E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; 7(2): 164-168
Received: 08-12-2023
Accepted: 15-01-2023

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Studies fertility status of sugarcane growing soils of Rahuri tehsil of Ahmednagar district (MS) using Geospatial technologies

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i2c.301

Abstract
The detailed soil survey was carried out in sugarcane farmland of Rahuri tehsil of Ahmednagar district, Maharashtra state (India) to study the fertility status of sugarcane growing soils using nutrient index approach, mainly of primary and micro nutrients. High resolution remote sensing data IRS, LISS IV data of 5.8 meter resolution and digital elevation model (DEM) of cartosat (10 meter resolution) were used for land uses, slopes and landform analysis. By using geographic information system (GIS) technique total 188 soil samples at 0-30 cm were collected at 2 km grid intervals and soil analysis was carried out for checking the fertility status. The results reviled that all the samples found moderate to strongly alkaline, very low to high organic carbon percentage (0.35-1.15%), medium to high $CaCO_3$. Concerning the available macro nutrients N, P and K which was observed between 103.7-224.8 kg ha^{-1}, 9.3-25.5 kg ha^{-1} and 345.6-652.2 kg ha^{-1}. Regarding the micro nutrients Fe, Cu, Mn and Zn was recorded 3.6 to 7.2 mg kg^{-1}, 0.8 to 2.9 mg kg^{-1}, 4.3 to 13.0 mg kg^{-1} and 0.02 to 1.5 mg kg^{-1}.

Keywords: Fertility, primary nutrients, micronutrient, nutrient index

Introduction
Sugarcane is grown in various states in tropical and subtropical region of the India. The tropical sugarcane region includes the states of Maharashtra, Andhra Pradesh, Tamil Nadu, Karnataka, Gujrat, Madhya Pradesh and Goa. In the tropical region climatic conditions are more favorable for its growth. The sub-tropical states includes Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal, Assam and north eastern states of India. (Sugar annual, 2022) [16].
Sugarcane is a most important cash crop of Maharashtra. It involves less risk and farmers are assured some extent about return even in adverse condition. Sugarcane provides raw material for the second largest agro-based industry after textile. The sugar industry in Maharashtra has been play a vital role in socio-economic development.
The sugarcane growing soils of Maharashtra are degraded due to salinity and sodicity owing to modern farming practices such as intensive cropping, removal or burning of crop residues, imbalanced use of chemical fertilizers, extra tillage, canal irrigation water and scanty rainfall and high temperature resulting in accumulation of salts therefore decrease the nutrient availability and decrease crop yield (Kharche *et al.*, 2010) [8]. Soil fertility is one of the important factors which controlling the yield of crops. The nutrient requirement also varies in different soil types. Macronutrients including Nitrogen, Phosphorus and Potassium as well as micronutrients including zinc, ferrous, copper and manganese are essential elements which is required for the growth of sugarcane.
Soil characterization in relation to fertility status of the sugarcane growing soils is an important aspect in context of sustainable agriculture production. Therefore, there is an urgent need to characterize the soil and map the soils for fertility aspects to sustain the soil fertility and soil productivity in sugarcane growing area (Kadu *et al.*, 2017) [7].

Geospatial technologies such as high resolution satellite data, Global Positioning System (GPS) and Geographic Information System (GIS) effectively useful for mapping the soils, monitoring and management. The satellite image data provides integrated information on soil types, erosion, land use, surface water bodies and qualitative assessment of groundwater potential. (Reddy, 2016) [13].

Materials and Methods

Study area

Rahuri Tehsil in Ahmednagar district of Maharashtra is located between 19^0 15' N to 19^0 34' north latitude to 74^0 23' E to 74^0 50' east longitude and which falls under agro-ecological zone 6 (semi-arid region) of Western Ghats in Mula and Pravara basin which is classified under water scarcity zone. The Mula river are the lifelines of the sugarcane growing area of Rahuri tehsil. Total 45-50% area of the study area is irrigated due to Mula river.

Climate

The temperature of the study area varies from 33 ºC to 41 ºC. The cold weather starts in the middle of the November and continues up to the end of February. December is the very coldest month of the year.

Land use

Total geographical area of the study area is 99113.22 ha out of that agriculture land use is 75%, 15% land comes under forest and other rest land is 10%. The major crops of the study was observed Sugarcane, Onion, Jowar, Maize, Wheat, Pomegranate and fodder etc.

Methodology

Soil sample collection and analysis

Depending on the variability of physiography, soil survey of the study area was carried out on 1:10000 scales using temporal IRS P6 -LISS-IV data. Total 188 soil samples were collected at an interval of 325x325 meter. Each collected samples represented near about 10 hectares land. In the irrigated area sampling has been carried out at the closure interval, approximately at the grid interval of 150x150 meter and each collected samples of the irrigated area representing 2.5 hectare land. The exact soil sample collection location (latitude and longitude) were recorded by using a hand held GPS device.

Chemical characterization of the soil samples was carried out by following standard analytical techniques. Soil reaction (pH) and electrical conductivity (EC) was determined in 1:2 suspension using standard pH meter by potentiometric (Jackson, 1973) [6]. Soil available nitrogen (N) was determined by alkaline potassium permanganate method given by Subbiah and Asija (1956) [15], soil available phosphorus (P) and available potassium (K) were determined by Olsen's and Flame Photometer method (Jackson, 1967) [5] and micronutrient fertility of the soil was determined by following the DTPA extraction method by using AAS (Lindsay and Norvell, 1978) [9].

Generation of fertility maps

The fertility status of the study area for macro and micro nutrient levels and their extent were calculated and mapping was carried out by using Arc-GIS 9, version 9.3 software.

Results and Discussion

Chemical characteristics of soil

It is found that soil reaction (pH) of the study area varied from 7.4 to 9.1 and on the basis of Brady (1985) [20] soil pH classification, 10 samples were found slightly alkaline in reaction (pH 7.4 to 7.8), 137 samples were found that moderately alkaline in reaction (pH 7.9 to 8.4) and 41 samples were found strongly alkaline in reaction (pH 8.5 to 9.0). The relative high pH of the soils might be due to the presence of high degree of base saturation. Similar soil reaction (pH) values were reported in the Mula command area of irrigated agroecosystem of Maharashtra (Kharche *et al.*, 2010) [8]. The electric conductivity (EC) of the study area were ranged from 0.09 to 1.39 dS m^{-1}. The high EC indicated that the soils are degraded due to high salt content. On the basis of the limits suggested by Muhr *et al*. (1963) [10] for judging salt problem of soils, 85% of the soil samples were found normal salt content (EC<1.0 dSm^{-1}) and remaining 15% samples were found in the category of presence of high soluble salt content (EC>1.0 dSm^{-1}). High salt content greatly influence to the germination of the crops. The similar results were reported by Kharche *et al.* (2010) [8] and Nagaraju *et al.* (2014) [11]. The soil fertility and sugarcane yield greatly influence by soil organic carbon percentages present in soil. The organic carbon percentage in soils were varied from 0.35 to 1.13 per-cent. High OC was found in forest area due to continuous addition of organic materials. The calcareousness is common in soils of arid and semiarid climate particularly in Vertisols (Black soils) due to precipitation of carbonates and bicarbonates. The $CaCO_3$ percentage in the study area varied from 3.1 to 10.5 per-cent. The similar results were reported by Durgude *et al.* (1999) [4].

Available nitrogen and effect of soil characteristics

The soil available nitrogen (N) in the study area were ranged from 103.7 to 224.8 kg ha^{-1} (Table 2, fig. 1). Higher soil pH declined the organic matter status by faster degradation which greatly reflected the status of available nitrogen. On the basis of the ratings suggested by Subbiah and Asija (1956) [15], the soils of study area showed very low to low in available nitrogen kg ha^{-1}. Significant positive correlation (r= 0.280**) was found between organic carbon and available nitrogen (Table 1). This relation was found because most of the soil nitrogen is in organic farm. Similar results were also reported by Ammannawar *et al*. (2017) [1].

Table 1: Correlation coefficient (r) values of pH, organic carbon and calcium carbonate content with macro and micronutrients

Soil properties	Available Nutrients						
	N	P_2O_5	K_2O	Fe	Mn	Zn	Cu
pH	-0.098**	-0.375**	-0.107**	-0.0016*	0.042*	-0.013*	0.023*
Organic carbon	0.280**	0.421**	0.011**	0.021*	-0.062*	0.128*	-0.044*
$CaCO_3$	----	----	----	-0.034*	-0.126*	0.054*	-0.008*

** Significant at 1% level

* Significant at 5% level

Table 2: Number of percent of samples in low, medium and high categories of different chemical properties

Soil parameters	% samples n=188			
	Range/Critical limit	Low	Medium	High
Available N	280-500 kg ha^{-1}	94.6 (178)	5.3 (10)	---
Available P	11-24 kg ha^{-1}	38.2 (72)	61.7 (116)	---
Available K	116-275 kg ha^{-1}	---	----	100.0 (188)
Available Fe	2.5-4.5 mg kg^{-1}	10.0 (19)	26.0 (49)	63.8 (120)
Available Mn	2.0 mg kg^{-1}	---	---	100 (188)
Available Zn	0.6 mg kg^{-1}	39.8 (75)	60.1 (113)	---
Available Cu	2.0 mg kg^{-1}	5.3 (10)	9.5 (18)	85.1 (160)

Available phosphorus and effect of soil characteristics

The available phosphorus in the study area were ranged from 9.3 to 25.5 kg ha^{-1} (Table 2, fig. 1). Low available phosphorus in soil might be due to alkaline condition and high content of $CaCO_3$ in the soil. Similar result were also reported by Waikar *et al.* (2004) [19], Bhalerao and Pharande (2003) [3]. The range is quite large which might be due to variation in soil properties *viz.* pH, calcareousness, organic matter percentage and various agronomic practices. On the basis of limits suggested by Muhr *et al.* (1963) [10], 38% samples were found low available phosphorus (<20 kg ha^{-1}) and 62% samples were found medium availability of phosphorus (20 to 50 kg ha^{-1}) in available phosphorus. A significant positive correlation (r= 0.421**) (Table 1) was observed between organic carbon and available phosphorus (Table 1). Available phosphorus was significant and negatively correlated with pH (r= -0.375**) (Table 1) because at higher pH calcium react with phosphorus and formed insoluble Ca- phosphate that's why reduce the phosphorus availability (Tisdale *et al.* 1997) [17]. The presence of more than 50% of phosphorus in organic forms and after decomposition of organic matter as humus is formed which forms complex with Al and Fe and that is a protective cover for P fixation with Al and Fe thus reduce phosphorus fixation. The results are in agreement with the findings of Kharche *et al.* (2010) [8].

Available potassium and effect of soil characteristics

The available potassium in the study area ranged from 345.6 to 652.2 kg ha^{-1} (Table 2, fig 1). The very high available of potassium in the soil could be attributed to the dissolution and diffusion of K from internal crystal lattice of silicate clay minerals and may be due to high clay content and montmorillonite clay minerals present.

Soil nutrient index

The concept of "Soil Nutrient Index" of the soils of study area were observed in the category of 'low' fertility statuses for nitrogen and phosphorus and 'high' with respect to potassium. The values were worked out from soil nutrient index for nitrogen, phosphorus and potassium were 1.03, 1.62 and 3.02 respectively, against the nutrient index values <1.67 for low, 1.67 to 2.33 for medium and >2.33 for high fertility status of the study area.

Available micronutrients and effect of soil characteristics

The soils of the study area were analyzed for DTPA extractable iron and the most of the study area observed in the range of 3.59 – 7.24 mg kg^{-1}. Same result was recorded by Pawar *et al.* (2001) [12]. Based on the critical limits reported by Challa *et al.*, (1995) [2], the soils of the study area were sufficient availability of ferrous nutrient (Table 2, Fig. 2 a).

DTPA extractable copper of the study area showed the bulk of area fell in the range value of 0.87 and 2.98 mg kg^{-1} which comes under adequate concerning copper nutrition (Table 2, Fig. 2 a). The availability of metal ion (Fe, Cu) increase with increase in organic matter content because organic matter may supply chelating agents. Same result was recorded by Pharande *et al.* (1996) [21] and Vaddepally *et al.* (2017) [22].

DTPA extractable manganese in the study area ranged from 4.3 and 13.0 mg kg^{-1} was extensive in the forest and the area used for sugarcane cultivation (Table 2, fig. 2 b) Based on the critical limit given by Challa *et al.*, (1995) [2] the soils of study area were found in sufficient in manganese nutrition. Same result was reported by Vaddepally *et al.* (2017) [22].

Spatial distribution of zinc is shown in the map (Table 2, fig. 2 b) Zinc nutrition in the study area were ranged from 0.02-1.52 mg kg^{-1} and the soils of the study area was found inadequate in zinc nutrition. Based on the critical limit given by Challa *et al.*, (1995) [2] 40% samples of the study area were found deficient in zinc nutrition and 60% samples were found in sufficient in available Zn. Same result was recorded by Pharande *et al.*, 1996 and Vaddepally *et al.* (2017) [21, 22].

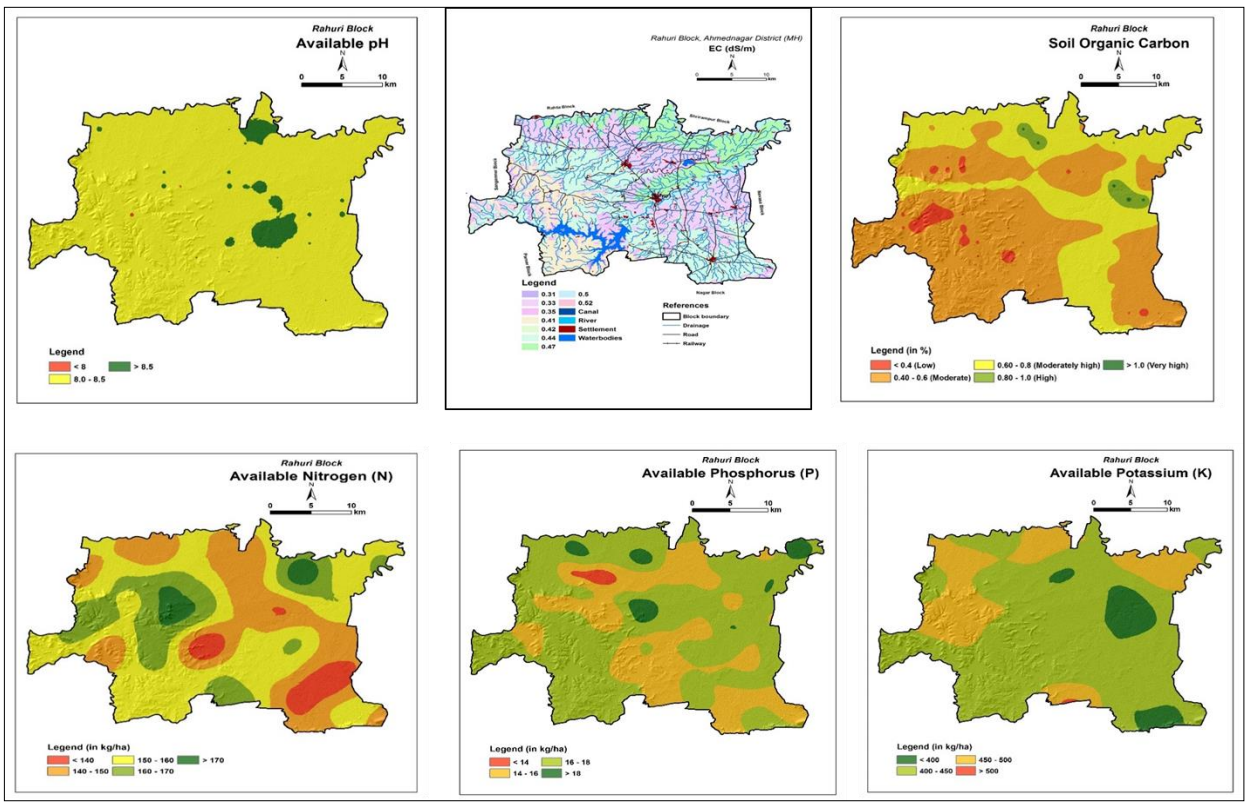

Fig 1: Fertility status map of Rahuiri tehsil of Ahmednagar district (MH)

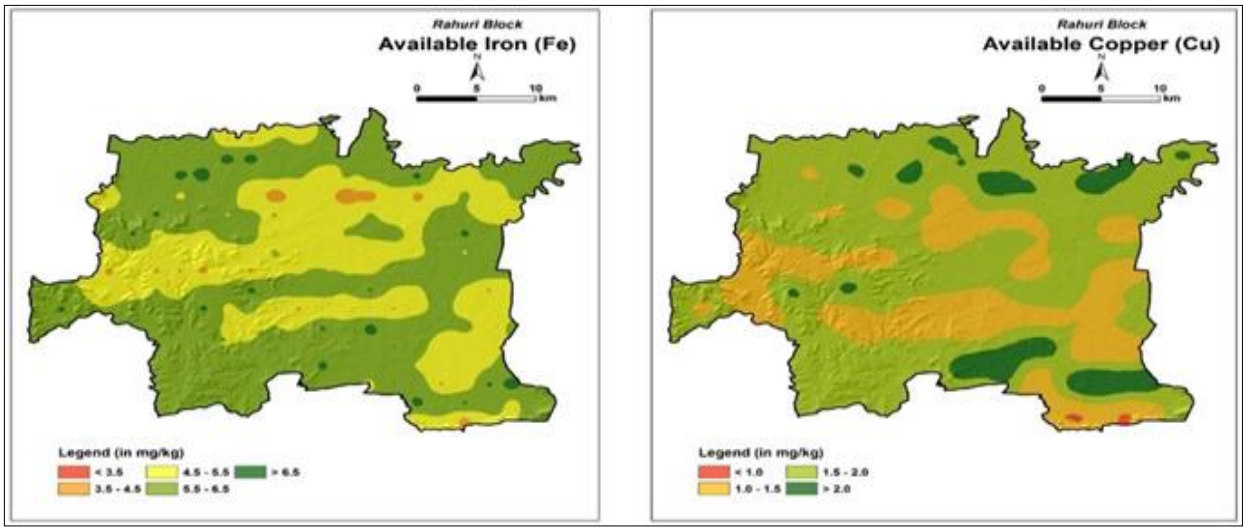

Fig 2a: Spatial distribution of available Iron and Copper in 0 to 30 cm soil in Rahuri tehsil

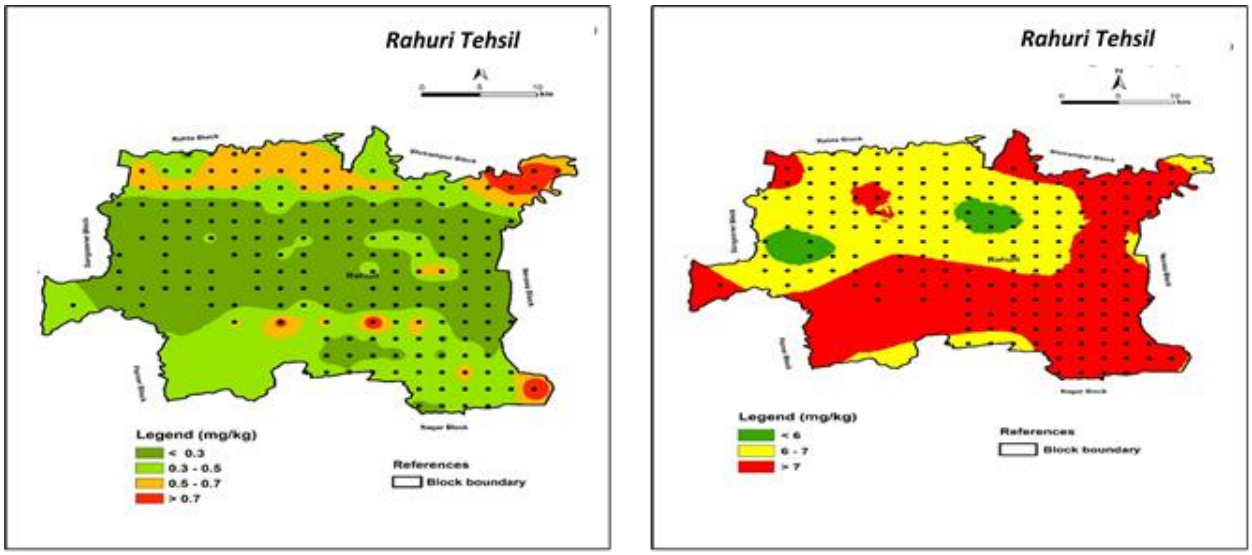

Fig 2b: Spatial distribution of available Zinc and Manganese in 0 to 30 cm soil in Rahuri tehsil

Conclusion

The soil fertility evaluation, it was found that the sugarcane growing soils of central India is moderate to strongly alkaline in soil reaction, saline and sodic in nature, low to high in organic carbon percentage and low to high in calcium carbonate percentage. The soils were categorized as very low in available nitrogen, low to moderate in available phosphorus and very high available potassium. The micronutrient status of soils were indicate that availability of Fe, Cu and Mn were sufficient and availability of Zn micronutrient were deficient in all-over sugarcane growing soils. This study might be a great help to the farmers for soil fertility management and policy planners in effectively employing the technological intervention.

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