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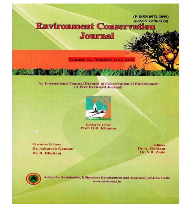

Effect of *Ailanthus* species and seasons on yarn parameters of eri silk

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ABSTRACT

Present research entails an in-depth analysis on the effect of two secondary host plants of eri silkworm *viz.,* borpat (*Ailanthus grandis* Prain) and borkesseru (*Ailanthus excels* Roxb.) and seasons on yarn parameters of eri silk as quality of silk depends on food quality and rearing season. Seasons had significant effect on all the yarn parameters *viz*., yarn size, breaking load, tenacity and elongation except twist per inch. Significantly the highest yarn size (10.26^{s}) was observed in autumn season which was *at par* with the spring season. But the maximum breaking load (0.67 kg) and tenacity (1.40 g/denier) were recorded in spring season and elongation (26.54%) in early summer season. Regardless of the seasons, significantly the higher breaking load (0.64 kg) and tenacity (1.51 g/denier) were recorded on the borkesseru leaves. The interaction effect of seasons and two host plants on eri silk yarn was found to be non-significant. Diversiform effect of both the seasons and the host plants pertaining to yarn characters were witnessed. It can be ensured that all the seasons and host plants are relevant with slight alteration in the yarn quality.

Introduction

The finished product of sericulture industry is the silk, the 'Queen of Textiles'. In India, North-Eastern region is considered as hotspot of seri-biodiversity contingent upon *vanya* silk area. The eri silkworm (*Samia ricini* Boisduval), a *vanya* silkworm, is reared indoor mostly as a part time job by the females of the tribal communities of North-East region. The North-Eastern region of India shares major portion of eri silk production in the country and Assam being the highest producer. Eri silk is also known as 'poor man's silk'. It is also referred as 'Ahimsa silk' or 'Non violent silk' as processing of cocoon does not require killing of the pupa. The unique properties of this fiber in terms of its fineness, density, cross sectional shape and surface properties play an important role in determining its end use and have immense potential for commercial exploitation by making finest quality blankets, sweaters and suiting materials (Tamta and Mahajan, 2021).

Silkworm nutrition is an important component in silk production, and this constituent determines the silk quality and silk trade all over the world (Ruth *et al.,* 2019). Qualities and production of eri silk cocoon and eri silk yarn depends on the different food plants (Gahlaut and Arjun, 2016). Silk yarn quality is also affected by the rearing activities. The execution of fibres during processing and the properties of the finished product are determined by the physical properties of spun yarn. In respect of physical properties of spun yarn, the seasonal variation plays an important role (Renuka and Shamitha, 2014; Bhuyan *et al.,* 2017). Lower (1988) disclosed that with respect to the seasons, the physical properties of the silk *viz.,* strength and elongation differs. In terms of single fibre denier and tenacity of eri silk, noticeable differences were observed when the silkworms were reared on different seasons (Chattopadhyay *et al*., 2018). Variation in the yarn quality is greatly influenced

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by the environmental condition also (Nath *et al.,* 2013). Despite the fact that various studies have been conducted, there is insufficient of literature on the impact of season and secondary host plants on yarn parameters of eri silk. The current study will have the potential to aid in the development of a feasible usage of the secondary host plant in appropriate seasons for eri silkworm without jeopardizing the quality and quantity of silk produce per crop.

Material and Methods

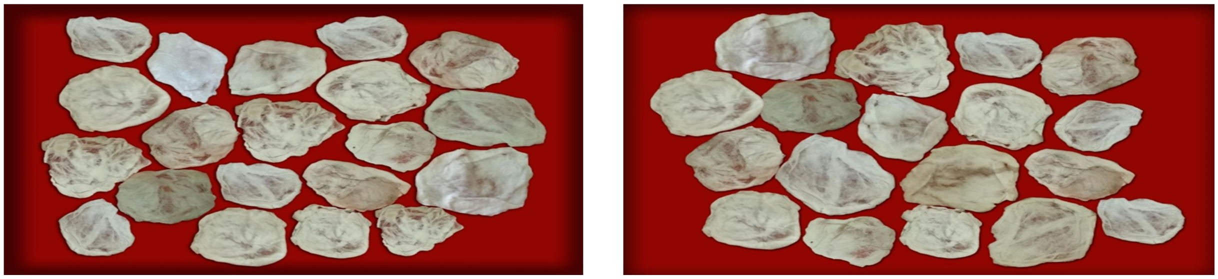
The eri spun yarn from feeding two *Ailanthus* species *viz*., borkesseru and borpat under family simaroubaceae were tested during four different seasons *viz.,* spring (March-April), early summer (May-June), late summer (August-September), autumn (October-November) in the year 2019. The sericin of harvested cocoons was eliminated by the degumming process as suggested and optimized by Somashekar (2003). The eri cakes (Figure1: A & B) were prepared from degummed cocoons by squeezing and the cakes were dried for further spinning process. The spinning of the degummed cocoons for producing single spun yarn filament out of discontinuous filament of the cocoons was performed in the Choudhury spinning machine. The testing of eri spun yarn (Figure 2: A & B) samples for yarn size (count's'), breaking load (kg), tenacity (g/denier) and elongation (%) were conducted in Indian Jute Industries' Research Association (IJIRA), Guwahati, Assam. The breaking load, tenacity and elongation test of the spun yarn were performed according to I.S procedure (1960-1991) by using computerized Instron tensile tester (Model no. 4444) with CRT (Constant Rate Traverse) principle. The twist per inch of the eri silk yarn was recorded by using manual yarn twist tester. The data were laid out in two factorial completely randomized designs for statistical analysis. Each treatment consisted of three replications. The data were subjected to ANOVA table in order to separate out all possible errors. The experimental errors of the various effects were determined by calculating their respective F-values following (Panse and Sukhatme, 1989).

Results and Discussion

The effect of seasons and host plants on yarn size (Table 1) of eri silk was found to be significantly different. Markedly the highest yarn size was observed in the autumn season (10.26^{s}) whereas the undermost in the early summer (9.09^{s}) which was found *at par* with the spring season (9.41^{s}). Host plants have non-significant effect on yarn size. However, the higher yarn size was recorded on borpat leaves (9.77^{s}) compared to borkesseru leaves (9.42^{s}). The interaction effect due to season and host plant was found to be non-significant.

The analysis (Table 2) for the effect of host plants on breaking load of eri silk yarn revealed significant effect during various seasons. The highest significant breaking load values were recorded in spring season (0.67 kg) and the lowest was observed in the autumn season (0.49 kg) among various seasons. Apart from the season's, highest significant breaking load was found in borkesseru leaves (0.64 kg) while the lowest in borpat leaves (0.54 kg). Interrelationship between the seasons and host plants were also found to be non-significant for the trait studied. However, the breaking load was recorded highest on borkesseru leaves in spring season (0.71 kg) and the least on borpat leaves during autumn season (0.44 kg) respectively. Seasons and host plants had significant effect on the tenacity (Table 3) of eri silk yarn. Notably tenacity of the eri silk yarn was revealed highest in the spring season (1.40 g/denier) and lowest in the late summer (1.22 g/denier). Irrespective of the seasons, comparatively tenacity of the eri silk yarn was recorded significantly higher on the borkesseru leaves (1.51 g/denier) than borpat leaves (1.11 g/denier). Interrelation impact on tenacity due to season and host plant was found to be non-significant.

A perusal of data (Table 4) revealed that the season had significant effect on the elongation percentage of eri silk yarn. The elongation percentage was found to be significantly maximum in early summer (26.54%) and minimum in autumn season (23.67%). Despite of showing non-significant effect by the host plants on elongation percentage, borkesseru leaves (25.26%) exhibited the maximum elongation percentage.The interaction effect was found to be non-significant due to seasons and host plants. However, borkesseru leaves in early summer (27.31%) showed the maximum elongation percentage and the borpat during autumn season (23.06%) exhibited minimum values.



A. Degummed eri cakes (borpat) B. Degummed eri cakes (borkesseru)

Figure 1: Degumming of eri cocoons and preparation of eri cakes

Table 1: Effect of season and *Ailanthus* species on eri silk yarn size (count 's')

Seasons	Host plants		Mean
	Borpat	Borkesseru	
Spring (Mar-April)	9.62	9.20	9.41
Early summer (May-June)	9.23	8.96	9.09
Late summer (Aug-Sept)	9.89	9.33	9.61
Autumn (Oct-Nov)	10.33	10.19	10.26
Mean	9.77	9.42	
	SED (±)	CD (5%)	
Seasons	0.24	0.51	
Host plants	0.17	NS	
Seasons × Host plants	0.34	NS	

Data are mean of 3 replications, NS = Non-Significant, SED = Standard error of difference

Table 2: Effect of season and *Ailanthus* species on breaking load (kg) of eri silk yarn.

Seasons	Host plants		Mean
	Borpat	Borkesseru	
Spring (Mar-April)	0.63	0.71	0.67
Early summer (May-June)	0.58	0.68	0.63
Late summer (Aug-Sept)	0.52	0.63	0.58
Autumn (Oct-Nov)	0.44	0.54	0.49
Mean	0.54	0.64	
	SED (±)	CD (5%)	
Seasons	0.02	0.04	
Host plants	0.01	0.03	
Seasons × Host plants	0.03	NS	

Data are mean of 3 replications, NS = Non-Significant, SED = Standard error of difference

Table 3: Effect of season and *Ailanthus* species on tenacity (g/denier) of eri silk yarn

Seasons	Host plants		Mean
	Borpat	Borkesseru	
Spring (Mar-April)	1.18	1.62	1.40
Early summer (May-June)	1.12	1.54	1.33
Late summer (Aug-Sept)	1.03	1.40	1.22
Autumn (Oct-Nov)	1.10	1.46	1.28
Mean	1.11	1.51	
	SED (±)	CD (5%)	
Seasons	0.04	0.08	
Host plants	0.03	0.06	
Seasons × Host plants	0.06	NS	

Data are mean of 3 replications, NS = Non-Significant, SED = Standard error of difference

Spring **Early summer** **Late summer** **Autumn**

A. Eri spun yarn produced from eri silkworm reared on borpat leaves in different seasons

Spring **Early summer** **Late summer** **Autumn**

B. Eri spun yarn produced from eri silkworm reared on borkesseru leaves in different seasons

Figure 2: Eri spun yarn in different seasons.

The impact of seasons and host plants *viz*., borpat and borkesseru (Table 5) was found to be non-significant for twist per inch of eri silk yarn. It was found significantly the highest in the late summer (10.10 TPI) and the lowest values were observed in the spring season (9.27 TPI). Regardless of the seasons, the notable higher value in respect to twist per inch was observed in the borkesseru leaves (10.31 TPI) in contrast to borpat leaves (9.22 TPI). The interaction effect on twist per inch due to season and host plant was also found to be non-significant. The physical properties of eri spun yarn are technically important which contribute to the behaviour of the yarn in processing and to the quality of the final product. The yarn count is the numerical expression which shows fineness or roughness of a yarn. The breaking load of a yarn indicates the maximum amount of stress that can be developed in a yarn due to the applied loads prior to breakdown of the yarn. The combine property of strength and elongation of silk yarn is a measure of toughness of material which is related to weaving property.

Table 4: Effect of season and *Ailanthus* species on elongation (%) of eri silk yarn

Seasons	Host plants		Mean
	Borpat	Borkesseru	
Spring (Mar-April)	24.07	24.98	24.53
Early summer (May-June)	25.76	27.31	26.54
Late summer (Aug-Sept)	23.77	24.48	24.13
Autumn (Oct-Nov)	23.06	24.28	23.67
Mean	24.17	25.26	
	SED (±)	CD (5%)	
Seasons	0.81	1.74	
Host plants	0.58	NS	
Seasons × Host plants	1.15	NS	

Data are mean of 3 replications, NS = Non-Significant, SED = Standard error of difference

Table 5: Effect of season and *Ailanthus* species on twist per inch (TPI) of eri silk yarn

Seasons	Host plants		Mean
	Borpat	Borkesseru	
Spring (Mar-April)	8.73	9.80	9.27
Early summer (May-June)	9.23	10.33	9.78
Late summer (Aug-Sept)	9.57	10.62	10.10
Autumn (Oct-Nov)	9.36	10.49	9.93
Mean	9.22	10.31	
	SED (±)	CD (5%)	
Seasons	1.38	NS	
Host plants	0.97	NS	
Seasons × Host plants	1.95	NS	

Data are mean of 3 replications, NS = Non-Significant, SED = Standard error of difference

Baruah *et al*. (1990) revealed that tensile strength of cocoon filaments of eri, muga and *pat* (mulberry) were 4.96 g/d, 5.54 g/d and 3.18 g/d respectively and their elongation (%) was 34.5%, 35.80% and 18.72% respectively which show the dependency of elongation of filaments on tenacity. The strength of the yarn is generally increased by the twist however detrimental impact would occur beyond the optimum point and ultimately the yarn will degrade (Sonwalkar, 2001). In case of mill spinning, the elongation (%) of the spun yarn decreases with the rise in the count (Kariyappa *et al.,* 2006). Saikia (2008) observed that tenacity and elongation percentage in barkesseru (5.83 g/tex and 23.58% respectively) was comparatively higher than in borpat (5.18 g/tex and 23.10% respectively) while on contrary, lower values in comparison to both were observed in castor. The present study revealed highest twist per inch during early summer and in borkesseru leaves though the results are not significant. In respect to twist per inch slightly lower values were observed in the present investigation as compared to the findings of Chutia (2011) who revealed highest twist per inch (16.8 TPI) in kesseru followed by tapioca (16.2 TPI) and castor (16.0 TPI) during autumn season. Goswami *et al.* (2014) found comparatively higher tensile strength and elongation (%) of green leaf fed cocoons than the red petiole castor leaf fed cocoons in case of eri silk yarn might be due to the result of higher content of the moisture percentage in the green variety castor leaf and the season observed best was spring. Brahma (2015) recorded the highest values in terms of yarn count's', breaking load, tenacity and elongation percentage in castor followed by borpat (13.95 's', 0.61 kg, 1.20 g/d and 18.90% respectively) whereas mixture of borpat with castor and kesseru exhibited slightly lower values. For garments appropriate twist is needed for the support of the dimensional stability of fabric (Sreenivasa *et al.,* 2016). Sharma and Kalita (2017) noticed variation in the quality of the yarn by the six strains of eri silkworm where, the higher maximum load and breaking tenacity (7.90 ± 0.86g and 3.419 ± 0.31 g/d) was exhibited by Greenish Blue Spotted and lowest by Yellow Plain (5.64 ± 1.29g and 2.25 ± 0.515 g/d). In contrast to the present findings, Bhuyan *et al.* (2017) revealed that elongation showed no significant difference in the cocoons from Kesseru fed worms in different seasons. However, Chattopadhyay *et al.* (2018) while studying on the structural and fibre quality characteristics of eri silk cocoons in different seasons and places observed significant influence in case of breaking elongation for all the three factors *viz.,* places, seasons and cocoon layers.

Conclusion

Eri silk is gaining popularity in the national and international market due to its 'ahimsa' way of cocoon processing, unique property and low cost compared to other natural silks. In order to capture the global competitive market and generating sustainable livelihood among the farmers by earning more income from this activity quality of the silk should be maintained. Quality of yarn is affected by various factors. In terms of physical properties of eri spun yarn food, rearing activities and seasonal variation play vital role. Due to the physical structure and chemical composition of the cocoon shells variation in the properties or characteristics of silk yarn occurs. The silk from the same species might differ due to the change in environmental conditions at the time of rearing, spinning of cocoon, mounting and processing of silk. Present study clearly revealed that spring season and borkesseru leaves exhibited better results in terms of physical property of the eri silk yarn.

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Conflict of interest

The authors declare that they have no conflict of interest.

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