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Soil nutritional evaluation using parkers nutrient index in tasar silkworm host plants growing soils of Jashpur districts of Chhattisgarh

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Abstract
Due to continuous tasar sericulture practices and use of imbalanced fertilizers, the areas gradually tend to show depletion of nutrients which has a negative impact on quality and quantity of cocoons. Hence, a detailed soil survey was undertaken in Jashpur District of Chhattisgarh state of India with an aim of evaluating the fertility status of soils under tasar host plants i.e. *Terminalia arjuna* and *T. tomentosa* growing regions. A total of 144 surface samples were collected from a depth of 0-30 cm and analyzed for physico-chemical properties of soil using standard analytical methods. The results indicated that the most of the soil samples were moderately acidic and lower in Soil Organic Carbon (SOC) percentage. Majority of the soil samples were low in nitrogen (97.9% samples), phosphorus (44.4% samples) and medium (69.44% samples) in potassium availability. Similarly, 47.22 % soil samples were medium in sulphur availability. Among the micronutrients, Zn was found to be sufficient in 37% cases, medium in 56% and deficient in 7%, whereas, B was found to be sufficient in 98%, Fe in 55%, Mn in 99% and Cu in 78%. Based on soil Nutrient Index Value (NIV), majority soil samples sites were showed low index in respect to SOC and available N and medium NIV in S. However, all other available nutrients i.e. P, K and micronutrients were higher NIV.

Keywords: Chhattisgarh, Jashpur, nutrient index, soil nutrients, Tasar host plants

1. Introduction
India has the distinction of being the only country in the world producing all the five commercially exploited silk varieties viz. Mulberry silk, tropical and temperate/Oak Tasar, Eri Silk and Muga. Tasar silkworm is reared in the jungles of central and north-eastern parts of India. Tasar culture is the main source of income for many tribal communities in India. Tasar silkworm (*Antheraea mylitta* D.) is a polyphagous insect feeding primarily on Asan (*Terminalia tomentosa*), Arjun (*T. arjuna*), Sal (*Sorea robusta)* and secondarily on more than two dozens of food plants [1]. The growth and development of tasar silkworm larvae and economic characters of cocoons are directly proportional to the nutritional contents of leaves [2]. The quality of tasar food plant leaves depend on the nutritional status of the soil.

Soil is the basic entity unit of life for all living organism being on earth. Soil is most valuable natural resource and takes several million years to form a defined soil pattern. Soil fertility is change unremittingly under the pressure of natural and human active factors. Repetitive rearing of tasar silkworm in host plants removes considerable amounts of nutrients from soil. Imbalanced and inadequate use of chemical fertilizers, improper irrigation and various cultural practices also deplete the soil quality rapidly [3]. Hence, assessment of fertility status of the soils of an area or a region is a vital aspect in the context of sustainable tasar silk production. Soil testing assess the present fertility status and gives information about availability of nutrient in soils which forms the source for the fertilizer recommendations for maximizing the quantity and quality of cocoons and concurrently sustain the fertility in soil for longer time. For proper soil management in tasar host plant growing regions, the tasar farmer should know what amendments are necessary to optimize the productivity of soil for profitable crops. At present, site specific information on fertility status of soils in tasar host plant growing regions of Jashpur district of Chhattisgarh are not available. Hence this study mainly focused on the soil fertility evaluation of various tasar host plant growing areas in Jashpur district of Chhattisgarh.

2. Materials and Methods

Soil samples were collected from tasar growing farmers' fields under *Terminalia arjuna* plantations. As such fields of Kunkuri (Geo-position 22°67' N latitude and 83°82' E longitude), Kansabel (22°95' N latitude and 83°62' E longitude), Farshabhahar (22°57' N latitude and 83°43' E longitude) and Duldula (22°72' N latitude and 84°10' E longitude) blocks under Jashpur district of Chhattisgarh state were selected for the study. The Jashpur district lies in the north-eastern corner of the Chhattisgarh state in India. Study areas falls under hottest regions with an annual rainfall of 1450 mm.

In order to studies on assessment of physico-chemical properties in soils of Jashpur district, 144 (25 from Kunkuri, 72 from Kansabel, 38 from Farshabhar and 9 from Duldula blocks) representative surface (0-30 cm) soil samples were collected, passed through <2 mm sieve and stored in properly labeled plastic bags. Soil pH and electrical conductivity (EC) were determined by potentiometer and direct reading conductivity meter using 1: 2.5 soil water suspensions [4]. The soil organic carbon (SOC) was determined by wet digestion method [5]. The soil samples were also analyzed for mineralizable N by alkaline permanganate method [6], available P [7], ammonium acetate extractable K [8] and sulphur [9]. The available Fe, Mn, Cu and Zn in soil samples were extracted with a DTPA solution (0.005M DTPA + 0.01 M $CaCl_2$ + 0.1M triethanolamine, pH 7.3 [10]. The hot water soluble B was estimated by UV-VIS Spectrophotometer [11]. Nutrient index value (NIV) was calculated using the following equation [12, 13].

$$Nutrient\ Index\ Value = ((NL \times 1 + NM \times 2 + NH \times 3))/NT$$

Where, NL, NM and NH are per cent samples testing low, medium and high category, respectively. NT means total number of soil samples have been used for calculating NIV.

3. Results and Discussion

3.1 Soil physical properties

The pH value of the soils of Kunkuri, Kansabel, Farshabhahar and Duldula blocks ranged from 4.7-7.10, 4.34-6.96, 3.90-6.54 and 5.18-6.23 with a mean value of 5.82, 5.81, 5.63 and 5.70, respectively (Table 1). The overall range of soil pH varied from 3.90-7.10 with an average pH of 5.74.

Table 1: Range and mean values of Physical properties of soil under selected tasar host plant growing area of Jashpur district

Village	No. of samples	pH		EC (dS m^{-1})		OC (%)	
		Range	Mean	Range	Mean	Range	Mean
Kunkuri	25	4.7-7.10	5.82	0.052-0.240	0.11	0.24-1.17	0.62
Kanshabel	72	4.34-6.96	5.81	0.028-0.31	0.11	0.21-1.08	0.51
Farshabhahar	38	3.90-6.54	5.63	0.024-0.328	0.08	0.21-1.05	0.47
Duldula	09	5.18-6.23	5.70	0.041-0.097	0.07	0.45-1.29	0.77
Range and Average		3.90-7.10	5.74	0.024-0.328	0.092	0.21-1.29	0.59
S.D.		0.54		0.04		0.24	

The pH value of soil suspension (1:2) of all representative soils was mostly moderately acidic (41.0%) followed by strongly acidic (26.4%) and slightly acidic (25.0%). Very limited number of soils showed neutral category of soil pH (2.8%) (Fig.1). Acid reaction of soil pH is mainly due to intensive weathering and leaching of soluble salts by the rainwater as these tasar practices done in vast forest regions experience hot and humid climatic conditions.

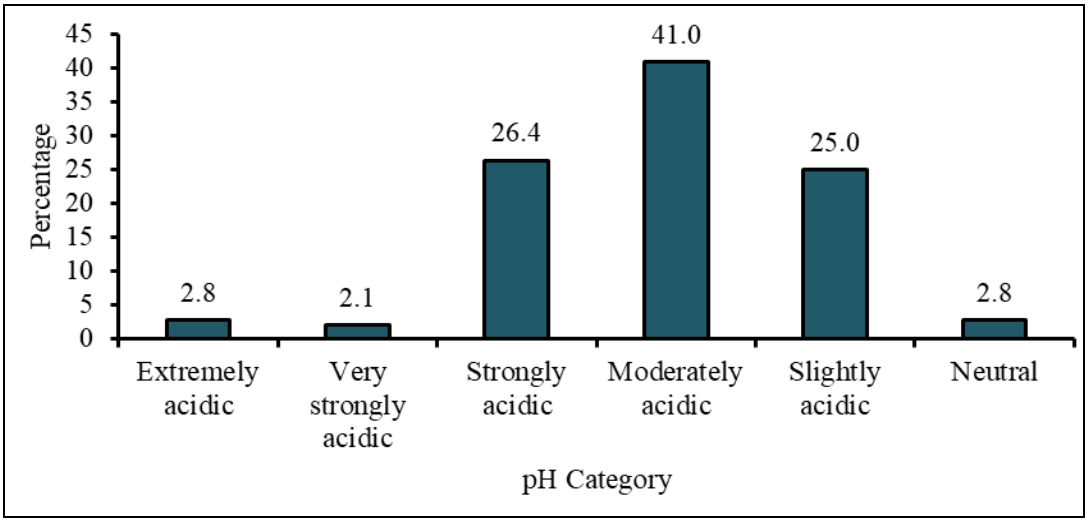

Fig 1: Percentage of soil pH in different category under selected tasar host plant growing area of Jashpur district

While the organic carbon content of Kunkuri, Kansabel, Farshabhahar and Duldula blocks soils were ranged from 0.24-1.17, 0.21-1.08, 0.21-1.05 and 0.45-1.29% with mean values of 0.62, 0.51, 0.47 and 0.77%, respectively (Table 1). The soils of the sampling area showed average range of SOC varied from 0.21 to 1.29 % with mean average value of the 0.59 % SOC. The analysed data showed that majority of soil samples falls under low SOC content (48.6%), medium in 38.2% and remaining 13.2% soil samples were low (Fig.2). The decreases in SOM at some locations might be associated with factors like high temperature (more organic matter decomposition) and erosion of soil due to high rainfall. Choudhary and Yadav [14] also reported that high temperature and rainfall may like to cause low organic matter of top soil.

3.2 Soil chemical properties

The available N varied from 66.5 to 342.7 kg ha^{-1} with mean average value of 154.6 kg ha^{-1}. The higher mean concentration of available N found in Kunkuri block (192.7 kg ha^{-1}) followed by Kansabel (153.3 kg ha^{-1}) and Duldula (140.9 kg ha^{-1}). The available N was low in Farshabhahar block (131.4 kg ha^{-1}) (Table 2). The results indicated that 97.9% of the samples falls under low fertility, while only 2.1% of the samples under medium fertility class (Fig. 2). It is quite obvious that being mobile in nature and low uptake recovery due to its losses through various mechanism like NH_3 volatilization, succeeding, denitrification, chemical and microbial fixation, leaching and runoff results in residual/available N becomes poor in soils [15]. Similar results were also reported by Rajeshwar *et al*., [16].

Table 2: Range and mean values of chemical properties status of soil under selected tasar host plant growing area of Jashpur district

Village	No. of samples	N (kg ha^{-1})	P (kg ha^{-1})			K (kg ha^{-1})		S (ppm)	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean
Kunkuri	25	96.7-342.7	192.7	1.70-33.30	10.14	189-334	273.5	7.15-19.83	11.48
Kanshabel	72	66.5-326.4	153.3	1.6-37.5	9.21	111-347	206.1	1.60-37.50	9.21
Farshabhahar	38	87.9-175.7	131.4	13.2-47.4	29.19	190-328	270.9	7.7-25.0	12.45
Duldula	09	120.5-198.3	140.9	14.0-68.3	34.02	149-308	245.3	8.18-16.55	11.29
Range and Average		66.5-342.7	154.6	1.6-68.3	20.6	111-347	249.0	1.60-37.50	11.10
S.D.		55.22	9.68			49.44		2.55	

In the present study, available P distribution ranges vary from 1.6 to 68.3 kg ha^{-1} with a mean values 20.6 kg ha^{-1} (Table 2). The higher mean value of available P (34.02 kg ha^{-1}) was found in Duldula followed by Farshabhahar (29.19 kg ha^{-1}) and Kunkuri (10.14 kg ha^{-1}). Kansabel block was recorded by low fertility status of available P as 9.21 kg ha^{-1}. The study indicates that about 44.4% of the sampled area exhibited low and 27.8% each under medium and high category of available P content (Fig. 2).

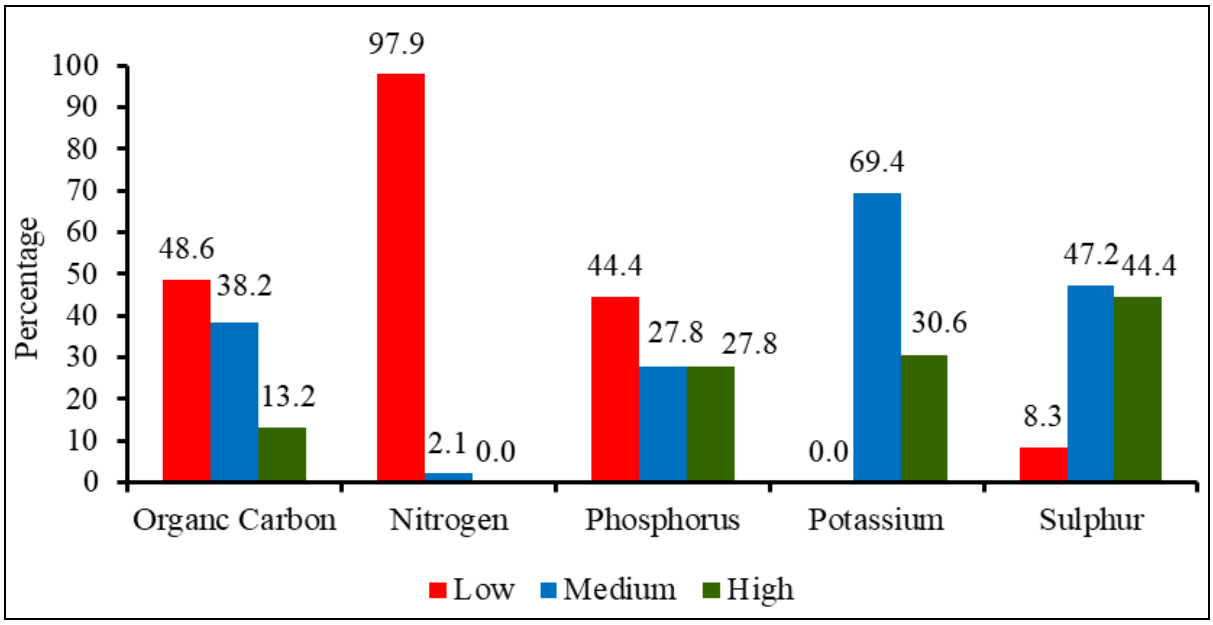

Fig 2: Percentage of OC & Macro nutrients in different category under sampling area

The results showed that the available K content in selected areas ranged from 111-347 kg ha^{-1} with an average value of 249 kg ha^{-1}. The higher mean value of available K was found in Kunkuri block (273.5 kg ha^{-1}) followed by Farshabhahar (270.9 kg ha^{-1}) and Duldula (245.3 kg ha^{-1}) (Table 2). The lower content of available K found in Kansabel block (206.1 kg ha^{-1}). The data revealed that 69.44% of total soil samples tested was in high level of available K and only 30.56% samples under medium range (Fig.2). Adequate level of available K in Vertisols of the study area may be attributed to the prevalence of K-rich clay minerals like illite and kaolinite. The available sulphur (S) content varied from 1.6-37.5 mg kg^{-1} with mean value of 11.1 mg kg^{-1} of soil in different study areas. Among the study area, the mean concentration of available S was higher in Farshabhahar (12.45 mg kg^{-1} of soil) and lower in Kansabel block (9.21 mg kg of soil). About 47.22 percent of soils show medium available S content and remaining 44.44 percent with high S content (Fig.2). Thus, the soils of all the sites are likely to respond sulphur fertilization. These results were also supported by Kumar *et al*. [17].

3.3 Micronutrients status of soil

The range and mean values of micronutrients in selected soils of tasar growing areas under Jashpur district are shown in Table 3 and their category illustrated in Fig. 3.

The contents of available DTPA-Zn in the locations ranged from 0.12 mg kg^{-1} in Farshabhahar to 8.22 mg kg^{-1} in Duldula with a mean value of 2.98 mg kg^{-1}. Based on the critical limits of Takkar and Mann [18], 56% samples were medium and 37% of the samples were sufficient. All the soil samples of selected areas showed pH in acid range might be resulted in favour to build up Zn in available form. Similar results were reported by Mahesh *et al*., [19] and Murthy *et al*., [20].

Table 3: Range and mean values of micronutrient status of soil under selected tasar host plant growing area of Jashpur district

Village	No. of samples	Zn (ppm)		B (ppm)		Fe (ppm)		Mn (ppm)		Cu (ppm)	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Kunkuri	25	0.24-5.45	2.04	0.38-27.9	9.4	0.10-19.78	8.70	3.40-62.35	30.22	0.28-7.53	1.41
Kansabel	72	0.16-6.96	2.54	1.08-33.46	5.29	1.53-35.95	11.92	3.13-60.75	25.351	0.10-3.20	0.83
Farshabahar	38	0.12-7.38	3.93	9.19-35.02	14.49	0.20-31.85	10.66	9.75-49.48	30.55	0.25-6.18	1.16
Duldula	09	0.54-8.22	3.42	8.89-13.57	11.10	0.33-9.73	4.98	29.03-48.7	38.46	0.43-0.85	0.56
Range and Mean		0.12-8.22	2.98	0.38-35.02	10.07	0.10-35.95	9.07	3.13-62.35	31.15	0.10-7.53	0.99
S.D.		1.83		7.01		7.64		13.25		0.97	

The content of available DTPA-B in soils varied from 0.38 mg kg^{-1} in Kunkuri to 35.02 mg kg^{-1} in Farshabhahar with an average value of 10.07 mg kg^{-1}. Results further illustrated on available DTPA-B in soil samples indicated that 98% soil samples were sufficiency in DTPA- B content and each one percentage of the soil samples were medium and low category, respectively with 0.50 mg kg^{-1} as the critical limit proposed by Lindsay and Novel [21].

The DTPA-Fe in the soil samples varied from 0.10 mg kg^{-1} in Kunkuri to 35.95 mg kg^{-1} in Kansabel with the mean value of 9.07 mg kg^{-1}, considering 4.8 mg kg^{-1} as critical limit for Fe deficiency [22]. The data indicated that 55% of soil samples were sufficient and 24 and 22% of soil samples were low and medium in DTPA-Fe availability, respectively. Fe deficiency is very unlikely in acid soils; as it is known to be soluble under relatively acid and reducing conditions [23].

DTPA-Mn in the studies soils ranged from 3.13 mg kg^{-1} Kansabel to 62.35 mg kg^{-1} in Kunkuri with an average value of 31.15 mg kg^{-1}. Considering 2.0 mg kg^{-1} as critical limit for Mn deficient, here all the 100% samples were sufficient in availability (Fig.1). These figures suggest that Mn content of the soils is high and cannot be a limiting factor to successful crop production in the area. This implies that the soils contain sufficient Mn for successful tasar sericulture in the area studied as they are above the critical limits of 2.0 mg kg^{-1}.

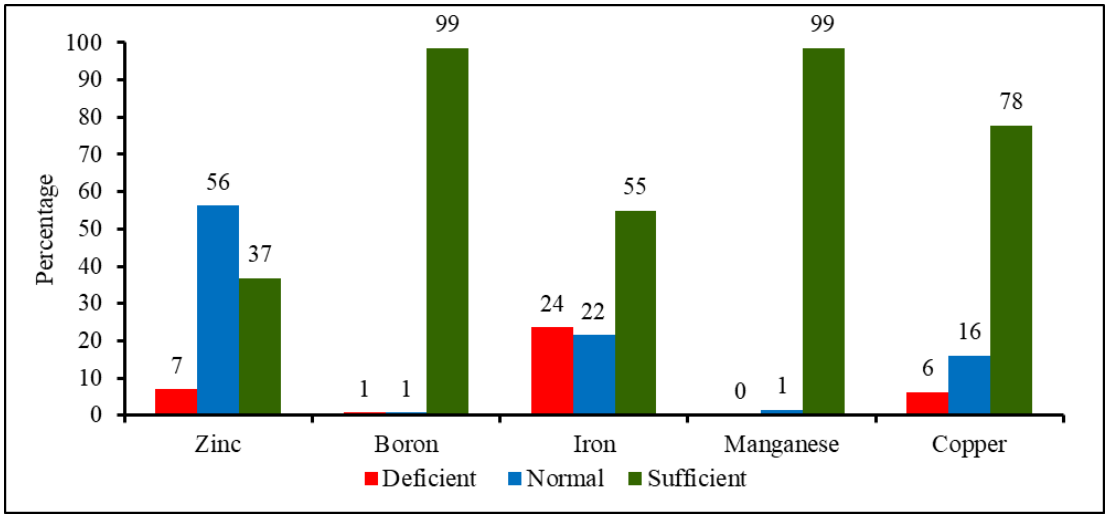

Fig 3: Percentage of Micro nutrients in different category under sampling area

The content of DTPA-Cu ranged from 0.10 mg kg^{-1} in Kansabel to 7.53 mg kg^{-1} in Kunkuri with mean value of 0.99 mg kg^{-1} in the studied locations. The data illustrated that 78% of the soil samples were sufficient, 16% samples were marginal and 6% of the soil samples were deficient. Cu deficiency was common in sandy soils with high pH [24]. Thus, it could be predicted that the deficiency of Cu would not occur in these soils in the nearest future.

3.4 Soil Nutrient Indices of different tasar regions

Soil nutrient index was calculated from low, medium and high ratings of soil nutrients. If the index value was less than 1.67, the fertility status was low; the status was medium, if value between 1.67 and 2.33. If the value was 2.33 or greater meant status was high. Based on soil NIV, Kunkuri and Duldula soils were showed medium and Kansabel and Farshabhahar showed low NIV of SOC. whereas, status of available nitrogen was low in all the places (Table 4).

Table 4: Nutrient Index Value of Tasar growing soil under sampling area

Place	OC	N	P	K	S	Zn	B	Fe	Mn	Cu
Kunkuri	1.96 (M)	1.04 (L)	1.60 (L)	2.52 (H)	1.80 (M)	2.80 (H)	2.88 (H)	2.36 (H)	2.96 (H)	3.00 (H)
Kansabel	1.60 (L)	1.03 (L)	1.40 (L)	2.10 (M)	2.83 (H)	2.75 (H)	3.00 (H)	2.39 (H)	2.97 (H)	2.65 (H)
Farshabhahar	1.39 (L)	1.00 (L)	2.63 (H)	2.50 (H)	1.95 (M)	2.76 (H)	3.00 (H)	2.26 (M)	3.00 (H)	2.89 (H)
Duldula	2.22 (M)	1.00 (L)	2.89 (H)	2.44 (H)	1.77 (M)	2.44 (H)	3.00 (H)	1.89 (M)	3.00 (H)	3.00 (H)

Note: L: Low; M: Medium; H: High

With respect to phosphorus, Kunkuri and Kansabel were of low index whereas Farshabhahar and Duldula soils were high in NIV. On the other hand, potassium fertility status was high in all the places except Kansabel region which showed medium NIV. In all the soils, sulphur status was medium rate except high in Kansabel. Conversely, micronutrients (Zn, B,

Fe, Mn and Cu) of all the tasar host plant growing soils of Jashpur districts fertility rating was high except medium fertility status of Fe in Farshabhahar and Duldula places. According to Ravikumar & Somashekar [25] the NPK status of Karnataka was L-L-H. In Uttar Pradesh the NPK status was L-M-M and the micronutrients were in sufficient amount [26].

4. Conclusion

Soil fertility status of selected tasar growing fields of all the four blocks of Jashpur district indicates extremely acidic to neutral with majority in moderately acidic and low to medium range for organic carbon status. Soil samples were low in available nitrogen and phosphorus in many places. The majority of the fields showed medium in available potassium and sulphur. All the micronutrients namely Zn, B, Fe, Mn and Cu were sufficient for tasar host plants. Thus, regular and site specific nutrient management are suggested for enhanced leaf yield and production of quality tasar cocoons in all selected regions. Hence, a balanced use of nutrients in organic and inorganic source seems to be essential for sustainable productivity and soil health in tasar growing regions.

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