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Assessment of Macro-nutrients of Cultivated Soils in Rangareddy District of Telangana, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In the present study a comprehensive field survey was undertaken to evaluate the levels of soil macro nutrients in the arable lands of Rangareddy district, situated in the Southern Telangana region. A total of 179 surface soil samples (0–15 cm depth) were collected from the cultivable soils

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in parts of Rangareddy district, considering topography and soil types. This collection was accomplished using a stratified random sampling approach, conducted after the kharif season and prior to the commencement of the rabi season. The collected soil samples were analysed for soil Available Nitrogen (Avl. N) (Kg ha^{-1}), Available Phosphorus (Avl. P) (Kg ha^{-1}) and Available Potassium (Avl. K) (Kg ha^{-1}) using standard protocols. The prevalent soil types in the study area predominantly consist of clay, clayey loam, and gravelly clay. The concentrations of Avl. N, Avl. P, and Avl. K exhibited a range of 13.86 to 501.73 Kg ha^{-1}, 1.13 to 127.58 Kg ha^{-1}, and 69.88 to 896.0 Kg ha^{-1}, respectively. The outcomes pertaining to different crop varieties indicated that the highest content of Avl. N was observed in plantation crops, while the maximum Avl. P and Avl. K were recorded in agricultural soils. Conversely, the least Avl. N was noted in agricultural crop types, and the lowest Avl. P and Avl. K were registered in plantation crop types. Regarding soil categorizations, clay soils demonstrated the highest levels of Avl. NPK, whereas gravelly soils exhibited the lowest Avl. N content, and clayey loam soils displayed the lowest levels of Avl. P and Avl. K.

Keywords: Available nitrogen; available phosphorous; available potassium; soil types; crop types.

1. INTRODUCTION

Soils are integral components of terrestrial ecosystems, vital for sustaining life and promoting crop growth. They comprise intricate systems composed of minerals, organic matter, water, air, and living organisms. The evaluation of soil quality primarily revolves around soil fertility, which denotes the soil's ability to provide nutrients, water, air, and warmth for plant development. Monitoring soil health is crucial in precision agriculture, as optimal plant growth hinges on appropriate physical and chemical attributes within the soil [1]. Chemical properties of soil chiefly encompass the macro nutrients essential for plant growth, with these nutrient levels varying across different growth stages [2]. Ensuring sufficient levels of these vital macro nutrients such as nitrogen, phosphorus, and potassium (NPK) is pivotal, as they serve as indicators of soil quality and are critical for plant growth and vitality. The application of these macro nutrients through fertilization techniques is a common practice.

However, proper fertilization management is essential to avert negative consequences. Excessive fertilization can lead to environmental contamination by creating surplus artificial nutrient deposits that plants cannot fully utilize. While fertilizers have long been employed to enhance crop productivity, determining appropriate application rates tailored to specific plant requirements has historically been challenging and economically intricate.

In the realm of agriculture, assessing the levels of Nitrogen (N), Potassium (K), and Phosphorus (P) is pivotal in comprehending plant well-being and metabolic processes. This evaluation contributes to enhanced plant health management and metabolic functioning [3]. Ramane et al. [4] propose that the required fertilizer quantity hinges on the existing NPK nutrient composition in the soil. Owing to the variability of NPK nutrients in cultivated areas, researchers have developed and deployed a range of techniques for soil and plant nutrient assessment, spanning traditional chemical analysis to innovative methods like colorimetry, sensors, and spectroscopy-based technologies [5].

Hence, the assessment and measurement of soil macro nutrients (NPK) are imperative for effective monitoring and proactive management. A dependable and environmentally sustainable approach is necessary to rapidly determine soil macro nutrient levels in agricultural soils, identify areas of concern, and implement appropriate remediation procedures [6], Hong et al., 2019 [7]). By keeping the above-mentioned views in mind, a systematic survey was carried out to evaluate the soil macro nutrient status in the cultivable soils of Rangareddy district.

2. MATERIALS AND METHODS

2.1 Collection of Soil Samples

Rangareddy is situated (16˚ 66’ to 17˚ 54’ N and 77˚9’ to 78˚9’ E) in the Southern Telangana zone with an area of 5031 Km^2. The soils on the study site were classified as clay, clayey loam, and gravelly clay soils based on soil texture. Most of the Rangareddy district is covered with cultivable land with an area of about 3622.32 Sq. km. with different crop types like agricultural, horticultural and orchards. Around 179 surface (0–15 cm depth) soil samples from cultivable lands were collected from Ranga Reddy district considering topography and soil type using stratified random sampling after the completion of the kharif season and before the onset of the rabi season in 2022. The soil samples were collected only from cultivable lands, including agricultural, horticultural and plantation crops. The samples were air dried and sieved through a 2 mm mesh for Avl. NPK.

2.2 Laboratory Analysis

The soil Avl. N (Kg ha^{-1}) was estimated by using alkaline permanganate method as described by Subbaiah and Asija [8], Avl. P (Kg ha^{-1}) was estimated by Olsen's extractant as described by Olsen et al. [9] and Avl. K (Kg ha^{-1}) was estimated by using neutral normal ammonium acetate method and potassium in the extract was determined by using Flame photometer as described by Jackson [10].

3. RESULTS AND DISCUSSION

3.1 Soil Macronutrient Status

The descriptive statistics of soil Avl. N, Avl. P and Avl. K of Rangareddy are presented in Table 1. The results for Avl. N exhibit a range spanning from 13.86 to 501.73 Kg ha^{-1}, with an average of 129.46 Kg ha^{-1} and a standard deviation of 111.31. Similarly, the outcomes for Avl. P showcase values ranging from 1.13 to 127.58 Kg ha^{-1}, with a mean of 48.10 Kg ha^{-1} and a standard deviation of 33.81. The Avl. K results reveal values spanning from 69.88 to 896.0 Kg ha^{-1}, with an average of 307.18 Kg ha^{-1} and a standard deviation of 122.32. Chaitanya et al. [11] investigated soils suitable for vegetable cultivation in Rangareddy district, and reported that Avl. N, Avl. P, and Avl. K ranged from 138.0 to 250.9 Kg ha^{-1}, 10 to 64.9 Kg ha^{-1}, and 182.8 to 1856.1 Kg ha^{-1}, respectively. Kumari et al. [12] undertook a study on the distribution of the soil enzyme acid phosphatase and its correlation with physico-chemical properties in Rangareddy, and observed variations in Avl. N from 201.5 to 472.5 Kg ha^{-1}, Avl. P_2O_5 from 11.6 to 79.1 Kg ha^{-1}, and Avl. K_2O from 118 to 411 Kg ha^{-1}. Therefore, the results of the present study align with the outcomes reported in previous published research.

3.2 Distribution of Soil Avl. NPK under Various Crop Types

The majority of Rangareddy district comprises cultivable land, spanning approximately 3622.32 square kilometers, hosting various crop types including agricultural, horticultural, and plantation crops. Thus, samples were collected from distinct crop categories: out of the 179 samples, 98 were from agricultural crops, 62 from horticultural crops, and 19 from plantation crops. Descriptive statistics regarding soil physicochemical properties such as available nitrogen (Avl. N), available phosphorus (Avl. P), and available potassium (Avl. K) for different crop types are presented in Table 2. In soils cultivated with agricultural crops, Avl. N values ranged from 13.86 to 468.89 Kg ha^{-1}, with a mean of 122.05 Kg ha^{-1} and a standard deviation of 107.45. Avl. P values ranged from 1.43 to 127.58 Kg ha^{-1}, with a mean of 49.65 Kg ha^{-1} and a standard deviation of 33.98. Avl. K values ranged from 91.84 to 896.0 Kg ha^{-1}, with a mean of 316.05 Kg ha^{-1} and a standard deviation of 123.71. Conversely, in soils cultivated with horticultural crops, Avl. N values varied from 21.29 to 412.27 Kg ha^{-1}, with a mean of 132.20 Kg ha^{-1} and a standard deviation of 104.22. Avl. P values ranged from 1.80 to 124.20 Kg ha^{-1}, with a mean of 47.85 Kg ha^{-1} and a standard deviation of 35.44. Avl. K values spanned from 71.68 to 725.76 Kg ha^{-1}, with a mean of 300.20 Kg ha^{-1} and a standard deviation of 127.75. Lastly, in soils under plantation crops, Avl. N values exhibited a range of 30.49 to 501.73 Kg ha^{-1}, with a mean of 161.64 Kg ha^{-1} and a standard deviation of 150.00. Avl. P values ranged from 1.13 to 104.85 Kg ha^{-1}, with a mean of 42.26 Kg ha^{-1} and a standard deviation of 28.47. Avl. K values spanned from 69.88 to 470.40 Kg ha^{-1}, with a mean of 287.21 Kg ha^{-1} and a standard deviation of 99.37. Fig. 1 provides a graphical representation of soil Avl. NPK content for different crop types. The outcomes illustrate that the highest and lowest Avl. N (Kg ha^{-1}) values were recorded in soils with plantation crops and agricultural crops, respectively. Similarly, the highest and lowest Avl. P (Kg ha^{-1}) values were observed in soils with agricultural crops and plantation crops, respectively. Likewise, the highest and lowest Avl. K (Kg ha^{-1}) values were noted in soils with agricultural crops and plantation crops, respectively. Saritha et al. [13] conducted research on soils intended for tomato cultivation in Ranga Reddy, Telangana, revealing that the average available N, P_2O_5, and K_2O content in these soils were 196.44 Kg ha^{-1}, 54.96 Kg ha^{-1}, and 54.72 Kg ha^{-1}, respectively.

Table 1. Status of soil Avl. NPK

Parameters	Avl. N (Kg ha^{-1})	Avl. P (Kg ha^{-1})	Avl. K (Kg ha^{-1})
Maximum	501.73	127.58	896.00
Minimum	13.86	1.13	69.88
Mean	129.46	48.10	307.18
SD	111.31	33.81	122.32
CV (%)	85.98	70.28	39.82
Skewness	1.47	0.59	0.76
Kurtosis	1.44	-0.76	2.85
Range	487.87	126.45	826.12

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

Table 2. Distribution of soil Avl. NPK under various crop types

Agricultural crops (n=98)			
Parameters	**Avl. N (Kg ha^{-1})**	**Avl. P (Kg ha^{-1})**	**Avl. K (Kg ha^{-1})**
Maximum	468.89	127.58	896.00
Minimum	13.86	1.43	91.84
Mean	122.05	49.65	316.05
SD	107.45	33.98	123.71
CV (%)	88.04	68.43	39.14
Skewness	1.69	0.56	0.84
Kurtosis	2.30	-0.72	3.81
Horticulture crops (n=62)			
Parameters	**Avl. N (Kg ha^{-1})**	**Avl. P (Kg ha^{-1})**	**Avl. K (Kg ha^{-1})**
Maximum	412.27	124.20	725.76
Minimum	21.29	1.80	71.68
Mean	132.20	47.85	300.20
SD	104.22	35.44	127.75
CV (%)	78.83	74.07	42.56
Skewness	1.06	0.60	0.72
Kurtosis	0.26	-0.95	1.78
Plantation crops (n=19)			
Parameters	**Avl. N (Kg ha^{-1})**	**Avl. P (Kg ha^{-1})**	**Avl. K (Kg ha^{-1})**
Maximum	501.73	104.85	470.40
Minimum	30.49	1.13	69.88
Mean	161.64	42.26	287.21
SD	150.00	28.47	99.37
CV (%)	92.80	67.35	34.60
Skewness	1.25	0.48	0.04
Kurtosis	0.27	-0.45	0.24

Table 3. Distribution of soil Avl. NPK under various soil types

Clayey soils (n=86)			
Parameters	**Avl. N (Kg ha^{-1})**	**Avl. P (Kg ha^{-1})**	**Avl. K (Kg ha^{-1})**
Maximum	501.73	127.58	896.00
Minimum	22.55	1.43	71.68
Mean	125.91	42.20	304.61
SD	114.67	32.62	132.15
CV (%)	91.07	77.29	43.38

Clayey loam soils (n=90)			
Parameters	**Avl. N (Kg ha^{-1})**	**Avl. P (Kg ha^{-1})**	**Avl. K (Kg ha^{-1})**
Maximum	455.24	124.20	725.76
Minimum	16.88	1.13	69.88
Mean	134.31	53.72	310.03
SD	109.25	34.31	113.91
CV (%)	81.34	63.86	36.74
Gravelly soils (n=3)			
Parameters	**Avl. N (Kg ha^{-1})**	**Avl. P (Kg ha^{-1})**	**Avl. K (Kg ha^{-1})**
Maximum	187.24	85.95	394.24
Minimum	13.86	16.88	184.80
Mean	85.60	48.83	294.93
SD	90.47	34.83	105.14
CV (%)	105.70	71.33	35.65

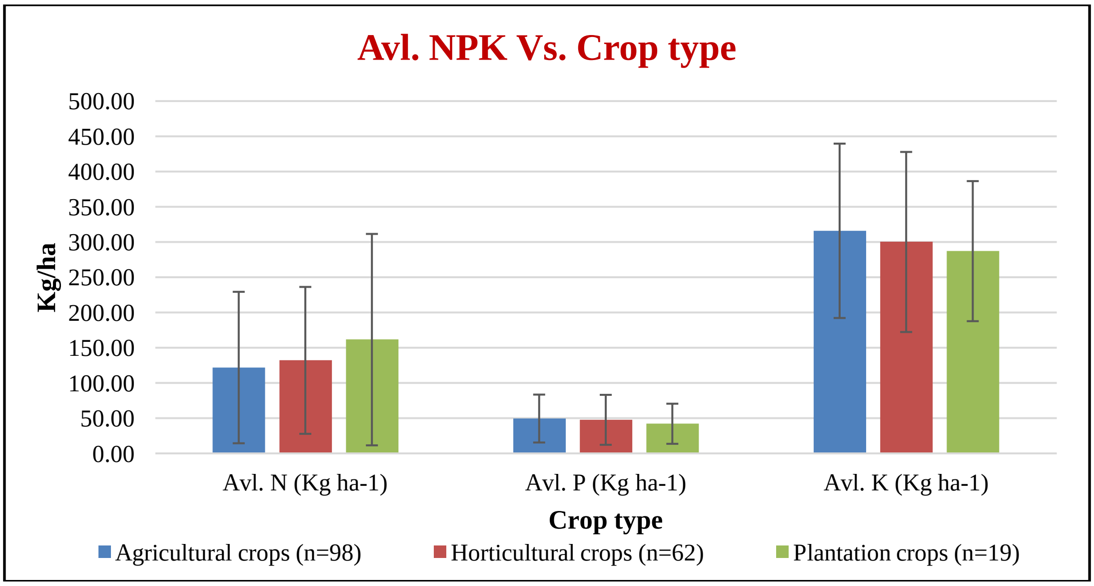

Fig. 1. Graphical representation of soil Avl. NPK under various crop types
**Error bars represent standard deviation*

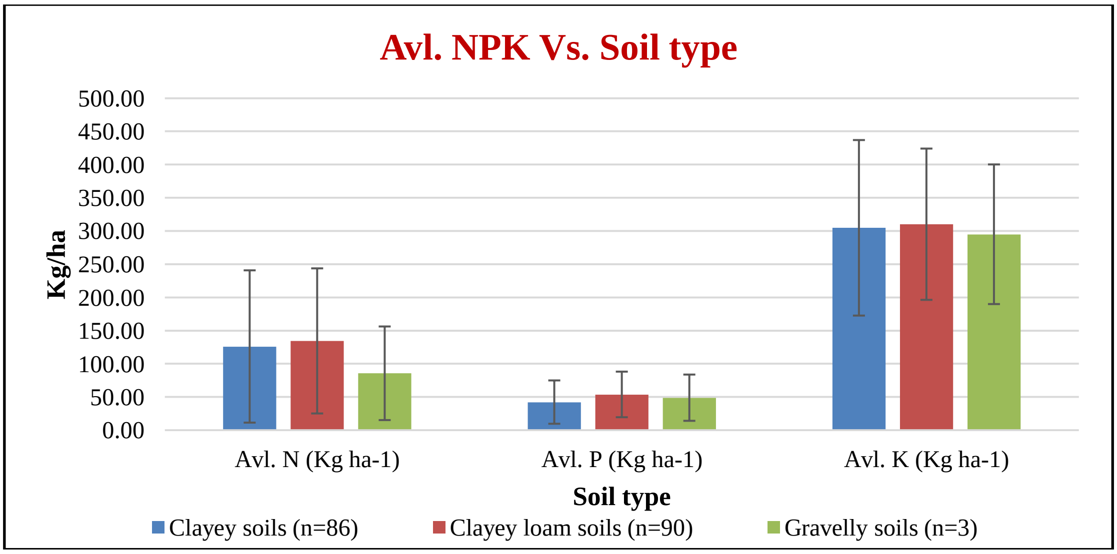

Fig. 2. Graphical representation of soil Avl. NPK under various crop types
**Error bars represent standard deviation*

3.3 Distribution of Soil Avl. NPK under Various Soil Types

Table 3 presents the descriptive statistics of soil physicochemical properties including available nitrogen (Avl. N), available phosphorus (Avl. P), and available potassium (Avl. K) for different soil types. For clayey soils, the Avl. N content ranged from 22.5 Kg/ha to 501.73 Kg ha^{-1}, with a mean of 125.91 Kg ha^{-1} and a standard deviation of 114.67. Avl. P content ranged from 1.43 Kg/ha to 127.58 Kg ha^{-1}, with a mean of 42.20 Kg ha^{-1} and a standard deviation of 32.62. Avl. K content ranged from 71.68 Kg ha^{-1} to 896.0 Kg ha^{-1}, with a mean of 304.61 Kg ha^{-1} and a standard deviation of 132.15. Similarly, for clayey loam soils, Avl. N content ranged from 16.88 Kg ha^{-1} to 455.24 Kg ha^{-1}, with a mean of 134.31 Kg ha^{-1} and a standard deviation of 109.25. Avl. P content varied from 1.13 Kg ha^{-1} to 124.20 Kg ha^{-1}, with a mean of 53.72 Kg ha^{-1} and a standard deviation of 34.31. Avl. K content ranged from 69.88 Kg ha^{-1} to 725.76 Kg ha^{-1}, with a mean of 310.03 Kg ha^{-1} and a standard deviation of 113.91. For gravelly clay soils, Avl. N content ranged from 13.86 Kg ha^{-1} to 187.24 Kg ha^{-1}, with a mean of 85.60 Kg ha^{-1} and a standard deviation of 90.47. Avl. P content ranged from 16.88 Kg ha^{-1} to 85.95 Kg ha^{-1}, with a mean of 48.83 Kg ha^{-1} and a standard deviation of 34.83. Avl. K content varied from 184.80 Kg ha^{-1} to 394.24 Kg ha^{-1}, with a mean of 294.93 Kg ha^{-1} and a standard deviation of 105.14. Fig. 2 provides a graphical representation of soil Avl. NPK content for different soil types. The outcomes indicate that the highest and lowest Avl. N values were recorded in clay soils and gravelly clay soils, respectively. Similarly, the highest and lowest Avl. P values were observed in clay soils and clayey loam soils, respectively. Additionally, the highest and lowest Avl. K values were noted in clay soils and clayey loam soils, respectively.

4. CONCLUSIONS

The study revealed that within the soils, the content of available nitrogen, available phosphorus, and available potassium spanned a range from 13.86 to 501.73 Kg ha^{-1}, 1.13 to 127.58 Kg ha^{-1}, and 69.88 to 896.0 Kg ha^{-1}, respectively. Findings concerning diverse crop types indicated that the highest Avl. N content was observed in plantation crop varieties, while the most elevated levels of Avl. P and Avl. K were found in agricultural soils. Conversely, the lowest Avl. N content was detected in agricultural crop types, and the lowest levels of Avl. P and Avl. K were registered in plantation crop types. In relation to different soil classifications, the outcomes revealed that the most substantial Avl. NPK content was found in clay soils. On the other end of the spectrum, gravelly soils exhibited the lowest Avl. N content, whereas clayey loam soils showcased the lowest levels of Avl. P and Avl. K.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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