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Assessment of Available Micronutrients Status in the Soils of Macuata Province of Fiji

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The study was carried out to assess the level of available micronutrients (Fe, Cu, Mn, and Zn) in relation to the other important soil properties. Twenty-nine soil samples were collected from various locations in the Macuata province of Fiji namely Naleba, Nakama, and Labasa to determine the properties of soil. The available micronutrient (DTPA extractable) viz., Fe, Mn, Cu, and Zn were analyzed using Atomic Absorption Spectrophotometer. The laboratory-analyzed data revealed that the soils of the study area are acidic in nature with low electrical conductivity and moderate soil organic carbon. Available micronutrient analysis revealed that iron (Fe), manganese (Mn), and copper (Cu) were found to be sufficient in most of the soil samples, whereas available zinc (Zn) was found to be marginal in 45 percent of the analyzed samples. Further, pH showed a positive correlation with Zn and Cu and a negative correlation with SOC. Soil organic carbon showed a negative correlation with Mn and Cu showed positive correlations with Zn.

Keywords: Soil properties; available micronutrients; Macuata.

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1. INTRODUCTION

An agro-sustainable ecosystem's productivity is significantly influenced by the soil. The soil's capacity to provide vital nutrients to developing plants is a key factor in determining its long-term productivity. Understanding the degree of soil fertility is crucial for identifying the obstacles to continued productivity, and it is one of the key elements influencing crop yields [1]. Micronutrient deficiency is now a significant barrier to soil stability, soil sustainability, and agricultural productivity [2]. Micronutrient deficiencies in soil have been widely reported to have a profound impact on the growth, metabolism, and reproductive processes of plants, animals, and people [3]. In general, the parent materials, organic matter, pH, mineralogy, soil forming processes, drainage, vegetation, and anthropogenic and natural processes, determine the quantity and distribution of micronutrients in soils [4]. Parent material, sewage sludge, municipal waste, farmyard manure (FYM), and organic matter are the main sources of these micronutrients. These micronutrients are found in the soil in extremely minute amounts, ranging from a few mg kg^{-1} to thousands of mg kg^{-1}. Micronutrients play a significant role in improving crop yields and preserving the health of the soil. The addition of organic materials and lime helps in improving soil health [5]. The presence of major nutrients influences the uptake of micronutrients due to either positive or negative interactions [6]. The intake of micronutrients may be impacted by the indiscriminate use of macronutrients [7]. Soil pH is a good indicator of available plant nutrients [8] and the soils of the study area are acidic with low levels of soil organic matter [9]. Continuous cultivation may change the physico-chemical characteristics of soils within a land use system, which may change the concentration of DTPA extractable micronutrients and the availability of those nutrients to plants. Keeping in view the above points this research was conducted to assess the micronutrient level in the soil of the Macuata Province of Fiji.

2. MATERIALS AND METHODS

2.1 Study Area

This research was carried out in the Nakama, Naleba, and Labasa villages of Macuata province, to determine the soil characteristics. The geographical reference of the study area is between 16°27'10.9"- 16°22'56.9" S, 179°18'25.4"- 179°24'24.4"E, and the average elevation of the area is 34 meters above mean sea level. The climate is tropical and the average annual temperature in the study area is about 24.9 °C and the rainfall is around 2064 mm per year [10]. Soils of the study area are acidic in nature and pH varies from 4.80-5.50 with low to medium organic carbon and low electrical conductivity (0.01 - 0.08 dSm^{-1}). Soils are classified under Ultisols and Oxisols. The two major groups of parent materials are tuffaceous sedimentary rocks which occupy about 36% of the landscape and basic volcanic rocks which occupy 48% of the landscape.

2.2 Soil Sampling and Analysis

Twenty-nine representative surface soil samples were collected using an auger from topsoil (0-20 cm) from the farmers' fields of Nakama, Naleba, and Labasa villages of Macuata province. Soil samples were collected keeping in view of the variation in soil type, slope, and land use to determine soil nutrients level. Soils were completely air-dried and passed through a 2mm sieve and stored in properly labeled plastic bags for analysis. The location of the sampling sites is shown in Fig. 1. Standard analytical methods are used [11,12] for measuring various soil attributes like pH, electrical conductivity (EC), and organic carbon (OC). The available micronutrients Fe, Mn, Cu, and Zn of soil samples were extracted with a DTPA solution [13]. The concentration of micronutrients in the extract was determined using Atomic Absorption Spectrophotometer (AAS). The relationship between different soil properties and micronutrient content was determined using the statistical software SPSS to calculate the correlation coefficient "r" (Table 3).

3. RESULTS AND DISCUSSION

The results of available micronutrients of the soils are summarized in Table 1. The soils of the study area are acidic in nature with a mean pH of 5.1. According to the classification of soil reaction suggested by Brady [14], 92% of samples were acidic and 8% were slightly acidic. Low values of pH are due to the acidic parent material, continuous rainfall that leaches most of the bases throughout the year, and decomposition of organic matter further decreasing the soil pH [15]. The average organic carbon content of these soils was 1.43%.

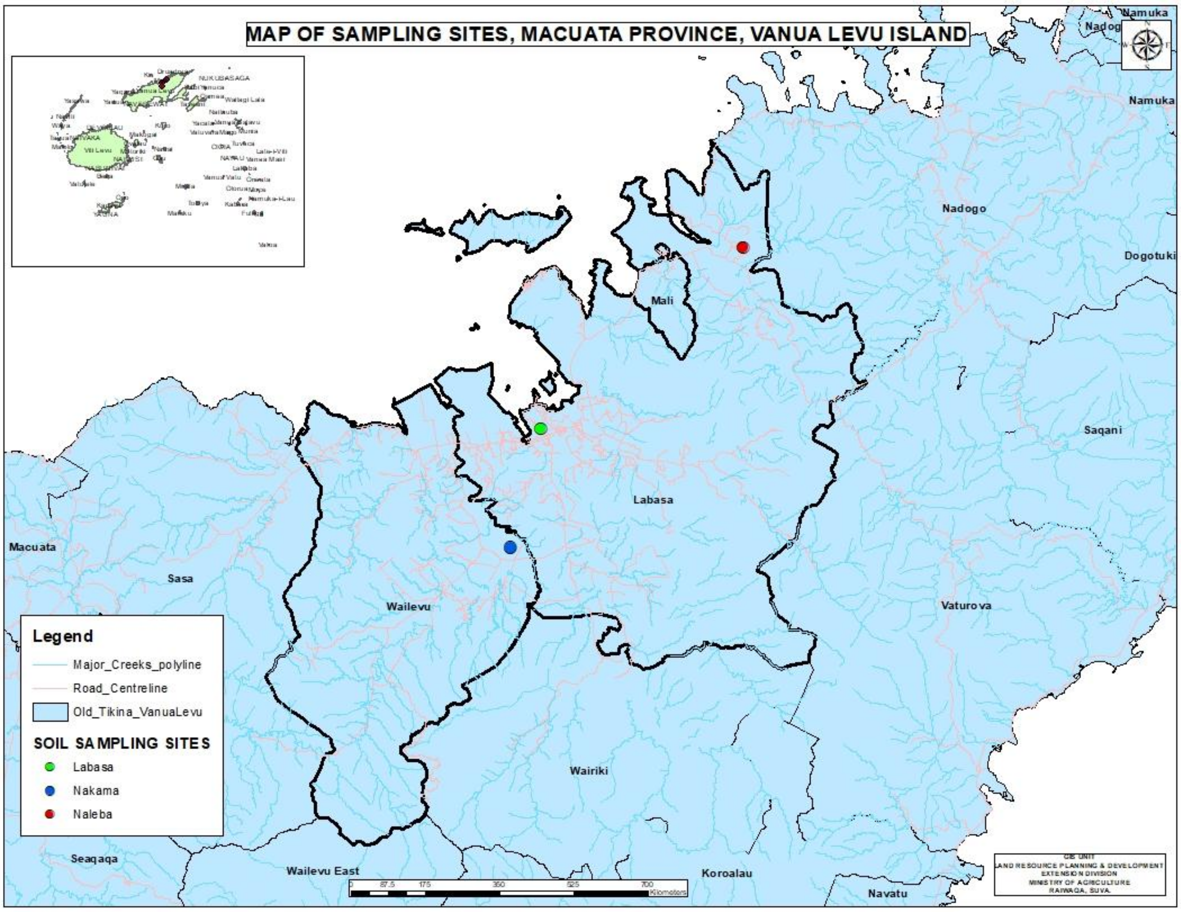

Fig. 1. Location map of the study area

3.1 Available Iron

Data on available iron in soil samples indicated that 89 % of soil samples were found sufficient in DTPA-iron content and 11 % of the soil sample were marginal (Fig. 2), considering 4.5 mg kg^{-1} as the critical limit [16]. The content of DTPA-Fe varied from 3.0-1196.0 mg kg^{-1} with an average value of 189.7 mg kg^{-1}. The higher content of iron might be due to the accumulation of organic carbon in the surface horizons [17].

3.2 Available Manganese

The DTPA available Mn in the soil samples varied from 17.0-316.0 mg kg^{-1} with a mean value of 74.6 mg kg^{-1} (Table 1). Based on the critical limit of 3.5 mg kg^{-1} for Mn deficiency [18]. All the soil samples were found to be sufficient in available Mn. This is similar to iron, the higher content of available Mn in surface soils is attributed to its chelation by organic compounds released during the decomposition of organic matter and crop residues, as the study area covers most of the plantation crop with the tropical ecological region. These observations are in accordance with the findings of Verma [19]. The sufficiency of available Mn might be due to high organic matter content under optimum soil reaction. Similar observations were also reported by [20].

3.3 Available Copper

The available Cu content of the soil samples varied from 0.5-10.0 mg kg^{-1} with a mean value of 4.1 mg kg^{-1} (Table 2). The data indicated that 4 % of soil samples were below the critical level [16]. As the study area is acidic in nature, with a decrease in soil pH the adsorption of Cu to the permanent charges will decrease, which is the common phenomenon making it higher available to crop. Moreover, Cu being an ingredient in fungicides and their frequent application either to soil or crops (like vegetables, dalo, cassava, and rice) might have increased their level in the soils. At higher pH, Cu adsorbs to variable charge sites by the formation of inner-sphere complexes at crystal edges or alumina sheet surfaces, thereby decreasing their availability to the crop [21].

3.4 Available Zinc

Available Zn in the soil samples varied from 0.3-4.2 mg kg^{-1} with a mean value of 3.4 mg kg^{-1} (Table 2). Based on the critical limit (0.60 mg kg^{-1}) suggested [22], 4 % of samples were deficient in DTPA extractable Zn that require Zn application for optimum production and to get the full benefit of applied NPK fertilizers in the studied area, 31 % of samples were marginal and 65% of the samples were sufficient in Zn availability. Zinc availability is also affected by soil pH. A decrease in soil pH can result in increased availability of Zn in soil [23].

All the investigated micronutrients are influenced by the soil environment [16]. Soil pH has been comprehensively identified as the single most important soil factor controlling the availability of micronutrients in soil [24]. The low values of soil pH in agricultural land might be due to the removal of bases in crop harvest and drainage to streams in runoff resulting in accelerated erosions [24]. The other possible reason is the formation of studied soils from the acidic parent material [25]. To utilize these soils efficiently, the application of lime and soil organic matter can be useful to manage adverse effects of soil acidity or the use of crops that are tolerant to high levels of exchangeable Al [26].

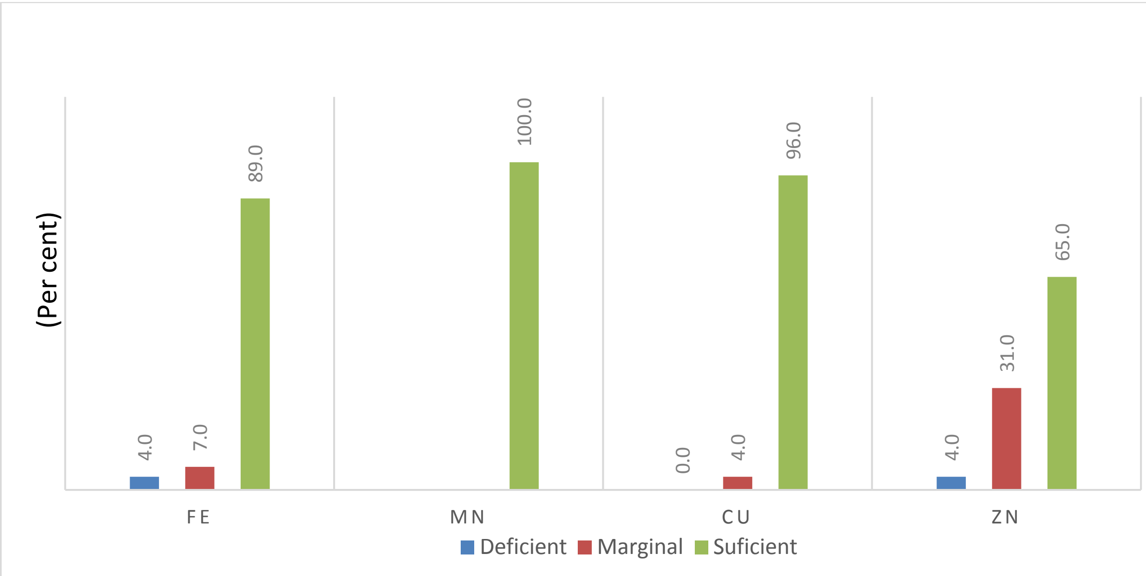

Fig. 2. Micronutrient status based on their critical range

Table 1. The average range of micronutrients of soils

Sr. No.	Micronutrients content (mg/kg^{-1})				
	Available micronutrients	**Minimum**	**Maximum**	**Average**	**St. Dev**
1	Iron	3.0	1196.0	189.7	311.8
2	Manganese	17.0	316.0	74.6	64.6
3	Copper	0.50	10.0	4.1	2.3
4	Zinc	0.30	4.2	3.4	4.2

Table 2. Critical soil test values of DTPA extractable micronutrients

Sr. No.	Micronutrients	Nutrient content (mg kg^{-1})		
		Low	**Medium**	**High**
	Iron [16]	<4.50	4.5-9.0	>9.0
	Manganese [18]	<2.5	2.5-3.5	>3.5
	Copper [16]	<0.2	0.2-0.4	>0.4
	Zinc [22]	<0.6	0.6-1.2	>1.2

Table 3. Correlation coefficient values of important soil properties

Soil properties	OC	Fe	Mn	Cu	Zn
Soil pH	-0.42*	-0.05	-0.13	0.38*	0.28
Organic Carbon (OC)		-0.03	-0.17	0.08	-0.02
Iron (Fe)			0.02	0.37*	0.05
Manganese (Mn)				0.15	0.02
Copper (Cu)					0.37*

*** Significant at P = 0.05 and * P = 0.01 level respectively*

Further, soil pH is a positive correlation with Cu (r=0.38*) and Zn (r=0.28) whereas a negative correlation was shown with OC (r=-0.42*). The average value of Fe increased significantly with an increase in Cu (r=0.37*) and Zn availability was positively correlated with Cu (r=0.37*).

4. CONCLUSION

The study revealed that the availability of iron, copper, and manganese in these soils appeared to be adequate whereas, zinc availability is at a deficient level. Results indicated that soil pH is the main soil characteristic that controlled the availability of these micronutrients.

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COMPETING INTERESTS

The authors have declared that no competing interests exist.

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