Assessment of Soil Particle Distribution and Primary Nutrient Status in the Groundnut-Producing Areas of Nalgonda, Telangana.

Abstract

The current research involved a thorough field survey to assess particle size distribution and the availability of primary nutrients in *rabi*-grown groundnut soils (2022-2023) across three productivity regions: high (998.86-1202.59 kg acre^{-1}), medium (795.13-998.86 kg acre^{-1}), and low (up to 795.13 kg acre^{-1}) in Nalgonda district, Telangana. A total of 150 surface soil samples (0 - 15 cm depth), with 50 samples from each productivity region, were collected before the sowing of *rabi* groundnut crop using a stratified random sampling method. These collected soil samples are further processed and analysed for soil texture, available nitrogen (N), phosphorus (P) and potassium (K). The sand, silt and clay content in high, medium and low productivity regions averaged 72.90 %, 71.29 %, 67.56 %; 6.82 %, 8.35 %, 10.16 % and 20.27 %, 20.36 %, 22.27 % respectively. The respective available N, P and K showed mean values of 257.29 kg ha^{-1}, 189.40 kg ha^{-1} and 138.99 kg ha^{-1}; 48.025 kg ha^{-1}, 44.512 kg ha^{-1}, 27.09 kg ha^{-1} and 251.91 kg ha^{-1}, 236.48 kg ha^{-1}, 174.86 kg ha^{-1} in high, medium and low productivity regions. In regions characterized by high productivity, there was a pronounced prevalence of sand content, significantly influencing soil particle aggregation. Notably, silt content exhibited considerable variation, particularly within areas of medium and low productivity, whereas clay content displayed the most variability in regions of low productivity. The availability of nitrogen decreased sequentially from high to medium productivity areas, and further from medium to low productivity regions. This same pattern was observed for available phosphorus and potassium, with substantial variations across the three productivity categories, declining consistently from high productivity regions to low productivity ones. Variations in available phosphorus (P) and potassium (K) exhibited extensive dispersion within every productivity category, as evidenced by the significant standard deviation and coefficient of variation values across these regions. This is particularly notable for potassium, highlighting the necessity of considering diverse soil conditions and factors affecting potassium availability when formulating fertilization plans.

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

1. INTRODUCTION

Soil, an indispensable natural resource, constitutes a crucial component of the terrestrial ecosystem and fulfills a multitude of roles, notably in facilitating plant growth (Nwachokor *et al*., 2009) [11]. Comprehending its properties is imperative for strategic land use planning aimed at optimizing agricultural output (Kumar *et al*., 2013) [6]. The physical, chemical, and biological attributes of soil exert substantial influence on its various functions, including its role as a medium for plant growth, regulation of water supply, recycling of raw materials, and provision of habitat for soil organisms (Vasu *et al*., 2016b) [19]. Agricultural soil quality, shaped by its physical properties, which primarily pertain to its strength and storage characteristics within the root zone of crops (Mohanty *et al*., 2007) [8], directly impacts both crop performance and environmental sustainability. Soil texture, a persistent trait, functions as a crucial gauge for multiple factors that dictate the agricultural capability of soil, encompassing water retention, infiltration rate, aeration, fertility, tillage ease, and susceptibility to erosion (Nath, 2014) [10]. The physical attributes of soil have further degraded due to overfertilization and inadequate management, posing a threat to soil productivity potential (Kumar *et al*., 2018) [7].

Nitrogen (N) is required by plants in comparatively larger amounts than other elements. As a crop of Leguminosae family, groundnut can fix as much as 40-80 kg N ha^{-1} yr^{-1}. About 86-92% of the N taken up by the groundnut comes from Biological Nitrogen Fixation (BNF) which is equivalent to 125-178 kg N ha^{-1}. Although legumes can fix their own N, they often need phosphorus and calcium and other nutrients for good seed formation. Phosphorus (P) is the second major essential nutrient element for crop growth and good quality yield. The most obvious effect of P is on the plant root system. The requirement of P in nodulating legumes is higher compared to non-nodulating crops as it plays a significant role in nodule formation and fixation of atmospheric nitrogen.

In addition to physical properties, soil fertility significantly influences plant growth, determined by the concentrations of water, micronutrients, organic and inorganic materials, as well as the availability of nitrogen (N), phosphorus (P), and potassium (K). The NPK ratio serves as a critical indicator of crop productivity, quality, and yield, distinguishing between balanced and imbalanced fertilization practices. Thus, achieving optimal crop production requires careful and balanced application of fertilizers (Tale and Ingole, 2015) [17]. Soil chemical fertility, particularly nutrient deficiency, plays a significant role in soil degradation, limiting productivity, stability, and sustainability (Hartemink, 2010) [1]. Nutrient cycling in the soil, influenced by various inputs and losses, maintains the equilibrium of organic and inorganic constituents. Long-term fertilizer trials have revealed diminishing yields with continuous chemical fertilizer use, attributed to a decrease in nutrient supply and soil fertility, which impacts global food security

(Shahid *et al*., 2013) [15], essential for sustainable agricultural production. However, the extensive use of agrochemicals resulting from industrialization and agricultural expansion poses risks such as soil degradation and adverse effects on agricultural productivity (Narkhede *et al*., 2011) [9].

Groundnut (*Arachis hypogaea* L.) is important oilseed crop and oil content of the seed varies from 44-50%, depending on the varieties and agronomic conditions. They are rich in protein and vitamins A, B. The cake can be used for manufacturing artificial fibre. The haulms are fed (green, dried or silaged) to livestock. Groundnut shell is used as fuel for manufacturing coarse boards, cork substitutes etc. Groundnut is also of value as a rotation crop. The production are concentrated in the four states of Gujarat, Andhra Pradesh, Tamil Nadu and Karnataka. Andhra Pradesh, Tamil Nadu, Karnataka and Orissa have irrigated areas. (Source-IndiaAgroNet.com).

Groundnut is grown in an area of 31.5 million hectares worldwide with a total production of 53.6 million tonnes and an average productivity of 1699 kg/ha (FAOSTAT, 2020) [3]. India is the second largest producer of groundnut after China with an area of 6.01 million hectares, production of 10.2 million tonnes and productivity of 1703 kg/ha (INDIASTAT, 2020-21) [4]. In India, Gujarat (2.16 million hectares) has most area under groundnut followed by Rajasthan, Andhra Pradesh, Karnataka and Tamil Nadu. In Telangana, groundnut is predominantly cultivated as a *rabi* crop in an area of 0.12 million hectares with a production and productivity of 0.29 million tonnes and 2286 kg/ha respectively (INDIASTAT, 2020-21) [4]. Highest productivity is in Bhadradri, Medium is in Nagarkurnool and lowest is in Janagaon and Nalgonda. The major groundnut growing districts in the state are Nagarkurnool, Wanaparthy, Gadwal and Mahabubnagar.

2. MATERIAL AND METHODS

2.1 Location of study site

Nalgonda district of Telangana state in India is located with the GPS coordinates of 17° 3' 23.8320" N Latitudes and 79° 16' 5.9988" E Longitudes with the borders of districts Yadadri Bhuvanagiri to the north, while the Suryapet to the east, Ranga Reddy to the west, and the Guntur

District of Andhra Pradesh state to the south(https://nalgonda.telangana.gov.in/about-district/)[2]. The study site of Groundnut soil regions of Nalgonda district, Telangana, India, are illustrated in Figure 1.

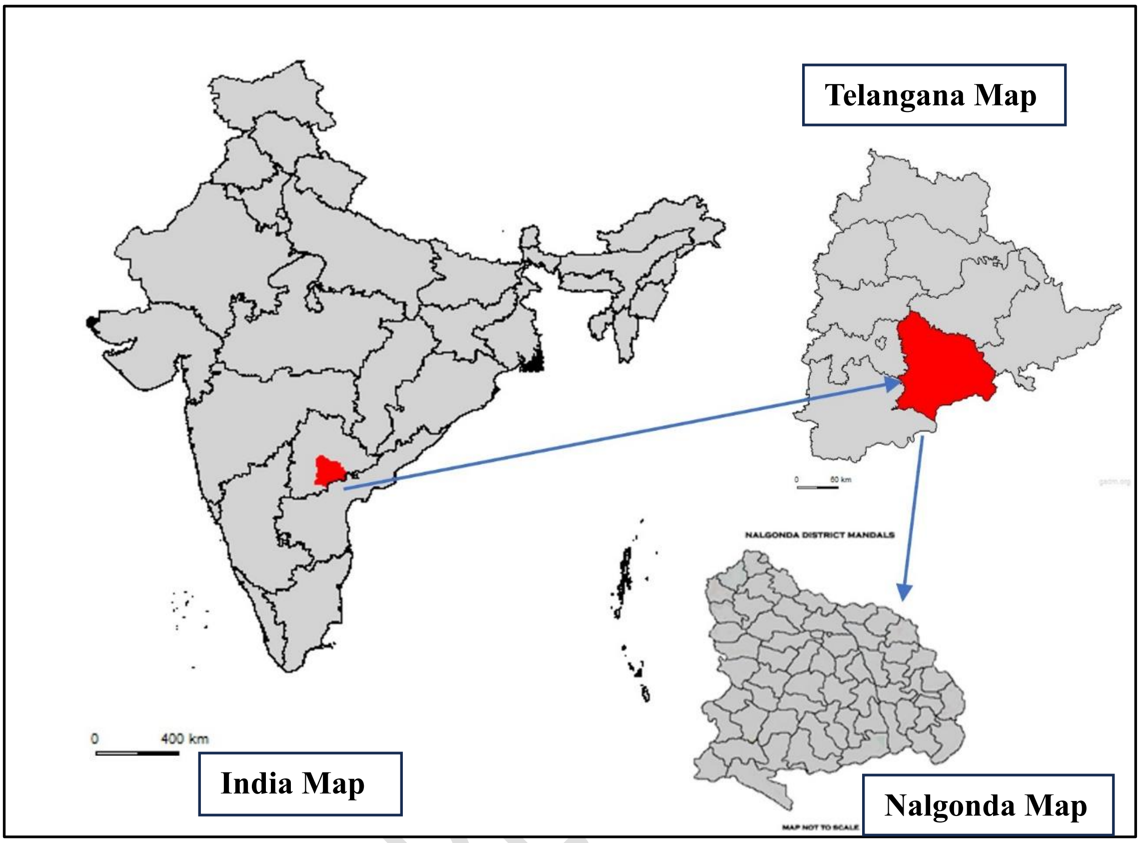

Fig. 1. Location of the study site

2.2 Soil sample collection

The present study involved the survey and collection of soil samples from the study area where groundnut was cultivated by dividing the mandals of the district into low (up to 795.13 kg acre^{-1}), medium (795.13-998.86 kg acre^{-1}) and high (998.86-1202.59 kg acre^{-1}) productive regions based on the area and yield data gathered from the District Agriculture office, Nalgonda. A total of 150 samples were collected, specifically 50 from each productive region from the topsoil layer (0 – 15 cm deep) before sowing the 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[13]. The analysis for available nitrogen was carried out by alkaline permanganate method (Subbaiah and Asija, 1956) [16], available phosphorus by Olsen's method using spectrophotometer or colorimeter at 660 nm (Olsen *et al*., 1954) [12] and available potassium by extraction with neutral normal ammonium acetate using flame photometer (Jackson, 1973) [5] that aimed to explore the relation between soil characteristics and groundnut productivity in the three regions of Nalgonda district.

3. RESULTS AND DISCUSSION

3.1 Valuation of Particle size analysis in the three productivity regions

Table 1 and Figure 2 depict the particle size distribution of soils, showcasing variations ranging from clay loamy to sandy clay, thereby highlighting the diverse soil compositions within the study area. In regions with high productivity, the sand content fluctuated between 39.68% and 89.37%, averaging at 72.90% with a standard deviation of 12.84 and 17.61% coefficient of variation. In medium productivity areas, the range was from 31.47 % to 91.23 %, averaging at 71.29% with a standard deviation of 13.87 and 19.47 % coefficient of variation. Low productivity regions saw a range of 31.63 % to 90.51 %, with an average of 67.56 %, a standard deviation of 14.68, and 21.74 % coefficient of variation.

Regarding silt content, high productivity regions showed a range from 2.24% to 18.48%, with an average of 6.82%, a standard deviation of 3.99, and a coefficient of variation of 58.45%. In medium productivity areas, the range extended from 2.85% to 23.72%, averaging at 8.35%, with a standard deviation of 4.56 and a coefficient of variation of 54.58%. Low productivity regions displayed a silt content range of 1.42% to 25.66%, with an average of 10.16%, a standard deviation of 6.02, and a coefficient of variation of 59.28%.

Upon analyzing clay content, high productivity regions exhibited a range from 6.88% to 46.11%, with an average of 20.27%, a standard deviation of 9.46, and a coefficient of variation of 46.70%. In medium productivity areas, the range spanned from 5.30% to 46.81%, averaging at 20.36%, with a standard deviation of 10.09 and a coefficient of variation of 49.60%. Low productivity regions showcased a clay content range of 8.07% to 47.10%, with an average of 22.27%, a standard deviation of 9.69, and a coefficient of variation of 43.52%. Figure 2 presents a visual representation of soil particle distribution across the three productivity regions.

Consequently, it can be deduced that the soils of the three regions exhibit distinct compositions. Sand content displays variability across productivity regions, with the highest average found in high productivity areas. Silt content exhibits significant variation, with the greatest coefficient of variation observed in low productivity regions. Clay content shows variations as well, with the highest average noted in low productivity regions and a noticeable coefficient of variation in medium productivity areas. High productivity regions typically feature higher mean sand content and lower silt and clay contents compared to the other two, facilitating the dispersion of soil particles.

Similar trends were observed in the high, medium, and low productive groundnut (peanut) soils studied by (Zhao *et al*., 2015) [20]. Particle size distribution plays a crucial role in determining soil texture, which, in turn, influences root production and, consequently, water and nutrient uptake. It's noteworthy that sandy soil promotes the growth of stems and leaves in peanut crops, resulting in higher yields compared to clay soil, which is less conducive to stem and leaf growth throughout the entire growth period. The variability in particle size distribution across different productivity levels underscores the significance of soil dispersion in effective agricultural management.

Table 1 Descriptive statistics of particle size analysis among the three groundnut productivity regions

HIGH PRODUCTIVITY REGIONS (n = 50)					
Soil Property	**Minimum**	**Maximum**	**Mean**	**SD**	**CV**
Sand (%)	39.68	89.37	72.90	12.84	17.61
Silt (%)	2.24	18.48	6.82	3.99	58.45
Clay (%)	6.88	46.11	20.27	9.46	46.70
MEDIUM PRODUCTIVITY REGIONS (n = 50)					
Soil Property	**Minimum**	**Maximum**	**Mean**	**SD**	**CV**
Sand (%)	31.47	91.23	71.29	13.87	19.47
Silt (%)	2.85	23.72	8.35	4.56	54.58
Clay (%)	5.30	46.81	20.36	10.09	49.60
LOW PRODUCTIVITY REGIONS (n = 50)					
Soil Property	**Minimum**	**Maximum**	**Mean**	**SD**	**CV**
Sand (%)	31.63	90.51	67.56	14.68	21.74
Silt (%)	1.42	25.66	10.16	6.02	59.28
Clay (%)	8.07	47.10	22.27	9.69	43.52

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

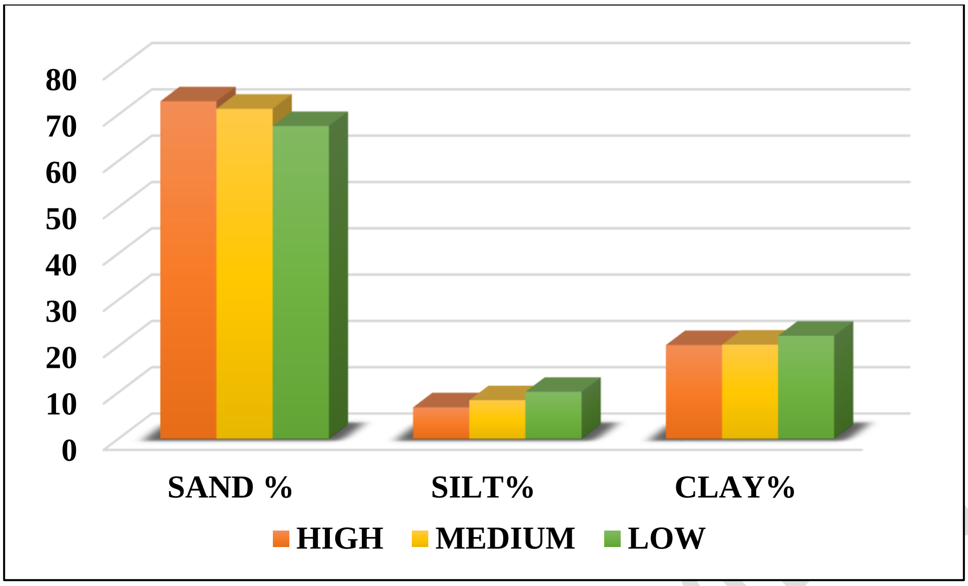

Figure 2. Particle size distribution among the three productivity groundnut regions

3.2 Valuation of Primary Nutrients in the three productivity regions

3.2.1 Available Nitrogen

Nitrogen is so vital because it is a major component of chlorophyll, the compound by which plants use sunlight energy to produce sugars from water and carbon dioxide (i.e., photosynthesis). It's also important because nitrogen is a: Major component of amino acids, the building blocks of proteins.

In high productivity regions, the available nitrogen (N) levels in the current study (Table 2) ranged from 169.84 to 349.60 kg ha-1, with a mean of 257.29 kg ha-1, a standard deviation of 55.22, and a coefficient of variation of 21.46%. Meanwhile, in medium productivity regions, the range spanned from 103.73 to 366.28 kg ha-1, with a mean of 189.40 kg ha-1. The standard deviation and coefficient of variation were 58.89 and 31.09% respectively. In low productivity regions, the available N ranged from87.43 to 213.49 kg ha-1, with a mean of 138.99 kg ha^{-1}, a standard deviation of 32.99, and a coefficient of variation of 23.74%. The mean available N values exhibited a decreasing trend from high to medium, and further from medium to low productivity regions. However, the standard deviation and coefficient of variation values suggested a moderate level of variability in N levels across the three productivity regions, with the highest variability observed in high and medium productivity areas. Overall, the categorization implies 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 groundnut productivity regions

HIGH PRODUCTIVITY REGIONS (n = 50)					
Soil Property	**Minimum**	**Maximum**	**Mean**	**SD**	**CV**
Available Nitrogen (kg ha^{-1})	169.84	349.60	257.29	55.22	21.46
Available Phosphorus (kg ha^{-1})	18.35	88.66	48.025	18.57	38.67
Available Potassium (kg ha^{-1})	173.65	389.85	251.91	41.06	16.30
MEDIUM PRODUCTIVITY REGIONS (n = 50)					
Soil Property	**Minimum**	**Maximum**	**Mean**	**SD**	**CV**
Available Nitrogen (kg ha^{-1})	103.73	366.28	189.40	58.89	31.09
Available Phosphorus (kg ha^{-1})	10.44	84.15	44.512	18.73	42.08
Available Potassium (kg ha^{-1})	108.10	343.85	236.48	52.09	22.02
LOW PRODUCTIVITY REGIONS (n = 50)					
Soil Property	**Minimum**	**Maximum**	**Mean**	**SD**	**CV**
Available Nitrogen (kg ha^{-1})	87.43	213.49	138.99	32.99	23.74
Available Phosphorus (kg ha^{-1})	10.45	47.16	27.09	8.38	30.94
Available Potassium (kg ha^{-1})	115.0	290.95	174.86	40.92	23.40

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

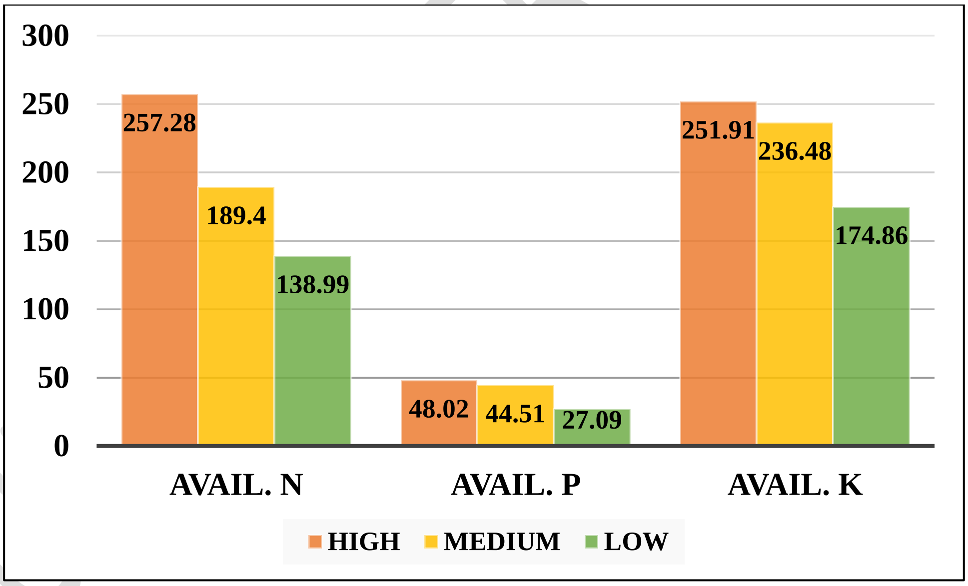

Figure 3. Depiction of Essential Nutrients Across Three Groundnut Productivity Regions

3.2.2 Available Phosphorus

Phosphorus is one of the major plant nutrients in the soil. It is a constituent of plant cells, essential for cell division and development of the growing tip of the plant. For this reason, it is vital for seedlings and young plants. In high productivity regions, the available phosphorus (P) ranged from 18.35 to 88.66 kg ha^{-1}, with a mean of 48.025 kg ha^{-1}, a standard deviation of

18.57, and a coefficient of variation of 38.67%. Meanwhile, in medium productivity regions, the range extended from 10.44 to 84.15 kg ha^{-1}, with a mean of 44.51 kg ha^{-1}, a standard deviation of 18.73, and a coefficient of variation of 42.08%. In low productivity regions, the range varied from 10.45 to 47.16 kg ha^{-1}, with a mean of 27.09 kg ha^{-1}, a standard deviation of 8.38, and a coefficient of variation of 30.94% (Table 2). These findings align with those of (Sannidi *et al*., 2022) [14]. The observed variability in available P levels underscores the significance of tailoring agricultural management practices to the specific phosphorus dynamics within each productivity category.

3.2.3 Available Potassium

Potassium is associated with the movement of water, nutrients and carbohydrates in plant tissue. It’s involved with enzyme activation within the plant, which affects protein, starch and adenosine triphosphate (ATP) production.

The production of ATP can regulate the rate of photosynthesis. Potassium also helps regulate the opening and closing of the stomata, which regulates the exchange of water vapor, oxygen and carbon dioxide. If K is deficient or not supplied in adequate amounts, it stunts plant growth and reduces yield.

The available potassium (K) content in soils in high productivity regions, varied from 173.65 to 389.85 kg ha^{-1}, with a mean of 251.91 kg ha$^{-1,}$ having standard deviation and coefficient of variation of 41.06 and 16.30 % respectively. Medium productivity regions displayed available K levels ranging from 108.10 to 343.85 kg ha^{-1}, with a mean of 236.48 kg ha^{-1} having standard deviation of 52.09 and 22.02 % coefficient of variation. Similarly, low productivity regions showcased K levels ranging from 115.0 to 290.95 kg ha^{-1}, with a mean of 174.86 kg ha^{-1} having standard deviation and coefficient of variation of 40.92 and 23.40 % respectively (Table 2) and are categorised from medium to high similar to the findings reported by Vasu *et al*., 2016a [18]. Figure 3 depicts a graphical representation of the primary nutrient values across the three productive regions. The notable standard deviation and coefficient of variation values observed across the productivity regions indicate a considerable dispersion of potassium (K) levels within each category. This variability can be attributed to factors such as soil composition, weathering, and other environmental influences. Hence, farmers and agronomists should take into account the diverse soil conditions and factors influencing potassium availability when devising fertilization strategies.

4. CONCLUSION

The research reveals notable disparities in sand, silt, and clay content, delineating distinct soil compositions contributing to the unique characteristics of each productivity zone. Notably, regions with high productivity exhibit the highest average sand content, impacting soil particle dispersion and subsequently crop yield. Silt content demonstrates significant variability, particularly in regions with medium and low productivity. Meanwhile, clay content displays variations, with high productivity areas showing the lowest average, favouring soil particle dispersion. Nitrogen availability in the soil exhibits a declining trend from high to medium and medium to low productivity regions. Fluctuations in available phosphorus underscore the importance of tailored agricultural management strategies considering phosphorus dynamics within each productivity category. Potassium levels within each category appear widely distributed, as evidenced by substantial standard deviation and coefficient of variation across productivity regions. When devising fertilization strategies, farmers and agronomists should consider various soil conditions and factors influencing potassium availability. Particle size distribution, pivotal in determining soil texture, affects water and nutrient uptake, consequently impacting root production and yield.

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