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Analysis of nutrient status, growth and yield parameters of Mulberry plants growing in different mandals of Anantapur district

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ABSTRACT

The present study was conducted to determine nutrient/fertility status of the soils were derived to analysed based on the Parkers Nutrient Index and the computed index stated that the Phosphorus and potassium were at medium and high levels, besides the OC and Nitrogen being at the low and medium levels. Though variations occur in the concentration of the soil attributes, the yield attributes obtained were seen optimal for all of the monitoring sites. This is particularly crucial in precision agriculture, where understanding variations in soil properties across a field is essential for optimizing resource use, such as fertilizer application. The geostatistical procedures, management zone delineations can be facilitated and site-specific fertilizer application can be recommended.
Objectives of the study: Studying the soil fertility status of mulberry growing areas in Anantapur districts is essential for several reasons:

1. **Optimizing Silk Production:** Mulberry plant health directly affects silk quality and yield. Understanding soil fertility and yield helps in optimizing growth conditions.
2. **Nutrient Management:** Identifying nutrient deficiencies allows for precise fertilizer application, improving soil health and plant productivity.

INTRODUCTION

Mulberry sericulture is highly significant in Anantapur districtof Andhra Pradesh due to several factors It provides livelihood to many rural families, contributing to their income and financial stability. Sericulture is labor-intensive, creating numerous job opportunities, especially for women and small farmers; The regions have favorable agro-climatic conditions for mulberry cultivation and silk production. To ensure long term productivity of the agricultural land, sustainable land management techniques are a must to be implemented (Kothari et al., 2018). The average yearly crop production rate has decreased the effects of landscape and the soil properties on the yield variability can help in site specific by 3.5% because of poor land management practices, which have also had a substantial impact on soil quality and crop productivity.Variability in the soil properties depends upon complex interactions of the climate, organisms, topography, parent materials of the study area, which was defined by jenny and modified by McBratney as SCORPAN factors. Perceiving management and the maintaining sustainability. The diversification of the crop growing patterns and management practices can considerably affect the physical, chemical, and biological qualities of the soil (Tejaswani et al., 2022).

For formulating efficient land use policies, information on the soil variability at both regional and national level is indispensable. Several of the other studies described the significant impact of the soil properties and its associated variability on the crop yield through statistical techniques. Identifying the nutrient status through the random sampled soil points can be made feasible through Parker's Nutrient Index. The index integrates the soil parameter ratings for individual observations and computes the index for each soil attributes. Though, the index can help in deriving the insights about the fertility status of the soils, the major constraint includes the non-accountability of the spatial variation associated with the soil attributes (Sudhakar et al., 2020).

Materials and Methods

Study Area

The district was situated between 76° 50′ and 78°30'E, of the eastern longitudes and 13° 40′ and 15° 15'N, of northern latitudes. It is with an area of 19230 sq.kms which is the largest district in the state. In Ananthapuram district, the soil and plant samples were collected from Bathalapalle, Dharmavaram, Ramagiri, Chennekothapalle, Parigi,Hindupur and Lepakshimandals. Random sampling method was used to collect samples from the major mulberry growing areas. Soil sample observations were made of fifty-nine sites at Anantapur district for the perennial year 2022. Surface soil samples were collected at a depth of 0-15cm. The collected soil samples were air dried under shade, powdered and sieved through 2mm sieve and stored in polythene covers. The processed soil samples were then subjected to analysis for determining available N, P, K, pH, EC, organic carbon, and micro nutrients by adopting standard procedures as given in Table 1 and the sample collection sites and the study area of the research were depicted in Figure 1. Further, plant samples collected were then subjected to the yield and biochemical property assessment utilizing the methodology stated in Table 1.

Table 1. Soil and plant sample analysis methodologies

S. No	Parameters	Methodology	References
Physico – Chemical properties			
1.	Soil reaction (pH) (1:2.5 soil:water suspension)	Potentiometry	Jackson (1973)
2.	Electrical Conductivity (EC) (1:2.5 soil:water suspension)	Conductometry	
Chemical properties			
1.	Available Nitrogen	Kjeldahl method	Subbaiah&Asija (1956)
2.	Available Phosphorous	0.5 M $NaHCO_3$ (pH – 8.5)	Olsen (1954)
3.	Available Potassium	Neutral Normal ammonium acetate method	Stanford and English (1949)
4.	Soil Organic Carbon	Chromic acid wet Digestion	Walkley and Black(1934)
5.	Micronutrients (Cu, Fe, Mn, Zn)	DTPA method	Lindsay & Norvell (1978)
Yield and Biochemical properties			
1.	Plant Height	Observation collected at field site	-
2.	Total Number of leaves in a plant	Observation collected at field site	-
3.	100 leaves fresh weight	Observation collected at field site	-
4.	Leaf Moisture Percentage	Dry Weight Method	-
5.	Relative Water Content	González &Gonzanlez-Vilar's Method	González &Gonzanlez-Vilar's (2001)
6.	Total chlorophyll estimation	Arnon Method	Arnon (1949)
7	Total carbohydrates estimation	Anthrone Method	Hedge and Hofreiter (1962)
	Total Protein estimation	Lowry's method	Lowry (1951)

Parker's Nutrient Index

To truncate the soil attribute information into a single dimension, nutrient index framed by the Parker et al., 1951 was used to discriminate the fertility levels of the soils in the study area. The segregation of the soil samples for computing the index was evaluated for pH, Available NPK and organic carbon data. The index value of less than 1.67 is considered as low and value greater than 2.33 is considered as high and value between 1.67 and 2.33 is considered as medium.The parkers nutrient index can be given as,

$$Nutrient\ Index = \frac{\{(1*A)+(2*B)+(3*C)\}}{N}$$

Where,

A = Number of soil samples in low category,

B = Number of soil samples in medium category,

C = Number of soil samples in high category,

N = Number of soil samples.

Results and Discussion

Descriptive statistics and Parkers Nutrient Index

The nutrient properties of the study area collected for analyzing the pH, Electrical conductivity (EC), Organic Carbon (OC), Nitrogen (N), Phosphorous (P), Potassium (K), Copper (Cu), Manganese (Mn), Iron (Fe), Zinc (Zn). In general, the variability associated with the soil properties depends upon the soil forming factors to which they are correlated (Holmes et al. 2005). The descriptive statistics including the Minimum, Maximum, Mean, Median, and, Standard Deviation (SD) for each soil properties collected from Anantapur district were depicted in the Table 2.

Table 2. Descriptive statistics of the soil properties collected from Anantapur district

Soil Properties	Unit	Minimum	Maximum	Mean	Median	SD
pH	-	5.21	9.01	7.50	7.33	0.91
EC	dS/m	0.04	5.54	0.51	0.11	0.91

OC	%	0.07	1.23	0.45	0.43	0.21
N	Kg/ha	116.00	264.00	173.81	171.00	34.69
P	Kg/ha	9.72	156.25	86.41	83.68	38.99
K	Kg/ha	104.28	1317.00	299.45	202.20	237.03
Cu	ppm	0.50	3.08	1.58	1.52	0.63
Mn	ppm	1.73	12.00	7.83	10.50	3.90
Fe	ppm	1.78	14.52	4.74	4.16	2.58
Zn	ppm	0.42	3.08	1.25	1.08	0.58

The soil of the study area had variation in the pH values with most variation in the Anantapur district with the Standard deviation of 0.91. Though pH values showed variation with the spatial context, they were typically neutral to alkaline. The minimum and maximum values of the pH ranged from 5.21 to 9.01 with mean value of 7.50. The mean value of the EC of the study area was 0.51indicating the higher variability with the standard deviation of 0.91 explaining the non-saline conditions of soils favorable for the mulberry cultivation in the study area.The OC is typically low throughout the study area with the maximum value of 1.23. The low levels of the OC may be due to the intensified agricultural cultivation, tillage activities, high temperature, and high erodibility of the soils (John et al., 2020). The standard deviation of the OC property of the study area resulted in 0.21. The NPK of the study area constitutes the major nutritive measure of the fields and from the descriptive statistics, high level of potassium levels indicates the inclusion of the off-farm compost and manures at rates that exceeds the crop removal.

Though the NPK levels are not on par to the normal levels, the difference may be reflected due to the perennial nature of the mulberry trees, not adhering to the alternative cropping system and management practices.From the micronutrient statistics, Cu, Zn, and Mn shows the higher level of concentration based on its recommended levels, with Fe depicting the medium concentration.The higher and the lower levels might be reflected due to the management practices and indirect influence of other agricultural supplements instigated during cultivation.Decline or increase in the micronutrient properties of the soils can greatly influence the physiological functioning of the trees and can result in the pest and disease infestation.The following table depicts the results obtained from the computation of the parker's nutrient index (Table 4).

Table 3. Parker's Nutrient Index and remarks

Nutrient	Nutrient Index	Status
OC	1.42	Low
N	1.01	Low
P	2.96	High
K	2.28	Medium

From the above table, fertility status can be inferred based on the nutrient index computed and the Nitrogen shows low which may be attributed to the intensified agricultural cultivation and leaching of soils. Further, the nitrogen levels can be increased by supplementing nitrogen enriching fertilizers to the fields. Further, Phosphorous levels are high which can be attributed to the low precipitation levels which limits the removal of the soluble phosphorus. Potassium is in medium to high levels and the high levels of phosphorous and potassium in the soils indicates that the parameters are more prone to changes in the land use. The micronutrients varied medium to low in Anantapur district. In general, the low micronutrient condition can lead to nutritional uptake deficiency and can lead to pest and disease infestation in the cultivated fields. Necessary and required amount supplements can help in enriching the soils and can eliminate the imbalances in the soil fertility status.

Yield and biochemical characteristics observed

Besides the soil property estimation, the yield and biochemical attributes of the mulberry crops were also obtained from the monitoring sites of Anantapur district. The descriptive statistics of the yield and biochemical attributes were then estimated to derive insights on the observed datasets. The descriptive statistics derived for the yield and biochemical properties were depicted in Table 4. The Height of the trees varied with the maximum and minimum value of 217.67 cm and 146 cm, respectively. The mean, median, and standard deviation of the tree height also varied with measures of 178.83 cm, 175 cm, 22.12 cm, respectively. Similarly, the No. of shoots in the plants of Anantapur district varied with the maximum and minimum of 28 and 11, respectively. The mean, median, and standard deviation of the no. of shoots in the trees varied with the measures of 18, 18, and 3, respectively. Further, the total no. of leaves in the trees varied with the maximum and minimum values of 436 and 154, respectively. The mean, median and standard deviation of the total no. of leaves in the trees varied with the measures of 223, 206, and 57, respectively. The fresh weight of the leaves accounted had a maximum and minimum values of 291.37g and 13.37g, respectively. The mean, median, and standard deviation measures varied as 453.85g, 471.67g, and 131.70g, respectively. Further, the most important biochemical parameters (i.e.) Total Carbohydrates and Total Proteins are considered indispensable as they form the basis of the revenue generation in the mulberry cultivation. The total carbohydrates of the trees sampled had the minimum and maximum of 5.74 mg/g, and 20.02 mg/g, respectively. The mean, median and standard deviation of the measure varied with values of 11.66 mg/g, 10.64 mg/g, 4.05 mg/g, respectively. The total protein of the trees sampled further has the maximum and minimum values of 95.85 mg/g, 55.80 mg/g and with the mean, median, and standard deviation of 79.31 mg/g, 80.10 mg/g, 9.34 mg/g, respectively.

Table 4. Descriptive statistics of the yield and biochemical characteristics observed

Yield Attributes	Unit	Minimum	Maximum	Mean	Median	SD
HT	cm	146.00	217.67	178.83	175.00	22.12
NS	-	11.00	28.00	18.00	18.00	3.00
TL	-	154.00	436.00	223.21	206.00	57.27
MS	-	13.37	291.37	27.13	21.37	35.29
FW	g	27.37	972.00	453.85	471.67	131.70
100 FW	g	125.37	592.34	207.37	192.67	62.97
LM	%	65.24	79.97	73.23	73.04	4.31
RW	-	61.76	84.71	77.12	78.71	5.47
TC	-	1.42	3.72	2.30	2.16	0.63
TCH	mg/g	5.74	20.02	11 .66	10.64	4.05
TP	mg/g	55.80	95.85	79.31	80.10	9.34

Note: HT – Height(cm); NS – No. of Shoots; TL –Total No. of leaves; MS – No. of leaves in main stem; FW – Fresh weight of the leaves; 100 FW – 100 leaves fresh weight; LM – leaf moisture; RW – Relative water content; TC– Total Chlorophyll; TCH – Total Carbohydrates; TP – Total Protein

From the descriptive statistics derived for the yield properties, it can be inferred that the biomass content of the plants, majorly contribute towards to the metabolites which can be inferred from the mean height, shoot, and leaves quantitative aspects. Though reference measurements were not available to categorize or rate the yield parameters, inferential statements were provided by comparing the observations from the statistics observed. The standard deviation of the parameters was generally comparable for all the yield attributes indicating optimal variations in the influential parameters. Several of the studies indicated that the presence of irregular management and irrigation practices, salinization, sodification, high clay content, lower topographical position, and other soil nutritive abnormalities can impact the yields attributes (Stavi *et al.*, 2021). Moreover, the climatic parameters usually have a significant impact as their fluctuations can make the environment most vulnerable to the pest and disease infestation(Yáñez-López *et al.*, 2012). Further, from the mean observed of the yield attributes, it can be inferred that almost every monitoring site of the study area resulted with an optimal yield estimate corresponding to the observed soil attributes.

The average soil pH of 7.50, which is close to neutral, is well-suited for mulberry cultivation as it falls within the optimal range of slightly acidic to neutral soils (pH 6.0 to 7.5). This neutral pH is likely advantageous for nutrient availability, as evidenced by the observed average plant height of 178.83 cm and the number of shoots, which stands at 18.00. The mean electrical conductivity (EC) of 0.51 dS/m indicates that the soils are predominantly non-saline. Low salinity is crucial for preventing osmotic stress that can hinder nutrient uptake and growth, which is reflected in the observed fresh leaf weight of 453.85 g and other growth parameters that align with non-saline conditions conducive to optimal growth (Munns& Tester, 2008). The mean organic carbon (OC) content is relatively low, which may be a limiting factor affecting growth potential and nutrient availability. This is apparent in the fresh leaf weight (453.85 g) and the total number of leaves (223.21), where the low organic matter content could influence growth consistency (Marin *et al.*, 2022).

Nitrogen levels, with a mean of 173.81 kg/ha, fall within the ideal range for mulberry growth. Adequate nitrogen is essential for vegetative development, which is reflected in the observed height and number of shoots, suggesting that nitrogen availability is supporting robust plant growth (Barker &Pilbeam, 2007). The mean phosphorus level of 86.41 kg/ha is adequate for promoting strong root development and energy transfer, which aligns with the observed growth metrics, such as the high number of leaves and fresh weight (Havlin*et al.,* 2014). The potassium levels show considerable variability, ranging from 104.28 to 1317.00 kg/ha. While potassium is vital for water regulation and stress resistance, the significant variability may impact growth consistency. Nevertheless, the average potassium level of 299.45 kg/ha seems to support fresh weight and leaf moisture, though the variation indicates that some plants might experience potassium deficiency or excess (Marschner, 2011).

Total chlorophyll (2.30) and total carbohydrates (11.66 mg/g) are consistent with sufficient micronutrient availability, which supports efficient photosynthesis and overall plant health. High leaf moisture (73.23%) and relative water content (77.12) suggest effective water management, likely benefiting from the favourable soil conditions.

CONCLUSION

The calculation of Parker's Nutrient Index, offers a comprehensive assessment of soil fertility and nutrient distribution. This research significantly contributes to the arsenal of tools available for precision agriculture, providing a scientific basis for tailored soil management practices to enhance mulberry cultivation efficiency and sustainability.

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