Original Research Article

Soil fertility status and nutrient index in different tasar silkworm host plants growing ecosystems of Purulia District, West Bengal, India

Abstract

This study was conducted to evaluate soil fertility status in the fourteen major tasar sericulture adopting villages in Purulia District, West Bengal. For this, a total of 160 surface soil samples (0-30 cm) were collected from dominant tasar sericulture villages along with the details regarding farmer's name, soil type, host plants details, etc. The collected samples were air dried, sieved and analysed for various soil fertility parameters such as pH, EC, organic carbon, macro and micronutrients. The data on various parameters were categorized into low, medium and high classes based on soil fertility ratings and nutrient index was calculated. Results revealed that soil reaction in the study area varied from strongly acidic to moderately acidic with saline free soil. The available nitrogen was low level in all the tasar host plant growing regions. In all the study regions, medium range of available phosphorus, potassium and sulphur was observed. All the micronutrients were high in the study villages. Regard NIV, all the macronutrients except nitrogen showed medium nutrient index in most places. Fertility rate of available micro nutrients were high index in all the tasar growing villages.

Keywords: Arjun, Asan, Nutrients, Purulia, Tasar silkworm

1. Introduction

Silk is a natural protein fibre composed mainly of *fibroin* and is produced by certain insect larva to form cocoons. Silk is produced from a number of insects but only the silk produced by the larva of the silk moth has been used for textile manufacturing. Currently, India is the 2nd largest producer of silk in the world, after China. The silk industry provides employment to over 7.85 million people in 51,000 villages across the country. Natural silks are classified into mulberry and non-mulberry. Non-mulberry silks are primarily known as Vanya or wild silks, primarily comprising tasar (tropical and temperate), muga, eri and anaphe. Tasar takes 10% share of the total raw silk produced in India and has shown an impressive growth of more than four times since 598.6 MT in 2008-09 to 2814 MT in 2015-16 (CSB, 2017).

Tasar silk is secreted by several species of the genus *Antheraea*; India has eight species, out of which *Antheraea mylitta D* has been commercially exploited and is the chief producer of *tasar* silk. Tasar sericulture is one of the traditional supplementary livelihoods of indigenous communities in Jharkhand, Bihar, Chhattisgarh, Odisha and West Bengal. Jharkhand has 81% of the total share with a production of 2,281 MT; the state has shown an impressive growth of more than six-fold from around 300 MT in 2008-09. Chhattisgarh is a distant second at 254 MT, with 9% share, followed by Odisha. West Bengal is in the 6th position in terms of tasar production, with raw silk production of 34 MT in 2015-16 (CSB, 2017). Production of raw silk has increased by 30% in during past five years in West Bengal. Tasar rearing has historically been an important traditional occupation among indigenous communities, primarily in western districts such as Bankura, Paschim Medinipur and Purulia that share a border with Jharkhand. These districts produce 96% of the cocoons. As of 2015-16, 21,145 families are engaged in tasar rearing across 476 villages, producing 34 MT cocoons.

Tasar silkworm is a polyphagous insect feeding primarily on Asan (*Terminalia tomentosa*), Arjun (*T. arjuna*), Sal (*Sorea robusta).* Tasar host plants under block plantation in Purulia region are spread over 2268.8 ha for commercial tasar cocoon production. However, tasar production in West Bengal state is declining in the past history i.e. 43.9 MT in 2010-11 to 34.0 MT in 2015-16. Decreasing of tasar production in the region may due to various reason such decline in host plants area, increase pest and disease attacks, drought and climate vagaries, insufficient availability of quality leaf, etc. Of which, nutritional quality leaf is play vital on higher quality and quantity tasar silk production. Srivastava *et al*., 2017a reported the silk quality and quantity of tasar silkworm depend upon nutritional value of their food plants. Further, the quality of tasar food plant leaves depend on the nutritional status of the soil. Soil fertility is one of the primary constraints to tasar production in predominant growing tasar areas. Continuous tasar sericulture practices for enhanced silk cocoon yield, removes substantial amounts of nutrients from soil. Imbalanced and inadequate use of chemical fertilizers, improper irrigation and various cultural practices also deplete the soil quality rapidly (Medhe *et al.*, 2012). Hence, evaluation of fertility status of the soils of an area or a region is an important aspect in the context of sustainable tasar sericulture. Soil testing assess the current fertility status and provides information regarding nutrient availability in soils which forms the basis for the fertilizer recommendations for maximizing host plant leaf yields as well as tasar cocoon yield and to maintain the optimum fertility in soil year after year. For appropriate soil management, the tasar growing farmer should know what amendments are necessary to optimize the productivity of soil for successful tasar production. Hence, this study mainly focused on the soil fertility evaluation of different tasar sericulture prevalent in Purulia district of West Bengal.

2. Materials and Methods

2.1 Site Description

This study was conducted in the Kashipur block of Purulia district 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.

2.2 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 of 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. Soil physical properties such as pH and electrical conductivity (EC) were determined by potentiometer and direct reading conductivity meter using 1: 2.5 soil water suspensions (Jackson, 1973) and organic carbon (Walkley & Black, 1934) was also analysed. The composite soil samples were analysed for available macronutrients such as nitrogen (Subbiah and Asija, 1956), phosphorus (Bray and Kurtz$_1$) potassium (1N ammonium acetate extractable) and sulphur (turbidimetric method) were determined following the methods described by Page *et al.*, (1982). The available micro nutrients such as Iron (Fe), Manganese (Mn), Copper (Cu) and Zinc (Zn) in soil samples were extracted with a DTPA solution (0.005M DTPA + 0.01 M $CaCl_2$ + 0.1M triethanolamine, pH 7.3 (Lindsay and Norvell, 1978). 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 (Wear, 1965). Nutrient index value (NIV) was calculated using the following equation (Pathak, 2010 and Kumar *et al*., 2013).

$$Nutrient\ Index\ Value = (NL \times 1 + NM \times 2 + NH \times 3)/100$$

Where, NL, NM and NH are per cent samples testing low, medium and high category, respectively.

3. Results and Discussion

3.1 Soil physical properties

Analysed results showed that pH of the study places varied between 4.46 and 6.80 with an average of 5.49 (Table 1). The result indicates that pH of soils in tasar growing regions is strong to moderate acidic in nature with 52.5 per cent soil samples were strongly acidic and 40.6 per cent samples were moderately acidic. 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*., 2017b). 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} 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. Organic matter is chief source of plant essential nutrients after their breakdown by microorganisms. The organic carbon content of the soils in the study area varied from 0.21 to 1.29% with mean value of 0.59%. The mean value was significantly high in Lara (0.71%) and Sonathali (0.70%) and low in Ranjandih (0.43%) (Table 1). The data 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.1). Continuous practices of sericulture leading to high plant removal might be accountable for the medium to low organic carbon content indicative of samples from these villages. Similar results were also confirmed by Kavitha and Sujatha (2015).

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**
Range		**4.46 – 6.80**	**0.02 – 0.66**	**0.21 – 1.29**

3.2 Soil chemical properties

3.2.1 Macronutrients (N, P, K and S)

Nitrogen is an essential for plant growth and thus, causes problems when it is deficient. Available nitrogen (N) in the study area ranges from 124.3 to 246.0 kg ha^{-1} with mean of 173.4 kg ha^{-1} (Table 2). The significantly higher mean value of available N found in Mekhyada (204.6 kg ha^{-1}) followed by Kalapathar (180.6 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. 1) in available N (i.e.<280 kg ha^{-1}). 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 (Pandiaraj *et al*. 2017a).

Table 2 Available macronutrient (kg ha^{-1}) 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***
Range		***124.3 - 246.0***	***6.30 - 38.10***	***95.2 - 481.6***	***2.00 - 23.18***

In the present study, available phosphorus (P) distribution ranges vary from 6.30 to 38.10 kg ha^{-1} with a mean values 17.79 kg ha^{-1} (Table 2). It mean content was significantly high in Sonathali (24.0 kg ha^{-1}) and low in Makhyada (9.5 kg ha^{-1}) villages. 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. 1).

Regarding potassium (K) 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} (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. 1 showing that about 60 percent of area show medium K 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}).

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). 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. 1). 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.*, (2017a) 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.

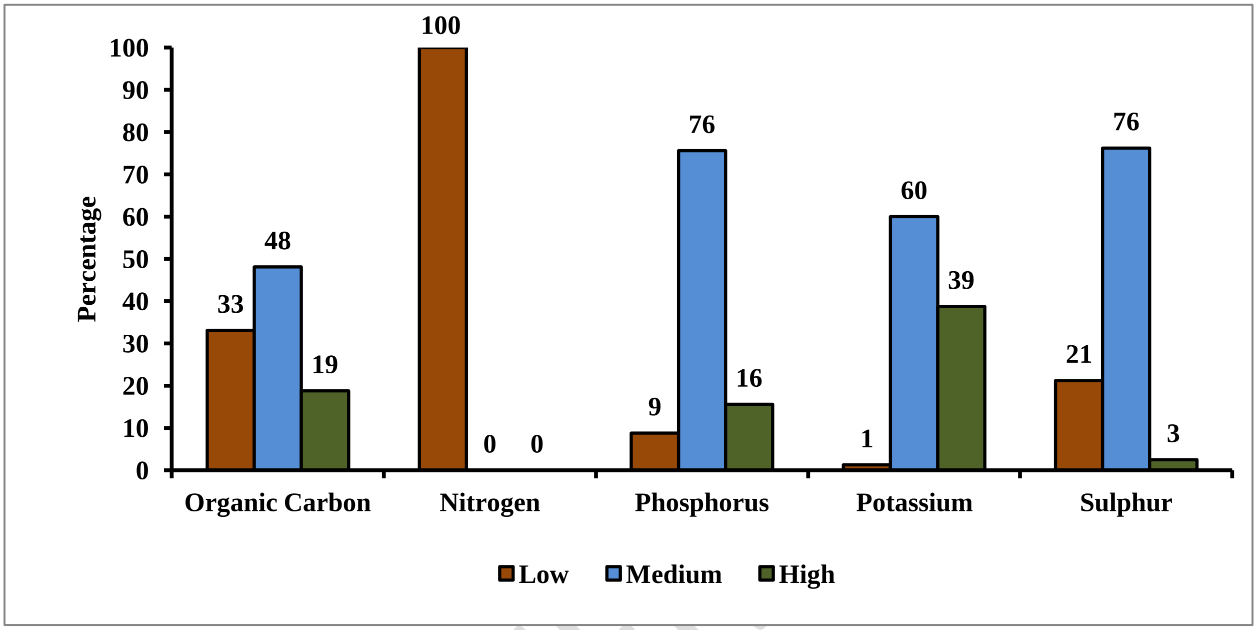

Fig. 1 Percentage of OC and Macronutrients in different category under sampling area

3.2.2 Micronutrients (Zn, B, Fe, Mn and Cu)

DTPA- extractable Zinc (Zn) in these soil series ranged from 0.37 to 15.85 mg kg^{-1} of soil (Table 3). It was significantly highest amount in soils of Makhyada (8.04 mg kg^{-1}) and lowest in Jurguridi (2.10 mg kg^{-1}). According to Katyal (1985) who suggested the critical limit as 0.6 mg kg^{-1} of soil, the soils under study shows that 97 per cent soils are sufficient and only 3.0 per cent are deficient in DTPA extractable Zn (Fig. 2). In the present study, all the soil samples of selected sites showed pH in acid range might be resulted in favour to accumulate Zn in available form. Similar results were reported by Murthy *et al*., 2005 and Mahesh *et al*., 2011.

The available Boron (B) content of the soils of tasar sericulture practicing in the study area varied from 0.76 to 17.82 mg kg^{-1} of soil with a mean value of 4.65 mg kg^{-1} (Table 3). A significant highest amount of available B had recorded in the soils of Damankiyari village (7.38 mg kg^{-1}) and lowest in Simla (3.01 mg kg^{-1}) and Siyada villages (3.63 mg kg^{-1}). Considering 0.5 mg kg^{-1} of available B as the critical limit (Stewart, 1953) in soil, 100 per cent soil samples of sites were sufficient in available B (Fig. 2).

DTPA extractable iron (Fe) content in these soil series varied from 2.30 to 19.70 mg kg^{-1} with a mean of 19.70 mg kg^{-1} (Table 3). The significant highest content of available Fe was observed in soils of Sonathali (14.34 mg kg^{-1}) and lowest in Jurgurdi (9.60 mg kg^{-1}). About 89 and 11 per cent soil samples of study places are found to be sufficient and deficient, respectively (Fig. 2) when we consider 4.5 mg kg^{-1} soils as threshold value for DTPA extractable Fe in soil (Katyal and Randhawa, 1983). Soils with acidic pH range leads higher solubility could be resulted in higher availability of Fe content. Therefore, iron availability is generally high in acid soils. This is supported by the findings of Medhe *et al*. (2012).

Table 3 Available micronutrient (mg kg^{-1}) status of soil at tasar silkworm's food plants grown regions of Purulia district

Village	No. of samples	Zn	B	Fe	Mn	Cu
Pabra	20	4.83^{d}	6.64^{b}	11.92^{b}	44.78^{d}	1.05^{gh}
Sonaijuri	05	3.35^{h}	4.04^{ef}	10.28^{d}	37.23^{fg}	1.32^{ef}
Damankiyari	23	4.07^{f}	7.38^{a}	9.22^{e}	38.04^{f}	1.51^{de}
Simla	06	5.76^{b}	3.01^{i}	10.36^{d}	41.13^{e}	0.93^{h}
Agardih	07	4.85^{d}	3.68^{gh}	11.74^{b}	59.41^{a}	0.84^{h}
Lara	12	2.93^{i}	4.46^{d}	10.39^{d}	49.60^{c}	1.15^{fg}
Gourangadih	20	5.06^{c}	4.03^{ef}	10.12^{d}	44.69^{d}	2.50^{b}
Gagnabad	18	3.30^{h}	3.78^{gh}	10.23^{d}	33.34^{i}	1.30^{ef}
Sonathali	07	4.44^{e}	3.56^{h}	14.34^{a}	35.82^{gh}	1.41^{de}
Siayda	10	3.63^{g}	3.12^{i}	10.26^{d}	49.01^{c}	0.85^{h}
Jurguridi	10	2.10^{j}	3.81^{fg}	7.60^{f}	40.21^{e}	1.85^{c}
Ranjandih	09	4.84^{d}	4.13^{e}	11.07^{c}	32.0^{8}	1.61^{d}
Kalapathar	12	3.78^{g}	3.22^{i}	10.18^{d}	34.96^{hi}	1.35^{ef}
Makhyada	01	8.04^{a}	4.89^{c}	9.60^{e}	54.00^{b}	9.61^{a}
Mean		**4.10**	**4.65**	**10.42**	**41.33**	**1.49**
Range		**0.37 – 15.85**	**0.76 – 17.82**	**2.30 – 19.70**	**9.05 – 81.05**	**0.26 – 9.87**

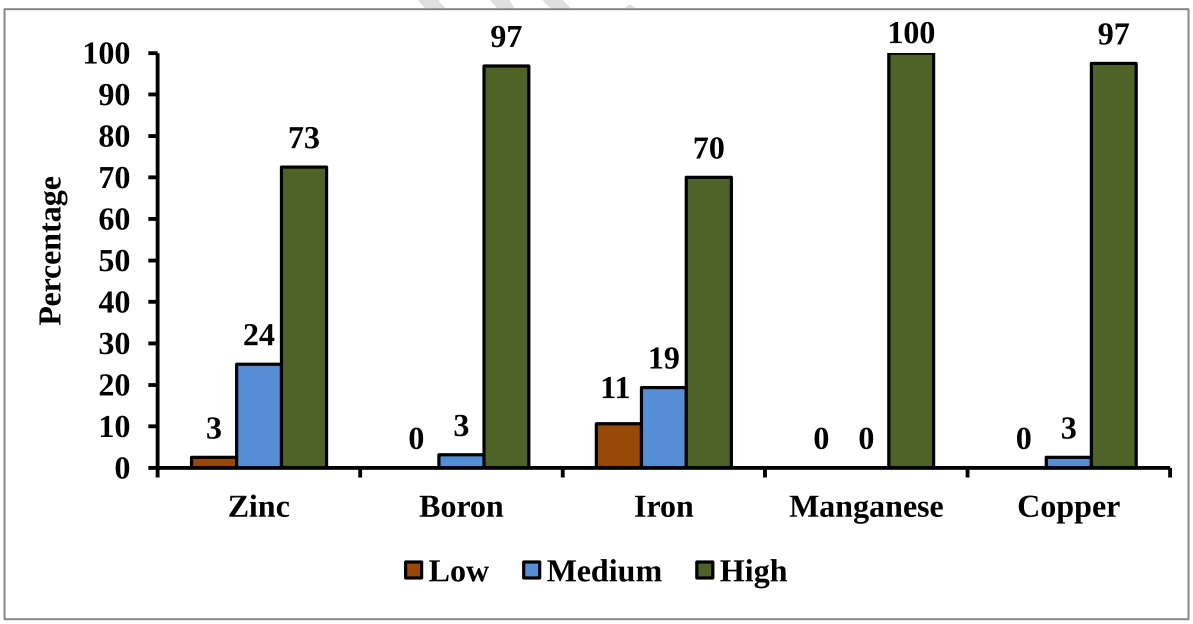

Fig. 2 Percentage of micronutrients in different category under sampling area

A wide variation in the DTPA extractable Manganese (Mn) (9.05 to 81.05 mg kg^{-1}) was observed in the different soil series with minimum in Gaganabad (33.34 mg kg-^{1}) and the maximum in Agardih (59.41 mg kg^{-1}) (Table 3). Considering 2.0 mg kg^{-1} soils of DTPA extractable Mn as critical limit (Takkar *et al*. 1989), all soils were sufficient in available Mn (Fig. 2). 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 available Cu in the soils varied from 0.26 to 9.87 mg kg^{-1} of soil with a mean value of 1.49 mg kg^{-1} (Table 3). The available Cu was the highest (9.61 mg kg^{-1}) in Makhyada and lowest in Agardih (0.84 mg kg^{-1}). All the soils are found to be adequate in DTPA-extractable Cu (Katyal and Randhawa 1983) as 0.2 mg Cu kg^{-1} soil is considerable the threshold value (Fig. 2).

3.3 Nutrient Index Value (NIV)

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 and the value between 1.67-2.33 then the status was medium. If the value greater than 2.33, the fertility status was high. Among the different tasar practicing villages, status of organic carbon was low in Pabra, Gagnabad, Siayda and Ranjandih and medium in other villages (Table 4). In all the villages, a level of N was observed low NIV.

Table 4 Soil fertility status of various tasar growing places with respect to soil nutrient indices

Village	OC	N	P	K	S	Zn	B	Fe	Mn	Cu
Pabra	L	L	M	M	M	H	H	H	H	H
Sonaijuri	M	L	M	H	L	H	H	H	H	H
Damankiyari	M	L	M	H	L	H	H	M	H	H
Simla	M	L	M	H	M	H	H	H	H	H
Agardih	M	L	M	M	M	H	H	H	H	H
Lara	M	L	M	H	M	H	H	M	H	H
Gourangadih	M	L	M	M	M	H	H	H	H	H
Gagnabad	L	L	M	H	M	H	H	H	H	H
Sonathali	M	L	H	M	M	H	H	H	H	H
Siayda	L	L	M	M	M	H	H	H	H	H
Jurguridi	M	L	M	M	M	H	H	H	H	H
Ranjandih	L	L	M	M	L	H	H	H	H	H
Kalapathar	M	L	M	H	M	H	H	M	H	H
Makhyada	M	L	L	M	L	H	H	H	H	H

Where, NIV – Nutrient Index Value; FR – Fertility Rate; L – Low; M – Medium; H – High; Index Value Low (L) < 1.67; Medium (M) 1.67 – 2.33; High (H) > 2.33; N= nitrogen; P = phosphorous; K= potassium; S= sulphur; Zn = zinc; B = boron; Fe = iron; Mn = manganese; Cu = copper

Among the tasar growing areas under the study, status of P was high in Sonathali and medium in other regions. Majority of the villages both available K and S were medium. S was low in the tasar growing regions of Sonaijuri, Damankiyari, Ranjandih and Makhyada. On the other hand, NIV of micronutrients in all the villages was high except Fe was medium in Damankiyari, Lara and Kalapathar regions. In general, all the macro nutrients except N were medium and micronutrients were high NIV (Table 5). According to Pandiaraj *et al*., (2017b) available NPS status of tasar growing regions of Bihar and Jharkhand was low. Further reported fertility rate of available K and micronutrients were high in most of the places.

Table 5. Nutrient indices for macro and micronutrients in general

Soil Nutrients	Nutrient Index	Fertility Rating
Organic carbon	1.88	M
Nitrogen	1.00	L
Phosphorus	2.01	M
Potassium	2.33	M
Sulphur	1.75	M
Zinc	2.72	H
Boron	2.96	H
Iron	2.61	H
Manganese	3.00	H
Copper	2.97	H

Where, NIV – Nutrient Index Value; FR – Fertility Rate; L – Low; M – Medium; H – High; Index Value Low (L) < 1.67; Medium (M) 1.67 – 2.33; High (H) > 2.33; N= nitrogen; P = phosphorous; K= potassium; S= sulphur; Zn = zinc; B = boron; Fe = iron; Mn = manganese; Cu = copper

Conclusion

Based on the above study it is concluded that soil fertility status of Purulia District varied between various tasar sericulture regions. The available nitrogen was low level in all the tasar host plant growing regions. In all the study regions, medium range of available phosphorus, potassium and sulphur was observed. Micronutrient of all tasar host plants growing soils are not limited for successful rearing of tasar silkworm. Regard NIV, all the macronutrients except nitrogen showed medium nutrient index in most of the places. Fertility rate of available micro nutrients were high index in all the tasar growing villages. Therefore, judicious use of suitable nutrients and managements should be adopted in order to boost the fertility status. use of organic manures, green manuring, biofertilizer application may help in nutrient build-up in the tasar host plants growing soils.

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