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An extensive soil survey on plant micronutrients status in tasar silkworm host plants growing sites in Mayurbhanj district of Odisha State

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Abstract
A total of 236 composite soil samples were collected at 0-30 cm depths from four the eighteen villages of Mayurbhanj district, Odisha. The soils were analysed properly for basic soil physical parameters viz., pH, electrical conductivity (EC) and soil organic carbon (SOC) and micronutrients viz. Zinc (Zn), Boron (B), Iron (Fe), Manganese (Mn) and Copper (Cu). The results revealed that the soils under the study were moderate to slightly acidic in reaction, safe in limit of EC and medium to high in SOC content. The micronutrient status and their relationship with soil properties were also studied. Among the micronutrients, Zn was found to be sufficient in 30% cases, medium in 55% and deficient in 15%, whereas, B and Mn were found to be sufficient in all the soil samples. DTPA-Fe and Cu in 81 and 89% are sufficient range, respectively.

Keywords: Host plants, Mayurbhanj, micronutrients, Organic carbon, Tasar silkworm

Introduction

Silk constitutes only 0.3% of total fabrics of the world, but still it is called as '*Queen of Textiles*' due to its certain inherent qualities. India has the distinction of being the only country in the world producing all the five commercially exploited silk varieties (i.e. Mulberry silk, tropical and temperate/Oak Tasar, Eri Silk and Muga). Of which, 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]. Tasar rearing has always been an important traditional occupation of indigenous communities in north-west Odisha, particularly Kendujhar, Mayurbhanj and Sundargarh districts which contributes 90% of the state's tasar production. A total of 47,284 families are engaged in tasar sericulture as a livelihood in the state which has an annual tasar raw silk production of 107 MT in 2015-16 [2]. The agro climatic conditions and natural resources in the state are suitable for Tasar Silkworm rearing.

The growth and development of tasar silkworm larvae and economic characters of cocoons are directly proportional to the nutritional contents of leaves [3]. The quality of tasar food plant leaves depend on the nutritional status of the soil. Plant required seventeen elements as essential for general growth and development of plant cell. Though macronutrients such N, P and K plays major role in growth of the plant, certain micronutrients are also vital for plants. Most micronutrients are metallic mineral element crucial for tasar food plant growth in particularly minute quantity. Although required in minute quantities, micronutrients have the same agronomic importance as macronutrients and play imperative roles in the growth of plants [4]. These metallic micronutrients mainly consist of Zinc (Zn), Iron (Fe), Boron (B) Copper (Cu) and Manganese (Mn). Most micronutrients are associated with the enzymatic systems of plants. The continuous negligence of micronutrient application and avoidance of organic manures are major causes of deficiency of these micronutrients. In addition to this, the current fertilizer recommendation for tasar food plants under block plantation is only for macronutrients; continuous application of one or two macronutrients may in due course deplete the soil reserve of other nutrients and limit the silk quality performance.

In view of the above facts, a detailed soil nutritional study is carried out at assessing the micronutrient status in the fields of tasar farmers of Mayurbhanj district of Odisha state so as to accomplish sustainable and boost the production for tasar silk production while in tandem judicious utilization of soils.

2. Materials and Methods

2.1 Study site

A survey was carried out in the different villages of Mayurbhanj district (Fig. 1), which is situated at 21°94'N latitude and 86°72'E longitude with an average elevation of 36 m MSL. Summers are hot and dry with average temperatures ranging from lows of 21.0°C to highs 31.5 °C. Most of the rainfall occurs during the south-west monsoons as average rainfall is 1800mm.

2.2 Soil sampling and analysis

A total of 236 soil samples were collected at depth intervals of 0-30 cm from the eighteen villages of Mayurbhanj district, Odisha. The soil samples were air dried, milled and passed through 2 mm sieves in order to run the analysis. The analysis of soil samples has been done by using standard methods. Soil Reaction (pH) and Electrical Conductivity (EC) was determined by using 1:2.5 soils: water suspension with the calibrated pH and conductivity meter by following the method given by Jackson [5]. Organic Carbon was determined by following modified Walkley and Black [6] method. 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 [7]. The concentration of micronutrients in the extract was determined by atomic absorption spectrophotometer (Agilent AAS-FS 280). The hot water soluble B was estimated by UV-VIS Spectrophotometer [8]. For evaluation of the soil fertility of the study area, the spatial distribution for each parameter attribute was assessed using descriptive statistics [9]. The coefficient of variation was ranked according to the procedure of Aweto [10], where, CV < 25% = low variation, CV >25 ≤ 50% = moderate variation, CV >50% = high variation.

3. Result and Discussion

3.1 Physical properties of soil

The availability of plant nutrients and consequently the fertility of the soil are affected by pH. The solubility of nearly all nutrients differs in response to pH. As acidity increases, the loss of these nutrients by leaching increases and their availability to plants decreases. The quantity of some nutrients may rise so greatly under acidic and alkaline conditions that they become toxic to plants [11]. Therefore, it is very crucial to adjust soil pH between 6.5 and 7.5 where most of the nutrients are available to plants for maintaining soil fertility [12]. In the present study, pH ranges from 3.63 to 7.10 with a mean of 5.30 reflecting acidic nature of soils (Table 1). In soils of Chadhepahadi and Dhobanisole show high pH values than soils of other villages whereas, Kuabuda region showed lower in soil pH. It is interesting to observe a narrow range (10.62%) of variation in pH among the soil samples. This can be attributed to high buffering capacity of the soils and presence of carbonate in the saturation extract [13]. According to classification of soil reaction suggested by Brady [14], 31.4 per cent soil samples were strongly acidic (pH 5.1 to 5.5) and 25.0 per cent samples very strongly acidic (pH 4.6-5.0) (Fig.1). Acidity of the sampled area might be due to the high rainfall leading to the leaching losses of bases [15].

Table 1: Physical properties of tasar host plants growing soils of Mayurbhanj districts in Odisha

Village	No. of Samples	pH	EC	OC
Rangamatia	11	5.09	0.052	0.54
Asansil	05	5.24	0.049	0.26
Partuka	10	5.02	0.053	0.40
Bhorsole	05	4.99	0.040	0.82
Kuabuda	17	4.33	0.061	0.54
Sangma Nagha	04	5.15	0.057	0.61
Keutunimari	01	4.86	0.069	0.69
Jhini	05	4.93	0.054	0.56
Chandua	16	5.18	0.043	0.64
Kakharusole	18	4.98	0.067	0.48
Gadargadi	26	4.93	0.053	0.38
Badatilou	23	5.46	0.046	0.56
Rathasole	04	5.83	0.041	0.90
Koilisuta	13	5.53	0.054	0.73
Pariakuli	06	5.31	0.058	0.83
Balikhanina	13	5.77	0.117	0.59
Dhobanisole	43	5.90	0.157	1.07
Chadhepahadi	16	6.21	0.193	1.13
Mean		*5.35*	*0.085*	*0.69*
Minimum		*3.63*	*0.010*	*0.03*
Maximum		*7.10*	*0.660*	*2.10*
SD		*0.57*	*0.07*	*0.38*
CV		*10.62*	*86.80*	*55.74*

The distribution of EC in the study area indicates that an average value of EC was 0.085 dS m^{-1} and varied from 0.01 to 0.66 dS m^{-1} having highest coefficient of variance is 86.80% shown in Table 1. Where EC has less than 1 dS m^{-1} meant that the soils are free from salinity, which account for 100% of entire study area. The considerably maximum value (0.207 dS m^{-1}) obtained in the Chadhepahadi (0.193 dS m^{-1}) and Dhobanisole villages (0.157 dS m^{-1}) and minimum in Bhorsole and Rathasole places.

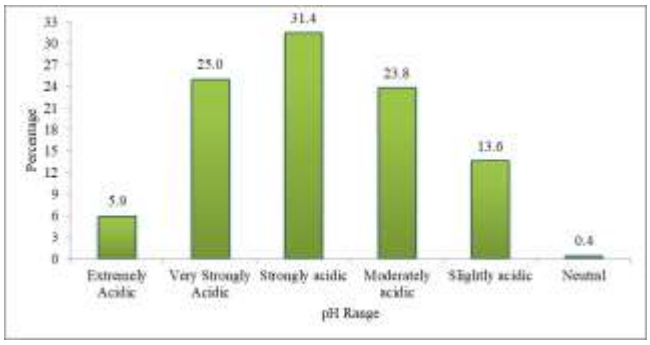

Fig 1: Percentage of soil pH in different category under sampling area

The soil organic matter (SOM) is a very important store of plant nutrients. It facilitate to maintain soil fertility by improving soil structure, increasing water holding capacity, retention of mineral nutrients, aeration and root penetration and drainage. Therefore, the SOM is a significant contributes to soil fertility. The soils organic carbon (SOC) in different tasar growing places of Mayurbhanj district ranged from 0.03 to 2.10% with an average of 0.69% having high coefficient of variance (55.74%). Chadhepahadi (1.13%) and Dhobanisole villages (1.07%) were recorded higher SOC content while lower SOC content in Asansil village (Table 1). Continuous cultivation leading to high plant removal might be accountable for the medium to low SOC content indicative of samples from these villages. The decreases in SOM at majority locations might be associated with factors like high temperature (more organic matter decomposition) and erosion of soil due to high rainfall. Choudhary and Yadav [16] also reported that high temperature and rainfall may like to cause low organic matter of top soil.

3.2 Micronutrients status of soil

The range and mean values of micronutrients in selected soils of tasar growing areas under Mayurbhanj district are shown in Table 2 and their category illustrated in Fig. 2.

The contents of available DTPA-Zn in the locations ranged from 0.02 mg kg^{-1} to 13.28 mg kg^{-1} with a mean value of 2.32 mg kg^{-1}. The significantly higher Zn content was observed in Bhorsole followed by Partuka villages as 10.25 and 9.57 mg kg^{-1}, respectively. Zn content of soil samples in Mayurbhanj district had showed greater variation. Based on the critical limits of Takkar and Mann [17], 55% samples were medium and 30% 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 resulted in very few samples (15%) observed deficiency range. Similar results were reported by Mahesh *et al*., [18] and Murthy *et al*., [19]. The solubility of native forms of Zn is highly pH and EC dependent and decreased by a factor of 100 per cent per unit raise in pH [20].

Table 2 Chemical properties of tasar host plants growing soils of Mayurbhanj districts in Odisha

Village	No. of Samples	Zn	B	Fe	Mn	Cu
Rangamatia	11	0.77	4.87	12.72	57.44	0.93
Asansil	05	2.61	5.53	16.41	99.33	0.84
Partuka	10	9.57	5.01	17.36	75.89	1.28
Bhorsole	05	10.25	4.74	13.92	67.32	1.23
Kuabuda	17	6.65	6.17	6.41	40.44	0.34
Sangma Nagha	04	0.77	7.41	3.19	23.28	0.60
Keutunimari	01	1.26	4.79	1.81	77.90	2.02
Jhini	05	0.91	4.83	26.79	73.48	1.02
Chandua	16	0.52	6.64	10.23	40.36	1.44
Kakharusole	18	0.45	6.11	11.39	44.13	1.01
Gadargadi	26	0.72	3.86	10.55	48.76	0.52
Badatilou	23	0.97	4.00	11.26	42.25	1.05
Rathasole	04	1.76	4.52	24.91	231.20	1.62
Koilisuta	13	1.78	4.40	13.57	134.28	1.02
Pariakuli	06	1.84	4.83	12.40	105.44	1.20
Balikhanina	13	2.12	5.12	41.20	93.55	4.41
Dhobanisole	43	2.36	4.55	62.41	125.00	5.16
Chadhepahadi	16	1.88	5.74	55.16	78.48	4.60
Mean		*2.32*	*5.02*	*25.75*	*77.45*	*2.15*
Minimum		*0.02*	*2.71*	*0.30*	*11.35*	*0.02*
Maximum		*13.28*	*16.30*	*123.15*	*629.38*	*12.50*
SD		*3.04*	*1.62*	*24.79*	*88.60*	*2.18*
CV		*130.85*	*32.17*	*96.29*	*114.38*	*101.56*

The content of available DTPA-B in soils varied from 2.71 mg kg^{-1} to 16.30 mg kg^{-1} with an average value of 5.02 mg kg^{-1}. Results further, illustrated on available DTPA-B in soil samples indicated that all soil samples were sufficiency in DTPA- B content with 0.50 mg kg^{-1} as the critical limit proposed by Lindsay and Novel [21]. The Boron availability showed Sangma Nagha recorded higher value followed by Chandua villages. Berger and Troug [22] reported that availability of B was comparatively more between pH 6.0 and 8.0 and it decreases below and above that range. The result of Anitha *et al*. [23] also indicated B availability would be more at optimum soil pH.

The DTPA-Fe in the soil samples varied from 0.30 mg kg^{-1} to 123.15 mg kg^{-1} with the mean value of 25.75 mg kg^{-1}. Considering 4.8 mg kg^{-1} as critical limit for Fe deficiency [24], the data indicated that 81% of soil samples were sufficient and 12 and 7% of soil samples were medium and low in DTPA-Fe availability, respectively. Villages namely Dhobanisole and Chadhepahadi have recorded greater accumulation of soil Fe content. Fe deficiency is very unlikely in acid soils; as it is known to be soluble under relatively acid and reducing conditions [25].

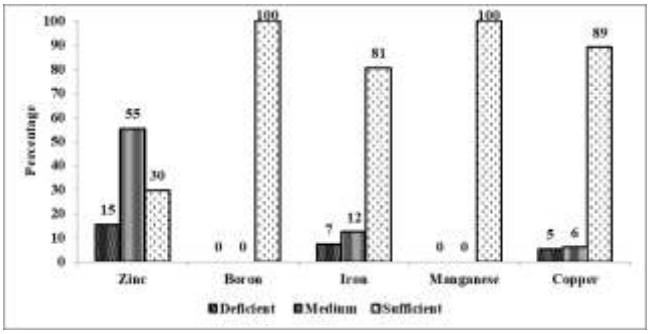

Fig 2: Percentage of micronutrients distribution in different category under sampling area

DTPA-Mn in the studies soils ranged from 11.35 mg kg^{-1} to 629.38 mg kg^{-1} with an average value of 77.45 mg kg^{-1}. Considering 2.0 mg kg^{-1} as critical limit for Mn deficient [26], here all the 100% samples were sufficient in availability. 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}.

The content of DTPA-Cu ranged from 0.02 mg kg^{-1} to 12.50 mg kg^{-1} with mean value of 2.15 mg kg^{-1} in the studied locations. The data illustrated that 89% of the soil samples were sufficient, 6% samples were marginal and 5% of the soil samples were deficient. The higher Cu content was observed from the samples of Dhobanisole (5.16 mg kg^{-1}) and Chadhepahadi (4.60 mg kg^{-1}) villages. Cu deficiency was common in sandy soils with high pH [27]. Thus, it could be predicted that the deficiency of Cu would not occur in these soils in the nearest future.

4. Conclusion

The results of present study indicated that the studied soils of Mayurbhanj districts of Odisha State were generally acidic. Soil pH and EC were in safe limit for the plant growth. The organic carbon was equally distributed from low to high and all the micronutrients namely Zn, B, Fe, Mn and Cu of majority soil samples were sufficient for tasar host plants. Strategies involving the application of micronutrients by basal placement, foliar sprays or use of organic manures can be adopted to sustain an optimum biomass yield of tasar host plants potential and subsequently enhanced tasar silkworm cocoon quality.

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