Assessment of Soil Particle Distribution, Primary Nutrient Status and their response to environmental factors across the Bengal gram Productive Regions of Sangareddy, Telangana

Abstract

The present study was carried out to know the fertility status of rabi grown bengal gram soils of Sanga Reddy district, Telangana state by thorough field survey during the year 2022-2023. Total of 150 soil samples (50 samples from each productivity regions) from soil surface (0 - 15 cm depth) across three productivity regions high (592-613 kg acre^{-1}), medium (571-592 kg/acre) and low (<571 kg acre^{-1}) were collected from the study area before sowing of the crop and analyzed for the soil particle size distribution, available Nitrogen(N), Phosphorous(P) and Potassium(K). Their status was quantified and analytical data was interpreted and statistical parameters like range, mean, standard deviation and coefficient of variation were calculated. The sand, silt and clay content in high, medium and low productivity regions averaged 32.1 %, 26.7%, 41.1 %; 33.7 %, 26.1 %, 40.1 % and 37.4 %, 25.1 %, 37.2 % respectively. The soil available N, P and K showed mean values of 224.3 kg ha^{-1}, 209.4 kg ha^{-1} and 204.0 kg ha^{-1}; 32.0 kg ha^{-1}, 28.4 kg ha^{-1}, 24.8 kg ha^{-1} and 316.4 kg ha^{-1}, 311.0 kg ha^{-1}, 306.1 kg ha^{-1} in high, medium and low productivity regions. Low productivity areas had the largest mean sand concentration, which influenced soil particle aggregation. Silt content varied greatly, particularly in medium and low productivity zones, whereas clay content varied the most in high productivity regions. Available N decreased from high to medium and medium to low production areas. Fluctuations in available P and K showed a wide distribution within each category, as evidenced by large standard deviation and coefficient of variation values across productivity regions, particularly for potassium, emphasising the importance of considering diverse soil conditions and factors influencing potassium availability when developing fertilisation strategies.

Key words: *Productivity, Particle size analysis, Primary Nutrients, Available Nitrogen, Available Phosphorus and Available Potassium.*

1. INTRODUCTION

Climate is the initial controlling factor of soil nutrients biogeochemical cycle, vegetation plays an important role in the circulation of soil nitrogen, phosphorus and potassium by influencing the input and output of nutrient elements, and vegetation growth is restricted by climatic conditions and interacts with soil environment [17]. Soil available nutrients are effective nutrients, which easily absorbed by soil for plant growth. Because they have high bioavailability, their contents in soil reflect the actual supply of nitrogen, phosphorus and potassium, therefore, they play important role in plant growth, soil productivity and soil quality [18]. Elevation largely predicted the change of climate environment, and the regional climate directly controlled the growth of vegetation. These indirect effects strengthened the connection between topography as well as climate factors. Some studies have pointed out that changes in natural environmental factors such as topography, climate and vegetation have a certain impact on the distribution and validity of soil nutrients to a large extent [19].

Soil is undoubtedly one of the most important components of the environment, yet it is perhaps one of the most undervalued, misused and abused of the Earth's resources. To a large extent soils determine the agricultural potential of an area, they influence many geomorphological and hydrological processes. Soil's physical, chemical and biological properties significantly impact its functions, such as in providing as a medium for plant growth, regulating water supply, recycling raw materials and serving as a habitat for soil organisms (Vasu *et al.,* 2016b) [16].

Soil texture has huge significance for soil development. It can help us to understand the age of the soil and soil development process. Practically, all soil properties and as a whole fertility, depend on it. Soil properties are influenced by texture as, water holding capacity, aeration, susceptibility to erosion, organic matter content, cation exchange capacity (CEC), pH buffering capacity etc. The cultivation, character and impact of the soil cultivation tools and the fertilization depend to a great extent on the soil texture. It is natural that the soil morphology is determined by its texture. Therefore, the studying of the texture in the field and laboratory conditions is the first necessary stage of research on soil as natural body. (Dilkova., 1998) [1].

Soil fertility, in addition to physical qualities, influences plant growth it's the concentrations of water, micronutrients, organic and inorganic elements, available nitrogen (N), available phosphorous (P), and available potassium (K). The NPK ratio is a key indicator of crop productivity, quality, and yield that distinguishes balanced from imbalanced fertilisation. Thus, balanced fertiliser application is critical for high crop yields (Tale and Ingole., 2015) [14]. Soil chemical fertility, particularly nutrient shortage, contributes significantly to soil degradation and limits soil production, stability, and sustainability

(Hartemink., 2010) [2]. The balance of organic and inorganic elements in soil is maintained by nutrient cycling, which is impacted by numerous inputs and losses. Long-term fertiliser trials (Ladha et al., 2003) [5] revealed decreasing yields when chemical fertilisers are applied continuously, owing to reduced nutrient supplying power and soil fertility, which affects the growing food needs of people worldwide (Shahid et al., 2013) [11], which is critical for sustainable agricultural production.

Bengal gram is also called as chickpea or gram (*Cicer arietinum*. L) in South Asia and Garbanzo bean in western countries. It is traditionally cultivated in many parts of the world in a wide range of agro-climatic environments. It helps in fixing nitrogen from atmosphere which improves organic matter content in the soil. Bengal gram is a major food legume and important pulse crop. This accounts for about 46.0 percent of the total production of pulses and 65.39 percent of the total world production of bengal gram. Hence, it is known as king of pulse crops.

India is the largest producer of bengal gram followed by Pakistan, Turkey and Iran. India produces around 10 to 11 million tonnes and contributes around 70 percent of the total world production. Bengal gram is the most largely produced pulse crop in India accounting for a share of 40 percent of the total pulse production.

But the bengal gram soil's fertility and quality were being depleted as a result of continuous cropping in areas like Telangana due to prolonged improper management practices that led to the destruction of soil properties because of monoculture, uneven application of inorganic fertilizer, and excessive reclamation (Ladha *et al*., 2003) [5] making it challenging to maintain bengal gram productivity. Achieving increased crop productivity, implementing effective soil conservation measures, and fostering sustainable agriculture management require a comprehensive understanding and examination of soil conditions. Therefore, considering the importance of above soil properties and their influence to identify the differences between bengal gram soils with varying productivity, this study has been undertaken to uncover variations in soil properties that help in development of sustainable land use management and the improvement of grain yield in bengal gram cultivation.

2. MATERIAL AND METHODS

2.1 Location of study site

Sangareddy district is located in the northern region of the Indian state of Telangana about 50 miles west from Hyderabad. It falls between 17.611629 and 17° 36' 41.8644" N latitude.

and 78.081810 and 78° 4' 54.5160" E longitude and lies on 524m above sea level. The district is spread over an area of 4,4645 square kms. Agriculture is the most predominant sector of the district economy. The gross cropped area of the district is 2,65,290 hectares. The study site of bengalgram soil regions of Sangareddy district, Telangana, India, is illustrated in Figure 1 and 2.

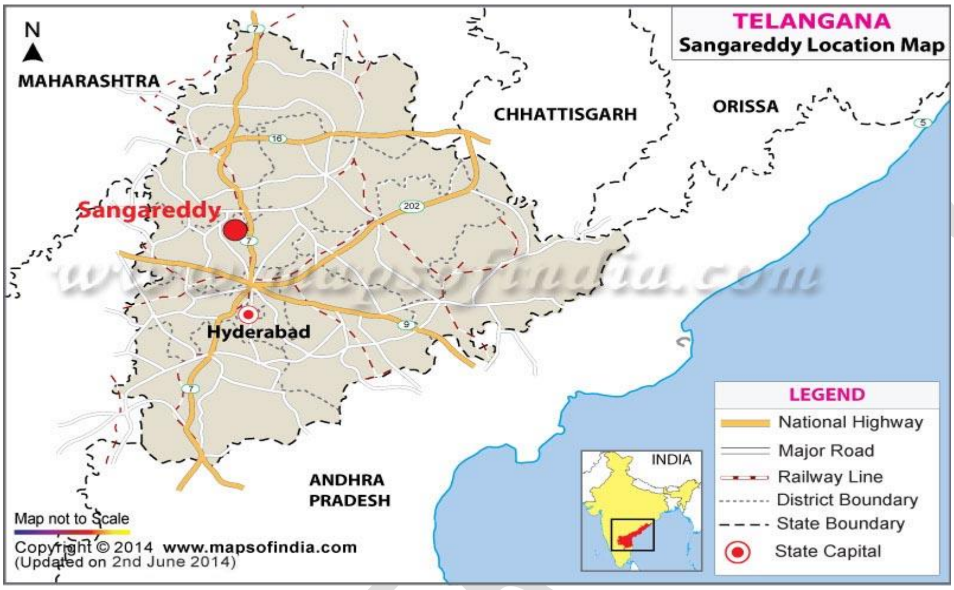

Figure 1. Location of the Study Site

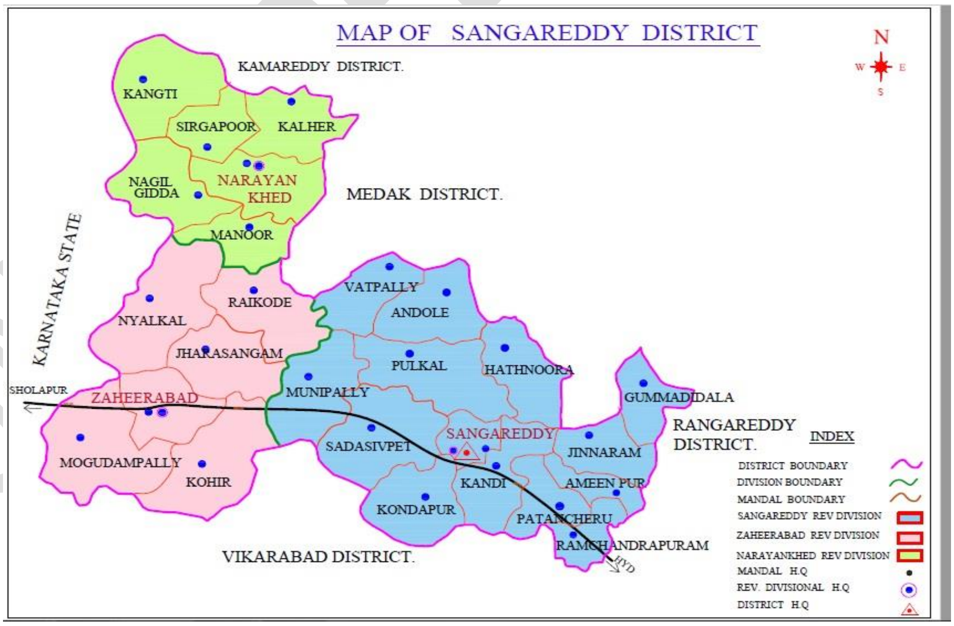

Fig 2. Map of study area

2.2 Soil sample collection

The present study involved the survey and collection of soil samples from the study area where *rabi* bengal gram was cultivated by dividing the mandals of the district into low (<571 kg acre^{-1}), medium (571-592 kg acre^{-1}) and high (592-613 kg acre^{-1}) productive regions based on the area and yield data gathered from the district agriculture office, Sangareddy. A total of 150 samples were collected, specifically 50 from each productive region from the topsoil layer (0 – 15 cm deep) before sowing of the *rabi* crop, 2022-2023 by stratified random sampling method. These samples were then air-dried, crushed to pass through 2 mm sieve, stored in plastic bags and subjected to further laboratory analysis.

2.3 Laboratory Analysis

The collected soil samples were analysed for the parameters *i.e.,* soil texture by Bouyoucos hydrometer method that elucidates the particles size distribution as described by Piper, 1966 [8]. The analysis for available nitrogen was carried out by alkaline permanganate method (Subbaiah and Asija, 1956) [13], available phosphorus by olsen's method using colorimeter at 660 nm (Olsen *et al*., 1954) [7] and available potassium by extraction with neutral normal ammonium acetate using flame photometer (Jackson, 1973) [4] that aimed to explore the relation between soil characteristics and rice productivity in the three regions of Sangareddy district.

3. RESULTS AND DISCUSSION

3.1 Computation of particle size analysis in the three productivity regions

In terms of soil physical features, Table 1 and Figure 2 show the particle size distribution of soils classified as clay, clay loamy, gravelly clay, sandy clay loam, and sandy clay, revealing the diversity of the research area's soils. Sand concentration in high-productivity locations varied between 12.4% and 61.1%, with an average of 32.1%, a standard deviation of 9.4, and a coefficient of variation of 29.4%. The range for medium productivity regions was 14.6% to 61.1%, with an average of 33.7%, a standard deviation of 10.2, and a coefficient of variation of 30.2%. The low productivity locations ranged from 20.4% to 57.1%, with an average of 37.5%, a standard deviation of 8.4, and a coefficient of variation of 22.4%.

In terms of silt content, high productivity locations ranged from 9.9% to 34.1%, with an average of 26.7%, a standard deviation of 4.7, and a coefficient of variation of 17.7 percent. The range for medium productivity regions was 9.9% to 30.8%, with an average of 26.1%, a standard deviation of 5.0, and a coefficient of variation of 19.2%. Low productivity locations showed a range of 5.0% to 31.2%, with an average of 25.1%, a standard deviation of 6.35, and a high coefficient of variation of 28.7%.

On the examination of clay content, high productivity regions showcased a range of 24.5% to 69.7%, averaging at 41.1% with a standard deviation of 9.4 and a 23.0% coefficient of variation. In medium productivity areas, the range was 28.9% to 55.8%, averaging at 40.1% with a standard deviation of 8.2 and a 20.6% coefficient of variation. Low productivity regions displayed a range of 19.9% to 62.0%, with an average of 37.2%, standard deviation of 7.94 and a 20.3% coefficient of variation. Figure 2 provides a graphical representation of distribution of soil particles in three productive regions.

Thus, it can be inferred that soils of three regions contributed to their unique composition. Sand content varied across productivity regions, with the highest mean observed in low productivity areas. Silt content varied significantly, with the highest coefficient of variation observed in medium and low productivity regions. Clay content displays variations, with the highest mean observed in high productivity regions and a notable coefficient of variation in low productivity areas. High productivity regions tend to have lower mean sand and high silt, clay contents compared to the other two, favouring the aggregation of soil particles. The similar results were observed in high, medium and low productive paddy soils of Liu *et al*., 2014 [6]. Particle size distribution that helps in the determination of soil texture, which in turn shows its impact on root production and, consequently, water and nutrient uptake. Notably, clay soil proves advantageous for higher grain yield due to its ability to retain water and nutrients, resulting in heavier seeds, and improved grain filling compared to sandy soil (Dou *et al*., 2016) [2]. The variability in particle size distribution across different productivity levels emphasizes the importance of soil aggregation in the effective agricultural management.

Table 1. Descriptive statistics of particle size analysis among the three Bengal gram productivity regions

HIGH PRODUCTIVITY REGIONS (n = 50)					
Soil Property	**Minimum**	**Maximum**	**Mean**	**SD**	**CV**
Sand (%)	12.40	61.12	32.14	9.46	29.43
Silt (%)	9.97	34.10	26.73	4.75	17.75
Clay (%)	24.56	69.70	41.13	9.49	23.07
MEDIUM PRODUCTIVITY REGIONS (n = 50)					
Soil Property	**Minimum**	**Maximum**	**Mean**	**SD**	**CV**
Sand (%)	14.60	61.12	33.73	10.22	30.29
Silt (%)	9.97	30.80	26.15	5.04	19.26
Clay (%)	28.90	55.80	40.11	8.27	20.62

LOW PRODUCTIVITY REGIONS (n = 50)					
Soil Property	**Minimum**	**Maximum**	**Mean**	**SD**	**CV**
Sand (%)	20.40	57.15	37.48	8.41	22.44
Silt (%)	5.00	31.20	25.12	6.35	28.71
Clay (%)	19.90	62.00	37.20	7.94	20.39

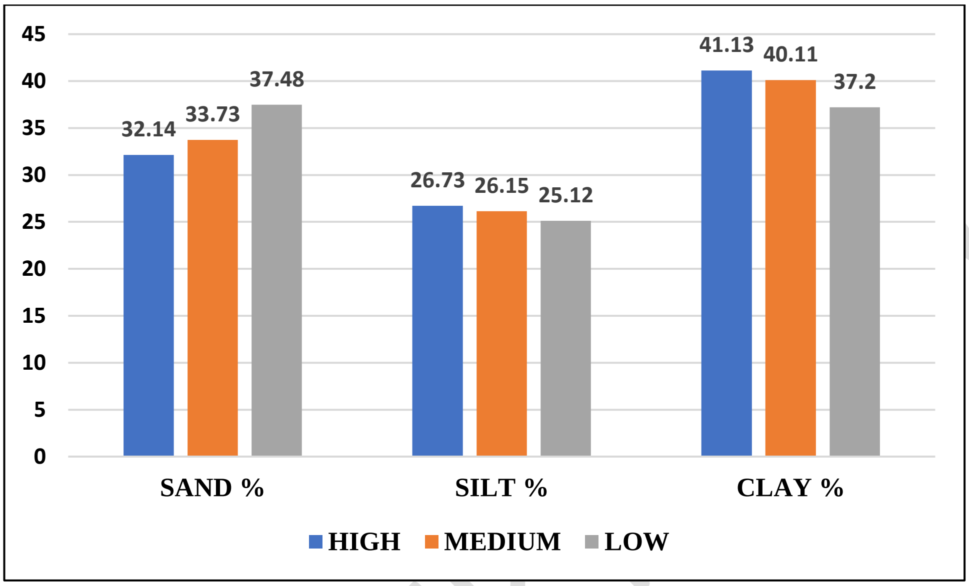

Figure 3. Particle size distribution among the three productivity Bengal gram regions

3.2 Computation of Primary Nutrients in the three productivity regions

3.2.1 Available Nitrogen

Nitrogen (N) is a major fertiliser for agriculture and food production. Nitrogen (N) is often the most limiting factor in crop production. Hence, application of fertilizer nitrogen results in higher biomass yields, protein yield and concentration in plant tissue is commonly increased. Information about nitrogen (N) availability in soil is important for optimizing N fertilizer recommendations.

In high-productivity zones, available nitrogen (N) in the current study (Table 2) ranged from 170.60 to 307.33 kg ha^{-1}, with a mean of 224.34 kg ha^{-1}, standard deviation of 31.42, and coefficient of variation of 14.01%. In medium productivity regions, the range was 155.55 to 292.28 kg ha^{-1} with a mean of 209.40 kg ha^{-1}, with standard deviation and coefficient of variation of 28.12 and 13.43%, respectively, and in low productivity regions, the range was 111.64 to 265.93 kg ha^{-1} with a mean of 204.09 kg ha^{-1}, with standard deviation of 37.34 and coefficient of variation 18.30%. The mean available N value followed a decreasing trend from high to medium and medium to low productivity regions whereas the standard deviation and coefficient of variation values indicated a moderate level of variability in N levels across the three productivity regions, with the highest variability in high and medium productivity areas. The categorization suggests a low to medium level of nitrogen availability in the soils across the studied regions.

Table 2 Descriptive statistics of primary nutrients among the three bengalgram productivity regions

HIGH PRODUCTIVITY REGIONS (n = 50)					
Soil Property	**Minimum**	**Maximum**	**Mean**	**SD**	**CV**
Available Nitrogen (kg ha^{-1})	170.60	307.33	224.34	31.42	14.01
Available Phosphorus (kg ha^{-1})	12.38	55.13	32.09	11.28	35.14
Available Potassium (kg ha^{-1})	196.88	434.25	316.49	55.27	17.46
MEDIUM PRODUCTIVITY REGIONS (n = 50)					
Soil Property	**Minimum**	**Maximum**	**Mean**	**SD**	**CV**
Available Nitrogen (kg ha^{-1})	155.55	292.28	209.40	28.12	13.43
Available Phosphorus (kg ha^{-1})	12.60	52.67	28.44	8.55	30.07
Available Potassium (kg ha^{-1})	198.0	423.00	311.01	59.79	19.22
LOW PRODUCTIVITY REGIONS (n = 50)					
Soil Property	**Minimum**	**Maximum**	**Mean**	**SD**	**CV**
Available Nitrogen (kg ha^{-1})	111.64	265.93	204.09	37.34	18.30
Available Phosphorus (kg ha^{-1})	14.25	48.58	24.85	8.42	33.89
Available Potassium (kg ha^{-1})	121.50	417.38	306.15	59.57	19.46

**SD – Standard deviation, CV – Coefficient of Variation*

3.2.2 Available Phosphorus

Phosphorus, as a macronutrient, is required for the conversion of sugars and starches, photosynthesis, energy transmission, and nutrient movement inside plants. In the current study, available P in high productivity locations ranged from 12.38 to 55.13 kg ha^{-1}, with a mean of 32.09 kg ha^{-1}, a standard deviation of 11.28, and a coefficient of variation of 35.14%. The available phosphorus in medium productivity regions ranged from 12.60 to 52.67 kg ha^{-1}, with a mean of 28.44 kg ha^{-1}, a standard deviation of 8.55, and a coefficient of variation of 30.07%. In low production zones, the range fluctuated between 14.25 to 48.58 kg ha^{-1}, with a mean of 24.85 kg ha^{-1}, standard deviation of 8.42 and coefficient of variation 33.89%, respectively. (Table 2). These outcomes are in line with the findings of Sannidi *et al*., 2022 [9]. This observed variability in available P levels emphasizes the importance of agricultural management practices based on the specific phosphorus dynamics within each productivity category.

3.2.3 Available Potassium

Potassium (K) is the second most abundant nutrient in plant photosynthetic tissues after nitrogen. It plays a fundamental role in plant function, especially in water-use efficiency and economy. It plays a particularly crucial role in a number of physiological processes vital to growth, yield, quality, and stress resistance of crops (Sekhon., 1999) [10], Srinivasarao and Vittal., 2007) [12].

The available K concentration in soils of high productivity locations ranged from 196.88 to 434.25 kg ha^{-1}, with a mean of 316.49 kg ha^{-1}, and standard deviation and coefficient of variation of 55.27 and 17.46%, respectively. Medium productivity zones have available K levels ranging from 198.0 to 423.00 kg ha^{-1}, with a mean of 311.01 kg ha^{-1}, 59.79 standard deviation, and 19.22% coefficient of variation. Similarly, low productivity locations displayed K levels ranging from 121.50 to 417.38 kg ha^{-1}, with a mean of 306.15 kg ha^{-1}, having standard deviation and coefficient of variation of 59.57 and 19.46%, respectively (Table 2) and are categorised from medium to high similar to the findings reported by Vasu *et al.*, 2016a [15]. The figure 4. provides a graphical representation of values of primary nutrients in the three productive regions. The large standard deviation and coefficient of variation values across productivity regions indicate a wide range of K levels within each group. Soil composition, weathering, and other environmental factors may all contribute to this heterogeneity. When adopting fertilisation techniques, farmers and agronomists should take into account the variety of soil conditions and factors impacting potassium availability.

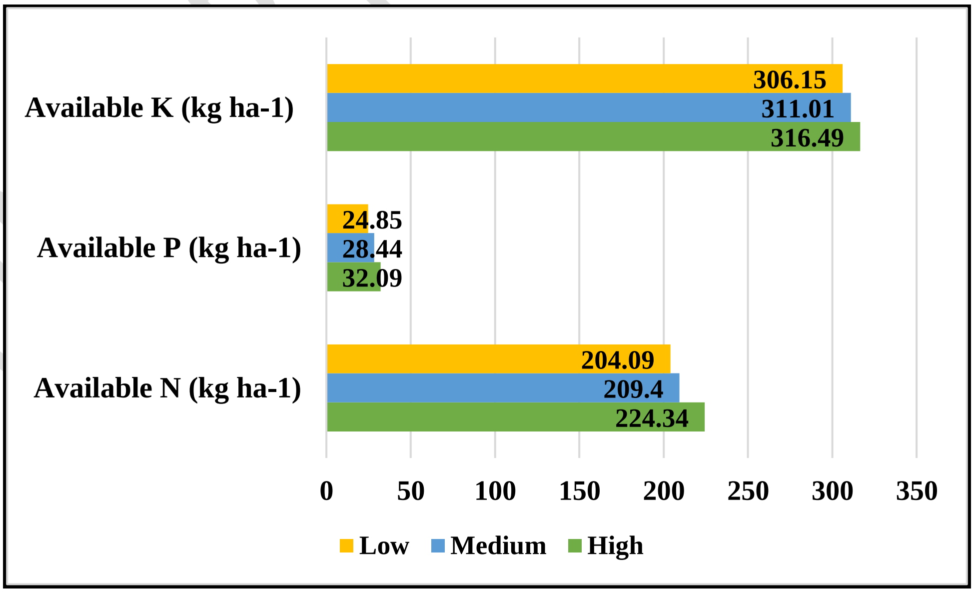

Figure 4. Depiction of Primary Nutrients Across Three Bengal gram Productivity Regions

4. CONCLUSION

The study reveals significant variation in sand, silt, and clay concentration, highlighting the varied soil compositions that contribute to the specific character of each productivity region. Notably, low productivity areas had the largest mean sand concentration, which influenced soil particle aggregation and, thus, crop yield. Silt content varied significantly, especially in medium and low production zones, whereas clay content varied, with the greatest mean in high productivity areas, promoting soil particle aggregation. The study area's soils had a low to medium level of nitrogen availability, which declined from high to medium to low productivity regions. The observed changes in available phosphorus levels underline the importance of agricultural management systems that account for phosphorus dynamics within each productivity category. Potassium levels appear to be widely dispersed within each category, as evidenced by high standard deviation and coefficient of variation values across the productivity regions. When developing fertilisation methods, farmers and soil scientists should consider a wide range of soil conditions and factors that influence potassium availability. Particle size distribution, which aids in the measurement of soil texture, influences water and nutrient uptake, resulting in an impact on root formation and, consequently yield.

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