the treatments during pre-monsoon period as per the requirement. The quantity of nutrients used in different farming systems was given in the table 1 and the average nutrients composition of different organic manures used in the experiment were given in table 2. Analysis of variance (ANOVA) was carried out using the randomised block design method and Least Significance Difference (LSD) was calculated for treatment means at 5% probability (Gomez and Gomez 1984).

Soil samples were collected from 0-30 cm depth at harvest stage of arecanut. Five cores collected from each treatment plot were mixed thoroughly and a composite sample was taken. Soil samples were air-dried, ground, and sieved (2 mm) for analysis. The pH of the soil was estimated in 1:2.5 soil: water suspension by using systronic digital pH meter. The electrical conductivity was estimated in supernatant solution of 1:2.5 soil: water suspension using conductivity bridge. Organic C was determined by the wet digestion method of Walkley and Black (1934). Available nitrogen was estimated by distilling soil with 0.5% KMnO4 in a micro-Kjeldhal apparatus (Subbiah and Asija 1956). Available phosphorus was extracted with 0.03 N NH_4F + 0.025 N HCl and estimated spectrophotometrically (Bray and Kurtz 1945). Available potassium was extracted with neutral 1N NH_4OAC and estimated using flame emission spectroscopy. Available micronutrients (Zn, Fe, Mn and Cu) were extracting with DTPA (Lindsay and Norvell 1978) and estimated by atomic absorption spectrophotometer (Varian spectra AA 20 plus).

RESULTS AND DISCUSSION

Effect of different crop production practices on soil fertility status

Soil pH and electrical conductivity (EC). Pooled data (2020-2021) indicated that, compared to initial value slight increase in soil pH and EC was observed in all the treatments, but found non-significant among the treatments (Table 3). This might be due application of lime to all the treatments during pre- monsoon period. Among the treatments, highest increase in soil pH was observed in organic farming (7.38) followed by RPP (7.30). Whereas highest (0.36 dS m^{-1}) and lowest (0.25 dS m^{-1}) EC among the treatments was recorded in chemical and organic farming, respectively. The slight increase in soil pH in organic farming and RPP might be attributed to release of basic cations during decomposition of farm yard manure (FYM) and vermicompost, which in turn enhances the soil physico-chemical properties and reduces the loss of basic cations from the soil through leaching. The lower EC value might be due to the reduction of salt concentration in soil solution and increased water holding capacity with the addition of organic matter. Fan *et al.* (2011) reported that decrease in soil pH with use of chemical fertilizers and decrease in soil pH with continuous application of jeevamrutha.

Soil Organic Carbon (SOC). Compared to initial value increase in soil organic carbon content was observed in RPP, organic and natural farming, whereas it decreased in chemical farming in both the years (2020 and 2021). Pooled data indicated that, the soil organic carbon content was significantly varied among the treatments. The highest soil organic carbon content was found in organic farming (0.81 %) which was on par with natural farming (0.76 %) and least was noticed in chemical farming (0.57 %) at harvest stage of arecanut (Table 3). Increased soil organic carbon content might be due to application of organic manures such as farm yard manure and vermicompost to organic treated and ghanajeevamrutha, jeevamrutha and mulching practices in natural farming, resulted in enhanced soil micro flora with drastic increase in different soil enzymes which in turn contributes more organic carbon to the soil. The decrease in soil organic carbon content in chemical farming might be due to less humus formation and also oxidation caused by high temperature and leaching of soluble humic complexes due to coarse textured nature of soil. Other similar findings were Chaithra (2018).

Major nutrients (Available nitrogen, phosphorus and potassium). In the first year of experiment i.e. 2020, the available nitrogen and potassium contents in soil did not vary significantly among the treatments whereas significant difference was noticed in second year of experiment i.e. 2021. The available phosphorus content in soil did not vary significantly among the treatments in both the years (2020 and 2021). Pooled data indicated that, significantly highest available nitrogen (329.01 kg ha^{-1}), phosphorus (31.77 kg ha^{-1}) and potassium (216.52 kg ha^{-1}) contents in soil were recorded in RPP, which was on par with organic farming. The lowest of available nitrogen (305 kg ha^{-1}), phosphorus (18.01 kg ha^{-1}) and potassium (170.57 kg ha^{-1}) contents in soil were recorded in natural farming practice at harvest stage of arecanut (Table 4). Because of combined application of chemical fertilizers and organic manures in RPP treatment enhances the mineralization of nutrients and reduces the loss of nutrients through leaching, denitrification and volatilization and also release of weak organic acids during decomposition of organic manures dissolve the fixed nutrients and enhances its availability in the soil (Tandon and Ranganathan 1988). Similar results were observed by Bhat and Sujatha (2007); Paul *et al.* (2020).

Secondary nutrients (Exchangeable calcium and magnesium and available sulphur). Pooled data (2020 and 2021) indicated that, available sulphur, exchangeable calcium and magnesium contents in soil did not vary significantly among the treatments at harvest stage of arecanut. However the highest available sulphur (14.63 mg kg^{-1}), exchangeable calcium (7.34 cmol (p+) kg^{-1}) and magnesium (2.97 cmol (p+) kg^{-1}) contents in soil were noticed in organic farming which was followed by natural farming and lowest of these nutrients were recorded in chemical farming (Table 5). Addition of lime along with organic manures reduces the loss of basic cations and increased the secondary nutrients content in soil (Shambhavi *et al.*, 2018). The consistently declining trend of secondary nutrients with the chemical farming warrants the supplementation of NPK fertilizers with calcium and magnesium for the maintenance of soil health and sustainable crop production.

Micronutrients (DTPA extractable iron, zinc and manganese). Pooled data (2020 and 2021) indicated that, DTPA extractable zinc, copper, iron and manganese contents in soil were found non-significant among the treatments. However compared to initial value slight increase in these micronutrients was observed in RPP, organic and natural farming practices, whereas slight decrease was noticed in chemical farming practice (Table 6). Among the treatments, the highest DTPA extractable zinc was observed in RPP (0.93 mg kg^{-1}), which was followed by organic and natural farming. This might be due to application of zinc sulphate to the RPP treatment at the time of pre-monsoon period. Whereas highest copper (1.76 mg kg^{-1}) was recorded in natural farming and iron (9.61 mg kg^{-1}) and manganese (15.40 mg kg^{-1}) contents in organic farming and lowest of these micronutrients (0.61, 0.80, 8.00 and 13.17 mg kg^{-1} Zn, Cu, Fe and Mn, respectively) were observed in chemical farming. These results are in agreement with the findings of Verma and Mathur (2007); Zhang *et al.* (2015).

Table 1: Nutrients management under different crop production practices.

Crop	Recommended Package of Practices (RPP)	Organic farming (OF)	Natural Farming (NF)	Chemical Farming (CF)
Arecanut	FYM: 20 kg/palm/year 100:40:140 g N: P_2O_5: K_2O /palm/year	Nutrient were supplied equivalent to recommended dose of fertilizer through FYM and vermicompost	Ganajeevamrutha @ 500 kg/ha premonsoon and 500 kg/ha post monsoon Jeevamrutha - sprinkled on soil @ 500 l/ha at 15 days interval	Required quantities of NPK supplied through chemical fertilizers (Urea, DAP and MOP)

Table 2: Average nutrients composition of different organic manures used in the experiment.

Manure type	pH	EC	N	P	K	Ca	Mg	S	Zn	Fe	Mn	Cu
		dS/m	-----------------------------------					%	-----------------------------------			
Desi cow dung	7.82	1.78	0.53	0.17	0.23	0.37	0.12	0.40	0.02	0.61	0.06	0.12
Desi cow urine	7.54	2.16	1.09	0.097	0.31	0.28	0.16	0.21	0.07	0.53	0.04	0.05
Beejamrutha	8.12	1.15	1.03	0.17	0.25	0.13	0.08	0.25	0.012	0.12	0.02	0.06
Jeevamruta	4.51	1.98	1.10	0.25	0.38	0.25	0.18	0.10	0.05	0.45	0.07	0.03
Ghana jeevamruta	7.95	1.72	1.62	0.52	0.75	4.90	2.95	0.55	0.02	0.36	0.53	0.04
FYM	7.85	2.26	0.53	0.22	0.50	2.82	0.25	0.35	0.05	0.23	0.06	0.07
Vermicompost	7.96	1.26	1.65	0.45	0.61	1.05	0.86	0.52	0.015	0.04	0.27	0.06

Table 3: Effect of different crop production practices on soil chemical properties in arecanut + black pepper mixed cropping system.

Treatment	Soil pH (1: 2.5)			Electrical Conductivity (dS m^{-1})			Organic Carbon (%)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
T_1: RPP	7.32	7.37	7.30	0.26	0.30	0.28	0.69	0.73	0.71
T_2: OF	7.49	7.45	7.38	0.23	0.27	0.25	0.74	0.85	0.81
T_3: NF	7.25	7.29	7.20	0.28	0.35	0.31	0.72	0.80	0.76
T_4: CF	7.20	7.19	7.14	0.32	0.39	0.36	0.60	0.55	0.57
S. Em ±	0.08	0.06	0.07	0.03	0.03	0.03	0.03	0.05	0.06
CD at 5 %	NS	NS	NS	NS	NS	NS	0.08	0.15	0.17

Note: RPP: Recommended package of practice, OF: Organic farming, NF: Natural farming, CF: Chemical farming

Table 4: Effect of different crop production practices on major nutrients status of soil in arecanut + black pepper mixed cropping system.

Treatment	Avail. N (kg ha^{-1})			Avail. P_2O_5 (kg ha^{-1})			Avail. K_2O (kg ha^{-1})		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
T_1: RPP	327.85	330.17	329.01	32.74	30.81	31.77	211.99	221.05	216.52
T_2: OF	321.43	326.69	324.06	26.21	27.38	26.79	193.15	210.40	201.78
T_3: NF	304.04	305.95	305.00	15.72	20.30	18.01	170.79	170.34	170.57
T_4: CF	316.26	314.19	315.22	16.27	21.25	18.76	175.62	182.32	178.97
S. Em ±	5.77	4.17	4.50	4.48	3.10	3.76	7.80	7.14	7.03
CD at 5 %	NS	12.85	13.87	NS	NS	NS	24.02	22.01	21.67

Note: RPP: Recommended package of practice, OF: Organic farming, NF: Natural farming, CF: Chemical farming

Table 5: Effect of different crop production practices on secondary nutrients status of soil in arecanut + black pepper mixed cropping system.

Treatment	Available sulphur (mg kg^{-1})			Exchangeable calcium [cmol (p+) kg^{-1}]			Exchangeable magnesium [cmol (p+) kg^{-1}]		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
T_1: RPP	13.14	13.95	13.55	6.13	6.17	6.15	2.43	2.64	2.53
T_2: OF	14.11	15.14	14.63	7.31	7.37	7.34	2.70	3.24	2.97
T_3: NF	13.19	14.11	13.65	6.90	7.03	6.96	2.49	2.86	2.67
T_4: CF	12.14	12.49	12.32	5.45	4.74	5.09	2.27	2.31	2.29
S. Em ±	0.52	0.67	0.59	0.62	0.93	0.78	0.16	0.35	0.17
CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: RPP: Recommended package of practice, OF: Organic farming, NF: Natural farming, CF: Chemical farming

Table 6: Effect of different crop production practices on micro nutrients status of soil in arecanut + black pepper mixed cropping system.

Treatment	Zinc (mg kg^{-1})			Copper (mg kg^{-1})			Iron (mg kg^{-1})			Manganese (mg kg^{-1})		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
T_1: RPP	0.90	0.97	0.93	1.20	1.06	1.13	8.06	8.12	8.09	13.84	14.11	13.98
T_2: OF	0.85	0.87	0.86	1.35	1.89	1.62	9.12	10.09	9.61	14.74	16.06	15.40
T_3: NF	0.76	0.76	0.76	1.55	1.97	1.76	8.41	8.75	8.58	14.00	14.55	14.28
T_4: CF	0.62	0.60	0.61	0.85	0.76	0.80	7.95	8.05	8.00	13.50	12.84	13.17
S. Em ±	0.07	0.08	0.08	0.17	0.25	0.24	0.30	0.60	0.44	0.32	0.99	0.64
CD at 5 %	NS	0.25	NS	NS	0.77	NS	NS	NS	NS	NS	NS	NS

Note: RPP: Recommended package of practice, OF: Organic farming, NF: Natural farming, CF: Chemical farming

CONCLUSIONS

The current analysis amply demonstrated that there was improvement in the soil health with natural and organic farming in arecanut plantation. Hence, reducing the input of chemical fertilizers and application of natural fertilizers such as organic manure *viz.,* jeevamrutha, ghanajeevamrutha, FYM, vermicompost, crop residues, green manure and compost could sustain the soil health.

FUTURE SCOPE

As the chemicals pose a hazardous effect on soil and environmental health, integrating the good management practices from both organic farming and natural farming may pave a way for improved yields along with maintaining the soil and environmental health.

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Conflict of Interest. None.

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