Original Research Article

~~Effect of d~~Different farming systems ~~on~~ Concerningsoil health and yield of areca-nut and black pepper

Abstract

~~A~~ We conducted atwo ~~two~~ two-year (2020 and 2021)field experiment ~~was conducted~~ in the farmer's field at Hanagal,Sirsi, Karnataka to study the ~~effect~~ impactsof different farming practices (Recommended package of practice; ~~(~~RPP~~)~~, Organic farming, Natural farming, and Chemical farming) on rhizospheremicroflora, soil nutrient status, and yield of areca-nut and black pepper.The ~~pooled data (2020 and 2021) depicted that,~~results revealed thatsoil pH and electrical conductivity did not vary significantly due to different farming systems.Whereas, the significantly ($P<0.05$) highest soil organic carbon content was~~found~~ in organic farming (0.74%) which was on par with natural farming (0.66%) and least ~~was noticed~~ in chemical farming (0.71%).The highest available nitrogen (258.31 kg.ha^{-1}), phosphorus (39.06 kg.ha^{-1}), and potassium (205.47 kg.ha^{-1}) ~~contents in soil~~ were ~~recorded~~ in RPP. Whereas the highest secondary nutrients and micronutrient~~s~~ contents~~in soil was~~were~~observed~~ in organic and natural farming. The lowest of all these nutrients were recorded in chemical farming at the harvest stage of areca-nut. Soil microflora, dehydrogenase, and phosphatase activity in the areca-nut and black pepper rhizosphere were significantly ($P<0.05$) highest in natural farming and lowest in chemical farming. ~~With respect to~~Concerning yield, the significantly highest areca-nut (~~chali~~ Chaliyield 29.35 q.ha^{-1}) and black pepper (dry yield12.07 q.ha^{-1}) yield was ~~observed~~ in RPP and maximum net return also observed in RPP (Rs. 10, 62, 500 ha^{-1}).

Keywords: Areca-nut, black pepper, enzyme activity, microflora, nutrients status, SOC

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INTRODUCTION

Agriculture has been the backbone of the Indian economy for centuries. Recently, ~~More~~ more than half of the country's population ~~at present~~ depends on agriculture and allied services for their livelihoods [17]. Over the last few decades, there has been a major transformation in the Indian agricultural sector. With the introduction of 'Green Revolution' technologies, agriculture in India has transitioned from subsistence to commercial farming. However, ~~in spite of~~despite the success, the ~~input~~ input-intensive 'Green Revolution' ~~in recent decades~~ has often masked significant externalities, affecting natural resources,~~and~~

human health, ~~as well as~~and agriculture itself. The green revolution increased agricultural output through higher fertilizer and pesticide application, improved irrigation, soil management regimes, ~~and~~ crops, ~~as well as~~and significant land conversions. Using chemicals in agriculture ~~is like~~resembles giving our soils steroids. It not only depletes the land but also causes the farmer to go into debt. The prevailing agriculture system in India is ~~characterised~~ characterized by high production costs, ~~high~~ high-interest rates ~~for credit~~, volatile market prices for crops, and rising costs for fossil fuel-based inputs and private seeds. As a result, Indian farmers (~~especially the~~ smallholders) increasingly find themselves in ~~a~~ debt [11]. ~~In this concern, there is a~~The need for an alternative farming system increased significantly. Various forms of alternative low-input farming practices have emerged in different corners ~~across~~ ofthe world, promising reduced input costs and higher yields for farmers.As a result, Natural Farming is the only solution to an ever-increasing challenge (NF). 'Natural farming' is farming in harmony with nature and without the use of chemicals. SubhashPalekar, the ZBNF's discoverer, provided several theories, principles, and methodologies. These principles include m~~M~~ulching, soil protection measures, natural insecticides, and fertilizers that are used by zero-budget farmers. Crop rotation, green manures and compost, biological pest management, and mechanical cultivation are the main inputs of ZBNF. Jeevamrutha, Beejamrutha, Acchadana, and Whapasa are the most well-known ZBNF pillars, and their influence was tested with an organic, recommended package of practice and chemical farming on nutrient-heavy crops. Areca-nut and black pepper ~~is~~ arethe major cropping systems of the Uttara Kannada district cultivated over more than 10,000 hectares. It is ~~grown all over the district and is~~ the major source of livelihood for small and marginal farmers. An attempt is made here to evaluate the effect of different farming practices (chemical, organic, natural, and recommended package of practices; RPP) on rhizospheremicroflora, soil fertility, and yield of areca-nut and black pepper.

MATERIALS AND METHODS

We carried out a~~A~~ field demonstration on the use of various farming systems ~~was carried out~~ during 2020 and 2021 on a silty loam, moderately deep, red soil in areca-nut and black pepper mixed cropping system at a farmer's field~~,~~in Hanagal, Karnataka. The experiment was conducted in the areca-nut (var. Mangala) plantation ~~of~~ at ~~an approximate age of~~ 12 years and the black pepper vines (var. Panniyur-1) ~~of~~ at~~an approximate age of~~ five years. The climate of the experimental area is warm and 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 5.67, electrical conductivity (EC) 0.17dS.m^{-1}, organic carbon 0.56%. Available nitrogen, phosphorus, potassium, and ~~sulphur~~ sulfurwere 242, 29.99, 195 kg.ha^{-1},and 11 mg.kg^{-1}, respectively. The exchangeable calcium and magnesium contents were 18.70and 3.90cmol (p^{+}) kg^{-1}, respectively. ~~Whereas,~~DTPA extractable iron, zinc, copper, and manganese were 5.51, 0.67, 2.28, and 15.70 mg.kg^{-1}, respectively.

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Soil samples were collected from the areca-nut and black pepper rhizosphereat the harvest stage of areca-nut for enumeration of beneficial microflora (P-solubilizers and Free-living N fixers) and enzyme activity (dehydrogenase and phosphatase). Enumeration of N fixers and P solubilizerswas carried out by plate technique using Norries N free ~~agar medium~~and Pikovskayas agar~~ medium~~, respectively.The ~~estimation of~~ dehydrogenase and phosphatase activity of soil samples were determined ~~by following~~as described by~~the procedure described by~~ Casida *et al.* [4] and Evazi and Tabatabai[6]~~, respectively~~.

We designed ~~The experiment was laid out with the following treatments in~~ a ~~randomised~~ randomized block ~~design~~ with five replications for the following treatments: 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 the pre-monsoon period as per the requirement. The ~~quantity of~~ nutrients used in different farming systems was given in ~~the t~~Table 1and the average nutrient~~s~~ composition of different organic manures used in the experiment were given in ~~table~~Table 2.Analysis of variance (ANOVA) was carried out using the ~~randomised~~ randomized block design methodand Least Significance Difference (LSD) was calculated for treatment means at5% probability [8].

Soil samples were collected from 0-30 cm depth at the harvest stage of areca-nut. 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 a systronic digital pH meter. The electrical conductivity was estimated in the supernatant solution of 1:2.5 soil:water suspension using a conductivity bridge. Organic C was determined by the wet digestion method of Walkley and Black [19]. Available nitrogen was estimated by distilling soil with 0.5% KMnO4 in a micro-Kjeldhal apparatus [15]. Available phosphorus was extracted with

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0.03 N NH_4F + 0.025 N HCl and estimated spectrophotometrically [3]. Available potassium was extracted with neutral 1N NH_4OAC and estimated using flame emission spectroscopy. Available micronutrients (Zn, Fe, Mn, and Cu) were~~extracting~~ extractedwith DTPA[10] and estimated by atomic absorption spectrophotometer (Varian spectra AA 20 plus).

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RESULTS AND DISCUSSION

Effect of different crop production practices on soil fertility status

1. Soil pH and electrical conductivity (EC)

~~Pooled data (2020-2021) indicated that, compared to initial value~~The results revealed a slight non-significant 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~~ attributed to the application of lime to all the treatments during the pre-monsoon period. ~~Among the treatments,~~ The highest increase in soil pH was ~~observed~~ in organic farming ~~(5.89)~~ followed by RPP ~~(5.83)~~. Whereas the highest ~~(0.26 dS m^{-1})~~ and lowest~~(0.20 dS m^{-1})~~EC among the treatments ~~was recorded~~were in chemical and organic farming, respectively. The slight increase in soil pH in organic farming and RPP might be attributed to the release of basic cations during the decomposition of farm yard manure (FYM) and vermicompost (VC), 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.* [7] reported that a decrease in soil pH with the use of chemical fertilizers and a decrease in soil pH with continuous application of jeevamrutha was noticed by Ravi *et al.* [13].

2. Soil Organic Carbon (SOC)

~~Compared to initial value~~An 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, t~~The soil organic carbon content was significantly (P<0.05) high in organic farming ~~(0.74%)~~ which was on par with natural farming ~~(0.66%)~~ and the least was ~~noticed~~ in chemical farming ~~(0.47%)~~(Table 3). Increased soil organic carbon content might be due to the application of organic manures such as ~~farm yard manure~~FYM and ~~vermicompost~~ VC to organic treated and ghanajeevamrutha, jeevamrutha, and mulching practices in natural farming, ~~resulted~~ resultingin enhanced soil microflora with a 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 the coarse textured nature of the soil.Other sSimilar findings were from Chaithra[5] and Gupta *et al.* [9].

3. Major nutrients (Available nitrogen, phosphorus, and potassium)

In the first year of the experiment i.e. 2020, the available nitrogen, phosphorus, and potassium contents in soil did not vary significantly among the treatments. But in the second year of experiment i.e. 2021 these nutrients were significantly (P<0.05) varied among the treatments.

Pooled data (2020 -2021) indicated that,The significantly highest available nitrogen (258.31 kg ha^{-1}), phosphorus, (39.06 kg ha^{-1}) and potassium (205.47 kg ha^{-1}) contents in soil were recorded in RPP, which was on par with organic and chemical farming, and the lowest of these nutrients wereasobserved in the natural farming (Table 4). Because The 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.Tand also he release of weak organic acids during the decomposition of organic manures dissolves the fixed nutrients and enhances its theiravailability in the soil[16].Similar results were observed by BhatandSujatha[2] and Paul *et al.* [12].

4. Secondary nutrients (Exchangeable calcium and magnesium and available sulphursulfur)

Pooled data (2020 and 2021) indicated that, tThe highest available sulphur sulfurcontent (12.08 mg kg^{-1})was recorded in organic farming, which was on par with natural farming,(11.67 mg kg^{-1}) and the lowest was observed in chemical farming (9.25 mg kg^{-1}).

Exchangeable calcium and magnesium contents in soil did not differ significantly in both the years (2020 and 2021). However,the highest exchangeable calcium [21.86 cmol (p+) kg^{-1}] and magnesium [4.32 cmol (p+) kg^{-1}] contents in soil was wererecorded in organic farming, which was followed by natural farming and RPP, and the lowest of these nutrients were observed in chemical farming[17.12 and 3.38 cmol (p+) kg^{-1}, respectively](Table

5).Addition The addition of lime along with organic manures reduces the loss of basic cations and increased the secondary nutrients content in soil [14]. 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.

5. 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 sA slight increase in these micronutrients was observed in RPP, organic, and natural farming practices, whereas a slight decrease was noticed in chemical farming practices(Table 6). Among the treatments, the highest DTPA extractable zinc was observed in RPP (0.79 mg kg^{-1}), which was followed by organic and natural farming. This might be due to the application of zinc sulphate sulfateto the RPP treatment at the time of the pre-monsoon period. Whereas the highest copper(3.26 mg kg^{-1}) was recorded in natural farming and and iron (6.79 mg kg^{-1}) and manganese (16.68 mg kg^{-1}) contents in organic farming,and the lowest of these micronutrients (0.53, 1.62, 5.28 and 14.09 mg kg^{-1}Zn, Cu, Fe, and Mn, respectively) were observed in chemical farming.These results are in agreement with the findingsthose of Verma and Mathur[18]and Zhang *et al.*[20].

Effect of different crop production practices on soil microbial population and enzyme activity

Pooled data (2020 and 2021) indicated that,The significantly (P<0.05) highest population of free nitrogen fixers (8.60 $\times 10^4$ cfu g^{-1} of soil), phosphorus solubilizing microbes (7.69$\times 10^4$ cfu g^{-1} of soil), dehydrogenase, (9.55µg TPF formed g^{-1} soil d^{-1}) and phosphatase (6.80µg pnp released g^{-1} soil h^{-1}) activity were recorded in natural farming, which was on par with organic farming,and the lowest were recorded in chemical farming (Fig 1 and 2). The application of jeevamrutha at frequent intervals helps to increase the soil biological activity in the soil [1,13].

Effect of different crop production practices on yield and net returns from areca-nut and black pepper

Chali yield of areca-nut (29.35 qha^{-1}) and dry pepper yield (12.07q ha^{-1}) was recorded as maximum in RPP, which was on par with organic and chemical farming.however,The minimum values were recorded in the natural farming system (22.72 and 4.92q ha^{-1}, respectively).

The maximum net return was observed in RPP of around Rs. 10,62,500 per ha (Fig 3). The judicious application of recommended dosages of fertilizers and plant protection chemicals influenced to obtain optimum yield under the recommended package of practice. The Anet returns of Rs. 8,43,918per ha was gained from natural framing practice which is lower among all the treatments without the premium price.

Conclusion

The current analysis amply demonstrated that there wasAnimprovement in the soil health with natural and organic farming and there was no appreciable difference between various crop production practices in terms of areca-nut and black pepper yield. 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 by keeping good growth and yield of areca-nut and black pepper. Though the application of natural fertilizers may yield less when compare with chemical farming concerning soil health and nutrient status it plays a significant role and the reduction in areca-nut and black pepper yield should be compensated by premium pricing of organic produce.

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Table 1: Nutrients management under different crop production practices

Particulars	Recommended Package of Practices (RPP)	Organic farming (OF)	Natural Farming (NF)	Chemical Farming (CF)
Arecanut + Black pepper	FYM: 20 kg/palm/year 100:40:140 g N: P_2O_5: K_2O /palm/year (same dose to black pepper also)	Nutrients were supplied equivalent to the recommended dose of fertilizer through FYM and vermicompost	Ganajeevamrutha@ (500 kg/ha) premonsoon and (500 kg/ha) post 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 areca-nut + 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	5.80	5.87	5.83	0.21	0.24	0.23	0.60	0.62	0.61
T_2: OF	5.85	5.93	5.89	0.19	0.21	0.20	0.71	0.78	0.74
T_3: NF	5.78	5.83	5.80	0.22	0.25	0.24	0.63	0.69	0.66
T_4: CF	5.73	5.79	5.76	0.24	0.28	0.26	0.50	0.45	0.47
S. Em ±	0.13	0.04	0.13	0.03	0.03	0.04	0.04	0.04	0.05
CD at 5 %	NS	NS	NS	NS	NS	NS	0.12	0.13	0.16

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 areca-nut + 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	257.05	259.57	258.31	36.69	41.42	39.06	201.95	208.99	205.47
T_2: OF	243.90	250.26	247.08	34.44	37.07	35.76	192.92	203.37	198.15
T_3: NF	235.29	241.50	238.39	28.40	31.40	29.90	180.35	186.52	183.44
T_4: CF	240.00	244.98	242.49	26.11	31.87	28.99	186.32	192.07	189.20
S. Em ±	4.21	3.40	3.67	4.22	3.24	3.68	4.95	5.75	5.35
CD at 5 %	12.96	10.48	11.31	NS	NS	NS	15.27	17.73	NS

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 areca-nut + black pepper mixed cropping system

Treatment	Available ~~sulphur~~ sulfur (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	11.01	11.31	11.16	18.20	19.77	18.98	3.90	3.94	3.92
T_2: OF	12.04	12.11	12.08	19.98	23.34	21.86	4.19	4.45	4.32
T_3: NF	11.53	11.80	11.67	18.70	20.10	19.40	3.92	3.95	3.93
T_4: CF	9.44	9.06	9.25	17.74	16.49	17.12	3.47	3.29	3.38
S. Em ±	0.74	0.89	0.75	0.74	1.16	1.46	0.17	0.31	0.24
CD at 5 %	NS	NS	NS	NS	3.58	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 micronutrients ~~status~~ of soil in areca-nut + 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	0.75	0.84	0.79	2.72	2.82	2.77	5.45	5.87	5.66	15.19	15.19	15.19
T_2: OF	0.69	0.72	0.70	2.95	3.16	3.05	6.28	7.30	6.79	16.53	16.83	16.68
T_3: NF	0.65	0.66	0.65	3.26	3.27	3.26	5.60	6.12	5.86	15.74	15.64	15.69
T_4: CF	0.55	0.51	0.53	1.85	1.40	1.62	5.30	5.27	5.28	14.75	13.43	14.09
S. Em ±	0.05	0.07	0.06	0.39	0.48	0.42	0.29	0.49	0.38	0.47	0.77	0.62
CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

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

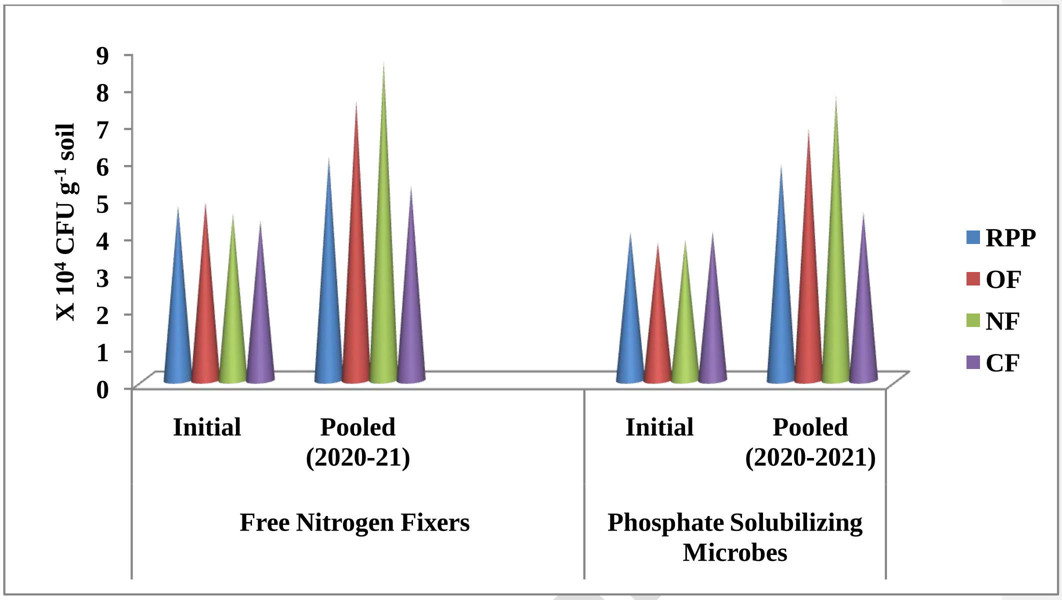

Fig. 1: Effect of different crop production practices on free nitrogen fixers and phosphate solubilizing microbes in areca-nut and pepper rhizosphere

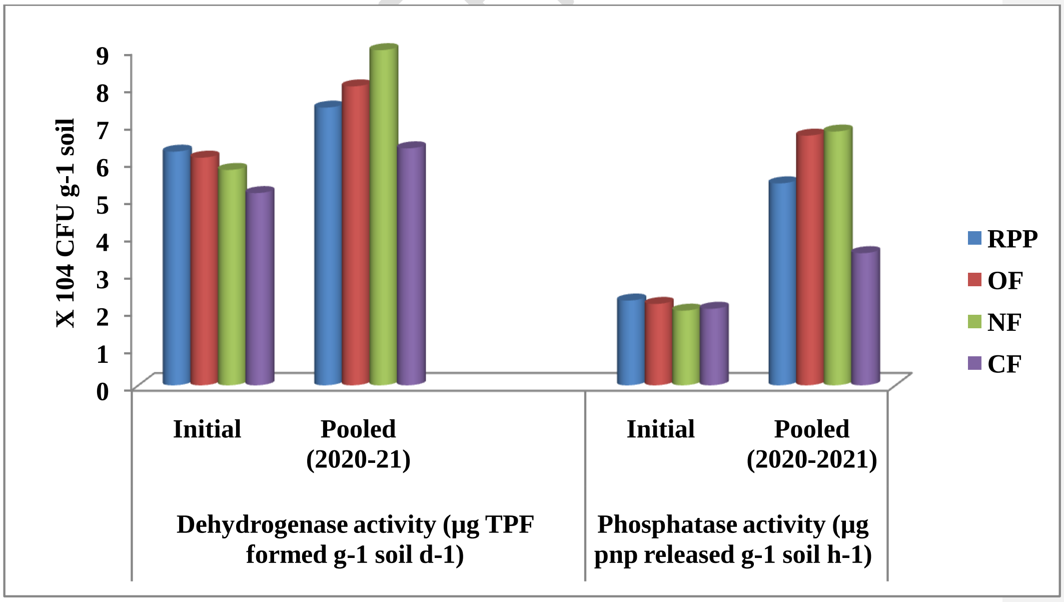

Fig 2: Effect of different crop production practices on dehydrogenase and phosphatase enzyme activity in areca-nut and pepper rhizosphere

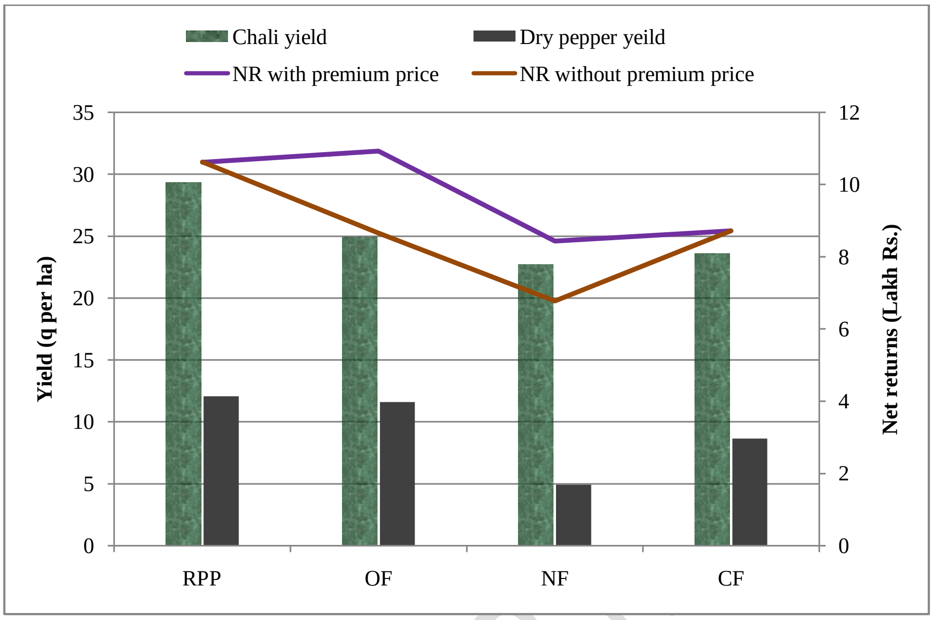

Fig 3: Effect of different crop production practices on yield and net returns from areca-nut and black pepper