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Assessing soil fertility status of tasar host plants growing soils in Purulia district of West Bengal state

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Abstract
A detailed soil survey was undertaken in Kashipur block of Purulia district in West Bengal state of India with the aim of evaluating the fertility status of tasar host plant (*Terminalia arjuna*, Arjun and *T.tomentosa*, Asan) growing soils. A total of 160 surface samples were randomly collected from 14 villages from a depth of 0-30 cm and analyzed for pH, electrical conductivity, organic carbon, available nitrogen, phosphorus, potassium and sulphur using standard analytical methods. Based of fertility ratings, pH of soils was strongly acidic to moderately acidic. Electrical conductivity was normal (<1.0 dS/m) in all the places. Soil organic carbon was medium (48% of total samples) to low (33% of total samples) in most of the places. All soil samples were low in available nitrogen. Soil samples were medium in available phosphorus (76%), potassium (60) and 76% in sulphur availability.

Keywords: macronutrients, organic carbon, purulia, silkworm, tasar

Introduction
In any cultivation operations, soil is the dominant magnitude as it is the support for all crops and plants. There are non-renewable resources, formed at the rate of one inch every 250 to 1200 years (John Madeley, 2002) [15]. To make cultivable productive, it may takes another 3000 to 12,000 years (Venkata Ramana *et al*., 2015) [26]. This natural resource is limited and also impossible for within time span of a human life (Mandal *et al*., 2009) [8]. The top soil having an average depth of about 15–30 cm on which plants grow and the farming activities flourishes. At present, it is facing grave problems due to human pressure and utilization incompatible with its capacity. Therefore, it is crucial to keep healthy and productive soil to maintain our soil to function optimally to increase crop production with suitable soil amendment and crop management practices (MacCarthy *et al*., 2013).
Tasar silkworm (*Antheraea mylitta* D.) is a polyphagous insect feeding mainly on Asan (*T. tomentosa*), Arjun (*T. arjuna*), Sal (*S. robusta)* and secondarily on more than two dozens of food plants (Gupta and Sinha, 2013) [11]. Tasar silk production as a livelihood component of tribal communities and it motivates them against deforestation and illegal cutting of trees and to regenerate forests. The main tasar growing states are Jharkhand, Chhattisgarh, Odisha, West Bengal, Telangana, Madhya Pradesh and Maharashtra. It is a backbone for tribal development because about 1.25 lakh tribal families are associated with tasar culture in the country (Rai *et al.*, 2006) [22]. In rural areas of the tasar growing states, the living standards of people mainly depend on tasar sericulture, which is often determined by the fertility and productivity of soil. Soil fertility is one of the primary constraints to tasar production in predominant growing tasar areas (Gruhn *et al*., 2000) [10]. It comprises not only in supply of nutrient, but also indicates their nutrient supplying capability; moreover fertility of soil is subject to man's control (Deshmukh, 2012) [9]. It may be maintained by intercropping with leguminous plant, mulching and the application of manure and fertilizers. The conventional fertilizing method is not scientifically appropriate and efficient because soil fertility varies between regions. Overuse of fertilizers can indeed lead to a waste of fertilizer resources and a serious environmental pollution (Clay, 2002; Yang and Zhang, 2008) [6, 28]. Hence, a comprehensive knowledge of soil fertility provides a better understanding in the current situation and for identifying soil nutrient distribution and trends (Dafonte *et al*., 2010) [8]. If their status in the soil is known before the brushing of silkworm, it provides a sound basis for determining the nutrient requirements for the desired tasar silk production. Soil Health Card (SHC) is a potential tool for providing a comprehensive details of soil fertility and productive of tasar host plants growing regions. Therefore, the objective of this study was to conduct spatial distribution and

variability of observed values through randomized soil sampling, for estimating soil pH, electrical conductivity (EC), organic carbon and macro nutrients (N, P, K and S) as well as its status for a site specific management approach in the tasar sericulture fields of Kashipur block, Purulia district, West Bengal state, India.

Materials and Materials

Study site

This study was conducted in the Kashipur block of Purulia district (Fig. 1), which is situated at 23°26'N latitude and 86°40'E longitude with an average elevation of 228 m MSL and an estimated area of 801.88 km^2. Summers are hot and dry with temperatures ranging from lows of 23 °C to highs above 48 °C. Most of the rainfall occurs during the south-west monsoons.

Soil sampling and analysis

A total of 160 soil samples were collected at depth intervals of 0-30 cm from the fourteen villages of Kashipur block in Purulia district, West Bengal where tasar sericulture is dominating in study area. 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 was determined by using 1:2.5 soils: water suspension with the calibrated pH and conductivity meter by following the method given by Jackson (1973) [14].

Organic Carbon was determined by following modified Walkley and Black (1934) [27] method. Available nitrogen was determined by alkaline permanganate method as described by Subbiah and Asija, (1956) [25]. Available Phosphorous was determined by spectrophotometer by following Bray and Kurtz (1945) [4] method. Available Potassium was determined by Flame Photometer with 1N neutral ammonium acetate as an extractant by following Hanway and Heidel (1952) [12] method. Available Sulphur was determined by following Turbidimetric Chesin and Yien (1950) [5] method.

For evaluation of the soil fertility of the study area, the spatial distribution for each parameter attribute was assessed using descriptive statistics (Iqbal *et al*., 2005) [13]. The coefficient of variation was ranked according to the procedure of (Aweto, 1982) where, CV < 25% = low variation, CV >25 ≤ 50% = moderate variation, CV >50% = high variation. Duncan's Multiple Range Test was employed in data analysis using SPSS-16v.

Results and Discussion

Soil physical properties

It is vital estimation for soils, determines the magnitude of the acidity and alkalinity and directly influences crop productivity. The pH value reflects the integrated consequence of the acid-base reactions taking place in the soil system (Mokolobate and Haynes, 2002) [20]. In the study area, soil pH values ranged from 4.46 to 6.80, with a mean of 5.49 and a median of 5.47 (Table 1). According to the results, the pH of soils in all villages is strongly acidic to moderate in nature. In soils of Makhyada village show high pH values (5.96) than soils of other villages followed by Lara (5.88) and Pabra villages (5.70) whereas Simla village (5.19) showed lower in soil pH. The soil pH showed low variability (6.33%) among the soil samples. According to classification of soil reaction suggested by Brady (1985), 52.5 per cent soil samples were strongly acidic (pH 5.1 to 5.5), and 40.6 per cent samples were moderately acidic (pH 5.6-6.0) (Fig.1). Therefore, periodically agricultural lime application is essential for improvement of soil pH. Acidic in reaction of the sampled area might be due to the high rainfall leading to the leaching losses (Srivastava *et al*., 2017) [21]. Besides, the acidity occurring in the tasar host plants growing soils was also due to the presence of Al and H ions.

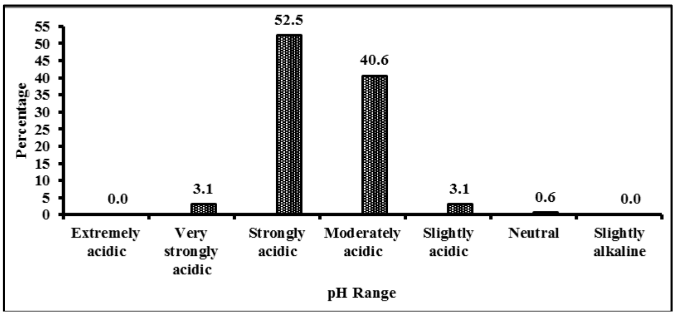

Fig 1: Percentage of soil pH in different category under sampling area

Soil electrical conductivity (EC) is a measurement that correlates with soil properties that effect productivity, including soil texture, cation exchange capacity (CEC), drainage conditions, organic matter level, salinity, and subsoil characteristics (Corwin and Lesch, 2005) [7]. The EC of soils varies depending on the amount of moisture held by soil particles. The distribution of EC in the study area indicates that the mean value is 0.120 dS m^{-1} and ranged from 0.02 to 0.66 dS m^{-1} having highest coefficient of variance is 97.74% 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 significant maximum value (0.207 dS m^{-1}) obtained in the Jurguridi village and lower in Pabra village.

Organic matter is chief source of plant essential nutrients after their breakdown by microorganisms. It supplies plant nutrient, improve the soil structure, water infiltration and retention, feeds soil micro-flora and fauna, and the retention and cycling of applied fertilizer (Johnston, 2007) [16]. The organic carbon content of the soils in the study area varied from 0.21 to 1.29% with mean value of 0.59% having moderate coefficient of variance (33.53%). The mean value was significantly high in Lara (0.71%) and Sonathali (0.70%) and low in Ranjandih (0.43%) (Table 1).

Table 1: Physical parameter status of soil at tasar silkworm's food plants grown regions of Purulia district.

Village	No. of samples	pH	EC	Organic carbon
Pabra	20	5.70^{abc}	0.040^{l}	0.51^{e}
Sonaijuri	05	5.62^{bcd}	0.169^{c}	0.59^{cd}
Damankiari	23	5.45^{cdef}	0.115^{f}	0.66^{b}
Simla	06	5.19^{f}	0.048^{k}	0.67^{b}
Agardih	07	5.39^{def}	0.074^{i}	0.65^{b}
Lara	12	5.88^{ab}	0.175^{b}	0.71^{a}
Gourangadih	20	5.30^{ef}	0.165^{c}	0.66^{b}

Gagnabad	18	5.37[def]	0.152[d]	0.47[f]
Sonathali	07	5.64[bcd]	0.093[g]	0.70[a]
Siada	10	5.48[cde]	0.088[h]	0.51[e]
Jurguridi	10	5.45[cdef]	0.207[a]	0.59[cd]
Ranjandih	09	5.37[def]	0.078[i]	0.43[g]
Kalapathar	12	5.51[cde]	0.120[e]	0.61[c]
Makhyada	01	5.96[a]	0.062[j]	0.57[d]
Mean		*5.49*	*0.120*	*0.59*
Median		*5.47*	*0.068*	*0.57*
Mode		*5.19*	*0.120*	*0.57*
Minimum		*4.46*	*0.02*	*0.21*
Maximum		*6.80*	*0.66*	*1.29*
SD		*0.35*	*0.12*	*0.20*
CV		*6.33*	*97.74*	*33.53*

*Means followed by different letter (s) within column differ significantly at 5% level of significance

The study revealed that the organic carbon content of soils in the study area is significantly high with about 48% of soil samples falling in the medium (i.e. >0.50 - <0.75%) category followed by 33 and 19% of samples in the low (i.e. <0.5%) and high (i.e. >75%), respectively (Fig.2). Continuous cultivation leading to high plant removal might be accountable for the medium to low organic carbon content indicative of samples from these villages. In addition, low input of FYM and crop residues as well as rapid rate of decomposition due to high temperature, organic matter degradation and removal taken place at faster rate coupled with low vegetation cover, thereby leaving less chances of accumulation of organic matter in the soil which could further exacerbate the situation. Similar results were also confirmed by Kavitha and Sujatha (2015) [17].

Soil chemical properties

Nitrogen is essential for plant growth and thus, causes problems when it is deficient. Available nitrogen in the study area ranges from 124.3 to 246.0 kg ha^{-1} with mean and median values are 173.4 kg ha^{-1} and 169.5 kg ha^{-1}, respectively (Table 2). The coefficient of variance of sampling sites showed low as 11.60%. The significantly higher mean value of available N found in Mekhyada (204.6 kg ha^{-1}) followed by Kalapathar (180.6 kg ha^{-1}) and Gagnabad (180.3 kg ha^{-1}) villages. Lara village showed significantly lower available N as 166.9 kg ha^{-1}. This evidence is further confirmed by comparing the estimated values of nitrogen with critical limits for delineation of soil fertility around 100% of study area were less (Fig. 2) in available nitrogen (i.e.<280 kg ha^{-1}). The nitrogen content in soils is dependent on temperature, rainfall and altitude. In addition, continuous and intensive practices of tasar silkworm rearing leading to high crop removal together with inadequate replacement might be the reason for the high extent of nitrogen deficiency in these soils. Low nitrogen status in the tasar host plants growing soil could be due to less oxidation and mineralization rate of organic matter which could be due to less penetration of sunlight on the soil surface (Sinha *et al*. 2017) [21].

In the present study, available phosphorus distribution ranges vary from 6.30 to 38.10 kg ha^{-1} with a mean values 17.79 kg ha^{-1} and it shows median and mode as 15.90 and 13.4 kg ha^{-1} (Table 2). Available phosphorus showed medium variability (40.63%) among the tested soil samples. It mean content was significantly high in Sonathali (24.0 kg ha^{-1}) followed by Sonaijuri (20.4 kg ha^{-1}) village and significantly low in Makhyada (9.5 kg ha^{-1}). About 76% of study area shows medium phosphorous content (10-25 kg ha^{-1}), 16% of area is high (>25 kg ha^{-1}) and rest of 9% show low phosphorous content (<10 kg ha^{-1}) (Fig. 2). Arifin *et al.* (2007) [1] stated that the higher clay content and exchangeable Al related to a low to medium level of nutrients especially available phosphorus. However, the composition of forest floor plays an important role in P contents.

Table 2: Available macronutrient status of soil at tasar silkworm's food plants grown regions of Purulia district

Village	No. of samples	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (ppm)
Pabra	20	171.3[cd]	17.7[fg]	232.0[g]	12.39[e]
Sonaijuri	05	172.5[cd]	20.4[b]	289.0[c]	10.67[f]
Damankiari	23	171.0[cd]	16.7[h]	271.5[d]	10.60[f]
Simla	06	177.8[bc]	15.5[i]	331.3[a]	13.36[d]
Agardih	07	176.1[bc]	12.8[j]	248.8[f]	15.33[a]
Lara	12	166.9[d]	18.1[ef]	310.8[a]	14.86[ab]
Gourangadih	20	170.7[cd]	17.4[gh]	214.2[h]	14.26[c]
Gagnabad	18	180.3[b]	18.5[de]	268.8[de]	15.37[a]
Sonathali	07	172.2[cd]	24.0[a]	181.2[i]	14.52[bc]
Siada	10	172.9[cd]	17.3[gh]	235.8[g]	12.45[e]
Jurguridi	10	171.6[cd]	17.0[gh]	257.3[ef]	13.50[d]
Ranjandih	09	171.3[cd]	18.9[cd]	263.8[de]	10.99[f]
Kalapathar	12	180.6[b]	19.4[c]	261.3[def]	12.81[e]
Makhyada	01	204.6[a]	9.5[k]	145.6[j]	9.85[g]
Mean		173.4	17.79	254.8	13.10
Median		169.5	15.9	243.6	13.68
Mode		168.2	13.4	212.8	13.68
Minimum		124.3	6.30	95.2	2.00
Maximum		246.0	38.10	481.6	23.18
SD		20.12	7.23	77.5	3.84
CV		11.60	40.63	30.43	29.28

*Means followed by different letter (s) within column differ significantly at 5% level of significance

Regarding potassium content in the soil, the study region reveals a variation from 95.2 to 481.6 kg ha^{-1} with mean value of 254.8 kg ha^{-1}. The median, mode and coefficient of variance for available K were 243.6 kg ha^{-1}, 212.8 kg ha^{-1} and medium (30.43%) variability among the tasar host plants growing sites (Table 2). The available K content is significantly high in Simla (331.3 kg ha^{-1}) and Lara (310.8 kg ha^{-1}) villages. Fig. 2 showing that about 60 percent of area show medium potassium content (110-280 kg ha^{-1}) and 39 percent show high content (>280 kg ha^{-1}) and just 1 percent of samples with low potassium content (<110 kg ha^{-1}). 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.

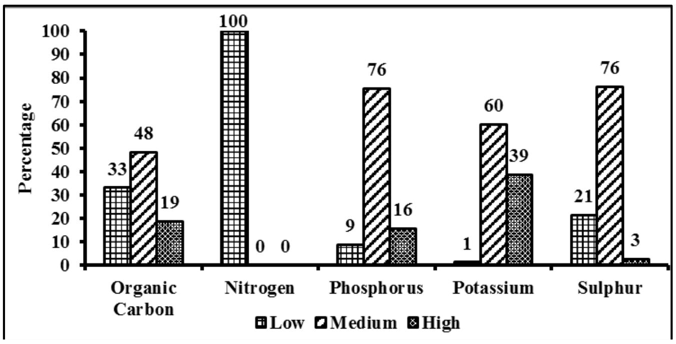

Fig 2: Percentage of OC & Macronutrients in different category under sampling area

The sulphur content of the soils varied from 2.00 to 23.18 ppm with mean value of 13.10 ppm of overall soil samples (Table 2). Available sulphur showed medium variability (29.28%) in the soil samples and median and mode of samples for available S is 13.68 ppm. The mean was significantly high in soils of Gagnabad (15.37 ppm) and Agardih (15.33 ppm) but significantly low in soils of Makhyada (9.85 ppm). A high proportion of soil samples (76%) were medium in available S, within the range of 10-20 ppm followed by low range as recorded in 21% of soil samples (Fig. 2). The low and medium levels of available sulphur in soils of the study area might be due to lack of sulphur addition and continuous removal of S by crops. Thus, the soils of all the sites are likely to respond sulphur fertilization. Similar results were observed by Pandiaraj *et al.*, (2017) [23] in tasar host plants growing zone of Jharkhand and Bihar where 57.3% and 40% of study area were observed to be low and medium, respectively in available sulphur.

Conclusion

The study has revealed that the pH of soils in all sites of tasar host plants growing soils were acidic range. Electrical conductivity was normal (<1.0 dS m^{-1}). Soil organic carbon of majority samples was medium to low with 48 and 33% of study area falling in the medium and low, respectively. The available N in all the sites falls under low category. However, medium to high content of available P, K and S existed in the soils. The condition therefore, demands the adoption of suitable management practices in order to enhance the fertility status. These practices may include such practices as site specific nutrient management, increased use of organic nutrient sources, sustainable land use by intercropping with leguminous crops and appropriate agronomic practices.

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