Studies on rearing performances of mulberry silkworm (*Bombyx mori* Linnaeus, 1758) in hooghly district of West Bengal (India): A newly explored area

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This study is aimed at proposing mulberry sericulture as an alternative to strengthen the agricultural economy of Hooghly district of West Bengal, India. Exploration of four breeds of mulberry silkworm, *Bombyx mori* (Linnaeus, 1758), popular in West Bengal (viz., two multivoltine breeds – Nistari Plain and Nistari Marked, One Bivoltine breed – SK6 X SK7 hybrid and one F1 Hybrid from cross between Nistari Plain and SK6 X SK7 hybrid) have been conducted in the Sericulture Research Laboratory, Post Graduate department of Zoology, Hooghly Mohsin College, Chinsurah, Hooghly, West Bengal, India, for three consecutive years (2016–2019) for various rearing parameters (viz., larval duration, matured larval weight, cocoon weight, shell weight, shell ratio, effective rate of rearing, absolute silk content and yield) along with common meteorological data (viz., average temperature, average relative humidity, photoperiod). The study reveals Hooghly district to be very conducive for mulberry sericulture with the multivoltine breeds to be most suitable, although rearing of F1 hybrid and bivoltine breeds should also be promoted for their better economic value. Among the seasons, late Autumn (Oct. – Nov.) and early Spring (Feb. – Mar.) are found to be most suitable commercial rearing seasons for almost all the breeds, whereas the extended summer months including Spring, Summer and rainy season (Mar. – Aug.) are unfavourable, indicating deleterious effect of temperature and humidity on the rearing performance of these breeds, for which remedies such as sub-lethal heat shock can be explored.

Keywords: Silkworm rearing, cocoon weight, absolute silk content, yield, effective rate of rearing, commercial rearing season

1   Introduction:

Hooghly, with its assemblage of numerous factories fringing the banks of Bhagirathi (river Ganga), has become model for industrially developed districts, but in spite of all these years of industrialization, the basic rural characteristics remain the same. Still over 70% of its inhabitants practice agriculture. A mixture of highly fertile Gangetic and Vindhya alluvium soils coupled with well-developed irrigation infrastructure have earned Hooghly the reputation of an agriculturally advanced district as well. The average household income of this Gangetic alluvial zone is highly dependent up on crops like cereals and potato and hence the significantly depressed prices of potato for the past few years has compelled the authorities to consider intensive agricultural practice while drafting the state agricultural plan for the district. In recent years only few selected crops are considered beneficial for intensive culture, but with increasing local demand, other allied agricultural produce are fast gaining popularity, as the demand far exceeds the production. The whole development plan is much in need of a thorough reorientation in the direction of balanced expansion of both the agriculture and its allied sectors. In this context introduction of sericulture which has long since practiced in the neighbouring districts like Malda (Taufique and Hoque, 2019) and Murshidabad, can be considered as momentous, keeping in mind its remunerative employment generation capacity (Chandan Roy et al., 2012). The introduction of sericulture which is a labour-intensive industry (Chandan

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Roy et al., 2012) will also be a boon for the district as with almost 1 : 1 male-female ratio, female workers will also be able to contribute equally (Dewangan, 2017). Bearing in mind, the fertile nature of the soil and conducive climatic condition of this district, an attempt for introduction of mulberry sericulture should be considered as need of the hour. The present study aims at identifying the commercial crop rearing seasons for successful mulberry silk culture in this region.

2   Materials and methods

Hooghly, one of the central districts of West Bengal, extends between 20° 30′ 32″ and 23° 1′ 20″ of North latitude and between 87°30′ 20″ and 88°30′ 15″ East longitude. Flanked by river Rupnarayan on its left, Hooghly extends from Guptipara Char to Bhabanipur Char on the river Bhagirathi and share its border with districts like Burdwan and Bankura in the north, and Howrah in the south, while the 24 Parganas (N) and Nadia lie in the east and Medinipur (W) limit its western most edge.

Most of the meteorological data related to average temperature, average relative humidity and photoperiod were recorded in the laboratory, while data like average monthly rainfall was collected from online weather data providers.

In the present study four breeds of mulberry silkworm, *Bombyx mori*, popular in West Bengal (viz., two multivoltine breeds – Nistari Plain and Nistari Marked, One Bivoltine breed – SK6 X SK7 hybrid and one F1 Hybrid from cross between Nistari Plain and SK6 X SK7 hybrid) were used. Eggs of disease free layings (DFLs) of each breed were procured as Egg-cards from Ranaghat and Shibnibas extension farms of State Sericulture Directorate and reared in the rearing room of the Sericulture Research Laboratory, Post Graduate department of Zoology, Hooghly Mohsin College,

Chinsurah, Hooghly. Larvae were fed with fresh mulberry leaves of improved variety-S_{1635}, procured from mulberry plantation, Hooghly Mohsin College. Saplings for the plantation were provided by Dhubulia extension farm, State Sericulture Directorate. Rearing was done throughout the year, for three consecutive years between 2016 and 2019. During this time eight commercial rearing parameters were recorded in triplicates for each breed for each season. Almost 300 larvae from a single disease free laying were used for each replicate. Data collected from each replicate were then pooled and subjected to suitable statistical analysis.

3   Result and discussion

Climatic condition

As photoperiod is known to have effect on larval weight (Hirasaka and Koyama, 1970; Rajanna, 1986) it was recorded throughout the year. Photoperiod of almost (Light : Dark) 1 : 1 was observed during Spring, while the ratio increased during the extended Summer months (May – Aug.) and Autumn (Sep. – Oct.). From late Autumn (Oct. – Nov.) to early Spring (Feb. – Mar.) the ratio was lower than 1 : 1. Average temperature also has massive impact on sericulture (Rahmathulla, 2012). During late Autumn and early Spring average temperature was recorded to be most suitable while it was marginally above the optimum (23–28 °C) during Spring. The extended Summer months (May – Aug.) accounted for the most unfavourable average temperature. Moreover photoperiod and average temperature were found to be significantly correlated. Relative humidity (RH) is another important deciding factor (Sisodia and Gaherwal, 2017) and found to be in significantly strong positive correlation with average Rainfall. Optimum combination of average temperature (23–28 °C) and RH (75–80%) (Sisodia and Gaherwal, 2017) was recorded during late Autumn and early Spring (Table 1).

Table 1   Mean meteorological data (2016–2019) of Hooghly district, West Bengal

Seasons	Average Photoperiod (hr.)		Average temperature (°C)	Average relative humidity (%)	Average rainfall (mm)
	light	dark			
Feb. – Mar. (early spring)	11:23	12:36	26.4	65.0	0.17
Mar. – Apr. (spring)	12:00	11:59	29.6	67.7	8.43
May – June (summer)	13:14	10:46	31.1	75.9	11.74
July – Aug. (rainy season)	13:24	10:36	29.8	84.5	32.06
Sep. – Oct. (autumn)	12:17	11:43	29.2	79.8	28.65
Oct. – Nov. (late autumn)	11:38	12:22	27.0	75.1	8.79
Dec. – Jan. (winter)	11:02	12:58	20.2	68.4	2.06

Seasonal influence on rearing performance

Effect of various seasonal parameters on commercial rearing performances (viz., larval duration, matured larval weight, cocoon weight, shell weight, shell ratio, effective rate of rearing, absolute silk content, yield etc.) of different breeds of mulberry silkworm is depicted in Table 2.

Larval duration

In case of Nistari plain breed, longest larval duration was observed during early Spring (Feb. – Mar.) and Winter (Dec. – Jan.) (23 days), followed non-significantly by that of Spring (Mar. – Apr.), rainy season (July – Aug.), Autumn (Sep. – Oct.) and late Autumn (Oct. – Nov.) (22 days). Significantly shortest larval duration was observed during Summer (May – June) (21 days).

Observation in Nistari marked breed revealed that Winter was longest (24 days) in terms of larval duration, followed non-significantly by late Autumn (23.03 days), and significantly by Autumn (22.03 days) and others, with Summer being the shortest (20.10 days), having non-significant difference with Spring (20.5 days). Larval duration during early Spring, rainy season (22 days) and Autumn (22.03 days) differed non-significantly.

Larval duration in F1 hybrid showed the following trend: Winter being the longest (25.33 days), followed non-significantly by late Autumn (25 days). Larval duration in remaining seasons varied within the range of 21.50 days and 23.04 days, it was shortest during Summer (21.5 days) and varied non-significantly from that of Spring (22.33 days) and rainy season (22.5 days).

In the selected bivoltine breed, longest larval duration was observed during late Autumn (27 days), followed non-significantly by that during Winter (26.5 days). Shortest larval duration was recorded during Summer (22 days), having non-significant difference with that during Spring (23 days).

As a whole hybrid and bivoltine breeds showed longer larval duration than multivoltine breeds. Irrespective of breeds, rainy months and Summer shortened the duration, while Winter prolonged the duration to the maximum extent (Table 1).

Larval weight

Average weight of randomly selected 10 matured larvae was recorded during all the seasons for all four breeds. In Nistari Plain breed, maximum larval weight was observed in Winter (29 g), followed non-significantly by that during early Spring (28.2 g) and significantly by late Autumn (27 g). For rest of the seasons larval weight in Nistari Plain was recorded to be within the range of 23.6 g and 26 g, with least larval weight (23.6 g) during

the Summer, having significant difference with that during Spring (25.1 g), rainy season (25.1 g) and Autumn (26 g).

Maximum larval weight in the Nistari marked breed was also recorded during Winter (29.9 g), followed significantly by late Autumn (27.8 g) and early Spring (27.2 g) having non-significant variation between the two. Larval weights during the remaining seasons were within the range of 23 g and 25.2 g, with minimum larval weight of 23 g during the Summer differed non-significantly with that during the rainy season (23.9 g).

In case of F1 hybrids, late Autumn (41.6 g) was the season with highest larval weight, followed significantly by early Spring (39 g), larval weight for rest of the seasons varied between 32.10 g and 35.11 g Least larval weight of 32.10 g during Summer, varied non-significantly with that during rainy season (33.20 g) and Autumn (33.21 g).

Larval weight in the selected Bivoltine breed was at its highest during late Autumn (40.1 g), followed non-significantly by early Spring (40 g), for rest of the seasons, larval weight was recorded within the range of 32 g and 37.50 g

Bivoltine breeds and hybrids showed higher larval weight than multivoltine breed.

Cocoon weight

Single cocoon weight of Nistari Plain breed was found to be highest during late Autumn (0.96 g), followed non-significantly by that during Autumn (0.95 g) and significantly by early Spring (0.92 g). Variation of cocoon weight for rest of the seasons was within the range of 0.72 g and 0.86 g Lowest cocoon weight of 0.72 g was recorded during Summer. Cocoon weight observed during rainy season (0.83 g) Spring (0.85 g) and Winter (0.86 g) differed non-significantly.

Maximum single cocoon weight in Nistari marked breed was observed during late Autumn (1.01 g), followed significantly by that during Winter (0.92 g) and others, varied from 0.53 g to 0.88 g Least cocoon weight recorded during Summer (0.53 g) did not vary significantly from that during Rainy season (0.55 g).

In case of F1 hybrid, late Autumn (1.90 g) was the season, in which highest cocoon weight was recorded, followed significantly by early Spring (1.70 g), for rest of the seasons the recordings were within the range of 1.44 g and 1.65 g, whereas least cocoon weight during Summer (1.44 g) did not vary significantly with that during rainy season (1.47 g).

The selected Bivoltine breed produced maximum cocoon weight during late Autumn (1.80 g), followed non-significantly by early Spring (1.75 g). Single cocoon

Table 2 Effect of seasons on rearing performance of mulberry silkworm in Hooghly district of West Bengal

Rearing parameter		Larval duration (days)				Weight of 10 matured larvae (g)				Single cocoon weight (g)				Single shell weight (g)			
Season		NP	NM	F1	BV	NP	NM	F1	BV	NP	NM	F1	BV	NP	NM	F1	BV
Feb. – Mar.	early spring	23.00	22.00	23.00	24.00	28.20	27.20	39.00	40.00	0.92	0.75	1.70	1.75	0.10	0.10	0.28	0.30
Mar. – Apr.	spring	22.00	20.50	22.33	23.00	25.10	24.30	35.04	37.50	0.85	0.64	1.50	1.65	0.10	0.09	0.22	0.31
May – June	summer	21.00	20.10	21.50	22.00	23.60	23.00	32.10	34.00	0.72	0.53	1.44	1.56	0.08	0.07	0.18	0.25
July – Aug.	rainy	22.00	22.00	22.50	24.00	25.10	23.90	33.20	35.00	0.83	0.55	1.47	1.60	0.09	0.08	0.18	0.26
Sep. – Oct.	autumn	22.00	22.03	23.04	25.00	26.00	25.20	33.21	36.00	0.95	0.88	1.55	1.66	0.12	0.10	0.20	0.29
Oct. – Nov.	late autumn	22.00	23.03	25.00	27.00	27.00	27.80	41.60	40.10	0.96	1.01	1.90	1.80	0.14	0.14	0.36	0.32
Dec. – Jan.	winter	23.00	24.00	25.33	26.50	29.00	29.90	35.11	32.00	0.86	0.92	1.65	1.50	0.11	0.11	0.30	0.24
CD at 5%		1.20	1.7	1.04	1.08	1.3	1.13	1.30	1.29	0.04	0.03	0.04	0.06	0.02	0.01	0.03	0.01

Rearing parameter		Shell ratio (%)				ERR (%)				Absolute silk content (kg)				Yield/10,000 larvae brushed (kg)			
Season		NP	NM	F1	BV	NP	NM	F1	BV	NP	NM	F1	BV	NP	NM	F1	BV
Feb. – Mar.	early spring	10.87	13.33	16.47	17.14	79.67	78.00	98.33	75.81	0.80	0.78	2.75	2.27	7.33	5.85	16.72	13.27
Mar. – Apr.	spring	11.76	14.06	14.67	18.79	76.38	77.10	88.89	66.67	0.76	0.69	1.96	2.07	6.49	4.93	13.33	11.00
May – June	summer	11.11	13.21	12.50	16.03	54.20	52.00	40.67	49.33	0.43	0.36	0.73	1.23	3.90	2.76	5.86	7.70
July – Aug.	rainy	10.84	14.55	12.24	16.25	58.55	57.02	51.64	53.22	0.53	0.46	0.93	1.38	4.86	3.14	7.59	8.52
Sep. – Oct.	autumn	12.63	11.36	12.90	17.47	57.00	62.03	51.55	56.78	0.68	0.62	1.03	1.65	5.42	5.46	7.99	9.43
Oct. – Nov.	late autumn	14.58	13.86	18.95	17.78	81.40	81.00	98.33	73.33	1.14	1.13	3.54	2.35	7.81	8.18	18.68	13.20
Dec. – Jan.	winter	12.79	11.96	18.18	16.00	66.50	69.44	75.64	70.80	0.73	0.76	2.27	1.70	5.72	6.39	12.48	10.62
CD at 5%		1.8	1.09	1.40	1.02	8.61	8.96	9.36	7.95	0.04	0.03	0.02	0.04	0.35	0.34	0.37	0.46

** ERR – effective rate of rearing, NP – nistari plain breed, NM – nistari marked breed, F1 – F1 hybrid, BV – selected Bivoltine breed, CD at 5% – critical difference at 5%

weight in this breed varied within the range of 1.50 g and 1.66 g for the remaining seasons. Lowest cocoon weight in Winter (1.50 g) found not to vary significantly with that during Summer (1.56 g).

As a whole bivoltines performed better than hybrids and multivoltines. From the seasonal point of view, Spring, Summer and Rainy months were found adverse.

Shell weight

Observations on Nistari Plain breed revealed that, single shell weight reached its maximum during late Autumn (0.14 g), followed non-significantly by Autumn (0.12 g) and significantly by Winter (0.11 g), while rest of the shell weights were in the range of 0.08 g and 0.10 g Lowest shell weight recorded during Summer (0.08 g) did not differ significantly from that during rainy season (0.09 g), Spring (0.10 g) and early Spring (0.10 g).

In Nistari marked breed, highest single shell weight was observed during late Autumn (0.14 g), followed significantly by Winter (0.11 g), and remaining seasons (0.07 g to 0.10 g). Shell weight during Summer (0.07 g) found to be the lowest, which did not differ significantly from that during rainy season (0.08 g).

Highest shell weight in F1 hybrid was recorded during late Autumn (0.36 g), followed significantly by that during Winter (0.30 g), for rest of the seasons, shell weight varied within the range of 0.18 g and 0.28 g, lowest being recorded during Summer and rainy season (0.18 g).

In case of the Bivoltine breed, shell weight was recorded to be maximum during late Autumn (0.32 g), followed non-significantly by Spring (0.31 g) and significantly by early Spring (0.30 g) and rest of the seasons (0.24 gm to 0.29 g) with lowest shell weight being recorded during Winter (0.24 g), which differed non-significantly with that during Summer (0.25 g).

Like single cocoon weight, shell weight also found to be highest in bivoltine breeds, followed by hybrids and multivoltines. Average single shell weight was found to be in significantly strong positive correlation with average single cocoon weight (0.961), average SR% (0.921), average ERR (0.839), average ASC (0.962) and average Yield (0.942). March to August were seasonally adverse for shell weight.

Shell ratio (%)

In Nistari Plain breed SR% was computed to be maximum during late Autumn (14.58) having significant variation with the rest of the observations (10.84 to 12.79). Lowest SR% computed during rainy season (10.84) and early Spring (10.87) were found not to differ significantly with those during Summer (11.11) and Spring (11.76).

SR% reached its maximum in Nistari marked breed during rainy season (14.55), followed non-significantly by that during Spring (14.06). Recordings in the rest of the seasons varied from 11.36 to 13.86. Lowest SR% during Autumn (11.36) did not differ significantly with that during Winter (11.96).

In case of F1 hybrid, highest SR% was computed during late Autumn (18.95), followed non-significantly by that during Winter (18.18) and significantly by the rest of the season (12.24 to 16.47). Lowest SR% computed during rainy season (12.24) did not vary significantly from those during Summer (12.5) and Autumn (12.9).

The selected Bivoltine breed exhibited maximum SR% during Spring (18.79), followed significantly by that during late Autumn (17.78) and non-significantly by that during early Spring (17.14) and Autumn (17.47). For the remaining seasons the SR% were computed within the range of 16 and 16.25. Lowest SR% was observed during Winter (16).

As a whole F1 hybrid and bivoltine breed exhibited better SR% than the multivoltine breeds. Average SR% showed significantly strong positive correlation with average ERR (0.866), average ASC (0.944) and average Yield (0.908). Summer was found to be seasonally adverse for SR% in almost all the breeds.

Effective rate of rearing (%)

Maximum Effective rate of rearing (ERR%) in Nistari Plain breed was computed during late Autumn (81.4), followed non-significantly by that during early Spring and Spring and significantly by the rest of the seasons (54.20 to 66.50). Lowest ERR observed during Summer (54.20) found not to vary significantly with that during rainy season (58.55) and Autumn (57).

In Nistari marked breed highest ERR was recorded during late Autumn, followed non-significantly by that during early Spring (78) and Spring (77.10), and significantly by the remaining seasons (52 to 69.44) and no significant difference was found between the lowest ERR during Summer (52) and that during rainy season (57.02).

In F1 hybrid ERR was observed to be maximum during late Autumn and early Spring (98.33) followed significantly by Spring (88.89) and others. Significantly lowest ERR in F1 hybrid was observed during Summer (40.67). No significant difference was observed between ERR during rainy season (51.64) and Autumn (51.55).

ERR of Bivoltine breed reached its maximum during early Spring (75.81), followed non-significantly by that during late Autumn (73.33) and Winter (70.80) and significantly by the rest of the seasons (49.33 to 70.80). Lowest ERR recorded during Summer (49.33) was found not to vary

Table 3 Correlation matrix: Average weather parameters vs Average rearing parameters

	Photoperiod-L	Photoperiod-D	Temperature	Humidity	Rainfall	Larval duration	MLW	CW	SW	SR	ERR	ASC	Yield
Photoperiod-L	1												
Photoperiod-D	-1.000**	1											
Temperature	0.812*	-0.812*	1										
Humidity	0.769*	-0.769*	0.503	1									
Rainfall	0.734	-0.734	0.557	0.925**	1								
Larval duration	-0.733	0.733	-0.840*	-0.171	-0.256	1							
MLW	-0.789*	0.789*	-0.516	-0.516	-0.566	0.689	1						
CW	-0.700	0.700	-0.427	-0.241	-0.302	0.751	0.901**	1					
SW	-0.754	0.754	-0.449	-0.406	-0.498	0.699	0.931**	0.961**	1				
SR	-0.694	0.694	-0.441	-0.435	-0.540	0.638	0.836*	0.807*	0.921**	1			
ERR	-0.802*	0.802*	-0.452	-0.709	-0.683	0.514	0.910**	0.731	0.839*	0.866*	1		
ASC	-0.786*	0.786*	-0.469	-0.550	-0.609	0.643	0.963**	0.882**	0.962**	0.944**	0.950**	1	
Yield	-0.807*	0.807*	-0.473	-0.586	-0.611	0.630	0.975**	0.872*	0.942**	0.908**	0.968**	0.994**	1

* correlation is significant at the 0.05 level (2-tailed); ** correlation is significant at the 0.01 level (2-tailed)

significantly with that during Autumn (56.78) and rainy season (53.22).

ERR % was observed to be best in hybrids and strikingly lowest in bivoltines. ERR% was affected during Summer, Rainy and Autumn months. Correlation studies showed significantly positive correlation with average single shell weight (0.839), average mature larval weight (0.910), average SR% (0.866), average ASC (0.950) and average Yield (0.968).

Absolute Silk content

In case of Nistari Plain breed, Absolute Silk content (ASC) was calculated to be highest during late Autumn (1.14 kg), for rest of the seasons ASC was calculated to be in the range of 0.43 kg and 0.80 kg Lowest ASC recorded during Summer (0.43 kg) differed significantly with that during rainy season (0.53 kg).

Highest ASC in Nistari marked breed was calculated during late Autumn (1.13 kg). ASC in remaining seasons was calculated to be within the range of 0.36 kg and 0.78 kg Least ASC calculated during Summer (0.36 kg) was found to differ significantly with that during rainy season (0.46 kg).

Observations regarding ASC in F1 hybrid was calculated to be maximum during late Autumn (3.54 kg), followed significantly by that during early Spring (2.75 kg) and Winter (2.27 kg). ASC in rest of the seasons was calculated to be within the range of 0.73 kg and 1.96 kg Least ASC calculated during Summer (0.73 kg) differed significantly from that during rainy season (0.93 kg).

ASC in bivoltine breed was calculated to be maximum during late Autumn (2.35 kg), followed significantly by that during early Spring (2.27). For the remaining seasons, ASC varied between 1.23 kg and 2.07 kg Least ASC was calculated during Summer (1.23 kg).

ASC was calculated to be best in hybrids and worst in multivoltines, late Autumn being the best season and Summer and rainy season being the worst. Average ASC was found to be in significantly strong positive correlation with average ERR (0.950) and average Yield (0.994).

Yield

In Nistari Plain breed maximum yield was calculated during late Autumn (7.81 kg), followed significantly by early Spring (7.33 kg). Yield in remaining seasons varied between 3.90 kg and 6.49 kg Lowest yield calculated during Summer (3.90 kg) differed significantly from that during rainy season (4.86 kg).

Highest yield in Nistari marked breed was calculated during late Autumn (8.18 kg), significantly followed by rest of the seasons where yield was calculated to be

within the range of 2.76 kg and 6.39 kg Yield during Summer (2.76 kg) was calculated to be lowest and differed significantly with that during rainy season (3.14 kg).

In case of F1 hybrid, maximum yield was calculated during late Autumn (18.68 kg), followed significantly by that during early Spring (16.72 kg). Yield for rest of the seasons was calculated to be within the range of 5.86 kg and 13.33 kg Least yield was calculated during Summer (5.86 kg) and differed significantly from that during rainy season (7.59 kg).

In Bivoltine breed highest yield was calculated during early Spring (13.27 kg), followed non-significantly by that during late Autumn (13.20 kg). Remaining seasons exhibited yield within the range of 7.7 kg and 11 kg Lowest of the yield was calculated during Summer (7.7 kg) and differed significantly from that during rainy season (8.52 kg).

It was observed that Yield was best in F1 hybrid followed by Bivoltines and lowest in Multivoltines. Irrespective of breeds, late Autumn was found to be most suitable followed by early Spring, but affected during Summer and Rainy months. Correlation studies showed that Yield had significant positive correlation with single cocoon weight (0.872), single shell weight (0.942), ERR % (0.968) and ASC (0.994).

From the above discussion it became clear that almost all the rearing parameters were observed to be better during late Autumn (Oct. – Nov.) and worse during both Summer (May – June) and Rainy season (July – Aug.), and most of the observations in these two seasons found not to differ significantly as well.

4   Conclusion

Effective rate of rearing, absolute silk content and yield are three of the most important rearing parameters for the farmers. Thorough observations and statistical analysis of the recorded data (Table 2) reveal that during late Autumn and early Spring these three parameters are found to be at their best, because of optimum larval duration, followed by better matured larval weight, which reflects an increase in cocoon and shell weight, having strong positive correlation (0.961). Therefore, late Autumn and early Spring can be considered as two of the best seasons for commercial rearing in Hooghly district of West Bengal; November to April has also been observed as favourable season for mulberry silkworm rearing in traditional silkworm rearing belt of West Bengal by Majumdar et. al., and these two seasons are also found to be favourable in other parts of India in studies conducted by Kumar et. al. (2013) and Rahmathulla (2012). These findings are also supported
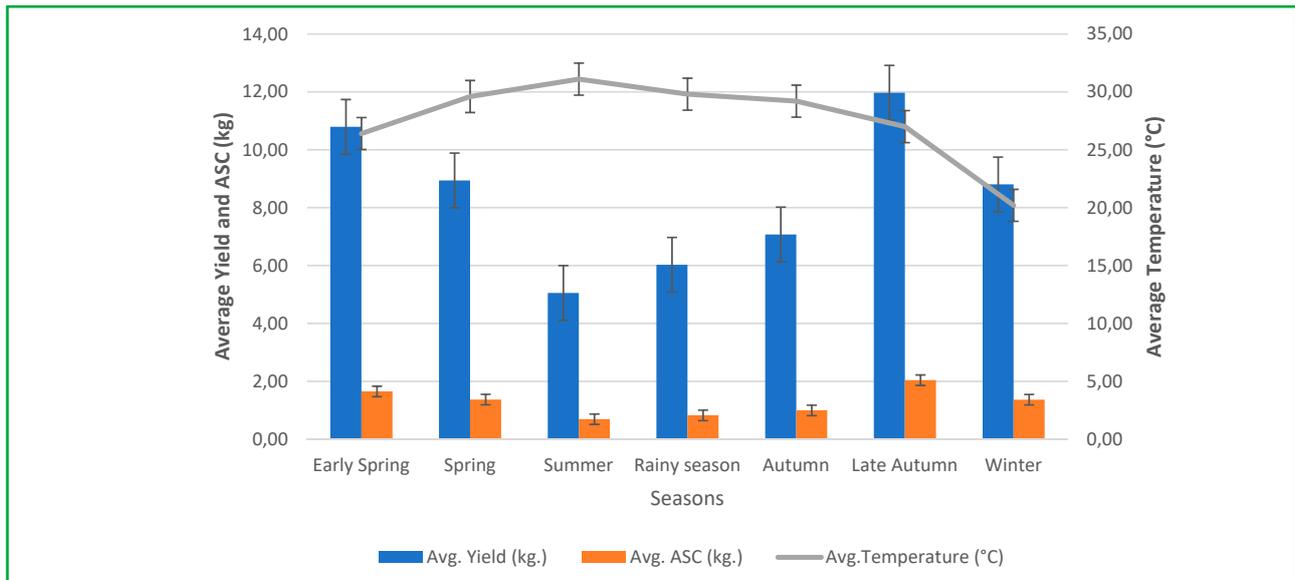
Figure 1   Clustered combo bar chart of avg. yield and ASC with avg. temperature as line chart on secondary axis
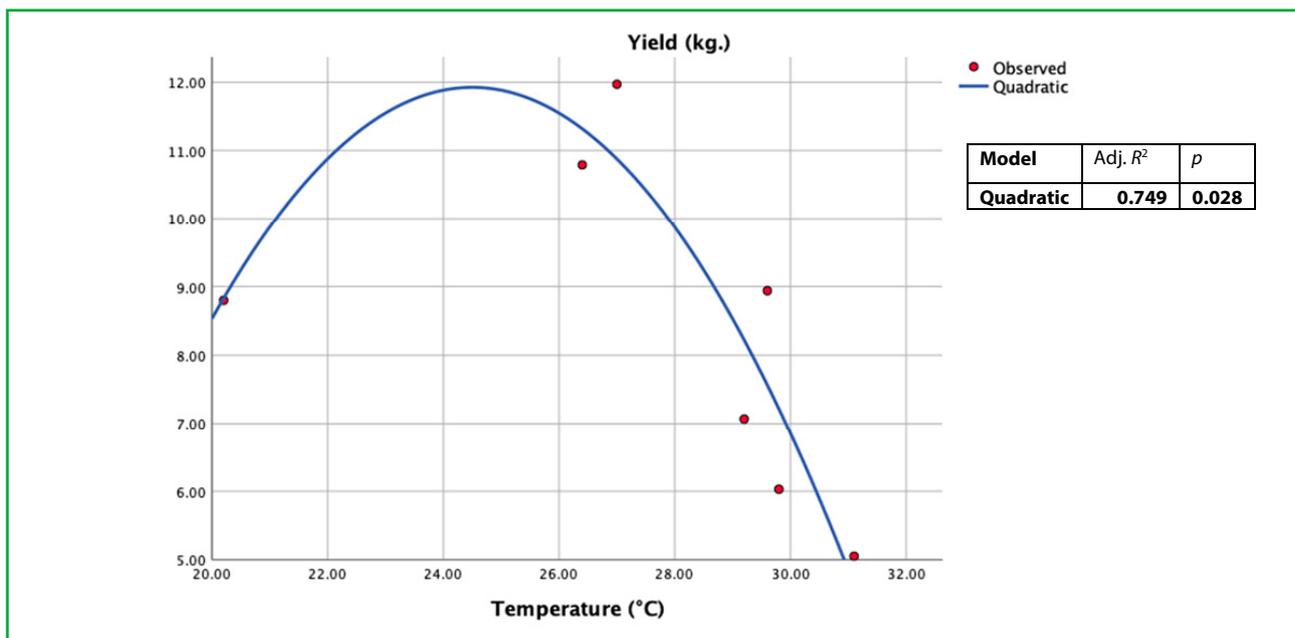

Figure 2   Quadratic regression between average temperature (°C) and average yield (kg)

by the statistical tests comparing average rearing performance data with the mean meteorological data. When average yield and average ASC are plotted against average temperature in a combo clustered-column and line (on secondary axis) chart (Figure 1), highest average yield and highest average ASC are observed during late Autumn (Oct. – Nov.), followed closely by that during early Spring (Feb.-Mar.). From the quadratic regression analysis it is evident that best average yield (Figure 2: Adj. $R^2 = 0.749$ and Sig. = 0.028) and average ASC (Figure 3: Adj. $R^2 = 0.066$ and Sig. = 0.051) is achieved when the average temperature ranges between 25–26.5 °C.

Effect of Temperature and Humidity on average rearing parameters is also evident from the Correlation matrix shown in Table 3, where average ERR, average ASC and average Yield are negatively correlated with Temperature and Humidity, indicating high temperature and relative humidity affecting rearing performance.

Climatic conditions especially temperature and humidity play pivotal role in silkworm rearing (Sisodia and Gaherwal, 2017), this is in clear conformity with the findings of the present study regarding exploration of mulberry sericulture in Hooghly district of West
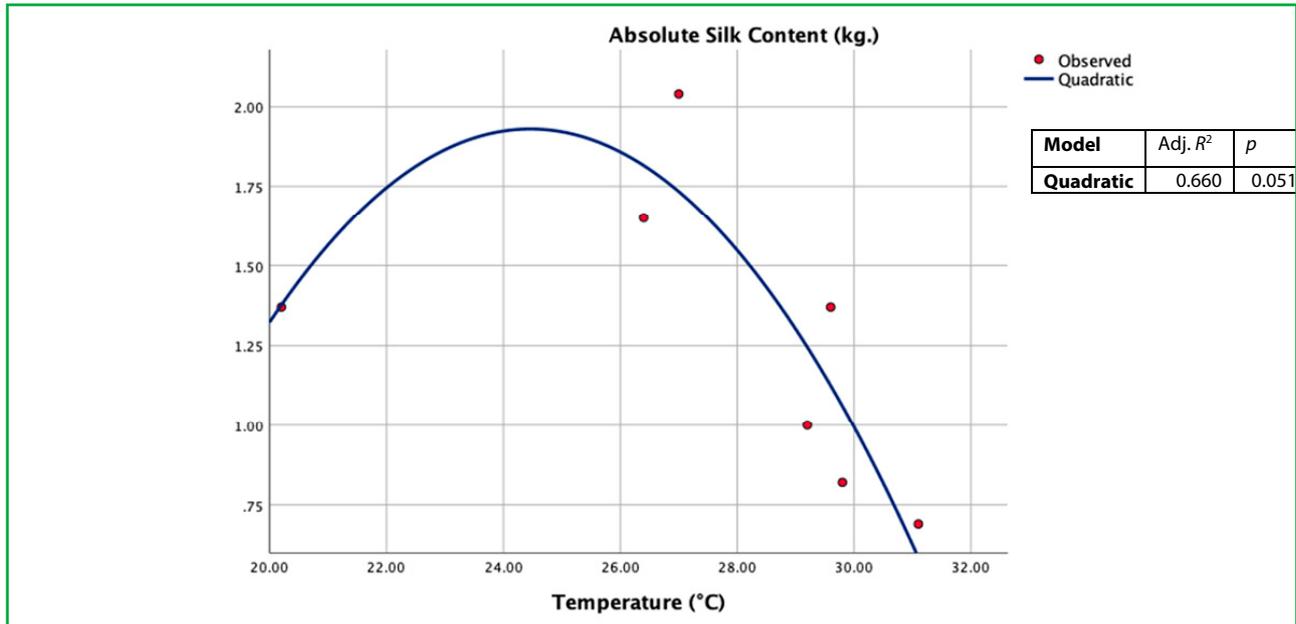
Figure 3   Quadratic regression between average temperature (°C) and average ASC (kg)

Bengal and also in studies conducted in other districts of the state (Hoque and Taufique, 2018). Late Autumn is the most suitable season for silkworm rearing having similarity with adjoining districts, where sericulture is in practice (Majumdar et al., 2017). Early Spring (Feb. – Mar.) can also be exploited as 2nd commercial crop rearing season. Still, Summer, Rainy season and Spring, i.e. the extended summer months (March to August) are found to be unfavourable for rearing of any kind of breeds, other researchers have also confirmed the wet Summer months (June to September) as unfavourable for mulberry sericulture in West Bengal (Majumdar et al., 2017). Further investigations are needed to find out, how this situation can be handled; heat shock (sublethal) (Rahmathulla, 2012)can be searched of. And so far as silkworm breeds are concerned, in Hooghly district of West Bengal, multivoltine breeds are more suitable to handle but hybrids are best to rear. Bivoltines can also be explored for its quality and high price as and when DFLs are available during late Autumn and early Spring.

Acknowledgments

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