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NUTRIENT DYNAMICS AND SUSTAINABILITY OF WILD TASAR SILKWORM ON SAL FLORA

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ABSTRACT

Nutrient content in tasar host plant foliage is one of the important factors for sustainability of tasar silkworm, *Antheraea mylitta* D. Various sericigenous flora is abundantly found in the forests of tropical belt in India for its survivability. An investigation on nutrient dynamics of primary tasar host plants was carried out to understand the sustainability of wild tasar ecoraces on these host plants. Leaf analysis of primary tasar host plants viz. *Terminalia arjuna* (Arjun), *Terminalia tomentosa* (Asan) and *Shorea robusta* (Sal) by following digestion method and using Atomic Absorption Spectrophotometer reveals the fact that there are remarkable differences in intra and inter nutrient contents in the foliage of host plants of Sal and Arjun-Asan. Average nutrient contents viz. N, Fe, Zn and Mn were found more in Sal with significant value of difference in case of Mn ((t-test significance at less than 0.01%) than compared to Asan and Arjun whereas contents viz. K, P, Mg & Cu were found less or with no significant difference. On the basis of chemical analysis of 550 leaf samples of different status and different nutrient level in leaves of primary tasar host plants, it was inferred that survivability and sustainability of all wild eco-races of tasar silkworm depends on the suitable range of nutrient dynamics of its host plant. Concentration of nutrients in plant associated with plant itself was found influenced with plant part, age, leaf position on shoot and type of shoot. Content of Mn in leaf of *Shorea robusta* found greatly varied within the plant with difference in the height and position of the leaf. Toxic level of manganese content was found in leaves of lower position and lower twigs of the Sal plant whereas the level of this element in leaves of upper twigs and in top position of Sal tree was found in suitable and safe range for tasar silkworm. Tall Sal tree is known to be the origin of all wild eco-races of tasar as it fits both biotic and abiotic factors for tasar silkworm. When tall Sal trees are cut, coppice and dwarf Sal plant develop which does not fit for safe range of essential nutrient content of manganese for tasar insect. Manganese content in leaf of coppice Sal plant of tender, medium and mature was found as 1315.25±123.09, 1560 ± 167.46 and 1923.17±318.01 respectively whereas it was found as 382.25±37.92, 612.42± 51.38 and 712.08±84.00 in tender, medium and mature leaf of tall Sal tree. Mn content in leaf having different maturity level of other two primary tasar host plants, Arjun and Asan was found in the range of 41 ppm to 105 ppm only. Manganese concentration in leaf of coppice plants of *Shorea robusta* was found in much higher level than compared to other two primary tasar host plants, *Terminalia tomentosa* and *Terminalia. arjuna.* The same ecorace when reared in other primary host plants having lower nutrient of N, Fe, Zn & Mn and in lower altitude, survivability of the silkworm and quality and size of the tasar cocoon diminishes. Hence, it is the need of the hour that Sal jungles should be conserved for making dense Sal flora having larger height and size so that important wild tasar silkworm can be conserved in the tropical forests.
Keywords : Concentration, nutrient, *Shorea robusta, Terminalia arjuna* and *Terminalia tomentosa*

Introduction

Tropical Tasar is produced in humid and dense forest areas over the central and southern plateau in India. It covers the states of Andhra Pradesh, Telengana, Chhattisgarh, Jharkhand, Maharashtra, Odisha, Madhya Pradesh, Uttar Pradesh and West Bengal with about 111.68 lakh hectares having tropical tasar silkworm host plants viz. *Terminalia arjuna* Bedd.(Arjun), T. *tomentosa W*&A (Asan) and *Shorea robusta* Gaertn. F. (Sal). In these areas the Tasar silkworm *Antheraea mylitta* D. exists in the form of several eco-races. Various sericigenous flora are abundantly found in forest area of tropical belt of India for sustainability of tasar silkworm, *Antheraea mylitta* D. Tasar silkworm is polyphagous in nature and feeds on several host plants. However, it has food preference. The host plants, which silkworm normally prefers are known as primary host plants. Other host plants, where the silkworm can sustain its life, but normally do not prefer, are called secondary host plants. Arjun, Asan and Sal are primary host plants of tropical Tasar silkworm, *A. mylitta* D.

In insects, growth rate is related to the nutrients absorbed by the body from different host plants (Sangh, 1956; House, 1962; Deshmukh *et al*., 1977). Leaves of the food plants greatly influence the growth and development of insect (Chapman, 1975). Extensively, tasar silkworm thrives on the leaves of primary tasar food plants- *Terminalia tomentosa* (Asan), *Terminalia arjuna* (Arjun) and *Shorea rubusta* (Sal) which are widely available in the tropical belt in India. Out of many ecological and biological factors which influence the crop production, the quality of tasar food plants used for rearing is one of the most contributing factors. Growth and development of the silkworms depend on the quality of leaves of the host plants. Better the quality of leaves, greater is the possibility of obtaining good cocoon crops (Sinha *et al*., 1986). Further, the quality leaf production depends on the soil nutrient status of plantation site. The need of leaf analysis in perennial horticultural crops and forest trees has proved its superiority over other diagnostic methods (Bhargava and Chadha; 1988). Hence, the element-wise nutrient status in the leaf of primary tasar host plant and its variation with season is very much essential to diagnose deficiencies and excess of various essential elements. Tasar silkworm, like other tropical insects, has seasonal influence on life cycle traits as well as the expression of quantitative traits in the form of fecundity, cocoon weight, shell weight etc.. The leaf nutrient status influences on various metabolic activities of silkworm resulting in variation in cocoon traits. Several studies have been carried out on foliar constituents of tasar food plants (Sinha *et al*., 1971; Agarwal *et al*., 1980; Sinha *et al*., 1989; Sinha *et al*., 1992 and Sinha *et al*., 2005). In mulberry; mineral nutrition deficiency and requirement were studied by several workers (Krishnaswami *et al*., 1971; Singhal *et al*., 1999; Singhvi *et al*., 2002 and Singhal *et al*., 2004).The criteria of choosing a sampling time for diagnostic leaf analysis is that during that phase of plant development, variation of nutrient content in a particular part of the plant should be minimum (Poovarodom *et al*., 2002). It has also been reported (Demirsoy *et al*., 2010) that the nutrient contents in leaf, crown and root changed according to different treatments and plant growth periods in case of Sweet Charlie, strawberry. However, element-wise nutrient content in leaf of primary tasar host plants and their dynamics have least been investigated. Hence, a study was undertaken to know the month-wise variation in nutrient content in leaf of primary tasar host plants during rearing season of *Antheraea mylitta* D. Studies on month -wise variation in leaf nutrient content of primary tasar host plants with different status will help the farmers and field workers in understanding nutrient level with specific time of rearing. Moreover, critical limit and optimum level of nutrients has not been studied till date for tasar host plants. Leaf tissue analysis is a widely performed diagnostic tool to determine the annual crop nutrient needs prior to nutrient interference (Obreza *et al*., 2008). Variation in the quality of larval food can have a negative impact in larval weight gain, developmental time and survival as well as adult performances (Scriber and Slansky, 1981; Slansky and Scriber, 1982).

Thus, it is a great relevance to ascertain the levels and variation of nutrient contents in leaf of primary host plants of tasar silkworm, *Antheraea mylitta* Drury to which it consumes during the rearing period and to generate information for the suitable range of nutrient content for its healthy development and sustainability.

Material and Methods

Leaf sampling and analysis

The composite leaf samples of primary host plants from both forest and block plantations were collected during the month of July from tasar growing areas of Jharkhand, Odisha and Chhattisgarh. Composite leaf samples from different primary tasar host plants viz. *T. tomentosa* and *T.arjuna* under block plantation and *Shorea robusta* under forest plantation were also collected during the month from June (45 days after sprouting of leaves) to December, once in every month in equal interval from farm of Central Tasar Research and Training Institute, Nagri, Ranchi (India). Plants under investigation were not applied with any input. Leaf samples of coppice and tall Sal tree with different maturity levels were also chemically analyzed to know the nutrient dynamics in the samples. As such, a total of 550 leaf samples of primary tasar host plants were analyzed. The samples were thoroughly washed with tap water followed by 0.1N HCl solution and double distilled water. The washed samples were air dried and then kept in hot air oven at 70ºĊ. The dried leaves were ground to powder and stored in plastic bottles for chemical analysis. Total nitrogen in leaf samples was determined by the Kjeldahl method using Kelplus system. For estimation of nutrients other than nitrogen, 1.00 g each leaf sample was digested in 10 ml 9:4 mixture of HNO_3: $HClO_4$ at 200º C until the liquid became colourless (Bhargava and Raghupathi; 1993). Phosphorous, Potassium, Magnesium, Copper, Iron, Manganese and Zinc were estimated by the methods as described in the book of H.L.S Tandon (2001). The month wise leaf nutrient status of *T. tomentosa*, *T. arjuna* and *Shorea robusta* along with their variation in nutrient level were studied. Analytical data range was categorized into low, medium and high taking into consideration the average month-wise variation and randomized leaf sample analysis of different tasar growing areas under block and forest plantation.

Results

The month wise leaf nutrient status of *T. tomentosa*, *T. arjuna* and *Shorea robusta* along with their variation in nutrient level were found as shown in graphical representations from Fig. 1 to Fig. 8. Average nutrient contents viz. N, P, K, Mg, Cu, Fe, Mn, and Zn were found as shown in Fig. 9 and Fig. 10. The variation of nutrient content of manganese in leaf of Sal plant with different maturity level was found as shown in Fig. 11.

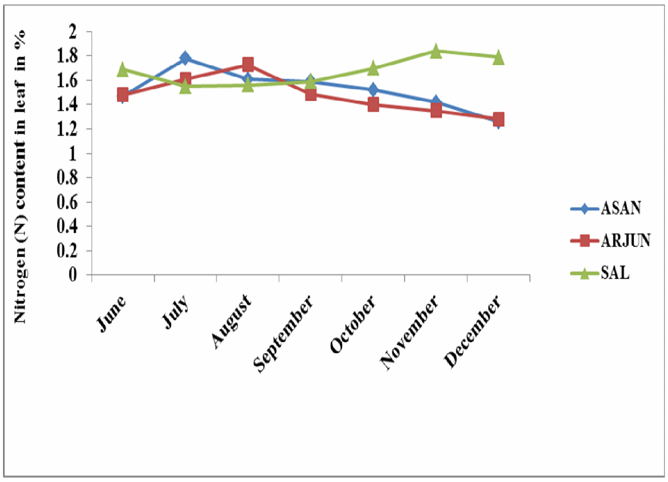

Fig. 1: Month-wise variation of nutrient content of Nitrogen (N) in leaf and their trends during rearing period

Nitrogen content in leaf of primary tasar host plants viz. *T. arjuna* and *T. tomentosa* gradually decreases from July to December. In case of *Shorea robusta*, nitrogen content in leaf becomes higher during the month of October & November

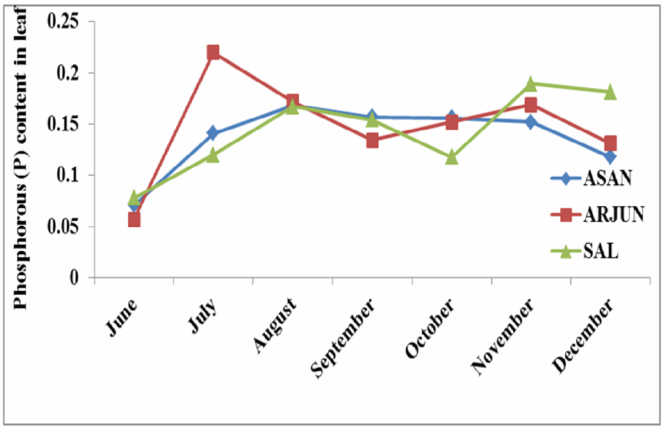

Fig. 2 : Month-wise variation of nutrient content of Phosphorous (P) in leaf and their trends during rearing period

Phosphorous content in leaves remains higher in monsoon season and gradually decreases till winter for all the three primary tasar host plants

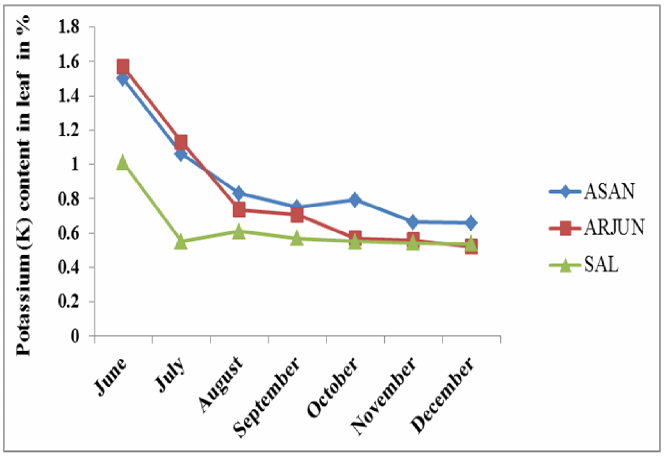

Fig. 3 : Month-wise variation of nutrient content of Potassium(K) in leaf and their trends during rearing period

Potassium content in leaves remains higher in pre monsoon season and gradually decreases till winter for all the three primary tasar host plants.

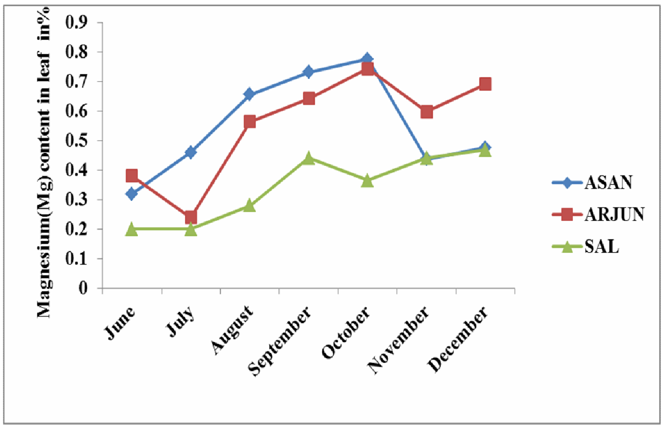

Fig. 4 : Nutrient content of Magnesium (Mg) and month wise trend during rearing period of tasar silkworm.

Increased level of magnesium content exists in mature leaves. Mg content in leaf gradually increases over the time (June to December).

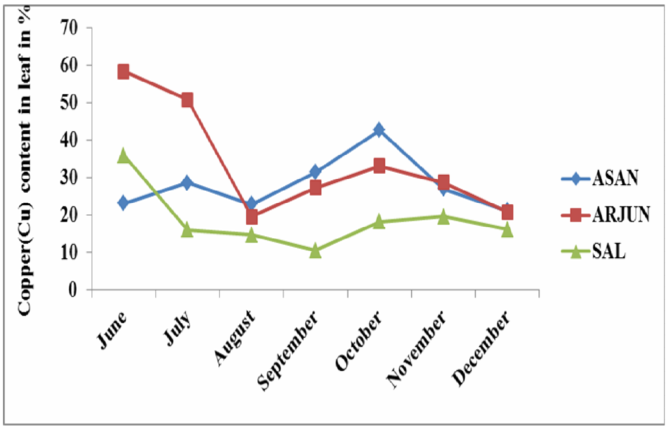

Fig. 5 : Nutrient content of Copper (Cu) and month wise trend during rearing period of tasar

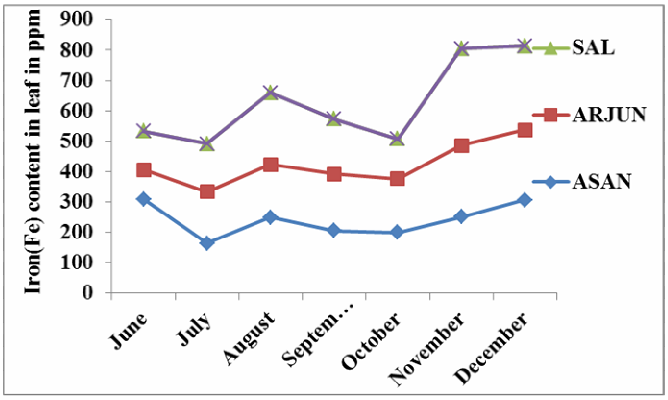

Fig. 6 : Nutrient content of Iron (Fe) and month wise trend during rearing period of tasar

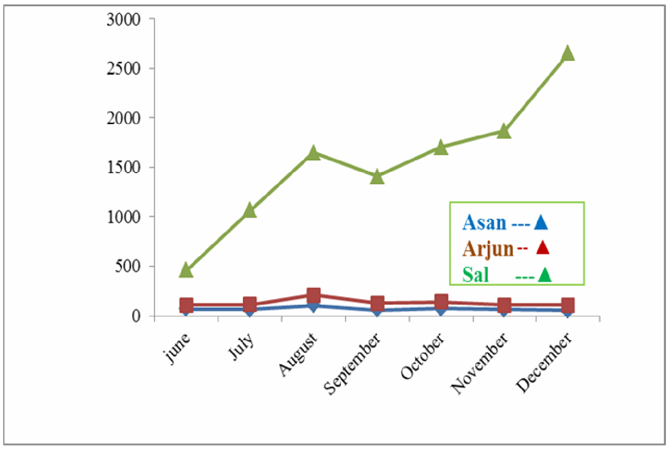

Fig. 7 : Nutrient content of Manganese (Mn) and month wise trend during rearing period of tasar

Manganese concentration in leaf of coppice plants of *Shorea robusta* was found in much higher level than compared to other two primary tasar host plants, *T. tomentosa* and *T. arjuna.* There are no specific month-wise trends in nutrient content in leaf of primary tasar host plants for Cu, Fe, Mn and Zn. However, as a general trend Mn and Fe content increases over the maturity of leaves whereas Cu and Zn content decreases over the maturity of leaves.

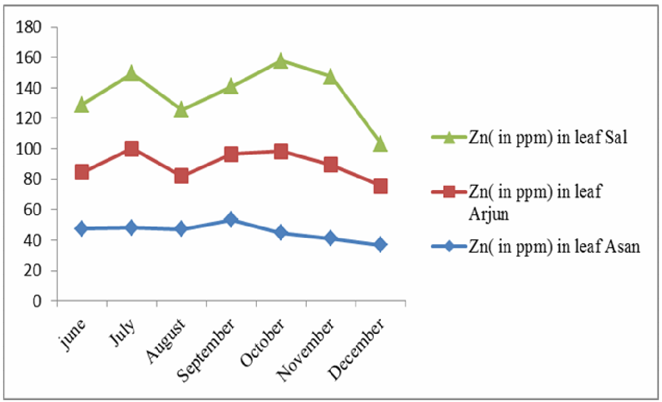

Fig. 8 : Nutrient content of Zinc (Zn) and month wise trend during rearing period of tasar

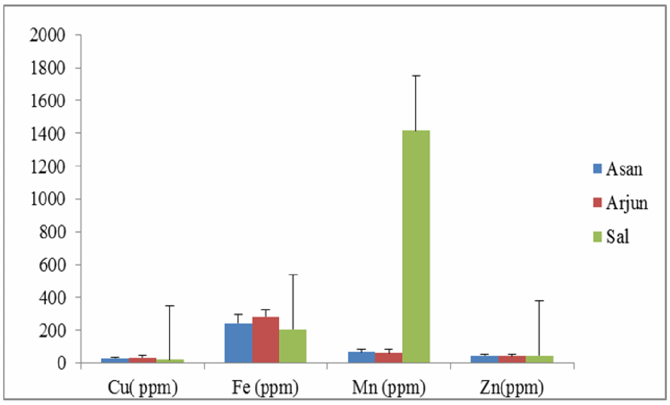

Fig. 10 : Variation in average nutrient Cu, Fe, Mn and Zn primary tasar host plants

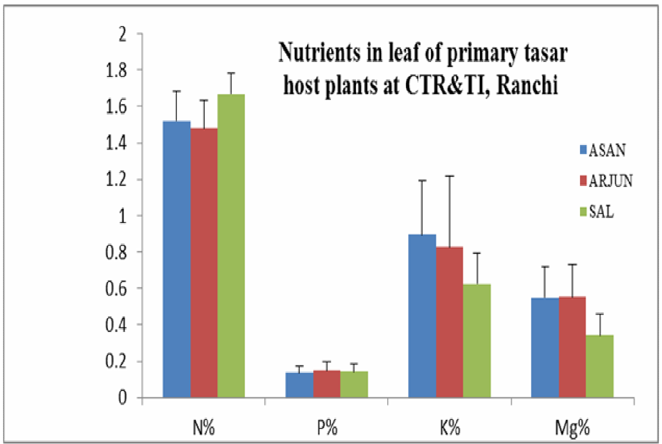

Fig. 9 : Variation in average nutrient contents of N, P, K and Mg, primary tasar host plants

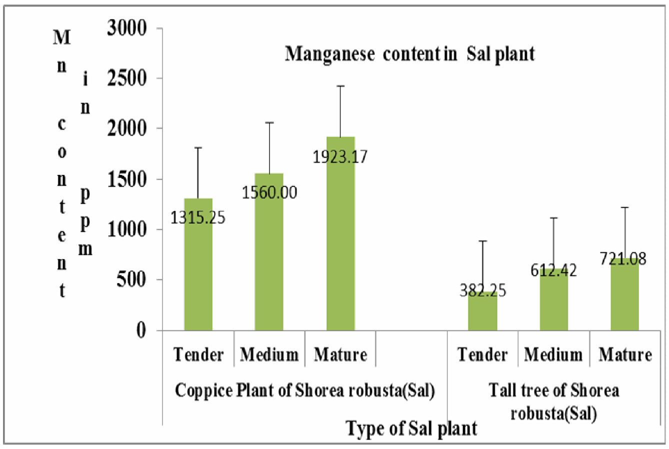

Fig. 11: Variation of nutrient content of manganese in leaf of Sal plant with different maturity level

Table 1 : Nutrient content of Mn in leaf of Sal plant with different maturity level.

SUMMARY	Count	Sum	Average	Variance
CP(Tender)	12	15783	1315.25	15151.66
TT(Tender)	12	4587	382.25	1438.20
CP(Medium)	12	18720	1560.00	28044.73
TT(Medium)	12	7349	612.42	2640.27
CP(Mature)	12	23078	1923.17	101132.70
TT(Mature)	12	8653	721.08	7056.27

CP: Coppice Plant of Sal, TT: Tall Tree of Sal

Manganese content in leaf of coppice Sal plant of tender, medium and mature was found as 1315.25±123.09, 1560 ± 167.46 and 1923.17±318.01 respectively whereas it was found as 382.25±37.92, 612.42± 51.38 and 712.08±84.00 in tender, medium and mature leaf of tall Sal tree as shown in Table-1& Figure-11. Mn content in leaf having different maturity level of other two primary tasar host plants, Arjun and Asan was found in the range of 41 ppm to 105 ppm only. Statistically content of Mn between Asan and Sal and between Arjun and Sal were found with t-test significance at less than 0.01%.

Table 2: Descriptive Statistics on nutrient contents in leaf of primary tasar host plants

Statistical parameter	N(%)	P(%)	K(%)	Mg(%)	Mn(ppm)	Fe(ppm)	Cu(ppm)	Zn(ppm)
Mean	1.560	0.185	1.010	0.466	359.56	228.62	29.10	42.53
Standard Error	0.019	0.018	0.033	0.015	42.64	5.34	1.63	0.92
Median	1.550	0.135	0.885	0.422	56.30	214.53	23.90	41.00
Mode	1.650	0.152	0.670	0.118	100.00	128.00	15.00	28.34
Standard Deviation	0.283	0.265	0.483	0.226	629.56	78.83	24.13	13.52
Sample Variance	0.080	0.070	0.233	0.051	396347.46	6213.86	582.33	182.92
Kurtosis	0.651	26.240	2.084	-0.559	6.80	0.39	14.96	0.55
Skewness	0.625	5.054	1.352	0.534	2.35	0.60	3.28	0.79
Range	1.620	1.856	2.640	0.948	4152.60	437.00	189.90	69.66
Minimum	0.890	0.030	0.200	0.103	17.40	63.00	5.10	17.50

Maximum	2.510	1.886	2.840	1.051	4170.00	500.00	195.00	87.16
Sum	340.120	40.296	220.180	101.627	78384.15	49839.67	6344.56	9271.69
Count	218.000	218.000	218.000	218.000	218.00	218.00	218.00	218.00
Largest(1)	2.510	1.886	2.840	1.051	4170.00	500.00	195.00	87.16
Smallest(1)	0.890	0.030	0.200	0.103	17.40	63.00	5.10	17.50
Confidence Level(95.0%)	0.038	0.035	0.064	0.030	84.04	10.52	3.22	1.81

On the basis of analytical results of nutrient contents in primary tasar host plants, the level of nutrient content in leaf was classified as in the Table 3.

Table 3 : Classification of nutrient content in leaf in primary tasar host plants

Nutrient Element	**Classification of nutrient content in leaf**		
	Low level	**Medium level**	**High level**
Nitrogen (%)	0.80 -1.49	1.5 - 2.00	> 2.00
Phosphorous (%)	0.04 – 0.13	0.14 – 0.20	> 0.20
Potassium (%)	0.30 – 0.65	0.66 – 1.70	> 1.70
Magnesium (%)	0.20 – 0.40	0.41 – 0.80	> 0.80
Copper (ppm)	3.5 – 7.00	7.1 – 35.00	> 35.00
Iron (ppm)	20– 49	50– 350	> 350
Manganese (ppm)	20 - 49	50 - 500	> 500
Zinc (ppm)	20 -39	40 -120	> 120

Discussion

Silk is a protein fiber. Nitrogen is the main constituent element of protein. The results shows that Sal leaves contain more nitrogen content as compared to other two primary host plants Arjun and Asan. Metal nutrient contents like manganese, iron and zinc are also comparatively more in case of Sal leaves. These metals have greater role in governing the physiological changes which occurs within the insect body to produce cocoons of different characteristics. Content of these micronutrients in leaves of different primary host plants varied as a result of which unequal intake quantity of these trace elements resulted in variable cocoon characters. For each essential trace element which comes under micronutrient, there are two ranges of intake associated with adverse health effects: intakes that are too low and can lead to nutritional deficits and intakes that are too high and can lead to toxicity. Between these two ranges, there is a range of safe and adequate intakes that is compatible with good health (Santamaria, 2008). Sal based eco-races were found entirely different than that of other two primary tasar host plants, Asan and Arjun. Comparisons of *Shorea* based ecoraces and *Terminalia* based ecoraces for commercial attributes (cocoon weight, shell weight and silk ratio) indicated that majority of the ecoraces collected from the *S. robusta* plants had more silk contents when compared with that of *Terminalia* based ecoraces (Srivastava *et al*., 2013). Average nutrient contents viz. N, Fe, Zn and Mn were found more in Sal with significant value of difference than compared to Asan and Arjun whereas contents viz. K, P, Mg & Cu were found less or with no significant difference. It was found that manganese content in tender leaf of natural Sal tree is in less quantity compared to mature leaves of the same plant. However, tender leaves of coppice Sal plant contain higher content of Mn compared to tender leaves of tree type Sal plant. Higher content of Manganese must be interfering with the digestion and could not be assimilated by the tasar silkworm properly leading to imbalance in the physiological activities causing heavy mortality of the larvae (Giri and Misra, 2018) Further rearing on leaves of coppice Sal tree for young age is not advisable because of higher content of manganese in tender leaves of coppice plant. Content of Mn in leaf of *Shorea robusta* found greatly varied within the plant with difference in the height and position of the leaf. Toxic level of manganese content was found in leaves of lower position and lower twigs of the Sal plant whereas the level of this element in leaves of upper twigs and in top position of Sal tree was found in suitable and safe range for tasar silkworm. Tall Sal tree is known to be the origin of all wild ecoraces of tasar as it fits both biotic and abiotic factors for tasar silkworm. When tall Sal trees are cut, coppice and dwarf Sal plants develop which do not fit for the safe range of essential nutrient content of manganese for tasar insect.

Sal based wild tasar ecoraces like Modal, Raily, Munga, wild Daba and Laria are larger in size and have more silk content and silk ratio percentage. The same ecorace when reared in other primary host plants having lower nutrient of N, Fe, Zn & Mn and in lower altitude, survivability of the silkworm and quality and size of the tasar cocoon diminishes. Hence, it is the need of the hour that Sal jungles should be conserved for making dense Sal flora having larger height and size so that important wild tasar silkworm can be conserved in the tropical forests.

Conclusion

Nitrogen content in leaf of primary tasar host plants viz. *T. arjuna* and *T. tomentosa* gradually decreases from July to December. In case of *Shorea robusta*, nitrogen content in leaf becomes higher during the month of October & November. There are no specific month-wise trends in nutrient content in leaf of primary tasar host plants for Cu, Fe, Mn and Zn. However, as a general trend Mn and Fe content increases over the maturity of leaves whereas Cu and Zn content decreases over the maturity of leaves. Manganese concentration in leaf of coppice plants of *Shorea robusta* was found in much higher level than compared to other two primary tasar host plants, *T. tomentosa* and *T. arjuna*. Toxic level of manganese content was found in leaves of lower position and lower twigs of the Sal plant whereas the level of this element in leaves of upper twigs and in top position of tall Sal tree was found in suitable and safe range for tasar silkworm. Tall Sal tree is known to be the origin of all wild ecoraces of tasar as it fits both biotic and abiotic factors for tasar silkworm. Hence, it is the need of the hour that Sal jungles should be conserved for making dense Sal flora having larger height and size so that important wild tasar silkworm can be conserved in the tropical forests.

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