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Evaluation of physicochemical properties with the availability of plant nutrients in forests and crop farms in different Fijian provinces

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Abstract

Soils are the foundation of agriculture and forestry and it provides many functions such as the supply of water and nutrients and anchorage for plant growth and more. Forest farming and agriculture farming are 2 entities of the ecosystem and they may lead to changes in soil properties. To cope with the challenges in the soil management system, data on current chemical and physical soil properties are more necessary. Therefore, we present a comparative study on soil properties existing in soil and forest farms of Fiji Island. Soil samples from 24 different locations were collected from 8 sites based on the heterogeneity and land use of soils, keeping in view the variation in soil type and slope to determine physicochemical properties and nutrient status. The physical properties such as bulk density (1.05-1.20 Mg m-3), percent porosity (54.14-56.62), moisture % (16.78-18.53%) and soil permeability (11.79-12.35 cm hr^{-1} was comparatively higher in forest farms compared to the agricultural farms. The soil pH in forest farms and agriculture farms ranged from 5.42-6.10 and 5.30-5.61 respectively. A higher range of CEC was found in forest farms (17.7-19.2) may be due to the higher amount of soil organic matter in forest farms in comparison to agricultural farms. The results also showed that the nutrients such as N, P, K, Ca and Mg and micronutrients (Cu, Fe, Mn and Zn) values were low on the agricultural farms. The study suggests the combined use of good agricultural practices, limited use of agrochemicals and minimal soil disturbance at agriculture farms to prevent further degradation, acidification and nutrient stocks.

Keywords

Agriculture farms, forest farms, Fiji, plant nutrients, soil properties

Introduction

The impact of human exploitation and climate change has led to a decline in the availability of plant nutrients in crop fields and forest areas. These changes majorly occurred in forest farms and crop farms. The application of inappropriate and large amounts of chemicals might have depleted the nutrient levels in the crop field and forest, which hinders the sustainable development of the agriculture and forestry ecosystem. Soil fertility is one of the important factors that control the yield of crops and the growth of forestry species on a forest farm because that is the nutrient pool that plant utilizes for their growth and development. The concept of soil health and soil quality has consistently evolved with an increase in understanding of soil and soil quality attributes.

These depletions of nutrients from the soil are a major problem in crop fields and forests, especially affecting the productivity and development of plants (1). The interaction between the physical, chemical and biological properties of soil affects its quality. The physical properties of soil define the movement of air, water and dissolved chemicals through the soil and these properties influence the germination and root growth of any plant (2). Plenty of soil's physical properties were altered by climate change in Fiji and also in other island countries (3), which may greatly influence the growth and production of crops and forest species. Mostly the soil organic matters are the residues of decomposed plants and animals and the presence of these soil organic matters is the best indicator of soil quality (4) and it has an important role in determining the sustainable productivity of agriculture and forest ecosystem. The sustainable productivity of soil mainly depends upon its ability to supply essential nutrients to the growing plants. One of the major constraints in agriculture productivity is the deficiency of macronutrients in soil, especially from sewage sludge, manure and food waste (1). These micronutrients occur in very small amounts in the soil ranging from a few mg kg^{-1} to thousand mg kg^{-1} in soil. The important role of micronutrients is to maintain soil health and the uptake of micronutrients is affected by the presence of major nutrients due to either negative or positive interactions (5). Soil properties cannot be measured directly, but soil properties are sensitive to climate changes and improper management of macronutrients, can be used as indicators for property measurement (6). Soil pH is a good indicator of available plant nutrients (7).

The attraction for growing high-yielding varieties without considering the fertility of soils could result in the depletion of soil organic matter reserves and reduce the quality of soils. Soil organic matters such as carbon (C) and Nitrogen (N) carbon play an important pathway in biotic and abiotic compartments of terrestrial ecosystems (8). The measurement of C and N from the forest soils is very important and its understanding makes a clear picture of their role in the chemical reaction in biotic and abiotic compartments. Determination of physicochemical properties and available nutrient status of the soil of an area is vital for improving sustainable productivity (9). Very little work is carried out on the soil properties in agriculture and forest farms in the pacific island nations. Considering all the above, a comparative study was carried out on forest and crop farms to study soil properties and nutrient availability in 4 major provinces of Fiji.

Materials and Methods

Study area

The research was conducted at crop farms and forest farms in Naitasiri, Rewa, Nadroga-Navosa and Ba provinces of the Fiji Islands. The selected crop farms were used for the cultivation of agriculture and animal fodders, with several management practices. The forest farms designated for the current research contain the intentional cultivation of native plant species for both wood and underwood crop production. The elevation ranges from 20 m, 10 m and 60 m respectively above mean sea level. Fiji has a warm tropical climate perfect and the maximum temperatures rarely move out of the 31 °C (88 °F) to 26 °C (79 °F) range all year round, and the temperature falls between (23 °C- 27 °C) with an annual average rainfall of about 2500 mm (10). Fiji is also attributed to the various soil type and plants growing in it's over 300 islands. Fiji has three major classes of landforms such as plain, low mountains and hills. From the above three, the samples for this research study are collected from low mountains and plains only. It is mentioned in the earlier research reports that the low-lying areas in Fiji contain a high concentration of iron aluminium oxides and hydroxides (11). The majority of the areas in the country are fertile and are used for agriculture, therefore agriculture has become one of the leading industries in Fiji. Wood production or commercial forestry may be the best form of land use where erosion or low fertility is the dominant limitation. So, in general, the soil in Fiji is suitable for agricultural, pastoral or forestry use.

Soil sampling and analysis

The soil samples collected from the 2 areas of each province are tabulated in Table 1. The Nitasiri and Rewa province are in Suva, the capital of Fiji and are exposed to the trade winds and high rainfall. So, there is no dry season and the climate here is considered equatorial. The Nadroga-Navosa province gets moderate rainfall and has dry seasons with an average of 80% relative humidity. Finally, the Ba province shows extreme seasonal variation in rainfall patterns and experiences significant seasonal variation in the perceived relative humidity with an average of 62% and a dry climate. The locations of soil sample collection for Forest farms and agricultural crop farms were adjacent to each other in each province so the study started with an assumption that there will be no differences in terms of soil type, topography, climate and other factors, based on the rainfall pattern in each province soil fertility may vary.

Table 1. Location and soil sample collection sites.

Province	Sampling Site	Location coordinates	
Naitasiri	Colo-I-Suva Forest Farm	18°03'27.5"S	178°27'26.3"E
	Wainibuku Farm House	18°02'52.2"S	178°28'59.2"E
Rewa	CAFF Forest Farm	18°03'14.0"S	178°31'35.5"E
	CAFF Agriculture farm	18°02'42.6"S	178°31'53.1"E
Nadroga-Navosa	Ministry of Forestry- Silviculture & Research Farm area	18°15'58.5"S	178°00'46.6"E
	Private farming areas Singatoka Valley	18°07'33.4"S	177°30'59.5"E
Ba	Fiji Pine Forest plantations	17°35'10.0"S	177°31'59.0"E
	Koroniqali Farm	17°40'50.7"S	177°28'27.4"E

This research was conducted in the above areas with a size of 20 x 20 m for each plot and within the plot, a few subplots were marked for a random collection of the soil samples. Eight representative surface soil samples were prepared from 24 different locations in the study area (Fig. 1) considering the heterogeneity of soils by keeping in view the variation in soil type, slope and land use to determine physicochemical properties and nutrient status. Collected samples were prepared as per standard methods and stored in properly labelled plastic bags for analysis. Standard analytical methods (12, 13) were followed for measuring various soil attributes like pH, electrical conductivity (EC), organic carbon (OC), cation exchange capacity (CEC) and important plant nutrients (total nitrogen, available phosphorus and available potassium. The available micronutrients Fe, Mn, Cu and Zn of soil samples were extracted with a DTPA solution. The concentration of micronutrients in the extract was determined using Atomic Absorption Spectrophotometer (AAS).

and also in the Soil Chemistry Laboratory, College of Agriculture Fisheries and Forestry.

Results

The present research provides information on the availability of plant nutrients with the physical and chemical properties of soils of forest and agriculture farms of different provinces in the Fiji Islands. The findings of the study are discussed below.

Physical Properties

The physical properties analysed from the forest and agriculture farms were mainly bulk density, percent porosity, moisture % and soil permeability, which are summarized Table 2. The obtained results indicate that the bulk density of the studied soils ranges from 1.05-1.20 Mg m^{-3} in forest farms while 1.18-1.40 Mg m^{-3} in agriculture farms. The bulk density was higher in forest farms compared to the agricultural farms in the studied provinces. Data indicates that the porosity % ranges from 54.14-56.62, which is higher in forest farms whereas 46.23-49.75 a lower % in agriculture farms. Higher % porosity was observed in forest farms compared to agricultural farms.

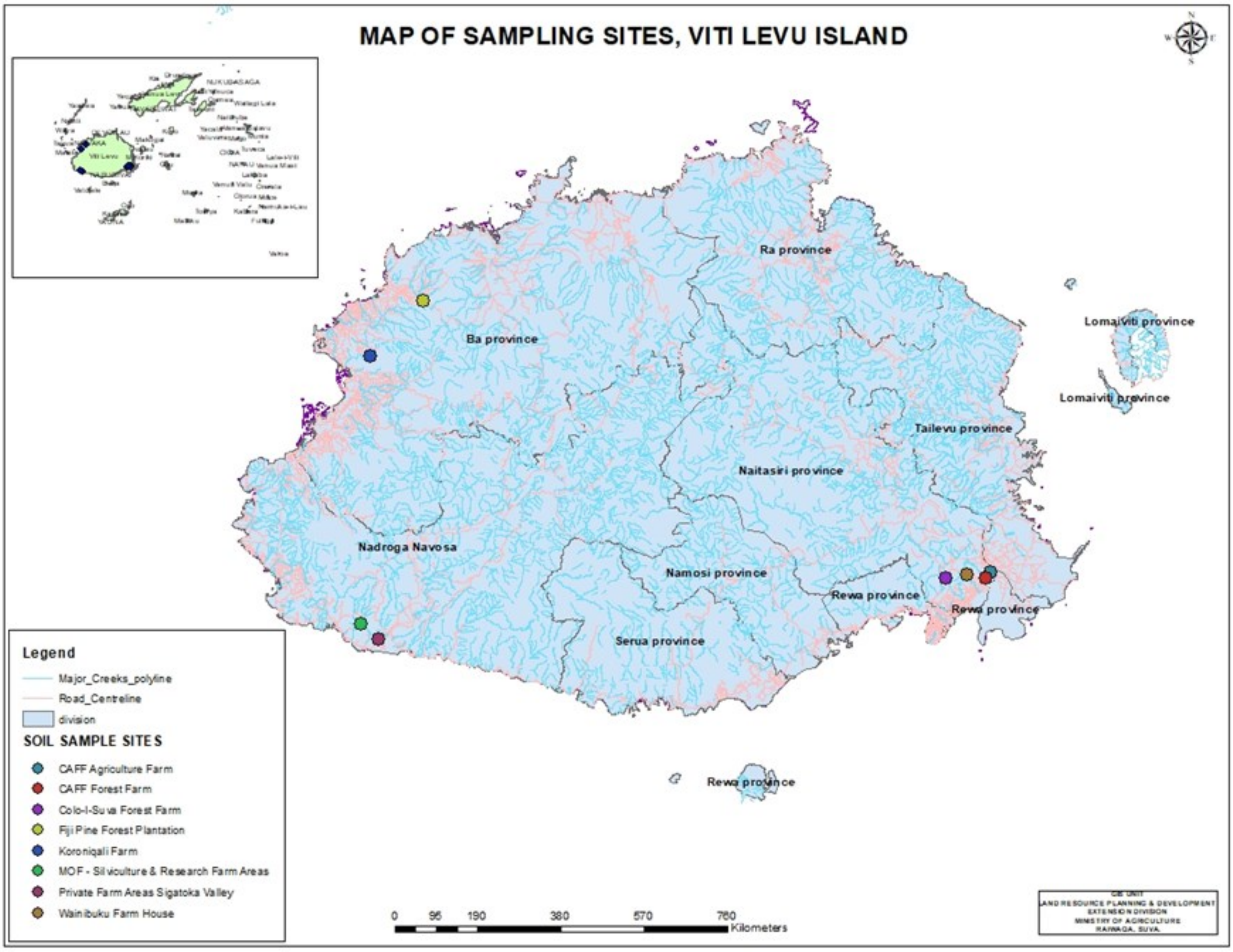

Fig. 1. Sample collection sites.

Statistical analysis

The relationship between different soil properties and micronutrient content was determined using the statistical software SPSS to calculate the correlation coefficient "r". These experiments were conducted at Fiji Agricultural Chemistry Laboratory, Koronivia Research Station (KRS)

The available water content ranged from 16.78-18.53 % on forest farms and 10.80-12.68 % in the case of

Table 2. Physical properties of soil in Forest and Agricultural farms.

Soil property	Province	Forest farms	Agriculture Farms	Changes (%)
Bulk density (g cm^{-3})	Naitasiri	1.05	1.18	12.4
	Rewa	1.16	1.22	5.2
	Nadroga-Navosa	1.20	1.36	13.3
	Ba	1.18	1.40	18.6
Porosity (%)	Naitasiri	56.62	46.23	-18.4
	Rewa	54.14	47.52	-12.2
	Nadroga-Navosa	54.82	49.75	-9.2
	Ba	55.73	46.33	-16.9
Available water (%)	Naitasiri	18.53	12.98	-30.0
	Rewa	17.73	11.79	-33.5
	Nadroga-Navosa	16.78	11.85	-29.4
	Ba	17.47	10.80	-38.2
Permeability (cm $hour^{-1}$)	Naitasiri	12.35	2.78	-77.5
	Rewa	12.30	2.74	-77.7
	Nadroga-Navosa	11.69	2.64	-77.4
	Ba	11.21	2.29	-79.6

agriculture farms. Higher moisture % in the forest. Data indicated that the recorded moisture % was higher in the forest farms in all provinces. The permeability of soils in the forest farms was higher in comparison to agricultural farms. The permeability ranged from 11.79-12.35 cm $hour^{-1}$ on forest farms and 2.29-2.78 cm $hour^{-1}$ on agriculture farms. These data indicate improved physical conditions of forest farms in terms of the movement of air and moisture in comparison to agriculture farms. The graph (Fig. 2) represents the variations in soil physical properties of different sample sites of forest farms and agriculture farms.

(N), available phosphorus (P), potassium (exch-K), calcium (exch-Ca) and magnesium- exch-Mg). The results of the observed data are summarized in Table 3. The soil pH in forest farms soils ranged from 5.42-6.10 whereas 5.30-5.61 in agriculture farms. The soils of the studied area were in the range of moderate to slightly acidic, this is because of frequent rainfall and the acidic nature of the parent material. Cation exchange capacity was in the range of 17.7-19.2 in forest farms while 12.2-16.7 in agricultural farms. Higher CEC in forest farms could be due to the higher amount of soil organic matter in forest farms in comparison to agricultural farms.

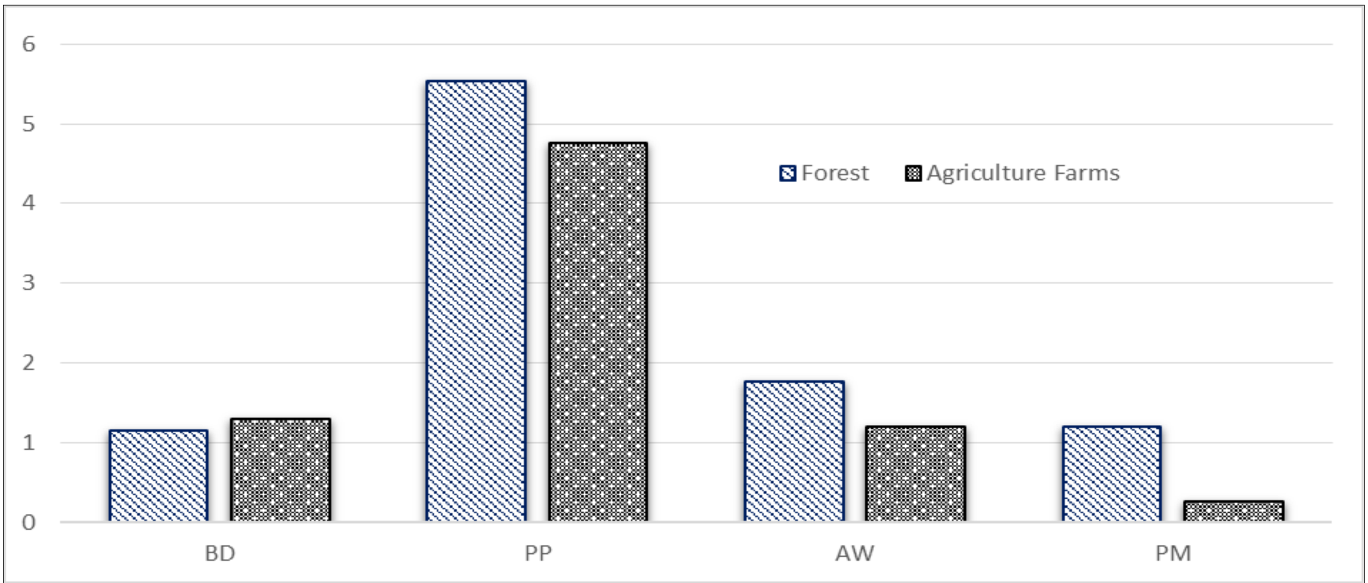

Fig. 2. Change in soil physical properties between forest and agricultural farms. BD (bulk density, Mg m^{-3}), PP (porosity, %), AW (available water, %), PM (permeability, cm hr^{-1}).

Chemical Properties

The soil chemical properties from the forest and agriculture farm were analysed to determine soil pH, cation exchange capacity (CEC), organic carbon (OC), total nitrogen

Organic carbon soils were in the range from 1.63-2.67 % in forest farms whereas from 0.38-0.73 % in agricultural farms. A higher amount of organic matter was recorded in forest farms in comparison to agricultural

Table 3. Chemical properties of soil in Forest and Agriculture farms.

Soil property	Province	Forest farms	Agriculture Farms	Change
pH	Naitasiri	6.10	5.61	-8.0
	Rewa	5.91	5.43	-8.1
	Nadroga-Navosa	5.73	5.64	-1.6
	Ba	5.42	5.30	-2.2
CEC (cmol(+)/kg)	Naitasiri	18.8	12.2	-35.1
	Rewa	19.2	-35.1	-31.8
	Nadroga-Navosa	21.2	-35.1	-21.2
	Ba	17.7	-35.1	-19.2
Organic Carbon (%)	Naitasiri	2.67	0.73	-72.7
	Rewa	2.59	0.64	-75.3
	Nadroga-Navosa	2.52	0.56	-77.8
	Ba	1.63	0.38	-76.7
Total nitrogen (%)	Naitasiri	0.25	0.07	-72.0
	Rewa	0.21	0.05	-76.2
	Nadroga-Navosa	0.20	0.04	-80.0
	Ba	0.16	0.03	-81.3
Available phosphorous (mg kg^{-1})	Naitasiri	19.63	8.63	-56.0
	Rewa	17.55	7.87	-55.2
	Nadroga-Navosa	16.87	7.16	-57.6
	Ba	12.42	6.42	-48.3
Exchangeable potassium (cmol(+)/kg)	Naitasiri	1.43	1.23	-14.0
	Rewa	1.52	1.35	-11.2
	Nadroga-Navosa	1.47	1.31	-10.9
	Ba	1.48	1.31	-11.5
Exchangeable calcium (cmol(+)/kg)	Naitasiri	7.63	2.56	-66.4
	Rewa	6.57	2.95	-55.1
	Nadroga-Navosa	8.31	2.86	-65.6
	Ba	7.86	2.74	-65.1
Exchangeable magnesium (cmol(+)/kg)	Naitasiri	1.48	1.19	-19.6
	Rewa	1.44	1.15	-20.1
	Nadroga-Navosa	1.55	1.36	-12.3
	Ba	1.51	1.37	-9.3

farms which could be correlated with several factors that improve the higher organic matter in the forest. The total nitrogen of the collected soil samples was in the range of 0.16 -0.25 % in forest farms while from 0.03-0.07 % in agricultural farms. Low nitrogen content in agricultural farms might be due to the depletion of organic matter due to farming practices in tropical soils. The variations in soil chemical properties are represented in the graph (Fig. 2) and show a clear difference between forestry farms and agriculture farms.

The available phosphorus content of the soil was from 12.42-19.63 mg kg^{-1} in forest farms whereas 6.42-8.63 mg kg^{-1} in agricultural farms. Low P content in agricultural farms might be due to the continuous use of agricultural land without considering sustainable land use and supply of appropriate P doses. Exchangeable potassium in the study area was in the range from 1.43-1.52 (cmol (+)/kg) in forest farms whereas from 1.23-1.56 (cmol (+)/kg) in agricultural farms. The exchangeable potassium of forest and agriculture farms was found sufficient which might be due to the optimum supply of K from parent materials. Exchangeable calcium was in the range from 6.57-8.31 (cmol (+)/kg) in forest farms whereas from 2.56-2.95 (cmol (+)/kg) in agricultural farms. The calcium content in forest farms was quite higher in comparison to agriculture farms similarly magnesium content in forest farms was in the range of 1.43-1.52 (cmol (+)/kg) while 1.23-1.56 (cmol (+)/kg) in agriculture farms. The study revealed that the activity at agricultural farms for intensive crop production had caused a significant decrease in natural soil fertility. The nutrient elements of soil such as N, P, K, Ca and Mg values were low in comparison to the forest farm. The use of advanced agricultural tools, tractors, types of machinery and other soil disturbances are comparatively less in the forest farm which might be the reason for the decrease in nutrient levels.

Micronutrients

The comparative results of extractable micronutrients (i.e., Fe, Mn, Zn and Cu) are summarized (Table 4). The mean values of DTPA available iron in the forest farms varied from 24.21-32.31 mg kg^{-1} and 21.28-28.46 mg kg^{-1} in agriculture farms, considering 4.5 mg kg^{-1} as the critical limit (14), the iron content was found to sufficient in forest and agricultural farms in all studied four provinces. The mean value of DTPA available manganese in the soil samples of forest farms varied from 21.38-27.22 mg kg^{-1} and 19.61-23.50 mg kg^{-1} in agriculture farms. Based on the critical limit of 3.5 mg kg^{-1} for Mn deficiency (15), the manganese content was observed sufficient in all the studied provinces.

Table 4. Critical soil test values of DTPA extractable micronutrients.

Micronutrients	Nutrient content (mg kg^{-1})		
	Low	Medium	High
Iron [Lindsay and Norvell, 1978]	<4.50	4.5-9.0	>9.0
Manganese [Sakal *et al.*, 1985]	<2.5	2.5-3.5	>3.5
Copper [Lindsay and Norvell, 1978]	<0.2	0.2-0.4	>0.4
Zinc [Takkar and Mann, 1975]	<0.6	0.6-1.2	>1.2

The available copper content of the soil samples was in the range of 1.55-2.19 mg kg^{-1} in forest farms and 1.53 -2.13 mg kg^{-1} in agriculture farms, considering 0.40 mg kg^{-1} as the critical limit, the copper content was found sufficient in forest and agricultural farms. The available zinc content varied from 0.99-1.14 mg kg^{-1} in forest farms and 0.97-1.11 mg kg^{-1} in agriculture farms. Based on the critical limit (1.20 mg kg^{-1}) suggested soils were moderate in DTPA extractable Zn which requires appropriate management practices (16). All the investigated micronutrients are influenced by the soil environment (14). Soil pH has been comprehensively identified as the single most important soil factor controlling the availability of micronutrients in the soil.

Discussion

The results obtained from this research reveal that the physical and chemical properties of the forestry farms soils are comparatively higher than the agriculture farms. The forestry farm soils are not much disturbed by heavy machinery and that may be the primary reason for the improvement in chemical and physical properties. The physical properties of forest farm soils develop under farming conditions by long-term vegetation unlike those of agriculture farms. In other words, farming operations, cultivar changes based on season and fertilizer and weedicide application all have a negative impact on soil's physical properties.

For the above reasons, other physical properties such as soil texture and porosity were also found to be higher in forest farms than in agricultural farms. Soil's physical properties influence forest tree species in farms as well as their growth and biomass production (17). The selected forest farms were under a good canopy system and the soil was covered by crowns to protect the soil from destruction. That may be the second reason why the most important physical properties such as water content, permeability and porosity were found stable and significantly high when compared to the agricultural farms. In all selected agriculture farms, we noted the poor canopy system, usage of heavy machinery and application of fertilizers that led to the decrease in the soil's physical and chemical properties (18). If there is a poor canopy where the tree crowns are not covering the soil, the lashes of heavy rain may fall directly on the soil surface of agriculture farms, causing soil damage or soil compaction. This damage reduces the soil porosity and permeability and causes soil surface runoff and soil erosion. It was reported that the surface runoff/flood could be caused by a decrease in soil infiltration capacity and impoverishment of land cover vegetation (19). The current research matches the above research, especially in the results from agriculture farms that are significantly different from forest farms. The retention of soil moisture is important for the growth of plants. If the moisture content were to decrease, the temperature of the soil would decrease. The above process is taking place on forest farms. Due to the above, the soil moisture content was high in forest farms because the plant residues and the canopy cover reduced the effect of absorption and reflection of solar radiation and evaporation of water from the soil surface and maintained the soil moisture.

Lower values for soil chemical properties such as pH and CEC in agriculture farms may be due to the loss of clay and other organic matter caused by using heavy machinery, pesticides and fungicides. In the current research study, the soil pH was in the range of moderate to slightly acidic due to frequent rainfall in the selected areas and the acidic nature of the parent material. Frequent rainfall is an effective agent which removes the basic cations and makes the soil naturally acidic (20, 21). Rainfall is most effective in causing soils to become acidic so that the salts are transported into groundwater and carried to the oceans. The current study in Fiji also found the same trend and the same as in earlier studies (22). The variations in the forest farm and the agriculture farm may not only be due to the rainfall pattern but also to crop growth, the use of fertilizers etc. (23). Higher CEC in forest farms could be due to the higher amount of soil organic matter in forest farms in comparison to agricultural farms. Forest farms, like agriculture farms, do not use ploughing or clearing and have unaltered primary minerals that make up the bulk nutrients and inorganic compounds, which may explain the higher CEC. The previous studies revealed that CEC (cation exchange capacity) and exchangeable base content of the soil become limiting factors in soil productivity. The influence of vegetative cover in forest farms may also be a contributing factor to the increase in CEC (20, 24).

In the current research, it is also revealed that the activity of agricultural farms for crop improvement has caused a significant decrease in natural soil fertility. The nutrient elements of soil such as N, P, K, Ca and Mg values are low when compared to the forest farm. The use of tractors and other forms of soil loosening activities is comparatively less in the forestry farm, which may be the reason for the above-mentioned decrease in the soil nutrients in the research areas. This is in agreement with previous research that discovered that disturbances in natural forests pose a risk to productivity and cause a decrease in the nutrient elements of soil (25). In general, it is reported that forest soils usually have higher organic matter than agricultural soils (17). The results from the current research found a higher amount of organic matter in forest farms when compared with agricultural farms, which could be correlated with many factors that improve the higher organic matter in the forest. Similar results were also reported by (26). It was showed that forest lands with certain disturbances had significant enrichment in the soil carbon, while in agricultural land there was a significant depletion in the amount of carbon.

Current research also states the low nitrogen content in agricultural farms may be due to the depletion of organic matter due to farming practices in tropical soils. It was reported that the usage of synthetic fertilizers decreases the population of microbial communities for nitrogen fixation, causing a significant decrease in the farming areas (27). The same study in forestry farms shows slightly higher nitrogen content due to canopy and less use of synthetic fertilizers. These results are also in correlation with the previous studies, which mentioned that the variation in nitrogen content was due to vegetation cover types and natural soil characteristics (28). Next to nitrogen, potassium (K) is an essential plant nutrient. Potassium helps plants in physiological processes and insect and disease resistance (29). Earlier research noted that the use of synthetic fertilizers in agricultural farms reduces the concentration of potassium (30) in the soil and the same is found in the current study also. The reduction in Mg level is becoming an important concern in agricultural farming in which the soils are only fertilized with N, P and K. This reduction is a critical issue in highly disrupted soil types of agriculture farms, where it is subjected to potential leaching (31). It was reported that in soils with limited fertility, like agriculture farms, the leaching of Mg may be more dependent upon numerous variables such as soil and crop type, environmental conditions etc. (32). The results of the current study also show the same trend and a clear difference was monitored between the 2 farms. It was reported that the introduction of intensive agriculture with its reliance on NPK fertilizers has reduced the amount of the remaining essential nutrients in the soil (33, 34). Moreover, in many developing countries, including Fiji, the fertilizer use favours nitrogen disproportionately to the crops' demands. As a result, the long-term use of chemical fertilizers in agriculture may disturb soil nutrient balances (35).

The current research study made a comparison between the presence of micronutrients (copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn)) that are present in agriculture and forestry farm soil. These essential plant nutrients play an imperative role in plant growth and development, and it’s the reduction in micronutrient levels in soil, is a global phenomenon these days (36, 37). The use of synthetic fertilizers affects the soil's physical and chemical properties which in turn reduces the micronutrient level in

Table 5. Micronutrient level of soil in Forest and Agriculture farms.

Micronutrient	Province	Micronutrients content (ppm)					
		Forest farms			Agriculture Farms		
		Minimum	Maximum	Mean	Minimum	Maximum	Mean
Iron (Fe)	Naitasiri	0.93	65.77	32.31	0.80	62.77	28.46
	Rewa	1.10	68.82	29.72	0.92	64.82	26.12
	Nadroga-Navosa	1.05	70.69	27.13	0.95	60.69	25.73
	Ba	0.99	70.22	24.21	0.87	61.22	21.28
Manganese (Mn)	Naitasiri	1.24	98.93	27.22	0.64	78.23	23.50
	Rewa	1.52	97.82	24.16	0.71	76.25	20.83
	Nadroga-Navosa	1.34	97.81	25.50	0.68	78.27	21.74
	Ba	1.32	96.84	21.38	0.73	77.54	19.61
Copper (Cu)	Naitasiri	1.19	5.58	2.19	0.29	4.38	2.13
	Rewa	1.24	5.72	1.98	0.42	4.27	1.92
	Nadroga-Navosa	1.28	5.89	1.81	0.83	4.59	1.16
	Ba	1.23	5.87	1.55	0.88	4.57	1.53
Zinc (Zn)	Naitasiri	0.14	5.83	1.14	0.01	4.38	1.11
	Rewa	0.12	5.45	1.06	0.09	4.45	1.13
	Nadroga-Navosa	0.14	5.67	1.05	0.03	5.83	1.02
	Ba	0.15	5.78	0.99	0.10	4.62	0.97

the soil (38). The current research results match the earlier observations that the Cu, Fe, Mn and Zn levels are slightly reduced in agriculture farms when compared with forest farms. In forest farms, the micronutrient levels are high due to less use of chemical fertilizers and some farms use organic materials such as plant residues and other waste materials to improve the efficiency and fertility of soil (39).

Conclusion

The observed finding revealed that there had been soil damage in agricultural farms with the decrease in natural soil fertility. Lower values of soil pH, nutrient elements such as N, P, K, Ca and Mg and micronutrients (copper (Cu), iron (Fe), manganese (Mn), zinc (Zn)) in agriculture farms may be due to the poor canopy system, use of agricultural implements and application of chemical fertilizers. Forest farms, like agriculture farms, do not use ploughing or clearing and have unaltered improved soil properties with a high amount of available nutrients and a diversity of soil organisms that maintain high soil quality.

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Authors contributions

PN assisted in write up and grammar. IRS carried out the research trial, analysis and attending to reviewers' comments. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

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