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Influence of *Shorea robusta* leaf extract treatment on *Terminalia arjuna* plants over tasar silkworm growth and economic traits

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Abstract
Continuous rearing of tasar silkworm on same Arjun plantations has led to decrease in silkworm commercial characters owing to depleting leaf nutrient quality. Plantations rarely receive manures due to poor economic status of tribal farmers. Considering the presence of vital nutrients and high anti-nutritional factors in Shorea robusta (Sal), nine treatments of Sal leaf extract having different dilutions and treatment duration were applied over Arjun plants. Tasar silkworm reared on treated Arjun plants revealed significant improvement for larval body weight, cocoon weight, pupa weight, fecundity and reeling parameters. Among treatmentsT4 (500 ml extract + 500 ml water, 3 days interval) has significantly enhanced fecundity by 13% over control, besides enhancing larval weight, pupal weight, filament length and silk weight. On contrary, silkworm reared directly on Sal plants shown high larval mortality (95%) and survived larvae spinned cocoons of inferior quality, this was attributed to high level of anti-nutritional factors in Sal. Thus, supplementation of silkworm nutrition through Sal leaf extract is an eco-friendly, feasible and zero cost approach for tasar farmers.

Keywords: Sal, leaf extract, tasar silkworm, anti-nutritional factors, commercial plantation and fecundity.

Introduction
In sericulture, India is the only country produces five different kind of silk *viz*., Mulberry, Eri, Muga, Tropical tasar and temperate tasar. Among these, tasar silk is unique for its natural luster, texture, color and durability [1]. India is the only producer of tropical tasar silk in the world with raw silk production of 2977 MT [2]. Tasar culture is livelihood for 1.25 lakhs tribal families residing in the edge of forest in Northern and North-East India [3]. Creation of rural employment, alleviation of poverty and elevation of socio-economic status of tribals are unique features of Indian tropical tasar industry [4, 5].

Tasar culture is being practiced traditionally by tribal people since centuries through collection of naturally grown silkworm cocoons from forest plants [6, 7], mainly Sal (*Shoria robusta*) and Asan (*Terminalia tomentosa*). In recent decade's tasar culture has taken commercial facet, wherein tasar silkworm (*Antheraea mylitta* D.) are being reared on forest grown food plants (mainly Asan), as well as in systematically planted Arjun plantations [1]. Under commercial plantation cocoon productivity is high owing to high leaf biomass, which ensures farmers high returns with low investment [8]. To support livelihood of tribal tasar farmers commercial plantations have been raised in forest and non-agricultural land though various government schemes [9]. These plantations have been distributed to tribal farmers to carry out silkworm rearing [10].

Continuous rearing of tasar silkworm on same Arjun plantations has led to decrease in silkworm commercial characters like fecundity, shell weight and filament length. Fecundity is an economic trait largely influences seed chain in tasar industry. Improvement of fecundity would reduce drudgery involved in pebrine testing to a considerable extent, besides meeting huge demand of DFLs [11]. Fecundity is dependent on several independent characters mainly silkworm larval body weight and pupa weight [11]. These traits are mainly influenced by leaf nutrient quality. Fecundity and cocoon characters of silkworm reared under block plantations are deteriorating owing to poor leaf nutrient quality in Arjun, which in turn due to the depletion of soil nutrient status [12].

Plantations receive low/no manures and fertilizers due to poor economic condition of tribal farmers [13, 10].

Leaf nutrient can be enriched through external supplementation of nutrients and/or metabolites. Several attempts have been made to supplement nutrients to mulberry silkworm by spraying proteins [14], vitamins [15], plant product or plant extract on mulberry leaves [16, 17, 18, 19]. In tasar silkworm also attempt can be made to supply the nutrients/metabolites from leaf extract of other food plants, preferably *Shorea robusta* (Sal).

Naturally grown tasar silkworm ecoraces feeds mainly on Sal and spins cocoons with significantly high shell weight and filament length[20].On the contrary, rearing of Semi-domesticated silkworm of Daba ecorace on Sal plants has shown high mortality at fourth and fifth instar larval stage (unpublished data) and survived larva spins cocoons of inferior quality (unpublished data). Leaf nutrient analysis has reported that, mature Sal leaf has high phenol [21][22], tannin and crude fibre content along with low moisture [23] which are detrimental to larval feeding [21]. However, superior cocoon parameters in natural Sal fed ecoraces emphasizes the presence of vital nutrients in Sal leaf.

Considering the presence of vital nutrients in Sal leaf an attempt was made in this study to supply Sal nutrients on Arjun plants under block plantation by preparing Sal leaf extract. This could enrich silkworm nutrition and further improves fecundity and cocoon parameters. To reduce the concentration of anti-nutritional factors, Sal leaf extract was prepared with various dilutions.

Materials and methods

The field investigation was undertaken in the campus of PPC (Pilot Project Center) Hatgamharia, Chaibasa, Jharkhand, India. Sal leaf extract was sprayed on *Terminalia arjuna* plants under commercial plantation having spacing of 6' x 6' and Tasar silkworm (*Antheraea mylitta* D.) was reared during first crop 2019. On the other hand, silkworm rearing was also performed on Sal plants and Arjun plants as control. For both of these experiments Semi-domestic silkworm of Daba ecorace was used.

Preparation of silkworm DFLs

Disease free layings (DFLs) were prepared from Daba bi-voltine race by following mother moth examination for microsporidia spores [24], which cause pebrine disease in silkworm. DFLs were then washed with Depuratex disinfectant (CTR&TI, Ranchi) to remove egg meconium and egg surface sterilization [24]. For leaf extract treatment experiment ten DFLs were used and for rearing on Sal and Arjun host plants five DFLs each were used.

Bushing of larva

Eggs were incubated for 8-10 days by maintaining suitable temperature (28-30°C) and relative humidity (70-80 %). Eggs were hatched for three consecutive days, which were brushed on host plants using a soft brush. To protect silkworm from birds, insect pest and predators plantation was covered with nylon net (40' x 30' x 10').

Preparation of leaf extracts treatment combination

Fresh Sal leaves were collected from forest area at morning time. Leaf extract was prepared by grinding fresh leaves with water @ 1 kg/3 liter using mixer grinder. Extract was collected by sieving in cotton cloth and volume was made up to three liters. This extract was then used to prepare two more dilutions as mentioned in table 1. For each dilution of leaf extract three treatment intervals (3, 7 and 11 days) were made. Untreated Arjun plants were considered as control (T_0). Gutter sprayer was used to spray Sal leaf extract @ 500 ml/ plant. Number of sprays received for each treatment combinations are tabulated in table 1.

Table 1: List of treatment combinations having different dilutions of Sal leaf extract and treatment interval.

#	Symbol	Treatments		
		Dilutions	Treatment interval (day)	Number of spray
1	T0	Control (Untreated)	-	-
2	T1	1 litter extract	3	7
3	T2	1 litter extract	7	4
4	T3	1 litter extract	11	3
5	T4	500 ml extract + 500 ml water	3	7
6	T5	500 ml extract + 500 ml water	7	4
7	T6	500 ml extract + 500 ml water	11	3
8	T7	250 ml extract + 750 ml water	3	7
9	T8	250 ml extract + 750 ml water	7	4
10	T9	250 ml extract + 750 ml water	11	3

Experiment design

Sal leaf extract treatment experiment was executed in Randomized Block Design (RBD) with three replications. For each treatment one DFL (~200 eggs) was used, after second molt third instar larva were equally divided and transferred to different plants in three replications. Application (spraying) of Sal leaf extract treatments over Arjun plants was initiated when silkworm larva attained third instar stage and continued till initiation of cocoon spinning. After five days of cocoon spinning, cocoons were harvested separately inreplication-wise.

Observations recorded

Silkworm larval body weight (g) was recorded at third day of fifth instar stage in field using portable weighing balance. After harvesting, cocoons weight (g), shell weight (g) and pupa weight (g) were recorded. These parameters were recorded in ten larva/cocoons, separately for male and female silkworm reared on Sal leaf extract treated Arjun plants. Whereas in silkworm reared on Sal plants above parameters were recorded in 15 larva/cocoons.

Reeling parameters were assessed by taking 8 male and 8 female cocoons from each Sal leaf extract treatment combination. Cocoons were initially stifled and cooked to assess their reeling parameters. Single cocoon filament length (m) was measured using Epprouvette and breaks were noted. Yarn was dried in hot air oven at 60°C for 20 minutes and recorded yarn weight (g)and waste silk weight (g). Yarn denier and non- broken filament length (NBFL) was estimated by using following expression.

Yarn denier= Filament weight (g)/Yarn length (m) ×9000

Non- broken filament length (NBFL)= Filament length(m)/No. of cocoon+ No. of breaks

For recording fecundity cocoons derived from each treatment were hanged in separate cages. Emerged moths were natural coupled and allowed mating for 8 hours. Mated female moths were kept for oviposition in plastic cups for three days and number of eggs was recorded.

Statistical analysis

Analysis of variance (ANOVA) for Randomized block design (RBD) was performed using MS Excel 2013 and critical difference (CD) value was used to compare significance across treatment means. To compare the means performance of silkworm reared on Sal and Arjun host plants Paired t-test was used by employing SPSS v16.0.

Results

Considering the rich nutrient profile of Sal leaf, present study was undertaken to supplement vital nutrients to silkworm besides decreasing the concentration of anti-nutritional factors. In this study optimization was done for dose and duration of leaf extract by testing nine different treatment combinations to obtain enhanced silkworm growth parameters and commercial characters.

Analysis of variance for RBD revealed significant variation among Sal leaf extract treatments for their effect on fifth instar female larval weight, female pupa weight and fecundity (Table 2). Similarly, significant variation was also observed for reeling parameters of female cocoon *viz*., filament length, Non-Breakable Filament Length (NBFL), yarn weight, total silk weight and Denier (Table 3). In male silkworm except larval body weight Sal leaf extract treatments have shown no significant effect on other traits (Table 2). This indicates Sal leaf nutrients have more influence on female silkworm than male. Thus, leaf extract concentration and their treatment interval have differential influence on both pre-cocoon and post cocoon (reeling) parameters of tasar silkworm.

Table 2: Analysis of variance of nine Sal leaf extract treatments on tasar silkworm body, cocoon traits and fecundity.

Source of Variation		Larval body weight		Cocoon weight		Pupa weight		Shell weight		Shell ratio		Fecundity
	d. f.	M	F	M	F	M	F	M	F	M	F	F
Replication	2	0.20	0.45	0.03	0.02	0.02	0.05	0.0005	0.0045	0.18	0.62	5
Treatments	9	0.30*	1.92*	0.36	0.53*	0.39	0.65*	0.005	0.008	1.61	0.35	143.8*
Error	18	0.08	0.74	0.19	0.26	0.19	0.16	0.007	0.003	1.20	0.66	26.66
CV (%)		0.9	2.6	5.0	4.4	5.54	3.83	9.35	5.46	10.61	8.88	2.18

*Significant at 0.05 probability level.

Abbreviations**:** d. f., Degrees of Freedom; M, Male silkworm; F, female silkworm; CV, Coefficient of variation

Table 3: Analysis of variance of nine Sal leaf extract treatments on silkworm cocoon reeling parameters.

Source of Variation	d. f.	Filament Length		Number of breaks		NBFL		Yarn weight		Waste weight		Total silk weight		Denier	
		M	F	M	F	M	F	M	F	M	F	M	F	M	F
Replication	2	13847*	603	0.00	0.03	720*	307	0.03	0.02	0.00	0.03*	0.03	0.93*	1.20	2.35
Treatments	9	1741	9836**	0.25	0.50	315	515*	0.00	0.02*	0.01	0.01	0.01	1.62*	1.12	2.05*
Error	18	12054	1706	0.24	0.18	694	204	0.02	0.01	0.02	0.01	0.01	1.36	1.37	1.62
CV (%)		28	10	14.1	11.2	29	15	27.8	13.98	39.58	17.30	10.2	10.00	10.08	10.46

**,*Significant at 0.01 and 0.05 probability level.

Abbreviations: NBFL, Non-breakable filament length; M, Male silkworm; F, female silkworm; CV, Coefficient of variation

Effect of Sal leaf extract treatment on silkworm larva growth

Among nine treatments six treatments have shown pronounced effect on larval body weight, irrespective of the sex (Table 4). Treatments having dilution of 500 ml extract + 500 ml water (T4, T5 and T6) and 250 ml extract + 750 ml water (T7, T8 and T9) with treatment interval of three, seven and eleven days have significantly enhanced maximum larval body weight (33.1 to 33.9 g) as compared to control (30.8 g). Variation among these treatments is insignificant (CD = 1.95 g). Besides body weight, tasar silkworm fed on Sal leaf extract treated Arjun plants exhibited dark green larval body color as compared to silkworm fed on untreated plants (Fig. 1).

Fig 1: Change of body color in fifth instar tasar silkworm fed on Sal leaf extract treated Arjun plants. Silkworm larva fed on treated Arjun plant shown dark green body color with high body weight (left) compared to larva fed on untreated Arjun plants.

Table 5: Mean performance different sal leaf extract treatment on tasar silkworm cocoon reeling parameters (n = 8).

Treatments	Filament length (m)		No. of breaks		NBFL (m)		Yarn Wt. (g)		Waste Wt. (g)		Total silk wt. (g)		Denier	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Control	366	311	2.9	3.0	104	76	0.46	0.37	0.36	0.49	0.82	0.75	11.7	11.4
T1	451	446 [a]	3.1	4.2	109	88	0.51	0.49	0.36	0.33	0.87	0.82	10.3	9.9
T2	399	435 [a]	3.7	3.8	91	87	0.51	0.60 [a]	0.31	0.49	0.81	1.10 [a]	11.6	11.9
T3	398	393	3.4	3.5	95	94	0.54	0.55 [a]	0.35	0.41	0.91	0.97	11.6	12.8
T4	403	544 [b]	3.5	3.1	96	138 [a]	0.54	0.78 [b]	0.50	0.50	1.04	1.28 [b]	12.3	13.2
T5	423	498 [a]	3.7	4.2	87	100	0.53	0.67 [b]	0.33	0.37	0.86	1.04 [a]	12.0	12.4
T6	365	435 [a]	3.3	4.5	86	85	0.45	0.62 [a]	0.43	0.38	0.88	0.99 [a]	11.1	12.8
T7	360	387	3.3	3.1	88	106	0.47	0.53	0.54	0.51	1.00	1.04 [a]	12.0	12.6
T8	365	332	3.7	3.8	66	89	0.43	0.56 [a]	0.34	0.49	0.77	1.05 [a]	10.6	13.2
T9	391	406 [a]	4.1	4.0	77	85	0.51	0.53	0.32	0.49	0.83	1.01 [a]	12.7	11.5
CD (5%)	248	93	1.11	0.95	60	32	0.31	0.18	0.34	0.17	0.20	0.23	2.64	2.88

Note: Values with letter '[a, b]' are significantly different from control and values with different letters are significant among themselves.
Abbreviations: NBFL, Non-breakable filament length; M, Male silkworm; F, female silkworm; CD (5%), Critical Difference at 5% level of significance.

Effect of Sal leaf extract treatment on silkworm commercial traits

Treatment 4 combination, 500 ml extract + 500 ml water, sprayed 7 times in 3 days interval has significantly enhanced female pupal weight (11.9 g) as compared to control (10.6 g). Remaining treatments effect is insignificant over pupal weight (CD = 0.92 g). However, T4, T5, T6, T7 and T8 treatments have significantly enhanced silkworm fecundity up to 252 (range 232-252 eggs) as compared to control (224 eggs). Statistically T4 to T8 treatments are insignificant (CD=12), however T4 has shown considerably highest effect over fecundity i.e. 252 eggs/moth, which is 13% more than the control.

Tasar silkworm reared during first season (July-August) generally forms cocoon with less silk content compared to second season (September-October). Hence first season crop is mainly taken for seed purpose and thus called this season as seed crop. However, an attempt was made to understand the treatment effect on reeling parameters. The filament length of the silkworm cocoon was significantly improved by most of the treatments *viz*., T1, T2, T4, T5, T6 and T9 (Table 5). Among them T4 has shown highest improvement in filament length. Whereas Non Breakable Filament Length (NBFL) was not affected by any of the treatments exceptT4. However, yarn weight was significantly enhanced by six treatments *viz*., T2, T3, T4, T5, T6 and T8, out of these T4shown highest yarn weight (0.78 g) followed by T5 (0.67 g). Similarly, total silk weight was significantly enhanced by all the treatments except T1 and T3 treatments. Denier of the yarn was unaffected by any of the treatments (Table 5). Thus, in general most of the treatments have shown significant positive effect over reeling parameters as compared to control.

Table 4: Mean performance different sal leaf extract treatment on tasar silkworm body, cocoon traits and fecundity (n = 10).

Treatments	Number of cocoons/DFL	Larval body weight (g)		Cocoon weight (g)		Pupa weight (g)		Shell weight(g)		Shell ratio (%)		Fecundity
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Female
Control	85	29.7	30.8	8.9	11.7	7.9	10.6	0.95	1.05	10.7	9.0	224
T1	83	30.8 [a]	32.7	8.0	11.0	7.0	10.0	1.00	1.05	12.6	9.6	231
T2	95	30.8 [a]	32.1	9.2	11.5	8.2	10.5	0.90	1.15	9.8	10.1	233
T3	84	30.9 [a]	32.2	9.1	11.5	8.2	10.5	0.90	1.10	9.9	9.6	229
T4	95	30.9 [a]	33.8 [a]	9.2	12.7	8.2	11.9 [a]	0.90	1.15	9.9	9.2	252[a]
T5	80	30.8 [a]	33.9 [a]	9.2	12.3	8.2	11.3	0.85	1.10	9.3	9.0	242[a]
T6	74	31.0 [a]	33.2 [a]	8.7	11.3	7.7	10.4	0.85	1.00	9.8	8.8	244[a]
T7	82	31.1[a]	33.6 [a]	8.2	11.0	7.2	10.0	0.85	0.95	10.4	8.6	243[a]
T8	97	30.8 [a]	33.7 [a]	8.7	11.7	7.7	10.7	0.90	1.05	10.3	9.0	239[a]
T9	81	30.8 [a]	33.1 [a]	8.9	11.4	7.9	10.5	0.95	1.05	10.7	9.2	232
CD (5%)		0.6	1.95	0.99	1.16	0.98	0.92	0.19	0.13	2.48	1.85	12

Note: Values with letter '[a]' are significantly different from control and insignificant among themselves.
Abbreviations: DFL, Disease Free Laying; CD (5%), Critical Difference at 5% level of significance.

Performance of tasar silkworm on Sal plants

To compare silkworm rearing performance on Sal leaf extract treated Arjun plants, silkworm was also reared on Sal plants. During initial three instar larval stage silkworm hasshownnormal feeding and larval growth on both Arjun and Sal plants. As silkworm larva attained fifth instar stage 95% of larval mortality (Table 6) was observed on Sal fed silkworm by showing symptom of hanging head downwards. Remaining survived larva have shown significantly lesser body weight (34.67 g in female and 23.41 g in male) at fifth instar stage and compared to those reared on Arjun (38.54 g in female and 25.70 g in male) (Table 7). Sal derived silkworm, particularly of female sex have spinned cocoons of inferior quality with low cocoon weight (10.86 g), pupa weight (9.67 g) and shell weight (1.18 g) compared to those from Arjun (12.45 g, 11.07 g and 1.28 g). While cocoon parameters of male silkworm were on par with those derived from Arjun plants.

Table 6: Survivability of Semi-domestic Daba silkworm reared on Arjun and Sal food plants during first crop 2019.

S. No.	Host plants	No. of worms brushed	No. of larva survived at cocoon spinning
1	Arjun	845	386 (46%)
2	Sal	845	40 (5%)

Table 7: Performance of Semi-domestic Daba silkworm reared on Arjun and Sal food plants for their growth and cocoon characters (n=15), during first crop 2019.

Characters	Sex	Arjun	Sal
Larval body weight (g)	Female	30.95 ± 0.52	26.87*** ± 0.32
	Male	28.71 ± 0.78	25.41* ± 0.55
Cocoon weight (g)	Female	11.75 ± 0.27	10.16*** ± 0.20
	Male	8.86 ± 0.22	8.51 ± 0.12
Pupa weight (g)	Female	10.61 ± 0.26	9.27** ± 0.20
	Male	7.91 ± 0.17	7.58 ± 0.10
Shell weight (g)	Female	1.05 ± 0.03	0.89* ± 0.02
	Male	0.95 ± 0.06	0.91 ± 0.03
Shell ratio (%)	Female	9.00 ± 0.24	8.76 ± 0.23
	Male	10.72 ± 0.18	10.69 ± 0.20

*, ** &*** Significant at $p<0.05$, $p<0.01$ and $p<0.001$

It was noticed that silkworm larva feed on Sal plant were having dark green larval body color compared to those reared in Arjun plants. Hand feeling observation of Sal fed larva revealed hard intestine texture, while Arjun leaf fed larva had soft intestine texture.

Discussion

Shorea robusta Gaertn F. (Sal) is a primary food plant of tropical tasar silkworm *Antherea mylitta* D., abundantly available in most of the tasar silkworm rearing regions of India. Several wild tasar silkworm ecoraces feeds mainly on Sal in different forest ecosystems [25] and produces good quality cocoons [20] as compared to those reared on Arjun plants under block plantation. Sal fed ecorace Modal produces average filament length of 1480m in comparison to Daba ecorace fed on Arjun (850 m) [20]. One of the major reasons for improved silk quality could be due to its excellent leaf nutrient profile. Considering these facts, rearing performance of Semi-domestic Daba silkworm was compared on Sal and Arjun food plants.

In Sal fed silkworm high larval mortality was seen at fourth and fifth instar stage, which could be attributed to high phenol and tannin content in leaf [21]. It was reported that some compounds in Sal leaf inhibits the secretion/synthesis of digestive enzymes such as amylase and protease in silkworm gut[21]. Sal leaf has high crude fibre content (21.7%) and low leaf moisture content (61-67%) as compared to Arjun, having low fibre (10.9%) and high leaf moisture (71-75%) [23], which could make Sal leaf as less palatable to silkworm [21]. Plants produces phenolics to counter the attack of herbivore insects [26][27] through their cytotoxic mechanism. On the other hand, insects can able to detoxify phyto-phenols to considerable extent through synthesis of Prephenoloxidases (PPOs) in foregut [28]. Generally species with moderate level of leaf phenol are metabolized through foregut PPOs, and so they are not absorbed and do not induce cytotoxic effects. In Arjun leaf phenol level could be within the range catalytic activity of PPOs secreted by silkworm and hence less mortality was observed in Arjun fed silkworm. Whereas in Sal leaf level of phenolics would exceeds the catalytic activity of the gut PPOs in silkworm and which cause cytotoxicity [28].

Reduced larval body weight, cocoon weight, pupa weight and shell weight in Sal fed silkworm could be due to the presence of high level of anti-nutritional factors like phenols, tannins in Sal [21], which could reduce the bioavailability of vital nutrients. Similar observation was reported in*Euphydryas chalcedona* larva fed on *Diplacus aurantiaeus* having high leaf phenolic resin content [28]. High crude fibre content and low moisture in Sal leaf [23] further reduces the palatability and could reduce the leaf consumption by silkworm. Sal fed larva was observed to have rough texture of intestine, which is due to high fibre content in Sal leaf. Phenols gets oxidized by polyphenol oxidase (PPO) and peroxidase (POD) and forms Quinones, which bind covalently to leaf proteins, and inhibit the protein [30]. Quinone can alkylate nucleophilic amino acids, such as lysine, histidine, cysteine, and methionine of proteins, reduce nutritional value of proteins, which affects growth and development of insect [30].

Silkworm fed on Sal plants and Sal leaf extract treated Arjun plants shown dark greenish larval body color as compared to Arjun fed larva (light green). This could be attributed to the presence of unique compounds in Sal.

It was reported that [23] Sal fed silkworm larva and pupa possess high concentration of protein and carbohydrate as compared to those reared on Arjun in first crop. This highlights the significance of Sal leaf nutrient quality. Considering the presence of vital nutrients and high level of anti-nutritional factors in Sal leaf present study was conducted to supplement vital nutrients of Sal to tasar silkworm trough preparation of leaf extract. Nine treatment combinations were prepared to optimize the level of anti-nutritional factors. It was observed that silkworm fed on Arjun plants treated with T1, T2 and T3 treatments (leaf extract without dilution treated in three different interval) have not shown any significant improvement on larval body weight compared to control. Whereas, diluted treatments shown significant effect over larval body weight. This indicates the presence of high level of anti-nutritional compounds in undiluted Sal leaf extract and could have reduced the bio-availability of vital nutrients in leaf extract. While in diluted treatments vital nutrients of Sal were available to silkworm due to reduced level of anti-nutritional compounds. In mulberry silkworm also several attempts have been made to supplement nutrients through spraying plant product or plant extract on mulberry leaves [16, 17, 18, 19].

Among nine treatments five treatment combinations (T4, T5, T6, T7 and T8) have significantly enhanced fecundity. Among them, T4 shown 13% enhancement in fecundity over control, which could make significant impact in large scale silkworm seed production. It is generally observed that tasar silkworm spins less silk during first crop. However, majority of Sal leaf extract treatments have significantly enhanced single filament length, yarn weight and total silk weight. This gives the clue that Sal leaf has vital nutrients to enhance silk production in silkworm. Among treatments T4 has shown high influence over most of the commercial characters *viz*., fecundity, larval body weight, cocoon weight, pupa weight, shell ratio, fecundity, filament length, NBFL, yarn weight and total silk weight.

Conclusion

Poor leaf nutrient quality under block plantation is major problem in Tasar culture. Supplementation of inputs to block plantation to improve leaf quality is not practical approach owing to poor economic status of tasar farmers. Present study has shown the way of enriching the leaf quality of block plantation through Sal leaf extract treatment. Abundant availability of Sal plants in the vicinity of block plantations makes this approach as more practical and zero cost involvement makes it as farmer's friendly approach. This experiment needs to be repeated at large scale to see the feasibility of this approach in enhancing silkworm cocoon quality. Identification of vital nutrients and anti-nutritional

factors in Sal essential to prepare strategy for exploring Sal flora for tasar sericulture.

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