Assessment of the Impact of Abiotic Factors on Sustainable Sericulture Development in Jammu Division

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Abstract

Sericulture is one of the oldest subsidiary agriculture based occupation in Jammu. Sericulture industry rely on the rearing performances of silkworm. Silkworm is one of the most important domesticated insects, which produced luxuriant and glorious silk thread in the form of cocoon by ingesting mulberry leaves. The biological as well as cocoon related characters were highly influenced by optimum temperature, rearing seasons and quality of mulberry leaf. The seasonal differences considerably affect the physiological and morphological characteristics of *Bombyx mori* L. The variations in the environmental conditions during past years, strongly recommended the need of management of the temperature and humidity for sustainable cocoon production. The present study was therefore carried out at two levels (field and laboratory) in sericulture potential districts (Udhampur and Kathua) of Jammu region during 2022-2023 to evaluate the role of abiotic factors on sericulture development. Around 200 cocoon growers were selected randomly and interviewed. For experimentation, Bivoltine silkworm hybrid FC1XFC2 was selected and reared under different temperature and humidity treatments to assure the field data. Results obtained during rearing of this breed showed a significant and key role of abiotic factors in survivability of silkworm larvae. During step wise correlation method 5% C.D was depicted in survival rate of larvae. Along with this average weight of single cocoon was evaluated as 1.5 gm in Kathua followed by 1.39 gm in Udhampur. Filament length was observed to be 740 and 664 mts respectively which directly have a great effect on cocoon quality and quantity. The data revealed that the mortality rate increased with continuous variation in different abiotic factors, causing great threat to sericulture industry.

Keywords Abiotic factors, Temperature, Humidity, Disease

Introduction

Sericulture is an agro based multidinous activity which involved cultivation of mulberry, rearing of silkworm cocoons, marketing and reeling of cocoons for value added products (Rakhmonava, 2020). Sericulture has now assumed a great importance as a premier village and cottage industry among the agrarian community in the state that has adopted. It is a short gestation period labor cum intensive industry which can go a long way in promoting inclusive growth and alleviating poverty in rural areas of Jammu division. It is a subsidiary occupation to supplement their income (Rathore *et al*., 2018). The seasonal differences in the environmental (temperature and humidity) components considerably affect the physiological activities of silkworm. The mulberry silkworm, having undergone centuries of domestication, has become exceptionally fragile and sensitive (Balavenkatasubbaiah *et al*., 2014 and Khan, 2014). As a result, it struggles to survive in environment with natural fluctuations in temperature and humidity, requiring controlled conditions to thrive. The success of the sericulture industry depends upon several variables but environmental conditions such as temperature & humidity was of particular importance (Gencoglan and Baspinar, 2016). The temperature has a direct correlation with the growth of silkworm. Wide fluctuations of temperature was harmful for the development of the silkworm. Temperature is probably the single most important environment factor that influenced behavior, development and survival (Sisodia and Gaherwal, 2017; Sharma *et al.*, 2024). Humidity played a vital role in silkworm rearing and its role was both direct and indirect. The combined effect of both temperature and humidity greatly determined the growth of the cocoons. Both directly influenced physiological activities of the silkworms (Ram *et al*., 2016).

Keeping this background in mind, the present research work was carried out to evaluate role of temperature and humidity for survivability of silkworm during rearing & quality and quantity production of cocoon.

Materials and method

The present survey was carried out in two district of Jammu i.e. Udhampur and Kathua. A total of 200 silkworm rearers, 100 from each district were randomly selected as these districts have maximum growers. The primary data was collected from silkworm rearers using open ended questionnaire/personal interview during the year 2022-2023. In the present study, an attempt was made to evaluate the pre and post cocoon parameters of silkworms. For experimentation, bivoltine silkworm hybrid FC1XFC2 were procured from Sericulture Development Department, Kamsar (Poonch) which were reared during spring and autumn season by providing three different treatments of temperature and humidity to the breeds i.e. average and optimum temperature, low temperature and humidity and high temperature and humidity. In order to avoid any kind of infection, the rearing room, floor and tools of the rearing room were disinfected with serichlor-20 solution. The silk worms were reared (in triplicate) after disinfection of the room. Larvae were fed with chopped leaves; 1^{st}, 2^{nd}, 3^{rd} and 4^{th} instars were fed three times a day, timing were be like 1 am, 2 pm and 5 pm. 5^{th} instar was fed two times a day around 11 am and 4 am. Bed changing was done twice in 2^{nd} instar and thrice in 3^{rd} instar and daily in 4^{th} and 5^{th} instars. Proper spacing was done for proper growth and developments of worms. On 8^{th} day, cocoons were harvested as premature cocoons affect quality. Parameters like cocoon yield, larval mortality, larval survivability, single cocoon weight, single shell weight, single larva weight, shell ratio, average filament length, size of the silk filaments and absolute silk content were studied as per modified methods. The primary and secondary data (experimentation) was analyzed by using SPSS package.

Results

The results of the present study gives insight on the role of different environmental factors on the survivability of mulberry silkworm larvae in Udhampur and Kathua districts of Jammu region. The district wise results obtained from socio-economic profiling of silkworm were represented in Table1

Table 1 District wise socio-economic profile (descriptive statistic) of the silkworm rearers

S.No.	District → / Parameters ↓	Kathua (n=100)	Udhampur (n=100)	Overall (n=200)
1	Average age (yrs)	46.37±1.35	47.11±1.31	46.74±1.33
2	Mean Family size (no.)	6.28±0.33	5.52±0.24	5.9±0.29
3	Education level	1.54±0.36	1.40±0.34	1.47±0.35
4	Average land holdings (ha)	3.54±0.05	4.92 ±0.08	4.23±0.06
5	Average experience (yrs)	13.33±1.08	10.86±0.81	12.10±0.95
6	Average distance of sericulture office (km)	42.01±2.15	31.55±0.18	36.78±1.16
7	Average distance from cocoon market (km)	38.25±0.10	44.29±0.19	41.27±0.15
8	Average transportation charges (₹)	72.80±7.53	60.33±2.83	66.56±3.41
9	Average annual income (₹)	17150.33±2263.25	14075.54±1798.87	15612.94±2031.06

During study, it was observed that there were various factors which have a direct influence on the quantity and quality of the silk. Parameters such as single cocoon weight, single shell weight and shell ratio were studied during spring and autumn season by using multiple regression. Based on P-value factors namely average cocoon weight, average shell weight and average ratio of the shell were

observed significant. All these independent variables together predicted around 74% (R^2= 0.74) & 77% (R^2= 0.77) of average income generated in autumn season in Kathua and Udhampur district while 66% (R^2= 0.66) and 62% (R^2=0.62) of average income generated in autumn season in Kathua and Udhampur district (Table 2). The overall impact of various independent variables were directly affecting the quantity and quality was presented in Table 3.

Table 2 Factors influencing income generation from sericulture activity during spring and autumn rearing (2022-2023)

	Spring Season						**Autumn Season**					
District → / **Parameter** ↓	**Kathua**			**Udhampur**			**Kathua**			**Udhampur**		
	R.C.	S.E.	P-value	R.C.	S.E.	P-value	**R.C.**	**S.E.**	**P-value**	**R.C.**	**S.E.**	**P-value**
Constant	186.38	1500	-0.13	19.70	67.79	0.43	53.80	69.47	0.70	138.03	57.10	0.64
Average Single Cocoon Weight	159.30	43.45	0.01*	82.53	45.14	0.05*	75.96	72.52	0.10*	131.79	21.25	0.89
Average single Shell weight	141.78	89.45	0.04*	228.76	28.95	0.008**	168.60	58.20	0.01**	272.06	9.69	0.03*
Average Shell ratio	17.32	1.84	0.55	27.19	37.01	0.73	9.73	17.15	0.25	25.29	10.11	0.45
Model Summary R^2	0.74			0.77		77%	0.62			0.66		
F-value	4.75			5.67			34.87**			51.24**		

R. C= Regression coefficient, S.E= Standard error, significant at * 0.05% and** highly significant at 0.01%

Table 3 Overall impact of various independent variables on annual income through sericulture

S.No.	Independent Variables	Spring (2022&2023)			Autumn (2022&2023)		
		R.C.	S.E.	P-value	R.C.	S.E.	P-value
1	Constant value	-2.11	15.8	-1.88	82.50	22.79	0.81
2	Single cocoon weight	136.22	25.66	0.04*	59.05	13.77	0.03*
3	Single shell weight	82.57	16.80	0.02**	22.66	67.70	0.07
4	Shell ratio	23.551	10.33	0.10	10.01	0.57	0.03
Model summary							
R^2 value		0.57			0.71		
F –value		3.57			36.22		

Average survival rate of silkworm larvae was also studied and presented in table 4. The data on average larval survival was recorded in district Kathua during silkworm rearing was 64 percent followed by Udhampur district 76.1 percent during the season 2022. During the rearing in 2023, the data was recorded on larval survival rate was 72.69 percent and 79.88 percent.

During silkworm rearing, average weight of single cocoon was recorded in district Kathua was analysed as (1.37 gm) and least was in Udhampur (1.36 gm). Whereas season wise single cocoon weight was 1.25 gm in Kathua and 1.34 gm in Udhampur. During silkworm rearing, average weight of single shell was recorded in district Kathua was analysed as (0.195 gm) and least was in Udhampur (0.227 g). Whereas season wise single shell weight was 0.27 gm in Kathua and 0.235 in Udhampur (Table 4)

Table 4 Average single cocoon weight (gm) & Average shell weight (gm)

Year	**Average single cocoon weight (gm)**								**Average shell weight(gm)**							
	Season	**2022**			**2023**			**Season**	**2022**			**2023**				
Districts		**Practices**			**Practices**				**Practices**			**Practices**				
		P0	**P1**	**Sub Means**	**P0**	**P1**	**Sub Means**		**P0**	**P1**	**Sub Means**	**P0**	**P1**	**Sub Means**		
D1 KATHUA	**Spring (S1)**	1.30	1.60	1.45	1.29	1.50	1.39	**Spring (S1)**	0.20	0.30	0.25	0.23	0.35	0.29		
	Autumn (S2)	1.20	1.40	1.3	1.30	1.29	1.29	**Autumn (S2)**	0.15	0.13	0.14	0.20	0.30	0.25		
	Sub Means	1.25	1.5	1.37	1.29	1.39	1.34	**Sub Means**	0.175	0.215	0.195	0.215	0.325	0.27		
D2 UDHAMPUR	**Spring (S1)**	1.39	1.50	1.44	1.30	1.40	1.22	**Spring (S1)**	0.20	0.32	0.26	0.20	0.30	0.25		
	Autumn (S2)	1.29	1.30	1.29	1.20	1.35	1.27	**Autumn (S2)**	0.19	0.20	0.195	0.19	0.25	0.22		
	Sub Means	1.34	1.4	1.36	1.25	1.37	1.24	**Sub Means**	0.195	0.26	0.227	0.195	0.275	0.235		
Factor Means	**Districts**	**D1**	**D2**		**D1**	**D2**		**Districts**	**D1**	**D2**		**D1**	**D2**			
		1.37	**1.36**		**1.34**	**1.24**			**0.195**	**0.227**		**0.27**	**0.235**			
	Seasons	S1	S2		S1	S2		**Seasons**	S1	S2		S1	S2			
		1.25	**1.34**		**1.29**	**1.25**			**0.20**	**0.20**		**0.23**	**0.20**			
	Practices	**P0**	**P1**		**P0**	**P1**		**Practices**	**P0**	**P1**		**P0**	**P1**			
		1.5	**1.4**		**1.39**	**1.37**			**0.30**	**0.32**		**0.20**	**0.30**			
CD(P≤0.05)	District (D) =1.01 Season (s) =1.02 Practices (T) =0.01 D×S =0.10 D×T =0.10 S×T=0.11 D×S×T =0.12						District (D)=0.03 Season (s)=0.04 Practices (P)=0.10 D×S=0.10 D×P=0.11 S×P=0.10 D×S×P=0.15	District (D) = 0.01 Season (s) = 0.02 Practices (T) = 0.05 D×S =0.01 D×T =0.02 S×T=0.01 D×S×T = 0.05						District (D)=0.01 Season (s)=0.01 Practices (P)=0.03 D×S=0.01 D×P=0.2 S×P=0.01 D×S×P=0.05		

District wise average filament length in (mts) during rearing in different seasons 2022-2023 was recorded in district Kathua was 670.245 mts followed by Udhampur 383.023 mts in 2022 and during 2023 it was recorded 578.66 mts in Kathua and 558.46 mts in Udhampur respectively**.** Minimum average denier, average filament size in 2022 during the season of rearing was recorded in Kathua district was 1.97 with respect to Udhampur district 1.92 where as in rearing season 2023 (Table 5)

Table 5 Average filament length (mts) & Average filament size

		Average filament length							Average filament size					
Year	**Season**	**2022**			**2023**			**Season**	**2022**			**2023**		
Districts		**Practices**			**Practices**				**Practices**			**Practices**		
		P0	**P1**	**Sub Means**	**P0**	**P1**	**Sub Means**		**P0**	**P1**	**Sub Means**	**P0**	**P1**	**Sub Means**
D1 KATHUA	**Spring (S1)**	590	795	692.5	480.65	680	584.32	**Spring (S1)**	1.60	2.50	2.05	2.60	1.54	2.07
	Autumn (S2)	610.66	685.32	647.99	498	648	573	**Autumn (S2)**	1.50	2.30	1.9	2.50	1.38	1.89
	Sub Means	600.33	740.16	670.24	489.32	664	578.66	**Sub Means**	1.55	2.4	1.97	2.5	1.46	1.98
D2 UDHAMPUR	**Spring (S1)**	598	805	701.5	445	660	552.2	**Spring (S1)**	1.50	2.50	2	2.50	2.30	2.4
	Autumn (S2)	585	706	645.5	526.5	603	564.75	**Autumn (S2)**	1.40	2.30	1.85	2.40	2.35	2.37
	Sub Means	591.5	755.5	383.025	485.75	631.5	558.46	**Sub Means**	1.45	2.4	1.92	2.45	2.32	2.385
Factor Means		**D1**	**D2**		**D1**	**D2**			**D1**	**D2**		**D1**	**D2**	
	Districts	**670.245**	**383.025**		**578.66**	**558.46**		**Districts**	**1.97**	**1.92**		**1.98**	**2.385**	
	Seasons	S1	S2		S1	S2		**Seasons**	S1	S2		S1	S2	
		590	**598**		**480.65**	**445**			1.60	1.50		2.60	2.50	
		P0	**P1**		**P0**	**P1**			**P0**	**P1**		**P0**	**P1**	
	Practices	**600.32**	**940.16**		**489.32**	**664**		**Practices**	2.50	2.50		1.54	2.30	
CD(P≤0.05)	District (D) =9.54 Season (s) =22.42 Practices (T) =41.50 D×S =40.77 D×T =38.64 S×T=47.32 D×S×T =49.77						District (D)= 7.70 Season (s)=16.33 Practices (P)=31.33 D×S=27.59 D×P=22.52 S×P=27.59 D×S×P=31.99	District (D) =0.01 Season (s) =0.03 Practices (T) =0.02 D×S =0.01 D×T =0.01 S×T=0.02 D×S×T =0.03						District (D)= 0/01 Season (s)=0.01 Practices (P)=0.02 D×S=0.01 D×P=0.02 S×P=0.01 D×S×P=0.02

Experimental studies revealed changes in low and high conditions of temperature and humidity shown in Table 6

Table 6 Changes in instars under low and high conditions of temperature & humidity

S.No	Instar	Tc (°C)/Hc (%)	Symptoms/Changes	T_L (°C)/H_L (%)	Symptoms/Changes	T_H (°C)/H_H (%)	Symptoms/Changes
1	1st	27±1/85	No changes	26±1/80	Slow growth	29±1/86	Irregular growth
2	2nd	28±1/85	No changes	24±1/75	Sluggish movement	30±1/87	Fast growth
3	3rd	27±1/80	No changes	22±1/70	Loss of appetite	31±1/88	Become weak
4	4th	24±1/70	No changes	20±1/65	Prolonged larval period	32±1/89	Prone to disease
5	5th	25±1/70	No changes	18±1/60	Stop feeding, outbreak of disease	33±1/90	Stop feeding, Outbreak of disease

Tc/Hc: control temperature / control humidity, T_L/H_L:low temperatrure /low humidity;T_H/H_H:high temperature /high humidity

Table 7 Silkworm rearing and reeling parameter recorded

S.No.	Parameters	Different temperature/Humidity conditions (T)		
		Control	**Low (T1)**	**High (T2)**
1.	Disease incidence (%)	2%	55	42
2.	Cocoon harvesting (days)	6-8 days in summer, 8-10 days in winter	10-11 days in summer, 12-14 days in winter	4-6 days in summer, 6-7 days in winter
3.	Larval duration (days/hours)	24-28 days	30-35 days	25-27 days
4.	Effective rate of rearing (%)	66.66%	52%	45%
5.	Survivability (%)	98%	73%	78%
6.	Mortality(%)	2%	85%	88%
7.	Weight single larva (gm)	0.10gm	0.05gm	0.03gm
8.	Weight single cocoon (gm)	Dry 1gm, wet 1.2 gm	0.9/1gm	0.5/1gm
9.	Weight single shell (gm)	1.1gms	0.4gm	0.8gm
10.	Cocoon yield (%)	98%	32.53%	23.58%
11.	Filament length (mts)	900-1000mts	500-600mts	300-500mts
12.	Raw silk (%)	10-12%	6-7%	5-6%
13.	Shell ratio	91.6	71.61%	65%

T1: Low temperature and humidity treatment; T2: High temperature and humidity treatment

The primary and secondary data revealed that abiotic factors played a vital and crucial role in increasing/decreasing cocoon yield. These abiotic factors have direct impact on field as well as experimental level. Any fluctuations in their optimum values affect the structural and functional level of silkworm larvae which in turn effect the cocoon production by decreasing average cocoon weight, average shell weight, shell ratio, filament length and filament size which decrease the quality and quantity of the silk (Table 7).

The result of the present study gives insight on the role of different abiotic factors on the survivability of silkworm. The larval mortality occurred due to viral disease. The data was analyzed and it revealed that larval mortality rate increased with fluctuation in the temperature and humidity larvae. Larval mortality was due to viral disease and emergence of viral disease occurred due to change or fluctuation in temperature humidity conditions was noticed. Hence the environmental factors played a major role in declining the survivability rate of silkworm

Discussion

Silkworm rearing was a long process starting from egg stage and terminating adults laying eggs and dying. Prevailing environmental conditions especially temperature and humidity were vital in determining silkworm physiology. Hence, maintenance of recommended temperature humidity for every stage of rearing was of utmost important for successful silkworm rearing. The seasonal variations in the environment affects the larvae very abundantly. Environment played an important role during silkworm rearing where suitable temperature and humidity was necessary for producing quality cocoons. If the temperature is low, the larval period is prolonged. The ideal temperature range for optimal silkworm growth was found to be between 20-28°C, with a narrower range of 23-28°C being identified as the most conducive for maintaining high productivity. Temperature was found to have a profound impact on the health and well-being of the silkworms, underscoring the importance of maintaining optimal temperature conditions to ensure their optimal growth and development which was similar to Vijayakumari *et al.* (2001) and Sharma *et al.* (2019). Temperature above 30°C affects

the health of worms and temperature below 20° C affects the physiological activities. As a result worms become too weak and susceptible to disease. High temperature adversely affects nearly all biological processes and eventually affect the quality/quantity of cocoon crop.

The study areas exhibited a climate range of subtropical to temperate, facilitating bivoltine sericulture, with silkworm rearing activities being conducted twice annually. Comparative analysis revealed that spring rearing was more successful than autumn rearing, primarily due to seasonal variations and environmental fluctuations that significantly impacted silkworm growth and development. Consequently, the highest mortality rates were observed during autumn rearing where observations were concordant to the finding of Rajeshwar *et al.* (2019).

In the present study data revealed that abiotic factors such as temperature and humidity showed significant effect on the survivability rate of silkworms, its filament length, cocoon weight , shell ratio and shell weight. So conditions regarding temperature and humidity should be maintained well in order to get good quality and quantity of silk Temperature was found to have a profound impact on the health and well-being of the silkworms, underscoring the importance of maintaining optimal temperature conditions to ensure their optimal growth and development which was similar to Vijayakumari *et al.* (2001) and Sharma *et al.* (2023).

The economic viability of the sericulture industry is heavily reliant on the quality as well as quantity of cocoons and silk produced, emphasizing the critical role these factors play in driving industry growth. Multiple regression was applied to find out impact of temperature and humidity on quality of cocoon where parameters like single cocoon weight, shell weight, shell ratio, filament length with respect to both the district was highly significant with maximum shell ratio of (23%) and maximum filament length (805 mts) recorded during spring season. These parameters have a direct relationship with the income generated from the crop. These findings were closely related to the findings of Sreenivas and Hiriyanna (2014).

2014). The quality of cocoons is a crucial determinant in sericulture, as a poor shell ratio and low cocoon weight percentage can significantly compromise silk quality, ultimately leading to decreased income for farmers. Cocoon length, cocoon weight and filament length played a huge role in deciding quality of cocoon which were validated by Fatima *et al.* (2024) and Akarsha *et al.* (2023)

Conclusion

The mortality rate increases with continuous variation in different abiotic factors. The larval mortality rate increased due to the disease infestation in the larva of silkworm. Optimum and average availability of abiotic factors can result in more survivability. From the results analyzed by the study, it was evaluated that independent variables such as education, total land holding, distance from sericulture office and from cocoon market had a significant influence on cocoon yield.. The positive regression coefficient value obtained from the data predicted that proper distribution of healthy reared worms can significantly increase the cocoon yield and lessen the crop loss. Multi-displinary approaches should be adopted to strengthen the extension program and knowledge of new and improved technologies

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