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Evaluation of Soil Fertility Status for Soil Health Card in Various Tasar Growing Fields of Bihar and Jharkhand States, India

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A B S T R A C T

Study was conducted to evaluate soil fertility status in the four different tasar growing regions in Banka District of Bihar and Dumka District of Jharkhand. A total of 75 surface soil samples (0-30 cm) were collected from the fields of primary tasar food plants (*Terminalia arjuna* and *T. tomentosa*) along with the details regarding farmer's name, land type, fertilizer details, geo location, etc. The collected samples were air dried, sieved and analyzed for various soil fertility parameters such as pH, EC, organic carbon, macro and micro nutrients etc. 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 slightly acidic to slightly alkaline with pH values varying from 5.18 to 7.58. Nutrient index value of organic carbon was high in all the places except in Digal Pahari; on the contrary, available nitrogen and phosphorus and Sulphur were low index in all the places. Fertility rate of available potassium and micro nutrients were high in most of the places but Zn was recorded high in Tetariya village and rest of the villages showed medium index level of Zn.

Introduction

Tasar silk production as a livelihood component of tribal communities motivates to control deforestation and illegal cutting of trees and to regenerate forests. It is a backbone for tribal development because about 1.25 lakh tribal families of different tasar growing states are associated with tasar culture in the country (Rai *et al.*, 2006). Tasar silkworm (*Antheraea mylitta* D.) is a polyphagous insect feeding primarily on Asan (*T. tomentosa*), Arjun (*T. arjuna*), Sal (*S. robusta)* and secondarily on more than two dozens of food plants (Gupta and Sinha, 2013). The silk quality and quantity of tasar silkworm depend upon nutritional value of their food plants (Singhvi, 2014). Good quality of leaves indicates greater possibility of obtaining good cocoon crops. Sahay *et al.*, (2001) indicated that leaf quality is one of the important factors contributing to success of tasar crops. Further, the quality of tasar food plant leaves depend on the nutritional status of the soil. Subbaswamy *et al.*, (2004) stated quality of leaves depends on the soil fertility and balanced supply of essential nutrients from soil.

Therefore, soil fertility is one of the imperative factors controlling quality and quantity of the produce. Soil depiction in relation to evaluation of fertility status of the soils of an area or region is a vital aspect in perspective of sustainable tasar production. Because of imbalanced and inadequate and/or nil fertilizer use by tasar growers coupled with low efficiency of other inputs, the response (production) efficiency of chemical fertilizer nutrients has declined tremendously under continuous practices of tasar production without addition of sufficient manures and fertilizers in recent years. Moreover, nutrient status is an unseen factor in plant growth, except when imbalances become so severe that visual symptoms appear on the plant (Flynn *et al.,* 2004). In tasar silk growing areas, a recent general reduction in the production of quality tasar silk has drawn attention of stakeholders in the sericulture sector to this serious trend. Therefore, at present, the greatest challenge before tasar growing area's sericulture is to boost tasar food plant production and productivity as well as sustainability of tasar silkworm as a whole.

However, the need for improved silk quality and productivity is more now than ever because the increasing the demand of silk growth at steady rate in India. With resultant reduction in the land-man ratio and this has drastically reduced the per–capita availability of land invariably leads to soil fertility depletion through continuous or intensive rearing practices of silkworm along with short, unfertilized fallow. Low fertility of Indian soils is the major constraint in achieving high silk productivity goals. In rain-fed systems, nutrient replenishment through fertilizers and manures remains far below the crop removal, thus causing mining of native reserves over the years. Site-specific estimates of the nutrient fertility status of the soils are therefore very important to rational fertilizer use. Reliable site-specific information can only be accomplished through soil health card. Hon'ble Prime Minister of India, Shri Narendra Modi, in an address to the countrymen on 19 February 2015, called for focusing attention on the health of soil in agricultural areas across the country to boost productivity and bring about increased prosperity. The card is a tool to help tasar growers to monitor and improve soil health based on their own field experience and working knowledge of their soils. The card, which will carry crop and zonal-wise recommendation of fertilizers required for farm lands will help farmers identify health of soil and judiciously use soil nutrients. Although soil fertility evaluation through soil health card is a powerful tool to support high tasar silk productivity by way of rationalizing nutrient use, its current impact on farm practice is presently not visible. In order to make it an effective and farmer oriented service, it is imperative to expand the arena of soil fertility evaluation beyond the nutrient requirement of the soil as well as develop fertilizer recommendations for high quality silk production targets. Considering all the above facts, a study was made from tasar growing areas under soil health card project of Government of India in Salaiya and Tetariya village of Banka district of Bihar and Dhaka and Digal Pahari village of Dumka district of Jharkhand state were selected.

Materials and Methods

Soil samples were collected from tasar growing farmer's fields under *Terminalia arjuna* plantations. As such fields of Salaiya (Geo-position 23°46' N latitude and 80°42' E longitude) and Tetariya (24°77' N latitude and 86°28' E longitude) village of Katoriya block, Banka district of Bihar state and Dhaka (27°02' N latitude and 87°04' E longitude) and Digal Pahari (24°16' N latitude and 84°26' E longitude) village of Shikaripara block, Dumka district of Jharkhand state were selected for the study. The climate of Katoria and Dumka regions are semi-arid with an annual rainfall of 1200 and 1300mm, respectively. A total of 75 surface soil samples (0 – 20 cm) were collected from the fields of four villages and composite soil samples were prepared. All the composite soil samples were air-dried, ground and passed through 2 mm sieve for chemical 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 (Walkely & 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).

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

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.

Result and Discussion

Soil Physical Properties

Seventy five surface soils (0-30cm) of Banka district of Bihar and Dumka district of Jharkhand states were investigated. The results of soil pH, EC and organic carbon (OC) are presented in Table 1. Result shows that pH of the soils ranged from 5.18 to 7.58 (mean 7.40), EC varied from 0.01 to 0.13 dS m^{-1} (mean 0.05 dS m^{-1}) and OC percentage content ranged from 0.41 to 1.97% (mean 0.93%). According to classification of soil reaction suggested by Brady (1985), 73 per cent soil samples were neutral (pH 6.6 to 7.3), 12 per cent samples were slightly alkaline (pH 7.4 to 7.8) and 8 per cent samples were slightly acidic (pH 6.1 to 6.5). Acidic in reaction of the sampled area might be due to the high rainfall leading to the leaching losses of bases from the surface soils. Availability of abundant organic matter in tasar silkworm host plants growing areas resulted in decomposition of organic residues hasten the lower soil pH. On the basis of limits suggested by Muhr *et al.,* (1965), all the samples were exhibited in normal range with respect to electrical conductivity (EC <1.0 dSm^{-1}). The wide variation of EC of the soils is might be due to leaching of soluble salts to lower horizons by high rainfall. The low EC of soils show that the existing environment was not conducive for buildup of salts (Roy *et al.,* 1962). The organic carbon content was high (>0.75%) in 69.3% soil samples, medium (0.50 to 0.75%) in 24.0% soil samples and remaining 6.7% soil samples were low (<0.50%) (Fig. 1). The high organic content in the soils is due to luxuriant availability of organic matter like litters, grasses along with slow seasonal decomposition of organic matter (Kavitha and Sujatha, 2015).

Available macro nutrients (N, P, K and S)

Available nitrogen status varied from 92.9 to 327.6 kg ha^{-1} with an average value of 196.5 kg ha^{-1} (Table 1). On the basis of the rating suggested by Subbiah and Asija (1956), 97.33% of the soil samples were found to be low (280 kg ha^{-1}) and remaining in the category of medium (280-560 kg ha^{-1}) (Fig. 1). Low nitrogen status in the 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. Farmers are not applying any organic and nitrogen base fertilizer in field. Similar result was also reported by Verma *et al.*, (1980). The available phosphorus content varied from 1.9 to 43.3 kg ha^{-1} in Salaiya village with a mean value of 9.91 kg ha^{-1} (Table 1). On the basis of the limits suggested to Muhr *et al.*, (1965) most of the soil samples (76%) were low (<10 kg ha^{-1}) in available phosphorus status, 14.67 percentage samples were under medium (10-25 kg ha^{-1}) and rest (9.33%) were under high (25 kg ha^{-1}) category (Fig. 1). Status of available potassium in the soils ranged between 95.2 (Salaiya) to 616 kg ha^{-1} (Digal Pahari) with an average of 300.6 kg ha^{-1} (Table 1). According to Muhr *et al.*, (1965), most of the soil samples (56%) were found under medium and 42.67% samples under high range (Fig. 1). Similar relation was also reported by Chauhan (2001).

The available sulphur status varied from 0.23 to 96.98 ppm (Dhaka) with a mean value of 8.38 ppm (Table 1). Plant roots absorb sulphur in the form of SO_4^{2-} from the soil solution. Keeping this fact in view, the soils under study may be classified as deficient (<10 ppm), medium (10-20 ppm) and sufficient (>20 ppm) category as per the categorization given by Hariram and Dwivedi (1994). According to this category, 57.3% samples were found under deficient and 40% samples were found under medium category (Fig. 1). Thus, the soils of all the sites are likely to respond sulphur fertilization. These results were also supported by Kumar *et al.*, (2013).

Available Micro nutrients (Zn, B, Fe, Mn and Cu)

Available Zn in the studied surface soils varied from 0.83 to 8.58 mg kg^{-1} with a mean value of 2.29 mg kg^{-1} (Table 2). On the basis of critical limit suggested by Takkar and Mann (1975) as considering 0.5 to 2.0 mg kg^{-1}, 68% samples were medium and 32% of the samples were sufficient (Fig. 2), so continuous addition of manures and fertilizers might have increased the adequate levels of Zn in these soils. Interestingly, out of 75 soil samples collected in Bihar and Jharkhand states not even a single sample was found to be Zn deficient category against national average of 40% in deficiency range. This finding is in agreement with the earlier findings of Venkatesh *et al* (2003) and Sharma and Chaudhary (2007). Amount of Zn required for alleviating the Zn deficiency varied with severity of Zn deficiency soil types and nature of plants. In the majority of instances 5.5 kg Zn ha^{-1} was found to be ideal dose.

Hot water soluble B content of the soils of various tasar eco-systems varied from 0.47 to 2.67 mg kg^{-1} with a mean value of 0.90 mg kg^{-1} (Table 2). The range of average B in soils of different states of India varied from traces to 12.2 mg kg^{-1} (Das, 2000). Among the micro nutrients, deficiency of B was one of the severe limiting nutrient after Zn in the study area, might be due to leaching by high rainfall coupled with low levels of cation exchange capacity. In general, management of B in the soils is difficult because of its high mobility and fixation at high pH (Saleem *et al*, 2010). The data depicted that 4% of the soil samples were deficient, 59% were medium and 37% were sufficient in availability B content (Fig. 2) considering 0.5 mg kg^{-1} as critical range. Available iron content in the surface soils ranged from 3.25 to 35.72 mg kg^{-1} with an average of 15.93 mg kg^{-1} (Table 2). Data on available Fe in soil samples indicated that 4, 9 and 87% soil samples were deficient, medium and sufficient range of DTPA Fe content, respectively (Fig. 2).

Table.1 Range and mean values of Physico-chemical properties and available macro-nutrient status of soil under study area

Village	No. of samples	pH		EC (dS m^{-1})		OC (%)		N (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})		S (ppm)	
		range	Mean	range	Mean	range	Mean	range	Mean	range	Mean	range	Mean	range	Mean
Salaiya	37	5.18-7.51	**6.90**	0.010-0.130	**0.058**	0.41-1.49	**0.85**	92.9-298.8	**173.6**	1.90-43.30	**7.44**	95.2-590.2	**270.4**	2.08-20.53	**9.33**
Dhaka	23	5.46-7.58	**6.78**	0.01-0.10	**0.051**	0.43-1.41	**0.94**	150.6-327.6	**209.8**	3.20-40.16	**11.81**	166.1-566.7	**285.9**	0.23-96.98	**11.19**
Digal Pahari	7	6.25-7.27	**6.71**	0.020-0.089	**0.044**	0.54-1.16	**0.80**	178.2-256.1	**206.9**	5.20-24.80	**14.69**	112.0-616.0	**319.3**	1.30-14.73	**7.88**
Tetariya	8	6.87-7.50	**7.02**	0.033-0.079	**0.054**	0.70-1.97	**1.11**	144.4-262.4	**195.7**	3.50-15.10	**5.71**	136.6-441.8	**326.9**	1.00-11.05	**5.10**
Range and Average mean		5.18-7.58	**6.85**	0.01-0.13	**0.051**	0.41-1.97	**0.93**	92.9-327.6	**196.5**	1.9-43.3	**9.91**	95.2-616	**300.6**	0.20-96.98	**8.38**

Table.3 Soil fertility status of various tasar growing places with respect to soil nutrient indices

Village		OC (%)	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (ppm)	Zn (ppm)	B (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)
Salaiya	NIV	2.51	1.03	1.19	2.35	1.54	2.30	2.14	2.89	3.00	2.92
	FR	H	L	L	H	L	M	M	H	H	H
Dhaka	NIV	1.09	1.43	2.39	1.39	2.35	2.43	2.69	3.00	2.78	2.74
	FR	H	L	L	H	L	M	H	H	H	H
Digal Pahari	NIV	2.57	1.0	1.71	2.43	1.43	2.00	2.57	3.00	3.00	2.28
	FR	M	L	M	M	L	M	H	H	H	M
Tetariya	NIV	2.87	1.00	1.12	2.75	1.25	2.50	2.62	2.75	3.00	3.00
	FR	H	L	L	H	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

Table.2 Range and mean values of micro-nutrient available status of soil under study area

Village	Zn (mg ha^{-1})		B (mg ha^{-1})		Fe (mg ha^{-1})		Mn (mg ha^{-1})		Cu (mg ha^{-1})	
	Range	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**
Salaiya	0.83-8.39	**2.27**	0.5-1.9	**0.78**	4.2-35.72	**17.04**	15.1-84.58	**45.64**	0.26-1.62	**0.84**
Dhaka	1.2-8.58	**2.31**	0.5-2.6	**1.01**	3.25-25.92	**14.74**	14.15-85.9	**43.21**	0.23-1.4	**0.59**
Digal Pahari	1.09-1.96	**1.59**	0.51-1.59	**1.05**	8.25-24.64	**16.81**	20.3-62.25	**36.36**	0.3-0.84	**0.45**
Tetariya	0.91-8.58	**2.88**	0.59-1.23	**0.98**	4.45-31.34	**13.46**	5.7-77.18	**34.27**	0.51-1.35	**0.92**
Range and Mean	**0.83-8.58**	**2.29**	**0.47-2.64**	**0.90**	**3.25-35.72**	**15.93**	**5.7-85.9**	**42.81**	**0.23-0.84**	**0.74**

Fig.1 Percentage of macro-nutrient status of various tasar growing regions soil on the basis of different category

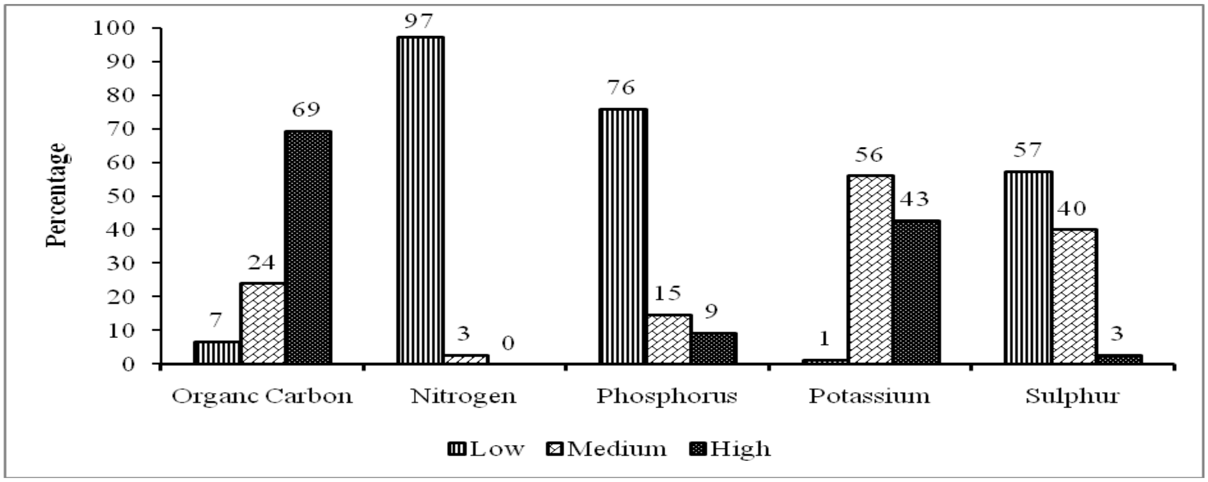
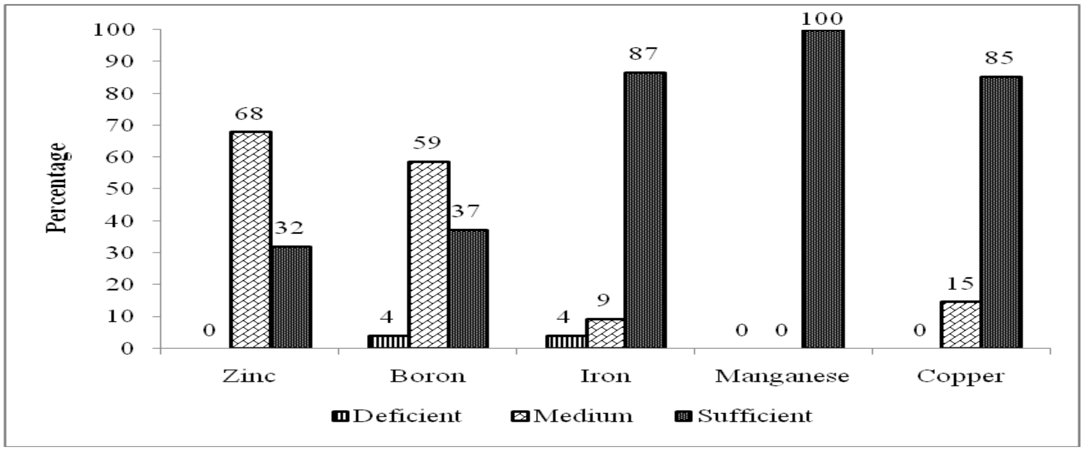


Fig.2 Percentage of micro-nutrient status of various tasar growing regions soil on the basis of different category



It showed that all the soils had significant amount of Fe considering 4.8 mg kg^{-1} as critical limit as suggested by Lindsay and Norvel (1978). 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 Methe *et al.,* (2012).

The DTPA Mn in the soil samples varied from 5.7 to 85.9 mg kg^{-1} with an average value of 42.81 mg kg^{-1} (Table 2). Considering 2.0 mg kg^{-1} as critical limit for Mn deficient (Sakal *et al.,* 1985), here all the 100% samples were sufficient in availability (Fig. 2).

The DTPA extractable Cu in soils of selected sites ranged from 0.23 to 0.84 mg kg^{-1} with a mean value of 0.74 mg kg^{-1} (Table 2). The data indicated that higher Cu content was recorded in Tetariya (0.92 mg kg^{-1}) and lower in Dhaka village (0.59 mg kg^{-1}). Further, the data indicated that 15% of the soil samples were medium range in availability of copper and 85% were sufficient (Fig. 2) considering 0.2 to 0.4 mg kg^{-1} as critical limit for Cu deficiency (Lindsay and Norvel, 1978). Chelating agent like Cu^{2+} firmly hold by organic carbon resulted in higher Cu content with increasing organic matter. This finding was in conformity with that of Singh *et al.,* (2006); Verma *et al.,* (2007) and Bassirani *et al.,* (2011).

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 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, with respect to organic carbon percentage, all places were recorded high fertility rate of nutrient index value except Digal Pahari where medium nutrient index was observed. Among the four places, status of nitrogen was low in all tasar food plants growing regions. In all the tasar region levels of P was low except Digal Pahari where recorded medium rate. In other hand, nutrient index value of K was recorded high in Salaiya, Dhaka and Tetariya places. S was low in all the places. Conversely, B, Fe, Mn and Cu fertility rating was high in all the tasar growing places except medium fertility status of B in Salaiya and medium status of Cu in Digal Pahari village. Whereas, fertility status of Zn in Tetariya village recorded in higher and medium in all the places, in this work, the P status was low in all tasar growing places similar result also reported by Tiwari (2001) that a wide spread deficiency of P in 98% of districts in India. According to Ravikumar & Somashekar (2014) 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 (Kumar *et al.,* 2013).

In conclusion, it is evidence that from this study, soil fertility status of selected tasar growing sites that all the four villages are acidic to neutral in reaction due to presence of high to medium organic matters. The available nitrogen and phosphorus in most of the soils falls under low category. However, medium to high content of potassium existed in the soils. The sulphur content in the soils varied from low to medium. Fertility rate of available micro nutrients were high index in most of the places but Zn had recorded high in Tetariya village and all other villages showed medium index level of Zn. 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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