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Performance of Muga silkworm on different host plants under different rearing seasons with respect of rearing performance and chemical constituents

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Abstract
Two primary host plants of Muga silkworm (*Antheraea assamensis* Helfer*), viz.* Som (*Persea bombycina*), Soalu (*Litsea monopetela*) were evaluated for rearing performance and cocoon characters during four different seasons under the agro climatic conditions of Boko, Assam. Mature larval weight was recorded significantly the highest from Soalu fed larvae, while it was the lowest from Soalu. Significantly heavier male cocoon and female cocoon weight was from Soalu. Biochemical constituents, viz. carbohydrates, crude fat and proteins etc. of the leaves were determined and correlated with the rearing performance. Among the rearing season Kotia crop recorded significantly highest rearing performance as well as biochemical constituent as compare to the rest of treatments.

Keywords: *Antheraea assamensis*, Som, Soalu, rearing performance, biochemical constituents

Introduction
Muga silkworm (*Antheraea assamensis* Helfer) is multivoltine in nature, *i.e.* 5-6 times rearing of the silkworm can be done in a year. Muga silkworms reared during autumn and spring seasons which are termed as 'Kotia' and 'Jethua' crops, respectively in Assamese, produce cocoons with heavier shell compared to silkworms reared during other seasons. The cocoons produced during these two seasons are used for producing yarn commercially and hence, these two crops are called as commercial crops. 'Kotia' commercial crop rearing is preceded by one crop rearing during June-July which is called 'Aherua' pre-seed crop and subsequent rearing during August-September is called 'Bhodia' seed crop. Similarly, 'Jethua' commercial crop rearing is preceded by 'Jarua' (December-January) pre-seed crop rearing followed by 'Chatua' seed crop rearing. The pre-seed and seed crops of Muga usually fall in adverse climatic seasons of extreme summer and winter and the productivity sometimes slashes down to 10-20% [3].

Muga silkworm is a polyphagous insect and feeds on a wide range of host plants. While 'Som' (*Persea bombycina* King) and 'Soalu' (*Litsea monopetela* Juss) are considered as the primary food plants, there are number of other food plants such as *Actinodaphnae obovata, A. anquistifolia, Celastrus monosperma, Cinnamomum glaucescens, C. glanduliferum, Gmelia arborea, Litsaea citrata, L. salicifolia, Magnolia sphenocarpa, Michelia champaca, Xanthozylum rehsta,* etc [18].

Commercial rearing of Muga silkworm for production of silk is mostly practiced along the Brahmaputra valley of Assam. On the other hand, pre-seed crops are mostly reared in lower Assam and in the foot hills of Meghalaya bordering Assam from where the traditional Muga rearers from upper Assam collect the seed cocoons during summer and winter for multiplication in the plains for raising seed cocoon for preparation of commercial Muga seed. Recently, rearing of Muga, both for commercial and seed production, has shifted to western Assam particularly in Goalpara and Kokrajhar districts of Assam and also to Jalpaiguri district of West Bengal. Over the last six decades, production of Muga raw silk in the region is fluctuating in between 24 -158 MT, which shows a gradual increasing trend in Muga silk production during last five decades. Last year Muga silk production of our country was recorded with 236MT which was highest till today. Muga silk production over the years has been hovering due to certain inherent problems associated with the culture.

Non-availability of the required quantity of quality Muga silkworm eggs (seeds) during commercial seasons has been identified as a major constraint of the industry. With reference to the requirement of commercial seed, Assam alone needs more than ten million dfls of Muga per annum. Of which, only 5 – 6% dfls are produced under the supervision of experts while the rest to the tune of about 95% seeds are produced by the farmers themselves based on their traditional knowledge [23]. Thus, the seeds produced by the farmers are either not free from transovarial diseases or not adequate to meet the requirement of commercial seeds. As a result, the Muga rearers often cannot utilize their plantation for rearing to its fullest potential.

Rearing of Muga silkworms is done in outdoor allowing them to feed on leaves of standing host plants till they mature and collected by rearers to form cocoons inside cocooning halls. Thus the silkworm populations remain under the influence of climatic or weather conditions. The survivability of worms as well as harvesting of ripened worms depends on several factors, out of which host plant has the major role. According to [6] relative contribution of such factors responsible for a successful crop harvest has been estimated as: Host plant (38.2%), climate (37.0%), rearing technique (9.3%), silkworm race (4.2%), silkworm egg (3.1%) and other factors (8.2%).

Since, host plants plays the major role for successful cocoon production, it is, therefore, important to evaluate the best host plant out of the primary and secondary host plants so as to propagate the best one for commercial utilization. In the present paper, attempt to compare the rearing performance of Muga silkworm on two different host plants and remaining two parameters was transfer from one to another during different seasons. The biochemical composition of the host plants' leaves were also estimated to find out the correlation with the rearing performance of Muga silkworm.

Materials & Methods

A. Rearing of Muga silkworm

The rearing experiment was conducted at P2 farm, Dhupguri, Boko, kamrup, Assam, during Jethua (April-May), Kotia (October-November), Bhodia (August-September) and Chotua (February-March) during 2016 to 2018. Som and Soalu plants (10 years old) were pruned and maintained following recommended package of practices [3]. Freshly hatched Muga silkworm larvae were brushed into 10 trees of each food plants @ 1000 worms per plant considering the quantity of leaf so as to complete the larval instars from brushing till maturation. Body weight of mature larvae, cocoon weight and hatching percentage were recorded in all the seasons.

B. Estimation of biochemical constituents of host plant leaves

Tender (top 1/3rd part), semi-mature (middle 1/3rd part) and mature (bottom 1/3rd part) leaves of above mentioned plant separately. Leaf samples were dried at 80°C, powdered, sieved and used for estimation of biochemical constituents. Total soluble protein content was determined with crystalline Bovine Serum Albumin (BSA) as standard. The total mineral was determined from the ash content as described in the [1] method. Moisture and Crude fibre were estimated following the method of [1]. Anthrone method [24] was followed to estimate reducing sugar and total soluble sugars, Data recorded during the course of investigation were statistically analyzed of "Analysis of Variance" technique given by [20]. The significance of difference was done by 'F' test. When 'F' value was found significant, Critical Difference (CD) was calculated by multiplying S. Ed. (Standard Error) with corresponding't' value at 5% level of probability. When mean difference among the treatments (varieties) were greater than the CD value the difference was considered as significant.

The standard error of mean S. Ed. Was calculated using the following expression:

$$\text{S.Ed. } (\pm) = \sqrt{\frac{2X \text{ Error mean square}}{\text{Number of replication}}}$$

Correlation co-efficient between rearing performance parameters and biochemical constituents of leaves and rearing performance and prevailing weather parameters were also calculated using the SPSS 11.5 statistical package.

Results

A. Rearing performance

Table 1 represents data on different rearing performance and other economic parameters of Muga silkworm reared on different host plants.

Rearing performance of the Muga silkworm on different seasons, it was observed that, Kotia was the best season crop in respect of larval weight, male and female cocoon weight. While best hatching percentage was observed during Jethua crop.

Mature larval weight was recorded significantly the highest from Soalu fed larvae (10.45 g), while it was the lowest from Soalu in chawky stage and Som in late age (8.66). In respect of cocoon weight, significantly heavier male and female cocoon weight were obtained from larvae which were fed with Soalu leaves. While hatching percentage obtained from leaves fed with Som. Significantly lowest cocoon weight of male and female as well as hatching percentage were recorded from Soalu in chotua crop.

B. Leaf biochemical composition

B.1. Crude fat and crude protein content: Results showed that crude fat content and crude protein increased non-significantly with the advancement of leaf age irrespective of host plant except crude protein in matured leaves. Leaves of Som and Soalu possessed significantly highest crude protein content (21.66% and 18.88%, respectively). Som leaves were superior among all the host plants irrespective of leaf maturity and season,

Among growing season, Bhodia crop sowed non-significantly highest crude protein content (22.83%) in Som plant while in Soalu, Kotia crop having highest crude protien content (19.51). In case of crude fat, among different growing season jehua crop recorded highest crude fat in Som plant and in Soalu plant Bhodia crop recoreded highest fat content as comparison to the rest of treatment. Lowest crude protein and crude fat content was recorded in chotua crop in both of the primary host of Muga silkworm.

B.2. Carbohydrate content: Table depicts the carbohydrate content increased non-significantly with the advancement of leaf age irrespective of host plant. Som leaves possessed significantly highest carbohydrate content (11.85) in Bhodia crop whereas lowest was recorded in Jethua crop (11.68). Results revealed that, Soalu leaves were superior in Bhodia crop among all the growing (11.88). Significantly lowest carbohydrate content was recorded in chotua crop in Soalu leaves (11.64).

Discussion

Dietary water plays a very important role in silkworm metabolism as it regulates the rate of ingestion by Muga silkworm. It acts as diluents of nutrients, but not as a phagostimulant. Moisture acts as an olfactory and gustatory stimulant [10] and its content is known to influence the metabolic activities related to food consumption, digestion and utilization [15, 22, 16] also highlighted the importance of moisture content of the feed in the case of other phytophagous insects [13] concluded that, higher moisture content in mulberry leaves favourably affected not only edibility but also their assimilability of nutrients in food and serves as a criterion in estimating the leaf quality [18] found that, higher the moisture content of leaves, higher the blood volume in different instars of Muga silkworm body, but lower the total haemocyte count and vice versa [17]. reported an average of 64.20% to 73.00% moisture content in eight different morphotypes of Som. In the present investigation, a declining trend in moisture content was observed from tender to mature leaves and Soalu leaves recorded higher moisture content in all levels of maturity among the host plants. Similar result was also obtained in the leaves of mulberry [19] and Som and Soalu plants [23]. He also reported moisture content in tender, medium and mature leaves as 74.00%, 65.50% and 56.20%, respectively in case of Som and 75.40%, 64.00% and 62.80%, respectively in Soalu [11] opined that 70% moisture or more is optimum for silkworm rearing. The tender and semi-mature leaves are succulent, contain higher moisture and as the mandibular structures in the young larvae are underdeveloped, they therefore prefer tender leaves for feeding.

The role of proteins and amino acids in silkworm nutrition has been emphasized by [7, 21]. Nitrogen is the most distinguishing chemical element present in proteins which in turn are the most ubiquitous organic nitrogenous compound in food stuff and in all living cells. In fact they appear to be involved in practically all the structure and functions of all cells [12]. The green leaves of plants are good sources of protein and may supply most of the essential amino acids required by growing cells. Nitrogen as protein and non-protein nitrogenous matter present in the food plant leaves are responsible for healthy growth of silkworm as silk substances consists of protein [23]. reported 16.18% crude protein content in the tender leaves of Som and 15.54% in medium and mature leaves; 20.72% in the tender, 18.17% in medium and 15.54% in mature leaves of Soalu [17] reported 9.65% to 11.88 mg/100g protein content in eight different morphotypes of Som. In the present study, Som leaves were superior over other host plants in this respect.

Carbohydrates, particularly reducing sugars are very important for growth and development of silkworms. Carbohydrates are utilized by the silkworms for energy source and for synthesis of both lipid and amino acids. These are very important for healthy growth of silkworm; especially they are effective for keeping healthy growth of infant larvae. Some sugars possess a gustatory stimulation effect on larval feeding on larval feeding of the silkworm [10]. The carbohydrates are generally the most effective in increasing fat body glycogen. The rate of increase of fat body glycogen and haemolymph trehalose is also dependent on the content of carbohydrate in diet [9, 23] reported an average of 4.85% and 4.71% total sugar content in the leaves of Som and Soalu, respectively, but higher in medium leaves. In the present investigation, a decreasing trend of total soluble sugar content was observed for all the host plants. This may be due to variation in different factors like season, variety of host plant used, place *etc*. Similar trend was observed in case of starch content of the leaves.

In the present investigation, it has been revealed that, for all the nutrient constituents as a whole, Som, *P. bombycina* was superior over other host plants irrespective of season and type of leaves, followed by Soalu, *L. polyaltha*.

While rearing performance of the Muga silkworm on different host plants during different seasons, it was observed that, Soalu was the best food plant in respect of larval weight, male and female cocoon weight and hatching percentage. This is certainly because of the superiority of Soalu leaves as discussed earlier. Silkworms fed with Soalu leaves exhibited heavier larval weight and female cocoon weight which may be due to higher moisture content of Soalu leaves. Since food plants play a significant role for silkworm rearing and acquiring commercially important characters *viz*. effective rate of rearing (ERR), Silk ratio (SR), larval growth pattern and fecundity. Similar results were also obtained by [12, 14, 18, 3, 4]. All such studies revealed superiority of Som and Soalu over rest of the treatments, for which these two host plants are referred to as primary host plants.

Table 1: Effect of different rearing season on larval weight (g), male, female cocoon weight (g) and hatching percentage (%) in different host plant of Muga silkworms.

Treatments	Larval Weight	Male Cocoon Weight	Female Cocoon Weight	Hatching Percentage
Kotia	11.92	4.54	5.47	87.25
Jethua	9.22	4.51	5.45	91.00
Bhodia	8.79	4.47	5.41	85.00
Chotua	7.33	3.89	4.35	85.25
SEm±	0.05	0.04	0.01	0.83
CD (0.05)	0.16	0.11	0.03	2.40
Som ($1^{st}$to 5^{th})	8.95	4.32	5.13	89.25
Soalu (1^{st} to 5^{th})	10.45	4.56	5.25	86.25
Som (1^{st} to 3^{rd}) + Soalu (4^{th} to 5^{th})	9.20	4.33	5.18	87.00
Soalu (1^{st} to 3^{rd}) + Som (4^{th} to 5^{th})	8.66	4.21	5.11	86.00
SEm±	0.05	0.04	0.01	0.83
CD (0.05)	0.16	0.11	0.03	2.40

Table 2: Effect of rearing seasons of Muga silkworm on crude protein, carbohydrate and crude fat in Som plant.

Treatments	Crude Protein	Carbohydrate	Crude Fat
Kotia	22.50	11.73	5.40
Jethua	20.75	11.68	5.57
Bhodia	22.83	11.85	5.37
Chotua	19.32	11.73	5.37
SEm±	1.00	0.38	0.27
CD (0.05)	NS	NS	NS
Tender	21.40	11.61	5.11
Semi mature	21.66	11.77	5.41
Matured	20.99	11.87	5.75
SEm±	0.87	0.33	0.23
CD (0.05)	NS	NS	NS

Table 3: Effect of rearing seasons of Muga silkworm on crude protein, carbohydrate and crude fat in Soalu plant.

Treatments	Crude Protein	Carbohydrate	Crude Fat
Kotia	19.51	11.72	3.59
Jethua	16.78	11.65	3.59
Bhodia	17.88	11.88	3.63
Chotua	17.68	11.64	3.45
SEm±	0.89	0.49	0.20
CD (0.05)	NS	NS	NS
Tender	17.34	11.56	2.48
Semi mature	18.88	11.72	4.05
Matured	17.68	11.89	4.17
SEm±	0.77	0.42	0.17
CD (0.05)	NS	NS	NS

Conclusion

The Kotia season in Soalu plant registered higher larval weight (g), male, female cocoon weight (g). Among the rearing season Bhodia crop recorded significantly highest biochemical constituent viz. crude protein, fat and crude fibre in all the type of different leaves as compare to the rest of treatments.

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