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Research Article

VARIATION IN SEASON-WISE PERFORMANCE OF MUGA SILKWORM (*ANTHERAEA ASSAMENSIS* HELFER) AIMED TO CLIMATE CHANGE TRENDS:A DESCRIPTIVE STUDY

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ABSTRACT

North-East India enjoys the pride to be the largest contributor of muga silk in India's total silk production. Muga silk is produced by wild sericigenous caterpillar *Antheraea assamensis* Helfer belonging to family Sturnidae. Muga silkworm is poikilothermic in nature and responds well to the biotic and abiotic factors around it.In the current investigation, an attempt was made to summarize the climate change pattern and its impact on muga rearing performance under Kokrajhar district of Assam, India for the period of 2020 to 2024. The study revealed hatching percentage to be moderately affected with an average of 76.93% despite of the seasonal variations. Maximum and minimum values for cocoon weight was recorded as 7.20g and 4.71g and 2.81g and 4.69g and low values of shell weight and Shell ratio percentage (SR%) with an average of 0.26g and 0.35g and 0.26 and 0.49% resp. for male and female cocoons. Maximum Effective Rate of Rearing (ERR%) was recorded in Baisakhi season as 58% and minimum in Late Bhodia as 11.03% with an average of 30.31% with highest percentage of disease incidence (PDI) value for flacherie infestation in Bhodia as 98.9%. For the studied period temp. and relative humidity (RH) pattern fluctuated to be as high as 28-39°C in Baisakhi-2021 (April-June) season and as low as 14-15°C for Aghenua-2020 (Nov-Dec) with max. RH as 89-99% in Bhodia-2021 (Sept-Oct) and min. 32-45% in Late Jarua-2020 (Feb-April). On the basis of current study, it has been concluded that, Baisakhi, Late Bhodia and Aghenua are the most appropriate seasons to conduct rearing in Kokrajhar District provided the availability of optimum temperature and humidity. The study could be further extended to make season wise crop calendar for muga rearing suitable for different agro-climatic zones of Assam and other non-traditional states.

Keywords: Muga, Season, Crop, Seed, Yield, Climate, Performance.

INTRODUCTION

World class golden silk produced by wild sericigenous caterpillar belonging to family Sturnidae is the pride of North-East India commonly known as muga silkworm (*Antheraea assamensis* Helfer). Muga culture in Assam is a traditional practice and ride of tribal communities providing means of livelihood to more than 1.80 Lakh families (Tikader *et al*., 2013 and Das *et al*., 2016). Besides Assam, its adjoining states including Mizoram, Minpur, Nagaland, Meghalaya, Sikkim, Arunachal Pradesh, West Bengal and now Madhya Pradesh and Uttarakhand are in que to contribute in this luxuriant silk production. Muga silkworm larvae prefers Som (*Persea bombycina*) and Soalu (*Litsea polyantha*) as their primary food choice and secondary host plants includes Dighloti (*Litsea salicifolia*) and Mejankari (*Litsea citrata*) (Chakravorty *et al*., 2004; Saikia *et al*., 2004). Muga is semi-domesticated silkworm specie and rearing is conducted outdoors whereas, grainage

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production is an indoor activity (Bindroo *et al*., 2009, Bhuyan *et al*., 2013 and Devi *et al*., 2020).

Muga silkworm (*Antheraea assemensis* Helfer) is a holometabolous insect having all distinct stages including egg, larva, pupa and moth. Muga silkworm is polyvoltine in nature, produces non-diapausing eggs thus producing 5-6 generations per year. In a broad spectrum, muga culture in Assam is practised in six traditional crop seasons named after Assamese moths such as, Jarua for winter season (December-February), Chotua; early spring (March-April), Jethua; spring (May-June), Aherua; early summer (June-July), Bhodia; late summer (August-September) and Kotia; autumn (October-November). Among these, Jarua and Aherua are pre-seed crops, Chotua and Bhodia are seed crops and Jethua and Kotia are the two commercial crops. In addition to these, three more seeds crop namely, Baisakhi (April-May), Aghenua (November-December) and Late Bhodia (September-November) that overlaps the existing crop schedule. Over the decades of regular muga culture in Assam and its adjoining states it has been observed that the main crops from grainage point of view viz., pre-seed and seed crop usually falls in adverse climatic seasons with high records of extreme summer and winter which results 10-20% reduction in the crop production (Chakravorty *et al*., 2005).

For successful harvest of silkworm crop the relative contribution of different biotic and abiotic factors accounts 38.2% for host plant, 37.0% climate, 9.3% rearing technique, 4.2% silkworm race, 3.1% silkworm egg and 8.2% other factors (Choudhury *et al*., 1992). Thus, climate is the second largest contributor and most important factor after host plant. Silkworm is poikilothermic in nature and remains under the influence of climatic or weather conditions (Tazima, 1978). Thus, change in environmental conditions directly interferes with performance of silkworm. Therefore, an attempt has been made to summarize the climate change pattern and its impact on muga rearing performance under Kokrajhar district of Assam, India,that could be utilized to make season-basedcalendar for improving success rate in muga culture in traditional and non-traditional states.

MATERIALS AND METHODS

Locale of the study

For the current study the data on rearing performance was collected from Central Silk Board, Muga Eri, Silkworm Seed Organization, P3 Unit, Kowabil, Kokrajhar Assam. The district is characterized by almost plain topography being flanked by foothills of Bhutan in the upper strip of north and high plain in the middle to lower strip towards the southern side with a gradation from north to south. Geographically the unit lies roughly within 89°46’ East to 90°38’ East and 26°19’ North to 26°54’ North Latitude. It experiences average summer temperature as 27.64° C to 31.67° C and winter as 19.34° C to 23.66° C with 2,400 mm to 3,000 mm average rainfall per annum (Bharat Bonia; 2020). The climate-wise the area falls under humid sub-tropical region characterized by warm-humid summer and cool-dry winter. The soil texture is mostly sandy loam to clay loam with p^H ranging from 4.7 to 7.8 i.e. acidic to neutral.

Rearing Parameters Studied

1. Hatching Percentage (%):For the current study it was calculated by using the formula as given below:

$$\text{Hatching (\%)} = \frac{\text{Number of eggs hatched}}{\text{Total number of eggs}} \times 100$$

2. No. of Worms Brushed (Nos.): brushing percentage or total number of worms brushed can be calculated based on the hatching performance of dfls and is calculated by the formula:

$$\text{Brushing Percentage (\%)} = \frac{\text{Number of eggs hatched-Number of late born larvae}}{\text{Total number of eggs}} \times 100$$

3. Total no. of Mature worms collected: in muga silkworm rearing. On 7th day of 5thinstar, the mature worm crawls down the host plant in the evening with onset of dusk (7.30 to 9.00 PM). This is the time for mature worm collection; the worms with empty gut and transparent abdomen producing rough sound on rubbing are the signs of mature muga silkworm larvae. the mature worms collected will be counted manually before keeping the worms in jali for spinning. It gives an estimate of expected no. of cocoons in muga culture.
4. Weight of Mature Worms (g) Male& Female: At the time of mature worm collection, 10 male and 10 female larvae based on visual examination have been randomly selected and weighed individually on electronic weighing balance to obtain values for male and female silkworm larval weight in grams.
5. Total no. of Cocoons Harvested: at 7th-10th day of spinning, all the cocoons formed in jalies were harvested and calculated manually to get the total no. of cocoons.
6. Cocoon Weight (g) Male & Female: 10 male and 10 female cocoons based on the visual examination (male smaller in size, female larger in size) were randomly selected and weighed on electronic weighing balance to obtain the cocoon weight in grams.
7. Shell Weight (g) Male & Female: same cocoons used for cocoon weight were cut with the help of sharp razer or blade and empty shells (without pupa) were weighed on electronic weighing balance to obtain the shell weight in grams.
8. Shell Ratio Percentage (SR%) Male & Female Cocoon: SR% gives an estimate of the total silk content available in the cocoon and is calculated by using the formula:

$$\text{Shell ratio Percentage (\%)} = \frac{\text{Shell Weight}}{\text{Cocoon Weight}} \times 100$$

9. Economic Rate of Rearing (ERR %): ERR% is the most vital parameter revealing the percentage of success of silkworm rearing. It can be calculated by using the formula:

$$ERR\% = \frac{\text{Total no. of worms brushed}}{\text{Total no. of cocoons harvested}} \times 100$$

10. Meteorological parameters: Temperature (°C) and Relative Humidity (RH %): Values for minimum and maximum temp. and RH were recorded with the help of hygroscopic thermometer.
11. Rainfall (mm): values for regular rainfall (mm) were recorded with the help of barometer.
12. Percentage of Disease Incidence (PDI %): Pebrine, grasserie and flacheriediseases were monitored in the studied muga silkworm rearing period. Out of this only flacherie disease outbreak was recorded for all the rearings. Thus, flacherie outbreak was recorded in percentage (%) by using the formula:

$$PDI = \frac{\text{Total no. of worms lost due to flacherie}}{\text{Total no. of mature worms collected}} \times 100$$

Statistical analysis

The four (04) years data on various parameters regarding rearing performance was pooled from 2020 to 2024 and subjected to statistical validation for analysis of variance (ANOVA) on SPSS software.

RESULT AND DISCUSSION

The ideal climatic conditions for better growth and development of muga silkworm lies in temp range of 20-31°C temperature with 65 to 95%of relative humidity (Chowdhury, 1981 and Tikader *et al*., 2013).Fluctuations in the optimum range of temp. and RH is directly proportional to the performance of silkworm at various stages(Gohain and Borua 1983; Saikia *et al*., 2012).This change in ideal conditions also affects the food consumption and utilization efficiency of silkworms leading to starvation and poor growth of worms (Das *et al*., 2002).Generally, in muga seed crop falls in slightly adverse climate seasons that results almost 14-40% of seed crop loss annually and sometimes the entire crop swipes off (Chakravorty *et al*., 2007).With the changing climate pattern, for the recent past, significant change in temp. humidity and rainfall pattern have been observed in potential muga producer districts like Kokrajhar that showed considerable crop loss in the studied period (Saikia *et al*., 2016). Various parameters for the study period of 2020 to 2024 have been recorded and results of the same has been enumerated under below section.

Hatching percentage in silkworm rearing depicts the healthiness of disease free layings (dfls) or eggs. It is one of the most important parameters in sericulture and in muga the optimum value of hatching percentage for quality dfls is 80-85%. For the current study hatching percentage was recorded to be at par for all the seasons ranging from62-85% with an average of 76.93%. The highest value was recorded for Aghenua (85%), Baisakhi (82%), Bhodia (80%)and least for late Bhodia (62%). Kakati *et al*. (2005) reported hatching percentage in Bhodia season as 85% for good quality muga dfls. Majumdar *et al*., 2020also conducted the similar kind of study on grainage performance of muga silkworm for Bhodia season under 35 to 37°C and RH less than 70%, and reported 78% hatching percentage in the same season. Generally female larvae are heavier in weight as compared to males due to their developing ovaries. Fully mature healthy female and male larvae weigh about 10-15g and 7-10grespectively. In the recent study conducted by Kumar *et al*., 2024, larval weight for female and male under optimum climatic conditions has been recorded as 11.12 to 11.4g and 7.22 to 7.78g respectively. Due to the uncertain climatic conditions during different seasons in the study location, overall growth and development of the larvae was recorded as below average with values of 7.20g and 4.71g for female and male resp. Larval weight is directly proportional to the cocoon weight and good quality seed cocoon in muga weighs about 4.5g and 5.5g in male and female cocoons as reported by Kumar *et al*., 2024 and for the current investigation it has been recorded as2.81g and 4.69gfor male and female cocoons resp. showing considerable impact of weather conditions. As per the findings of Tikdar *et al*., 2016, the shell weight male and female muga cocoon shell was reported as 0.285± 0.02g and 0.984± 0.02g with average shell ratio of 7.718 ± 0.23% and 6.963 ± 0.25% resp. On the other hand, current findings revealed comparatively low values of shell weight and SR% in male and female cocoons with an average of 0.26g and 0.35g and 0.26 and 0.49% resp.

Results showed effective rate of rearing with at par values reported by Kumar *et al*., 2024 and maximum ERR% was recorded as 58% in Baisakhi season followed by Aghenua as 55.71% and Late Bhodia as 50.05% and minimum in Late Bhodia as 11.03% with an average of 30.31%. Similar to other lepidopteran silkworm species, Antheraea assemensis Helfer is also susceptible to bacterial, fungal and protozoan diseases. For the studied period, silkworm larvae were examined for Pebrine, grasserie and flacherie disease infestation but only flacherie outbreak was recorded for all the rearing seasons with average value of PDI as 45.61%, maximum in Bhodia (98.9%) followed by Aghenua (95.75%) and least in Baisakhi (7.73%). The PDI values for flacherie infestation lies in close conformity with the earlier reports made by Tikdar *et al*., (2016), who mentioned crop loss caused due to flacherie disease as 20-30%.

For the studied period from 2020 to 2024, climate change senior has revealed drastic fluctuations over the year and even in single year for different seasons. All the factors directly hampered muga crop performance pattern in potential regions like BTC, Kokrajhar. As per the findings of earlier researchers, it has been reported that muga thrives well in a temp. range of 20-31°C and 65-95%

of RH (Tikader *et al*., 2013). For the studied period temp. and RH pattern fluctuated to be as high as 28-39°C in Baisakhi-2021 (April-June) season and as low as 14-15°C for Aghenua-2020 (Nov-Dec) with max. RH as 89-99% in Bhodia-2021 (Sept-Oct) and min. 32-45% in Late Jarua-2020 (Feb-April). The average temp. and RH was recorded as 27.4°C and 61.53% over the past four years (Figure 1).

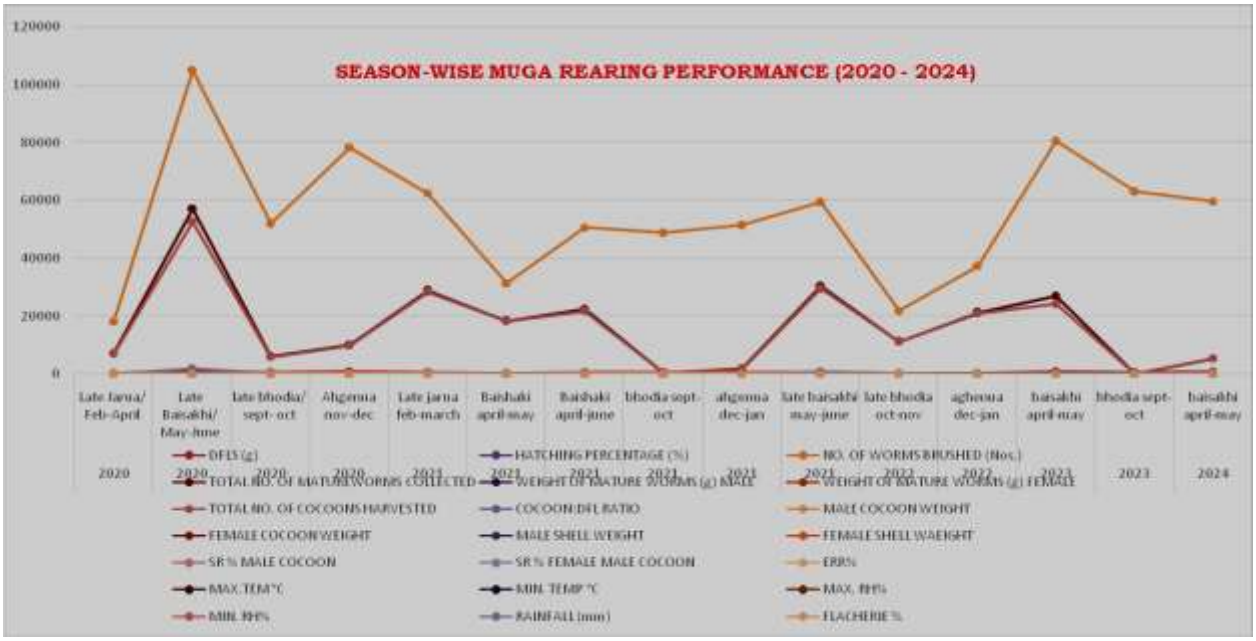

Figure 1. Season-Wise Muga Rearing Performance (2020 - 2024).

Year	Treatment	Hatching %	Larval Weight (g)		Cocoon Weight(g)		Shell Ratio (SR) %		Disease Incidence (%)	ERR%
			Male	Female	Male	Female	Male	Female	Flacherie	
2020	Late Jaurua	70	2.4	4.95	1.2	2.6	0.12	0.22	60.26	37.95
2020	Late Baisakhi	75	7.2	10.45	3.24	6.15	0.35	0.52	16.51	50
2020	Late Bhodia	62	6.25	8.85	2.86	5.35	0.26	0.33	87.91	11.03
2020	Aghenua	80	5.09	7.59	2.82	5.15	0.25	0.32	86.3	11.37
2021	Late Jarua	75	5.9	9.27	3.36	5.55	0.3	0.44	51.4	45.3
2021	Baisakhi	80	5.96	10.15	3.96	6.14	0.42	0.55	32.01	58
2021	Late Baisakhi	75	5.57	9.05	3.4	5.84	0.4	0.53	56.7	42.8
2021	Bhodia	66	5.11	7.95	3.02	5.21	0.31	0.38	98.9	0.6
2021	Aghenua	85	4.05	5.85	2.05	3.9	0.2	0.28	95.75	3.27
2022	Late Baisakhi	85	4.25	6.18	2.62	3.41	0.25	0.29	44.6	49.47
2022	Late Bhodia	78	5.48	9.44	4.16	6.28	0.44	0.54	46.08	50.5
2023	Aghenua	89	2.76	2.93	1.73	2.98	0.12	2.16	0	55.71
2023	Baisakhi	72	6.63	9.39	6.51	9.26	0.48	0.72	0	29.9
2023	Bhodia	82	0	0	0	0	0	0	0	0
2024	Baisakhi	80	4.09	6.03	1.25	2.61	0.12	0.21	7.73	8.76
	AVERAGE	76.933	4.716	7.205	2.812	4.695	0.268	0.499	45.61	30.310
	SD±	±7.3530	±1.875	±2.922	±1.521	±2.179	±0.138	±0.492	±35.735	±21.943
	SEm ±	±1.89	±0.48	±0.75	±0.39	±0.56	±0.03	±0.12	±9.22	±5.66

CONCLUSION

Silkworm is poikilothermic in nature, even slight change in ideal environmental conditions affects the growth by interfering withingestion: digestion ratio which results in poor crop harvests. In the current investigation, an attempt was made to summarize the climate change pattern and its impact on muga rearing performance under Kokrajhar district of Assam, India for the period of 2020 to 2024. The study revealed hatching percentage to be moderately affected with an average of 76.93% despite of the seasonal variations. The climate change has been reported to drastically reduce the larval characters including larval weigh, cocoon weight, shell weight and SR%. Maximum ERR% was recorded as 58% in Baisakhi season followed by Aghenua as 55.71% and Late Bhodia as 50.05% and minimum in Late Bhodia as 11.03% with an average of 30.31% with average value of PDI for flacherie infestation to be highest in Bhodia (98.9%). For the studied period temp. and RH pattern fluctuated to be as high as 28-39°C in Baisakhi-2021 (April-June) season and as low as 14-15°C for Aghenua-2020 (Nov-Dec) with max. RH as 89-99% in Bhodia-2021 (Sept-Oct) and min. 32-45% in Late Jarua-2020 (Feb-April). On the basis on current study, it has been concluded that, Baisakhi, Late Bhodia and Aghenua are the most appropriate seasons to conduct rearing in Kokrajhar District provided the availability of optimum temperature and humidity.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

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