Original Research Article

ASSESSMENT OF SOIL FERTILITY STATUS OF RAYAL CHERUVU VILLAGE IN RAMACHANDRAPURAM MANDAL OF TIRUPATI DISTRICT, ANDHRA PRADESH

Abstract

One hundred soil samples from Rayal Cheruvu village in Ramachandrapuram mandal of Tirupati district, Andhra Pradesh were collected by using GPS to study soil fertility status. These samples were ~~analysed~~ analyzed for ~~physico-chemical~~physicochemical and chemical parameters. The results revealed that soils were slightly acidic to strongly alkaline in reaction and non-saline. Soil organic carbon was low to medium. The available nitrogen was low, the available phosphorus ranged from low to high and the available potassium ranged from medium to high. The fertility status was used to assess soil fertility constraints in the study area.

Keywords: pH, EC, OC, macronutrients, micronutrients, and soil fertility constraints.

Introduction

Soil is a crucial natural resource that sustains life on earth and evaluating its condition is essential to understand its productivity and the overall sustainability of the ecosystem. For the soil to maintain sustainable health, ~~it is crucial that it aligns~~it must align harmoniously with its inherent properties and productivity. In India, the enhancement of crop productivity over the past few decades can be attributed to the increased utilization of fertilizers driven by the rising demand for food. Various factors contribute to the nutrient imbalance in these soils, such as increased demand from ~~high yielding~~high-yielding crops, intensive cropping, continued expansion of cropping onto marginal land with low levels of micronutrients, increased use of chemically pure micronutrient free fertilizers, decreased recycling of crop residues and limited use of animal wastes (Bell and Dell, 2006). Consequently, it becomes necessary to assess nutrient limitations in soils that undergo intensive cultivation with high-yielding crops. Though the data obtained through traditional soil survey methods were dependable and accurate, they ~~lacked the ability to~~could not establish spatial variability layers of soil properties. Hence the present investigation was executed ~~with the objective to~~to assess the soil fertility status of the area and to link the status of fertility with agricultural practices for identifying the important nutrient constraints for sustainable production of crops in Rayal Cheruvu village in Ramachandrapuram mandal of Tirupati district, Andhra Pradesh.

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Materials and Methods

The study area lies ~~in~~ between 13° 29' 8.1708" to 13° 31' 19.938" North Latitudes and 79° 22' 32.7” to 79° 26' 37.3704" East Longitudes. It has a total geographical area of 819.08 ha. The study area experiences tropical climatic conditions with extremely high humidity. The mean annual rainfall recorded was 788.67 mm and the majority was received from July to November. The mean annual temperature was 27.65^{o}C with a mean summer temperature of 32.79^{o}C and a mean winter temperature of 22.51°C. The maximum temperature recorded was 43.7^{o}C and the minimum temperature was 18.2^{o}C in the month of May and December, respectively. The natural vegetation of the study area comprises ~~of~~ *Argemone maxicana, Acacia nilotica, Azadirachta indica, Abutilon indica, Borassus flabellifer, Blumea lacera, Cynodon dactylon, Cyperus rotundus, Chenopodium alba, Cassia auriculata, Calotropis gigantea, Lamea pinnatifiea, Parthenium hysterophorus, Sygium cumini, Tamarindus indica and Tephrosia purpurea etc*.

A total of 100 surface samples were collected and georeferenced coordinates were noted using a handheld GPS in each sampling site. The soil samples were ~~air dried~~air-dried, ground, sieved (<2 mm), and ~~analysed~~analyzed for ~~physico-chemical~~physicochemical and chemical properties. The soil reaction (pH) and electrical conductivity (EC) of soils were measured using standard procedures as described by Jackson (1973). Organic carbon (OC) was determined using the Walkley-Black method (Jackson, 1973). Available nitrogen was estimated by the alkaline permanganate method (Subbiah and Asija 1956). Available phosphorus was measured using 0.5 *M* sodium bicarbonate ($NaHCO_3$) pH 8.5 as an extractant (Olsen *et al.*, 1954). Available potassium was determined using the neutral normal ammonium acetate method (Jackson, 1973). The variability of data was assessed using mean, standard deviation, and coefficient of variation for each set of data. Availability of N, P_2O_5, and K_2O in soils ~~were~~ was interpreted as low, medium, and high, and availability of micronutrients (Cu, Mn, Fe, and Zn) ~~were~~ was interpreted as deficient to sufficient by following the criteria given in Table 1 (Tandon, 1991).

Table 1. Ratings for pH, EC, available N, P_2O_5, and K_2O

pH	Ratings
Slightly acidic	6.1 – 6.5
Neutral	6.6 – 7.3
Slightly alkaline	7.4 – 7.8
Moderately alkaline	7.9 – 8.4

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Strongly alkaline	>8.4
EC(dS m^{-1})	
~~Non saline~~Nonsaline	<4
Saline	>4
OC (%)	
Low	< 0.5
Medium	0.5-0.75
High	> 0.75
Nitrogen (kg ha^{-1})	
Low	< 280
Medium	280-560
High	>560
Phosphorus (P_2O_5) (kg ha^{-1})	
Low	<25
Medium	25-59
High	>59
Potassium (K_2O) (kg ha^{-1})	
Low	<145
Medium	145-340
High	>340
Critical limits for DTPA extractable micronutrients (mg kg^{-1})	
Iron	4.0
Copper	0.2
Zinc	0.6
Manganese	2.0

Results and Discussion

Soil reaction

Soils of the Rayal Cheruvu village were neutral to strongly alkaline (6.7 to 8.5) in reaction with a mean pH of 7.50, standard deviation of 0.38, and CV of 5.11 ~~per cent~~percent. The major proportion of the village was neutral (52%) followed by slightly alkaline (25%), moderately alkaline (22%), and strongly alkaline (1%). The majority of soils exhibited neutral to slightly alkaline ~~reaction~~ reactions (6.6-7.8) (Table.2). This wide variation in pH (6.7 to 8.5) might be attributed to the nature of the parent material, climate of the region, organic matter, and topographic situation (Abua *et al.*, 2010 and Kavitha *et al.*, 2018).

Electrical conductivity

The electrical conductivity of soils in Rayal Cheruvu village was in the range of 0.09 to 0.98 dS m^{-1} with a mean of 0.60 dS m^{-1} and a standard deviation of 0.22 with a CV of 34.36 ~~per cent~~percent (Table.2). The soluble salt content in the soils of the study area revealed that~~,~~ the area was non-saline. The normal EC may be ascribed to the removal of bases by percolating and drainage water and excess leaching of salts to lower horizons (Leelavathi *et al.*, 2009 ~~and~~ Satish *et al.*, 2018).

Organic carbon

Soil organic carbon content (OC) of Rayal Cheruvu village in Tirupati district varied from 0.03 to 0.54 ~~per cent~~percent with a mean OC of 0.40 ~~per cent~~percent. The standard deviation was 0.11 ~~per cent~~percent with a CV of 29.98 ~~per cent~~percent (Table.2). About 95% of the study area was low in organic carbon and 5% of the study area was medium in soil organic carbon. Low organic carbon content in these soils might be attributed to the prevalence of tropical conditions, degradation of organic matter at a faster rate coupled with low vegetation cover on the fields leaving less chances of accumulation of organic carbon in the soils (Leelavathi *et al.*, 2009 and Sashikala *et al.*, 2021).

Available macronutrients

The available nitrogen in the surface soils of the Rayal Cheruvu village varied from 63 to 202 kg ha^{-1} with a mean of 98.10 kg ha^{-1} and a standard deviation of 27.95 with a CV value of 28.49 ~~per cent~~percent (Table.2). The study revealed that the total area of Rayal Cheruvu village was low in available N. This may be due to most of the farmers could not apply the required quantity of nitrogen to crops and also they applied more complex fertilizers than straight fertilizers which led to an imbalanced/ inadequate quantity of nitrogen supplied ~~and~~ also it is quite obvious that the efficiency of applied nitrogen is very low ~~due to the fact that~~because N is lost through various mechanisms like volatilization, nitrification, denitrification, chemical and microbial fixation, leaching, and runoff (Kavitha *et al.*, 2019).

The available phosphorus content in soils of Rayal Cheruvu village ranged from 11 to 72 kg P_2O_5 kg ha^{-1} with mean and standard deviation ~~value~~ values of 36.30 kg ha^{-1} and 14.46, respectively with a CV of 39.88 ~~per cent~~percent (Table.2). The study area was low to high in available phosphorus. About 69% of the study area has medium available phosphorus content, 23% of the study area was in the low range and 8% of the area was under high availability of phosphorus. The low available phosphorus content could be attributed to the fixation of releasing phosphorus by clay minerals. ~~Presence~~ The presence of a considerable amount of phosphorus may be attributed to the continuous application of phosphatic fertilizers to crops and the ~~adopting~~ adoption of good management practices (Vajantha *et al.*, 2023).

The available potassium content in soils of Rayal Cheruvu village ranged from 181 to 350 kg ha^{-1} with a mean value of 234.2 kg ha^{-1} and a standard deviation of 58.22 with a CV of 24.86 ~~per cent~~percent (Table.2). The soils were medium to high in available potassium content. About 92% of the study area was medium in available potassium and 8% of the study area has high available potassium. Adequate available potassium in these soils may be attributed to the prevalence of ~~potassium rich~~potassium-rich minerals like illite and feldspars (Leelavathi *et al.*, 2009 ~~and~~ Patil *et al.*, 2016).

Table 2. Summary of ground truth analysis data of ~~physico~~ physical-chemical~~chemical~~ properties and macronutrients of Rayal Cheruvu village

	pH	EC (dS m^{-1})	OC (%)	Available N	Available P_2O_5	Available K_2O
				(kg ha^{-1})		
Range	6.7-8.5	0.09-0.98	0.03-0.54	63-202	11-72	181-350
Mean	7.50	0.60	0.40	98.10	36.30	234.2
SD	0.38	0.22	0.11	27.95	14.46	58.22
CV	5.11	34.36	29.98	28.49	39.88	24.86

DTPA extractable micronutrients

Copper

The DTPA extractable copper in surface soils of the Rayal Cheruvu village varied from 0.06 to 3.68 mg kg^{-1} with a mean of 0.38 mg kg^{-1} and a standard deviation of 0.49 with a CV value of 130.14 ~~per cent~~percent (Table.3). The study revealed that~~,~~ 51% of the area was deficient and 49% of the area was sufficient in available copper content.

The higher concentration of copper in the surface soils might be due to higher biological activity and the chelating of organic compounds, released during the decomposition of organic matter left after harvesting of crop. (Leelavathy *et al.*, 2021).

Manganese

The DTPA extractable manganese in surface soils of the Rayal Cheruvu village varied from 0.09 to 10.60 mg kg^{-1} with a mean of 1.95 mg kg^{-1} and a standard deviation of 1.37 with a CV value of 70.28 ~~per cent~~percent (Table.3). The study revealed that~~,~~ 74% of the area was deficient and 26% of the area was sufficient in available manganese content.

The significant differences in the availability of manganese observed in the soils of the study area can be attributed to variations in the presence of minerals containing manganese, clay content, organic carbon levels, cation exchange capacity, and other associated elements (Vajantha *et al.*, 2014).

Iron

The DTPA extractable iron in surface soils of the Rayal Cheruvu village varied from 0.30 to 36.00 mg kg^{-1} with a mean of 9.37 mg kg^{-1} and a standard deviation of 6.56 with a CV value of 69.99 ~~per cent~~percent (Table.3). The study revealed that~~,~~ 92% of the area was sufficient and 8% of the area was deficient in available iron content.

The presence of organic carbon, which has a strong ability to affect the solubility and availability of iron through the chelation effect could potentially have protected iron from oxidation and precipitation. As a result, this could have led to enhanced availability of iron (Leelavathy *et al*., 2020).

Zinc

The DTPA extractable zinc in surface soils of the Rayal Cheruvu village varied from 0.17 to 2.53 mg kg^{-1} with a mean of 0.64 mg kg^{-1} and a standard deviation of 0.44 with a CV value of 69.11 ~~per cent~~percent (Table.3). The study revealed that~~,~~ 59% of the area was deficient and 41% of the area was sufficient in available zinc content.

The higher levels of available zinc might be due to the varying intensity of soil pedogenic processes and the formation of complexes with organic matter, which led to the chelation of zinc. The occurrence of zinc deficiency in the study area was due to the non-application of zinc fertilizers by farmers. (Leelavathy *et al.*, 2023 and Govardhan *et al.*, 2017).

Table 3. Summary of ground truth analysis data of soil DTPA extractable ~~micro nutrients~~micronutrients of Rayal Cheruvu village

	DTPA extractable Cu	DTPA extractable Mn	DTPA extractable Fe	DTPA extractable Zn
	(mg kg^{-1})			

Range	0.06-3.68	0.09-10.60	0.30-36	0.17-2.53
Mean	0.38	1.95	9.37	0.64
SD	0.49	1.37	6.56	0.44
CV	130.14	70.28	69.99	69.11

The candidate manuscript does not have a robust scientific discussion, I suggest the authors incorporate the suggested paragraphs, in this way, it would improve the scientific quality of the manuscript:

Soil fertility assessment plays a critical role in sustainable agriculture and ecosystem management. Understanding the fertility status of soils is essential for optimizing crop production, ensuring food security, and maintaining environmental health. This scientific discussion focuses on the assessment of soil fertility in Rayal Cheruvu Village and compares it with soil quality studies in tropical agricultural territories of Latin America. By doing so, we can gain insights into the similarities and differences in soil fertility patterns between these regions.

Assessing soil fertility is crucial for several reasons, soil fertility directly influences crop growth, nutrient uptake, and overall productivity (Olivares et al. 2022a). By knowing the fertility status, farmers can tailor their agricultural practices, including fertilization and soil amendments, to enhance yields and produce high-quality crops (Olivares, 2016; Olivares et al. 2022b).

Understanding soil fertility helps in proper land-use planning (López -Beltrán et al. 2019). Areas with low fertility can be designated for non-intensive land uses, reducing the risk of degradation (Olivares et al. 2015) and soil erosion (Olivares et al. 2011; Lopez and Olivares, 2019). Soil fertility assessment guides effective nutrient management strategies, preventing excessive or insufficient fertilization, which could lead to environmental pollution or nutrient deficiencies in crops, respectively (Olivares, 2023). Knowledge of soil fertility helps in avoiding the over-application of fertilizers, thus reducing the risk of nutrient runoff and its negative impact on water bodies and ecosystems (Olivares, 2018; Montenegro et al. 2021).

Rayal Cheruvu Village, like many other rural agricultural areas, relies heavily on farming for livelihood and sustenance. Conducting a soil fertility assessment in this region is highly relevant due to the following reasons. Understanding soil fertility is crucial for increasing agricultural productivity in Rayal Cheruvu Village. By identifying nutrient deficiencies or

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imbalances, farmers can make informed decisions on soil management and nutrient supplementation (Viloria et al. 2023; Rodriguez-Yzquierdo et al. 2023).

Soil degradation is a significant concern in many agricultural regions, and Rayal Cheruvu Village is no exception. Assessing soil fertility can help identify degraded areas, allowing for targeted soil restoration efforts and sustainable land use planning (Zingaretti and Olivares, 2018). Excessive use of fertilizers and poor soil management can lead to nutrient leaching and runoff, adversely affecting water quality in nearby water bodies such as Rayal Cheruvu. Soil fertility assessment can aid in mitigating such issues and protecting local aquatic ecosystems (Hernandez et al. 2018c).

Latin America is known for its vast agricultural lands and diverse soil types. Comparing the soil fertility assessment in Rayal Cheruvu Village with soil quality studies in tropical agricultural territories of Latin America can offer valuable insights into regional variations and similarities (Olivares et al. 2022c). Comparisons can be made regarding the mineral composition, organic matter content, and nutrient levels in soils between the two regions (Hernandez et al. 2017; Lobo et al. 2023). Differences in soil types may require distinct management approaches (Hernández and Olivares, 2020).

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By comparing the fertility status of soils, we can gain insights into the types of crops that thrive best in each region. This knowledge is essential for promoting appropriate crop choices and diversification (Hernandez et al. 2018a; 2020). Sharing experiences and best practices between the regions can lead to improved soil management strategies that are adapted to the specific needs and challenges of each area (Hernandez et al. 2018b; Paredes et al. 2021). Identifying common environmental challenges, such as nutrient runoff and soil erosion (Olivares et al. 2011; Zingaretti et al. 2016), can lead to the development of region-specific policies for sustainable agriculture and environmental protection (Camacho et al. 2018; Casana and Olivares, 2020).

Conclusions

The assessment of soil fertility in Rayal Cheruvu Village and its comparison with soil quality studies in tropical agricultural territories of Latin America holds immense importance in promoting sustainable agriculture, enhancing crop productivity, and safeguarding environmental health. The knowledge gained from such assessments can aid farmers, policymakers, and researchers in making informed decisions, fostering agricultural sustainability, and preserving the natural resources of these regions for future generations.

From the study, it can be concluded that~~,~~ the soils of Rayal Cheruvu village of Ramachandrapuram mandal in Tirupati district of Andhra Pradesh, India were neutral to strongly alkaline in reaction and non-saline. Soil organic carbon content was low to medium. Available N was low, P_2O_5 was low to high and K_2O was medium to high. Available micronutrients (Cu, Mn, Fe, and Zn) were deficient to sufficient in the study area.

The fertility status of nutrients ~~i~~In the study area revealed that~~,~~ available nitrogen and zinc were important soil fertility constraints, indicating their immediate attention for sustained crop production. The deficient nutrients need to be replenished to avoid the crops suffering from their deficiency and for optimum utilization of other nutrients.

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