ALTITUDINAL EFFECT AND HOST PLANT PREFERENCE ON GROWTH AND PRODUCTION OF *ANTHERAEA ASSAMA* WESTWOOD

THESIS SUBMITTED TO NAGALAND UNIVERSITY IN PARTIAL FULFILMENT FOR THE AWARD OF DEGREE OF DOCTOR OF PHILOSOPHY IN ZOOLOGY

By

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2012

CERTIFICATE

This is to certify that, the thesis entitled "Altitudinal Effect and Host Plant Preference on Growth and Production of Antheraea assama Westwood" incorporates the results of the original findings carried out by Mrs. Binita Tamuly Kakati under my guidance and supervision. She is a registered research scholar (Regd. No. 326/2007) of the Department and has fulfilled all the requirements of Ph. D. regulations of Nagaland University for the submission of her thesis.

The work is original and neither the thesis nor any part of it has been submitted elsewhere for the award of any degree or distinction.

The thesis is therefore, forwarded for adjudication and consideration for the award of degree of Doctor of Philosophy in Zoology under Nagaland University.

Dated: November, 2012
Place: Lumami

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AN ABTRACT OF THE THESIS SUBMITTED TO NAGALAND UNIVERSITY IN PARTIAL FULFILMENT FOR THE AWARD OF DEGREE OF DOCTOR OF PHILOSOPHY IN ZOOLOGY

Title of the thesis

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CONTENTS

CHAPTER I: Introduction

India has the distinction of being the only country in the world, producing all the five commercially exploited silk varieties viz. Mulberry, Tropical Tasar, Temperate/Oak Tasar, Eri and Muga of which the golden yellow muga silk of Assam is unique product of India and nowhere in the world is available. Muga culture is a continuous chain of several production activities starting from egg production to rearing of *Antheraea assama* West wood (= *Antheraea assamensis* Helfer) in the raised flora by rearers for production of cocoons. Muga silk worm fed with leaves of *Persea bombycina* Kost and *Litsea polyantha* (the two primary host plants) produces golden yellow cocoons, however when reared on *Litsea citrata* Blume, the secondary host plant produces creamy white cocoons.

Sustainability of muga silk industry has been facing serious threat in recent years due to global warming and various anthropogenic reasons. The traditional commercial muga growers of Assam generally visit foot hills as well as higher altitudinal areas of neighbouring hill states to collect wild, healthy seed cocoon for conducting commercial crop which emphasize that altitudinal effect, climatic variation and host plant preference play a great role in muga cocoon production. In this context, rearing schedule and technology of muga crops has to be standardized to suitably adjust the local conditions particularly in high altitude so that the crucial gap between production of seed cocoons and their requirement for each commercial crop is minimized. Hence a systematic study of rearing has been undertaken on three host plants (*Persea bombycina*, *Litsea polyantha* and *Litsea citrata*) in two locations at

North Lakhimpur, Assam (low altitude) and Mokokchung, Nagaland (High altitude) for two consecutive years to have comparative analysis of altitudinal effect and host plant preference on growth and production of *A. assama*.

CHAPTER II: Description of study sites, climate and host plants

The experimental sites selected for present study was located in Ungma of Mokokchung (Mokokchung district) in Nagaland at higher altitude (1325m amsl) and Japisajia of North Lakhimpur (Lakhimpur district) in Assam at lower altitude 135m amsl). Rearing of *A. assama* was conducted simultaneously in three different seasons i.e. spring (April-June), summer (July-September) and autumn (October-December) on three host plants namely *P. bombycina* (Som), *L. polyantha* (Soalu) and *L. citrata* (Mejankari). *P. bombycina* was common to both places, whereas *L. polyantha*, the another primary host plant was utilized in lower altitude and *L. citrata*, the important secondary host plant which grows abundantly in Nagaland was used in higher altitude.

The four distinct seasons prevailing in Nagaland are cold (winter), hot (pre-monsoon), rainy (monsoon) and cool dry season (retreating monsoon) and the hilly terrain with about 52% forest cover is instrumental in shaping the cool and pleasant climatic conditions. Mokokchung district, covering an area of 1615 Km^2 lies at $26^{o}17^{'}$-$26^{o}39^{'}$ N latitude and $94^{o}18^{'}$-$94^{o}37^{'}$ E longitude. Assam within the rain shadow zone lies at 26°30' - 29°30' N latitude and 91°30' - 97°30' E longitude. Persistent high humidity and moderate temperature throughout the year, extensive water bodies, local depressions, elevations and extensive forests play important role for shaping veritable climatic conditions of Assam**.** Climate wise the year in Assam can be divided broadly into the wet (March to September) and cool dry season (October to February) period. Lakhimpur district is located in north-east corner of Assam at $26^{o}48^{'}$-$27^{o}53^{'}$N latitude and $93^{o}42^{'}$-$94^{o}20^{'}$E longitude covering 2953 Km^{2}.

While variation in mean maximum temperature was not much evident, mean minimum temperature was considerably variable during different rearing seasons between Mokokchung and North Lakhimpur. The range of maximum and minimum temperature in all seasons was higher in Mokokchung than North Lakhimpur indicating colder climatic regime on the former. Persistent high humidity in North Lakhimpur than Mokokchung was mostly influenced by high rainfall and moderately high temperature throughout the year. Both locations in lower and higher altitude represent an ideal sub-tropical climate, however, Lakhimpur district of Assam exhibited certain self regulating mechanisms of occasional winter rain and summer drought while Mokokchung district witnessed prolong winter. The mean annual rainfall for last 20 years in Mokokchung was lower than North Lakhimpur

P. bombycina (Som) and *L. polyantha* (Soalu) are the primary food plant of muga silk worm and are used for production of commercial and seed cocoons in upper and lower Assam. Sixteen ecotypes of Som and ten ecotypes of Soalu are described. The cocoons produced in Som and Soalu are golden brown in colour. *L. citrata* (Mejankari) is the most important secondary host plant whose distribution in plains of Assam is very sparse but grown naturally in Mokokchung, wokha and

Tuensang district of Nagaland. Muga silk worm fed on *L. citrata* produces a kind of silk known as Mejankari silk which is admired for its durability, luster and creamy white shade.

CHAPTER III: Physico-chemical characteristics of soil and host plants

Analysis of physico-chemical characteristics of soil viz. moisture content (%), soil pH, organic carbon (%), total nitrogen (kg/ha), available phosphorus (kg/ha) and available potassium (kg/ha) in different seasons between North Lakhimpur and Mokokchung revealed that the soil quality in both sites were suitable for growth of muga silkworm food plants with balanced amount of these nutrients. Total nitrogen and phosphorus decreased with the increase in altitude, while organic carbon and potassium exhibited an opposite trend which might be due to various factors such as temperature, rainfall, altitudinal effect, vegetation cover, land use etc.

In North Lakhimpur, Assam (low altitude), highly significant variation in nutrient content among different leaf types of two primary food plants i.e. Som and Soalu was observed exhibiting a trend of tender > medium > mature in moisture, nitrogen, crude protein content, while the reverse trend i.e. mature>medium>tender was seen in crude fibre, carbohydrate and total ash. However no definite trend was seen in soluble and reducing sugar in both host plants. In Som, all the foliar contents were found to be maximum during summer followed by autumn and spring season, however in Soalu, different trend was observed i.e. spring>autumn>summer in case of nitrogen, crude protein, crude fibre, carbohydrate, reducing sugar;

summer>autumn>spring in moisture; autumn>spring>summer in soluble sugar and autumn>summer>spring in total ash. The annual mean of all foliar constituents were found to be higher in Som than Soalu. The results suggested both individual and combined effect of leaf types, seasons and host plants on the nutritive value of leaves which greatly influenced the silk worm feeding from initial to maturation stage to produce healthier cocoons in different rearing seasons.

In Mokokchung, Nagaland (high altitude) seasonal variation of foliar constituents viz. moisture content, nitrogen, crude protein, crude fibre, carbohydrate, soluble and reducing sugar and total ash in different leaf types of primary (*Persea bombycina*) and secondary (*Litsea citrata*) food plants were found to be highly significant. Moisture content was recorded to be minimum during spring and autumn season in Som than Mejankari, however the trend was found to be reverse in case of nitrogen, crude protein and crude fibre which were found to be less during summer in Som than Mejankari. Further percentage of carbohydrate, soluble sugar, reducing sugar and total ash were recorded to be maximum in all seasons in Som than Mejankari. While nitrogen, crude protein, crude fibre, carbohydrate, soluble sugar and total ash were higher in som during autumn, Mejankari retained higher percentage of these constituents during summer season except for carbohydrate which was maximum in spring season. The annual mean of all foliar constituents were found to be higher in Som than Mejankari except for moisture content The comparative studies on seasonal variations between leaf types of both *P.bombycina* and *L.citrata* revealed significant differences for moisture, total carbohydrate, soluble sugar, total nitrogen and crude protein whereas difference were insignificant for reducing sugar, crude fibre and total ash. The results suggested both individual and combined effect of leaf types, seasons and host plants on the nutritive value of leaves which greatly influenced the silk worm feeding on different larval stages and highlighted the importance of Mejankari at par with Som and Soalu host plant on rearing performance and cocoon production in different season.

Foliar constituents of *Persea bombycina* in both locations of lower and higher altitude, showed a declining trend in the moisture, nitrogen, and protein content from tender to mature leaves, however the reverse trend i.e. mature>medium>tender was found in respect of crude fibre, carbohydrate, reducing sugar and total ash in all seasons except for slightly higher amount of soluble sugar content in medium leaves highlighting significant altitudinal influence on the chemical composition in different maturity of leaves. Mean seasonal and annual value of moisture, nitrogen, protein and crude fibre was more in lower altitude (North Lakhimpur) and carbohydrate, soluble and reducing sugar and total ash was more in higher altitude (Mokokchung). On average, foliage in higher altitude exhibited comparatively higher values for carbohydrate, soluble sugar, reducing sugar and total ash whereas, the foliages of lower altitude revealed higher value for moisture, total nitrogen, crude protein and crude fibre content. Based on the present findings, it could be suggested that *Persea bombycina* located in higher altitude i.e. Mokokchung, the non traditional zone was nutritionally at par with the traditional zone of located in Lower altitude i.e. North Lakhimpur and suitable for muga silkworm rearing.

CHAPTER IV: Morphometric variation of *Antheraea assama* Westwood

Muga silkworm rearing in North Lakhimpur, Assam was conducted on *Persea bombycina* (Som) and *Litsea polyantha* (Soalu) in three seasons i.e. spring, summer and autumn only. Seasonal mean length and weight in different larval instars was higher in Soalu than Som. Length, breadth and weight of female cocoons and pupa was higher than its male counterpart in both host plants and respective seasons.

A comparative rearing experiment on Som and Mejankari in a muga producing area of Mokokchung Nagaland showed that seasonal mean of larval length ranged from 0.97±0.09 cm to 1.11±0.08 cm (1st instar) to 7.94±0.88 cm to 9.32±0.27 cm (5th instar) respectively in *L. citrata* and *P. bombycina*. While larval volume was found to be higher in Som than Mejankari, no significant difference was observed in larval weight between the two host plants. The larvae also produced luster and creamy white shaded cocoons.

Rearing of wild population of *Antheraea assama* in three different seasons on two host plants in Mokokchung, Nagaland exhibited strong seasonality and host plant effect on growth and development in different larval stages, cocoon and pupa. Each larval instar exhibited distinguishing colour variation and tubercular arrangement. The volume (length x breadth) and weight of the larva during first instar was comparatively less in Som than Mejankari which was however getting reverse along with developmental stages and attained maximum volume and weight in Mejankari. Cocoons colour varied in host plants and seasons. While cocoon and pupal parameters in Som was found to be better than that of Mejankari, spring season was more favourable followed by autumn and summer season showing significant interaction effect due to host plant x season. The moths of wild variety which was larger in size and deeper in colour than cultivated variety have wing span of 142- 153 mm in male and 153 -172mm in female.

The significant differences in length, breadth and weight in larval stages of *Antheraea assama* from first to fifth instars in different seasons highlighted the effect of altitudinal and climatic variation between Lakhimpur and Mokokchung. Morphometric parameters of female cocoon and pupa were higher than its male counterpart in respective seasons in both sites. The length, breadth and weight of cocoon and pupa was maximum during spring season with a decreasing trend through summer and autumn in lower altitude, however a seasonal fluctuation was observed in higher altitude exhibiting maximum during autumn. The volume and weight of cocoon and pupa during summer and autumn season in Mokokchung was higher than Lakhimpur and exhibited a strong interaction effect due to season, site and sex.

CHAPTER V: Altitudinal effect and host plant preference on rearing performance of *Antheraea assama* Ww.

Rearing of *A. assama* on *P.bombycina* took 21.2±1.37 to 34.0±2.11.days to complete its larval period, while on *L.polyantha* the duration was 20.1±1.34 to 33.0±2.19 days in indifferent seasons. The total mean production parameters viz. fecundity, hatching percentage, ERR and cocoon:dfl in Som and Soalu were 195.67±9.71 and 188±10.00, 82.33±6.43 and 81.00±5.57, 42.73±17.47 and

48.20±17.05, 46.67±20.82 and 45.67±27.68 respectively. Shell ratio, filament length, filament denier and raw silk recovery did not show significant difference between the two host plants.

In Mokokchung, the larval period of cultivated variety of *A. assama* ranged from 34.9±0.72 to 37.4± 0.99 days and 39.7±0.73 to 45.2±1.61 days in *P.bombycina* and *L.citrata* respectively in indifferent seasons. The important economic characters viz. fecundity (nos.), hatching percentage, ERR (%) and cocoon:dfl ratio in *Litsea citrata* ranged from 171.50±9.63 to 198.33±8.64, 60.12±2.66 to 71.25±1.71, 40.77±1.02 to 57.37±1.26 and 53.0±1.89 to70.0±4.56 respectively in different seasons. The mean dimension (length x breadth) and weight of cocoon, shell ratio, filament length, filament denier and raw silk recovery in *L.citrata* was comparable and at par with *P. bombycina.*

Rearing of wild variety of *A. assama* took 28.2±0.91 to 37.2±1.00 days to complete its larval period on *P. bombycina* while on *L. citrata,* the duration was 33.4±0.78 to 45.2±0.94 days in different seasons. The important economic characters viz. fecundity (Nos.), hatching %, effective rate of rearing (%) and cocoon:dfl ratio in *L. citrata* ranged from 199.10±9.63 to 200.20±8.64, 71.28±2.66 to 76.21±1.71, 28.35±1.02 to 58.87±1.26 and 39.90±1.89 to 87.40±4.56 respectively in different seasons. The golden to pinkish white and tough texture cocoons measured a length of 3.78±0.11 to 4.42±0.12 in male and 4.31±0.14 to 5.04±0.12 in female and a breadth of 1.44±0.04 to 1.56±0.06 in male and 1.64±0.06 to 1.68±0.07 in female when fed on the leaves of *L. citrata*. Shell ratio (%), filament length (cm), filament denier and raw silk recovery (%) of *L. citrata* fed cocoons are at par with that of *P. bombycina.*

Comparative rearing analysis of both cultivated and wild variety of muga silk worm on Som showed strong seasonality in larval duration having the sequence of summer<spring<autumn season and was correlated with the higher temperature and optimum humidity. While mean values for all production parameters was recorded to be less in cultivated variety than the wild ones, both varieties exhibited seasonal fluctuation of all production parameters with a minimum record during summer. Maximum green cocoon weight for both cultivated and wild variety was recorded in female during autumn and spring season respectively. While total mean of shell weight, silk ratio and raw silk recovery did not show any significant difference, the filament length and denier differed significantly between the two varieties.

Larval duration of cultivated and wild population on Mejankari also exhibited strong seasonality with temperature and humidity having the sequence of summer < spring< autumn season. While total mean fecundity and hatching percentage in wild population was recorded to be higher than cultivated one, the reversed trend was observed in mean effective rate of rearing and cocoons per dfl ratio. Total mean of green cocoon weight was higher in wild than the cultivated one. Shell weight and SR% was recorded to be maximum in female of cultivated population than the wild ones which had been found to be reversed in male cocoons. Filament length (m) and filament denier were found to be maximum in cultivated variety than wild one in all seasons; however there was apparently no difference in raw silk recovery (%) between the two populations in different seasons.

Total larval duration during summer and spring was significantly shorter in North Lakhimpur than Mokokchung, however no significant difference was observed during autumn season. Seasonal and mean pupal period was recorded to be shorter in North Lakhimpur than Mokokchung. Higher fecundity and hatching percentage in lower altitude and maximum ERR and cocoon production in higher altitude emphasized strong altitudinal effect on production parameters due to climatic variation in both places. Further season to season analysis on rearing and cocoon production between the two places highlighted the fact that rearing performance in higher altitude was comparatively better than lower altitude during summer and autumn season and also showed highly significant difference between locations, seasons and interaction effect due to location x season. Total mean of green cocoon weight (gm) was higher in Mokokchung than North Lakhimpur with the record of maximum weight in female during spring and minimum in male during autumn season in North Lakhimpur. Silk ratio (%) was recorded to be higher in Mokokchung than North Lakhimpur in both sexes in all seasons. While filament length and raw silk recovery was higher in North Lakhimpur than Mokokchung denier was recorded to be higher in Mokokcung than North Lakhimpur.

Rearing of muga silk worm even on same host plant in different seasons and locations resulted in variability among different characters like ERR, cocoon weight, shell weight, silk filament length and shell ratio and indicated a promising future in terms of producing novel silk with high economic value for the region. While spring and autumn seasons were the best suited for commercial crop production, cocoons produced during summer season could be used for seed purpose in ensuing autumn crop. Further, the diapausing character of *A. assama* indicated its adaptability to severe winter at higher altitudes and would provide enormous opportunities for rearing of wild variety.

The congenial climatic condition in Nagaland state particularly during spring, summer and autumn seasons was highly suitable for muga culture which might have tremendous potentialities to emerge as important subsidiary crop next to agriculture for livelihood. However the knowledge of muga silk production was very poor among farmers due to lack of transfer of technology, which was yet to reach grass root level. In spite of having certain problems like weak research and extension support, inadequate infrastructure, processing and market facilities of seed and commercial cocoons, inadequate package of practice for plantation, rearing and grainage, adjustment to the climatic fluctuation etc., muga culture has high prospect in this state for large scale development due to its great market demand particularly for seed cocoons, availability of vast track of vacant land for plantation, employment opportunity to skilled and unskilled manpower etc. A critical SWOT analysis is made towards upliftment of muga silk industry that requires the complete package from egg production to finished cloth to assist muga farmers, reelers, weavers and traders to generate income from the sale of their respective raw materials. Having seen the socioeconomic perspective of muga silk industry towards contributing renewal interest among marginal farmers, women and unemployed youths, it is suggested that Mokokchung may be considered as an alternative eco-pocket for rearing of muga silk worm particularly during pre-seed and seed crops which are the most important for any successful commercial crop.

CHAPTER VI: Summary

This chapter summarizes the overall findings in the present study. It gives an account of climatic variation of both study sites and description of host plants with reference physico-chemical characteristic of soil and host plants. Detail comparative study on morphometric variation and rearing performance of *Antheraea assama* (both varieties) on three host plants in low and high altitude highlighted altitudinal effect and host plant preference. A critical SWOT analysis is made to emphasize on socioeconomic perspective of muga silk industry in Nagaland.

The thesis is completed with the exhaustive list of references cited in the main text.

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DECLARATION

I hereby declare that the thesis entitled "A**ltitudinal effect and host plant preference on growth and production of *Antheraea assama* Westwood"** submitted by me is entirely the research work of my own. The thesis or part thereof has not been submitted elsewhere for any research degree or distinction.

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(Binita Tamuly Kakati)

CONTENTS

CHAPTER I

INTRODUCTION

Sericulture, a combination of agriculture and industry, is both art and science of rearing silkworms for production of "Silk" the queen of textiles which is adored by the million of people across the world. The two distinct sectors of sericulture, the mulberry and non-mulberry or wild, now called 'Vanya silk' is being practiced in various magnitudes to provide gainful occupation to more than five million persons in the rural and semi urban areas in different states of India. In the global scenario, India continues to be the second largest silk producer in the world (13.4%) mainly due to mulberry raw silk produced by certain major silk producing states. The production of silk in India during 2011-12 was recorded to the tune of 23000 MT, out of which the mulberry silk production was 18186 MT, while non-mulberry silk i.e. Tasar, Eri and Muga produced 1577 MT, 3110 MT and 127 MT, respectively (Source: Regional Office, Central Silk Board, Guwahati, Assam). In fact, India has the distinction of being the only country in the world, producing all the five commercially exploited silk varieties viz. Mulberry silk produced throughout the country, Tropical Tasar, Temperate/Oak Tasar, produced by tribal inhabiting Central India and Sub-Himalayan Region, Eri Silk (spun silk produced mainly in N. E. Region, now practiced in many other states) and Muga-Golden silk produced mainly in the Brahmaputra valley of Assam province in NE Region. The golden yellow muga silk of Assam is unique product of India and nowhere in the world is available due to peculiar insect behavioural adaptation and requisite climatic condition (Ahmed and Rajan, 2010). During 2011-12, the contribution of mulberry, muga, eri and tasar silk from north eastern region to respective variety of silk production in India was only 1.08%, 99.81%, 98.23% and 0.38%.

Muga culture has been practiced by about 44,000 families in the different states of north eastern region out of which Brahmaputra valley of Assam is the main production zone and contributes to about 90.55 percent of the India's total muga silk production. Muga production in Assam is mainly concentrated in the districts of Tinsukia, Dibrugarh, Sivasagar, Jorhat, Golaghat, Lakhimpur, Dhemaji, Kokrajhar, Udalguri, Goalpara and Kamrup. It is a continuous chain of several production activities starting from egg production to rearing of *Antheraea assama* West wood (= *Antheraea assamensis* Helfer) in the raised flora by rearers for production of cocoons. These cocoons are utilized by reelers and weavers for production of yarn and fabrics. Earlier, economics from muga culture could not be compared to the income from other agricultural/horticultural crops mainly because the muga farmers used to practice muga culture as an alternative source of livelihood and not as main source. Muga culture is practiced as a seasonal activity and in general farmers take up two to three crops, which involves hardly two to three months of family labour.

Muga food plants are perennial tree and are available in wide range of geographical region. While *Persea bombycina* Kost (Som) and *Litsea polyantha* Juss (Soalu) are predominantly used as the primary food plants for rearing of muga silkworm, *Litsea salicifolia* Roxb. (Dighloti) and *Litsea citrata* Blume (Mejankari) are considered as the secondary food plants. Due to continuous insect-plant interaction in wild, muga silk worms have adopted to different food plants for their survival in different ecological habitats recognizing many more new tertiary food plants such as *Litsea nitida* Roxb. (Kothalua), *Litsea glutinosa* Lour. (Bodokaki), *Cinamomum glanduliferum* Meissn. (Gansarai), *Actinodaphne obovata* Blume (Patihonda), *Actinodaphne angustifolia* Nees. (Baghnala), *Actinodaphne sikimensis* Meissn., *Michelia champaca* Linn. (Champa), *Zizyphus jujuba* Lamk. (Bogori), *Zanthoxylum rhetsa* DC. (Barjamani), *Celastrus monosperma* Roxb. (Bhomloti), *Magnolia sphenocarpa* Wall. (Panchapa), *Gmelia arborea* Linn. (Gumbharee)**,** *Laurus obtustifolia* Roxb (Gamari), *Sarcostemma brevistigma* W & A (Gummari), *Symplocos grandiflora* Wall (Griffith), *Symplococos paniculata* Wall., *Persea duthei* King., *Michelia oblonga* Wall (Phul-sopa), *Persea glaucescens* Nees. (Bondasum), *Plumeria acutifolia* Poiret (Gulnch), *Xanthoxylum armatum* Roxb. (Isamoti), *Phoebe lanceolata* Nees., *Lindera latifolia* HK., *Polyathia siniarum* Benth & HK. etc. (Thangavelu *et al*., 1988; Bindroo *et al*., 2006).

The nutritive value of host plants and their seasonal variability are closely related to that of the silk worm (Yokoyama, 1963). The growth, development and economic characters of silkworms are influenced to a great extent by the nutritional content of the leaf (Krishnaswami *et al.*, 1971; Muthukrishnan and Pandian, 1987; Reddy *el al.*, 1989; Maribashetty *et al*., 1999). The success of muga culture mainly depends on the accessibility of food plant and their leaf nutritional status, as the consequent silkworm rearing on them could result to higher number of cocoons or the cocoons of superior quality in terms of pupation or silk content. Importance of these food plants and their preference on muga silkworm rearing is thus mainly characterized by foliar constituents like moisture, nitrogen, protein, minerals, fat, crude fiber, sugar and starch content etc. Since quality of leaf has got a direct influence on the health, growth and survival of silkworm, selection of the food plants possessing superior nutritive value is of great importance for the healthy development of silkworm and in obtaining quality cocoon crops (Dutta *et al.,* 1997). Inspite of having certain significant variation on foliar constituents of *Persea bombycina* (Som) and *Litsea polyantha* (Soalu), both host plants contribute good nutritional value to muga silkworm resulting better rearing performance and silk content (Yadav and Goswami, 1992). Hazarika *et al.* (1995) found some relationship between soluble protein and total phenol content of Som with the feeding behaviour of muga silkworm. Sharma and Devi (1997) observed that the Som leaves were ideal during autumn while Soalu leaves were suitable in the late spring for rearing the muga silkworm. While analyzing the foliar constituents of different muga host plants, Dutta *et al.* (1997) revealed that with significant low percentage of crude fiber and high amount of total nitrogen, protein, starch and calcium content, Mejankari (*Litsea citrata*) leaves were the best in nutritive value followed by Som and Soalu and Dighloti (*Litsea salicifolia*) occupied last position in this respect. While emphasizing on continuous use of Som and Soalu plants for quality muga cocoon production, Ghose *et al*. (2000) observed that cocoons produced in Mejankari and

Dighloti plants were more lustrous due to higher sericin content in the cocoon shell and in the raw silk. Siddique *et al*. (2000) estimated the biochemical composition of 14 morphovariants of *Persea bombycina* and identified at least 4 high yielding, nutritive as well as palatable and superior variants for sustainable yield and cocoon production. On the basis of number of dependent characters including different nutrient contents, Sinha *et al.* (2000) ranked and identified nutritively superior morphotypes of muga host plant *Machilus bombycina* King. Das *et al*. (2000) identified 8 morphovariants of Som on the basis of different chemical parameters in Assam. Chowdhury *et al.* (2000) studied the effect of the essential oils of *Litsea cubeba* Pers. (=*Litsea citrata* Blume) on rearing performance of muga silkworm and silk quality in Assam. Neog *et al*. (2007) indicated superiority of tetraploid genotypes over diploid plants in terms of rearing performance as well as in content of biochemical constituents and inferred that leaf biochemical constituents have influence on the rearing of muga silkworms.

Sustainable development of muga silk industry depends on production of large quantity of commercial cocoons with their uninterrupted flow from producer to consumer level through enormous product diversification and capacity to resist its vulnerability to rapidly emerging urban industrialization. Success of commercial cocoon productivity of multivoltine muga silk worm in turn is determined by the availability of quality seed cocoons in the pre seed and seed crops and is measured in terms of productivity potential realized from egg layings laid by a particular mother moth which is the most important factor for both commercial and seed rearers in any crop (Chaudhuri, 1999). One of the major factors affecting the muga silk industry is the gap in seed cocoon production as both the seed crops (either pre-seed or seed crop) always fall either in the hot and humid summer or in extreme cold and foggy winter making these crops uncertain. The climatic conditions during the commercial crops should remain within optimum limit (temperature 20-31ºC and relative humidity 65-95%) and has been observed that temperature between 18º-26ºC and a relative humidity between 70-85% shows the best conditions for the commercial rearing (Zamal *et al.*, 2010). However, during last few decades, atmospheric pollution and the resultant variability in temperature and relative humidity due to global warming along with abnormal rainfall pattern, drought and flood has caused continuous failure of the crop or low crop yield in spite of all efforts and utilization of resources. Besides abnormal increase in temperature, the other reasons enlisted for the heavy loss of muga silkworm were air pollution caused by rampant use of pesticides in neighbouring tea gardens, pollution from the bricks kilns and burning of natural gases emitting from oil wells and seismic survey by ONGC for oil exploration (Annonymous, 2010). Being reared in outdoor, muga silk worm may not be able to adjust to the new changing environment (Singh and Maheshwari, 2003) and thus the differential seasonal conditions greatly influence the growth and development of muga silkworm in the form of cocoon weight, pupa weight, shell percentage, potential fecundity, reelability and denier of the silk (Chiang, 1985;

Yadav and Goswami, 1989; Yadav, 2000). In an analytical study conducted on relationship between various parameters of muga silkworm and different environmental factors, Zamal *et al*. (2010) observed that the fecundity, hatching percentage, moth emergence, and cocoon yield have declined with the rise of temperature over the years and the higher trend in temperature attributed for production of a lesser yielding crop. The relation between cocoon weight and shell weight of muga silkworm are significant and that their variations are significantly correlated to geographical area, host plant and environmental conditions during rearing period. While several muga seed farms are established in different places of Assam, the irony of the fact that, the strong scientific reasons of having clear cut demarcation of seed and commercial zone for muga silk worm rearing is not adhered to except for a few ones. Hence, quality muga silkworm seed, which plays vital role in productivity, sustainability and profitability of muga industry, continue to be the main constraint. The seed multiplication in muga sector is an important area, which calls for immediate attention and improvement to reduce the wide gap between the demand and supply of disease free layings (dfls) for commercial cocoon production.

Having suffered from the negative impact of climate change and other anthropogenic reasons, the traditional commercial muga growers of Assam generally visit foot hills as well as higher altitudinal areas of neighbouring hilly states like Meghalaya, Arunachal Pradesh and Nagaland to collect wild, healthy seed cocoons for conducting commercial crop which emphasize that altitudinal effect, climatic variation and host plant preference play a great role in muga cocoon production. Unlike *A. mylitta* which has 34 ecoraces (Thangavelu *et al.*, 1993), *A. assama* is believed to be a single race; however its wild counterpart is found in higher altitudinal areas of Meghalaya, Nagaland and Arunachal Pradesh showing wide range of colour polymorphism and voltinism (Sengupta *et al*., 1975; Goswami *et al*., 1987; Thangavelu *et al*., 1987; Borah *et al*., 1990; Sengupta *et al*., 1995; Sahu and Bindroo, 2007). The topographical and climatic differences among different north eastern states provides enormous opportunities for exploration of wild muga silkworm races which can be used along with the cultivated ones for the improvement of muga silk industry through hybrid vigour and production of disease resistant high yielding variety. While diapause is a rare occurrence in the cultivated population, the wild population enters diapauses in the pupal stage during the winter (Thangavelu *et al.*, 1986). In a bid to induct diapauses through preservation of muga seed cocoon at high altitude, Prasad and Sinha (1982) observed a variation of 12.3% to 83.2% of pupal mortality during May-June exhibiting late emergence after 12 to 16 days. They inferred that preservation of pupae at high altitude in winter season (December-January) was detrimental and pupae of domesticated muga silkworm did not either over winter or diapause at high altitude. Yadav and Sampson (1987) reported that hot and humid climatic condition of Mamit sub division located at an altitude of 2978 m above sea level in Mizoram was quite sustainable for Muga culture. Reddy (1999) reported that even when the seed cocoons/pupae were preserved at low temperatures for longer duration, egg parameters like fecundity, unfertilized eggs and hatchability were adversely affected irrespective of age of pupae and temperature of preservation. Further increase in the duration of preservation led to aging of male moths which was also attributed to less pairing efficiency and less productivity (Haniffa and Thatheyus, 1992). Choudhury *et al*. (1999) while analyzing the muga cocoon productivity in nine locations in Assam, Meghalaya and Arunachal Pradesh, highlighted pronounced effect of altitude, diurnal shift in temperature, variation of humidity and quantum of rainfall and rainy days. Sengupta *et al.* (1995) successfully conducted trial rearing of muga silkworm on *Persea bombycina and Litsea polyantha* in Dehradun, Uttarkhand a cooler place. Khatri (2003) also reported that rearing and grainage performance of muga silkworm during four crops viz, Aherua, jarua, Bhodia and Kotia over a period from 1998-2000 in Doon valleys were found to be better than those done in Assam. Biswas and Roy (2006) studied the effect of environment factors on seed production of muga silkworm in Terai region of West Bengal. Recently, muga culture has been introduced in Cochbehar in the state of West Bengal and Sikkim; however production is yet to reach commercial scale due to many constraints in its cultivation.

Muga silk worm fed with leaves of *Persea bombycina* and *Litsea polyantha* produces golden yellow silk, however when reared on *Litsea citrata*, the secondary host plants produce a kind of silk known as Mejankari silk which is admired for its durability, luster and glossy creamy white shade (Saikia and

Goswami, 1997). At one time, Karbi Anglong, Sivasagar, Jorhat, Golaghat, Dibrugarh and Tinsukia districts of Assam; Tirap and Changlang districts of Arunachal Pradesh; Mokokchung district of Nagaland and Ri-Bhoi district of Meghalaya were abundant with *Litsea citrata* (Mejankari) plantation. However, due to large scale deforestation, recurrence of severe flood, occupations of vast tracts of land by tea industry and Jhum (shifting) cultivation in the hilly states Mejankari trees are depleted now particularly in plains of Assam (Choudhury,2005). Since only the healthy and vigorous larvae have been found to thrive on Mejankari leaves, the worms hatched out of poor quality of muga seed are unable to survive on this tree (Choudhury, 1981).

Nagaland lies at varying altitude from 199 to 3048 m above mean sea level. The topography of the state is characteristically hilly, which is instrumental in shaping the cool and pleasant climatic conditions. Various factors like the altitude, geographical coordinates, distance from the sea and the wind direction influence the climate in Nagaland. Preliminary studies in Nagaland have ascertained that, rearing of cultivated variety of muga silkworm is comparatively new and conducted on Som (primary host plant) in certain government farm, however, the natural plantation of Mejankari food plant available in Mokokchung, Wokha and Tuensang district has not been used for muga silk worm rearing (Kakati and Chutia, 2009). Blessed with serene, isolated pollution free natural environment Nagaland also provides an exclusive niche for wild counterpart of *Antheraea assamensis,* the rearing potentiality of which is not yet evaluated

(Kakati, 2006). Further, the soil quality has an influence both on yield as well as quality of leaves which in turn influences the growth of silkworm as well as the quantity and quality of cocoons produced by them (Mahobia *et al*., 2003). Thus, muga culture in Nagaland has ample scope for the development because of the locational characteristics and climatic parameters of the state. It is often suggested to conduct rearing of summer crop in cold climate (at high altitude) as mortality and flies, wasps etc. are more during summer in hot places and will also provide hill amelioration to the worms. In this context, a separate rearing schedule and technology for muga crops per year has to be standardized to suitably adjust the local conditions so that the crucial gap between demand and production of seed cocoons during pre-seed and seed crops could be reduced by taking up seed crop rearing in certain area of Nagaland to cater the requirement for each commercial crop in Assam. While certain studies have been reported on rearing performance and host plant preference on Som, Soalu, Dighloti, Mejankari and Gonsoroi from Assam (Barah *et al*., 1992; Saikia and Goswami, 1997; Gogoi and Goswami, 1998) and also from other part of India (Jaya Prakash *et al*., 2004; Khatri *et al*., 2004), no detailed study has been undertaken on comparative analysis on altitudinal effect and host plant preference of growth and production of *A. assama*. Hence a comparative and systematic study on *A. assama* is undertaken on three host plants in two locations at North Lakhimpur, Assam (low altitude) and Mokokchung, Nagaland (High altitude) for two consecutive years with the following objectives:

1. Analysis of physico-chemical characteristics of soil and food plants in low and high altitude
2. Seasonal and altitudinal variation on morphometric characteristics of *A. assama* on three host plants
3. Seasonal variation on rearing performance of *A. assama* with reference to three host plants : Som (both locations), Soalu (Low altitude) and Mejankari (high altitude)
4. Comparative rearing performance of cultivated and wild population of *A. assama* on Som and Mejankari in high altitude
5. Comparative analysis of altitudinal effect on growth, life cycle and production parameters of *A. assama* (cultivated population)
6. Comparative analysis of host plant effect with reference to Som and Soalu in low altitude (cultivated population) and Som and Mejankari in high altitude on growth, life cycle and production parameters of *A. assama* (both cultivated and wild population).

CHAPTER II

DESCRIPTION OF STUDY SITES CLIMATE AND HOST PLANTS

The present study was carried out in two locations of different altitude i.e. Ungma of Mokokchung (Mokokchung district) in Nagaland at higher altitude (1325m amsl) and Japisajia of North Lakhimpur (Lakhimpur district) in Assam at lower altitude 135m amsl) **(Fig. 1).** Rearing of *Antheraea assama* Westwood (Muga silkworm) was conducted simultaneously in three different seasons i.e. spring (April-June), summer (July-September) and autumn (October-December) on three host plants namely *Persea bombycina* Kost (Som), *Litsea polyantha* Juss (Soalu) and *Litsea citrata* Blume (Mejankari). *Persea bombycina* (Som) was common to both places, whereas *Litsea polyantha* (Soalu), the another primary host plant was utilized in lower altitude and *Litsea citrata* (Mejankari), the important secondary host plant which grows abundantly in Nagaland was used in higher altitude. The details of study sites, climate and host plants of both locations are described below

Biogeography and Climate of Nagaland (*Higher Altitude*)

Nagaland is largely a mountainous state rising from the Brahmaputra Valley in Assam to about 2,000 feet (610 m) and rise further to the southeast, as high as 6,000 feet (1,800 m). Mount Saramati at an elevation of 12,552 feet (3,826 m) is the state's highest peak; this is where the Naga Hills merge with the Patkai Range in Burma. The state is dissected by a number of perennial and seasonal rivers. Physically the state of Nagaland is roughly triangular in shape, having an area of 16,579 km^2. It is one of the eight states of North Eastern Region

(NER) of India, sharing an international border with the adjacent country of Myanmar on the extreme south east. The state lies between $25^o60'$ N and $27^o40'$ N latitudes and between $95^o20'$ E and $95^o15'$ E longitudes. Nagaland is bounded by the states of Arunachal Pradesh on the North, Manipur on the South, Myanmar (Burma) on the East and Assam on the West **(Fig. 2 a).**

The hilly terrain of Nagaland is instrumental in shaping the cool and pleasant climatic conditions. The altitude varies from 199 to 3841 m above mean sea level. The climate is an important component in the study of the geography of Nagaland state. Various factors like the altitude, geographical coordinates, distance from the sea and the wind direction influence the climate in Nagaland. It is generally cool in winter and warm in summer especially in the interior places and high hills. The cold season begins in December and continues till the end of February. The temperature drops as low as of 5^oC with the maximum average temperature of 20^o C in winter. Chilled cold and dry weather strikes certain regions of the state. The temperature during the summer season remains between the 12^o C and 31^o C. The torrential monsoon downpour continues nonstop during the months of June to September. Heavy rainfall occurs between the months of May and August. September and October months influence occasional showers. The recorded average annual rainfall of the state ranges from 2000 mm to 2500 mm. The period of October and November is treated as the cool and dry season as this period is neither too hot nor too cold. February and March are the windiest months in the year. At times high winds blow almost throughout the day and night. The wind generally blows from south-west and at times its velocity rises up to 100 kilometers per hour. The wind dies out by March or April. Then the monsoon sets in from the months of May and continues till September. The higher altitudes are enveloped in snow.

The forest cover in the state is about 52% (8, 62,930 ha including 1,00,823 ha of government and 7,62,107 ha of private forests) of the total geographical area of 16,57,583 ha. Out of the total forest cover 55.4% is virgin forest, 32.9% is degraded forest and the rest of 11.7% belongs to other category. Despite being a small state, it possesses variety of forest types like tropical wet evergreen forests, tropical semi evergreen forests and sub-tropical broad-leaf wet hill forests distributed throughout the state **(Fig. 2 b).**

As far as sericulture is concerned, it may play an important role in socioeconomic upliftment and forest conservation in Nagaland **(Fig. 3).** Eri culture has been practiced since time immemorial by different tribes and sub tribes in both the plains and the hills of Nagaland. It is mainly done domestically for eri pupae consumption since the pupae have a high protein value and also yield oil. The silk layer is used for production of spun yarn. While rearing of mulberry silk worm is also practiced in different part of the state, muga culture is comparatively new to the state and yet to get its commercial rearing status.

<u>Description of study site and climate (Mokokchung, Nagaland)</u>

Study site and Climate: Mokokchung district which lies at $26^{o}17$'-$26^{o}39$' N latitude and $94^{o}18$'-$94^{o}37$' E longitude covers an area of 1615 Km^{2} and has an altitude of 1325 m above mean sea level (amsl). The area is generally undulating and hilly with alluvial, non-laterite, sandy loam forest soil. The rearing sites in the present investigation are located in Govt. Sericulture farm and Sanglimongba natural Mejankari plantation area of Ungma in Mokokchung district **(Fig. 4 a & b).** The ombrothermic data based on twenty years (1989 – 2008) highlights the climatic condition of Mokokchung district **(Fig. 5 a).** According to the prevailing weather conditions, the year in Nagaland may be divided in to four distinct seasons. They are, cold season (winter: December-February), hot season (pre-monsoon: March-May), rainy season (monsoon: June-September) and cool dry season (retreating monsoon: October-November). Climate is humid sub-tropical to warm temperature. The mean annual rainfall was 2600 mm with prolong rainy period from May to October. The temperature ranged from 12^{o}C to 32^{o}C in summer and 5^{o}C to 20^{o}C in winter and average humidity varies from 67% to 88%.

Climate during study period: The meteorological data during the study period (2007-2008) is shown in **Fig. 6 a.** The average minimum and maximum air temperature ranged from 8.0˚C (January and December) to 32.0˚C (August) respectively. The maximum relative humidity was recorded in the month August (90.1%) and minimum in the month of February (40.5%). While maximum annual rainfall was recorded in the month of July (496.0 mm), minimum was recorded during January (3.88 mm). The total annual rainfall of 2069.14 mm was distributed in 166 days during study period.

Biogeography and Climate of Assam ***(Lower Altitude)***

The location of Assam within the rain shadow zone lies between 26°30' N and 29°30' N latitude and between 91°30' E and 97°30' E longitude at an average altitude of 135 m above mean sea level (amsl). Assam is bordered in the North and East by the Kingdom of Bhutan and Arunachal Pradesh. Along the south lie Nagaland, Manipur and Mizoram. Meghalaya lies to her South-West, Bengal and Bangladesh to her West. Assam is connected with the rest of the Indian Union by a narrow corridor in West Bengal that runs for 56 km below the foothills of Bhutan and Sikkim **(Fig. 7 a)**. The dominant factors that control the climate of Assam particularly of Brahmaputra valley are (1) orography, (2) the alternative pressure cells of North-West India and Bay of Bengal (3) the dominant maritime tropical air mass (4) periodic western disturbances and (5) local mountain and valley winds. Besides these, the subtropical location, extensive water bodies, local depressions, elevations and extensive forests play important role for shaping veritable weather conditions of Assam **(Fig.7 b).**

The climate of Assam is depicted by its persistent high humidity mostly influenced by rainy season and moderate temperature throughout the year. Its most distinguishing feature is the abundant rainfall between March and May at a time when rain in upper India is at its minimum. By climate wise the year in Assam can be divided broadly into the wet (March to September) and cool dry season (October to February) period. The southwest monsoon begins in Assam from middle of June. The wet period can be further divided into spring or pre monsoon, summer or monsoon and retreating monsoon seasons. The cool dry season can be divided in to autumn and winter seasons. March constitutes the transitional month between winter and summer whereas October is the transitional month between rainy and winter season. From overall consideration of geographic, geologic, topographic and ecological climatic constituents of Assam, it can be very well said that Assam represents an ideal sub-tropical climate with some self regulating mechanism independent of itself like occasional winter rain, summer drought etc. This type of peculiar climate of Assam is found to be suitable for muga silk worm (*Antheraea assama*) as the state presents with a great number of naturally available and palatable food plants spread over sub-hills and plain areas **(Fig.8).**

Description of study site and climate (North Lakhimpur, Assam)

Study site and Climate: Lakhimpur district is located in north-east corner of Assam at $26^o48'$-$27^o53'$ N latitude and $93^o42'$-$94^o20'$ E longitude covering 2953 Km^2 at an altitude of 135 m amsl. The district falls in humid sub-tropical regions. Tropical rain forest, reeds, grasses and Bamboos are major natural forests available in the district. A strip of reserve forest is situated in northern part. Mixed deciduous and mixed evergreen forest is scattered all over the district but mainly concentrated at the foot hills. The eastern part of the district is conspicuous with presence of naturally grown Som (*Persea bombycina*) and Soalu (*Litsea polyantha*) plantation, the primary food plants of muga silkworm.

The rearing experiment was conducted on systematic plantation of Som and Soalu located adjacent to each other in Japisajia of Lakhimpur district of Assam **(Fig. 9 a & b).** The ombrothermic data based on twenty years (1989 – 2008) highlights the climatic condition of Lakhimpur district **(Fig. 5 b).** The average maximum atmospheric temperature of Assam was 31.94^{o} C in the month of August. The month of January was happened to be the coldest month of the year with the record of mean minimum environmental temperature of 9.38^{o} C. The average relative humidity was recorded maximum during July (89.16%) and minimum in November (73.16%). The mean annual rainfall for the last 20 years was 3158.54 mm with minimum (14.93 mm) and maximum (616.13 mm) during December and July respectively.

Climate during study period: The meteorological data during the study period (2007-2008) is shown in **Fig. 6 b.** The average minimum and maximum air temperature was recorded in the month January (12.8˚C) and June (35.0˚C) respectively. The maximum relative humidity was recorded in the month November (95.0%) and minimum in the month of December (48.0%). While maximum rainfall was recorded in the month of August (527.5 mm), there was no rainfall during February, March and December during the study period. The total annual rainfall of 2464.5 mm received in 86 days only.

Climatic variation between Higher and Lower altitude during study period

Table 1 highlights comparative seasonal climatic variation between North Lakhimpur and Mokokchung during study period. While variation was not much evident in mean maximum temperature during different rearing seasons (0.5^0C in spring to 1.8^0C in autumn), mean minimum temperature was considerably variable in all seasons (5.3^0C in summer to 8.3^0C in autumn) between Mokokchung and North Lakhimpur. The minimum temperature during autumn season particularly in Mokokchung was due to lowest temperature recorded in December. Further, the range of maximum and minimum temperature in all seasons was higher in Mokokchung (higher altitude) than North Lakhimpur (lower altitude) indicating colder climatic regime on the former.

Persistent high humidity in North Lakhimpur than Mokokchung was mostly influenced by high rainfall and moderately high temperature throughout the year particularly between March and September. The difference of maximum and minimum relative humidity in all seasons was higher in Mokokchung (27.8% in summer to 39.8% in spring) than North Lakhimpur (9.2 % in summer to 30.7% in autumn). Exceptionally high minimum relative humidity in North Lakhimpur during summer season might be due to high rainfall. While relative humidity was recorded to be higher in North Lakhimpur than Mokokchung, mean maximum relative humidity was less variable than mean minimum relative humidity between the two sites in respective seasons.

Both locations in lower and higher altitude represented an ideal sub-tropical climate, however, Lakhimpur district of Assam exhibited certain self regulating mechanisms of occasional winter rain and summer drought while Mokokchung district witnessed prolong winter. The mean annual rainfall for last 20 years in Mokokchung (2600 mm with prolong rainy season from May to October) was lower than North Lakhimpur (3158.54 mm having maximum downpours from June to September) **(Fig. 5 a & b).** Maximum and minimum rainfall in Mokokchung district was recorded in the month of July (496.0 mm) and January (3.88 mm) respectively. In Lakhimpur district of Assam, maximum rainfall was recorded in the month of August (527.5 mm), however, there was no rainfall during February, March and December during the study period **(Fig. 6 a & b)**. It was interesting to note that, the total annual rainfall of 2069.14 mm in Mokokchung district was distributed in 166 days in comparison to higher rainfall of 2464.5 mm in North Lakhimpur which was received in 86 days only. Comparison of seasonal variation of rainfall received per day vs. rainy days per month also revealed similar pattern having a record of maximum rain fall in summer season and minimum in autumn season in both locations.

Table 1: Mean seasonal meteorological data at North Lakhimpur (NLP) and Mokokchung (MKG) during study period

Season	Loc-ation	Parameter and value					
		Temp.^{0}C		R.H. (%)		Rainfall/ day (mm)	Rainy days/month
		Max.	Min.	Max.	Min.		
Spring (S I) (Apr-Jun)	NLP	31.1±4.4	23.4±3.6	91.3±2.4	64.4±8.1	8.9±5.0	8.7±3.8
	MKG	30.6±0.6	15.7±2.4	89.1±0.5	49.3±7.5	7.7±0.5	21.3±3.2
Summer(S II) (Jul-Sep)	NLP	32.2±0.7	25.0±1.5	91.0±3.3	81.8±0.8	15.1±3.2	15.0±5.0
	MKG	31.3±0.8	19.7±0.5	88.9±1.3	61.1±5.4	11.8±3.7	22.7±1.5
Autumn (S III) (Oct-Dec)	NLP	26.1±4.6	18.8±5.0	90.5±5.6	59.8±11.0	2.9±2.6	4.7±4.2
	MKG	24.3±3.3	10.5±2.8	87.1±0.2	51.8±2.8	2.6±3.0	8.3±9.3

HOST PLANTS

Persea bombycina Kost (Som)

Persea bombycina Kost is primary food plant of muga silk worm for commercial cocoon production **(Fig. 10 a & b).** The tree is naturally distributed in north eastern region of India, particularly in Assam but more abundant in the eastern region. The cocoons produced in Som are golden brown in colour. Hooker (1890) described *P. bombycina* (family lauraceae, sub-class Apetalae or monochlamydeae or dicotyledon) as a middle-sized, erect, evergreen species attaining a height of 24 meters. The bark is round and branches gray-spreading slender. Young shoots are covered with simple straight hairs. Size and shape of leaf are variable in breadth and thickness. They are alternate. The upper surface is almost hairless, lower one is slightly silky and hairy along with mid-rib stipulate. There are 6 to 10 pairs of lateral nerves. The tip is almost tapering and the buds are covered by scales. Sixteen ecotypes of Som are described of which only four eco-types namely Ampatiya, Azarpatiya, Jampatiya and Naharpatiya are preferred by muga silk worm. Das *et al.* (2000) identified fourteen genotypes of Som. The

Som tree having light brownish colour with an agreeable taste is considered suitable for muga rearing. Gogoi *et al*. (2006) grouped all the available Som genotypes into eight genotypes and termed as S1 to S8 of which tetraploid plants of four genotypes *viz*. S-3, S-4, S-5 and S-6 were developed through colchicines treatment.

Litsea polyantha **Juss (Soalu)**

Litsea polyantha Juss is an erect, non-deciduous tree, attaining a height of about 20-21 meters when fully grown **(Fig. 11 a & b)** and is distributed sporadically in the whole north eastern region of India but more abundantly found in lower Assam. Propagation of tree is done either by seed or by cutting of twigs. Soalu belongs to family Lauraceae, sub-class Apetalae. The bark is rough and brown. Branches are stout; Leaves are alternate, pubescent and downy with prominent nerves beneath, glabrous above. Leaf size is variable-oblong ovate with 3 to 16 cm long and 1 to 9 cm broad. The soalu fed silkworm produces dark golden brown colour cocoon. Among the three eco-types available, the one with oval leaf in cluster is the best for silkworm rearing (Chowdhury, 1965). Ten genotypes of Soalu have been identified (Das *et al*., 2000).

Litsea citrata **Blume (Mejankari)**

Mejankari is an erect, delicate and evergreen species - attaining a height of about 12 meters when fully grown **(Fig. 12 a & b).** It grows well in shady environment and prefers an elevated sloppy ground. It perishes in water-logged area and therefore requires a good drainage. It cannot stand strong sun and heavy rainfall. A tree withers if the surface roots are disturbed and susceptible to a type of bacterial disease (Chowdhury, 1981). The tree has a pleasant fragrance. Young shoots are silky, otherwise entirely glabrous. Dried up branches and leaves are black. The stem is green in an immature tree. The branches are fragile. The leaf is tapering and sticky when crushed (Rox burgh, 1874).

The tree is distributed in sub-montane areas of eastern Himalayas covering Sikkim to Mishmy hills (Arunachal Pradesh), Assam, Meghalaya and Nagaland up to an altitude of 6000 ft amsl (Bindroo *et al*., 2006). The distribution in plains is sparse. Propagation of seed is by bird droppings. For a plantation, the seed has to be softened for good germination (Kanjilal *et al.,* 1934). Hooker (1890) and Brandes (1971) described the species as having membranous leaves from 10 cm to 18 cm long. They are lanceolate, bright green above, dull and glaucous beneath. There are 4 to 7 slender petioles. Flowers are enclosed in four membranous bracts, ciliate at the edge. Four to six flowers are found on each head. An aromatic perfume can be extracted from the leaf and the seed of a Mejankari tree.

Muga silk worm fed on *Litsea citrata* produces a kind of silk known as Mejankari silk which is admired for its durability, luster and creamy white shade. At one time, certain tracts of Upper Assam were abundant with Mejankari plantation and cocoons were used to be harvested from natural population like Tasar silk worm for production of this silk. Due to large scale deforestation, recurrence of severe flood, occupation of vast tracts of land by tea industry, Mejankari trees are depleted and becoming rare in plains of Assam (Choudhury, 2005), however it is still naturally grown abundantly in the neighboring hilly state of Nagaland. In Nagaland, natural vegetation of mejankari is mainly distributed in Mokokchung, wokha and Tuensang district (Kakati and Chutia, 2009).

(a)

(b)

Fig.1 Map of India (a) and North Eastern Region showing location of Nagaland and Assam (b)

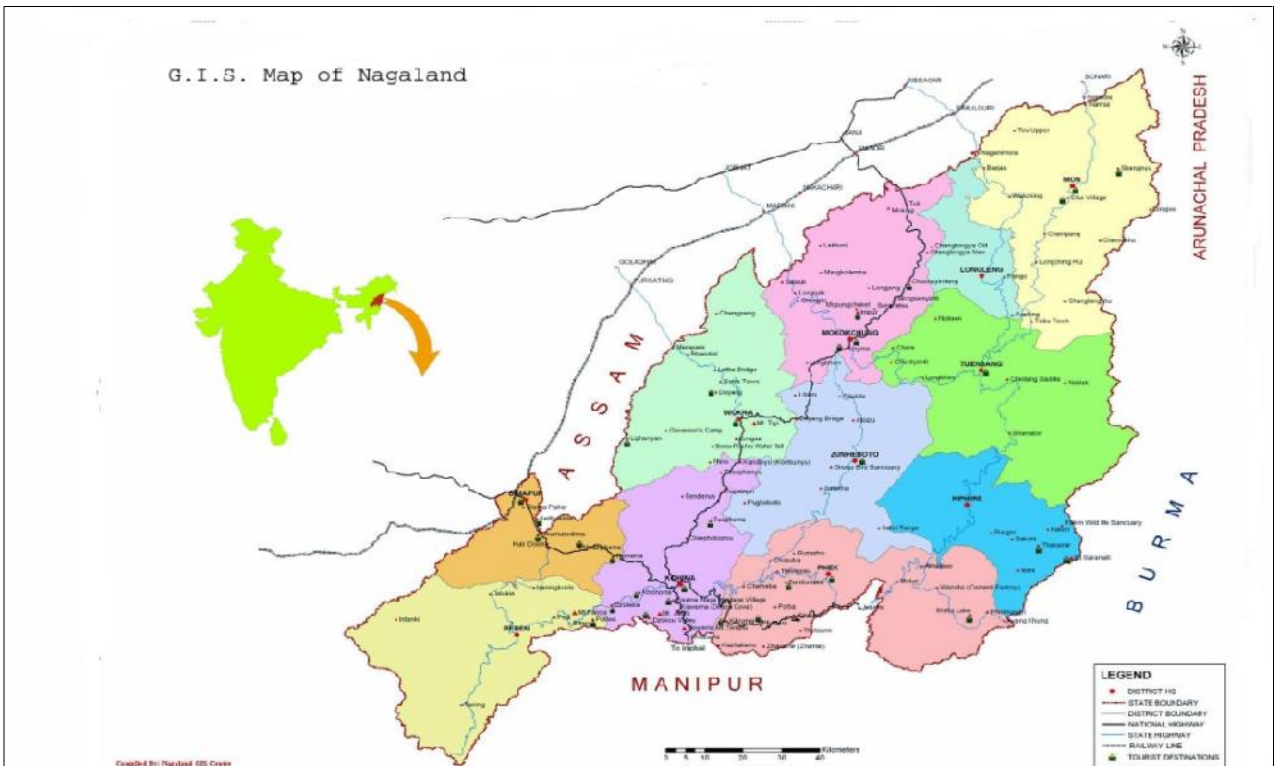


Fig.2 a Map of Nagaland State

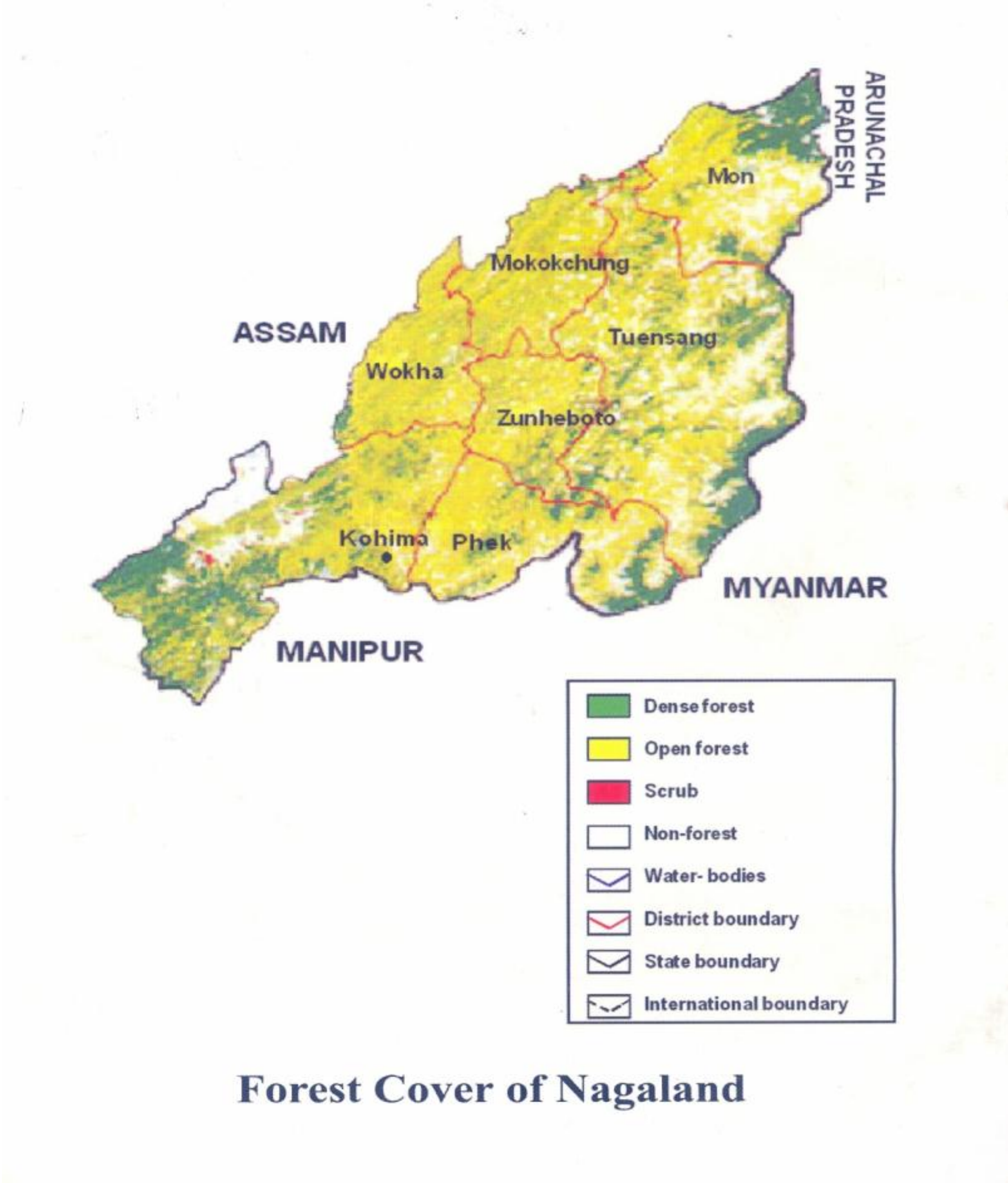


Fig.2 b Forest covers of Nagaland

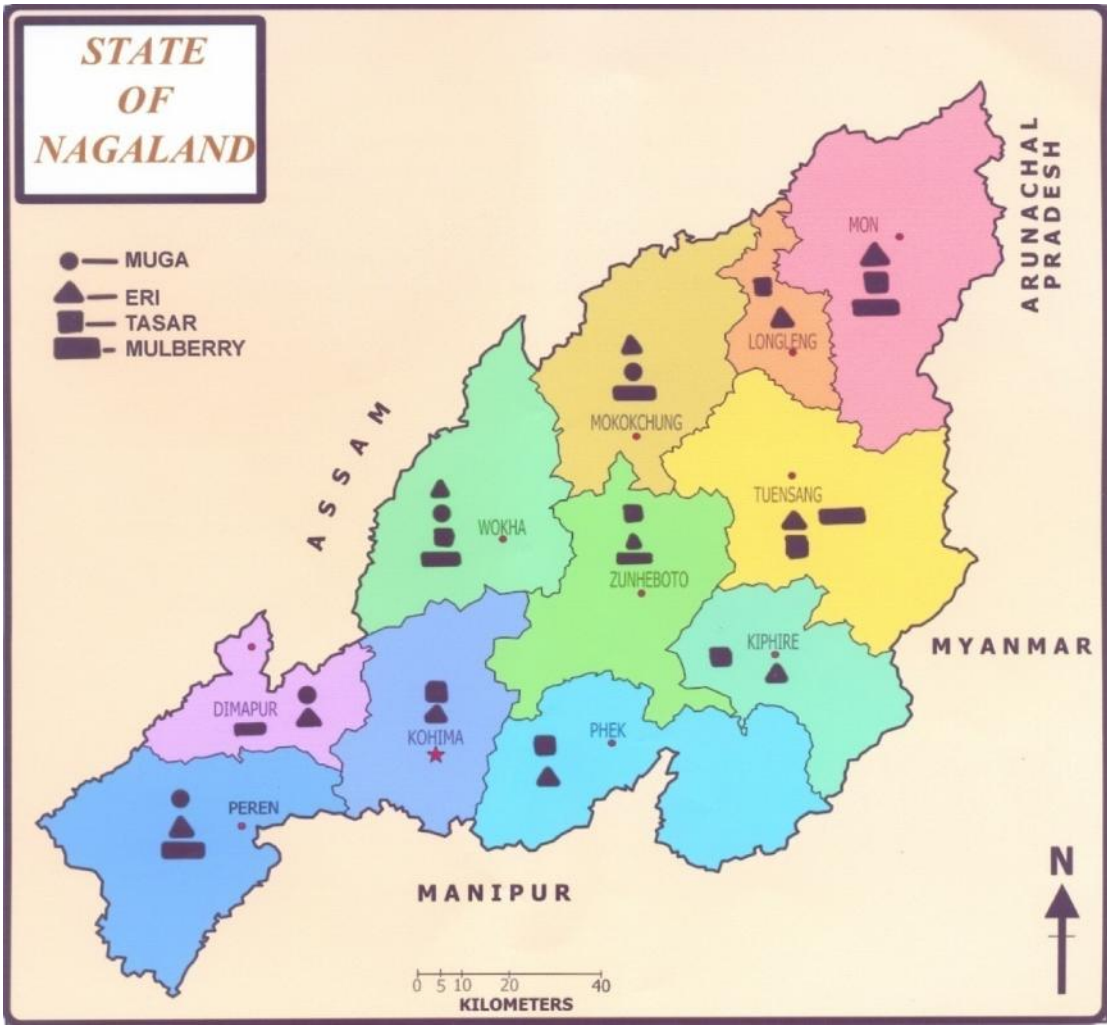
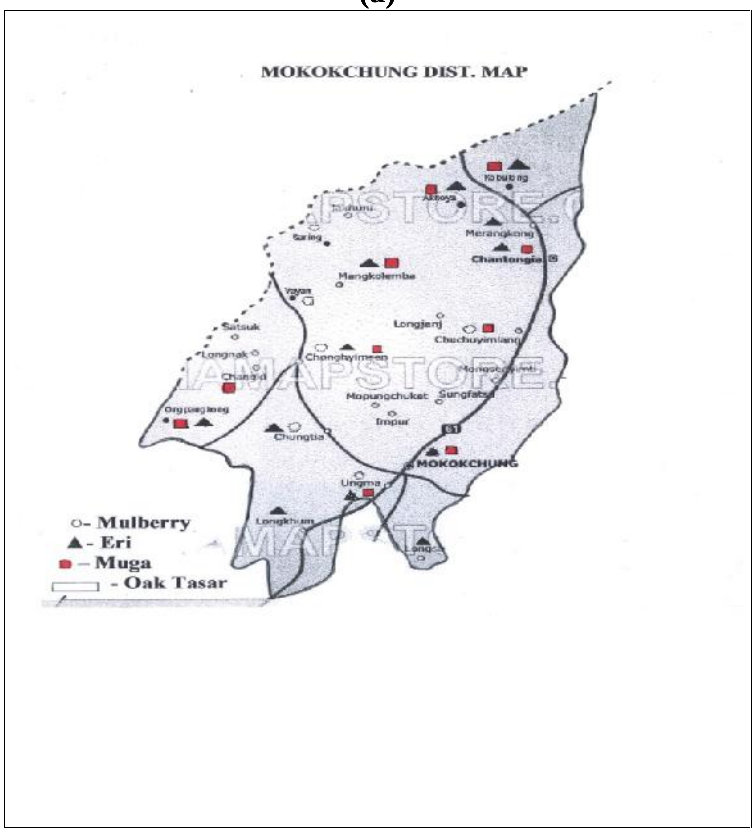


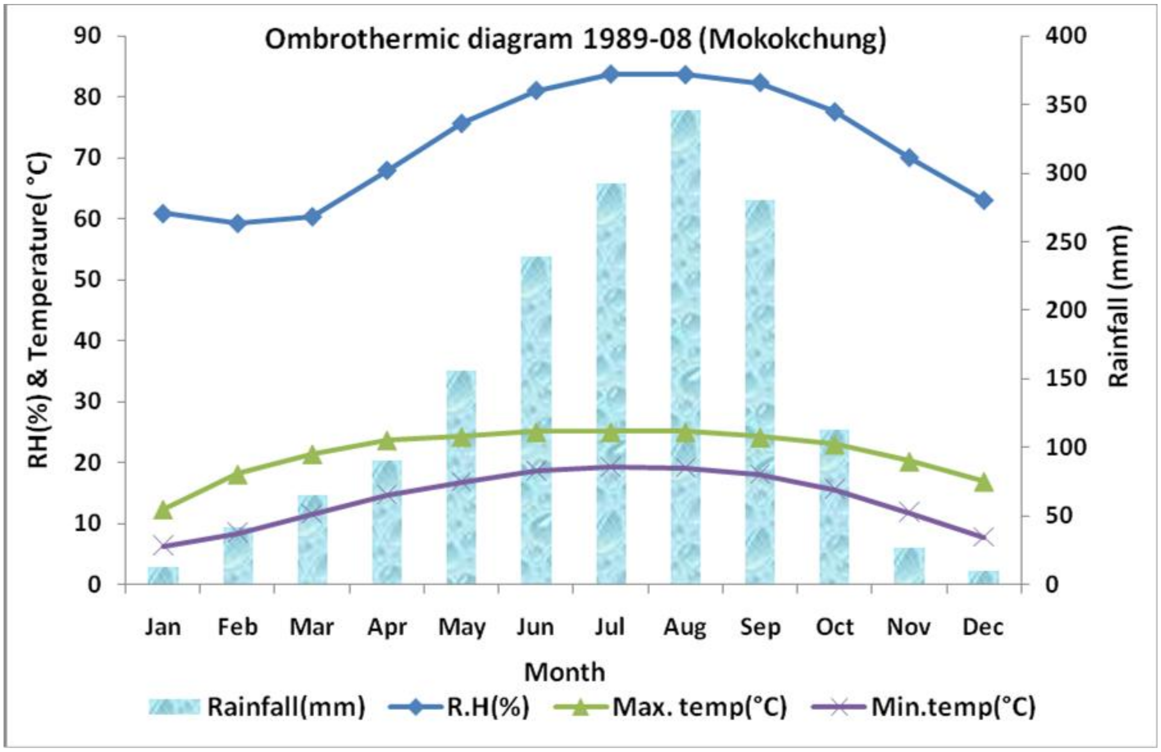
Fig. 3 Sericulture map of Nagaland

(a)

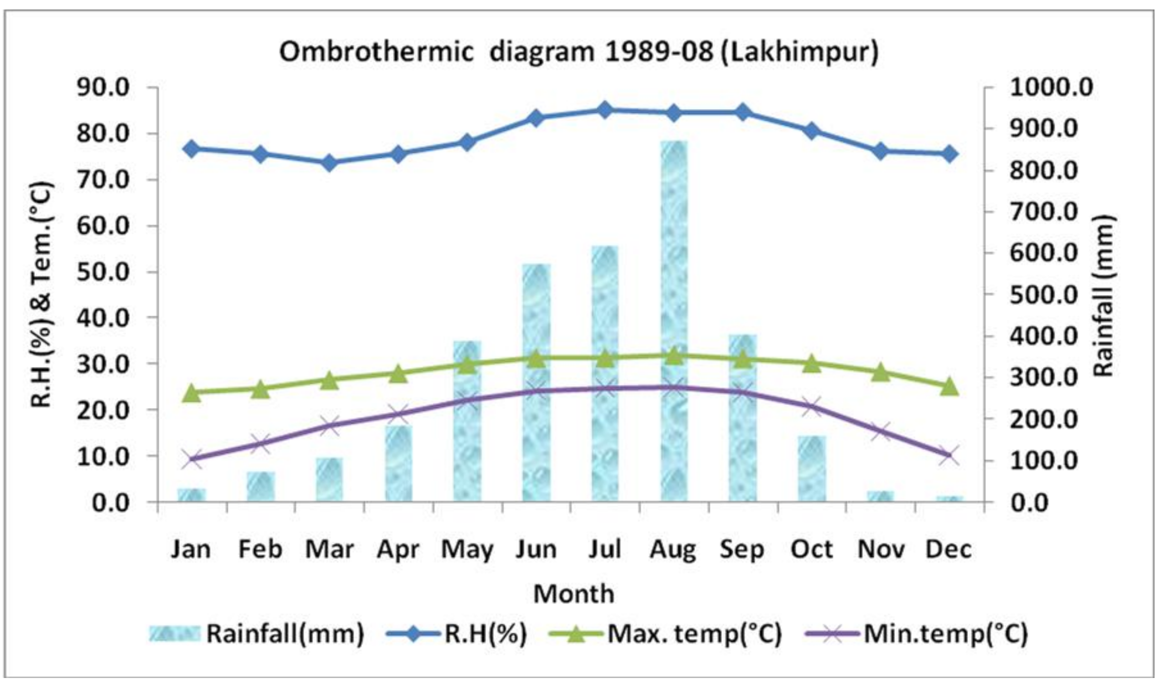


(b)

Fig. 4 Mokokchung district map (a) general (b) highlighting sericulture locations

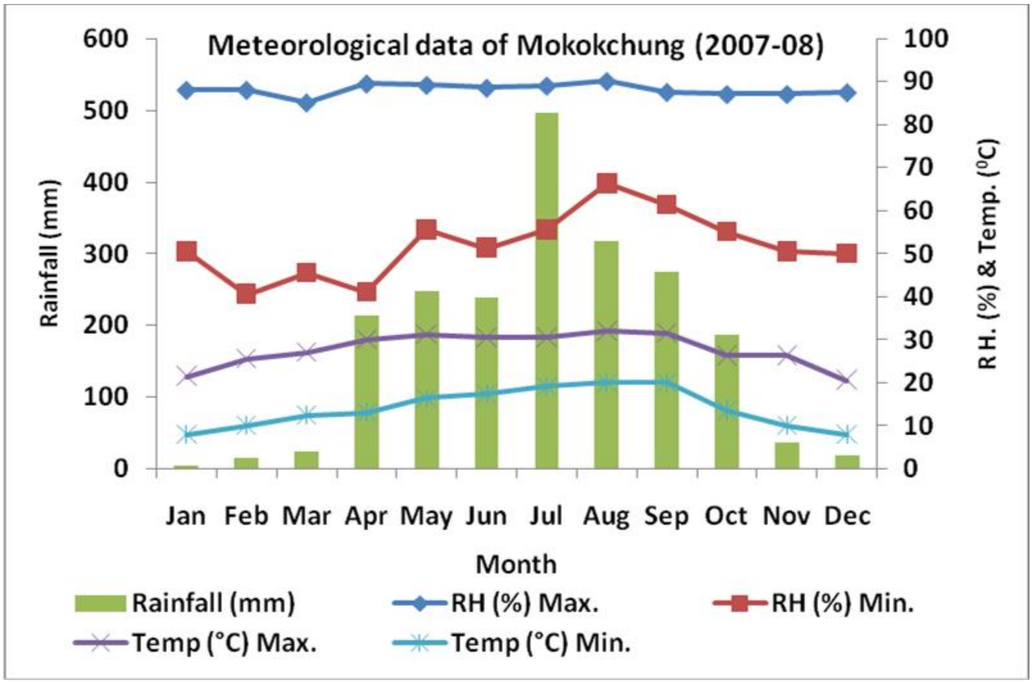


(a)

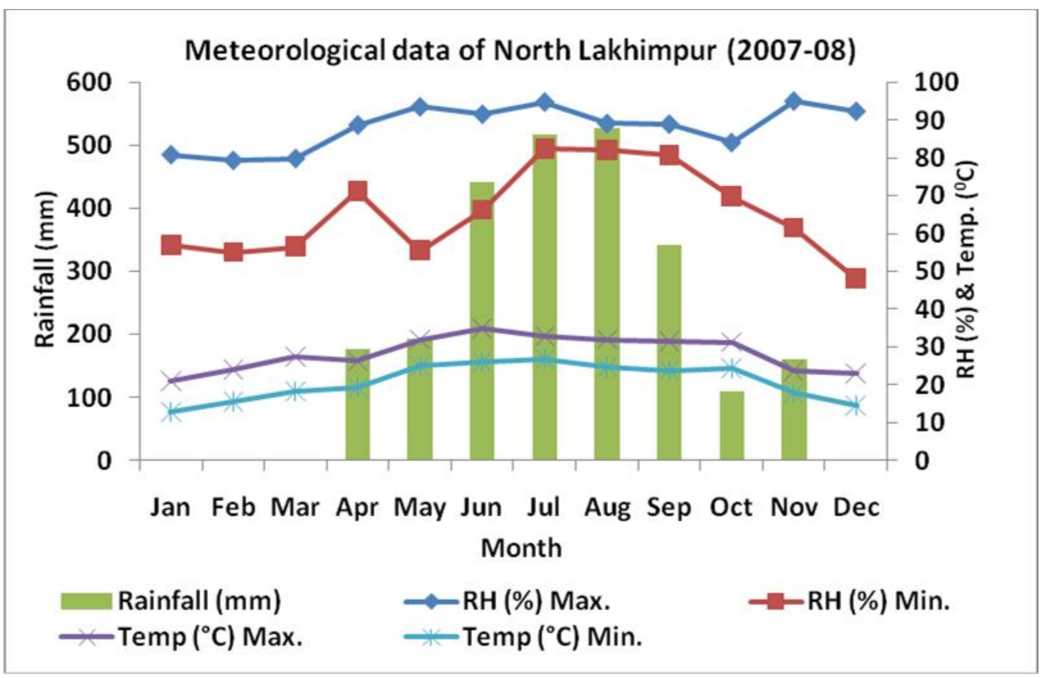


(b)

Fig. 5: Ombrothermic diagram of (a) Mokokchung and (b) Lakhimpur based on twenty years (1989 – 2008)



(a)



(b)

Fig. 6: Meteorological data of (a) Mokokchung and (b) North Lakhimpur during study period (2007-2008)

Fig.7 a Map of Assam State

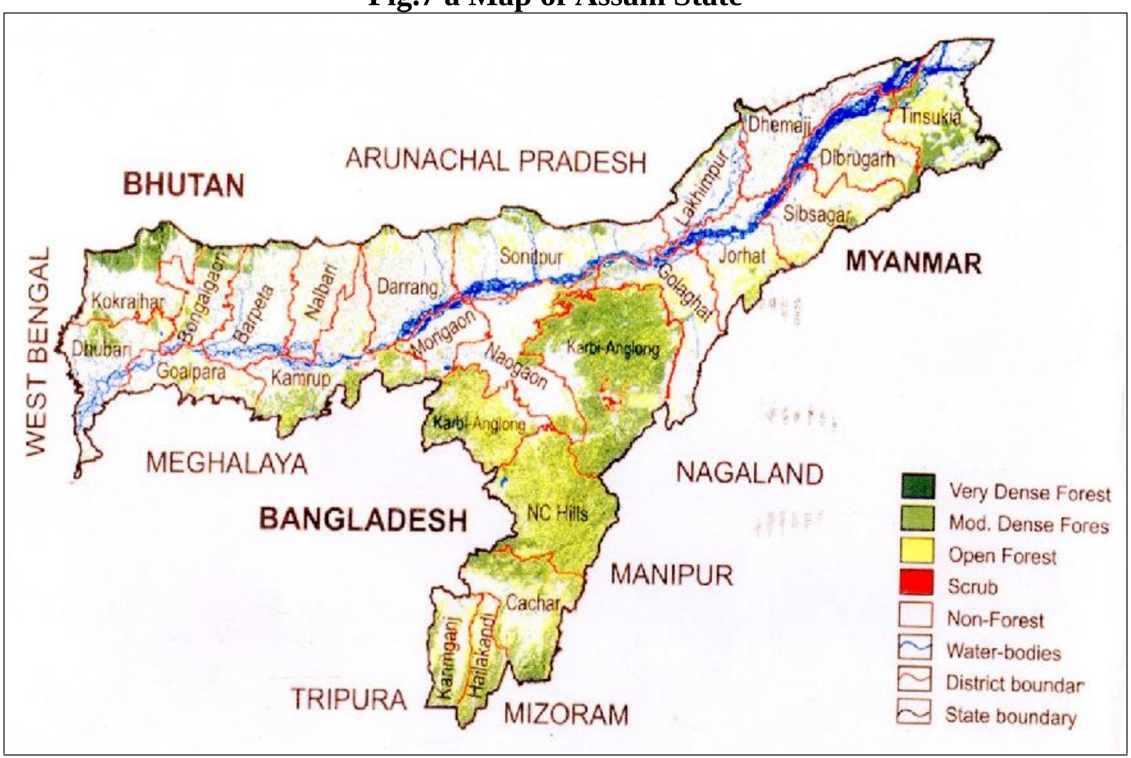


Fig. 7 b Forest cover of Assam

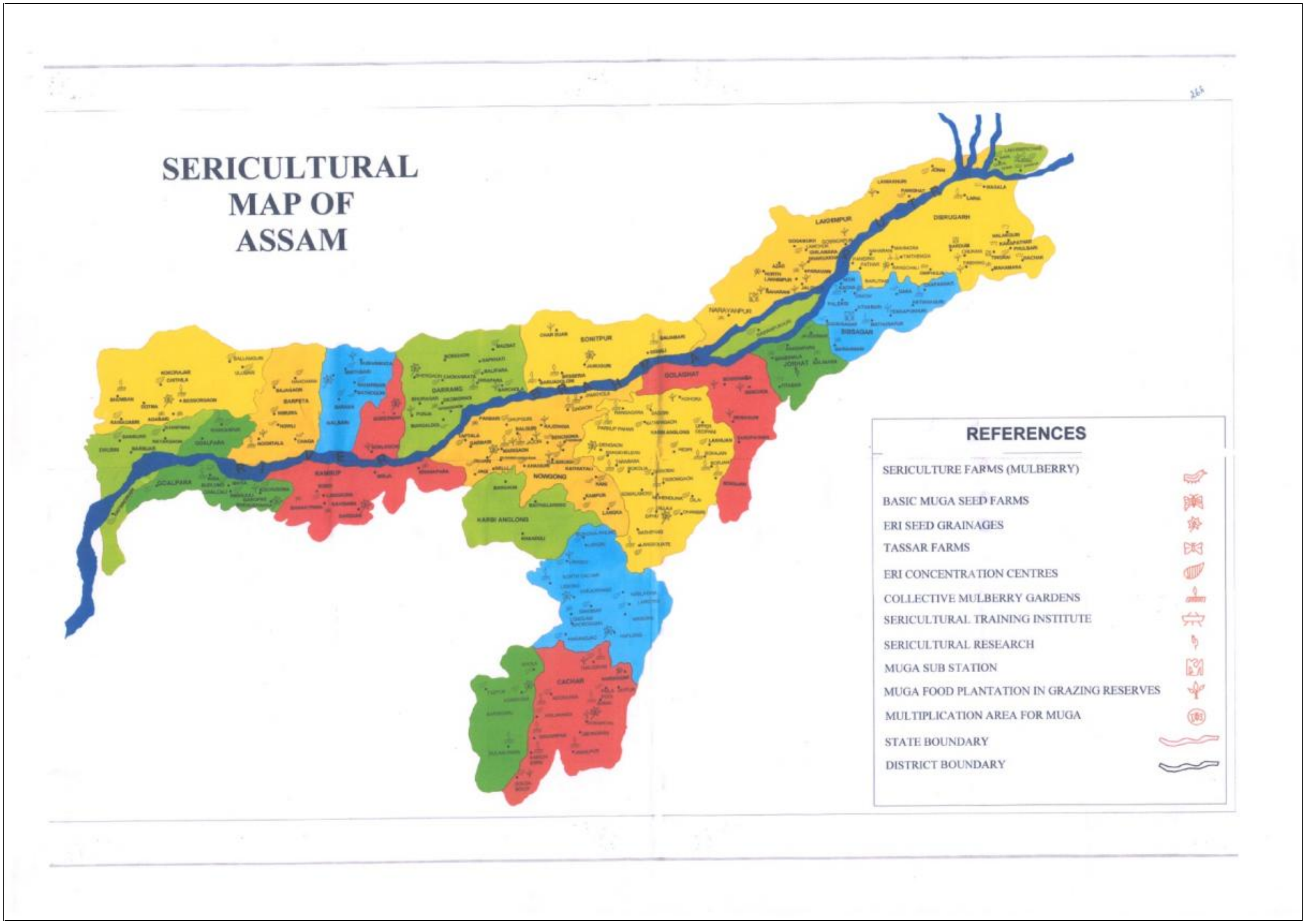
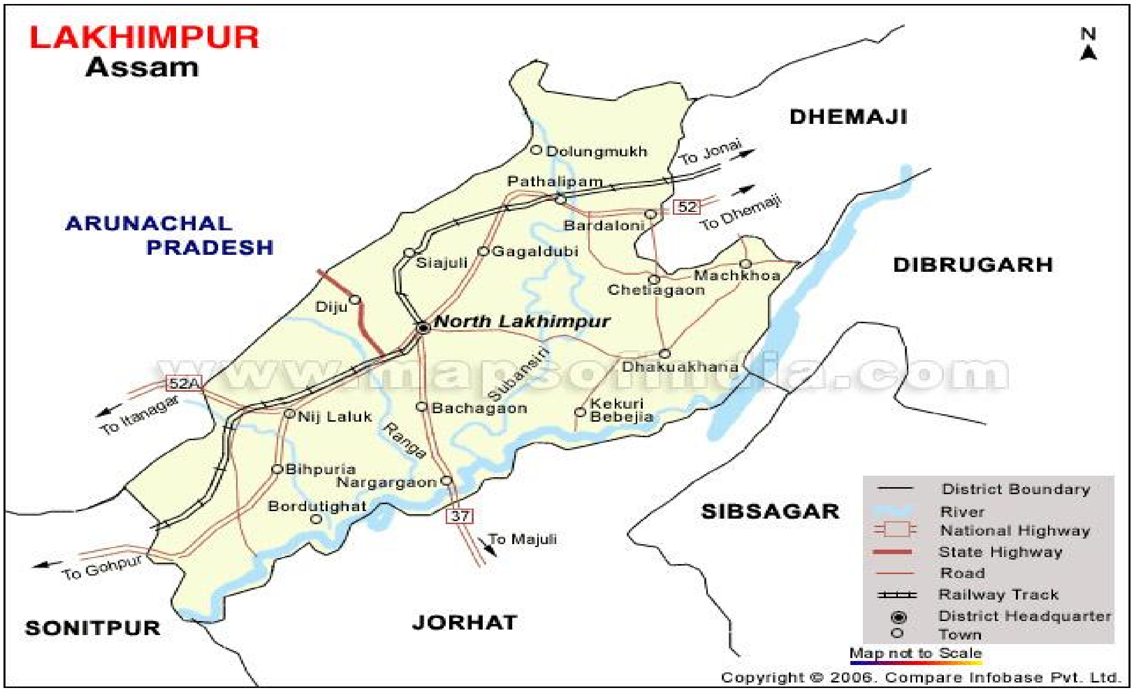
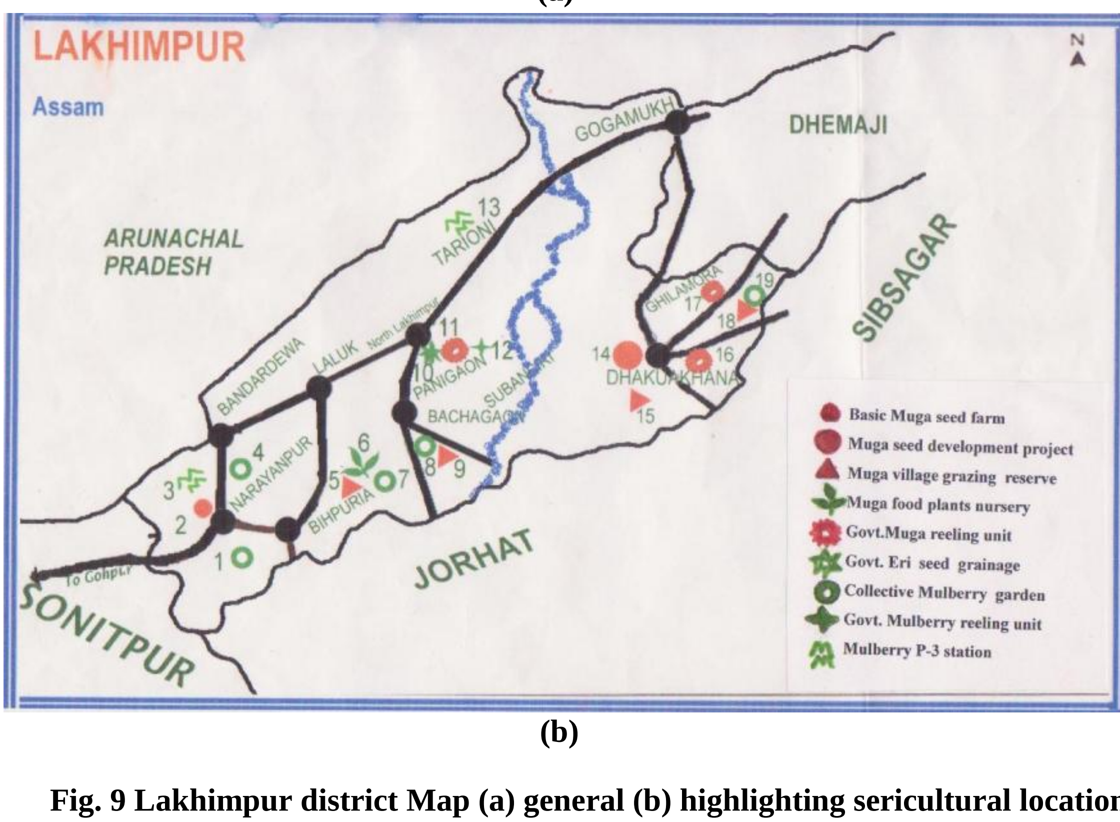


Fig.8 Sericultural map of Assam

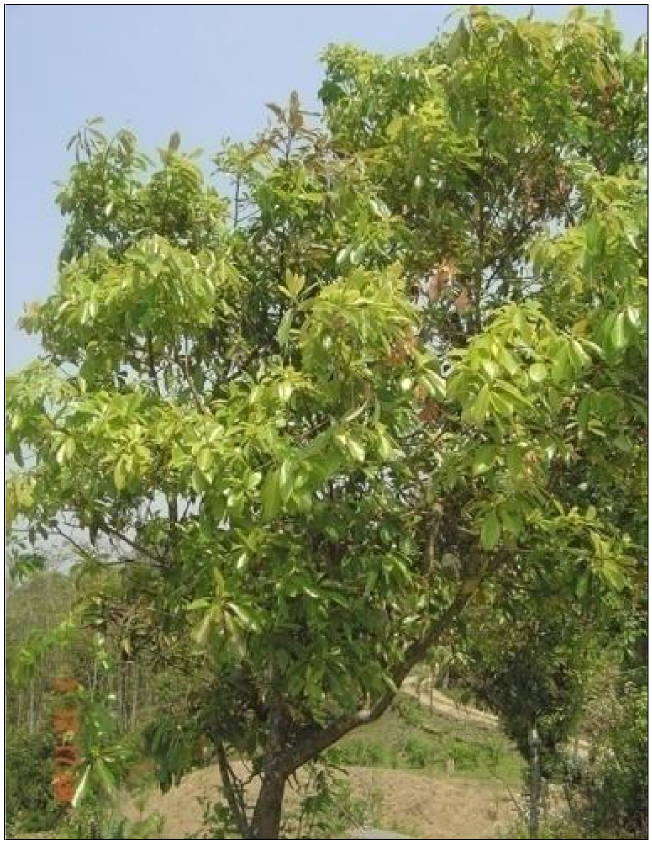


(a)



(b)

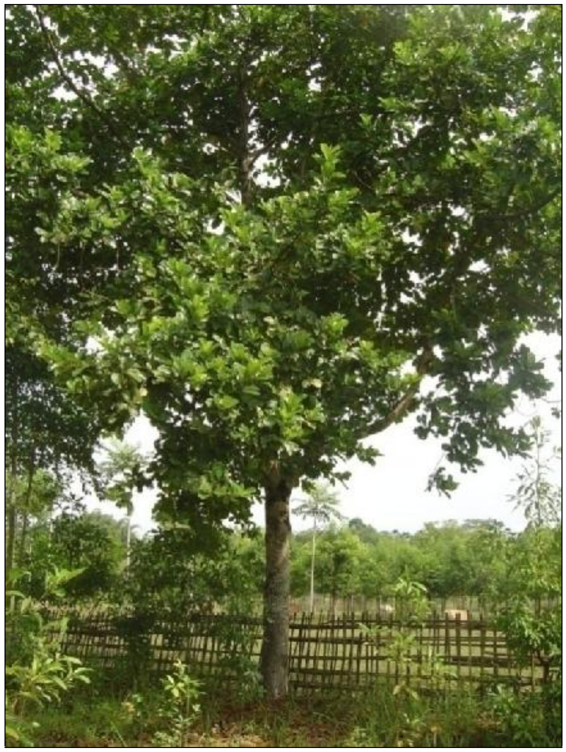
Fig. 9 Lakhimpur district Map (a) general (b) highlighting sericultural locations



(a)

(b)

Fig. 10 Som host plant (a) Single plant and (b) Systematic plantation



(a)

(b)

Fig. 11 Soalu host plant (a) Single plant and (b) Systematic plantation

Fig. 12 Mejankari host plant (a) Single plant and (b) Natural plantation

CHAPTER III

PHYSICO-CHEMICAL CHARACTERISTICS OF SOIL AND HOST PLANTS

MATERIALS AND METHODS

Collection and preparation of soil samples

Soil samples were collected randomly from both the study sites i.e. Japisajia in North Lakhimpur (Assam) and Ungma in Mokokchung (Nagaland) in three different rearing seasons i.e. spring (April-June), summer (July-September) and autumn (October-December) seasons corresponding to the rearing schedule of muga silkworm during 2007-2008, from 0-10 cm depth for chemical analysis. For analysis of soil moisture, weight of freshly collected soil was taken and thereafter the samples were kept in oven for 48 hours at $80^{o}C$. For other analysis the soil samples collected from each site were mixed up separately on seasonal basis and made three replications for analysis. The soil samples were thoroughly air dried in shade, ground in wooden mortar and pestle and passed through a 2 mm sieve. The powdered soil samples were stored in polythene bags and subsequently utilized for analysis of soil pH, organic carbon, total nitrogen, available phosphorous and available potassium.

Soil analysis

Soil moisture

The moisture content was determined by gravimetric method (Wilde *et al.*, 1985).

Soil pH

pH of the soil sample was determined in distilled water and 1N KCl solution taking soil solution ratio of 1:1 using an Elico pH meter, Model-L1-10.

Organic Carbon

The organic carbon percentage was determined by titration method as described by Walkley and Black (1934).

Total Nitrogen

Total Nitrogen was determined by the alkaline $KMnO_4$ method (Subbiah and Asija, 1956).

Available Phosphorus

Available phosphorus was determined by Bray's No.1 method (Bray and Kurtz, 1945).

Available Potassium

Available potassium was determined flame photometrically after extracting the soil with neutral normal NH_4 acetate (Jackson, 1973).

Collection and preparation of Leaf samples

Fresh leaves of all the three types i.e. tender, medium (Semi tender) and mature and of different sizes from the three host plants i.e. Som and Soalu from Sericulture farm, Japisajia, Lakhimpur and Som and Mejankari from Ungma, Mokokchung (rearing site) were collected separately in spring, summer and autumn seasons corresponding to the rearing schedule of muga silkworm. The leaves were properly cleaned and used for different estimations following standard methodology. The estimation for all leaf types were done seasonally in triplicate and mean value was recorded for interpretation of results. The data were statistically analysed following the analysis of variance for leaf types, seasons as well as host plants in a randomized complete block design and co-efficient of variation (CV %) was calculated following the method described by Gomez and Gomez (1984).

Leaf Analysis

Moisture Content

Fresh leaves of all ages (tender, semi-tender and mature) were collected seasonally from respective host plants as per rearing schedule and their moisture content were determined by using the method of AOAC (1980).

Total Nitrogen

Total Nitrogen was determined by using Microkjeldahl technique (KEL Plus).

Crude Protein

Crude protein content was calculated by multiplying total nitrogen with 6.25.

Crude Fiber Content

The crude fiber was determined by using the method of AOAC (1980).

Total Carbohydrate

Total carbohydrate was estimated by Anthrone method (Yem & Willis, 1954).

Total Soluble Sugar

Total soluble sugar was estimated by Anthrone method (Yem & Willis, 1954).

Reducing Sugar

Reducing sugar was estimated by the method described by Burner (1964).

Total Ash

The total ash % of the leaf sample was estimated by using muffle furnace at $600^{o}C$ (AOAC, 1980). 1 gm of leaf sample was dried in a nickel crucible and heated it on a low flame till the organic matter turned to burn. The crucible were placed in a muffle furnace and heated it $600^{o}C$ and stopped when greyish white ash formed, remove crucible from the furnace and cooled it in a desicator and weighed. The residue represented the total ash percentage. Calculation:

Weight of the crucible	$= W_1 g$
Weight of the crucible + Sample	$= W_2 g$
Weight of the crucible + Sample after ignition	$= W_3 g$
Weight of ash	$= W_3 - W_1 g$
Percentage of ash	$= \frac{(W_3 - W_1)}{W_2 - W_1} \times 100$

RESULTS AND DISCUSSION

Physico-Chemical Characteristics of Soil

Physico-chemical characteristics of soil are given in **Table 2**

Table 2: Comparative physico-chemical characteristics of soil in North Lakhimpur (NLP) and Mokokchung (MKG) during study period

Season	Location	Parameter & Value (Mean±SE)					
		Moisture %	pH	OC %	N Kg/ha	P Kg/ha	K Kg/ha
Spring (S I) (Apr-Jun)	NLP	15.03±0.68	5.61±0.11	1.18±0.13	501.76±76.02	37.61±0.81	238.11±1.84
	MKG	27.79±1.01	5.15±0.10	1.70±0.19	456.55±49.52	24.90±0.53	343.40±2.66
Summer (S II) (Jul-Sep)	NLP	37.83±4.02	5.35±0.06	1.04±0.09	522.14±27.89	34.75±2.31	229.55±5.32
	MKG	31.36±0.78	5.14±0.14	1.68±0.14	515.21±23.14	25.00±1.66	373.50±8.65
Autumn (S III) (Oct-Dec)	NLP	17.83±2.32	4.91±0.09	0.87±0.02	397.23±11.84	31.72±0.40	217.61±8.83
	MKG	18.05±0.58	4.90±0.09	1.52±0.05	399.00±11.90	23.48±0.73	372.50±15.11

Moisture Content (%): During spring season the percentage of moisture content of soil was recorded to be 15.03±0.68 and 27.79±1.01 in North Lakhimpur and Mokokchung respectively. The moisture content was found to be maximum during summer (37.83±4.02 and 31.36±0.78) and thereafter decreased in autumn season (17.83±2.32 and 18.05±0.58). The fluctuation in moisture content coincided with rainfall received during different seasons **(Fig. 13)**. Higher moisture content in Mokokchung in spring and autumn season might be due to higher rainfall coupled with more rainy days during respective seasons and also in preceding seasons. Having received more rainfall in summer season and also being a plain area, moisture content was recorded to be higher in North Lakhimpur than Mokokchung during summer season.

Soil pH: The soil pH in both study sites was acidic in nature. Maximum soil pH was recorded in spring season (5.61±0.11 and 5.15±0.10) followed by summer (5.35±0.06 and 5.14±0.14) and autumn (4.91±0.09 and 4.90±0.09) season in North Lakhimpur and Mokokchung respectively **(Fig. 13)**. It was observed that North Lakhimpur had recorded slightly higher pH than Mokokchung in all seasons which might be due to low organic matter content and microbial activity which ultimately resulted in low organic acid production. The acidic nature of soil pH might be due to the frequent and high rainfall during spring and summer seasons. Further with the increase of soil moisture content, the soil pH also has the tendency to shift towards acidic nature of soil i.e. decrease in soil pH (Vatsauliya and Alfred, 1980).

Organic Carbon (%): The soil organic carbon (%) was comparatively more in Mokokchung than North Lakhimpur in all seasons. It might be due to frequent growth of ground layer vegetation and subsequently, accumulation of litter and higher decomposition rate of organic matter in Mokokchung than North Lakhimpur where vegetation was very sparse. The soil organic matter was recorded maximum during spring season (1.18±0.13 and 1.70±0.19) followed by summer (1.04±0.09 and 1.68±0.14) and autumn (0.87±0.02and 1.52±0.05) season in North Lakhimpur and Mokokchung respectively **(Fig. 13)**. Slightly higher status of organic carbon during spring than summer season may be due to carry over and deposition of more litter and organic matter from preceding winter season.

Total Nitrogen (kg/ha): Maximum total nitrogen was recorded in summer (522.14±27.89 and 515.21±23.14 kg/ha) followed by spring (501.76±76.02 and 456.55±49.52 kg/ha) and autumn (397.23±11.84 and 399.00±11.90 kg/ha) in North Lakhimpur and Mokokchung respectively. During autumn season nitrogen content was recorded to be slightly higher in Mokokchung than North Lakhimpur **(Fig. 14)**.

Available Phosphorus (kg/ha): Available phosphorous was comparatively more in North Lakhimpur than Mokokchung in all seasons. In North Lakhimpur, phosphorous content showed a decreasing trend from spring (37.61±0.81 kg/ha) to autumn season (31.72±0.40 kg/ha), however, it was recorded slightly more during summer season (25.00±1.66 kg/ha) in Mokokchung showing the trend of summer>spring>autumn **(Fig. 14)**.

Available Potassium (kg/ha): Available potassium was recorded to be higher in Mokokchung than North Lakhimpur in all seasons. In North Lakhimpur, it was found to be maximum during spring season (238.11±1.84 kg/ha) showing a decreasing trend in summer (229.55±5.32 kg/ha) and autumn (217.61±8.83 kg/ha) season. However in Mokokchung, with the initial record of 343.40±2.66 kg/ha during spring, the amount was found to be maximum during summer (373.50±8.65 kg/ha) exhibiting slight decrease in autumn (372.50±15.11 kg/ha) season **(Fig. 14)**.

Total nitrogen and phosphorus decreased with the increase in altitude, while organic carbon and potassium exhibited an opposite trend which might be due to various factors such as temperature, rainfall, altitudinal aspect, vegetation cover, land use etc. Panthi (2010) observed that soil fertility in general decreased with increase in altitude i.e. total nitrogen, available phosphorus, available potassium and organic matter decreased with increase in altitude. Seasonal variation on soil quality between higher and lower altitude depends on many aspects such as soil texture, soil pH, nutrients, organic matter, water holding capacity, microorganism, structure, microclimate, irrigation facility, land fragmentations, soil erosion, agricultural system and practices, diseases and insects, consumption of nutrients by crops, leaching of nutrients etc. The present study shows that, the soil of both rearing sites were suitable for growth of silkworm host plants with balanced amount of these nutrients.

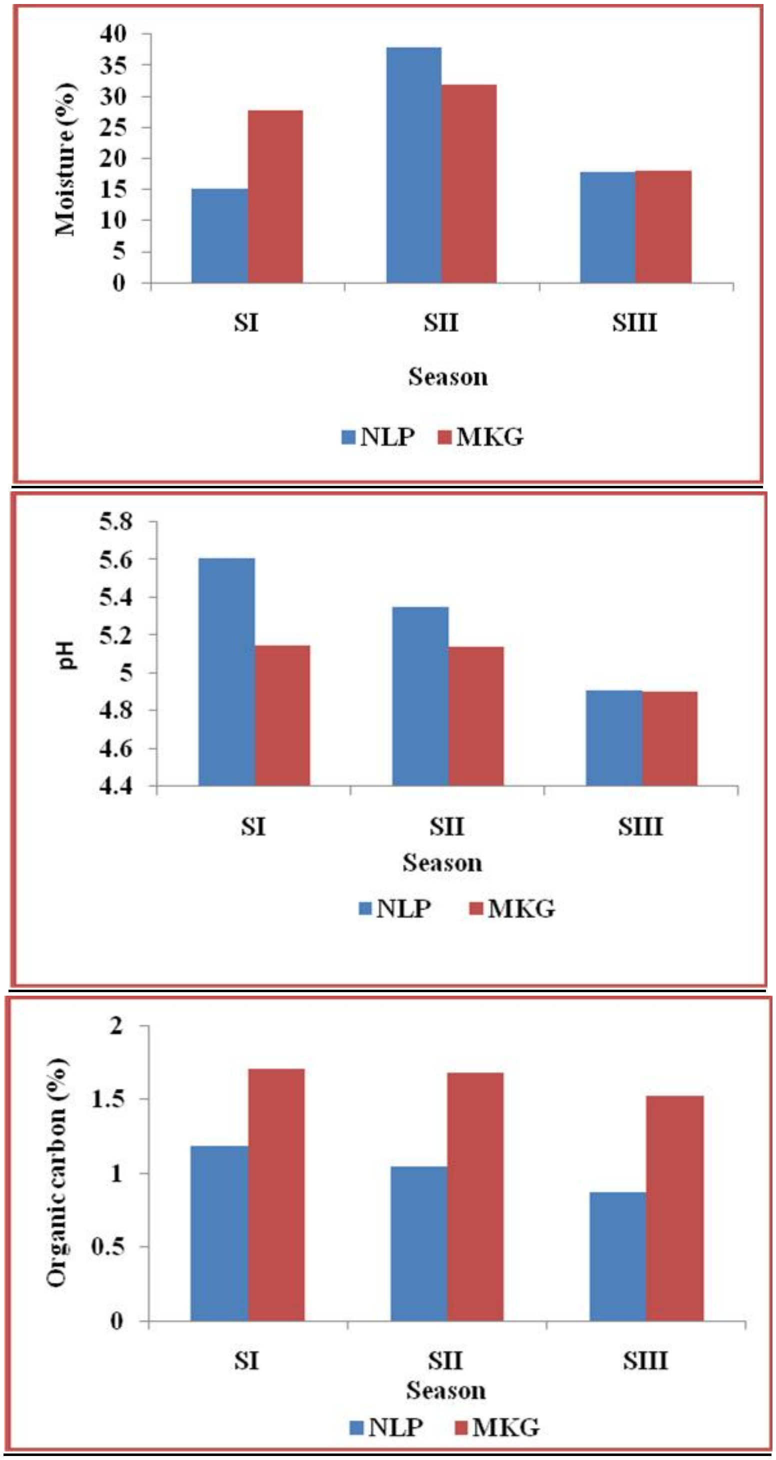


Fig.13: Physico-Chemical characteristics of soil in different rearing seasons during study period (SI= Spring; SII=Summer; SIII=Autumn (NLP=North Lakhimpur; MKG=Mokokchung)

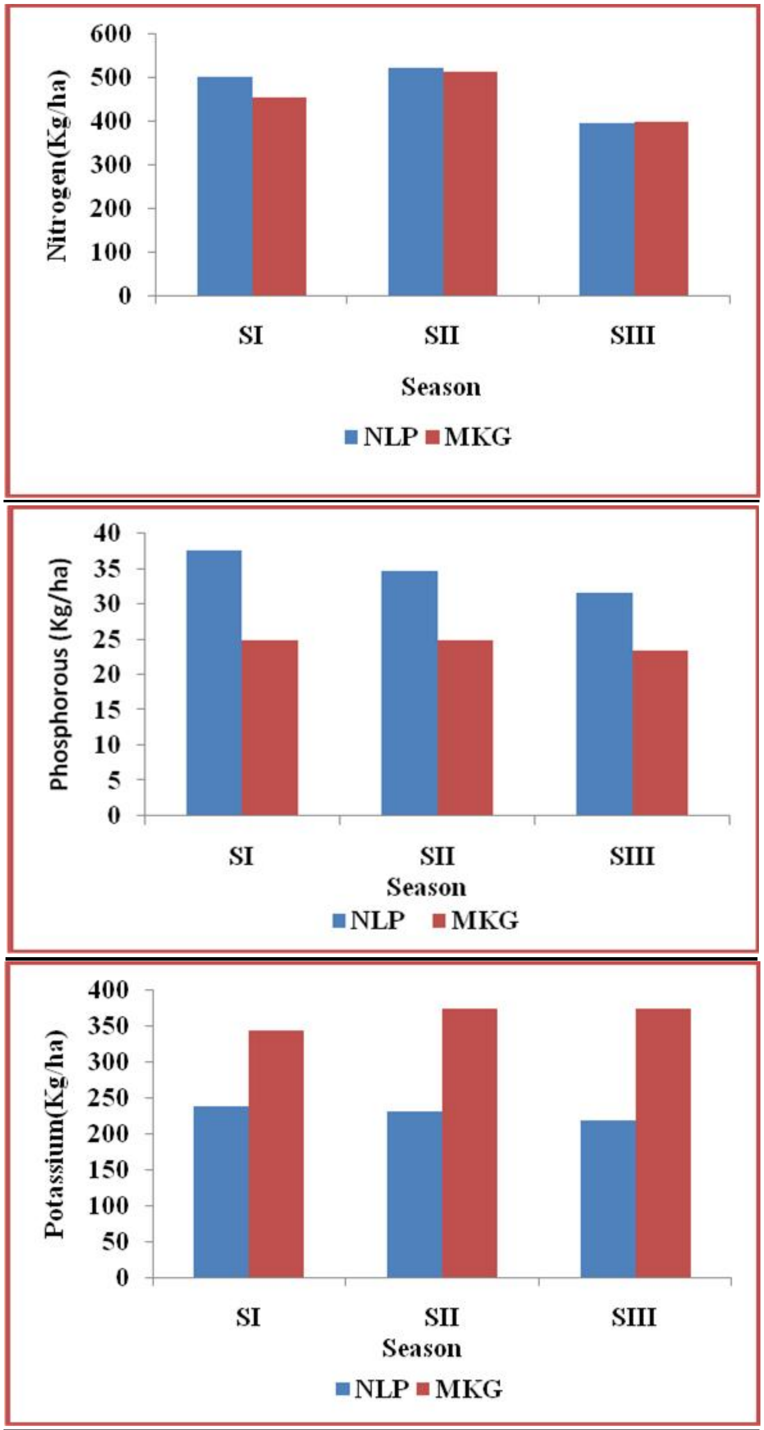


Fig.14: Physico-Chemical characteristics of soil in different rearing seasons during study period (SI= Spring; SII=Summer; SIII=Autumn (NLP=North Lakhimpur; MKG= Mokokchung)

Physico-Chemical Characteristics of Host Plants

Seasonal variation of foliar constituents of three leaf types of primary and secondary host plants in lower and higher altitude

Group A: At Lower altitude –North Lakhimpur
Host plants: *Persea bombycina* and *Litsea polyantha*

Foliar constituents of different leaf types of the two primary food plants *Persea bombycina* and *Litsea polyantha* estimated for three rearing seasons are given in **Table 3.**

Moisture Content: Moisture content was recorded maximum in tender leaves followed by medium and mature leaves of both host plants in all seasons. Summer season retained highest quantity of moisture followed by autumn and spring season in both food plants ($P < 0.01$). The mean moisture content was found to be higher in *P. bombycina* (68.89$\pm$0.74%) than *L. polyantha* (64.84$\pm$1.29%) showing highly significant difference at 1% level of probability. The interaction effect due to leaf type x host plant x season was also found to be highly significant **(Fig. 15).**

Total nitrogen: With the maximum content in tender leaf total nitrogen content was decreasing with maturation of leaves irrespective of seasons for both food plants and exhibited highly significant difference among leaf types, seasons and host plants. The nitrogen content of both plants was found to be variable with regard to seasonal fluctuation in the order of summer >autumn >spring and spring >autumn > summer in the case of *p. bombycina* and *L. polyantha* respectively

(Fig. 16). The crude protein of both plants showed seasonal variability at 0.1% level with maximum of 24.59±0.40% during summer followed by autumn (22.55±0.31%) and spring (20.82±0.54%) in the case of *P. bombycina* while *L. polyantha* recorded the maximum 20.24±0.88% during spring followed by autumn (19.55±0.65%) and summer (17.94±0.67%). The mean difference in total nitrogen (3.63±0.43 % and 3.10±0.87 %) and crude protein content (22.65±0.57 % and 19.24±0.66 %) in *P. bombycina* and *L. polyantha* respectively also reflected the very high interaction effect due to leaf type x host plant x season **(Fig. 17).**

Crude fibre: Crude fibre content was found to be maximum in mature leaf and minimum in tender leaf in all seasons for both food plants showing highly significant difference among leaf types **(Fig. 18)**. Seasonally *P. bombycina* retained more moisture in summer season (16.31±4.53%) while *L. polyantha* had maximum during spring season (13.37±1.26%). The seasonal fluctuation of the leaves of both plants was also highly variable (P< 0.1) and observed in the order of summer >autumn >spring in the case of *P. bombycina* and in the order of spring > autumn > summer in the case of *L. polyantha.* The mean crude fibre content was also recorded a high significant variation (0.1%) between the *P. bombycina* (13.95±0.85%) and *L. polyantha* (11.87±1.21%).

Carbohydrate: With the maximum in semi-tender leaf of *L. polyantha* during spring season, the percentage of total carbohydrate was recorded to be higher in mature leaf and minimum in tender leaf in all seasons. The mean total carbohydrate content was also found to be higher in *P.bombycina* (11.78±0.84%) than in *L. polyantha* (9.01±0.67 %) and the former retained more carbohydrate content than the later in all seasons. Seasonally, the carbohydrate content in the leaves as a whole was found maximum during summer (11.89±0.14%) in *P.bombycina* while it was maximum during spring (9.98±0.78%) in *L. polyantha*. The carbohydrate content of the leaves of both plants was found to be variable with regard to seasonal fluctuation ($P < 0.05$) and was observed in the order of summer > autumn > spring in the case of *P. bombycina* and in the order of spring > autumn > summer in the case of *L. polyantha* **(Fig. 19).**

Soluble and reducing sugar: The percentage of total soluble sugar was found to be higher in medium leaves in both host plants exhibiting significant difference among leaf types **(Fig. 20)**. On seasonal basis it was higher in the leaves of *P. bombycina* during summer season (4.63±0.06%), while in *L. polyantha*, it was higher during the autumn season (4.40±0.66%). The variability of reducing sugar content of the leaves of both plants were also highly significant with regard to leaf types and seasonal fluctuation and was observed in order of summer > autumn>spring in *P. bombycina* and in the order of spring>autumn > summer in *L. polyantha* **(Fig. 21).** The mean total soluble sugar and reducing sugar content were found to be higher in *P.bombycina* (4.36±0.66% and 2.35±0.77%) than in *L. polyantha* (4.09 ± 0.66 % and 2.12±0.31%) and exhibited very high interaction effect due to leaf types, seasons and host plants.

Ash content: The percentage of total ash was also increasing from tender to mature leaf in both host plants. The variability of ash content of the leaves as a whole for both plants was found to be highly significant with regard to seasonal fluctuation ($P<0.01$) and was observed in the order of summer > autumn > spring in the case of *P. bombycina* and in the order of autumn > spring > summer in the case of *L. polyantha*. The mean total ash content was found to be higher in *P. bombycina* (4.33 ± 0.54 %) than *L. polyantha* (4.13± 0.65%) which reflected significant combined effect of leaf types, seasons and host plants **(Fig. 22).**

Table 3: Seasonality of nutrient contents of different leaf types of *Persea bombycina* and *Litsea polyantha* in North Lakhimpur (T=Tender; St= Semi tender; Ma=Mature)

Food Plant	**Sea-son**	**Leaf Type**	**Nutrient content (Mean ± SE) all in percentage**							
			Moisture	**Nitrogen**	**Crude Protein**	**Crude fibre**	**Carboh-ydrate**	**Soluble sugar**	**Reducing sugar**	**Total ash**
Som	I	Te	83.78±1.25	3.51±0.07	21.89±0.44	7.15±0.03	11.53±0.02	4.01±0.03	2.14±0.02	3.04±0.05
		St	70.80±1.50	3.26±0.09	20.34±0.59	10.05±0.12	11.69±0.05	4.18±0.02	2.14±0.03	4.24±0.03
		Ma	48.09±0.63	3.24±0.06	20.22±0.37	19.01±0.05	11.84±0.06	4.11±0.07	2.13±0.05	4.76±0.16
	Mean		**67.56**±10.4	**3.33**±0.09	**20.82**±0.54	**12.07**±3.57	**11.69**±0.09	**4.10**±0.05	**2.14**±0.03	**4.01**±0.51
	II	Te	84.62±2.01	4.06±0.06	25.30±0.38	9.29±0.04	11.62±0.15	4.50±0.12	2.41±0.13	3.49±0.05
		St	74.59±2.57	3.93±0.04	24.57±0.27	14.87±0.07	11.99±0.14	4.68±0.13	2.59±0.13	4.60±0.08
		Ma	54.26±0.38	3.85±0.02	23.91±0.20	24.77±0.29	12.07±0.14	4.70±0.17	2.74±0.11	5.48±0.06
	Mean		**71.15**±8.93	**3.95**±0.06	**24.59**±0.40	**16.31**±4.53	**11.89**±0.14	**4.63**±0.06	**2.58**±0.10	**4.52**±0.57
	III	Te	82.16±1.24	3.74±0.13	23.36±0.80	7.90±0.18	11.69±0.03	4.36±0.03	2.28±0.04	3.20±0.05
		St	72.48±0.71	3.64±0.12	22.75±0.72	11.95±0.71	11.76±1.70	4.39±0.04	2.34±0.05	4.74±0.20
		Ma	49.24±0.21	3.45±0.14	21.55±0.87	20.53±0.67	11.81±0.03	4.30±0.06	2.39±0.05	5.43±0.03
	Mean		**67.96**±0.32	**3.61**±0.26	**22.55**±0.31	**13.46**±0.27	**11.76**±0.30	**4.35**±0.16	**2.34**±0.16	**4.45**±0.15
	Leaf Type mean	Te	83.52±0.73	3.77±0.21	23.52±0.72	8.11±0.67	11.61±0.55	4.29±0.34	2.28±0.43	3.24±0.45
		St	72.62±0.54	3.61±0.57	22.55±0.67	12.29±0.87	11.81±0.76	4.42±0.45	2.36±0.65	4.53±0.34
		Ma	50.53±0.91	3.51±0.62	21.89±0.81	21.44±0.69	11.91±0.89	4.37±0.54	2.42±0.51	5.22±0.25
	Annual mean		**68.89**±0.74	**3.63**±0.43	**22.65**±0.57	**13.95**±0.85	**11.78**±0.84	**4.36**±0.66	**2.35**±0.77	**4.33**±0.54
Soalu	**I**	Te	77.21±0.33	3.42±0.04	21.47±0.20	8.40±1.46	9.93±0.70	4.34±0.11	2.34±0.07	3.44±0.03
		St	66.07±0.52	3.15±0.08	19.65±0.48	11.87±2.06	10.07±0.69	4.43±0.12	2.49±0.05	4.32±0.10
		Ma	44.40±0.97	3.16±0.05	19.61±0.23	19.85±3.45	9.95±0.84	4.25±0.15	2.19±0.10	5.22±0.04
	Mean		**62.56**±0.76	**3.24**±0.56	**20.24**±0.88	**13.37**±1.26	**9.98**±0.78	**4.34**±0.42	**2.34**±0.21	**4.33**±0.23
	II	Te	81.74±0.97	2.98±0.05	18.63±0.33	6.95±1.21	8.01±0.03	3.44±0.02	1.84±0.02	2.99±0.09
		St	68.73±0.23	2.93±0.07	18.27±0.40	8.53±1.48	8.18±0.05	3.54±0.02	1.94±0.02	3.65±0.12
		Ma	50.37±1.73	2.71±0.08	16.92±0.48	15.50±2.69	8.27±0.05	3.64±0.02	1.89±0.09	4.45±0.25
	Mean		**66.95**±1.55	**2.87**±0.21	**17.94**±0.67	**10.33**±1.65	**8.15**±0.08	**3.54**±.09	**1.89**±0.08	**3.70**±0.33
	III	Te	79.78±1.62	3.32±0.04	20.71±0.26	8.24±1.43	8.72±0.19	4.44±0.30	2.29±0.14	4.33±0.07
		St	67.68±0.85	3.31±0.11	19.94±0.35	11.10±1.93	8.96±0.18	4.53±0.30	2.17±0.15	4.23±0.40
		Ma	47.58±0.60	2.88±0.06	18.01±0.30	16.35±2.84	9.03±0.15	4.24±0.30	1.89±0.09	4.58±0.26
	Mean		**65.01**±1.22	**3.17**±0.45	**19.55**±0.65	**11.90**±1.78	**8.90**±0.45	**4.40**±0.66	**2.12**±0.54	**4.38**±0.43
	Leaf Type mean	Te	79.57±1.75	3.24±0.56	20.27±0.38	7.86±1.45	8.89±0.25	4.07±0.39	2.16±0.26	3.59±0.38
		St	67.49±1.23	3.13±0.25	19.29±0.45	10.50±1.34	9.07±0.45	4.17±0.26	2.20±0.34	4.07±0.54
		Ma	47.45±0.97	2.92±0.77	18.18±0.75	17.24±1.66	9.08±0.75	4.04±0.54	1.99±0.44	4.75±0.33
	Annual mean		**64.84**±1.29	**3.10**±0.87	**19.24**±0.66	**11.87**±1.21	**9.01**±0.67	**4.09**±0.66	**2.12**±0.31	**4.13**±0.65
F	Leaf type (L)		433.54***	100.17***	106.99***	5096.71***	88.08***	6.49**	13.62***	521.80***
	Season (S)		5.96**	575.64***	574.49***	512.01***	42.51***	110.04***	130.25***	39.56***
	Host plant(H)		433.54***	48.60***	103.70***	310.78***	10.12***	59.16***	26.68***	60.91***
	L x S		1.088NS	5.438**	5.420**	35.884***	11.472***	2.321NS	6.329**	4.146*
	L x H		5.96**	69.14***	132.70***	30.81***	712.08***	263.57***	110.49***	25.72***
	S x H		1.09NS	7.85***	9.40***	4.52**	1.82NS	68.56***	10.75***	9.90***
	L x S x H		128.99***	192.03***	3.93*	5.33*	122.98***	66.29***	42.44***	12.65***
CV%			**4.97**	**1.5**	**1.48**	**2.90**	**0.58**	**2.47**	**3.53**	**4.3**

(* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Non significant)**

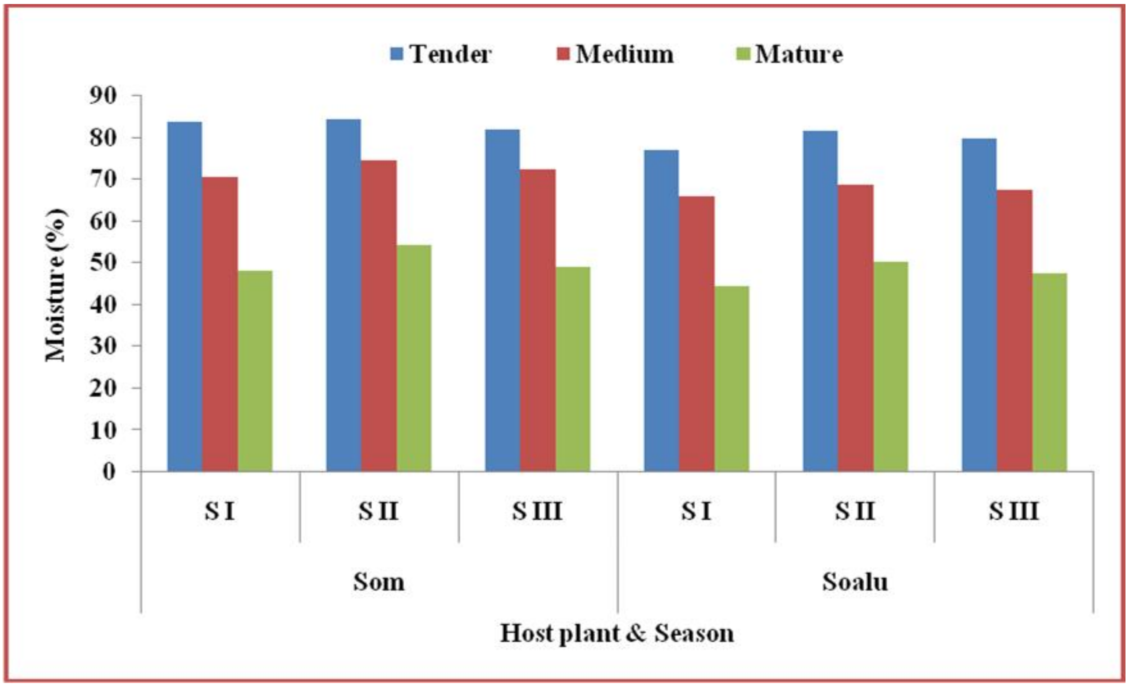


Fig. 15 (A) Moisture content in three leaf types of two host plants in different seasons North Lakhimpur

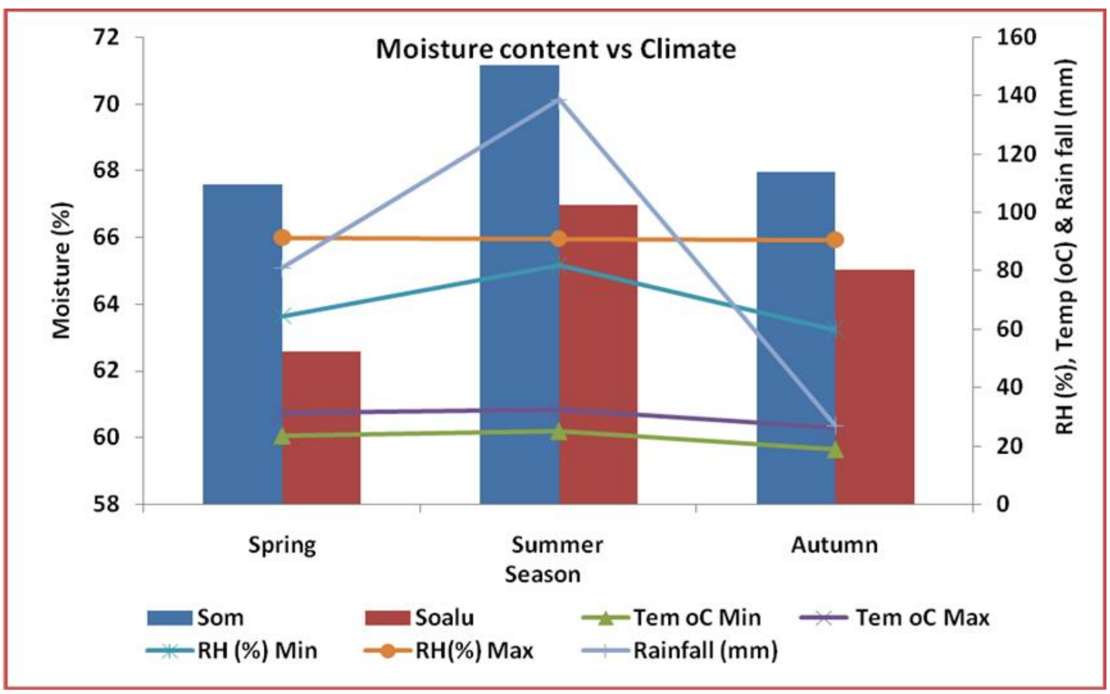


Fig. 15 (B) Mean leaf moisture content of two primary host plants (Som and Solalu) in relation to seasonal climatic variation in North Lakhimpur

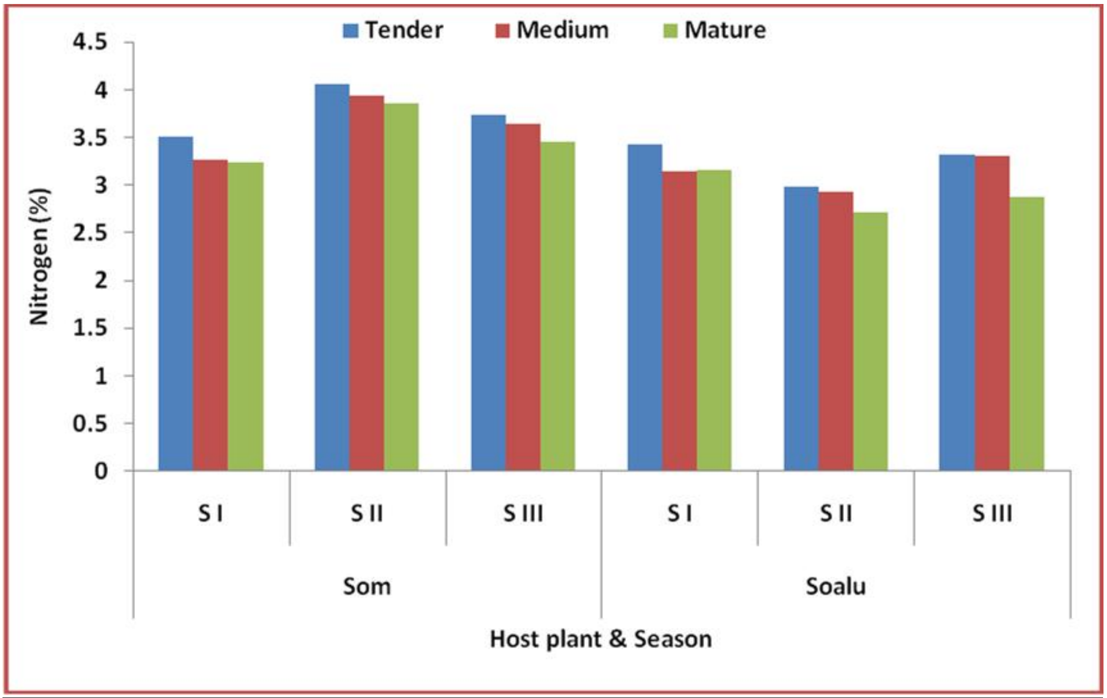


Fig.16 (A) Nitrogen content in three leaf types of two host plants in different seasons in North Lakhimpur

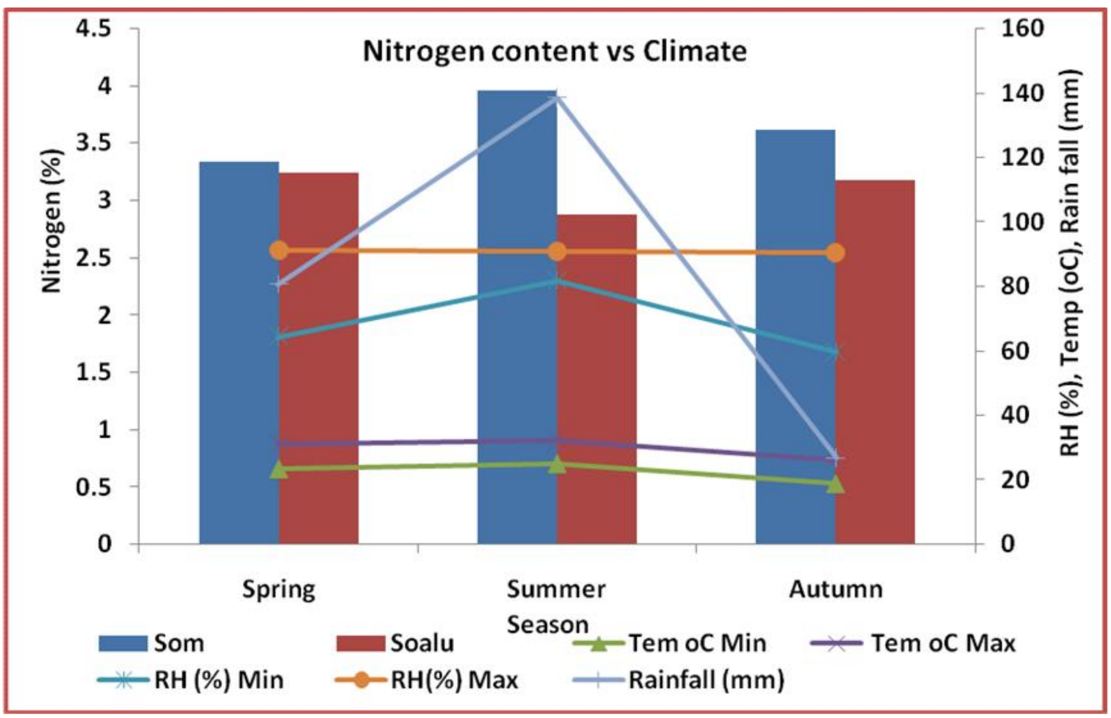


Fig.16 (B) Mean leaf nitrogen content of two primary host plants (Som and Soalu) in relation to seasonal climatic variation in North Lakhimpur

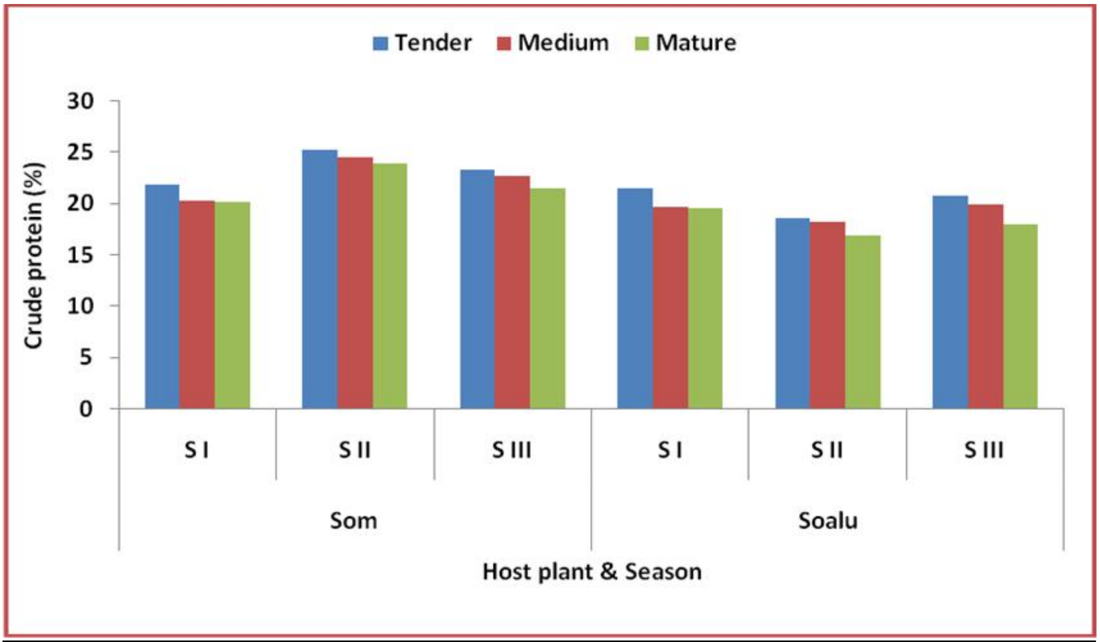


Fig.17 (A) Crude protein content in three leaf types of two host plants in different seasons in North Lakhimpur

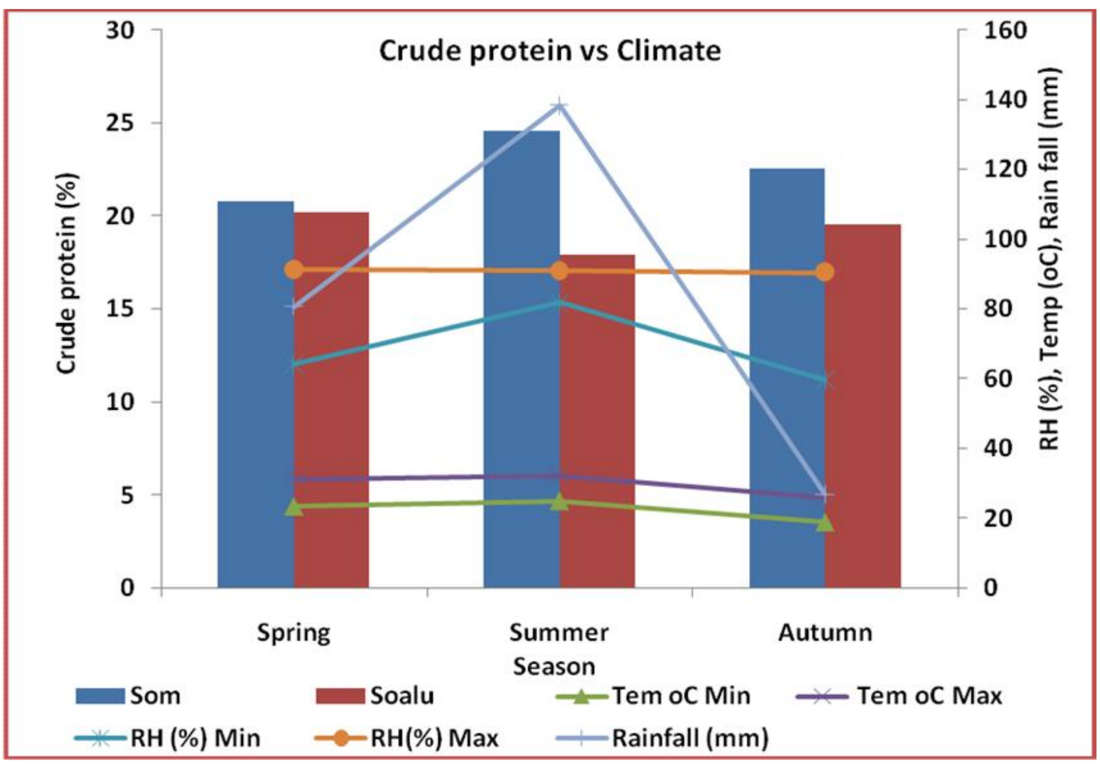


Fig.17 (B) Mean leaf crude protein content of two primary host plants (Som and Soalu) in relation to seasonal climatic variation in North Lakhimpur

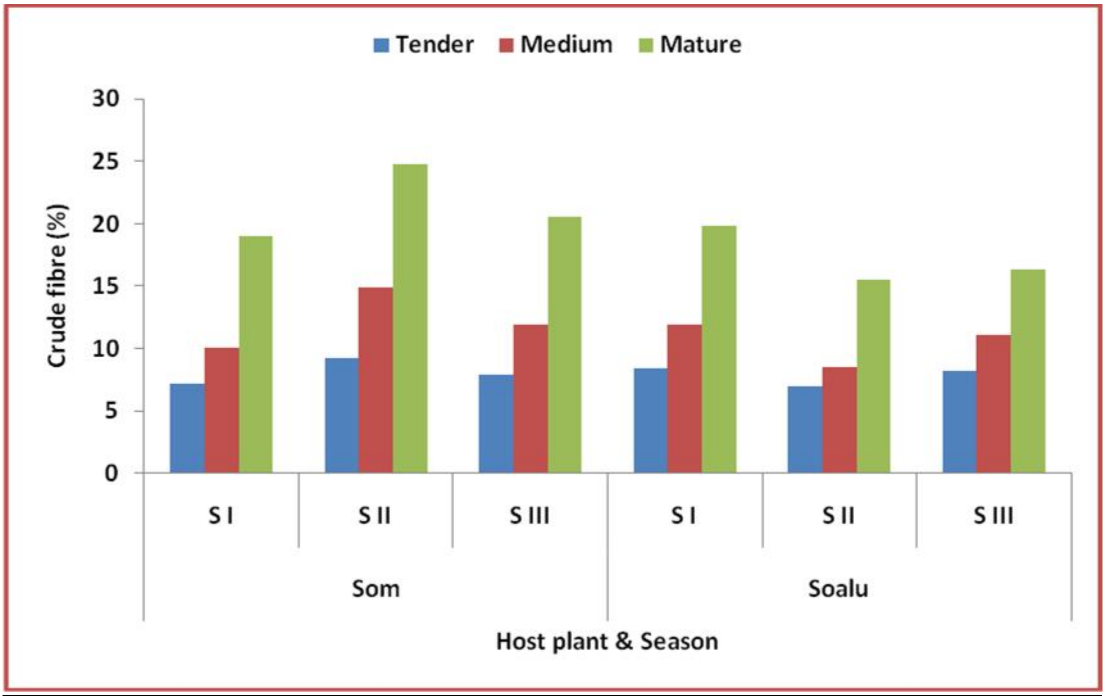


Fig.18 (A) Crude fibre content in three leaf types of two host plants in different seasons in North Lakhimpur

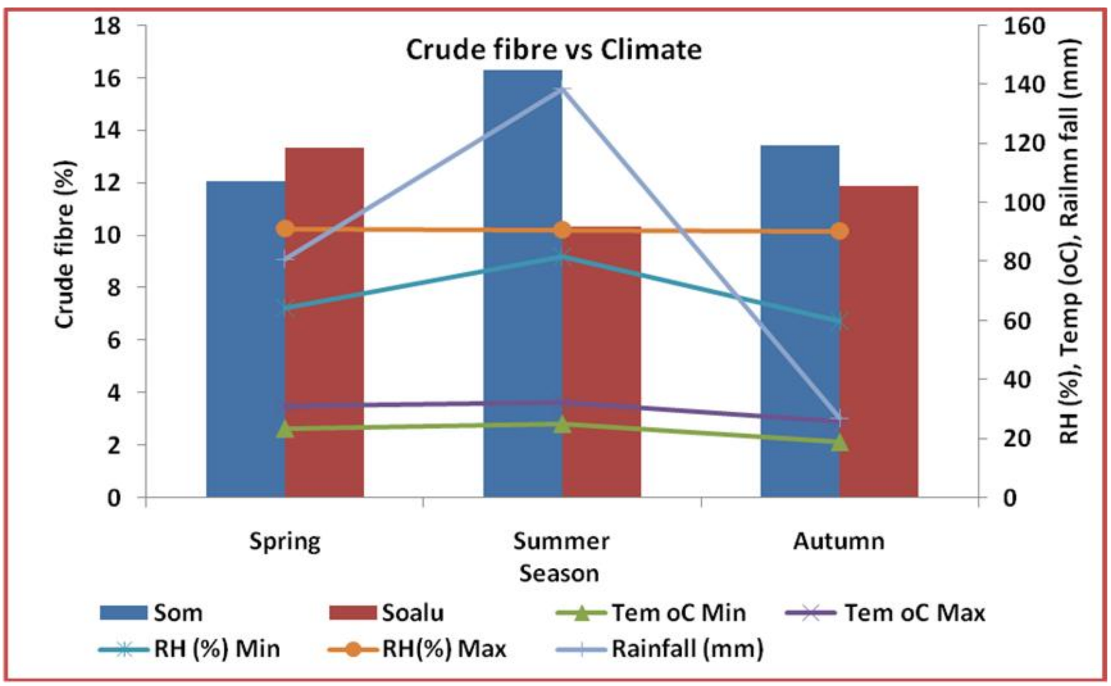


Fig.18 (B) Mean leaf crude fibre content of two primary host plants (Som and Solalu) in relation to seasonal climatic variation in North Lakhimpur

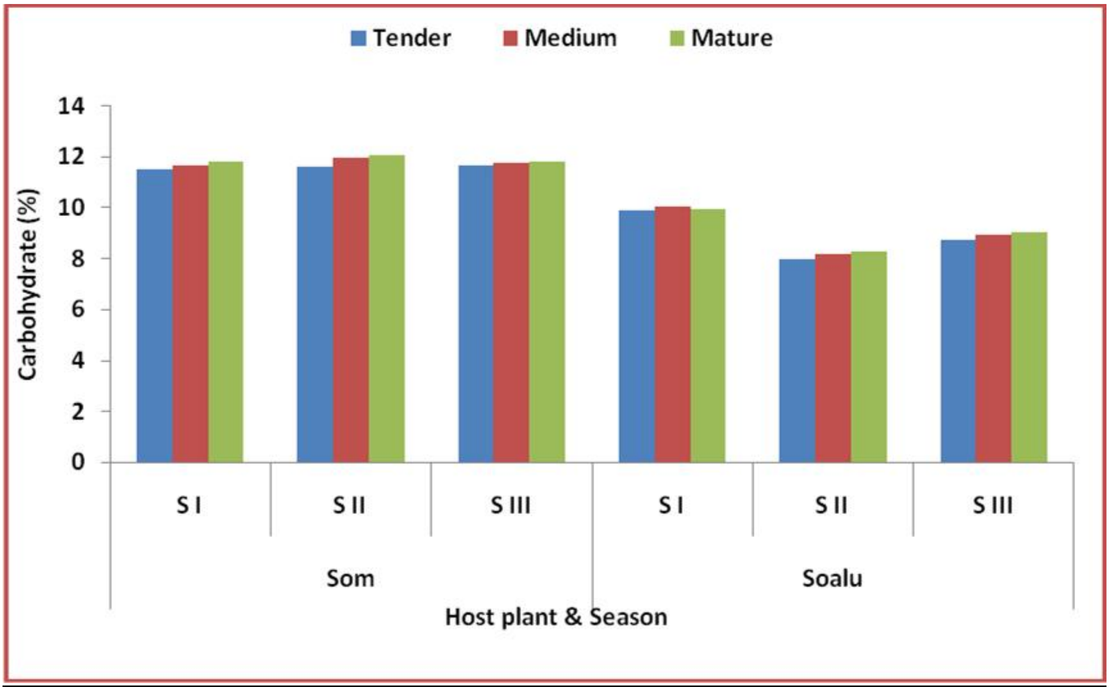


Fig. 19 (A) Carbohydrate content in three leaf types of two host plants in different seasons in North Lakhimpur

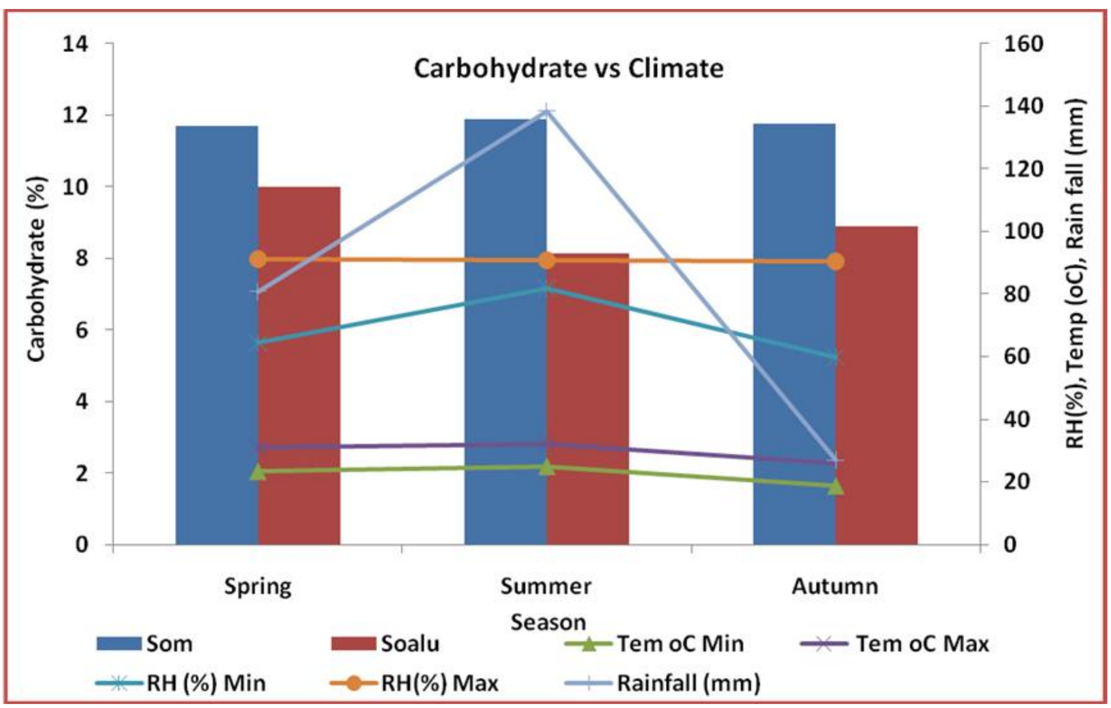


Fig. 19 (B) Mean leaf carbohydrate content of two primary host plants (Som and Soalu) in relation to seasonal climatic variation in North Lakhimpur

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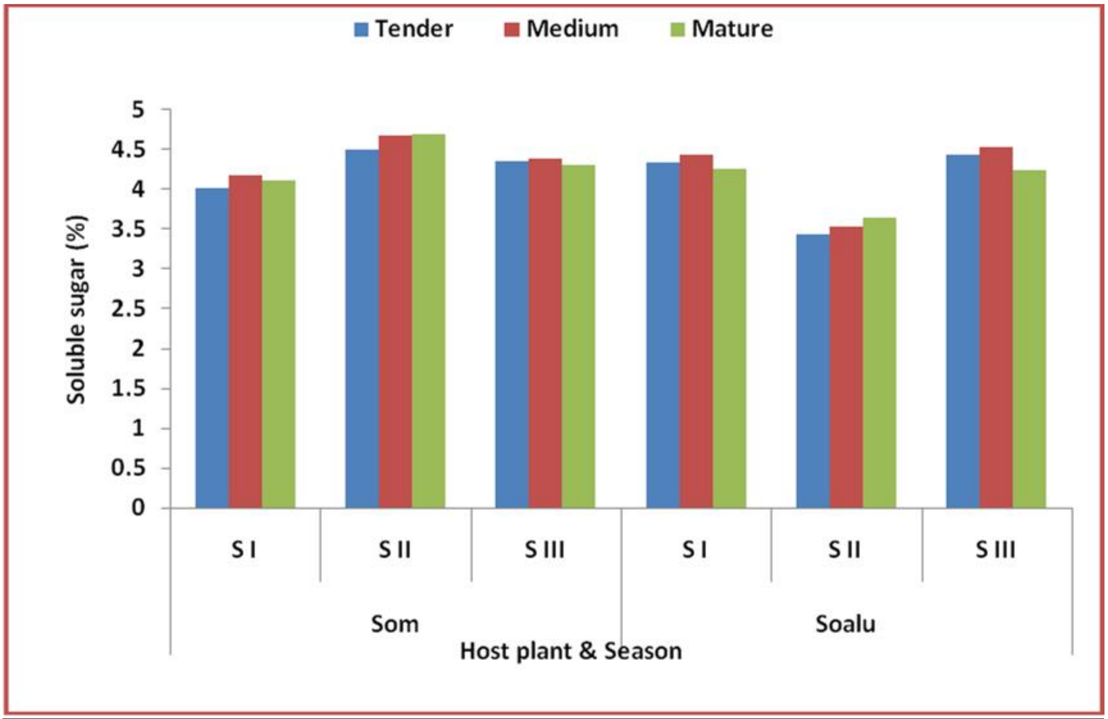


Fig. 20 (A) Soluble sugar content in three leaf types of two host plants in different seasons in North Lakhimpur

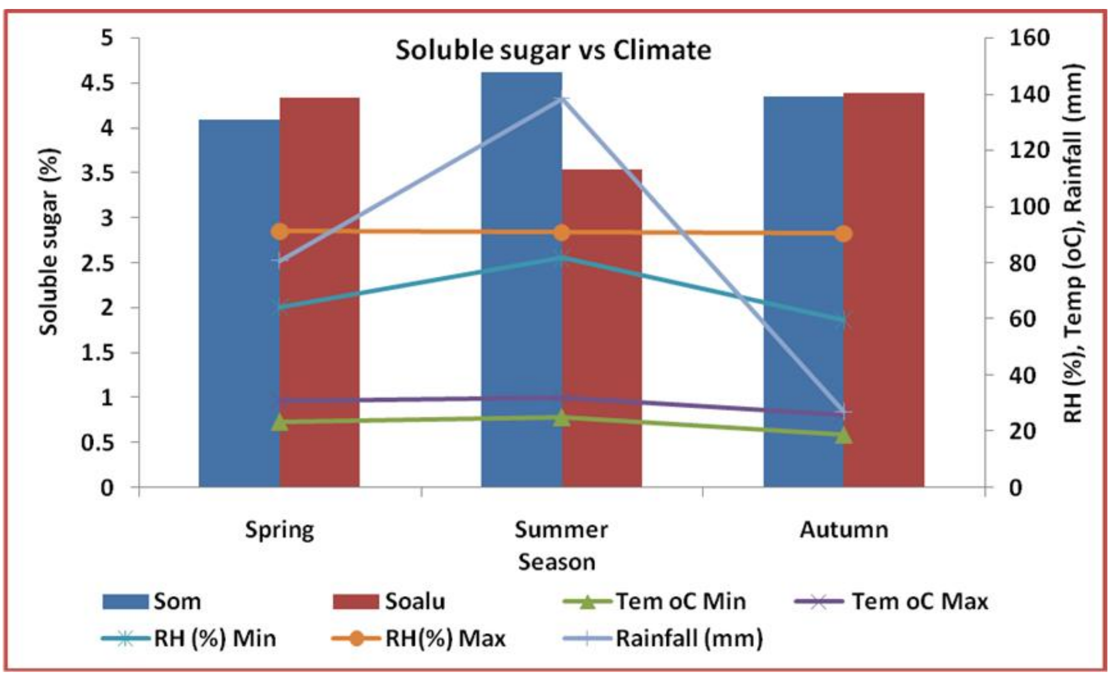


Fig. 20 (B) Mean leaf soluble sugar content of two primary host plants (Som and Soalu) in relation to seasonal climatic variation in North Lakhimpur

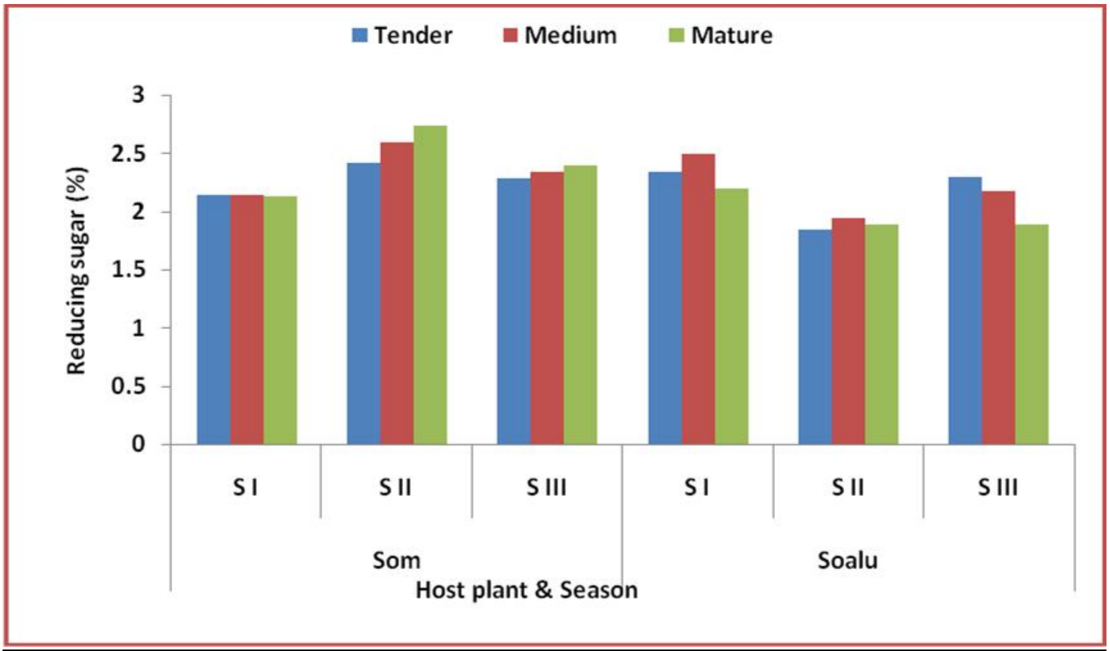


Fig. 21 (A) Reducing sugar content in three leaf types of two host plants in different seasons in North Lakhimpur

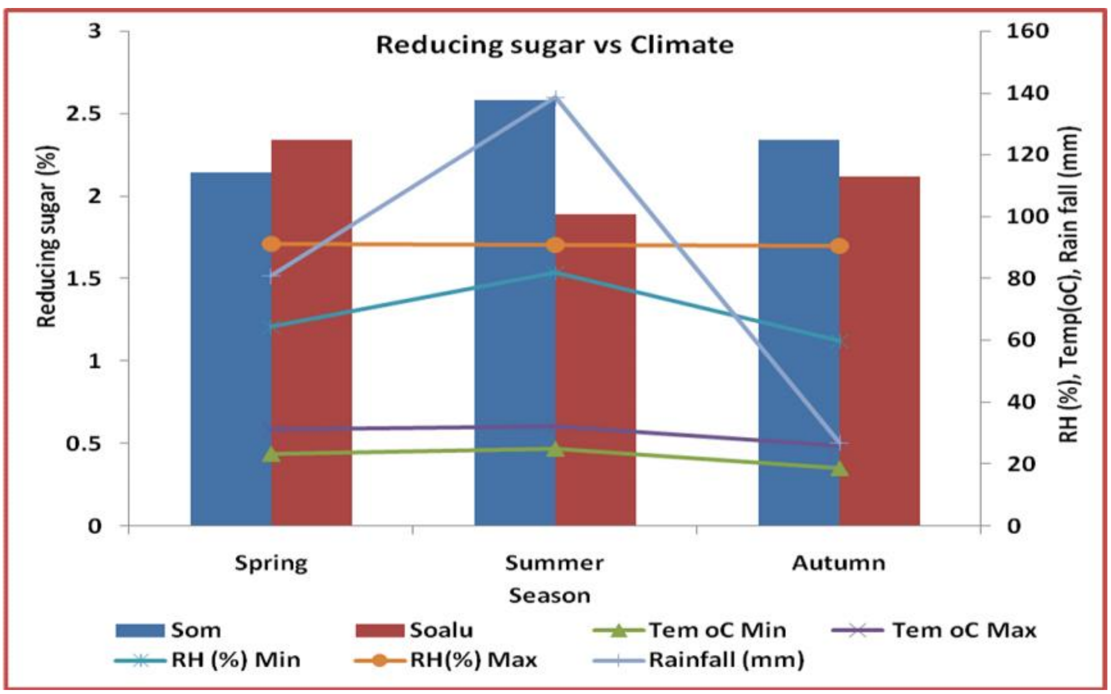


Fig. 21(B) Mean leaf reducing sugar content of two primary host plants (Som and Soalu) in relation to seasonal climatic variation in North Lakhimpur

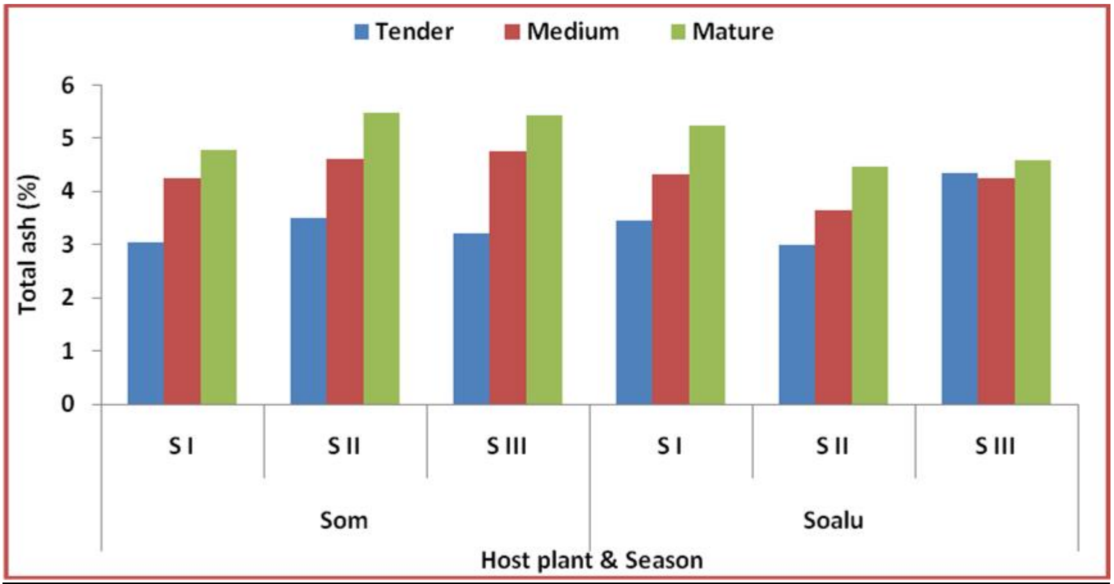


Fig.22 (A) Total ash content in three leaf types of two host plants in different seasons in North Lakhimpur

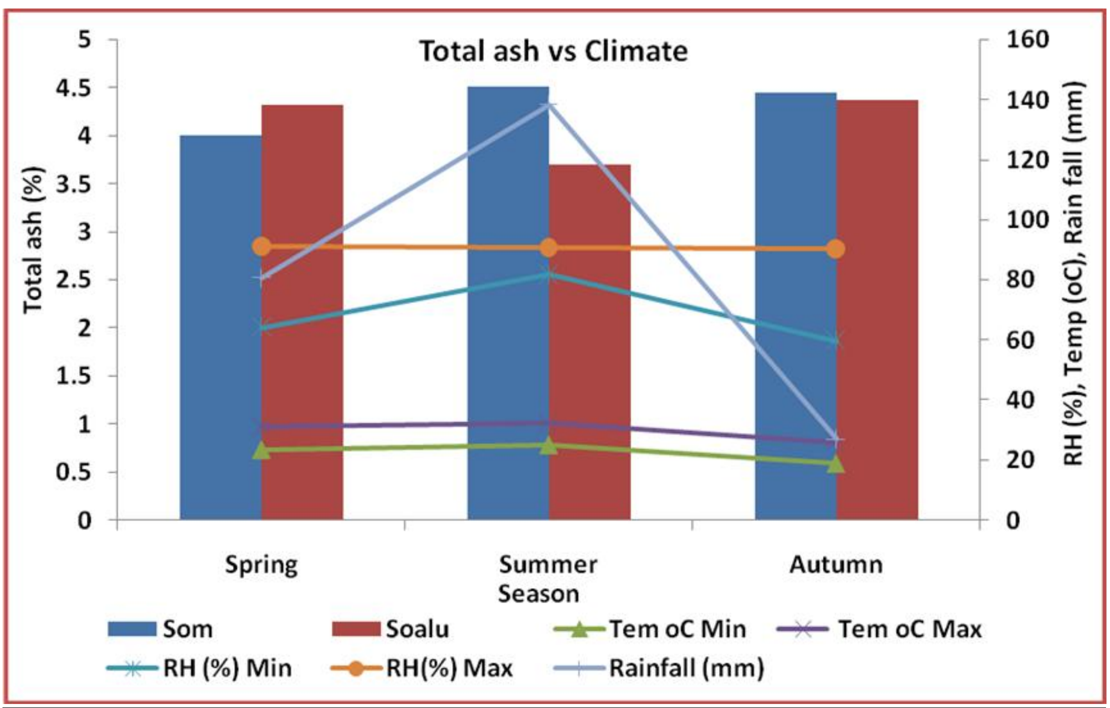


Fig. 22 (B) Mean leaf Ash content of two primary host plants (Som and Soalu) in relation to seasonal climatic variation in North Lakhimpur

Group B : At Higher altitude –Mokokchung
Host plants : *Persea bombycina* and *Litsea citrata*

Foliar constituents of different leaf types of the two food plants *Persea bombycina* (primary) and *Litsea citrata* (secondary) estimated for three rearing seasons are given in **Table 4.**

Moisture Content: Moisture content was recorded maximum in tender leaves followed by medium and mature leaves of host plants in all seasons. The difference among the seasons and host plants was found to be highly significant. In *P. bombycina* summer season retained highest quantity of moisture (67.13±14.6%) followed by autumn (59.96 ±14.9%) and spring (54.33±14.5%) season. However in *L. citrata* maximum moisture was recorded in autumn season (65.35±16.3%) followed by spring (64.24±17.2%) and summer season (63.77±14.9%). *P. bombycina* recorded higher moisture content than *L.citrata* during summer season. Mean moisture content was found to be higher in *L. citrata* (64.45±16.1%) than *P. bombycina* (60.47±14.7%) without having any significant difference. While interaction effect due to leaf type x season was found highly significant, there was no significant difference on interaction effect due to leaf type x host plant and season x host plant ($P < 0.01$). However combined effect of leaf type x season x host plant was found to be highly significant at 0.1% probability level **(Fig. 23).**

Total nitrogen: With the maximum content in tender leaf, total nitrogen content was decreasing with maturation of leaves in all seasons for both food plants (except for spring season in Mejankari where mature leaf contained little more than semi tender leaf) and exhibited highly significant difference among leaf types, seasons and host plants. The nitrogen content of both plants was found to be variable with regard to seasonal fluctuation in the order of autumn >spring>summer and summer >autumn > spring in the case of *p. bombycina* and *L. citrata* respectively **(Fig. 24).** The crude protein of both the plants showed seasonal variability at 0.1% level with maximum of 18.66 ± 0.78% during autumn followed by spring and summer in the case of *P. bombycina* while *L. citrata* recorded the maximum 18.56 ± 0.96% during summer followed by autumn and spring. The mean difference in total nitrogen (2.82 ± 0.13 % and 2.73 ± 0.14 %) and crude protein content (17.63 ± 0.64 % and 17.10 ± 0.94 %) in *P. bombycina* and *L. citrata* respectively also reflected the very high interaction effect due to leaf type x host plant x season **(Fig. 25).**

Crude fibre: Crude fibre content was found to be maximum in mature leaf and minimum in tender leaf in all seasons for the both food plants showing highly significant difference among leaf types. Seasonally *P. bombycina* retained more crude fibre in autumn season (7.45±3.57%) while *L. citrata* had maximum during summer season (8.35± 3.68%). The seasonal fluctuation in both plants exhibited highly significant difference (P< 0.1) and observed in the order of autumn>spring>summer in the case of *P. bombycina* and in the order of summer>spring > autumn in the case of *L. citrata.* The mean crude fibre content was also recorded a high significant variation (0.1%) between the *P. bombycina* (7.05 ± 3.46%) and *L. citrata* (6.98± 2.84%). The interaction effect due to leaf type x season, leaf type x host plant and season x host plant was highly significant at 0.1 % probability level; however, combined effect of leaf type x season and host plant was significant at 5 % **(Fig. 26).**

Carbohydrate: With the exception of maximum record in semi-tender leaf of *L. citrata* during spring season, the percentage of total carbohydrate was recorded to be higher in mature leaf and minimum in tender leaf in all other seasons in both host plants. The mean total carbohydrate content was also found to be higher in *P.bombycina* (17.36 ± 0.23%) than in *L. citrata* (12.61 ± 0.13 %) and the former retained more carbohydrate content than the later in all seasons. Seasonally, the carbohydrate content in the leaves as a whole was maximum during autumn (17.72±0.13%) in *P.bombycina* while it was maximum during spring (15.35±0.12%) in *L. citrata*. The carbohydrate content of the leaves of both plants was found to be variable with regard to seasonal fluctuation ($P< 0.01$) and was observed in the order of autumn>summer > spring in the case of *P. bombycina* and in the order of spring > summer> autumn in the case of *L. citrata* **(Fig. 27).**

Soluble and reducing sugar: Having shown no consistency in the percentage of total soluble sugar content, the difference was highly significant among different leaf types in both host plants **(Fig. 28).** On seasonal basis it was higher in the leaves of *P. bombycina* during autumn season (4.77 ± 0.05%), while in *L. citrata*, it was higher during the summer season (2.68 ± 0.05%). The variability of reducing sugar content of the leaves of both plants was also inconsistent. However the difference was highly significant with regard to leaf types and seasonal fluctuation and was observed in order of summer > autumn>spring in *P. bombycina* and in the order of spring>summer > autumn in *L. citrata*. The mean total soluble sugar and reducing sugar content were found to be higher in *P.bombycina* (4.50 ± 0.07% and 2.39±0.07%) than in *L. citrata* (2.08 ± 0.02 % and 0.72±0.03%) and exhibited very high interaction effect due to leaf types, seasons and host plants **(Fig. 29).**

Ash content: The percentage of total ash was also increasing from tender leaf to mature leaf in all seasons in both host plants except for slight decrease in semi tender leaf of Mejankari during autumn season. The ash content was higher in the leaves of *P. bombycina* during autumn season (7.77 ± 1.99 %) while in *L. citrata* it was higher during the summer season (5.42 ± 1.08%). The variability of ash content of the leaves as a whole for both plants was found to be highly significant with regard to seasonal fluctuation ($P<0.01$) and was observed in the order of autumn>summer>spring in the case of *P. bombycina* and in the order of summer>spring>autumn in the case of *L. citrata.* While *P. bombycina* retained more ash content than *L. citrata* in all seasons, the mean total ash content was found to be higher in former (7.17 ± 1.65 %) than later (4.97± 0.76 %) which reflected significant combined effect of leaf types, seasons and host plants **(Fig. 30).**

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 (Delvi *et al*., 1988). As insects could accumulate water from the metabolic food, the percentage of water content of host plant leaf also might influence the larval body weight (Waldbaur, 1968; Delvi, 1983; Delvi and Naik, 1984; Naik and Delvi, 1984; Naik, 1985; Muthukrishnan and Pandian,1987). Hazarika *et al*. (1994) 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. While studying the leaf moisture content in Jorhat region of Assam, Dutta *et al.* (1997) recorded highest moisture content in *Litsea polyantha* (71.84%) followed by *Litsea salicifolia* (69.98%) and *Litsea citrata* (69.55%) and the lowest in *Persea bombycina* (67.02%). Yadav and Goswami (1992) observed a gradual declining trend in moisture with the maturity of leaves in different host plants. In a study on the status of biochemical constituents in four morphotypes of *Persea bombycina*, Baruah and Baruah (2007) estimated higher moisture content in the tender leaves than that of semi mature and mature leaves, however other mineral contents showed an increasing trend from tender to mature leaves. Similar results were also observed in Tasar food plants (Jolly *et al.*, 1979), Eri food plants (Pathak, 1988) and was in accordance with the earlier findings of Thangavelu and Sahu (1986), Yadav and

Goswami (1987) on muga host plants. The environmental condition may be one of the factors responsible for fluctuation of moisture content of leaves in different seasons. Probably, the moisture quantity of the leaves maintain a degree of relationship in carbohydrate content in different seasons, because reduction of moisture content of leaves from summer to winter may be due to utilization of moisture to build the carbohydrates and other constituents of leaves, thereby increasing dry matters (Sharma and Devi, 1997). Many researchers also reported seasonal effect on total carbohydrate content in different silkworm host plants like Mulberry (Bose and Bindroo, 2001); Tasar (Sinha and Jolly, 1971); Muga (Dutta *et al*., 1997; Choudhury *et al*., 1998) and Eri host plants (Pathak, 1988; Dutta, 2000; Hazarika *et al*., 2005).

Carbohydrates, particularly total soluble sugar, reducing sugar and starch are also very important for growth and development of silkworms. In a comparative study, Yadav and Goswami (1992) observed that medium-aged leaves of Som and Soalu were higher in total sugar percent when compared with tender and mature leaves. However Jolly *et al*. (1974) reported a decreasing trend for total sugar percent with the maturity of the leaves in tasar silkworm food plants. Bharali (1984) reported that total soluble and reducing sugar content of different types of Som plant increased from spring to autumn. While comparing reducing sugar percentage, Dutta *et al*. (1997) observed that Som leaves contained maximum reducing sugar (2.56%), but did not differ significantly from that of Soalu (2.33%) and Mejankari (2.49%). Neog *et al*. (2007) confirmed that leaves of different maturity of eight genotypes of Som plant collected during two rearing seasons differed significantly from one another in respect of all the biochemical characters taken into study. They observed a declining trend in moisture, crude protein, soluble protein, reducing sugar and total soluble sugar from tender to mature leaves in all the accessions while contents of moisture retention capacity, total mineral, crude fibre and starch were in increasing trend. Chakravorty *et al.* (2004) reported 2.41% reducing sugars, 5.09% total soluble sugars and 5.87% starch in the leaves of Som plant.

Crude fibre is the ash free material and highly composed of cellulose and lignin, but can't be digested by the silkworm larvae; therefore reduction in the fibre content has been established as an advantage for better silkworm crop yield (Vasuki and Basavanna, 1969). Agarwal *et al*. (1980) stated that crude fibre played a very important role in the feeding of larvae. A negative correlation was existed between the crude fibre and the feeding of the larvae, showing that the lesser the percentage of crude fibre, the better would be the rearing results. Roeder (1953) reported that silkworms had the ability to digest crude fibre to the extent of 0.7% as against 74% by the animals. Yadav and Goswami (1992) observed that *Machilus bombycina* and *Litsea polyantha*, the primary food plants of muga silk worms recorded a comparatively low percentage of crude fibre in comparison to tasar silkworm food plants. Neog *et al.* (2007) recorded great variability of crude fibre content among eight genotypes of Som plants. Dutta *et al*. (1997) recorded the higher percentage of crude fibre in Som leaves (27.18%)

followed by Dighloti (*Litsea salicifolia*) (23.26%) and Soalu (15.49%), whereas Mejankari leaves possessed the lowest amount (7.91%).

Crude protein content has been reported to be the most important nutrient (Negi, 1986). Dutta *et al*. (1997) recorded maximum amount of total nitrogen and protein in Mejankari (3.08% and 15.53%) followed by Som (2.36% and 12.25%), Soalu (2.02% and 10.36%) and Dighloti (1.39% and 7.50%). Yadav and Goswami (1992) reported that *Litsea polyantha* leaves possessed higher total nitrogen and crude protein than *Machilus bombycina*, but variation between the leaf types for nitrogen was not significant. The protein content in different sericigenous plants are highly variable and are greatly influenced by environment and heredity (Agarwal *et al.*, 1980; Pathak, 1988). While studying the adult-juvenile foliage of *Celtis australi* L., a promising fodder tree species of Central Himalaya, India Singh *et al.* (2010) recorded higher level of crude protein in young leaves which decreased with leaf maturation. A similar pattern of variation in protein content with the season was also reported by earlier workers in the foliage of *C. australis* (Subba *et al*., 1994; Wood *et al*., 1995) and *Grewia optiva* (Khosla *et al*., 1980). A detailed study on six fodder trees of the Central Himalaya, India also suggested that early successional fast growing tree species like *Celtis* has much greater content of protein in leaves (16.97%) than late successional slow growing species (Khosla *et al*., 1992).

Thus the nutrient analysis of different leaf types of food plants is most essential, which acts as a guideline to muga culture to evaluate the nutritional status of different food plants for their selection for feeding of the silkworm. Further, variation in feeding parameter and palatability among different silkworm species might be due to the variation in quantitative requirement of each of the nutrients and also the required balance of nutrients within the species owing to many factors including the synthetic ability of the organism and metabolic activities involving specific interrelations between certain nutrients (House, 1974). The comparative studies on seasonal variation between leaf type of both *P.bombycina* (Som) and *L.citrata* (Mejankari) revealed significant differences for moisture, total carbohydrate, soluble sugar, total nitrogen and crude protein whereas difference were insignificant for reducing sugar, crude fibre and total ash. The results suggested both individual and combined effect of leaf types, seasons and host plants on the nutritive value of leaves which greatly influenced the silk worm feeding on different larval stages and highlighted the importance of Mejankari at par with Som and Soalu host plant on rearing performance and cocoon production in different season.

Table 4: Seasonality of nutrient contents of different leaf types of *Persea bombycina* and *Litsea citrata*
(Te=Tender, St=Semi tender, Ma=Mature)

Food Plant	Season	Leaf Type	Nutrient content (Mean ± SE) all in percentage							
			Moisture	Nitrogen	Crude protein	Crude fibre	Carbohydrate	Soluble Sugar	Reducing sugar	Total ash
Som	I	Te	67.39±2.40	2.89±0.32	18.07±2.03	4.20±1.75	16.85±0.92	4.16±0.31	2.23±0.26	5.03±0.16
		St	56.89±1.51	2.68±0.26	16.75±1.63	5.89±2.46	17.09±0.90	4.33±0.27	2.30±0.27	7.04±0.36
		Ma	38.71±1.92	2.67±0.31	16.70±1.95	11.17±4.7	17.29±1.00	4.26±0.30	2.21±0.10	7.88±0.36
	Mean		54.33±14.5	2.75±0.12	17.17±0.78	7.09±3.64	17.08±0.22	4.25±0.09	2.25±0.05	6.65±1.46
	II	Te	79.84±4.20	2.80±0.27	17.51±1.74	3.76±1.57	16.90±0.64	4.37±0.30	2.30±0.12	5.52±0.47
		St	70.35±5.16	2.72±0.30	17.03±1.85	6.02±2.51	17.43±0.50	4.54±0.34	2.47±0.12	7.18±0.48
		Ma	51.21±1.07	2.67±0.32	16.59±1.96	10.02±4.2	17.55±0.55	4.56±0.40	2.63±0.16	8.55±0.71
	Mean		67.13±14.6	2.73±0.07	17.04±0.46	6.60±3.17	17.29±0.35	4.49±0.10	2.50±0.17	7.08±1.52
	III	Te	72.41±5.21	3.09±0.16	19.34±0.98	4.39±1.83	17.59±0.63	4.77±0.17	2.39±0.10	5.59±0.50
		St	64.01±6.09	3.01±0.16	18.83±0.99	6.59±2.75	17.73±0.57	4.81±0.25	2.44±0.11	8.23±0.25
		Ma	43.46±3.66	2.85±0.15	17.81±0.95	11.38±4.7	17.84±0.58	4.72±0.25	2.50±0.10	9.48±0.80
	Mean		59.96±14.9	2.98±0.12	18.66±0.78	7.45±3.57	17.72±0.13	4.77±0.05	2.44±0.06	7.77±1.99
	Leaf type mean	Te	73.21±6.26	2.98±0.12	18.31±0.94	4.12±0.32	17.11±0.41	4.43±0.31	2.31±0.08	5.38±0.31
		St	63.75±6.73	2.80±0.18	17.54±1.13	6.17±0.37	17.42±0.32	4.56±0.24	2.40±0.09	7.48±0.65
		Ma	44.46±6.31	2.73±0.10	17.03±0.68	10.86±0.7	17.56±0.28	4.51±0.23	2.45±0.23	8.64±0.80
	Annual mean		60.47±14.7	2.82±0.13	17.63±0.64	7.05±3.46	17.36±0.23	4.50±0.07	2.39±0.07	7.17±1.65
Mejankari	I	Te	79.30±3.77	2.67±0.14	16.80±0.85	4.40±1.83	15.27±2.53	2.35±1.05	0.76±0.06	4.30±1.02
		St	67.89±4.06	2.46±0.12	15.35±0.71	5.84±2.43	15.49±2.51	2.40±1.08	0.80±0.05	5.37±1.14
		Ma	45.53±1.40	2.47±0.13	15.34±0.72	9.81±4.09	15.30±3.02	2.32±1.08	0.71±0.08	6.53±1.57
	Mean		64.24±17.2	2.53±0.12	15.83±0.84	6.68±2.80	15.35±0.12	2.36±0.04	0.76±0.05	5.40±1.12
	II	Te	77.81±6.31	3.09±0.26	19.30±1.64	5.62±2.34	11.43±2.88	2.71±1.81	0.72±0.13	4.38±0.69
		St	65.41±6.21	3.02±0.21	18.90±1.29	6.90±2.87	11.67±2.92	2.63±1.72	0.76±0.14	5.35±0.86
		Ma	48.10±6.79	2.80±0.18	17.48±1.12	12.53±5.2	11.77±2.88	2.71±1.77	0.75±0.20	6.54±1.30
	Mean		63.77±14.9	2.97±0.15	18.56±0.96	8.35±3.68	11.62±0.18	2.68±0.05	0.74±0.02	5.42±1.08
	III	Te	80.16±2.80	2.83±0.24	17.90±1.36	4.10±1.71	10.62±0.78	1.21±0.10	0.70±0.13	4.09±0.62
		St	68.05±2.64	2.82±0.26	17.25±1.52	5.50±2.29	10.92±0.86	1.23±0.10	0.66±0.13	3.90±0.47
		Ma	47.84±1.85	2.46±0.25	15.58±1.40	8.15±3.39	11.01±0.94	1.15±0.11	0.58±0.10	4.25±0.18
	Mean		65.35±16.3	2.70±0.21	16.91±1.20	5.92±2.06	10.85±0.20	1.20±0.04	0.65±0.06	4.08±0.18
	Leaf type mean	Te	79.09±1.19	2.86±0.21	18.00±1.13	4.71±0.81	12.44±2.48	2.09±0.78	0.73±0.03	4.26±0.15
		St	67.12±1.48	2.77±0.28	17.17±1.78	6.08±0.73	12.69±2.45	2.09±0.75	0.74±0.07	4.87±0.84
		Ma	47.16±1.42	2.58±0.19	16.13±1.17	10.16±2.2	12.61±2.41	2.06±0.81	0.68±0.09	5.77±1.32
	Annual mean		64.45±16.1	2.73±0.14	17.10±0.94	6.98±2.84	12.61±0.13	2.08±0.02	0.72±0.03	4.97±0.76
F	Leaf type (L)		396.20***	106.75***	104.13***	891.50***	81.76***	6.24**	12.17***	423.45***
	Season (S)		75.96***	218.77***	204.23***	13.47***	167.21***	99.01***	36.48***	49.00***
	Host plant(H)		0.26NS	9.06***	7.10***	2.82NS	7.11***	2.11NS	6.43**	5.42**
	L x S		930.39***	61.13***	121.13***	703.70***	8.46**	0.34NS	21.21***	55.92***
	L x H		2.36NS	138.18***	262.89***	111.02***	2301.68***	620.57***	65.64***	56.96***
	S x H		2.16NS	8.46***	9.85***	22.99***	1.52NS	0.79NS	10.06***	11.11***
	L x S x H		128.99***	192.03***	3.93*	5.33*	122.98***	66.29***	42.44***	12.65***
CV %			3.48	2.91	2.11	6.5	1.69	6.39	4.34	8.7

(* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Non significant)**

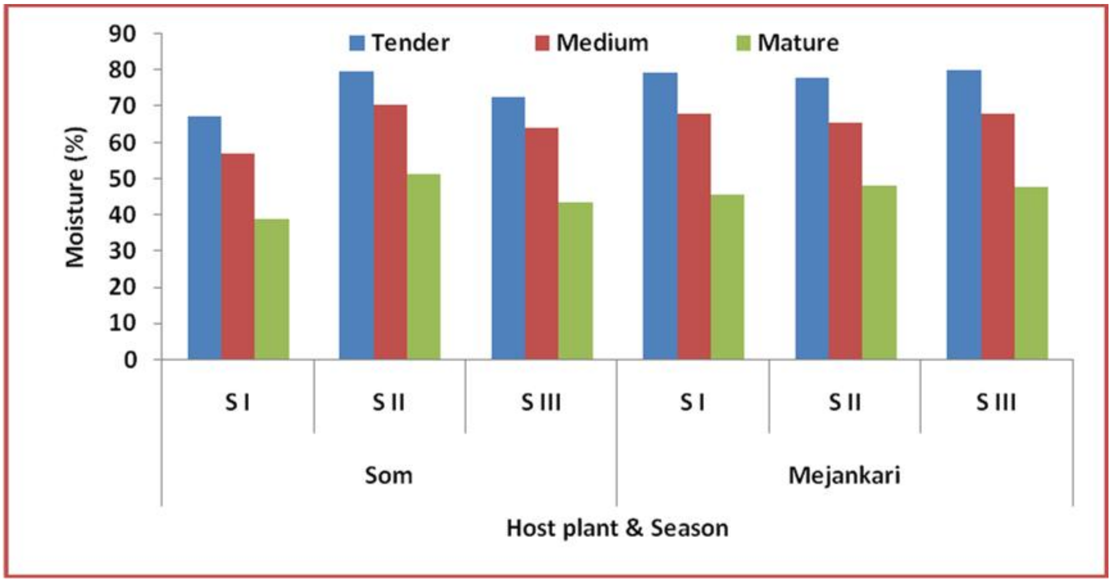


Fig. 23 (A) Moisture content in three leaf types of two host plants in different seasons in Nagaland

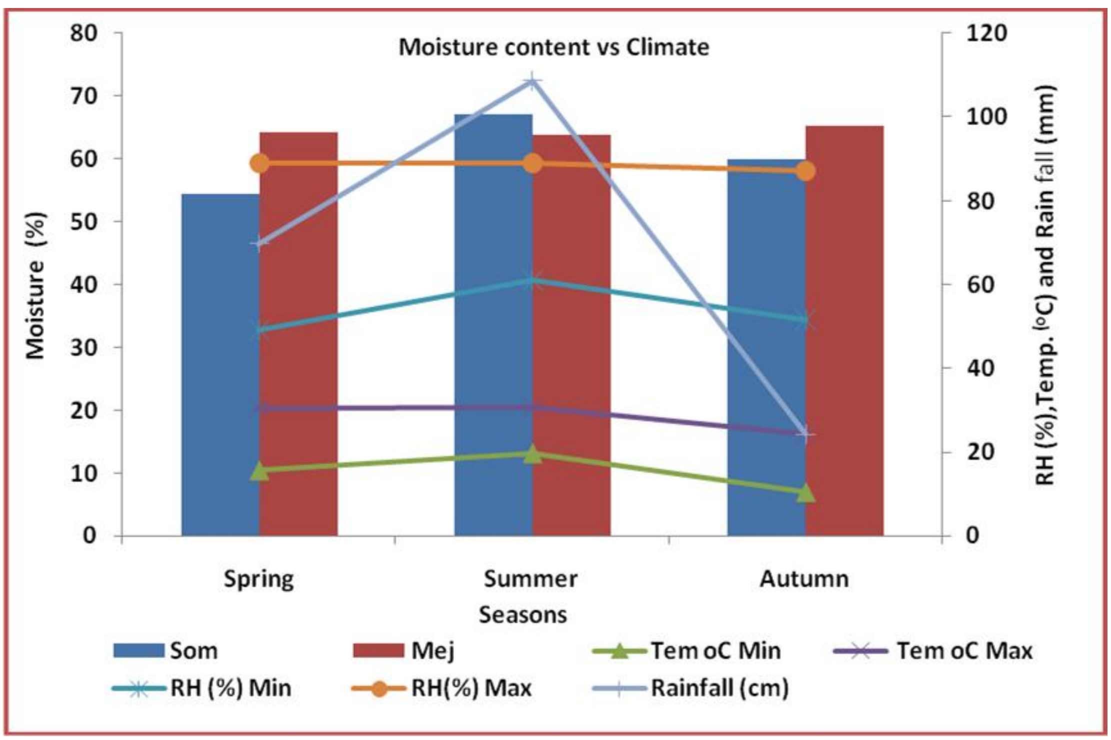


Fig.23 (B) Mean leaf moisture content of primary (Som) and secondary (Mejankari) host plants in relation to seasonal climatic variation in Nagaland

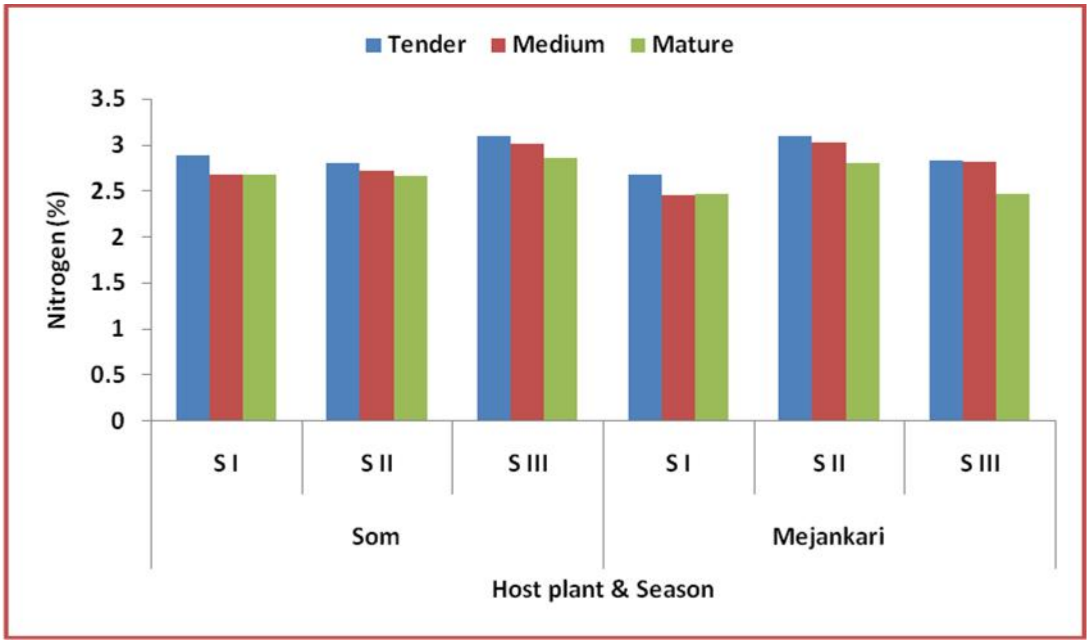


Fig. 24 (A) Nitrogen content in three leaf types of two host plants in different seasons in Nagaland

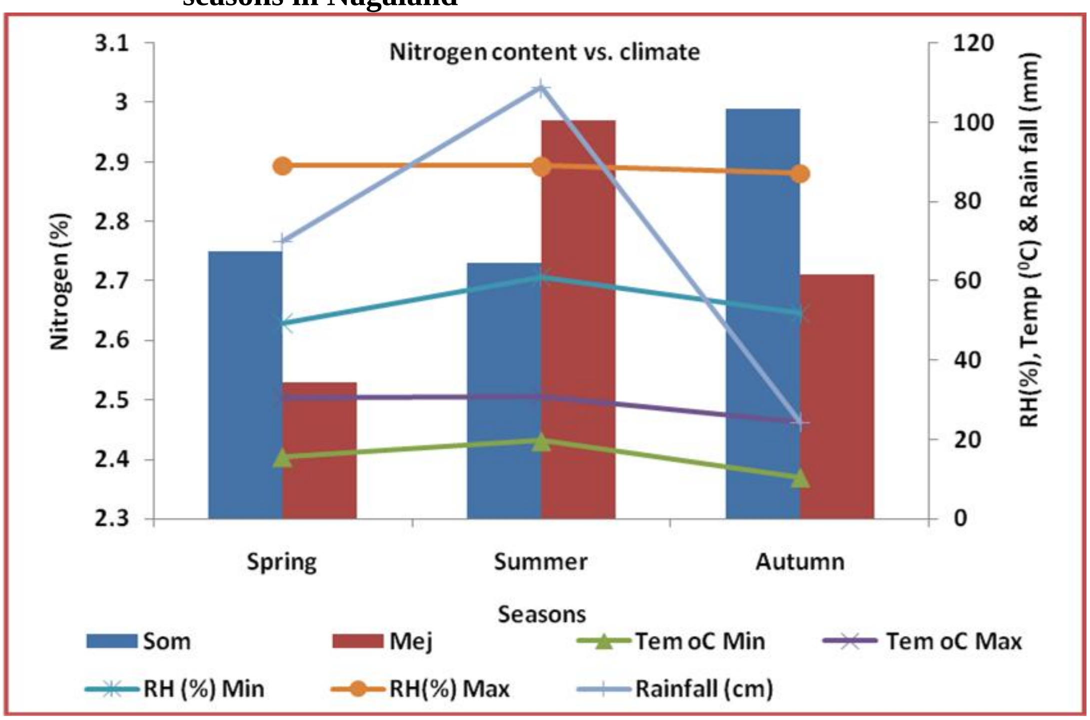


Fig. 24 (B) Mean leaf nitrogen content of primary (Som) and secondary (Mejankari) host plants in relation to seasonal climatic variation in Nagaland

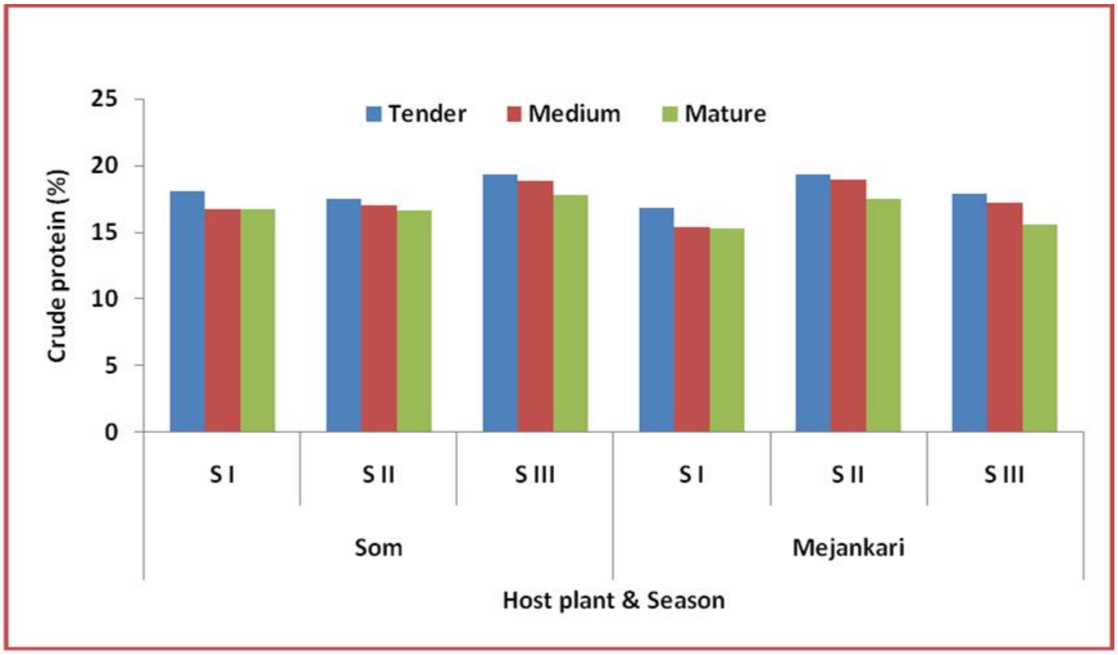


Fig. 25 (A) Crude protein content in three leaf types of two host plants in different seasons in Nagaland

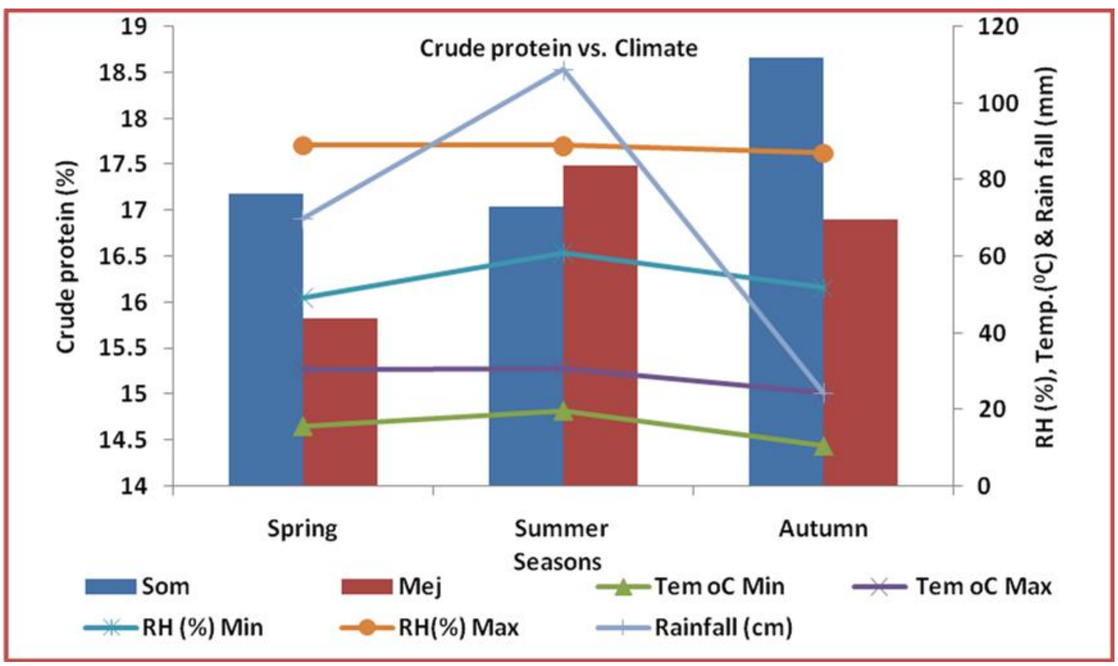


Fig. 25 (B) Mean leaf crude protein content of primary (Som) and secondary (Mejankari) host plants in relation to seasonal climatic variation in Nagaland

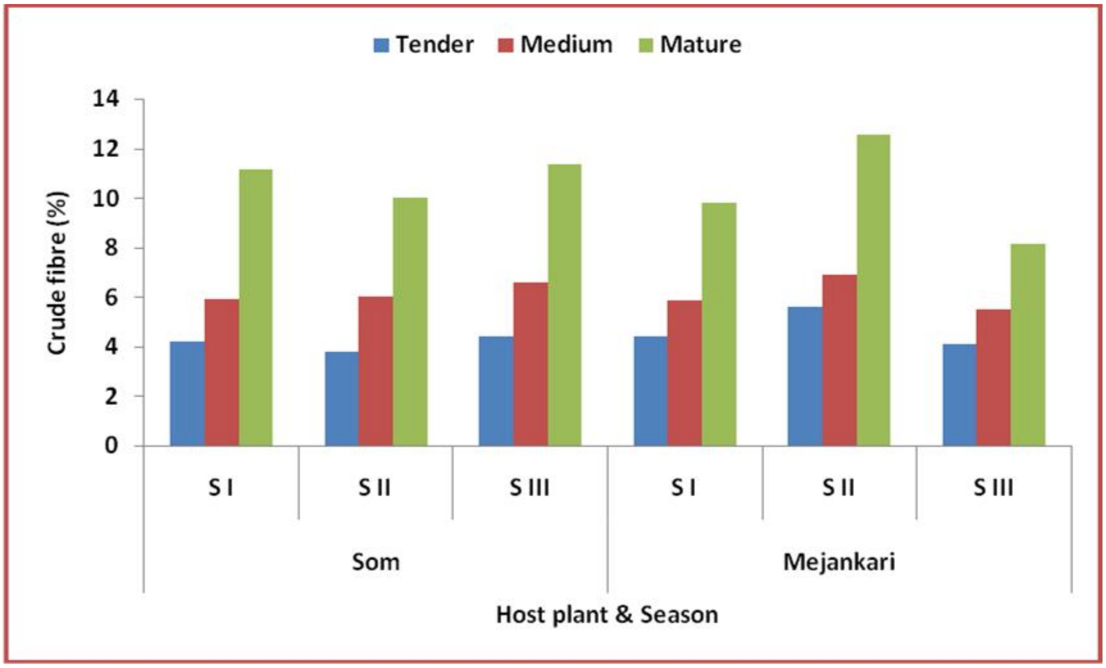


Fig. 26 (A) Crude fibre content in three leaf types of two host plants in different seasons in Nagaland

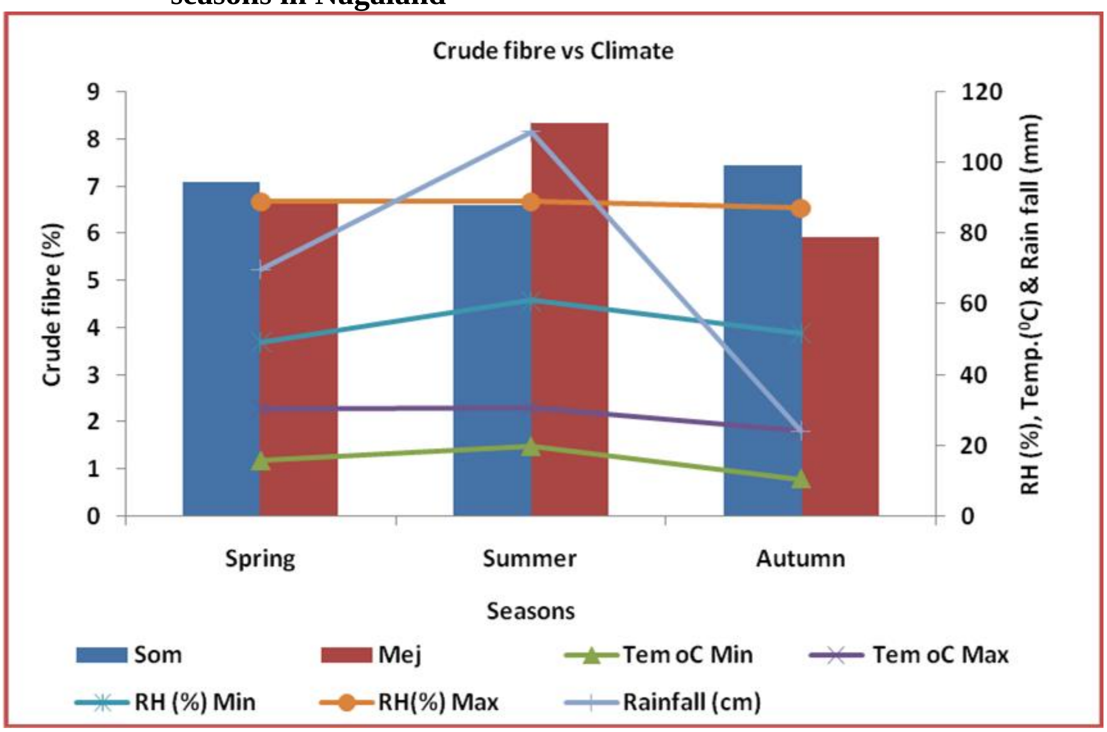


Fig. 26 (B) Mean leaf crude fibre content of primary (Som) and secondary (Mejankari) host plants in relation to seasonal climatic variation in Nagaland

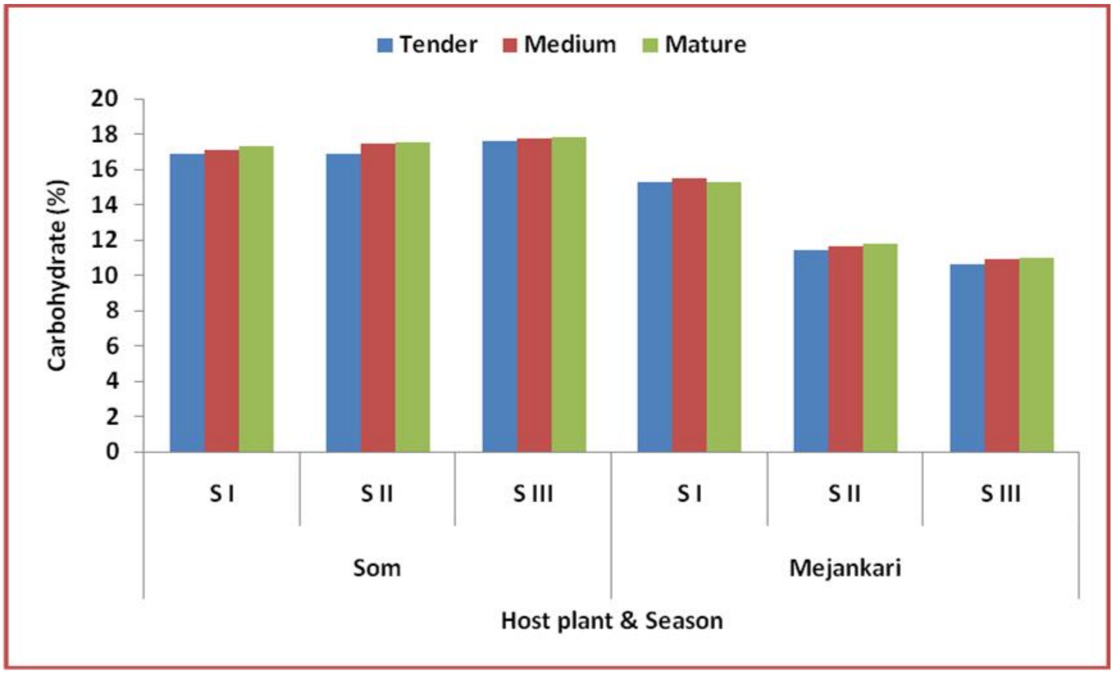


Fig.27 (A) Carbohydrate content in three leaf types of two host plants in different seasons in Nagaland

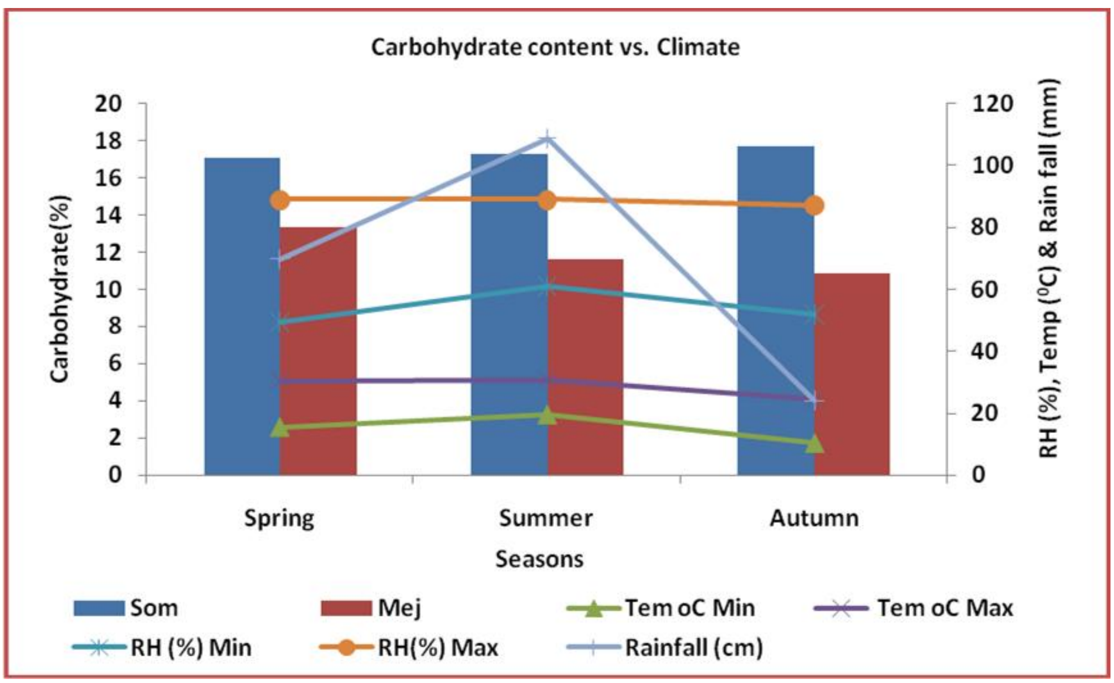


Fig.27 (B) Mean leaf carbohydrate content of primary (Som) and secondary (Mejankari) host plants in relation to seasonal climatic variation in Nagaland

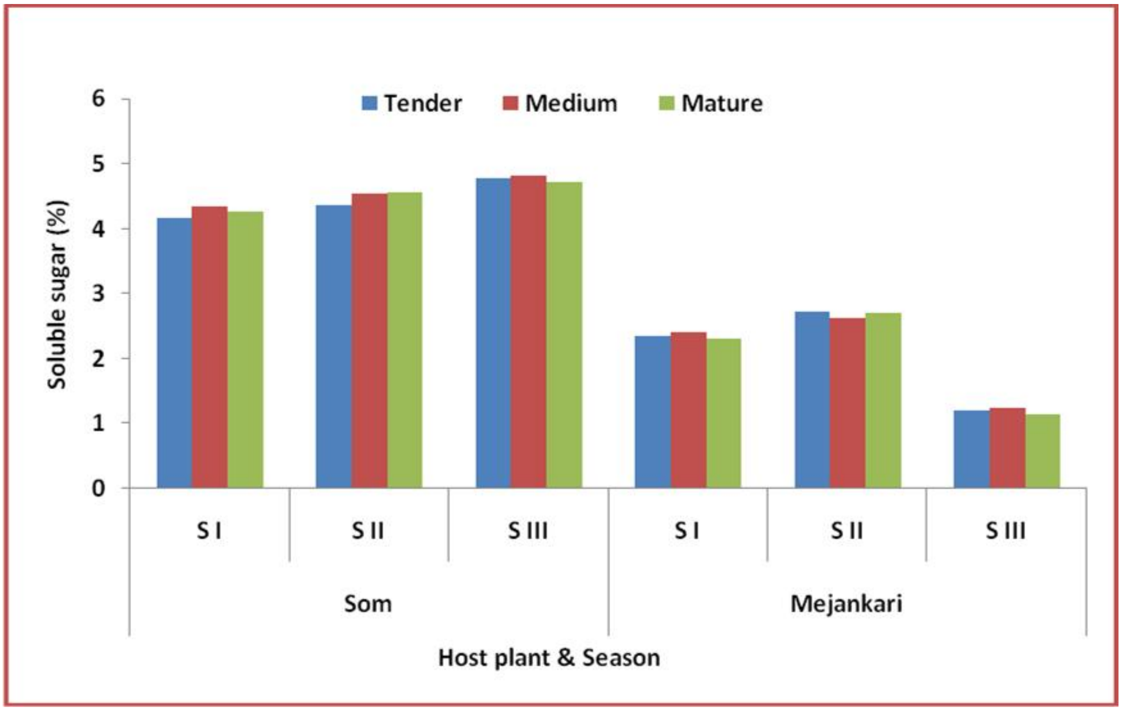


Fig. 28 (A) Soluble sugar content in three leaf types of two host plants in different seasons in Nagaland

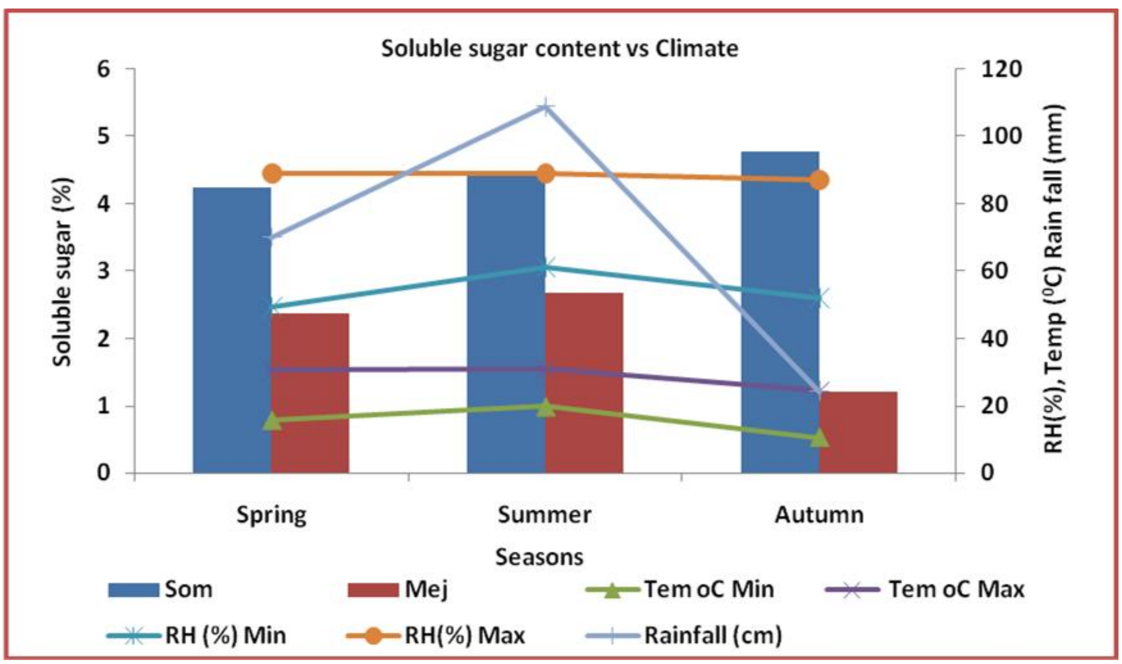


Fig. 28 (B) Mean leaf soluble sugar content of primary (Som) and secondary (Mejankari) host plants in relation to seasonal climatic variation in Nagaland

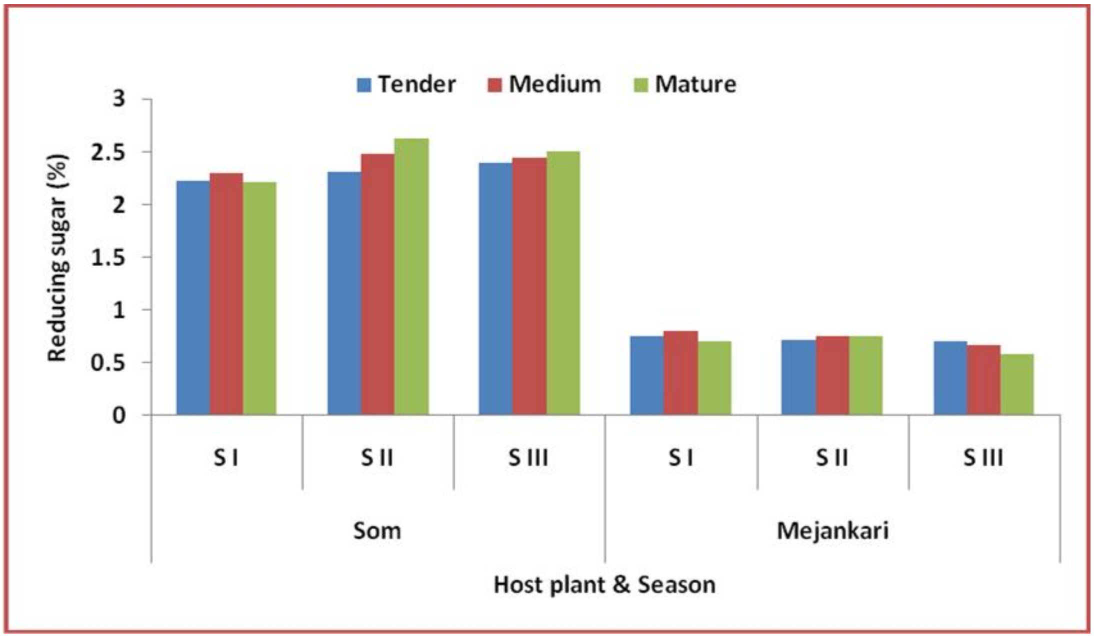


Fig. 29(A) Reducing sugar content in three leaf types of two host plants in different seasons in Nagaland

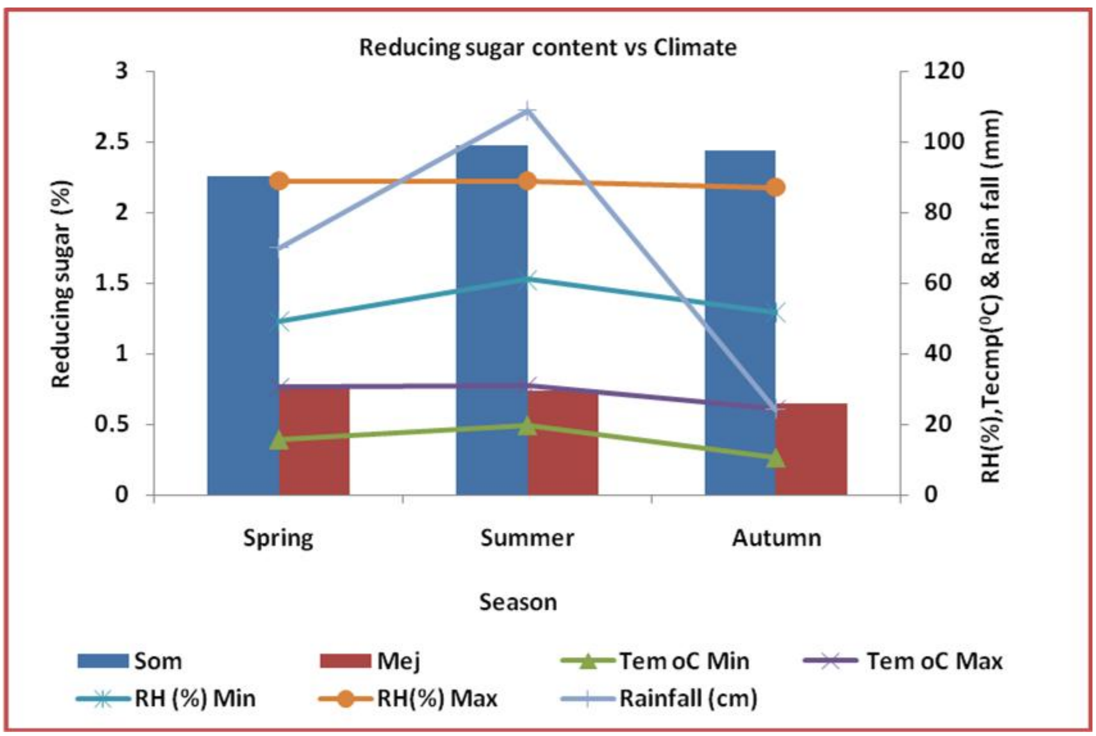


Fig.29(B) Mean leaf reducing sugar content of primary (Som) and secondary (Mejankari) host plants in relation to seasonal climatic variation in Nagaland

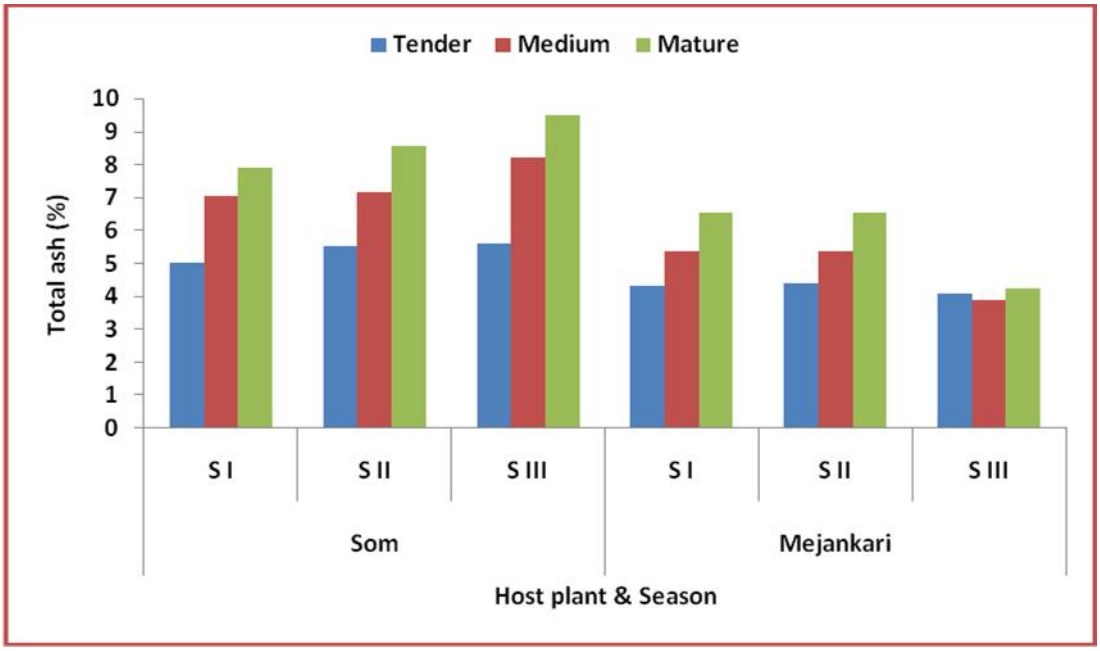


Fig. 30 (A) Total ash content in three leaf types of two host plants in different seasons in Nagaland

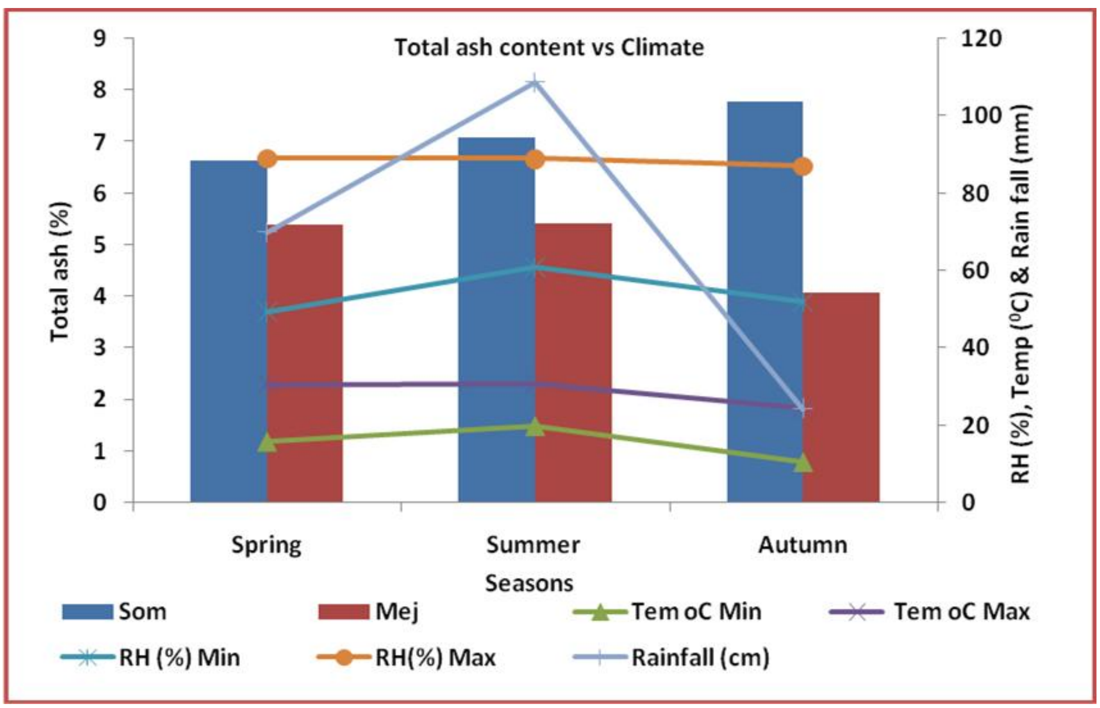


Fig. 30 (B) Mean leaf total ash content of primary (Som) and secondary (Mejankari) host plants in relation to seasonal climatic variation in Nagaland

Group C: Altitudinal variation on foliar constituents

Lower altitude: North Lakhimpur (135 amsl)

Higher altitude: Mokokchung (1325 amsl)

Host plant: *Persea bombycina* (Som)

Foliar constituents of different leaf types of the *Persea bombycina* between North Lakhimpur (Lower altitude) and Mokokchung (Higher altitude) estimated for three rearing seasons are given in **Table 5.**

A declining trend in the moisture, nitrogen, and protein content was observed from tender to mature leaves in all seasons in both locations. However, except for slightly higher amount of soluble sugar content in medium leaves, the reverse trend was obtained in respect of crude fibre, carbohydrate, reducing sugar and total ash in all seasons and locations. The seasonal and annual pooled average values of moisture, nitrogen, protein and crude fibre of all leaf types and different seasons in lower altitude (North Lakhimpur) was more than higher altitude (Mokokchung) in respective seasons and total annual mean **(Fig. 31).**

The mean annual moisture content for all leaf type in North Lakhimpur (68.89±0.74%) was recorded to be higher than Mokokchung (60.47±14.65%) exhibiting highly significant difference. Moisture content was found to be more in summer season (71.15±8.93% and 67.13±14.58%) followed by autumn (67.96±0.32% and 59.96±14.89%) and spring (67.56±10.40% and 54.33±14.51%) seasons in North Lakhimpur and Mokokchung respectively. Higher rainfall and relative humidity along with the effect of soil moisture during summer season may be accounted for higher moisture content in North Lakhimpur. While interaction effect due to leaf type x locations was highly significant, there was no significant difference on interaction effect due to leaf type x seasons and season x locations. However combined effect of leaf type x season x locations was found to be highly significant at 0.1% probability level **(Fig. 32).**

Similarly mean annual nitrogen and protein content for all leaf types and seasons were higher in North Lakhimpur (3.63±0.43% and 22.65±0.57%) than Mokokchung (2.82±0.13% and 18.73±0.64%) exhibiting highly significant difference among leaf types, seasons and locations. It may be due to translocation of more nitrogen from soil in North Lakhimpur which had higher concentration being plain area, than in Mokokchung where nitrogen may be leaching being hilly region. Morecroft *et al*. (1992) reported that nitrogen concentration in plants increased with altitudinal gradient and the variations in nitrogen content may partly be attributed to re-translocation of leaf nitrogen into branches before leaf fall and partly due to a dilution factor with expansion and maturity of the leaves (Khosla *et al*., 1992).

However, Singh *et al*. (2010) observed significant positive correlation between crude protein content and altitude in the adult foliage, and did not find significant relationship in juvenile foliages in *Celtis australis* L., a fodder tree species of Central Himalaya, India. Interaction effect due to leaf type x seasons,

seasons x locations and leaf type x locations was highly significant. However combined effect of leaf type x season x locations for nitrogen was found to be highly significant, while it was just significant in case of protein content **(Fig. 33 and 34).**

Crude fibre increased along with the maturity of leaf in both sites without marked difference in seasonal pattern **(Fig. 35).** Seasonally North Lakhimpur retained more crude fibre in summer season (16.31±4.53%) while Mokokchung had maximum during autumn season (7.45±3.57%). The seasonal fluctuation in both sites exhibited highly significant difference ($P < 0.1$) and observed in the order of summer>autumn>spring in the case of North Lakhimpur and in the order of autumn>spring > summer in the case of Mokokchung. The mean annual crude fibre content was also recorded higher in North Lakhimpur (13.95±0.85%) than Mokokchung (7.05±3.46%). The interaction effect due to leaf type x season, leaf type x location and season x location was highly significant at 0.1 % probability level; however, combined effect of leaf type x season x location was significant at 5 %. In a fodder tree of Central Himalaya, Singh *et al*. (2010) recorded significant positive correlation between crude fibre (CF) and altitude of juvenile foliage, indicating increasing trend of CF with an increasing altitude.

Highly significant difference in the pooled annual carbohydrate content for all leaf types was recorded between North Lakhimpur (11.78±0.84%) and Mokokchung (17.36±0.23%) which was also in accordance with the findings of

Singh *et al*. (2010) exhibiting significant positive correlation between starch content and altitude of foliage. Seasonally North Lakhimpur retained more carbohydrate in summer season (11.89±0.14%) while Mokokchung had maximum during autumn season (17.72±0.13%). The seasonal fluctuation in both sites exhibited highly significant difference (P< 0.1) and observed in the order of summer>autumn>spring in the case of North Lakhimpur and in the order of autumn>summer>spring in the case of Mokokchung **(Fig.36)**.

Except for the summer Season, both soluble and reducing sugar content were recorded to be more in higher altitude than lower altitude. The mean annual total soluble sugar and reducing sugar content was found to be higher in Mokokchung (4.50±0.07% and 2.39±0.07%) than in North Lakhimpur (4.36±0.66% and 2.36±0.77 %) and exhibited high interaction effect due to leaf type x season, leaf type x location and season x location except for leaf type x season in soluble sugar. Singh *et al.* (2010) also observed significant inverse correlation between soluble sugar content and elevation range of foliage, indicating decreasing trend of sugars with increasing altitude. However combined effect of leaf x season x locations was highly significant **(Fig. 37 and 38).**

The percentage of total ash was also increasing from tender leaf to mature leaf in all seasons in both locations. The variability of ash content of the leaves as a whole for both sites was found to be highly significant with regard to seasonal fluctuation (P<0.01) and was observed in the order of summer>autumn>spring in

North Lakhimpur and in the order of autumn>summer>spring in Mokokchung. While the host plant in Mokokchung retained more ash content than North Lakhimpur in all seasons, the mean total ash content was found to be higher in former (7.17$\pm$1.65%) than later (4.33$\pm$0.54%) reflecting highly significant combined effect of leaf types, seasons and host plants **(Fig. 39).**

From the present investigation, it is well documented that there is strong seasonality and correlation between altitude and nutritive value of silk worm host plant. Altitude has significant influence on the chemical composition of different leaf types of *Persea bombycna.* On average, foliages in higher altitude exhibited comparatively higher values for carbohydrate, soluble sugar, reducing sugar and total ash whereas, the foliages of lower altitude revealed higher value for moisture, total nitrogen, crude protein and crude fibre content. Based on the present findings, it has been observed that *Persea bombycina* located in higher altitude i.e. Mokokchung, the non traditional zone is nutritionally at par with the traditional zone of located in Lower altitude i.e. North Lakhimpur and is suitable for muga silkworm rearing.

Table 5: Variation of foliar constituents of *Persea bombycina* between lower--North Lakhimpur (NLP) and higher–Mokokchung (MKG) altitude

(Te=Tender; St=Semitender; Ma=Mature)

Site	Sea son	Leaf Type	Nutrient content (Mean ± SE) all in percentage							
			Moisture	**Nitrogen**	**Crude protein**	**Crude fibre**	**Carboh-ydrate**	**Soluble sugar**	**Reducing sugar**	**Total ash**
NLP	**I**	Te	83.78±1.25	3.51±0.07	21.89±0.44	7.15±0.03	11.53±0.02	4.01±0.03	2.14±0.02	3.04±0.05
		St	70.80±1.50	3.26±0.09	20.34±0.59	10.05±0.12	11.69±0.05	4.18±0.02	2.14±0.03	4.24±0.03
		Ma	48.09±0.63	3.24±0.06	20.22±0.37	19.01±0.05	11.84±0.06	4.11±0.07	2.13±0.05	4.76±0.16
	Mean		**67.56±10.4**	**3.33±0.09**	**20.82±0.54**	**12.07±3.57**	**11.69±0.09**	**4.10±0.05**	**2.14±0.03**	**4.01±0.51**
	II	Te	84.62±2.01	4.06±0.06	25.30±0.38	9.29±0.04	11.62±0.15	4.50±0.12	2.41±0.13	3.49±0.05
		St	74.59±2.57	3.93±0.04	24.57±0.27	14.87±0.07	11.99±0.14	4.68±0.13	2.59±0.13	4.60±0.08
		Ma	54.26±0.38	3.85±0.02	23.91±0.20	24.77±0.29	12.07±0.14	4.70±0.17	2.74±0.11	5.48±0.06
	Mean		**71.15±8.93**	**3.95±0.06**	**24.59±0.40**	**16.31±4.53**	**11.89±0.14**	**4.63±0.06**	**2.58±0.10**	**4.52±0.57**
	III	Te	82.16±1.24	3.74±0.13	23.36±0.80	7.90±0.18	11.69±0.03	4.36±0.03	2.28±0.04	3.20±0.05
		St	72.48±0.71	3.64±0.12	22.75±0.72	11.95±0.71	11.76±1.70	4.39±0.04	2.34±0.05	4.74±0.20
		Ma	49.24±0.21	3.45±0.14	21.55±0.87	20.53±0.67	11.81±0.03	4.30±0.06	2.39±0.05	5.43±0.03
	Mean		**67.96±0.32**	**3.61±0.26**	**22.55±0.31**	**13.46±0.27**	**11.76±0.30**	**4.35±0.16**	**2.34±0.16**	**4.45±0.15**
	Leaf type mean	Te	83.52±0.73	3.77±0.21	23.52±0.72	8.11±0.67	11.61±0.55	4.29±0.34	2.28±0.43	3.24±0.45
		St	72.62±0.54	3.61±0.57	22.55±0.67	12.29±0.87	11.81±0.76	4.42±0.45	2.36±0.65	4.53±0.34
		Ma	50.53±0.91	3.51±0.62	21.89±0.81	21.44±0.69	11.91±0.89	4.37±0.54	2.42±0.51	5.22±0.25
	Annual mean		**68.89±0.74**	**3.63±0.43**	**22.65±0.57**	**13.95±0.85**	**11.78±0.84**	**4.36±0.66**	**2.35±0.77**	**4.33±0.54**
MKG	**I**	Te	67.39±2.40	2.89±0.32	18.07±2.03	4.20±1.749	16.85±0.92	4.16±0.31	2.23±0.26	5.03±0.16
		St	56.89±1.51	2.68±0.26	16.75±1.63	5.89±2.46	17.09±0.90	4.33±0.27	2.30±0.27	7.04±0.36
		Ma	38.71±1.92	2.67±0.31	16.70±1.95	11.17±4.65	17.29±1.00	4.26±0.30	2.21±0.10	7.88±0.36
	Mean		**54.33±14.5**	**2.75±0.12**	**17.17±0.78**	**7.09±3.64**	**17.08±0.22**	**4.25±0.08**	**2.25±0.04**	**6.65±1.46**
	II	Te	79.84±4.20	2.80±0.27	17.51±1.74	3.76±1.57	16.90±0.64	4.37±0.30	2.30±0.12	5.52±0.47
		St	70.35±5.16	2.72±0.30	17.03±1.85	6.02±2.51	17.43±0.50	4.54±0.34	2.47±0.12	7.18±0.48
		Ma	51.21±1.07	2.67±0.32	16.59±1.96	10.02±4.18	17.55±0.55	4.56±0.40	2.63±0.16	8.55±0.71
	Mean		**67.13±14.6**	**2.73±0.07**	**17.04±0.46**	**6.60±3.170**	**17.29±0.35**	**4.49±0.10**	**2.50±0.17**	**7.08±1.52**
	III	Te	72.41±5.21	3.09±0.16	19.34±0.98	4.39±1.83	17.59±0.63	4.77±0.17	2.39±0.09	5.59±0.49
		St	64.01±6.09	3.01±0.16	18.83±0.99	6.59±2.75	17.73±0.57	4.81±0.25	2.44±0.11	8.23±0.25
		Ma	43.46±3.66	2.85±0.15	17.81±0.95	11.38±4.74	17.84±0.56	4.72±0.25	2.50±0.10	9.48±0.80
	Mean		St	**2.98±0.12**	**18.66±0.78**	**7.45±3.57**	**17.72±0.13**	**4.77±0.05**	**2.44±0.06**	**7.77±1.99**
	Leaf Type mean	Te	73.21±6.26	2.98±0.12	18.31±0.94	4.12±0.32	17.11±0.41	4.43±0.31	2.31±0.08	5.38±0.31
		St	63.75±6.73	2.80±0.18	17.54±1.13	6.17±0.37	17.42±0.32	4.56±0.24	2.40±0.09	7.48±0.65
		Ma	44.46±6.31	2.73±0.10	17.03±0.68	10.86±0.73	17.56±0.28	4.51±0.23	2.45±0.22	8.64±0.80
	Annual mean		**60.47±14.7**	**2.84±0.13**	**17.63±0.64**	**7.05±3.46**	**17.36±0.23**	**4.50±0.07**	**2.39±0.07**	**7.17±1.65**
F	Leaf type (L)		433.54***	100.17***	106.99***	5096.71***	88.08***	6.49**	13.62***	521.80***
	Season (S)		5.96**	575.64***	574.49***	512.01***	42.51***	110.04***	130.25***	39.56***
	Host plant(H)		433.54***	48.60***	103.70***	310.78***	10.12***	59.16***	26.68***	60.91***
	L x S		1.088NS	5.438**	5.420**	35.884***	11.472***	2.321NS	6.329**	4.146*
	L x H		5.96**	69.14***	132.70***	30.81***	712.08***	263.57***	110.49***	25.72***
	S x H		1.09NS	7.85***	9.40***	4.52**	1.82NS	68.56***	10.75***	9.90***
	L x S x H		128.99***	192.03***	3.93*	5.33*	122.98***	66.29***	42.44***	12.65***
CV%			**4.97**	**1.5**	**1.48**	**2.90**	**0.58**	**2.47**	**3.53**	**4.3**

(* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Non significant)**

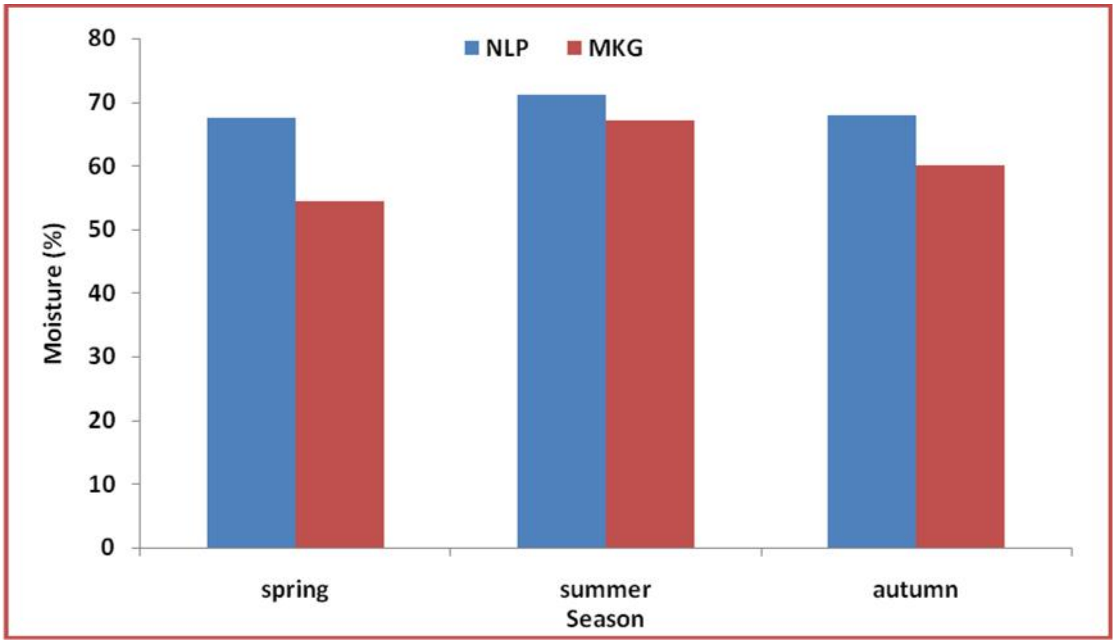


Fig. 31 (A) Seasonal variation of foliar moisture content between North Lakhimpur (NLP) and Mokokchung (MKG)

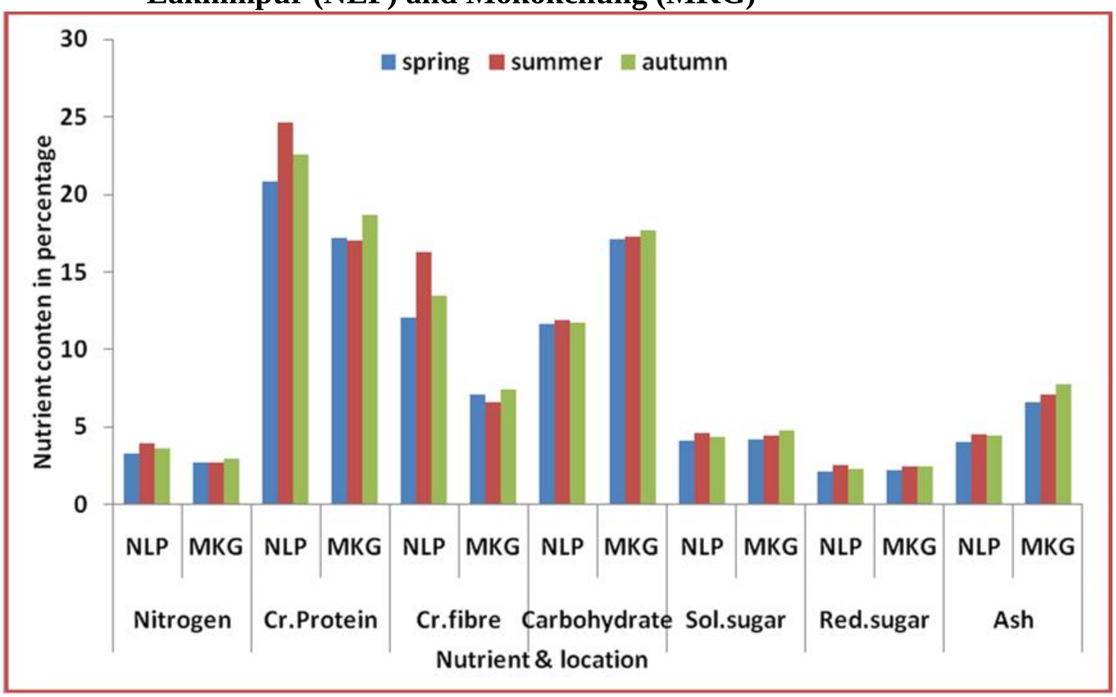


Fig. 31(B) Seasonal variation of foliar nutrient content between North Lakhimpur (NLP) and Mokokchung (MKG)

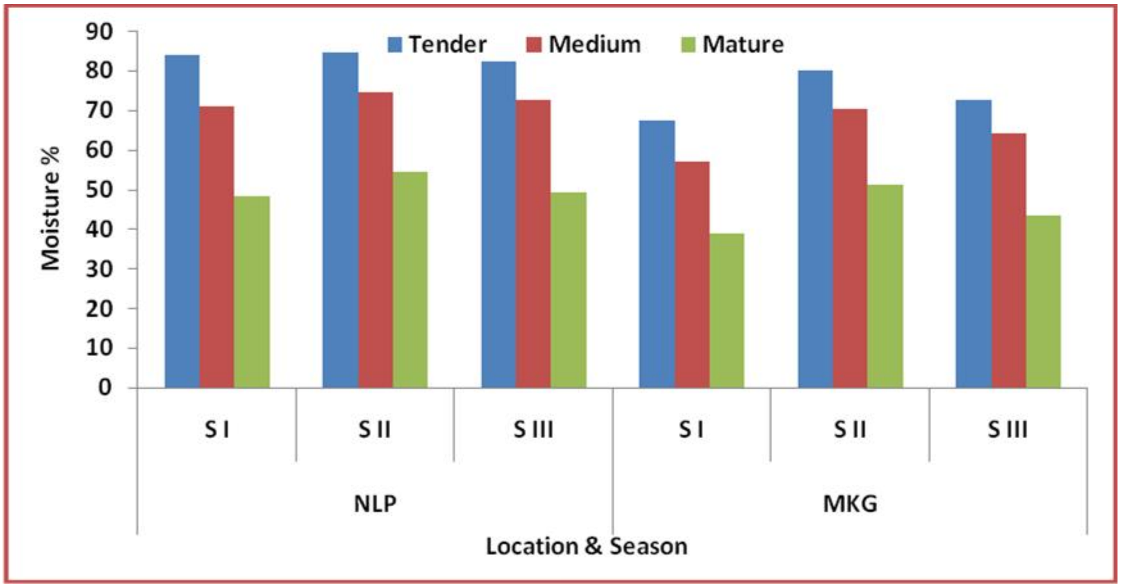


Fig. 32 (A) Seasonal variation of moisture content in three leaf types of Som host plant between North Lakhimpur (NLP) and Mokokchung (MKG)

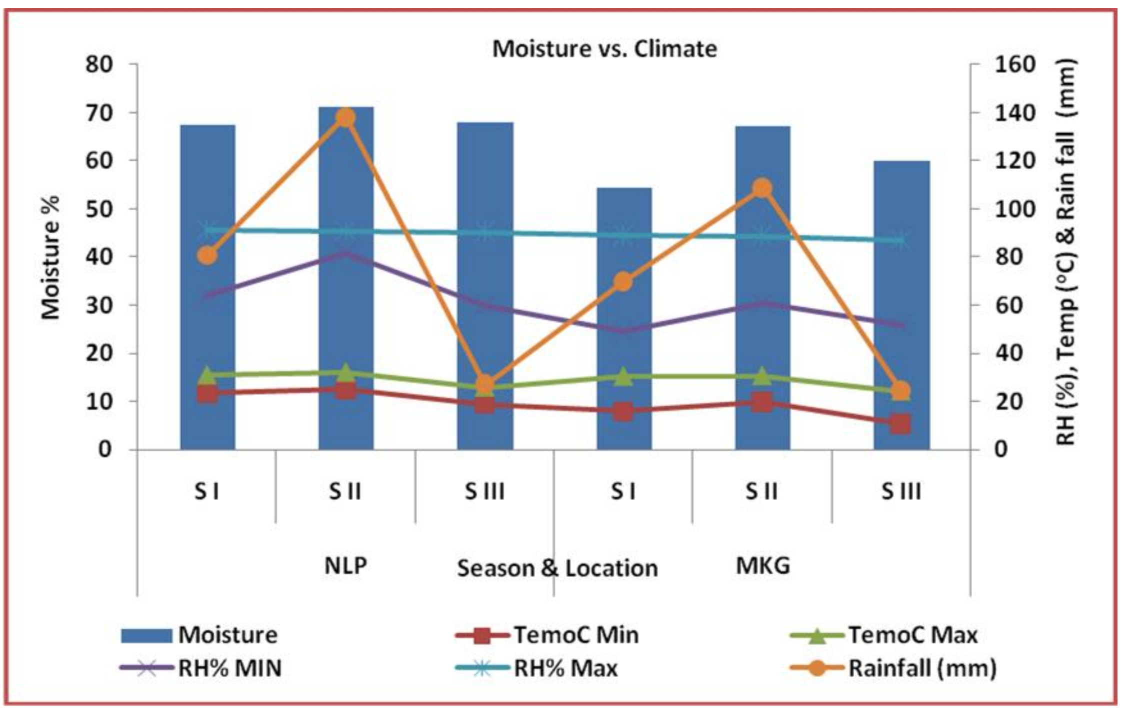


Fig. 32 (B) Mean leaf moisture content of Som host plant in relation to seasonal climatic variation between North Lakhimpur (NLP) and Mokokchung (MKG)

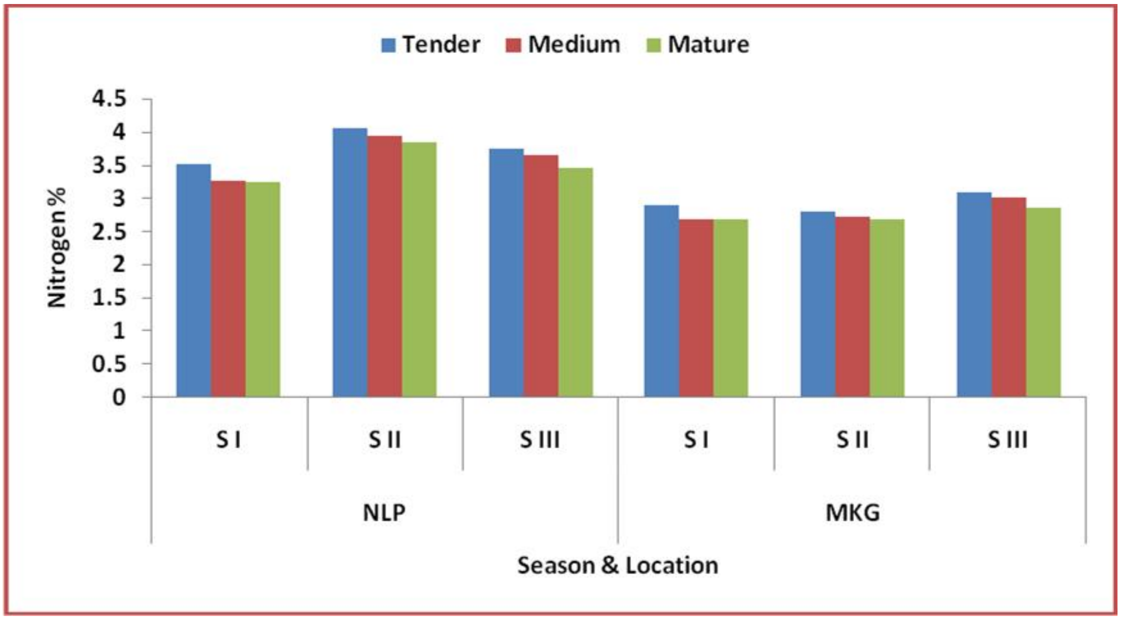


Fig. 33 (A) Seasonal variation of nitrogen content in three leaf types of Som host plant between North Lakhimpur (NLP) and Mokokchung (MKG)

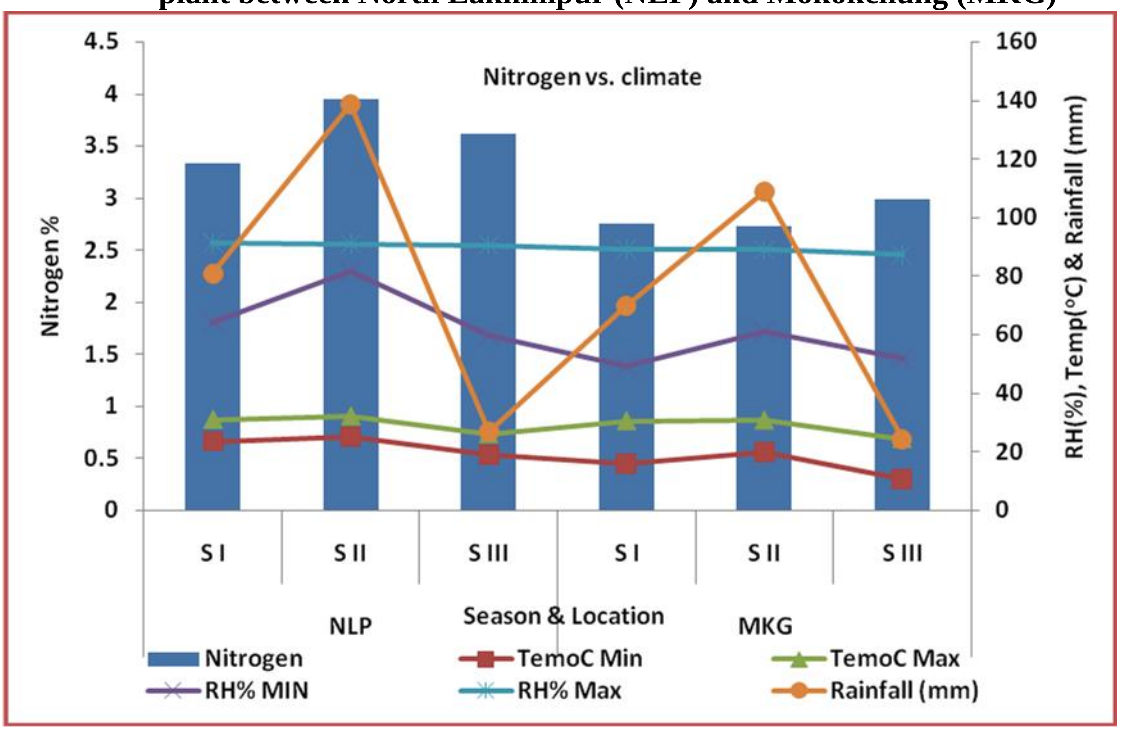


Fig. 33 (B) Mean leaf nitrogen content of Som host plant in relation to seasonal climatic variation between North Lakhimpur (NLP) and Mokokchung (MKG)

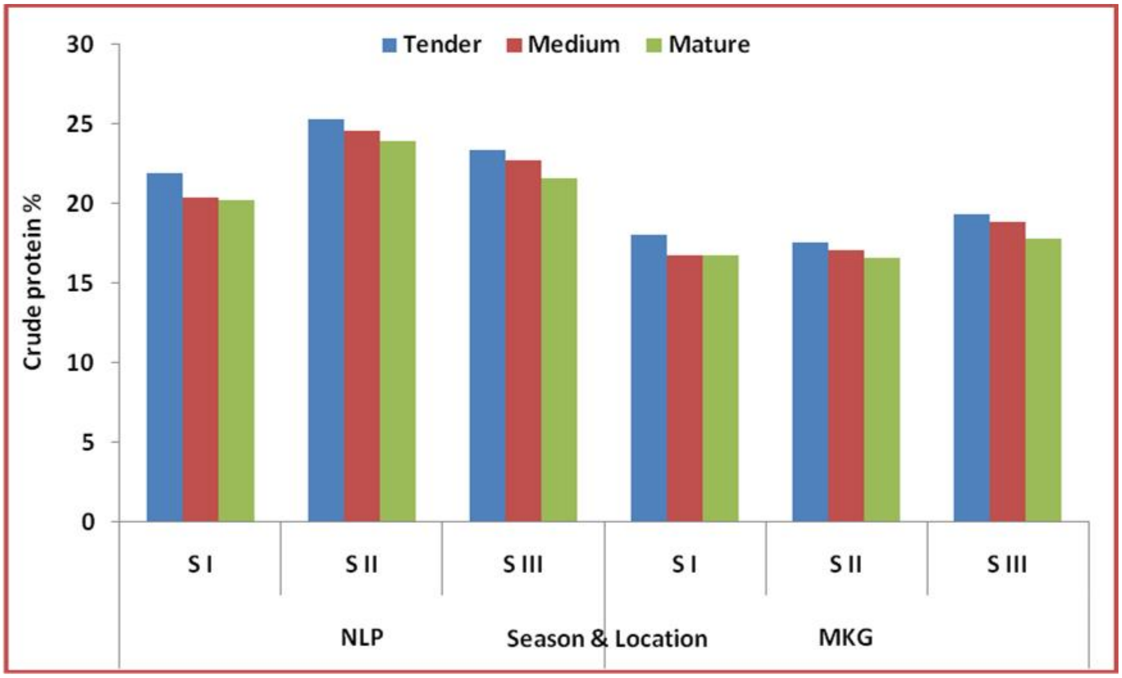


Fig. 34 (A) Seasonal variation of crude protein in three leaf types of Som host plant between North Lakhimpur (NLP) and Mokokchung (MKG)

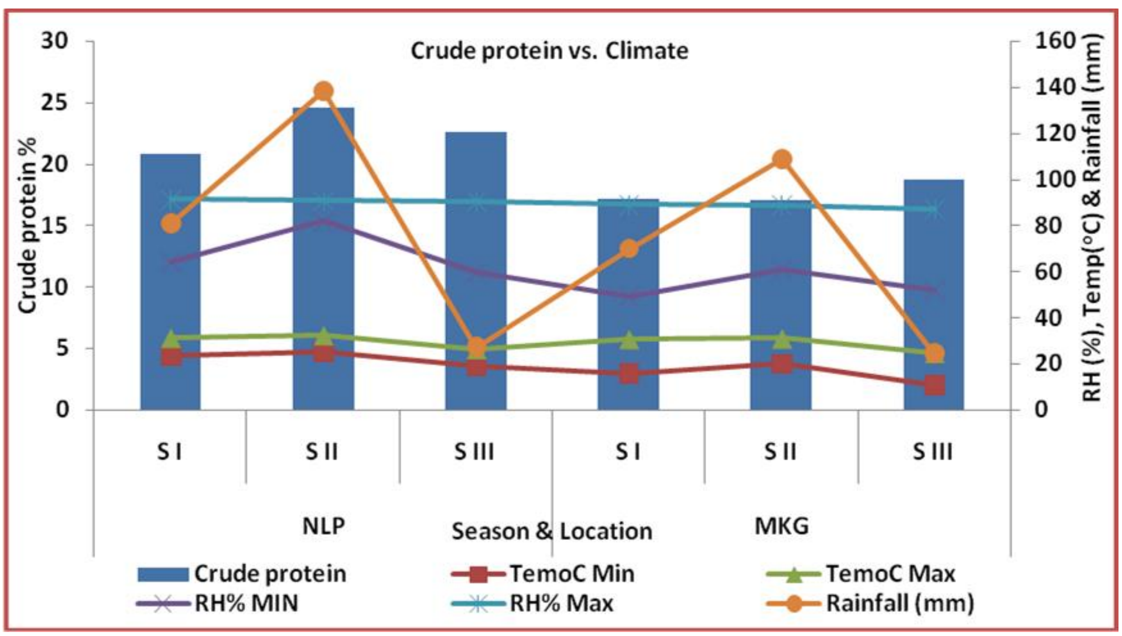


Fig. 34 (B) Mean leaf crude protein content of Som host plant in relation to seasonal climatic variation between North Lakhimpur (NLP) and Mokokchung (MKG)

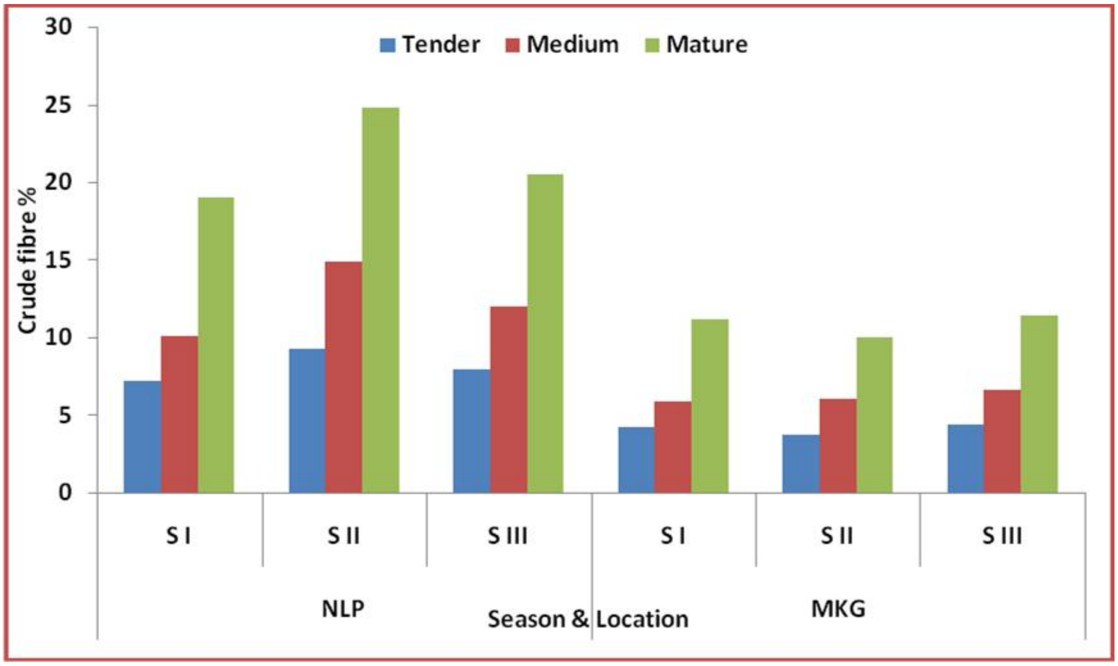


Fig. 35 (A) Seasonal variation of crude fibre in three leaf types of Som host plant between North Lakhimpur (NLP) and Mokokchung (MKG)

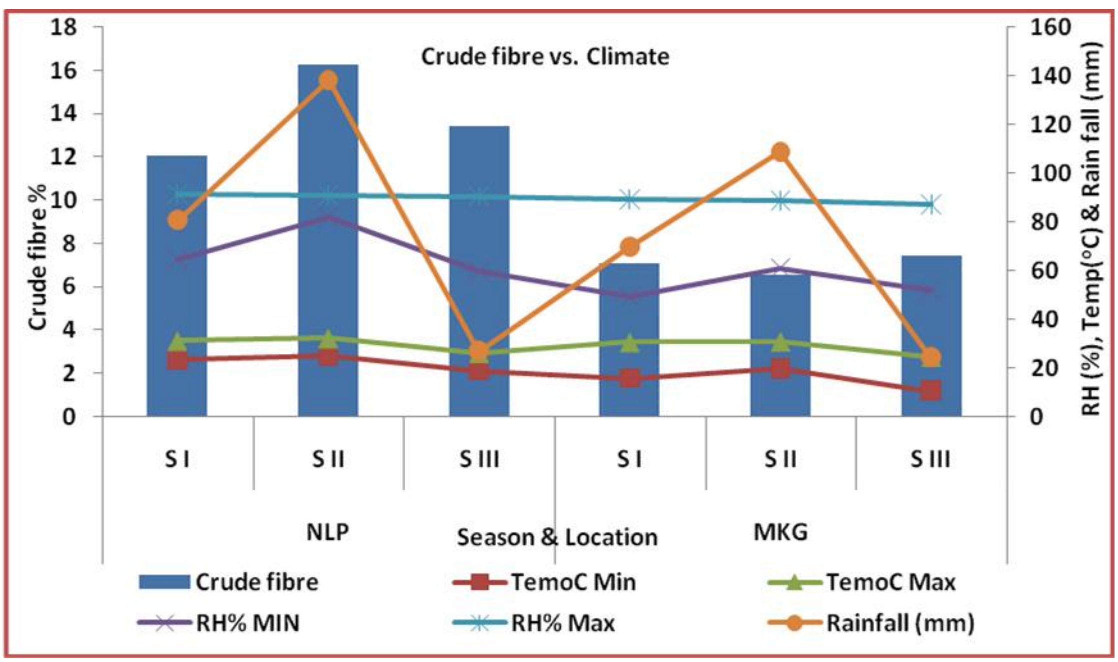


Fig. 35 (B) Mean leaf crude fibre content of Som host plant in relation to seasonal climatic variation between North Lakhimpur (NLP) and Mokokchung (MKG

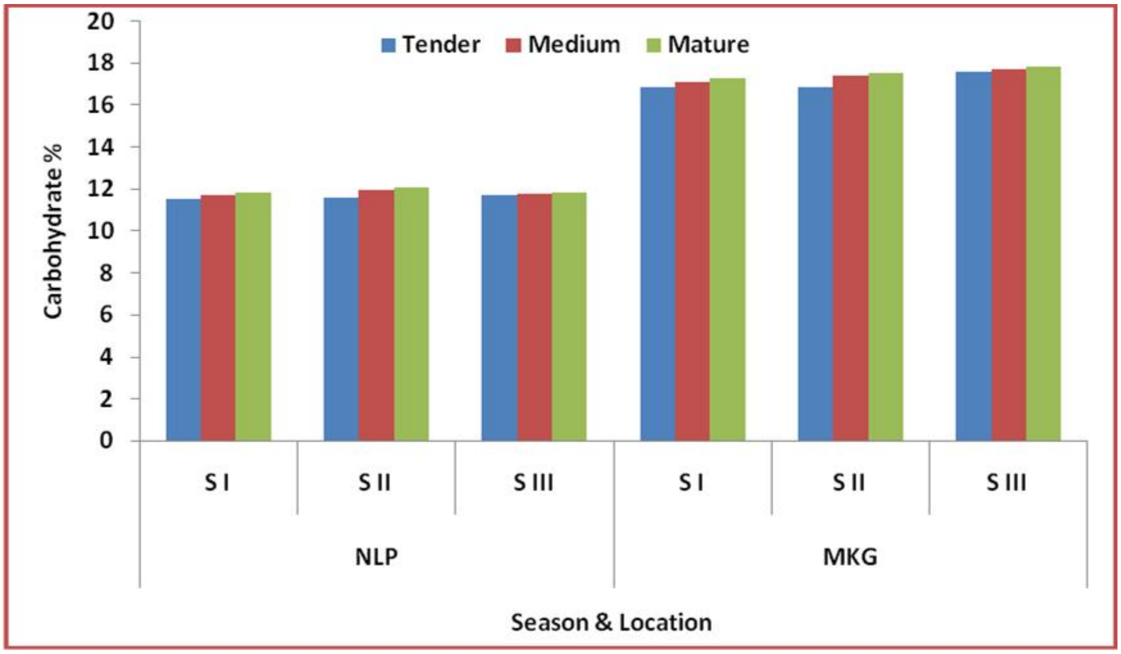


Fig.36 (A) Seasonal variation of carbohydrate content in three leaf types of Som host plant between North Lakhimpur (NLP) and Mokokchung (MKG)

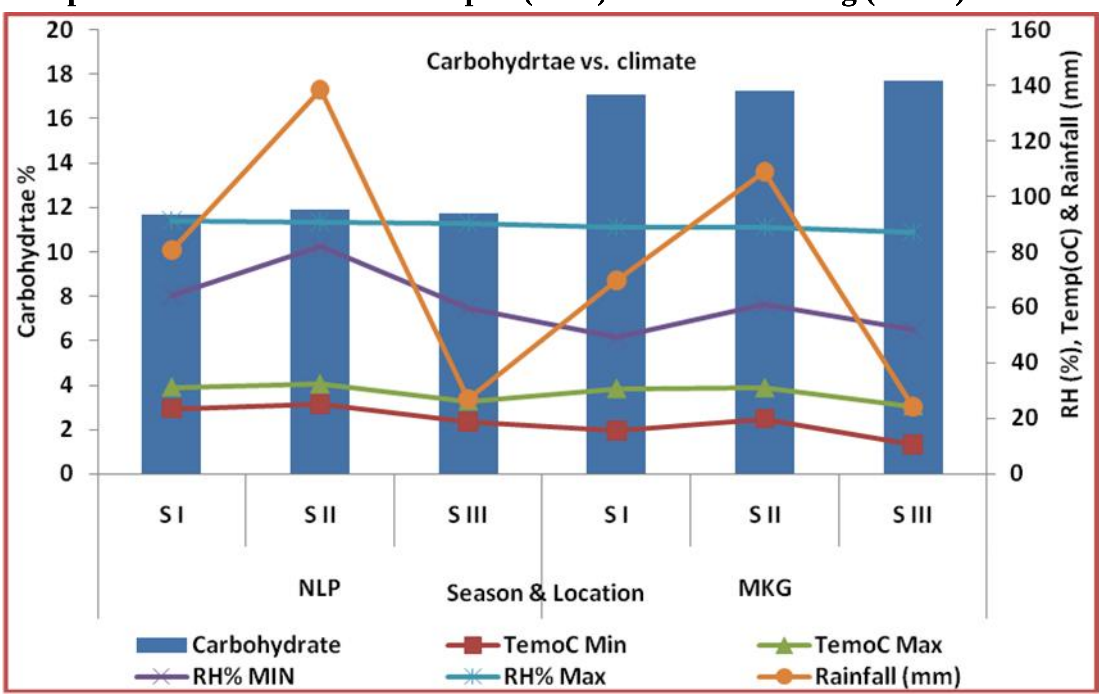


Fig. 36 (B) Mean leaf carbohydrate content of Som host plant in relation to seasonal climatic variation between North Lakhimpur (NLP) and Mokokchung (MKG)

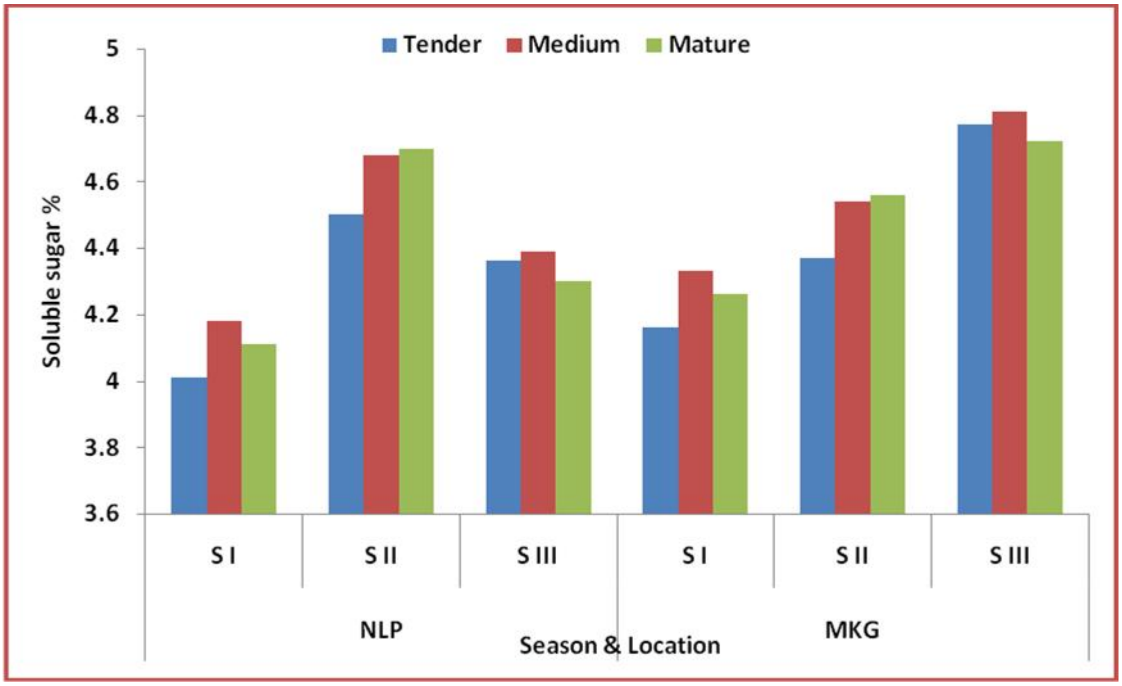


Fig. 37 (A) Seasonal variation of soluble sugar content in three leaf types of Som host plant between North Lakhimpur (NLP) and Mokokchung (MKG)

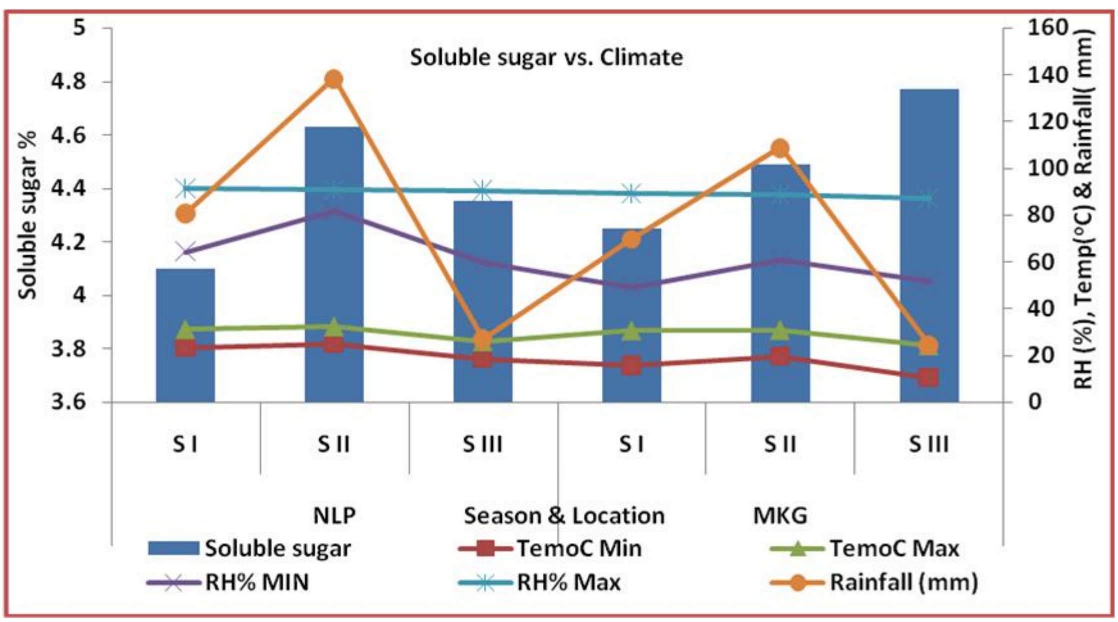


Fig.37 (B) Mean leaf soluble sugar content of Som host plant in relation to seasonal climatic variation between North Lakhimpur (NLP) and Mokokchung (MKG)

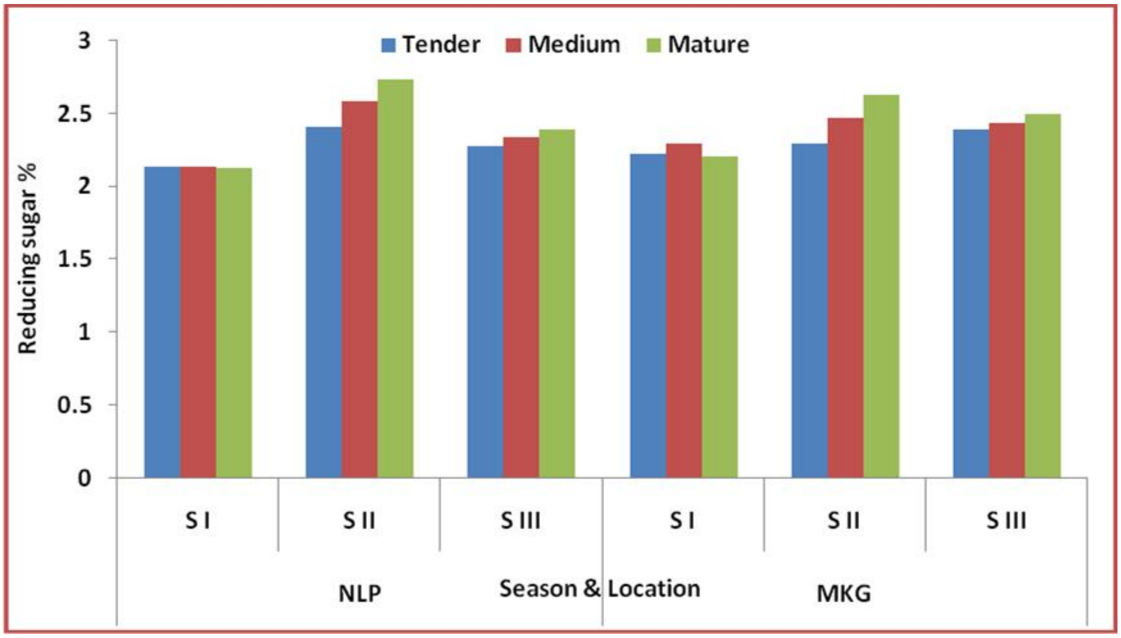


Fig. 38 (A) Seasonal variation of reducing sugar content in three leaf types of Som host plant between North Lakhimpur (NLP) and Mokokchung (MKG)

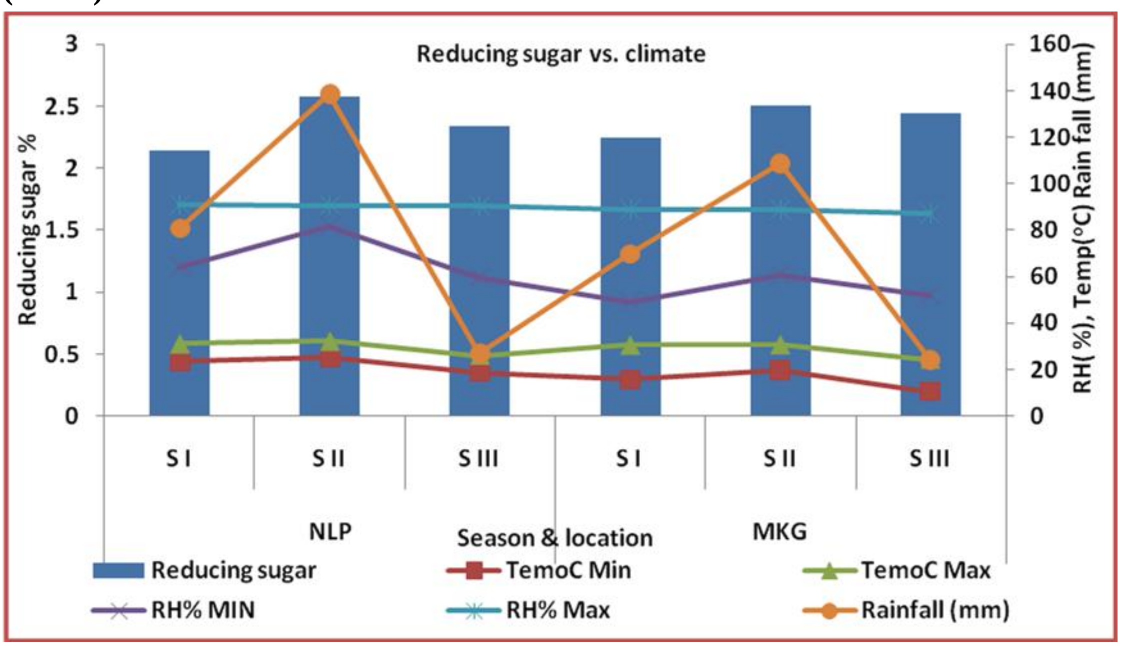


Fig. 38 (B) Mean leaf reducing sugar content of Som host plant in relation to seasonal climatic variation between North Lakhimpur (NLP) and Mokokchung (MKG)

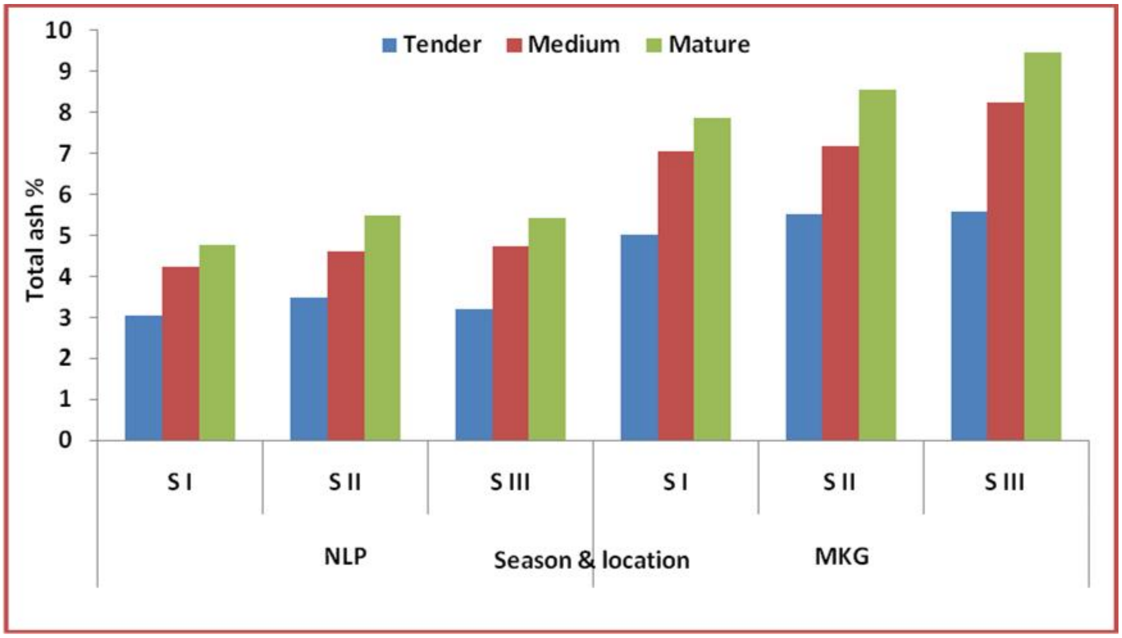


Fig. 39 (A) Seasonal variation of total ash content in three leaf types of Som host plant between North Lakhimpur (NLP) and Mokokchung (MKG)

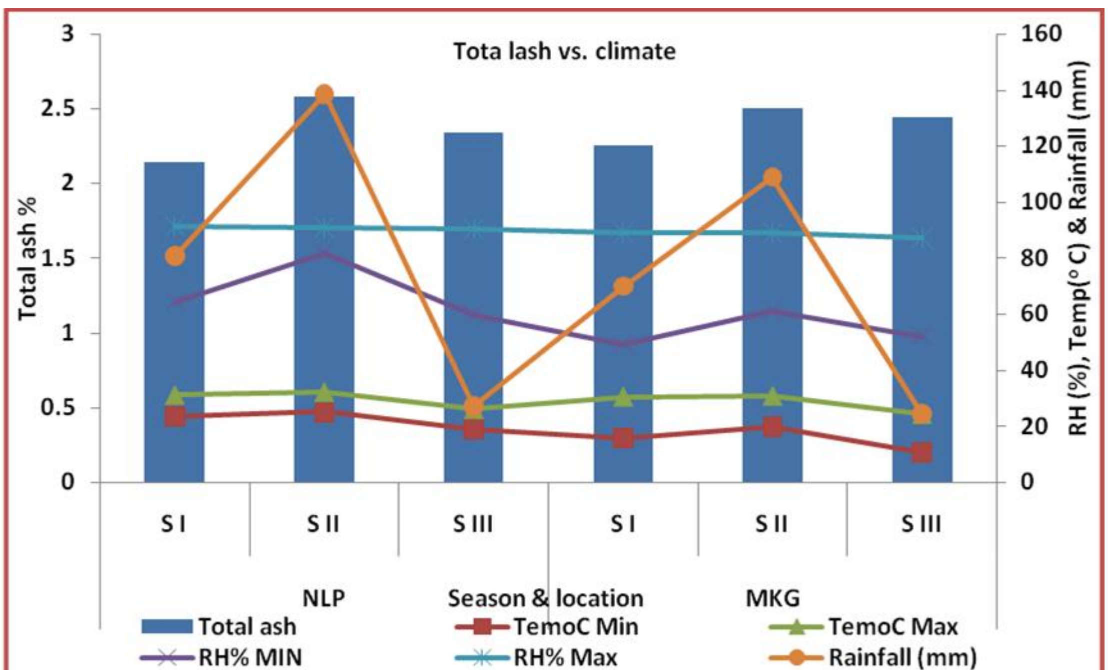


Fig. 39 (B) Mean leaf total ash content of Som host plant in relation to seasonal climatic variation between North Lakhimpur (NLP) and Mokokchung (MKG)

CHAPTER IV

MORPHOMETRIC VARIATION OF *ANTHERAEA ASSAMA* Westwood

MORPHOMETRIC VARIATION OF IMMATURE STAGES

The following descriptions were made from live specimens reared during 2007 and 2008 in different food plants at lower and higher altitude. The first instars were described with in 2 days after eclosion, while all other instars were described within 2-3 days following a molt. The life cycle in general, 5th instar larva highlighting colour morphism and adult moths are depicted in **Fig. 40 a, b & c.**

Qualitative description

Larva

Each larval instar of *Antheraea assama* of both cultivated and wild variety had distinct body colour and tubercular arrangement. Further qualitative variation between lower and higher altitude was not evident. However, certain differences in tubercular arrangement, colour pattern and behavior which were recorded between cultivated and wild variety are described below:

1st Instar: The newly hatched larva was orange yellow in colour with prominent black bands. The body colour gradually changed to prominent yellow colour and black bands became thinner from second day onwards. The head capsule was blackish brown in colour.

2nd Instar: The larva was yellowish green in colour. The claspers were black in colour, became triangular. The head capsule was also brown in colour. Tubercles were bluish in colour. There was a prominent black mid-dorsal line extending from 2nd thoracic segment to 7th abdominal segment. The other morphological characters were similar to the 1st instar larva. In this stage white shining spot appeared on the base of the dorsal tubercle extending from 2nd to 7th abdominal segment.

3rd Instar: The 3rd instar larva was light yellow-green in colour. The tubercles were violet in colour except lower lateral tubercles and were bigger and brighter in wild variety. White slivery shining spot were present around the base of the dorsal tubercle extending from 2nd thoracic segment to 7th abdominal segment. Sometimes the white shining spot may be absent in some of the tubercle. At this stage a strong yellowish colour lateral line appeared, which was extending from 1st to last abdominal segment. The shining silvery spots were quite visible from lateral side. The colour of the prothoracic segment was dorsally light yellow in colour. A pair of prominent prothoracic hood markings was present which was black at the base and violet tubercles with setae. Prominent yellowish lateral line appeared extending from first to last abdominal segment. The head capsule was brown in colour. The thoracic legs were brownish and prolegs were light greenish having yellowish middle and black distal portion. The claspers were brown with yellow and black spots on lateral side. The dorsal portion of the 10th abdominal segment was also yellowish in colour with black spots and setae. The mid dorsal line was transparent extending from prothoracic to the last abdominal segment.

4th Instar: The freshly molted out larva of fourth instar larva was greenish in colour and gradually turned to green. The prothoracic hood markings were black with brick red dot on the tips. The tubercles were brick red in colour, white shining spots were present on either side of the dorsal tubercles extending from 2nd thoracic segment to 8th abdominal segment; lower lateral tubercles were also green in colour. The prolegs were green with black bands and black hairs followed by the brown crochets. The claspers were yellow green in colour having black border dorsally. The 10th abdominal segment was black. The mid dorsal line was quite transparent.

5th Instar: The body colour of the 5th instar larva was light green to dark green. The tubercles were brick red in colour. Lower lateral tubercles were prominent, green in colour. The lateral line was much prominent and yellowish in colour with green shade. The white shining spots were extending around the base of the dorsal tubercles from 2nd thoracic to 8th abdominal segment. The lateral line was yellow with upper brown lining from 1st to last abdominal segment. Setae were also observed on the raised portion of 1st and 2nd abdominal segment on the corresponding position of the lower lateral tubercles of thoracic segment. The claspers were triangular with a green portion. Thoracic legs were brown in colour and the prolegs were green in colour. The prolegs were provided with 24-30 black dots which carried the body setae. The crochets were brown with a black band above. The prothoracic hood markings were reduced but the portion was yellowish in colour bearing setae. The lateral line was much prominent and yellowish in colour with green shade. The white shining spots were extending around the base of dorsal tubercles from second thoracic to eight abdominal segments. At this stage the total numbers of tubercles were recorded as 65 to 69 while the number of setae ranged from 365 to 506. The fifth instar larva of wild muga was very active and conspicuously different from the cultivated variety in body and tubercular colour.

Cocoon and pupa: The matured larva built its cocoon on fresh and dry leaves. While mature larva crawled down to the base of the host plants for cocooning, it was observed sometimes in wild population that the larvae remained in the tree and formed cocoons around the leaves or twigs. Cocoons from wild population were compact, smooth and less flossy with a long peduncle. Som fed cocoons were golden-brown, whereas Mejankari fed cocoons were pinkish brown to creamy white in colour. The obtect pupa was dark brown to reddish brown in colour, tapering towards posterior region.



1 Eggs 2. Hatching (cultivated muga) 3. Hatching (wild muga)



4.IstInstar larva 5. 2nd Instar larva 6.3rd Instar larva on molting



7. 4th Instar larva 8. 5th Instar larva on molting 9. 5th Instar larva



10. Cocoon 11. Pupa 12. Adult

Fig. 40 a Life cycle of *Antheraea assama*

Cultivated variety | Wild muga feeding on Mejankari

Yellow variety | **(b) Mature worm** | Blue variety

Male | **(c) Adult-Cultivated** | Female

Male | **(c) Adult-Wild** | Female

Fig: 40 b & c Cultivated and wild population of *A. assama*

Quantitative description

Seasonal variations of morphometric characters of *A. assama* (both cultivated and wild) feeding on different host plants at lower and higher altitude are described and summarized below

1. *A. assama* (cultivated) fed on Som and Soalu at North Lakhimpur (Lower altitude)

The morphometric variation of larval developmental stages of *A. assama* (cultivated) is given in **Table 6** and **Fig. 41 a**

Larva

1st Instar: While there was no significant impact of the seasons on the larval length within the host plants (1.19-1.25 cm in Soalu to 1.09-1.16 cm in Som), mean larval length was significantly higher in Soalu (1.22 cm) than Som (1.12 cm). The breadth varied from 0.22- 0.23 cm with a mean of 0.23 cm in Solau and from 0.20-0.21 cm with a mean of 0.21 cm in Som that showed highly significant difference between host plants at 0.1% and significant difference among seasons at 1% level of probability. With fluctuation of weight of the silk worm in different seasons in both host plants, the mean seasonal value was recorded higher in Soalu (0.04 gm) than Som (0.03 gm) exhibiting highly significant difference between the two host plants. Further, the interaction effect due to host plant x season was significant in larval length and weight.

2nd Instar: Significant difference was observed in larval length between Soalu (1.83 cm) and Som (1.88 cm), however seasonal impact and interaction effect due to host plant x season was not significant. Mean difference in breadth between the two host plants, seasonal difference within the host plant and interaction effect due to host plant and season were highly significant. Weight of the silk worm was also maximum during summer in both host plants with higher record of seasonal mean in Soalu (0.14 gm) than Som (0.05 gm) exhibiting highly significant effect of host plants and seasons. Interaction effect due to host plant and season was also significant.

3rd Instar: The larval length in Soalu varied from 3.00 to 3.08 cm having a seasonal mean of 3.04 cm, while in Som it was recorded as 2.82 cm with seasonal fluctuation between 2.79 and 2.87 cm showing highly significant difference between host plants and also among seasons. However, interaction effect due to host plant x season was significant at 5% probability level. The breadth varied from 0.39- 0.45 cm with a mean of 0.41 cm in Solau and from 0.37-0.39 cm with a mean of 0.38 cm in Som that showed highly significant difference between host plants, among seasons and also combined effect of both host plant and seasons at 0.1% level of probability. While highly significant difference was recorded on mean larval weight between Soalu (1.02 gm) and Som (0.76 gm), seasonal effect was significant at 5% level of probability having maximum of 1.04 gm during spring in Soalu and 0.76 gm during spring and summer in Som. However interaction effect due to host plant x season was not significant.

4th Instar: Larval length was higher in Soalu (4.17 cm) than Som (4.06 cm), Spring season recorded maximum length in both host plants (4.22 cm and 4.09 cm in Soalu and Som respectively) having shown highly significant difference between host plants. However interaction effect due to host plant x season was insignificant. The breadth varied from 0.70- 0.75 cm with a mean of 0.72 cm in Solau and from 0.64-0.70 cm with a mean of 0.66 cm in Som that showed highly significant difference between host plants at 0.1% and significant difference among seasons at 1% level of probability. Weight of the silkworm ranged from 1.69 gm (Som) to 1.77 gm (Soalu) with maximum record during spring season in both host plants (1.71 gm and 1.82 gm in Som and Soalu respectively). Highly significant difference was observed between host plants and among seasons in both breadth and weight in 4th instar larva. While interaction effect due to host plants x seasons was insignificant in breadth, but it was found to be significant in weight.

5th Instar: There was a strong seasonal and host plant influence together with interaction effect of host plant x season on larval length and breadth in 5th larval stage. Mean larval length and breadth was higher in Soalu (10.25 cm and 1.78 cm) than Som (9.53 cm and 1.59 cm). The higher larval weight in Solau (7.59 gm) than Som (6.88 gm) exhibited highly significant difference. However, larval weight fluctuated among different seasons in both host plants with maximum record during spring in Soalu (7.70 gm) and Som (6.91 gm). The interaction effect due to host plant x season was not significant.

Cocoon

The length, breadth and weight of female cocoon were significantly higher than male counterpart in all seasons in both host plants **(Table 7 a, b)**. While there was significant impact of the seasons on the cocoon length within the host plants (4.29-4.57 cm in Som to 4.56-4.71 cm in Soalu), mean cocoon length was highly significant between two host plants exhibiting 4.64 cm (Soalu) and 4.45 cm (Som). The interaction effect on cocoon length due to season x host plant was not significant, however the effect due to season x sex and host plant x sex were found significant and highly significant respectively. The breadth varied from 1.80- 1.91 cm with a mean of 1.87 cm in Som and from 1.78-2.00 cm with a mean of 1.91cm in Soalu that showed highly significant difference between the seasons at 0.1%, having no significant impact of host plant. The interaction effect due to season x host plant was not significant but, it was highly significant due to season x sex and host plant x sex. While mean seasonal cocoon weight was higher in Soalu (5.67 gm) than Som (4.66 gm), maximum of weight was recorded during spring (5.22 gm) and summer (6.26 gm) in Som and Soalu respectively showing highly significant effect of seasons and host plants. The interaction effect due to season x host plant, season x sex and host plant x sex was also highly significant. However combined effect of season x host plant x sex was not found to be significant on length, breadth and weight of cocoon **(Fig. 41 b).**

Pupa

While the length and weight of female pupa was significantly higher than male counterpart in all seasons in both host plants, pupal breadth fluctuated in different seasons having shown higher mean value in male than female **(Table 8 a, b).** The pupal length in Soalu varied from 4.28 to 4.35 cm having a seasonal mean of 4.34 cm, while in Som it was recorded as 3.89 cm with seasonal fluctuation between 3.88 and 3.90 cm. The breadth varied from 1.42- 1.46 cm with a mean of 1.45 cm in Som and from 1.74-1.92 cm with a mean of 1.80 cm in Som. Weight of the pupa ranged from 4.29 gm (Som) to 5.29 gm (Soalu) with maximum record during spring (4.80 gm) and summer (5.84 gm) in Som and Soalu respectively. Highly significant difference among seasons and host plants together with interaction effect due to host plant x season, season x sex, host plant x sex and also combined effect of season x host plant x sex was observed on variation of pupal length and breadth at 0.1% probability level. Pupal weight also exhibited highly significant difference at 0.1% probability level in all parameters except for host plant and interaction effect due to host plant x sex which showed significant effect at 5% and 1% probability level **(Fig. 41 b).**

Table 6: Morphometric variation of developmental stages of *Antheraea assama* (cultivated) on Soalu and Som host plants at North Lakhimpur
(* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Non significant)**

Para-Meter	Host plant	Season	Stages (Mean±SE)				
			1st	**2nd**	**3rd**	**4th**	**5th**
Length (cm)	Soalu	Spring	1.25±0.089	1.81±0.100	3.05±0.119	4.22±0.223	10.28±0.039
		Summer	1.21±0.085	1.85±0.147	3.08±0.073	4.16±0.016	10.25±0.057
		Autumn	1.19±0.072	1.83±0.145	3.00±0.063	4.14±0.037	10.23±0.080
		Mean	**1.22**±0.084	**1.83±0.131**	**3.04±0.093**	**4.17±0.133**	**10.25±0.064**
	Som	Spring	1.09±0.155	1.91±0.134	2.87±0.073	4.09±0.107	9.64±0.185
		Summer	1.16±0.118	1.88±0.087	2.81±0.123	4.06±0.110	9.47±0.284
		Autumn	1.11±0.089	1.85±0.101	2.79±0.135	4.03±0.100	9.47±0.284
		Mean	**1.12**±0.123	**1.88±0.109**	**2.82±0.118**	**4.06±0.106**	**9.53±0.264**
	Grand mean		**1.17±0.067**	**1.85±0.040**	**2.93±0.157**	**4.11±0.076**	**9.89±0.515**
	F	H. plant	30.76	10.243	246.664	29.505	1149.421
		Season	1.39	0.796	8.212	4.008	11.216
		H X S	3.32	2.220	3.609	0.165	3.755
	CV%		**8.04**	**5.16**	**2.64**	**2.65**	**1.19**
	CD%	H.plant	0.061***	0.047**	0.050***	0.071***	0.077***
		Season	NS	NS	0.047**	0.012*	0.094***
		H X S	0.06*	NS	0.050*	NS	0.075*
Breadth (cm)	Soalu	Spring	0.23±0.025	0.34±0.005	0.45±0.008	0.75±0.015	1.88±0.037
		Summer	0.23±0.010	0.30±0.038	0.40±0.035	0.72±0.034	1.75±0.023
		Autumn	0.22±0.013	0.28±0.024	0.39±0.036	0.70±0.042	1.70±0.126
		Mean	**0.23±0.017**	**0.31±0.037**	**0.41±0.039**	**0.72±0.037**	**1.78±0.107**
	Som	Spring	0.21±0.015	0.27±0.025	0.39±0.011	0.70±0.027	1.60±0.017
		Summer	0.20±0.014	0.26±0.015	0.38±0.011	0.66±0.069	1.59±0.035
		Autumn	0.20±0.012	0.25±0.009	0.37±0.015	0.64±0.063	1.59±0.035
		Mean	**0.20±0.015**	**0.26±0.020**	**0.38±0.017**	**0.67±0.060**	**1.59±0.031**
	Grand mean		**0.22±0.017**	**0.29±0.035**	**0.40±0.025**	**0.69±0.042**	**1.68±0.130**
	F	H. plant	63.39	459.026	138.314	92.941	315.969
		Season	7.59	116.081	74.370	24.303	30.326
		H X S	0.54	25.157	12.055	0.509	21.557
	CV%		**7.80**	**4.47**	**4.12**	**4.92**	**3.37**
	CD%	H. plant	0.011***	0.008***	0.011***	0.022***	0.037***
		Season	0.010**	0.010***	0.013***	0.027***	0.045***
		H X S	NS	0.014***	0.018***	NS	0.063***
Weight (gm)	Soalu	Spring	0.05±0.015	0.14±0.007	1.04±0.101	1.82±0.051	7.70±0.201
		Summer	0.04±0.010	0.15±0.006	1.02±0.099	1.74±0.066	7.53±0.070
		Autumn	0.04±0.008	0.13±0.011	0.99±0.080	1.76±0.067	7.54±0.080
		Mean	**0.04±0.012**	**0.14±0.092**	**1.02±0.094**	**1.77±0.069**	**7.59±0.151**
	Som	Spring	0.03±0.006	0.05±0.006	0.76±0.029	1.71±0.076	6.91±0.950
		Summer	0.03±0.007	0.06±0.009	0.76±0.018	1.70±0.060	6.87±0.792
		Autumn	0.03±0.006	0.06±0.008	0.74±0.030	1.65±0.089	6.87±0.792
		Mean	**0.03±0.006**	**0.05±0.087**	**0.76±0.285**	**1.69±0.079**	**6.88±0.834**
	Grand mean		**0.04±0.007**	**0.10±0.064**	**0.89±0.184**	**1.73±0.057**	**7.24±0.502**
	F	H. plant	12.862	3475.610	797.339	64.876	345.257
		Season	5.080	9.604	5.149	9.454	3.462
		H X S	4.598	7.672	0.483	5.362	1.147
	CV%		**22.63**	**8.46**	**5.71**	**3.33**	**2.88**
	CD%	H. plant	0.005***	0.005***	0.033***	0.038***	0.136
		Season	0.004*	0.006***	0.022*	0.046***	0.094*
		H X S	0.005*	0.007**	NS	0.049**	NS

Table 7 a: Variation of cocoon parameters of *Antheraea assama* (Cultivated) on Som and soalu host plants at North Lakhimpur

Sex	Season	Host plant and Parameter (Mean± SE)					
		Som			Soalu		
		Length (cm)	Breadth (cm)	Weight (gm)	Length (cm)	Breadth (cm)	Weight (gm)
Male	Spring	3.78±0.032	1.64±0.025	4.24±0.063	4.19±0.056	1.84±0.018	4.82±0.200
	Summer	3.69±0.122	1.60±0.061	3.66±0.262	4.20±0.082	1.83±0.027	4.92±0.193
	Autumn	3.45±0.074	1.45±0.054	3.55±0.187	4.10±0.070	1.55±0.058	4.65±0.046
	Mean	**3.64±0.171**	**1.57±0.099**	**3.82±0.369**	**4.16±0.055**	**1.74±0.164**	**4.80±0.138**
Female	Spring	5.35±0.023	2.18±0.017	6.20±0.041	5.12±0.019	2.10±0.041	6.04±0.085
	Summer	5.30±0.105	2.17±0.029	5.22±0.556	5.22±0.098	2.16±0.099	7.59±0.281
	Autumn	5.12±0.119	2.15±0.066	5.09±0.260	5.02±0.071	2.00±0.039	6.00±0.088
	Mean	**5.26±0.120**	**2.16±0.015**	**5.50±0.610**	**5.12±0.097**	**2.09±0.083**	**6.54±0.906**
Seasonal mean	Spring	4.57±1.110	1.91±0.382	5.22±1.386	4.66±0.658	1.97±0.184	5.43±0.863
	Summer	4.50±1.138	1.89±0.403	4.44±1.103	4.71±0.721	2.00±0.233	6.26±1.888
	Autumn	4.29±1.181	1.80±0.495	4.32±1.089	4.56±0.651	1.78±0.318	5.33±0.955
Grand mean		**4.45±0.145**	**1.87±0.056**	**4.66±0.490**	**4.46±0.075**	**1.91±0.120**	**5.67±0.510**
F	Sex	8370.585	6207.254	1062.906	5356.493	1189.397	4421.477
	Season	90.714	73.115	119.462	43.159	193.731	502.220
	S X S	2.917	41.836	7.272	51.113	30.493	309.218
CV%		**2.17**	**2.23**	**6.08**	**1.55**	**2.86**	**2.54**
CD%	Sex	0.063***	0.027***	0.185***	0.047***	0.036***	0.094***
	Season	0.077***	0.033***	0.226***	0.057***	0.044***	0.115***
	S X S	NS	0.047***	0.243**	0.081***	0.062***	0.163***

(* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Non significant)**

Table 7b: Variation of cocoon parameters of *Antheraea assama* (Cultivated) on Som and soalu host plants at North Lakhimpur

Host plant	Sex	Season	Parameters (Mean±SE)		
			Length (cm)	**Breadth (cm)**	**Weight (gm)**
Som	**Male**	Spring	3.78±0.032	1.64±0.025	4.24±0.063
		Summer	3.69±0.122	1.60±0.061	3.66±0.262
		Autumn	3.45±0.074	1.45±0.054	3.55±0.187
		Mean	**3.64±0.171**	**1.56±0.100**	**3.82±0.371**
	Female	Spring	5.35±0.023	2.18±0.017	6.20±0.041
		Summer	5.30±0.105	2.17±0.029	5.22±0.556
		Autumn	5.12±0.119	2.15±0.066	5.09±0.260
		Mean	**5.25±2.613**	**2.17±0.015**	**5.50±0.607**
	Seasonal mean	Spring	4.57±1.110	1.91±0.382	5.22±1.386
		Summer	4.49±1.138	1.88±0.403	4.44±1.103
		Autumn	4.29±1.181	1.80±0.495	4.32±1.089
	Total mean		**4.45±0.144**	**1.86±0.057**	**4.66±0.489**
Soalu	Male	Spring	4.19±0.056	1.84±0.018	4.82±0.200
		Summer	4.20±0.082	1.83±0.027	4.92±0.193
		Autumn	4.10±0.070	1.55±0.058	4.65±0.046
		Mean	**4.16±0.055**	**1.74±0.165**	**4.80±0.137**
	Female	Spring	5.12±0.019	2.10±0.041	6.04±0.085
		Summer	5.22±0.098	2.16±0.099	7.59±0.281
		Autumn	5.02±0.071	2.00±0.039	6.00±0.088
		Mean	**5.12±0.100**	**2.09±0.081**	**6.54±0.907**
	Seasonal mean	Spring	4.66±0.658	1.97±0.184	5.43±0.863
		Summer	4.71±0.721	2.00±0.233	6.26±1.888
		Autumn	4.56±0.651	1.78±0.318	5.33±0.985
	Total mean		**4.60±0.683**	**1.91±0.265**	**5.67±0.011**
Average of host plant	Male	Spring	3.99±0.290	1.74±0.141	4.53±0.410
		Summer	3.95±0.361	1.71±0.163	4.29±0.891
		Autumn	4.28±0.247	1.50±0.071	4.10±0.778
		Mean	**4.12±0.233**	**1.65±0.131**	**4.31±0.215**
	Female	Spring	5.24±0.163	2.14±0.057	6.12±0.113
		Summer	5.26±0.057	2.17±0.007	6.41±1.676
		Autumn	5.07±0.071	2.08±0.106	5.55±0.643
		Mean	**5.19±0.104**	**2.13±0.046**	**6.03±0.438**
Total average for season		Spring	4.62±0.064	1.94±0.042	5.33±0.148
		Summer	4.60±0.156	1.94±0.085	5.35±1.287
		Autumn	4.43±0.191	1.79±0.014	4.83±0.714
Grand Mean			**4.66±0.757**	**1.91±0.311**	**5.17±1.209**
F	Season		5.272*	17.396***	5.946**
	Host plant		10.424**	2.124 NS	66.755***
	Sex		668.367***	460.078***	243.310***
	Season X host plant		1.405 NS	2.955 NS	19.179***
	Season X Sex		3.5*	7.01**	19.022***
	Host plant X Sex		34.437	25.795***	2.503 NS
	Season X Host plant X Sex		0.241 NS	0.084 NS	0.929
CV%			**8.02**	**8.72**	**3.69**

(* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Non significant)**

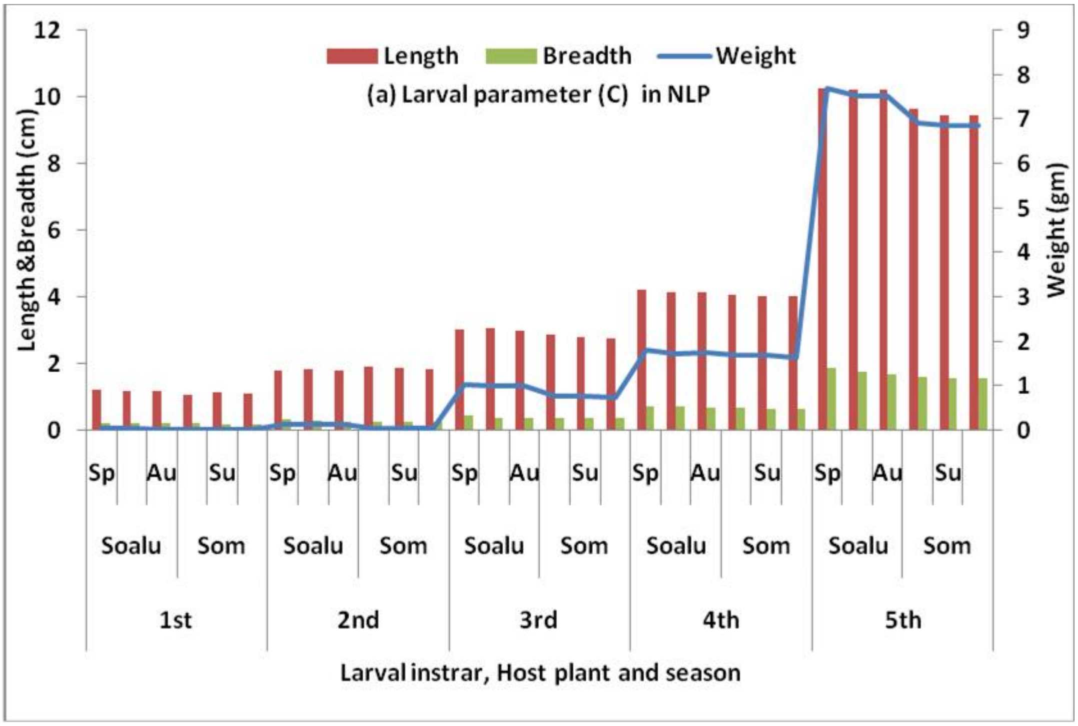
Table 8 a: Variation of pupal parameters of *Antheraea assama* (Cultivated) on Som and soalu host plants at North Lakhimpur)

Sex	Season	Host plant and Parameter (Mean± SE)					
		Som			Soalu		
		Length (cm)	Breadth (cm)	Weight (gm)	Length (cm)	Breadth (cm)	Weight (gm)
Male	Spring	3.33±0.045	1.48±0.068	3.86±0.055	3.82±0.174	1.64±0.026	4.44±0.076
	Summer	3.27±0.088	1.41±0.056	3.30±0.234	4.26±0.293	2.01±0.166	4.48±0.214
	Autumn	3.31±0.076	1.47±0.066	3.81±0.134	3.75±0.187	1.63±0.040	4.34±0.092
	Mean	**3.30±0.031**	**1.45±0.038**	**3.66±0.310**	**3.94±0.276**	**1.76±0.217**	**4.42±0.072**
Female	Spring	4.47±0.025	1.45±0.029	5.75±0.075	4.88±0.017	1.87±0.026	5.61±0.114
	Summer	4.48±0.080	1.44±0.047	4.71±0.401	4.55±0.118	1.83±0.101	7.20±0.252
	Autumn	4.46±0.030	1.44±0.032	4.84±0.266	4.82±0.190	1.84±0.058	5.68±0.097
	Mean	**4.47±0.010**	**1.44±0.006**	**5.10±0.567**	**4.75±0.176**	**1.85±0.021**	**6.16±0.898**
Seasonal mean	Spring	3.90±0.806	1.47±0.021	4.80±1.336	4.35±0.750	1.76±0.163	5.03±0.827
	Summer	3.88±0.856	1.43±0.021	4.01±0.997	4.41±0.205	1.92±0.127	5.84±1.923
	Autumn	3.89±0.813	1.46±0.021	4.05±0.728	4.28±0.757	1.74±0.148	5.01±0.948
Grand mean		**3.89±0.010**	**1.45±0.021**	**4.29±0.006**	**4.35±0.065**	**1.81±0.099**	**5.29±0.474**
F	Sex	9903.591	1.284	1694.11	544.758	21.375	3676.708
	Season	1.056	7.798	171.802	4.115	39.777	362.374
	S X S	3.174	7.111	12.923	56.990	49.628	296.891
CV%		**1.66**	**2.84**	**5.02**	**4.34**	**5.75**	**2.92**
CD%	Sex	0.042***	NS	0.140***	0.123***	0.068***	0.103***
	Season	NS	0.025**	0.172***	0.085*	0.083***	0.126***
	S X S	NS	0.046***	0.243***	0.213***	0.117***	0.178***

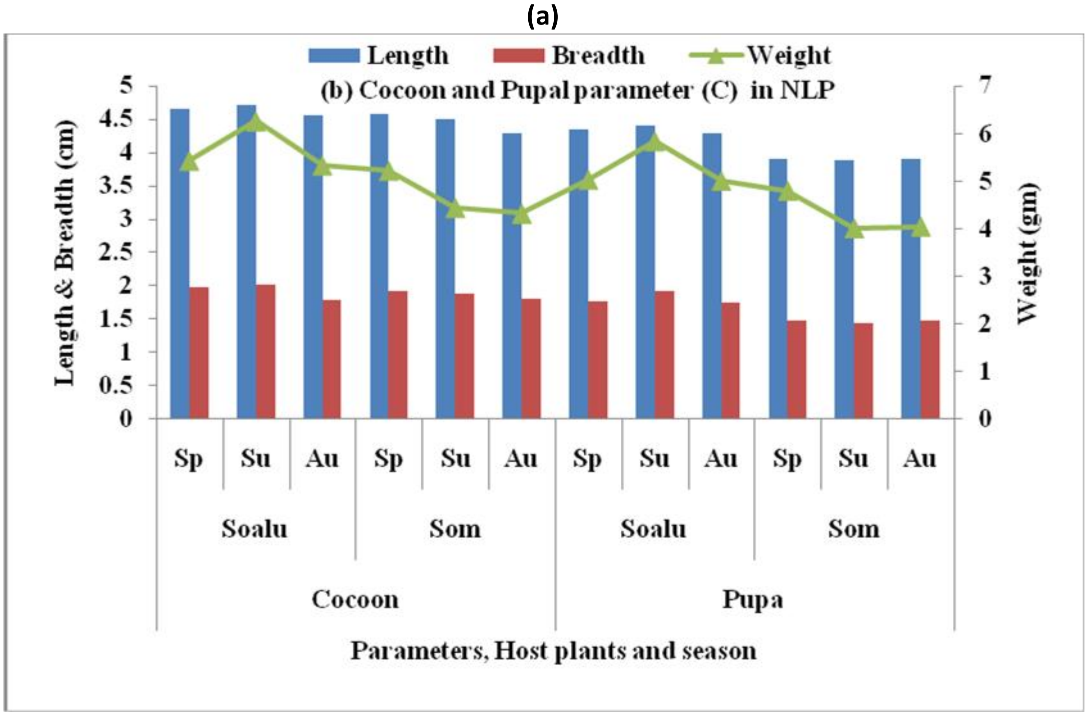
(* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Non significant)**

Table 8 b: Variation of pupal parameters of *Antheraea assama* (Cultivated) on Som and soalu host plants at North Lakhimpur (* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Non significant)**

Host plant	Sex	Season	Parameters (Mean±SE)		
			Length (cm)	Breadth (cm)	Weight (gm)
Som	**Male**	Spring	3.33±0,045	1.48±0.068	3.86±0.055
		Summer	3.27±0.088	1.41±0.056	3.30±0.234
		Autumn	3.31±0.076	1.47±0.066	3.81±0.227
		Mean	**3.30±0.031**	**1.45±0.038**	**3.66±0.310**
	Female	Spring	4.47±0.025	1.45±0.029	5.75±0.075
		Summer	4.48±0.080	1.44±0.047	4.71±0.401
		Autumn	4.46±0.030	1.44±0.032	4.84±0.266
		Mean	**4.47±0.010**	**1.44±0.006**	**5.10±0.567**
	Seasonal mean	Spring	3.90±0.806	1.47±0.021	4.80±1.336
		Summer	3.88±0.856	1.43±0.021	4.01±0.997
		Autumn	3.89±0.813	1.46±0.021	4.05±0.728
	Total mean		**3.89±0.010**	**1.45±0.021**	**4.29±0.445**
Soalu	Male	Spring	3.82±0.174	1.64±0.026	4.44±0.076
		Summer	4.26±0.293	2.01±0.166	4.48±0.214
		Autumn	3.75±0.187	1.63±0.040	4.34±0.092
		Mean	**3.94±0.276**	**1.76±0.217**	**4.42±0.072**
	Female	Spring	4.88±0.017	1.87±0.026	5.61±0.114
		Summer	4.55±0.118	1.83±0.101	7.20±0.252
		Autumn	4.82±0.190	1.84±0.058	5.68±0.097
		Mean	**4.75±0.176**	**1.85±0.021**	**6.16±0.898**
	Seasonal mean	Spring	4.35±0.750	1.75±0.163	5.03±0.827
		Summer	4.41±0.205	1.92±0.127	5.84±1.923
		Autumn	4.28±0.757	1.74±0.148	5.01±0.948
	Total mean		**4.34±0.065**	**1.80±0.099**	**5.29±0.474**
Average of host plant	Male	Spring	3.57±0.346	1.56±0.113	4.15±0.410
		Summer	3.77±0.700	1.71±0.424	3.89±0.834
		Autumn	3.53±0.311	1.55±0.113	4.08±0.375
		Mean	**3.62±0.129**	**1.61±0.090**	**4.04±0.135**
	Female	Spring	4.67±0.290	1.66±0.297	5.68±0.099
		Summer	4.51±0.049	1.64±0.276	5.96±1.761
		Autumn	4.64±0.255	1.64±0.283	5.26±0.594
		Mean	**4.61±0.085**	**1.65±0.012**	**5.63±0.352**
Total average for season		Spring	4.12±0.778	1.61±0.071	4.92±1.082
		Summer	4.14±0.523	1.68±0.049	4.92±1.464
		Autumn	4.09±0.785	1.60±0.064	4.67±0.834
Grand Mean			**4.12±0.025**	**1.63±0.044**	**4.84±0.144**
F	Season		3.466***	27.306***	134.211***
	Host plant		665.439***	1408.303***	2040.898*
	Sex		3071.594***	17.271***	5719.723***
	Season X host plant		4.438***	54.059***	437.859***
	Season X Sex		45.082***	35.609***	76.596***
	Host plant X Sex		106.681***	25.461***	7.869**
	Season X Host plant X Sex		61.915***	65.129***	192.030***
CV%			**3.35**	**4.53**	**3.59**



(a)



(b)

Fig. 41 Seasonal morphometric variation of *Antheraea assama* (cultivated) on two host plants in North Lakhimpur

2. *A. assama* (cultivated) fed on Mejankari and Som at Mokokchung (Higher altitude)

The morphometric variation of larval developmental stages of *A. assama* (cultivated) is given in **Table 9** and **Fig. 42 a.**

Larva

1st Instar: Having no significant difference among the seasons within the host plants (0.87-1.03 cm in Mejankari to 1.05-1.20 cm in Som), mean larval length was significantly higher at 1% probability level between Mejankari (0.97 cm) and Som (1.11 cm). Interaction effect due to host plants and seasons was also significant. The mean larval breadth varied from 0.16 cm (Mejankari) to 0.15 cm (Som) and difference was not significant between the host plants and among seasons. While difference in larval weight was highly significant among seasons (0.02-0.05 gm in Mejankari to 0.02-0.05 g in Som), the difference in mean larval weight which was higher in Mejankari (0.04 gm) than Som (0.03gm) was not significant. Further, the interaction effect due to host plant x season was also not significant.

2nd Instar: While highly **s**ignificant difference was observed in larval length among different seasons (1.67-1.93 cm in Mejankari and 1.70-2.06 cm in Som), difference between the two host plants i.e. Mejankari (1.79 cm) and Som (1.85 cm) and interaction effect due to host plant x season was not significant. Mean difference in breadth between the two host plants, seasonal difference within the host plant and interaction effect due to host plant and season were highly significant. Weight of the silk worm was maximum during summer in both host plants with higher record of seasonal mean in Som (0.14 gm) than Mejankari (0.11 gm) exhibiting difference between host plants. However, difference was not significant among seasons and also for interaction effect of host plants and seasons.

3rd Instar: The larval length in Mejankari varied from 2.90 to 3.07 cm having a seasonal mean of 2.97 cm, while in Som it was recorded as 3.01 cm with seasonal fluctuation between 2.68 and 3.18 cm exhibiting no significant difference between host plants but highly significant difference among seasons and interaction effect due to host plant x season. No significance difference between host plants and among seasons was observed in larval breadth which varied from 0.37- 0.41 cm with a mean of 0.38 cm in Mejankari and from 0.38-0.41 cm with a mean of 0.39 cm in Som. However interaction effect due to host plants and seasons was significant at 1% level of probability. Weight of the silkworm was higher in Som (0.71 gm) than Mejankari (0.49 gm) with maximum record during spring in Som (1.07 gm) and during summer in Mejankari (0.54 gm). The difference was highly significant between host plants, among seasons and also interaction effect due to host plants x seasons.

4th Instar: Larval length was higher in Som (4.61 cm) than Mejankari (3.39 cm), however summer season recorded maximum length in both host plants

(4.89 cm and 4.30 cm in Som and Mejankari respectively) showing highly significant differences between host plants and among seasons. However interaction effect due to host plant x season was insignificant. The breadth varied from 0.38- 0.73 cm with a mean of 0.55 cm in Mejankari and from 0.60-0.70 cm with a mean of 0.68 cm in Som. Weight of the silkworm ranged from 1.36gm (Mejankari) to 1.64 gm (Som) with maximum record during spring in Mejankari (1.74 gm) and summer in Som (1.71 gm). The difference between host plants, among seasons and interaction effect between host plants and seasons for both breadth and weight was highly significant.

5th Instar: Having shown great fluctuation among three seasons larval length in Som (9.32 cm) was significantly higher than Mejankari (7.94 cm). The breadth varied from 0.99- 1.52 cm in different seasons with a mean of 1.33 cm in Mejankari and from 1.45-1.54 cm with a mean of 1.49 cm in Som that showed highly significant difference between host plants at 0.1% and significant difference among seasons at 1% level of probability. Strong seasonal and host plant influence together with interaction effect of host plant x season on larval length and breadth was observed. Larval weight was higher in Som (7.55 gm) than Mejankari (7.25 gm). However, it fluctuated among different seasons with maximum during autumn in Som (8.11 gm) and during spring in Mejankari (7.50 gm). Except for weak interaction effect due to host plants and seasons, difference was not significant between host plants and among seasons.

Cocoon

While the length, breadth and weight of female cocoon were significantly higher than male counterpart in all seasons in both host plants, the morphometric characteristics of Som fed cocoons were found to be superior to Mejankari. Average cocoon length was higher in Som (4.72 cm) than Mejankari (4.48 cm) with maximum during autumn (4.87 cm) and summer (4.65 cm) in Som and Mejankari respectively showing highly significant difference among seasons and between sexes **(Table 10)**. While interaction effect due to season x sex was highly significant on Som host plant, its effect was not significant on Mejankari. Variation in cocoon breadth was highly significant between two host plants exhibiting 1.70 cm (Mejankari) and 1.85 cm (Som) having shown seasonal variation within the host plants (1.80-1.89 cm in Som to 1.55-1.81 cm in Mejankari). The interaction effect due to season x sex was also found to be significant at 1% probability level. While mean seasonal cocoon weight was higher in Som (5.47 gm) than Mejankari (5.01 gm), maximum of weight was recorded during autumn (5.66 gm) and spring (4.60 gm) in Som and Mejankari respectively showing highly significant effect of seasons and host plants. The interaction effect due to season x sex was also highly significant **(Fig. 42 b).**

Pupa

The mean value of length, breadth and weight of female pupa was significantly higher than male counterpart with variation in different seasons and exhibited better performance in Som than Mejankari in both sexes **(Table 11).** The pupal length in Som varied from 3.79 to 4.08 cm having a seasonal mean of 3.94 cm, while in Mejankari it was recorded as 3.63 cm with seasonal fluctuation between 3.50 and 3.77 cm showing highly significant difference among seasons and between sexes. The breadth varied from 1.34- 1.51 cm with a mean of 1.42 cm in Som and from 1.33-1.39 cm with a mean of 1.36 cm in Mejankari. Highly significant difference of sexes and seasons was observed in Mejankari and Som respectively. Highly significant effect of seasons and host plants was evident on weight of the pupa that ranged from 4.60 gm (Mejankari) to 4.90 gm (Som) having the maximum record during spring (4.76 gm) and autumn (5.06 gm) in Mejankari and Som respectively. Except for the weight in Som, the interaction effect due to season and sex was also significant in all parameters in both host plants which was not found to be significant **(Fig. 42 b).**

Table 9: Morphometric variation of developmental stages of *Antheraea assama* (cultivated) on Mejankari and Som host plants at Mokokchung

Para-Meter	Host plant	Season	Stages (Mean±SE)				
			1st	**2nd**	**3rd**	**4th**	**5th**
Length (cm)	Mejan kari	Spring	1.03±0.114	1.67±0.099	2.90±0.414	4.20±0.043	8.59±0.596
		Summer	0.87±0.280	1.93±0.422	3.07±0.398	4.30±0.950	8.30±1.212
		Autumn	1.02±0.233	1.78±0.297	2.94±0.192	3.30±0.306	6.94±1.243
		Mean	**0.97±0.093**	**1.79±0.128**	**2.97±0.088**	**3.93±0.550**	**7.94±0.880**
	Som	Spring	1.05±0.181	1.70±0.236	3.17±0.264	4.82±0.093	9.33±0.162
		Summer	1.20±0.366	2.06±0.413	3.18±0.398	4.89±0.854	9.05±1.234
		Autumn	1.07±0.14	1.78±0.280	2.68±0.236	4.11±0.417	9.59±0.531
		Mean	**1.11±0.079**	**1.85±0.188**	**3.00±0.301**	**4.61±0.430**	**9.32±0.270**
	Grand mean		**1.04±0.009**	**1.82±0.042**	**2.99±0.021**	**4.27±0.481**	**8.63±0.976**
	F	Host plant	10.976	1.185	.69	33.537	77.318
		Season	0.049	12.478	13.74	23.446	6.611
		H X S	6.056	0.629	9.82	0.354	16.296
	CV%		**21.16**	**15.44**	**9.32**	**14.99**	**9.97**
	CD%	Host plant	0.109**	NS	NS	0.417***	0.561***
		Season	NS	0.224***	0.22***	0.511***	0.522**
		H X S	0.189**	NS	0.32***	NS	0.971***
Breadth (cm)	Mejan kari	Spring	0.13±0.028	0.18±0.041	0.37±0.034	0.73±0.034	1.52±0.095
		Summer	0.16±0.047	0.22±0.049	0.38±0.064	0.38±0.052	1.48±0.101
		Autumn	0.18±0.220	0.22±0.029	0.41±0.058	0.54±0.050	0.99±0.208
		Mean	**0.16±0.025**	**0.21±0.023**	**0.38±0.021**	**0.55±0.175**	**1.33±0.295**
	Som	Spring	0.15±0.037	0.19±0.037	0.41±0.075	0.74±0.012	1.54±0.064
		Summer	0.16±0.050	0.27±0.047	0.38±0.070	0.70±0.121	1.47±0.10
		Autumn	0.15±0.048	0.25±0.037	0.38±0.026	0.60±0.077	1.45±0.166
		Mean	**0.15±0.006**	**0.24±0.042**	**0.39±0.017**	**0.68±0.072**	**1.49±0.047**
	Grand mean		**0.15±0.006**	**0.22±0.018**	**0.38±0.006**	**0.62±0.093**	**1.41±0.110**
	F	Host plant	0.083	26.018	0.183	64.956	53.802
		Season	0.816	34.629	1.098	57.447	80.811
		H X S	0.838	5.285	5.442	34.293	50.543
	CV%		**63.45**	**15.94**	**12.11**	**14.49**	**8.35**
	CD%	Host plant	NS	0.023***	NS	0.058***	0.076***
		Season	NS	0.028***	NS	0.071***	0.094***
		H X S	NS	0.030**	0.053**	0.101***	0.133***
Weight (gm)	Mejan kari	Spring	0.02±0.012	0.09±0.007	0.51±0.059	1.74±0.103	7.50±0.061
		Summer	0.05±0.030	0.13±0.050	0.54±0.164	1.62±0.872	7.46±1.851
		Autumn	0.03±0.017	0.11±0.04	0.43±0.09	0.73±0.30	6.79±1.15
		Mean	**0.03±0.015**	**0.11±0.020**	**0.49±0.057**	**1.36±0.552**	**7.25±0.399**
	Som	Spring	0.03±0.006	0.13±0.043	1.07±0.359	1.68±0.037	6.91±0.079
		Summer	0.05±0.026	0.15±0.039	0.77±0.489	1.71±0.541	7.61±1.949
		Autumn	0.02±0.018	0.13±0.132	0.28±0.037	1.53±0.233	8.11±1.081
		Mean	**0.03±0.015**	**0.14±0.012**	**0.71±0.399**	**1.64±0.096**	**7.55±0.603**
	Grand mean		**0.03±0.00**	**0.13±0.021**	**0.60±0.156**	**1.50±0.198**	**7.40±0.212**
	F	Host plant	0.154	4.197	17.233	13.544	1.366
		Season	12.019	1.691	25.779	24.561	0.600
		H X S	1.046	0.144	16.01	12.222	4.793
	CV%		**55.74**	**59.44**	**46.46**	**27.55**	**18.79**
	CD%	Host plant	NS	0.027*	0.182***	0.270***	NS
		Season	0.016***	NS	0.233***	0.330***	NS
		H X S	NS	NS	0.239***	0.467***	0.890*

(* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Non significant)**

Table 10: Variation of cocoon parameters of *Antheraea assama* (Cultivated) on Mejankari and Som host plants at Mokokchung

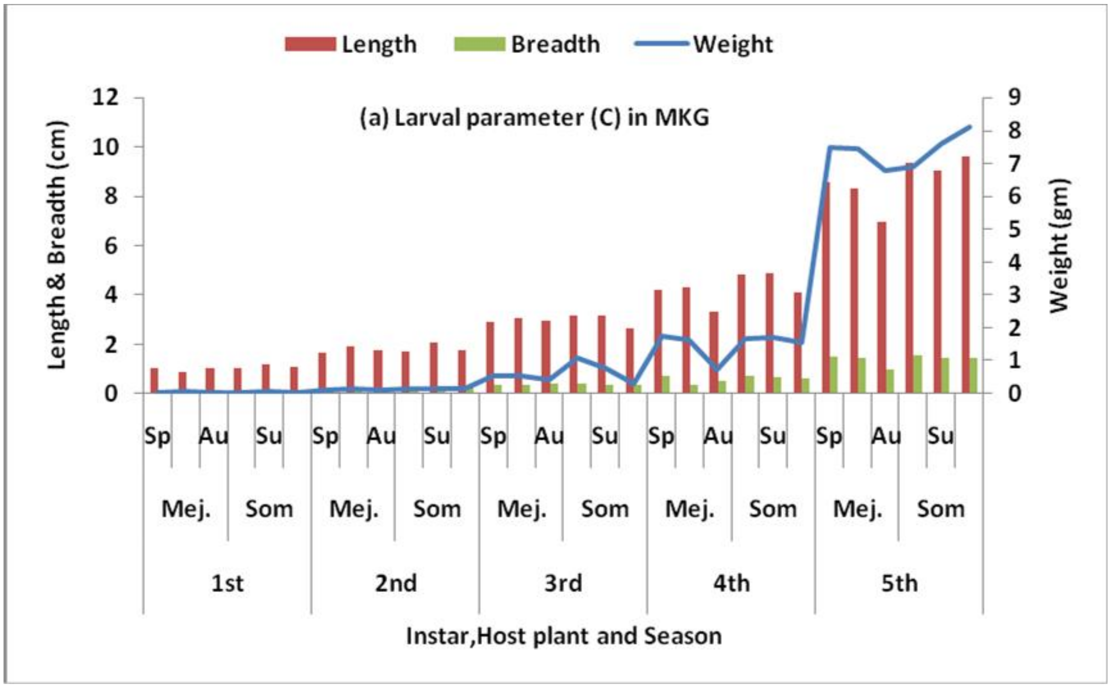
Sex	Season	Host plant and Parameter (Mean±SE)					
		Mejankari			Som		
		Length (cm)	Breadth (cm)	Weight (gm)	Length (cm)	Breadth (cm)	Weight (gm)
Male	Spring	4.21±0.296	1.55±0.240	4.71±0.156	4.17±0.299	1.56±0.048	4.84±0.147
	Summer	4.31±0.229	1.59±0.146	4.69±0.130	4.30±0.190	1.61±0.149	4.87±0.201
	Autumn	3.85±0.435	1.45±0.087	4.33±0.488	4.63±0.217	1.72±0.163	5.12±0.220
	Mean	**4.12±0.242**	**1.53±0.072**	**4.58±0.214**	**4.37±0.237**	**1.63±0.082**	**4.95±0.154**
Female	Spring	5.00±0.228	1.97±0.158	5.78±0.215	5.06±0.127	2.03±0.164	5.98±0.146
	Summer	4.98±0.211	2.03±0.196	5.67±0.138	5.02±0.157	2.16±0.159	5.80±0.230
	Autumn	4.53±0.157	1.64±0.236	4.88±0.888	5.12±0.240	2.04±0.182	6.19±0.348
	Mean	**4.84±0.266**	**1.88±0.210**	**5.44±0.491**	**5.07±0.050**	**2.08±0.072**	**5.99±0.195**
Seasonal mean	Spring	4.60±0.559	1.76±0.297	5.24±0.757	4.61±0.629	1.80±0.332	5.42±0.806
	Summer	4.65±0.474	1.81±0.311	5.18±0.693	4.66±0.509	1.89±0.389	5.34±0.658
	Autumn	4.19±0.481	1.55±0.134	4.61±0.389	4.88±0.346	1.88±0.226	5.66±0.757
Grand mean		**4.48±0.252**	**1.71±0.138**	**5.01±0.348**	**4.72±0.144**	**1.86±0.049**	**5.47±0.167**
F	Sex	155.893	142.721	290.280	345.532	286.598	1891.337
	Season	25.831	29.767	64.171	17.565	4.827	62.733
	S X S	0.505	6.993	10.122	9.031	6.186	5.872
CV%		**6.98**	**9.49**	**5.54**	**4.36**	**7.88**	**2.40**
CD%	Sex	0.204***	0.105***	0.181***	0.134***	0.095***	0.085***
	Season	0.250***	0.129***	0.222***	0.164***	0.066*	0.105***
	S X S	NS	0.139**	0.313***	0.232***	0.0125**	0.113**

(* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Non significant)**

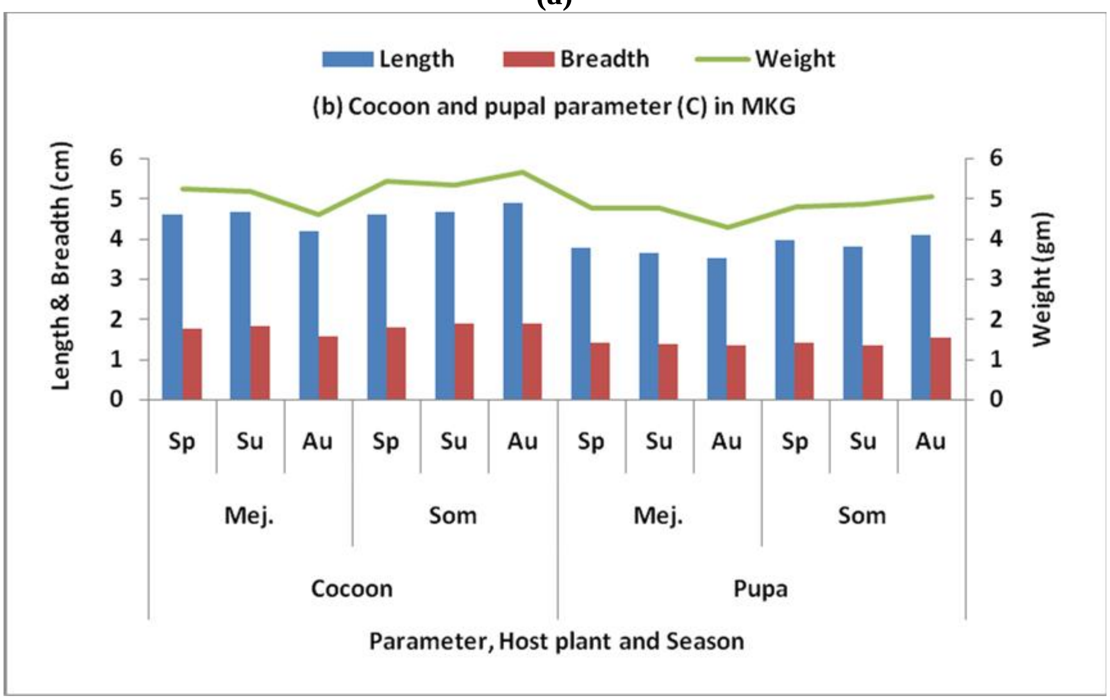
Table 11: Variation of pupal parameters of *Antheraea assama* (Cultivated) on Mejankari and Som host plants at Mokokchung

Sex	Season	Host plant and parameter (Mean±SE)					
		Mejankari			Som		
		Length (cm)	Breadth (cm)	Weight (gm)	Length (cm)	Breadth (cm)	Weight (gm)
Male	Spring	3.46±0.196	1.34±0.057	4.28±0.158	3.69±0.099	1.37±0.057	4.33±0.099
	Summer	3.52±0.212	1.32±0.086	4.29±0.131	3.45±0.284	1.35±0.095	4.45±0.199
	Autumn	3.38±0.408	1.33±0.107	4.01±0.458	3.88±0.263	1.49±0.081	4.61±0.218
	Mean	**3.45±0.010**	**1.33±0.010**	**4.19±0.159**	**3.67±0.215**	**1.40±0.076**	**4.46±0.140**
Female	Spring	4.09±0.305	1.44±0.073	5.24±0.220	4.23±0.056	1.44±0.064	5.27±0.148
	Summer	3.76±0.399	1.40±0.095	5.21±0.136	4.12±0.332	1.32±0.088	5.25±0.235
	Autumn	3.62±0.235	1.34±0.100	4.55±0.897	4.27±0.298	1.54±0.109	5.50±0.342
	Mean	**3.82±0.241**	**1.39±0.050**	**5.00±0.390**	**4.21±0.078**	**1.43±0.110**	**5.34±0.139**
Seasonal mean	Spring	3.78±0.445	1.39±0.071	4.76±0.679	3.96±0.382	1.41±0.049	4.80±0.665
	Summer	3.64±0.170	1.36±0.057	4.75±0.651	3.79±0.474	1.34±0.021	4.85±0.566
	Autumn	3.50±0.170	1.34±0.007	4.28±0.382	4.08±0.276	1.52±0.035	5.06±0.629
Grand mean		**3.64±0.140**	**1.36±0.025**	**4.60±0.274**	**3.94±0.146**	**1.42±0.091**	**4.90±0.138**
F	Sex	53.256	17.826	229.951	160.030	4.320	1187.809
	Season	10.100	4.687	34.837	15.792	49.440	38.014
	S X S	6.499	3.454	6.272	3.534	3.982	2.592
CV%		**7.62**	**6.36**	**7.37**	**5.85**	**5.58**	**2.84**
CD%	Sex	0.180***	0.056***	0.190***	0.150***	0.029*	0.069***
	Season	0.221***	0.039*	0.233***	0.184***	0.063***	0.111***
	S X S	0.237**	0.055*	0.329*	0.148*	0.051*	NS

(* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Non significant)**



(a)



(b)

Fig. 42 Seasonal morphometric variation of *Antheraea assama* (cultivated) on two host plants in Mokokchung

3. *A. assama* (wild) fed on Mejankari and Som at Mokokchung (Higher altitude)

The morphometric variation of larval developmental stages of *A. assama* (wild) is given in **Table 12** and **Fig. 43 a.**

Larva

1st Instar: While there was no significant impact of the seasons on the larval length within the host plants (0.96-1.14 cm in Mejankari to 0.90-1.02 cm in Som), mean larval length was significantly higher in Mejankari (1.07 cm) than Som (0.94 cm). The breadth varied from 0.11 - 0.16 cm with a mean of 0.14 cm in Mejankari and from 0.14-0.15cm with a mean of 0.14 cm in Som that showed difference among seasons at 5% level of probability having no significance difference between host plants. Weight of the silk worm was maximum during summer in both host plants, the mean seasonal value of which was recorded as 0.05 gm in Mejankari and Som. Although host plant impact was not evident, seasonal effect was highly significant. Further, the interaction effect due to host plant x season was significant in all parameters.

2nd Instar: Highly significant difference was observed in larval length among different seasons showing maximum and minimum during summer and spring seasons with a mean value of 1.84 cm and 1.81 cm in Mejankari and Som respectively. However interaction effect due to host plant x season was not significant. Mean difference in breadth between the two host plants was not significant, but seasonal difference within the host plant was highly significant. Weight of the silk worm was also maximum during summer in both host plants with a record of seasonal mean of 0.16 gm (Mejankari) and 0.19 gm (Som), which indicated highly significant effect of host plants and seasons.

3rd Instar: The larval length in Mejankari varied from 3.24 to 3.42 cm having a seasonal mean of 3.31 cm, however in Som it was recorded as 3.43 cm with seasonal fluctuation between 3.05 and 3.63 cm. While host plant effect was significant at 5% level, the seasonality and interaction effect due to host plant x season was highly significant. The breadth was recorded to be maximum during autumn in Mejankari (0.34 cm) and spring in Som (0.38 cm) having no significant difference among the seasons. However difference was highly significant between Mejankari (0.32 cm) and Som (0.36 cm) having mild combined interaction effect of host plant x season. While no significant difference was recorded on larval weight between Mejankari (0.56 gm) and Som (0.60 gm), seasonal effect was significant having maximum of 0.62 gm during summer in Mejankari and 0.91 gm during spring in Som. Interaction effect due to host plant x season was just significant at 5% level of probability.

4th Instar: Larval length was significantly higher in Som (4.90 cm) than Mejankari (4.19 cm), however summer season recorded maximum length in both host plants (4.58 cm and 5.20 cm in Mejankari and Som respectively) having shown highly significant differences among the seasons. However interaction effect due to host plant x season was insignificant. Breadth of the silkworm ranged from 0.57 cm (Som) to 0.72 cm (Mejankari) having shown maximum during spring season in both host plants. However larval weight was recorded to be higher in Som (1.99 gm) than Mejankari (1.31 gm) and exhibited fluctuation among the three seasons. Highly significant difference was observed between host plants, among seasons and also interaction effect due to host plants x seasons in breadth and weight in 4th instar larva.

5th Instar: There was strong seasonal and host plant influence together with interaction effect of host plant x season on larval length and breadth in 5th larval stage. Length and breadth ranges from 8.45-1.34 cm to 9.77-1.54 cm in Mejankari and Som respectively. Larval weight was higher in Som (11.56 gm) than Mejankari (10.74 gm) exhibiting highly significant difference. Further, difference was not significant among the seasons and fluctuated with maximum record during spring in Mejankari (11.11 gm) and autumn in Som (12.43 gm). However the interaction effect due to host plant x season was highly significant.

The volume (length x breadth) and weight of the larva during first instar was comparatively less in Som than Mejankari which was however getting reverse along with developmental stages and attained maximum volume and weight of 14.99 cm and 11.56 gm in Som and 11.35 cm and 10.74 gm in Mejankari respectively.

Cocoon

While the length, breadth and weight of female cocoon were significantly higher than male counterpart in all seasons in both host plants, the morphometric characteristics of Som fed cocoons were found superior to Mejankari except for breadth of female cocoon in Mejankari **(Table 13).** Average cocoon length was higher in Som (4.62 cm) than Mejankari (4.52 cm) with maximum during spring (4.86 cm) and autumn (4.71 cm) in Som and Mejankari respectively showing highly significant difference among seasons and between sexes. However interaction effect due to season x sex was not significant on both host plants. Variation in cocoon breadth was significant between two host plants exhibiting 1.59 cm (Mejankari) and 1.61 cm (Som) having shown seasonal variation within the host plants (1.52-1.72 cm in Som to 1.55-1.60 cm in Mejankari). The interaction effect due to season x sex was also found to be highly significant. While mean seasonal cocoon weight was higher in Som (5.76 gm) than Mejankari (5.58 gm), maximum of weight was recorded 6.70 gm and 6.49 gm during spring season in Som and Mejankari respectively showing highly significant effect of seasons and host plants. The interaction effect due to season x sex was also highly significant. Cocoon parameters in Som was found to be better that that of Mejankari and spring season was more favourable followed by autumn and summer season showing significant interaction effect due to sex x seasons **(Fig. 43 b).**

Pupa

The mean value of length, breadth and weight of female pupa was also significantly higher than male counterpart with variation in different seasons and exhibited better performance in Som than Mejankari in both sexes **(Table 14).** The pupal length in Som varied from 4.09 to 4.46 cm in different seasons having a mean of 4.33 cm, while in Mejankari it was recorded as 4.12 cm with seasonal fluctuation between 3.98 and 4.30 cm showing highly significant difference among seasons and between sexes. The breadth varied from 1.31- 1.49 cm with a mean of 1.40 cm in Som and from 1.31-1.37 cm with a mean of 1.34 cm in Mejankari. While highly significant difference in breadth between the two sexes was observed both in Som and Mejankari, seasonal difference was not found to be significant in Mejankari. Highly significant effect of seasons and host plants was evident on weight of the pupa that ranged from 5.05 gm (Mejankari) to 5.19 gm (Som) having the maximum record during spring in both Som (6.01 gm) and Mejankari (5.83 gm). Except for the weight in Som, the interaction effect due to season and sex was highly significant for weight in Som while in Mejankari; it was significant for length and weight of pupa **(Fig. 43 b).**

Adult: The wild variety of *A. assama* was large in size and deeper in colour in comparison to cultivated variety **(Fig. 40 c).** Female was orange brown to reddish brown in colour. Wing span was 153 to 172 mm. Forewing was 74 to 79 mm in length and hind wing was 51 to 56 mm in length. Body was about 43 to 46 mm in length and 11 to 14 mm in breadth. The ante median line (AM) and the oblique line (OL) was with a faint white border on the surface. Male moth was chocolate to orange brown in colour. The basal area of the forewing was greyish brown in colour. Apical area of the forewing was black to brown colour shade, strong coloured wing and highly feathery antenna. The wing span was 142 to 153 mm. Forewing was 66 to 75 mm in length and hind wing was 41 to 46 mm in length. The body was 34 to 39 mm in length and 9 to 12 mm in breadth respectively. The post median line (PM) was bordered by single white lining on either side in the male by a pinkish white inner and faint white outer line in the female. The size of male antenna was 14 to 15 mm in length and 7 to 8 mm in breadth and in case of female antenna was 13 to 14 mm in length and 3 to 4 mm in breadth.

Moth emergence occurred in the evening through the valve of base of the cocoon. Just after emergence, it clung to the wall of the moth cage and remained there for 4-5 hours till its wings were fully stretched. Mating occurred on the same day (mid night), usually continued to the following day evening if undisturbed and laid eggs in the same evening after breaking pair. They did not incline to mechanical pairing as was practiced in cultivated variety. The male moth died after 7-8 days of copulation and the female died after 9-11 days of oviposition.

Table 12: Morphometric variation of developmental stages of *Antheraea assama* (Wild) on Mejankari and Som host plants at Mokokchung (* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Non significant)**

Para-meter	Host plant	Season	Stages (Mean±SE)				
			1st	**2nd**	**3rd**	**4th**	**5th**
Length (cm)	Mejankari	Spring	1.14±0.131	1.72±0.108	3.24±0.179	4.48±0.189	9.14±0.490
		Summer	0.96±0.228	1.98±0.329	3.42±0.223	4.58±0.588	8.82±0.741
		Autumn	1.13±0.223	1.83±0.260	3.28±0.163	3.52±0.266	7.38±0.787
		Mean	**1.07±0.101**	**1.84±0.131**	**3.31±0.095**	**4.19±0.585**	**8.45±0.938**
	Som	Spring	0.90±0.145	1.67±0.221	3.61±0.265	5.13±0.310	9.77±0.510
		Summer	1.02±0.224	2.02±0.387	3.63±0.309	5.20±0.692	9.48±0.736
		Autumn	0.91±0.132	1.75±0.287	3.05±0.325	4.38±0.444	10.04±1.013
		Mean	**0.94±0.067**	**1.81±0.183**	**3.43±0.329**	**4.90±0.455**	**9.77±0.280**
	Grand mean		**1.01±0.092**	**1.83±0.021**	**3.37±0.085**	**4.55±0.502**	**9.11±0.933**
	F	Host plant	14.706	0.351	6.754	86.497	85.346
		Season	0.359	13.393	23.438	62.154	9.248
		H X S	8.067	0.555	16.278	0.983	22.222
	CV%		**18.76**	**14.34**	**7.23**	**9.20**	**8.59**
	CD%	Host plant	0.123***	NS	0.90*	0.273***	0.510***
		Season	NS	0.209***	0.182***	0.273***	0.624***
		H X S	0.162**	NS	0.275***	NS	0.883***
Breadth (cm)	Mejankari	Spring	0.11±0.018	0.20±0.035	0.31±0.048	0.96±0.241	1.54±0.084
		Summer	0.14±0.044	0.24±0.030	0.31±0.051	0.50±0.084	1.50±0.092
		Autumn	0.16±0.017	0.24±0.025	0.34±0.032	0.71±0.100	1.00±0.199
		Mean	**0.14±0.024**	**0.23±0.022**	**0.32±0.018**	**0.72±0.233**	**1.34±0.303**
	Som	Spring	0.14±0.032	0.18±0.033	0.38±0.055	0.62±0.112	1.60±0.083
		Summer	0.15±0.047	0.26±0.048	0.35±0.064	0.58±0.105	1.52±0.163
		Autumn	0.14±0.040	0.24±0.035	0.35±0.033	0.50±0.066	1.50±0.209
		Mean	**0.14±0.009**	**0.23±0.045**	**0.36±0.019**	**0.57±0.060**	**1.54±0.056**
	Grand mean		**0.14±0.000**	**0.23±0.000**	**0.34±0.028**	**0.65±0.106**	**1.44±0.141**
	F	Host plant	1.009	0.036	28.810	46.745	65.878
		Season	4.352	53.563	1.613	44.336	69.899
		H X S	4.755	6.394	3.292	30.729	42.224
	CV%		**26.63**	**12.78**	**11.99**	**19.19**	**9.03**
	CD%	Host plant	NS	NS	0.27***	0.140***	0.085***
		Season	0.017*	0.023***	NS	0.099***	0.104***
		H X S	0.042***	0.025**	0.026*	0.081***	0.104***
Weight (gm)	Mejankri	Spring	0.03±0.012	0.13±0.024	0.58±0.044	1.67±0.130	11.11±0.958
		Summer	0.07±0.016	0.19±0.029	0.62±0.089	1.56±0.565	11.04±0.945
		Autumn	0.04±0.015	0.16±0.022	0.49±0.060	0.70±0.266	10.06±0.979
		Mean	**0.05±0.023**	**0.16±0.030**	**0.56±0.066**	**1.31±0.531**	**10.74±0.586**
	Som	Spring	0.04±0.012	0.18±0.019	0.91±0.214	2.04±0.292	10.59±0.990
		Summer	0.07±0.015	0.21±0.025	0.65±0.329	2.08±0.508	11.66±1.090
		Autumn	0.03±0.008	0.19±0.059	0.24±0.024	1.85±0.359	12.43±1.411
		Mean	**0.05±0.021**	**0.19±0.015**	**0.60±0.336**	**1.99±0.121**	**11.56±0.927**
	Grand mean		**0.05±0.00**	**0.18±0.021**	**0.58±0.028**	**1.65±0.481**	**11.15±0.580**
	F	Host plant	0.706	23.760	1.534	111.218	16.718
		Season	102.521	20.542	5.680	33.992	2.307
		H X S	12.733	3.478	3.082	13.831	17.481
	CV%		**28.81**	**19.28**	**28.38**	**21.35**	**9.89**
	CD%	Host plant	NS	0.022***	NS	0.230***	0.718***
		Season	0.011***	0.027***	0.099**	0.230***	NS
		H X S	0.011**	0.021*	0.105*	0.398***	1.244***

Table 13: Variation of cocoon parameters of *Antheraea assama* (Wild) on Mejankari and Som host plants at Mokokchung

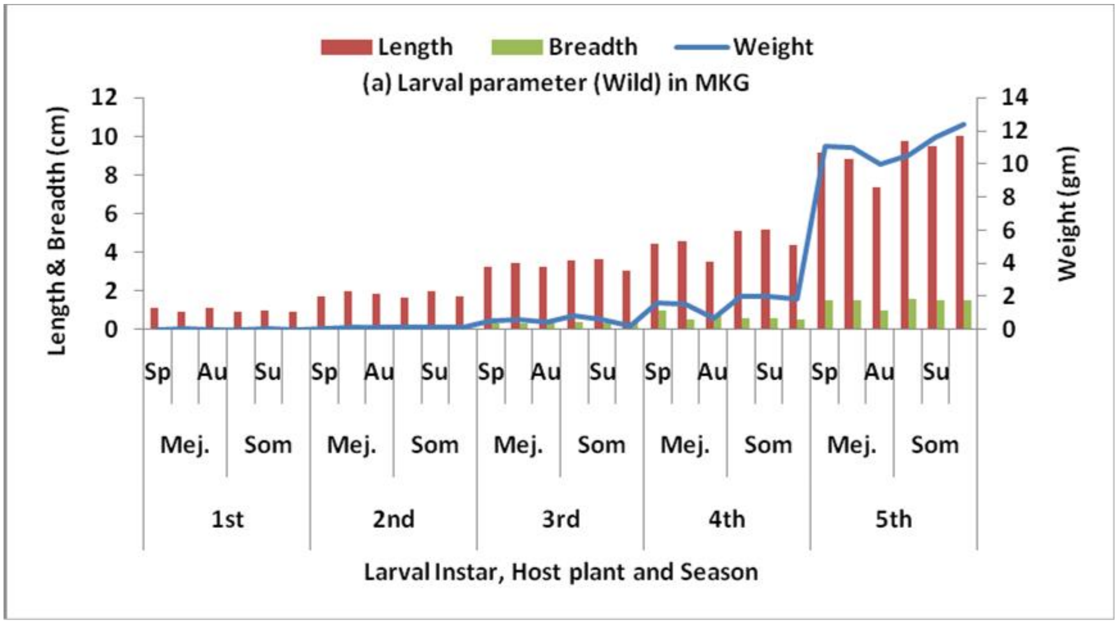
Sex	Season	Host plant and Parameter (Mean±SE)					
		Mejankari			Som		
		Length (cm)	Breadth (cm)	Weight (gm)	Length (cm)	Breadth (cm)	Weight (gm)
Male	Spring	4.42±0.101	1.44±0.059	5.65±0.128	4.56±0.193	1.37±0.135	5.13±0.148
	Summer	3.88±0.095	1.56±0.051	4.04±0.160	4.10±0.132	1.42±0.099	4.87±0.201
	Autumn	4.39±0.075	1.53±0.091	5.28±0.170	4.60±0.048	1.54±0.088	5.12±0.259
	Mean	**4.23±0.303**	**1.51±0.062**	**4.99±0.843**	**4.42±0.276**	**1.44±0.084**	**5.04±0.143**
Female	Spring	4.99±0.107	1.66±0.143	7.34±0.131	5.15±0.146	1.66±0.143	8.27±0.181
	Summer	4.40±0.093	1.64±0.081	4.76±0.105	4.44±0.221	1.77±0.098	5.05±0.242
	Autumn	5.04±0.093	1.68±0.077	6.49±0.265	4.88±0.141	1.89±0.091	6.09±0.283
	Mean	**4.81±0.356**	**1.66±0.020**	**6.20±1.315**	**4.82±0.358**	**1.77±0.115**	**6.47±1.643**
Seasonal mean	Spring	4.71±0.403	1.55±0.156	6.49±1.195	4.86±0.417	1.52±0.205	6.70±2.220
	Summer	4.14±0.368	1.60±0.057	4.40±0.509	4.27±0.240	1.60±0.247	4.96±0.127
	Autumn	4.71±0.460	1.60±0.106	5.89±0.856	4.74±0.198	1.72±0.247	5.61±0.686
Grand mean		**4.52±0.329**	**1.59±0.032**	**5.58±1.076**	**4.62±0.312**	**1.61±0.095**	**5.76±0.879**
F	Sex	870.99	80.014	1596.23	404.77	298.101	1737.13
	Season	499.317	4.038	1698.498	205.12	35.262	873.949
	S X S	3.185	5.968	85.306	0.601	1.344	670.261
CV%		**4.36**	**2.41**	**5.93**	**3.72**	**6.54**	**3.26**
CD%	Sex	0.071***	0.061***	0.098***	0.109***	0.069***	0.122***
	Season	0.086***	0.042*	0.132***	0.134***	0.084***	0.150***
	S X S	NS	0.081**	0.142**	NS	NS	0.212***

(* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Non significant)**

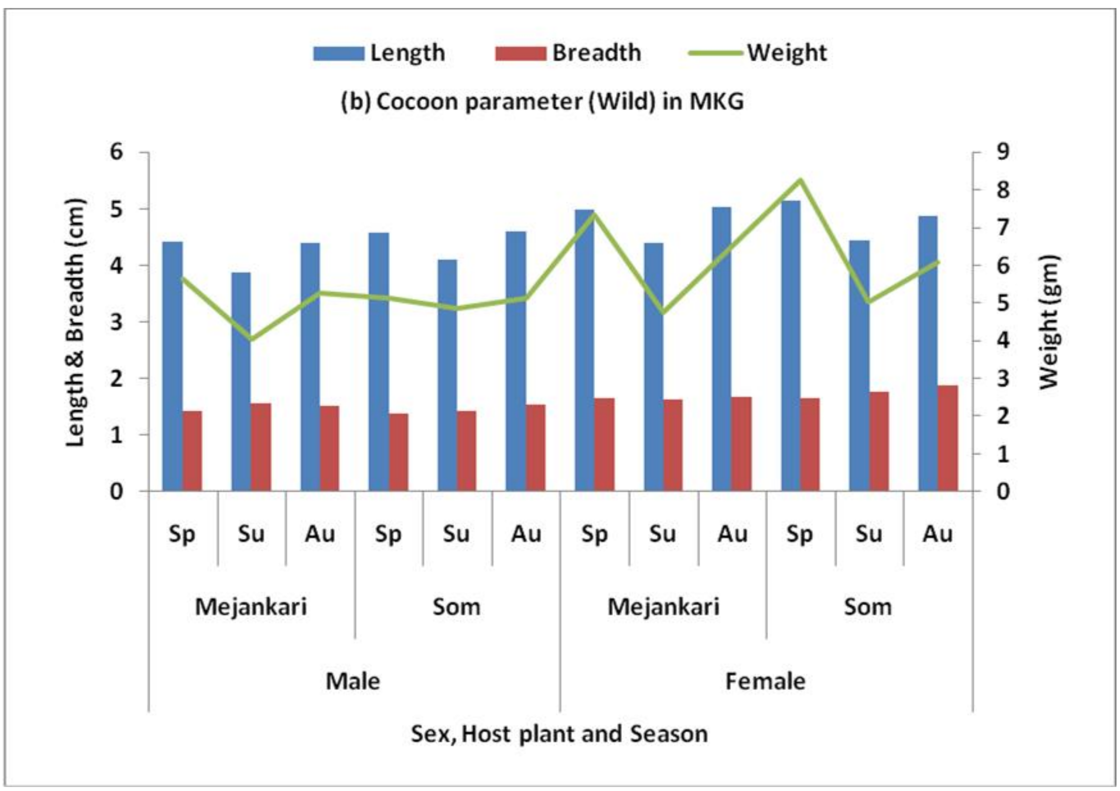
Table 14: Variation of pupal parameters of *Antheraea assama* (Wild) on Mejankari and Som host plants at Mokokchung

Sex	Season	Host plant and Parameter (Mean±SE)					
		Mejankari			Som		
		Length (cm)	Breadth (cm)	Weight (gm)	Length (cm)	Breadth (cm)	Weight (gm)
Male	Spring	3.81±0.287	1.28±0.094	5.06±0.126	4.37±0.464	1.20±0.110	4.49±0.121
	Summer	3.78±0.394	1.26±0.122	3.66±0.163	3.77±0.126	1.18±0.101	4.50±0.202
	Autumn	3.73±0.337	1.27±0.126	4.78±0.169	4.28±0.185	1.30±0.188	4.59±0.255
	Mean	**3.77±0.04**	**1.27±0.01**	**4.50±0.74**	**4.14±0.324**	**1.23±0.064**	**4.53±0.055**
Female	Spring	4.79±0.187	1.46±0.099	6.61±0.131	4.54±0.250	1.57±0.114	7.53±0.182
	Summer	4.31±0.205	1.42±0.088	4.33±0.100	4.42±0.283	1.44±0.120	4.56±0.236
	Autumn	4.24±0.390	1.36±0.082	5.86±0.261	4.58±0.202	1.68±0.116	5.47±0.279
	Mean	**4.45±0.299**	**1.41±0.050**	**5.60±1.162**	**4.51±0.083**	**1.56±0.120**	**5.85±1.522**
Seasonal mean	Spring	4.30±0.693	1.37±0.127	5.83±1.096	4.46±0.120	1.38±0.262	6.01±2.150
	Summer	4.05±0.375	1.34±0.113	3.99±0.474	4.09±0.460	1.31±0.184	4.53±0.042
	Autumn	3.98±0.361	1.31±0.064	5.32±0.764	4.43±0.212	1.49±0.269	5.03±0.622
Grand mean		**4.12±0.481**	**1.34±0.099**	**5.05±0.778**	**4.33±0.262**	**1.40±0.233**	**5.19±0.933**
F	Sex	116.672	66.849	1318.076	7.292	209.861	1456.468
	Season	8.759	3.078	1310.459	11.084	20.670	623.770
	S X S	6.448	2.629	70.007	2.927	2.682	654.699
CV%		**8.23**	**7.15**	**3.28**	**7.11**	**9.02**	**3.67**
CD%	Sex	0.222***	0.062***	0.108***	0.117*	0.082***	0.124***
	Season	0.272***	NS	0.132***	0.252***	0.100***	0.152***
	S X S	0.292**	NS	0.187***	NS	NS	0.215***

(* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Non significant)**



(a)



(b)

Fig. 43 Seasonal morphometric variation of *Antheraea assama* (Wild) on two host plants in Mokokchung

4. Comparison of cultivated (C) and wild (W) variety on Mejankari at Mokokchung

The morphometric variation of developmental stages of *A. assama* (cultivated and wild) on Mejankari host plant in Mokokchung is presented in **Table 15** and **Fig. 44 a**.

Larva

Length: Except for 2nd instar, mean larval length in different instars was higher in wild variety in comparison to cultivated one exhibiting highly significant difference between two varieties. Highly significant difference on seasonal influence was noticed in both varieties and wild variety recorded higher length in all instars than cultivated one in respective seasons. However, there was no significant difference of interaction effect due to varieties and seasons.

Breadth: Except for 1st and 3rd instar, mean larval breadth was higher in wild variety and similar trend had also been observed in both varieties among three seasons. Highly significant difference was observed between varieties and among seasons in all instars except for 1st instar and interaction effect due to variety and season was also not significant.

Weight: With minimum of 0.05 gm in 1st instar, weight of the wild variety increased upto 10.74 gm in 5th instar, however the maximum weight of 5th instar larva of cultivated variety was recorded as 7.25 gm. Except for 4th instar, mean larval weight was higher in wild variety than cultivated one in all instars exhibiting highly significant difference between the varieties. Summer season favoured growth in initial larval instars (1st to 3rd instar) however; weight of 4th and 5th instar larva was recorded higher during season for both varieties. While seasonal difference was highly significant, the interaction effect due to variety and seasons was not significant in all instars.

Cocoon

Length: Cocoon length in all seasons and sexes was higher in wild variety than the cultivated one, having a mean average length of 4.50 cm (wild) and 4.48 cm (cultivated) respectively, showing highly significant effect of sex and variety, but no seasonal impact. While interaction effect due to season x variety and sex x variety was significant, it was not significant due to sex x season. Further, combined effect of sex x season x variety was also not found to be significant on cocoon length.

Breadth: Except for autumn season, cocoon breadth was higher in cultivated variety than wild counterpart in both sexes with a record of average total mean of 1.70 cm and 1.59 cm respectively and exhibited highly significant difference between sex, season and variety. The interaction effect due to sex x season, sex x variety and season x variety and combined effect of sex, season and variety was also found to be highly significant.

Weight: Except for summer season cocoon weight was higher in wild variety than the cultivated one in both sexes, having a mean average weight of 5.60 gm and 5.01 gm respectively, showing highly significant effect of sex, seasons and variety. The interaction effect due to sex x season, sex x variety and season x variety and combined effect of sex, season and variety was also found to be highly significant **(Table 16 and Fig. 44 b).**

Pupa

Length: Having shown the seasonal variation of 3.99 to 4.30 cm (in wild) and 3.50 to 3.77 cm (in cultivated), pupal length in all seasons and sexes was higher in wild variety than the cultivated one, having a mean record of 4.11 cm (Wild) and 3.64 cm (Cultivated) respectively and exhibited highly significant effect of sex, season and variety. The interaction effect due to sex x season and sex x variety was also highly significant. However, interaction effect due to season x variety and combined effect of sex, season and variety was found to be non significant.

Breadth: Except for the minimum record in female cocoon in all seasons, cultivated variety exhibited higher cocoon breadth than wild counterpart in both sexes and seasons with a total mean of 1.36 cm and 1.34 cm respectively. The individual effect of sex, season and variety and the interaction effect due to sex x season, sex x variety was highly significant; however, interaction effect due to season x variety and combined effect of sex, season and variety was not significant.

Weight: As observed in cocoon, except for summer season in both sexes, pupal weight was also higher in wild variety than the cultivated one, having a mean average weight of 5.05 gm and 4.60 gm respectively, showing highly significant effect of sex, seasons and variety. The interaction effect due to sex x season, sex x variety and season x variety and combined effect of sex, season and variety was also found to be highly significant **(Table 17 and Fig. 44 b).**

Table 15: Morphometric variation of developmental stages of *Antheraea assama* (C & W) on Mejankari host plant in Mokokchung (* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Non significant)**

Parameter	Variety	Season	Stages (Mean±SE)				
			1st	**2nd**	**3rd**	**4th**	**5th**
Length (cm)	**C**	Spring	1.03±0.114	1.67±0.099	2.90±0.293	4.21±0.043	8.59±0.596
		Summer	0.87±0.280	1.93±0.422	3.07±0.398	4.30±0.950	8.30±1.212
		Autumn	1.02±0.233	1.78±0.297	2.94±0.192	3.30±0.306	6.94±1.243
		Mean	**0.97±0.090**	**1.79±0.131**	**2.97±0.089**	**3.93±0.550**	**7.94±0.880**
	W	Spring	1.14±0.131	1.72±0.108	3.24±0.179	4.48±0.189	9.14±0.490
		Summer	0.96±0.228	1.98±0.329	3.42±0.223	4.58±0.588	8.82±0.741
		Autumn	1.13±0.223	1.83±0.260	3.28±0.163	3.52±0.266	7.38±0.787
		Mean	**1.07±0.103**	**1.84±0.131**	**3.31±0.096**	**4.19±0.587**	**8.45±0.940**
	Grand mean		**1.02±0.071**	**1.82±0.035**	**3.14±0.240**	**4.06±0.184**	**8.19±0.361**
	F	Variety	18.884	2.763	58.766	22.781	12.629
		Season	23.360	25.143	5.617	149.101	55.155
		V X S	0.064	0.001	0.013	0.157	0.060
	CV%		**12.48**	**8.92**	**7.81**	**7.25**	**9.46**
	CD%	Variety	0.083***	NS	0.160***	0.192***	0.384**
		Season	0.102***	0.129***	0.149**	0.235***	0.619***
		H X S	NS	NS	NS	NS	NS
Breadth (cm)	**C**	Spring	0.13±0.028	0.18±0.041	0.37±0.034	0.73±0.034	1.52±0.095
		Summer	0.16±0.047	0.22±0.049	0.38±0.064	0.38±0.052	1.48±0.101
		Autumn	0.18±0.220	0.22±0.215	0.41±0.058	0.54±0.050	0.99±0.208
		Mean	**0.16±0.025**	**0.21±0.023**	**0.39±0.021**	**0.55±0.175**	**1.33±0.295**
	W	Spring	0.11±0.018	0.20±0.035	0.31±0.048	0.96±0.241	1.54±0.084
		Summer	0.14±0.044	0.24±0.030	0.31±0.051	0.50±0.084	1.50±0.092
		Autumn	0.16±0.017	0.24±0.022	0.34±0.032	0.71±0.100	1.00±0.199
		Mean	**0.14±0.025**	**0.23±0.023**	**0.32±0.017**	**0.72±0.230**	**1.35±0.301**
	Grand mean		**0.15±0.014**	**0.22±0.014**	**0.35±0.049**	**0.64±0.120**	**1.34±0.014**
	F	Variety	1.355	24.791	72.761	69.945	5.945
		Season	3.086	28.958	9.030	131.943	2514.685
		V X S	0.020	0.80	0.025	NS	0.245
	CV%		**61.88**	**11.60**	**11.36**	**17.70**	**2.83**
	CD%	Variety	NS	0.106***	0.026***	0.073***	0.014*
		Season	NS	0.020***	0.026***	0.073***	0.030***
		V X S	NS	NS	NS	NS	NS
Weight (gm)	**C**	Spring	0.02±0.012	0.09±0.007	0.51±0.059	1.74±0.103	7.50±0.061
		Summer	0.05±0.030	0.13±0.050	0.54±0.164	1.62±0.872	7.46±1.851
		Autumn	0.03±0.017	0.11±0.043	0.43±0.089	0.73±0.295	6.79±1.154
		Mean	**0.04±0.015**	**0.11±0.020**	**0.49±0.057**	**1.36±0.552**	**7.25±0.399**
	W	Spring	0.03±0.012	0.13±0.024	0.58±0.044	1.67±0.130	11.11±0.958
		Summer	0.07±0.016	0.19±0.029	0.62±0.089	1.56±0.565	11.04±0.945
		Autumn	0.04±0.015	0.16±0.022	0.49±0.060	0.70±0.266	10.06±0.979
		Mean	**0.05±0.021**	**0.16±0.030**	**0.56±0.067**	**1.31±0.531**	**10.74±0.587**
	Grand mean		**0.04±0.008**	**0.14±0.035**	**0.53±0.047**	**1.35±0.018**	**8.99±2.466**
	F	Variety	18.546	79.309	33.282	0.746	191.730
		Season	67.228	30.152	41.280	108.593	5.069
		V X S	2.817	2.286	0.119	0.043	0.331
	CV%		**35.17**	**22.51**	**11.81**	**24.60**	**15.34**
	CD%	Variety	0.010***	0.020***	0.041***	NS	0.899***
		Season	0.012***	0.024***	0.050***	0.262***	0.625*
		V X S	NS	NS	NS	NS	NS

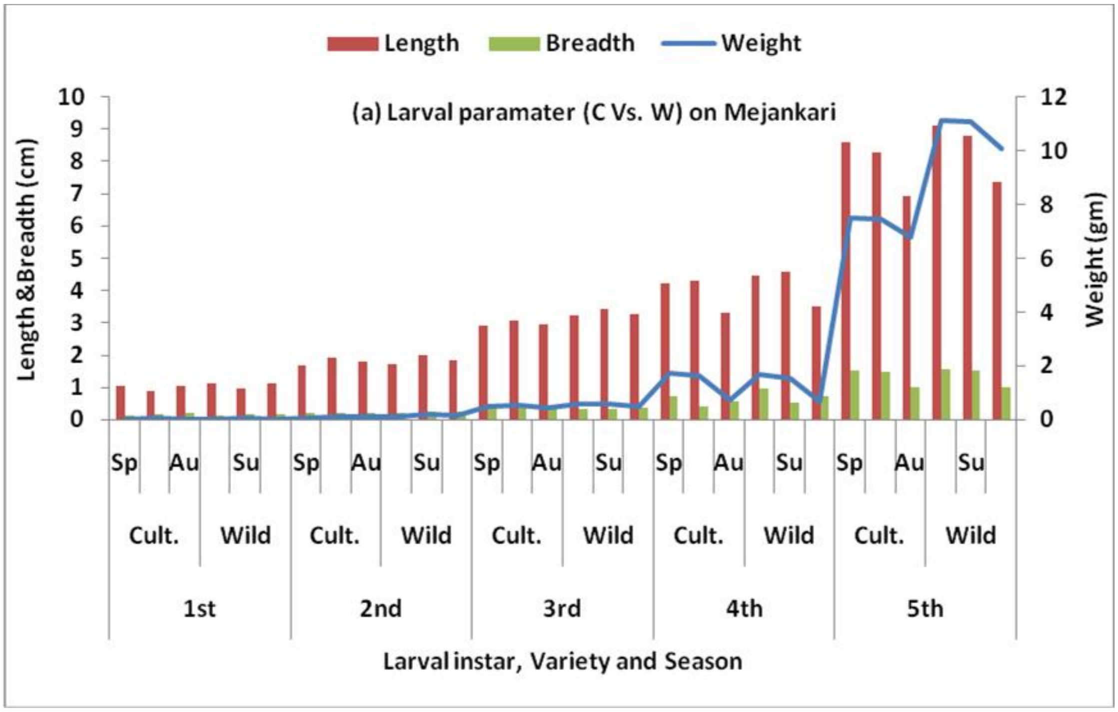
Table 16: Variation of cocoon parameters of *A. assama* (C & W) on Mejankari host plant at Mokokchung (* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Non significant)**

Variety	Sex	Season	Parameters (Mean±SE)		
			Length (cm)	Breadth (cm)	Weight (cm)
Cultivated	**Male**	Spring	4.21±0.296	1.55±0.24	4.71±0.156
		Summer	4.31±0.229	1.59±0.146	4.69±0.130
		Autumn	3.85±0.435	1.45±0.087	4.33±0.488
		Mean	**4.12±0.242**	**1.53±0.073**	**4.58±0.213**
	Female	Spring	5.00±0.228	1.97±0.158	5.78±0.215
		Summer	4.98±0.211	2.03±0.196	5.67±0.138
		Autumn	4.53±0.557	1.64±0.236	4.88±0.888
		Mean	**4.84±0.266**	**1.88±0.207**	**5.44±0.491**
	Seasonal mean	Spring	4.61±0.559	1.76±0.297	5.24±0.757
		Summer	4.65±0.474	1.81±0.311	5.18±0.693
		Autumn	4.19±0.481	1.55±0.134	4.60±0.389
	Total mean		**4.48±0.509**	**1.70±0.247**	**5.01±0.608**
Wild	Male	Spring	4.42±0.101	1.44±0.059	5.65±0.128
		Summer	3.78±0.136	1.56±0.051	4.04±0.160
		Autumn	4.39±0.075	1.53±0.091	5.28±0.170
		Mean	**4.20±0.361**	**1.51±0.062**	**4.99±0.843**
	Female	Spring	4.99±0.107	1.66±0.143	7.34±0.131
		Summer	4.31±0.159	1.64±0.081	4.76±0.105
		Autumn	5.04±0.093	1.68±0.077	6.49±0.265
		Mean	**4.80±0.408**	**1.66±0.020**	**6.20±1.315**
	Seasonal mean	Spring	4.71±0.403	1.55±0.156	6.50±1.195
		Summer	4.05±0.375	1.60±0.057	4.40±0.509
		Autumn	4.71±0.460	1.61±0.106	5.89±0.856
	Total mean		**4.50±0.381**	**1.59±0.032**	**5.60±1.080**
Average of C & W	Male	Spring	4.32±0.148	1.50±0.078	5.18±0.665
		Summer	4.05±0.375	1.58±0.021	4.37±0.460
		Autumn	4.12±0.382	1.49±0.057	4.81±0.672
		Mean	**4.16±0.140**	**1.52±0.046**	**4.79±0.406**
	Female	Spring	5.00±0.007	1.82±0.219	6.56±1.103
		Summer	4.70±0.474	1.84±0.276	5.22±0.643
		Autumn	4.78±0.361	1.66±0.028	5.69±1.138
		Mean	**4.83±0.155**	**1.77±0.095**	**5.82±0.680**
Total average for season		Spring	4.65±0.481	1.65±0.226	5.87±0.976
		Summer	4.40±0.460	1.71±0.184	4.79±0.601
		Autumn	4.45±0.467	1.58±0.120	5.25±0.622
Grand Mean			**4.50±0.132**	**1.65±0.065**	**5.30±0.542**
F	Sex		481.785***	234.044***	1385.28***
	Season		0.044 NS	54.750***	505.137**
	Varity		37.271***	20.158***	441.809***
	Sex X Sea		0.726 NS	6.699**	37.837***
	Sex X Var		4.817*	36.358***	37.751***
	Sea X Var		122.878***	29.415***	602.094***
	Sex X Sea X Var		0.932 NS	7.674**	29.247***
CV%			**5.10**	**7.80**	**4.06**

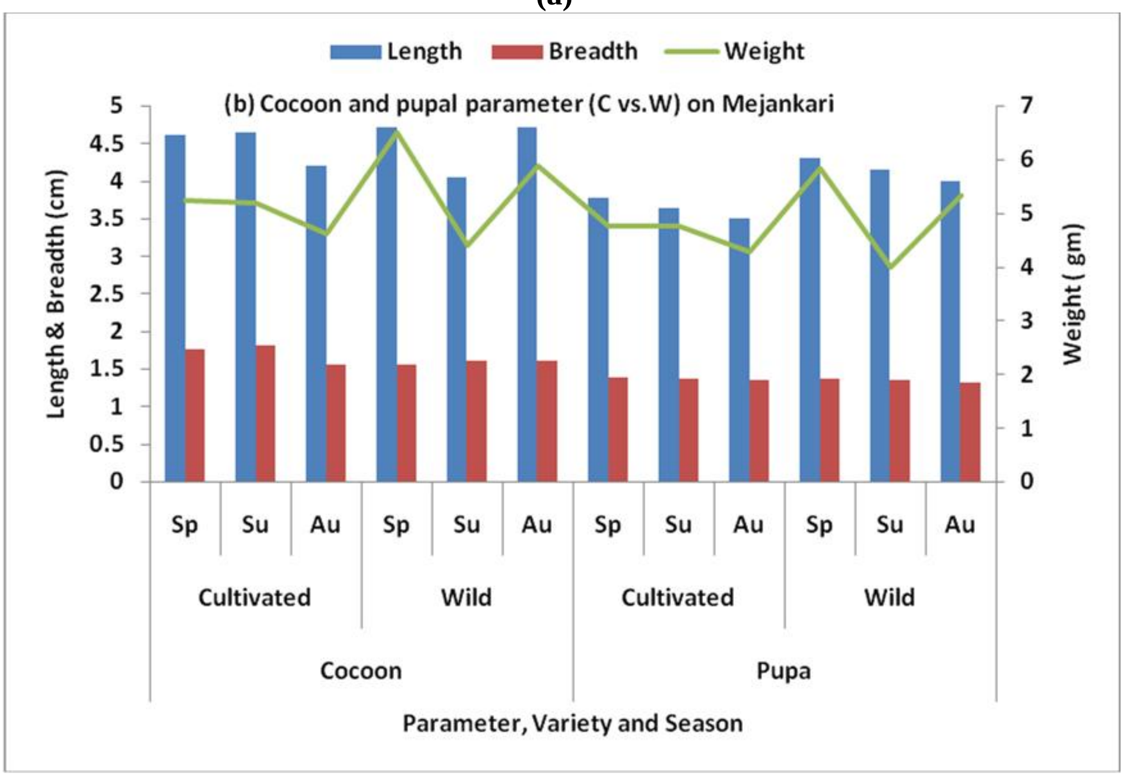
Table 17 Variation of pupal parameters of *A. assama* (C & W) on Mejankari host plant in Mokokchung

Variety	Sex	Season	Parameters (Mean±SE)		
			Length (cm)	**Breadth (cm)**	**Weight (gm)**
Cultivated	Male	Spring	3.46±0.196	1.34±0.057	4.28±0.158
		Summer	3.52±0.212	1.32±0.086	4.29±0.131
		Autumn	3.38±0.408	1.33±0.107	4.01±0.458
		Mean	**3.45±0.057**	**1.33±0.008**	**4.19±0.130**
	Female	Spring	4.09±0.305	1.44±0.073	5.24±0.220
		Summer	3.76±0.399	1.40±0.095	5.21±0.136
		Autumn	3.62±0.235	1.34±0.100	4.55±0.897
		Mean	**3.82±0.197**	**1.39±0.041**	**5.00±0.318**
	Seasonal mean	Spring	3.77±0.325	1.39±0.050	4.76±0.480
		Summer	3.64±0.120	1.36±0.040	4.75±0.460
		Autumn	3.50±0.120	1.34±0.005	4.28±0.270
	Total mean		**3.64±0.110**	**1.36±0.024**	**4.60±0.224**
Wild	Male	Spring	3.81±0.287	1.28±0.094	5.059±0.126
		Summer	3.88±0.334	1.26±0.122	3.66±0.163
		Autumn	3.73±0.337	1.27±0.126	4.78±0.169
		Mean	**3.81±0.061**	**1.27±0.088**	**4.50±0.605**
	Female	Spring	4.79±0.187	1.46±0.099	6.61±0.131
		Summer	4.40±0.371	1.42±0.088	4.33±0.100
		Autumn	4.24±0.390	1.36±0.082	5.86±0.261
		Mean	**4.48±0.231**	**1.41±0.041**	**5.60±0.949**
	Seasonal mean	Spring	4.30±0.490	1.37±0.090	5.84±0.775
		Summer	4.14±0.260	1.34±0.080	3.99±0.335
		Autumn	3.99±0.255	1.31±0.045	5.32±0.540
	Total mean		**4.11±0.137**	**1.34±0.024**	**5.05±0.779**
Average of C & W	Male	Spring	3.64±0.175	1.31±0.030	4.67±**0.551**
		Summer	3.70±0.180	1.29± 0.030	3.97±**0.445**
		Autumn	3.55±**0.175**	1.30±0.030	4.40±**0.544**
		Mean	**3.63±0.062**	**1.30±0.010**	**4.35±0.353**
	Female	Spring	4.44±0.350	1.45±**0.014**	5.93±0.969
		Summer	4.03±0.320	1.41±**0.014**	4.77±0.622
		Autumn	3.93±0.310	1.35±**0.014**	5.21±0.926
		Mean	**4.13±0.221**	**1.40±0.050**	**5.30±0.586**
Total average for season		Spring	4.04±0.566	1.38±0.099	5.29±0.891
		Summer	3.87±0.233	1.35±0.085	4.37±0.566
		Autumn	3.74±0.269	1.33±0.035	4.81±0.573
Grand Mean			**3.87±0.092**	**1.35±0.014**	**4.59±0.311**
F	Sex		238.508**	234.330***	1064.454***
	Season		26.171***	22.414***	333.021***
	Varity		225.246***	8.476**	240.660***
	Sex X Sea		18.108***	17.735***	26.358***
	Sex X Var		20.209***	30.990***	24.678***
	Sea X Var		0.121 NS	0.076 NS	427.530***
	Sex X Sea X Var		0.187NS	0.013 NS	21.590***
CV%			**6.71**	**3.93**	**4.69**

(* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Non significant)**



(a)



(b)

Fig. 44 Seasonal morphometric variation of *Antheraea assama* (cultivated vs. wild) on *Litsea citrata* (Mejankari) in Mokokchung

5. Comparison of cultivated (C) and wild (W) variety of *A. assama* on Som at Mokokchung

The morphometric variation of developmental stages of *A. assama* (cultivated and wild) on Som host plant in Mokokchung is presented in **Table 18** and **Fig. 45a**.

Larva

Length: Mean larval length in initial two instars i.e.1st and 2nd was recorded to be higher in cultivated variety. However in later stages, length in wild variety was comparatively more than corresponding instars of cultivated one with maximum of 9.77 cm (wild) and 9.32 cm (cultivated) respectively in 5th stage exhibiting highly significant difference between two varieties except for 2nd instar wherein difference was noticed at 5% probability level. While highly significant difference on seasonal influence was noticed in larval length in all instars, the interaction effect due to varieties x seasons was not significant.

Breadth: Except for 5th instar, which recorded higher larval breadth in wild (1.54 cm) than cultivated one (1.48 cm), mean larval breadth in other instars were more in cultivated variety than wild having a similar trend in both varieties among three seasons showing highly significant difference among the seasons in all instars. While highly significant difference between varieties was noticed in 3rd, 4th and 5th instars, interaction effect due to variety and season was not found to be significant in all instars.

Weight: With minimum 0.05 gm in 1st instar, weight of the wild variety increased up to 11.56 gm in 5th instar, however maximum weight of 5th instar larva of cultivated variety was recorded as 7.54 gm against the initial weight of 0.03 gm in 1st instar. Except for 3rd instar, mean larval weight was higher in wild variety than cultivated one in all instars exhibiting the highly significant difference between the varieties. Summer season was found to be suitable for growth in 1st, 2nd and 4th instar; however, 3rd and 5th instars gained maximum weight during spring and autumn season respectively. While seasonal difference was highly significant (except for 2nd instar), the interaction effect due to variety x seasons was not significant (except for 1st instar).

Cocoon

Length: Although summer and autumn seasons were found to be more suitable for cultivated variety and spring season favoured wild variety, total mean length was recorded to be higher in cultivated variety (4.72 cm) than the wild one (4.57 cm). Further male and female cocoons of cultivated variety were shorter and longer respectively than the respective sexes of wild variety and exhibited high significant effect of sex, season and variety. The interaction effect due to sex x season; season x variety and combined effect of sex x season x variety was highly significant which was however not noticed in sex x variety.

Breadth: Cocoon breadth in all seasons and sexes was higher in cultivated variety than the wild one, having a mean average breadth of 1.85 cm (cultivated) and 1.61 cm (wild) respectively, showing highly significant effect of sex, season and variety. While interaction effect due to season x variety was highly significant, the effect of sex x season was significant having no effect of sex x variety. Further, combined effect of sex x season x variety was also found to be highly significant.

Weight: Mean weight of wild cocoon was higher (5.76 gm) than the cultivated cocoon (5.47 gm) with a similar trend in both sexes. However on seasonal basis, spring season was more favourable for wild variety, while cocoon of cultivated variety gained more weight during summer and autumn seasons highlighting significant effect of sex, seasons and variety. The interaction effect due to sex x season, sex x variety and season x variety and combined effect of sex, season and variety was also found to be highly significant **(Table 19 and Fig. 45 b).**

Pupa

Length : Having shown the seasonal variation of 4.09 to 4.46 cm (in wild) and 3.79 to 4.08 cm (in cultivated), pupa length in all seasons and sexes was higher in wild variety than the cultivated one, with a mean record of 4.33 cm (wild) and 3.94 cm (cultivated) respectively and exhibited highly significant effect of sex, season and variety. The interaction effect due to sex x season and sex x variety was also highly significant. However, interaction effect due to season x variety and combined effect of sex, season and variety was found to be non significant.

Breadth: Except for the minimum record in female cocoon in all seasons, cultivated variety exhibited higher cocoon breadth than wild counterpart in both sexes and seasons with a total mean of 1.42 cm and 1.40 cm respectively. The individual effect of sex, season and variety and the interaction effect due to sex x season, sex x variety was highly significant; however, interaction effect due to season x variety and combined effect of sex, season and variety was not significant.

Weight: While weight of pupa in wild variety during summer and autumn seasons were comparatively less than the respective seasons in cultivated variety, total mean weight was higher in wild (5.19 gm) than cultivated (4.90 gm) with a record of similar trend in both sexes and exhibited highly significant effect of sex, seasons and variety. The interaction effect due to sex x season, sex x variety and season x variety and combined effect of sex, season and variety was also found to be highly significant **(Table 20 and Fig. 45 b).**

Table 18: Morphometric variation of developmental stages of *Antheraea assama* (C & W) on Som host plant in Mokokchung (* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Non significant)**

Parameter	Variety	Season	Stages (Mean±SE)				
			1st	**2nd**	**3rd**	**4th**	**5th**
Length (cm)	**C**	Spring	1.05±0.187	1.70±0.236	3.17±0.264	4.83±0.499	9.33±0.321
		Summer	1.20±0.366	2.06±0.413	3.18±0.398	4.89±0.854	9.05±1.234
		Autumn	1.07±0.142	1.78±0.280	2.68±0.236	4.12±0.417	9.59±0.531
		Mean	**1.11±0.081**	**1.85±0.189**	**3.01±0.286**	**4.61±0.428**	**9.32±0.027**
	W	Spring	0.90±0.145	1.62±0.360	3.61±0.265	5.13±0.310	9.77±0.510
		Summer	1.02±0.224	2.02±0.387	3.62±0.309	5.22±0.692	9.48±0.736
		Autumn	0.91±0.132	1.74±0.287	3.05±0.325	4.37±0.444	10.04±1.013
		Mean	**0.94±0.067**	**1.80±0.205**	**3.43±0.326**	**4.91±0.467**	**9.77±0.280**
	Grand mean		**1.03±0.120**	**1.83±0.035**	**3.22±0.297**	**4.76±0.212**	**9.55±0.318**
	F	Variety	28.158	5.341	78.250	16.070	14.160
		Season	7.362	196.226	57.722	50.025	7.329
		V X S	0.062	0.109	0.243	0.043	0.003
	CV%		**16.55**	**4.54**	**8.01**	**8.33**	**6.73**
	CD%	Variety	0.0034***	0.031*	0.168***	0.258***	0.419***
		Season	0.103**	0.066***	0.065***	0.316***	0.39**
		H X S	NS	NS	NS	NS	NS
Breadth (cm)	**C**	Spring	0.15±0.037	0.19±0.037	0.41±0.075	0.75±0.144	1.54±0.058
		Summer	0.16±0.050	0.27±0.047	0.38±0.070	0.70±0.121	1.47±0.109
		Autumn	0.15±0.048	0.25±0.037	0.38±0.026	0.60±0.077	1.45±0.166
		Mean	**0.15±0.006**	**0.24±0.042**	**0.40±0.017**	**0.68±0.045**	**1.48±0.047**
	W	Spring	0.14±0.032	0.18±0.033	0.38±0.055	0.62±0.112	1.60±0.083
		Summer	0.15±0.047	0.26±0.048	0.35±0.064	0.58±0.105	1.52±0.163
		Autumn	0.14±0.040	0.24±0.035	0.35±0.033	0.50±0.066	1.50±0.209
		Mean	**0.14±0.006**	**0.23±0.042**	**0.36±0.017**	**0.57±0.061**	**1.54±0.053**
	Grand mean		**0.15±0.007**	**0.24±0.007**	**0.38±0.028**	**0.63±0.078**	**1.51±0.064**
	F	Variety	3.200	3.326	26.144	48.817	12.770
		Season	5.414	113.701	16.981	22.155	17.684
		V X S	0.042	0.023	0.027	0.213	0.041
	CV%		**15.13**	**11.49**	**7.37**	**14.30**	**5.29**
	CD%	Variety	NS	NS	0.006***	0.058***	0.052***
		Season	0.014**	0.021***	0.022***	0.071***	0.064***
		V X S	NS	NS	NS	NS	NS
Weight (cm)	**C**	Spring	0.03±0.010	0.13±0.043	1.07±0.359	1.68±0.139	6.91±0.928
		Summer	0.05±0.026	0.15±0.039	0.77±0.489	1.71±0.541	7.61±1.949
		Autumn	0.02±0.008	0.13±0.132	0.28±0.037	1.53±0.233	8.11±1.081
		Mean	**0.03±0.014**	**0.14±0.012**	**0.71±0.399**	**1.64±0.096**	**7.54±0.603**
	W	Spring	0.04±0.012	0.18±0.019	0.91±0.214	2.04±0.292	10.59±0.990
		Summer	0.07±0.015	0.21±0.025	0.65±0.329	2.07±0.508	11.66±1.090
		Autumn	0.03±0.008	0.18±0.059	0.24±0.024	1.85±0.359	12.43±1.411
		Mean	**0.05±0.021**	**0.19±0.017**	**0.60±0.338**	**1.99±0.119**	**11.56±0.924**
	Grand mean		**0.04±0.014**	**0.17±0.035**	**0.66±0.078**	**1.81±0.247**	**9.55±2.843**
	F	Variety	44.444	34.348	13.051	40.541	217.885
		Season	172.840	3.010	198.676	5.370	10.548
		V X S	9.259	0.061	1.397	0.060	0.471
	CV%		**22.61**	**29.42**	**25.33**	**16.52**	**15.59**
	CD%	Variety	0.0006***	0.031***	0.107	0.195***	0.971***
		Season	0.0007***	NS	0.132	0.182**	1.189***
		V X S	0.01**	NS	NS	NS	NS

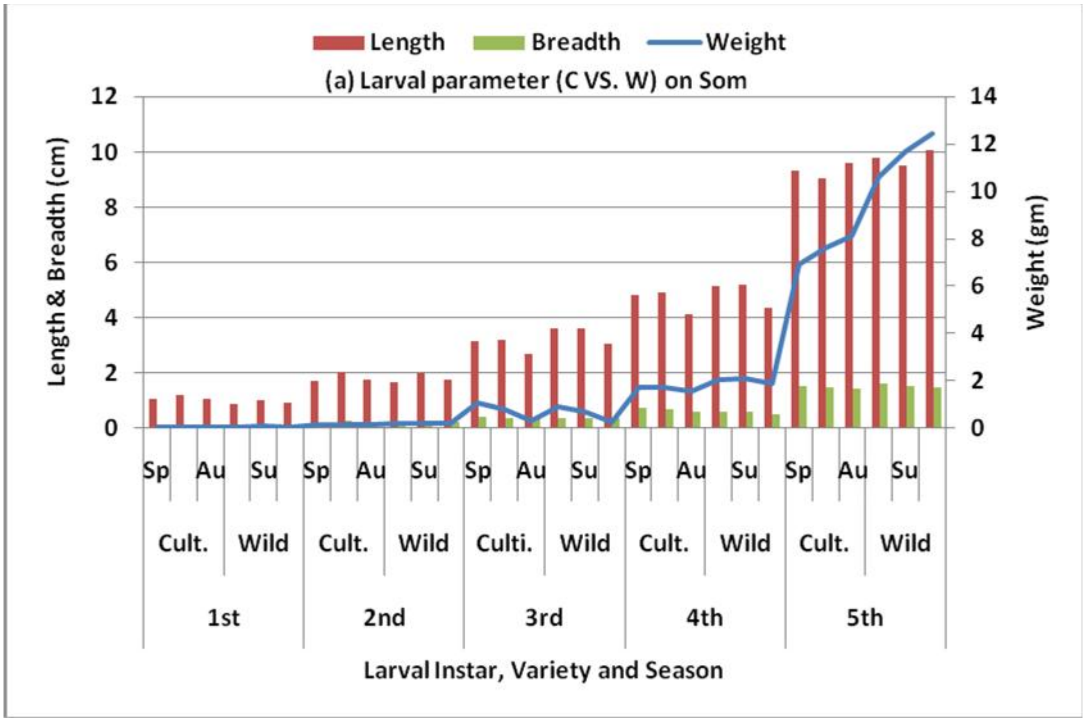
Table 19: Variation of cocoon parameters of *A. assama* (C & W) on Som host plant at Mokokchung

Variety	Sex	Season	Parameter (Mean±SE)		
			Length (cm)	Breadth (cm)	Weight (gm)
Cultivated	**Male**	Spring	4.17±0.299	1.56±0.048	4.85±0.147
		Summer	4.30±0.190	1.61±0.15	4.87±0.201
		Autumn	4.63±0.217	1.72±0.163	5.12±0.220
		Mean	**4.37±0.237**	**1.63±0.082**	**4.95±0.150**
	Female	Spring	5.06±0.127	2.03±0.164	5.98±0.146
		Summer	5.02±0.157	2.16±0.159	5.80±0.230
		Autumn	5.12±0.240	2.04±0.182	6.19±0.348
		Mean	**5.07±0.050**	**2.08±0.072**	**5.99±0.195**
	Seasonal mean	Spring	4.62±0.629	1.80±0.332	5.42±0.799
		Summer	4.66±0.509	1.89±0.389	5.34±0.658
		Autumn	4.87±0.346	1.88±0.226	5.66±0.757
	Total mean		**4.72±0.134**	**1.85±0.051**	**5.47±0.165**
Wild	Male	Spring	4.56±0.193	1.37±0.135	5.13±0.148
		Summer	4.10±0.135	1.42±0.099	4.87±0.201
		Autumn	4.28±0.182	1.54±0.088	5.12±0.259
		Mean	**4.31±0.232**	**1.44±0.087**	**5.04±0.147**
	Female	Spring	5.15±0.146	1.66±0.143	8.27±0.181
		Summer	4.44±0.221	1.77±0.098	5.05±0.242
		Autumn	4.88±0.141	1.89±0.091	6.09±0.283
		Mean	**4.82±0.358**	**1.77±0.115**	**6.47±1.643**
	Seasonal mean	Spring	4.86±0.417	1.52±0.205	6.70±2.220
		Summer	4.27±0.240	1.60±0.247	4.96±0.127
		Autumn	4.58±0.424	1.72±0.247	5.61±0.686
	Total mean		**4.57±0.295**	**1.61±0.101**	**5.76±0.879**
Average of C & W	Male	Spring	4.37±0.276	1.47±0.134	4.99±0.198
		Summer	4.20±0.141	1.52±0.134	4.87±0.00
		Autumn	4.46±0.247	1.63±0.127	5.12±0.00
		Mean	**4.34±0.132**	**1.54±0.082**	**4.99±0.125**
	Female	Spring	5.11±0.064	1.85±0.262	7.13±1.62
		Summer	4.73±0.410	1.97±0.276	5.43±0.530
		Autumn	5.00±0.170	1.97±0.106	6.14±0.071
		Mean	**4.94±0.196**	**1.93±0.069**	**6.23±0.854**
Total average for season		Spring	4.74±0.523	1.66±0.269	6.06±1.513
		Summer	4.47±0.375	1.75±0.318	5.15±0.396
		Autumn	4.73±0.382	1.80±0.240	5.63±0.721
Grand Mean			**4.67±0.179**	**1.73±0.071**	**5.61±0.455**
F	Sex		721.829***	652.199***	4133.77***
	Season		88.570***	28.156***	743.716***
	Varity		70.477***	257.163***	217.993***
	Sex X Sea		5.381**	4.589*	596.745***
	Sex X Var		2.816 NS	1.532NS	101.221***
	Sea X Var		92.891***	6.810**	695.841***
	Sex X Sea X Var		5.743**	5.805**	474.684***
CV%			**4.10**	**6.86**	**2.65**

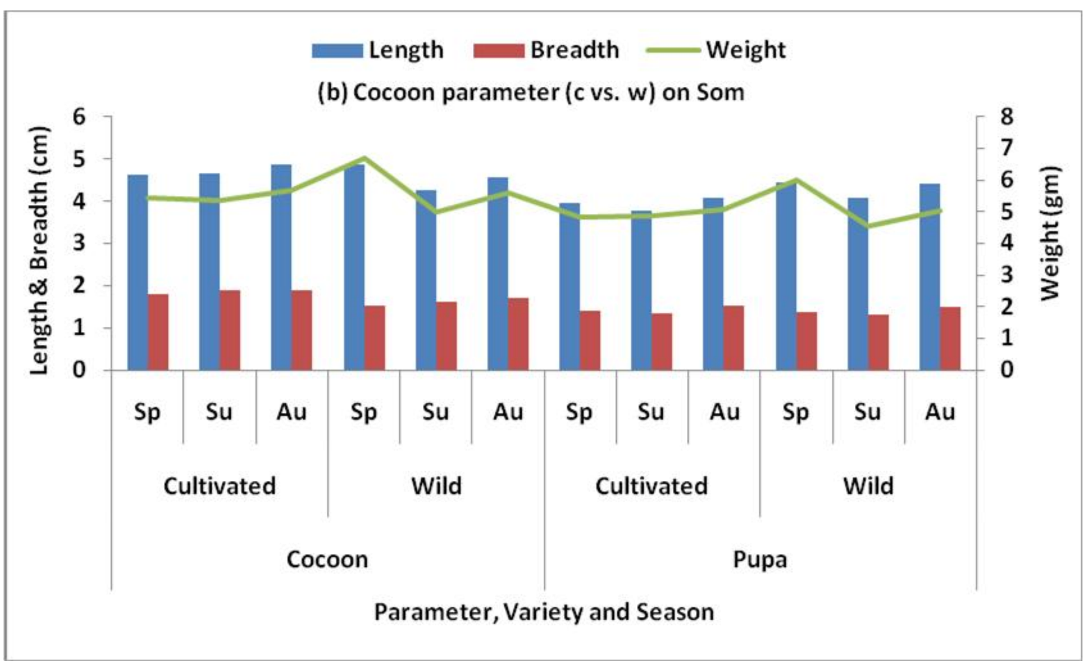
(* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Not significant)**

Table 20 Variation of pupal parameters of *A. assama* (C & W) on Som host plants at Mokokchung (* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Not significant)**

Variety	Sex	Season	Parameters (Mean±SE)		
			Length (cm)	**Breadth (cm)**	**Weight (gm)**
Cultivated	**Male**	Spring	3.69±0.099	1.37±0.057	4.33±0.099
		Summer	3.45±0.284	1.35±0.095	4.45±0.199
		Autumn	3.88±0.263	1.49±0.081	4.61±0.218
		Mean	**3.67±0.215**	**1.40±0.076**	**4.46±0.140**
	Female	Spring	4.23±0.056	1.44±0.064	5.27±0.148
		Summer	4.12±0.332	1.32±0.088	5.25±0.235
		Autumn	4.27±0.298	1.54±0.109	5.50±0.342
		Mean	**4.21±0.078**	**1.43±0.110**	**5.34±0.139**
	Seasonal mean	Spring	3.96±0.382	1.41±0.049	4.80±0.665
		Summer	3.79±0.474	1.34±0.021	4.85±0.566
		Autumn	4.08±0.276	1.52±0.035	5.06±0.629
	Total mean		**3.94±0.146**	**1.42±0.091**	**4.90±0.138**
Wild	Male	Spring	4.37±0.464	1.20±0.110	4.49±0.121
		Summer	3.77±0.126	1.18±0.101	4.50±0.202
		Autumn	4.28±0.185	1.30±0.188	4.59±0.255
		Mean	**4.14±0.324**	**1.23±0.064**	**4.53±0.055**
	Female	Spring	4.54±0.250	1.57±0.114	7.53±0.182
		Summer	4.42±0.283	1.44±0.120	4.56±0.236
		Autumn	4.58±0.202	1.68±0.116	5.47±0.279
		Mean	**4.51±0.083**	**1.56±0.120**	**5.85±1.522**
	Seasonal mean	Spring	4.46±0.120	1.38±0.262	6.01±2.150
		Summer	4.09±0.460	1.31±0.184	4.53±0.042
		Autumn	4.43±0.212	1.49±0.269	5.03±0.622
	Total mean		**4.33±0.262**	**1.40±0.233**	**5.19±0.933**
Average of C & W	Male	Spring	4.03±0.481	1.28±0.120	4.41±0.113
		Summer	3.61±0.226	1.27±0.120	4.48±0.035
		Autumn	4.08±0.283	1.39±0.134	4.60±0.014
		Mean	**3.91±0.258**	**1.31±0.067**	**4.50±0.096**
	Female	Spring	4.38±0.219	1.50±0.092	6.40±1.598
		Summer	4.27±0.212	1.38±0.085	4.91±0.488
		Autumn	4.43±0.219	1.61±0.099	5.49±0.021
		Mean	**4.36±0.082**	**1.50±0.115**	**5.60±0.751**
Total average for season		Spring	4.21±0.247	1.39±0.156	5.41±1.407
		Summer	3.94±0.467	1.33±0.078	4.70±0.304
		Autumn	4.26±0.247	1.50±0.156	5.05±0.629
Grand Mean			**4.14±0.172**	**1.41±0.086**	**5.05±0.355**
F	Sex		103.799***	180.843	3452.372***
	Season		28.244***	58.295	477.324***
	Varity		212.434***	2.909	233.064***
	Sex X Sea		6.926**	5.984	609.962***
	Sex X Var		31.181***	125.940	142.837***
	Sea X Var		0.132 NS	0.038	628.368***
	Sex X Sea X Var		0.083 NS	0.186	516.082***
CV%			**6.25**	**7.43**	**2.88**



(a)



(b)

Figure 45 Seasonal morphometric variations of *Antheraea assama* (cultivated vs. wild) on *P. bombycina* (Som) in Mokokchung

6. Altitudinal effect on morphometric variation of *A. assama*

Altitudinal effect on morphometric variation of developmental stages of *A. assama* (cultivated variety) is presented in **Table 21** and **Fig. 46a**.

The morphometric characters of cultivated variety of muga silkworm, reared on same host plant i.e. *Persea bombycina* (Som) at North Lakhimpur (NLP) - lower altitude and Mokokchung (MKG) - higher altitude were compared seasonally to assess the altitudinal effect on growth and development of pre-imaginal stages.

Larva

1st Instar: Mean larval length was higher in lower altitude i.e. NLP (1.12 cm) than higher altitude i.e. MKG (1.11 cm) however the difference was not significant. Spring and autumn seasons were more congenial in North Lakhimpur while summer season was suitable for Mokokchung exhibiting significant difference among the seasons between the two places. The interaction effect due to location x season was also not significant. There was no significant difference among seasons within the location; however, mean larval breadth was recorded more in all seasons in NLP than the respective seasons in MKG highlighting the altitudinal effect between lower (0.20 cm) and upper (0.15 cm) altitude. Interaction effect due to location and season was not significant. While there was no apparent difference in mean season weight (0.03 gm) of larva between the two places, fluctuation in weight in different seasons between the two locations was observed, exhibiting highly significant difference among seasons and altitudes. Further, the interaction effect due to location x season was significant.

2nd Instar: While no significant difference was observed in larval length between NLP (1.88 cm) and MKG (1.85 cm), seasonal impact and interaction effect due to location x season was highly significant. Mean and seasonal difference in breadth within and between the two locations and interaction effect due to locations and seasons were highly significant. Weight of the silk worm was maximum in all seasons in MKG than NLP with a record of seasonal mean of 0.14 gm and 0.06 gm respectively exhibiting highly significant altitudinal effect. However, seasonal difference and interaction effect due to location and season was not significant.

3rd Instar: The larval length in NLP varied from 2.79 to 2.87 cm having a seasonal mean of 2.82 cm, which was less than MKG (3.01 cm) with seasonal fluctuation between 2.68 cm and 3.18 cm showing highly significant difference between locations and also among seasons. Further, interaction effect due to host plant x season was also highly significant. The breadth varied from 0.37- 0.39 cm with a mean of 0.38 cm in NLP and from 0.38-0.41 cm with a mean of 0.39 cm in MKG that showed significant difference among seasons only at 5% probability level having no significant impact of altitude and also interaction effect due to location x seasons. While no significant difference was recorded on mean larval weight between NLP (0.75gm) and MKG (0.87 gm), seasonal difference was significant having maximum of 0.76 gm during spring and summer in NLP and 1.07 gm during spring MKG. Interaction effect due to location x season was also highly significant.

4th Instar: With a record of higher value in all seasons, larval length was maximum in MKG (4.61 cm) than NLP (4.06 cm) having shown highly significant difference between the two altitudes and respective seasons and also high interaction effect due to locations x seasons. The breadth varied from 0.64-0.70 cm with a mean of 0.66 cm in NLP and from 0.60- 0.75 cm with a mean of 0.68 cm in MKG, that showed highly significant difference among seasons with no significant altitudinal effect. However interaction effect due to location x season was significant at 5% probability level. Weight of the silkworm ranged from 1.69 gm in NLP to 1.64 gm in MKG with maximum record during spring (1.71) and summer (1.71) season in respective locations. However difference between locations, seasons and interaction effect due to location x season was not significant.

5th Instar: Mean larval length was higher in NLP (9.53 cm) than MKG (9.32 cm) exhibiting seasonal fluctuation between and within locations. However difference between locations, seasons and interaction effect due to location x season was not significant The breadth varied from 1.59-1.60 cm with a mean of 1.59 cm in NLP and from 1.45- 1.54 cm with a mean of 1.49 cm in MKG, showing highly significant difference between locations and significant difference at 5% probability level among seasons. However interaction effect due to location x season was not significant. The higher larval weight in MKG (7.54 gm) than NLP (6.88 gm) exhibited highly significant difference between the altitudes. However, larval weight fluctuated among different seasons in both places with maximum record during spring in NLP (6.91 gm) and autumn in MKG (8.11 gm). The interaction effect due to host plant x season was significant at 5% probability level.

Cocoon

While male and female cocoons in Mokokchung were longer (4.37 cm) and shorter (5.07 cm) respectively than their male (3.64 cm) and female (5.26 cm) counterpart in North Lakhimpur, total mean of cocoon length was higher in high altitude (4.72 cm) than low altitude (4.45 cm) exhibiting highly significant difference between sites and sexes. Further opposite trend of seasonal effect was observed in both places with increasing and decreasing in the length from spring to autumn season in MKG and NLP respectively having significant difference. The interaction effect on cocoon length due to sex x site, season x site and combined effect of season x site x sex was also highly significant, however effect of season x sex was significant at 5% probability level.

As in length, the breadth of male and female cocoons in Mokokchung (1.63 cm and 2.08 cm respectively) also recorded the similar pattern in North Lakhimpur (1.57 cm and 2.16 cm respectively) with high significant difference between sexes, however total mean breadth was higher in low altitude (1.87 cm) than high altitude (1.85 cm) having no significant difference. In lower altitude (NLP) cocoon breadth increased from autumn to spring season, however in high altitude spring season recorded minimum breadth and there after it fluctuated showing significance at 5% probability level. The interaction effect due to season x sex was not significant; however, it was significant due to season x site and sex x site at 0.1 % and 5% probability level. The combined effect of season, sites and sexes was also highly significant.

Highly significant difference was observed in cocoon weight between the locations, sexes and seasons. Mokokchung recorded maximum average cocoon weight (5.47 gm) than North Lakhimpur (4.66 gm). The weight of male and female cocoons (4.95 gm and 5.99 gm respectively) in higher altitude was also more than lower altitude (3.82 gm and 5.50 gm respectively). On seasonal basis, maximum cocoon weight was recorded during spring and autumn season in NLP and MKG respectively. The interaction effect due to sex x site, season x sex and season x site was highly significant. However, combined effect of season, site and sex was significant at 5% probability level **(Table 22 and Fig. 46 b).**

Pupa

While pupal length and weight in MKG was higher (3.94 cm and 4.90 gm) than NLP (3.89 cm and 4.29 gm), the reverse was true in case of breadth with the record of 1.42 cm (MKG) and 1.45 (NLP) However, there was variation in cocoon dimension having maximum size in female in NLP and Male in MKG. The weight of male and female pupa (4.46 gm and 5.34 gm respectively) in higher altitude was more than lower altitude (3.48 gm and 5.10 gm respectively). On seasonal basis, length, breadth and weight of the pupa was found to be in increasing trend from autumn to spring in NLP, however MKG recorded maximum of all these parameter during autumn with fluctuation in other seasons. Except for the insignificant interaction effect due to season x sex on the breadth, the effect of the seasons, sexes, locations along with the interaction and combined effect on all pupal parameters were significant at different level **(Table 23 and Fig. 46 b).**

Table 21: Altitudinal effect on larval morphometric variation of *A. assama* (C) (between North Lakhimpur and Mokokchung) (* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Not significant)**

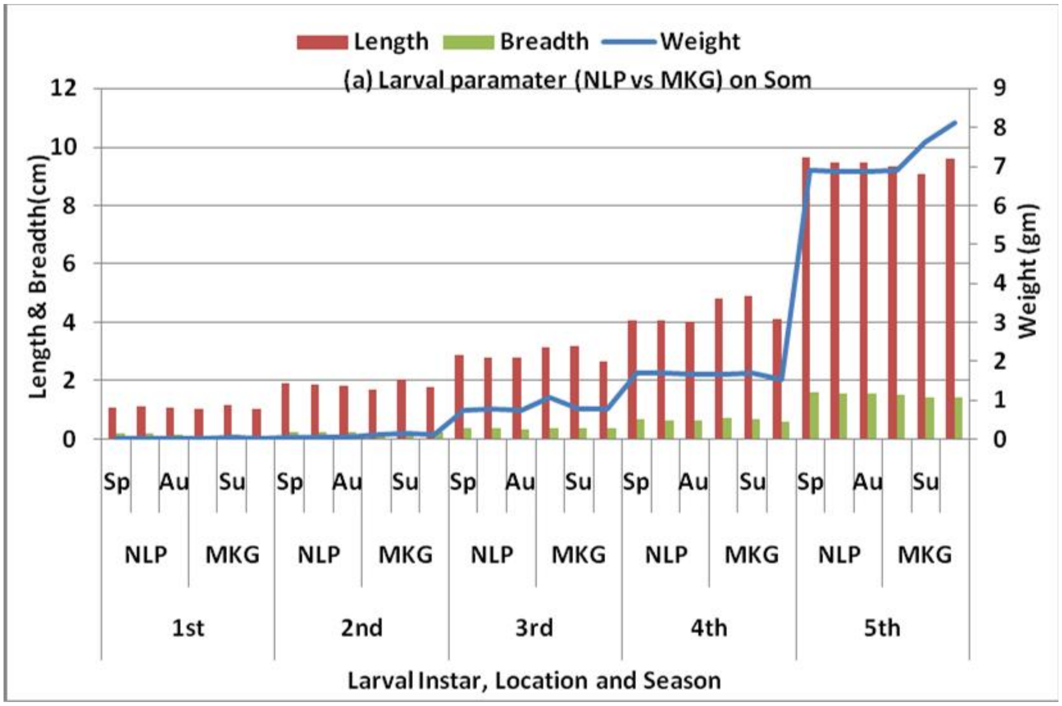
Para-meter	Location	Season	Stages (Mean±SE)				
			1st	**2nd**	**3rd**	**4th**	**5th**
Length (cm)	NLP	Spring	1.09±0.155	1.91±0.134	2.87±0.073	4.09±0.107	9.64±0.185
		Summer	1.16±0.118	1.88±0.087	2.81±0.123	4.06±0.110	9.47±0.284
		Autumn	1.11±0.089	1.85±0.101	2.79±0.135	4.03±0.100	9.47±0.284
		Mean	**1.12±0.036**	**1.88±0.030**	**2.82±0.042**	**4.06±0.030**	**9.53±0.098**
	MKG	Spring	1.05±0.181	1.70±0.236	3.17±0.264	4.82±0.093	9.33±0.162
		Summer	1.20±0.366	2.06±0.413	3.18±0.398	4.89±0.854	9.05±1.234
		Autumn	1.07±0.14	1.78±0.280	2.68±0.236	4.12±0.417	9.59±0.531
		Mean	**1.11±0.081**	**1.85±0.189**	**3.01±0.286**	**4.61±0.426**	**9.32±0.270**
	Grand mean		**1.12±0.007**	**1.86±0.021**	**2.92±0.134**	**4.34±0.389**	**9.42±0.148**
	F	Location	0.172	0.618	19.203	45.204	3.370
		Season	3.347	6.245	18.416	10.114	2.285
		LX S	0.479	7.232	12.230	8.378	2.222
	CV%		**17.79**	**12.46**	**8.11**	**10.34**	**6.41**
	CD%	Location	NS	NS	0.154***	0.292***	NS
		Season	0.090*	0.141**	0.189***	0.358***	NS
		LX S	NS	0.199**	0.267***	0.385**	NS
Breadth (cm)	NLP	Spring	0.21±0.015	0.27±0.025	0.39±0.011	0.70±0.027	1.60±0.017
		Summer	0.20±0.014	0.26±0.015	0.38±0.011	0.66±0.069	1.59±0.035
		Autumn	0.20±0.012	0.25±0.009	0.37±0.015	0.64±0.063	1.59±0.035
		Mean	**0.20±0.006**	**0.26±0.010**	**0.38±0.010**	**0.66±0.031**	**1.59±0.006**
	MKG	Spring	0.15±0.037	0.19±0.037	0.41±0.075	0.74±0.012	1.54±0.064
		Summer	0.16±0.050	0.27±0.047	0.38±0.070	0.70±0.121	1.47±0.100
		Autumn	0.15±0.048	0.25±0.037	0.38±0.026	0.60±0.077	1.45±0.166
		Mean	**0.15±0.006**	**0.24±0.042**	**0.39±0.085**	**0.68±0.072**	**1.49±0.047**
	Grand mean		**0.18±0.035**	**0.25±0.014**	**0.39±0.007**	**0.67±0.014**	**1.54±0.071**
	F	Location	8.155	18.559	1.341	1.634	45.528
		Season	1.658	12.523	4.572	15.947	4.628
		L X S	1.126	33.519	0.158	3.574	2.460
	CV%		**17.99**	**12.30**	**11.94**	**11.88**	**5.60**
	CD%	Location	0.016**	0.020***	NS	NS	0.056***
		Season	NS	0.024***	0.028*	0.064***	0.039*
		L X S	NS	0.034***	NS	0.051*	NS
Weight (gm)	NLP	Spring	0.03±0.006	0.05±0.006	0.76±0.029	1.71±0.076	6.91±0.950
		Summer	0.03±0.007	0.06±0.009	0.76±0.018	1.70±0.060	6.87±0.792
		Autumn	0.03±0.006	0.06±0.008	0.74±0.030	1.65±0.089	6.87±0.792
		Mean	**0.03±0.000**	**0.06±0.006**	**0.75±0.012**	**1.69±0.032**	**6.88±0.023**
	MKG	Spring	0.03±0.006	0.13±0.043	1.07±0.359	1.68±0.037	6.91±0.079
		Summer	0.05±0.026	0.15±0.039	0.77±0.489	1.71±0.541	7.61±1.949
		Autumn	0.02±0.018	0.13±0.132	0.78±0.437	1.53±0.233	8.11±1.081
		Mean	**0.03±0.015**	**0.14±0.012**	**0.87±0.170**	**1.64±0.096**	**7.54±0.603**
	Grand mean		**0.03±0.000**	**0.09±0.057**	**0.81±0.085**	**1.66±0.035**	**7.21±0.467**
	F	Location	9.812	68.322	1.077	1.183	12.500
		Season	15.313	0.776	24.718	2.809	3.186
		L X S	8.637	0.194	21.674	0.798	3.727
	CV%		**44.03**	**59.74**	**40.71**	**14.57**	**14.24**
	CD%	Location	0.0007**	0.037***	NS	NS	0.509**
		Season	0.011***	NS	0.209***	NS	NS
		LX S	0.015***	NS	0.295***	NS	0.658*

Table 22: Altitudinal effect on cocoon parameters of *A. assama* (C) (between North Lakhimpur and Mokokchung) (* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Not significant)**

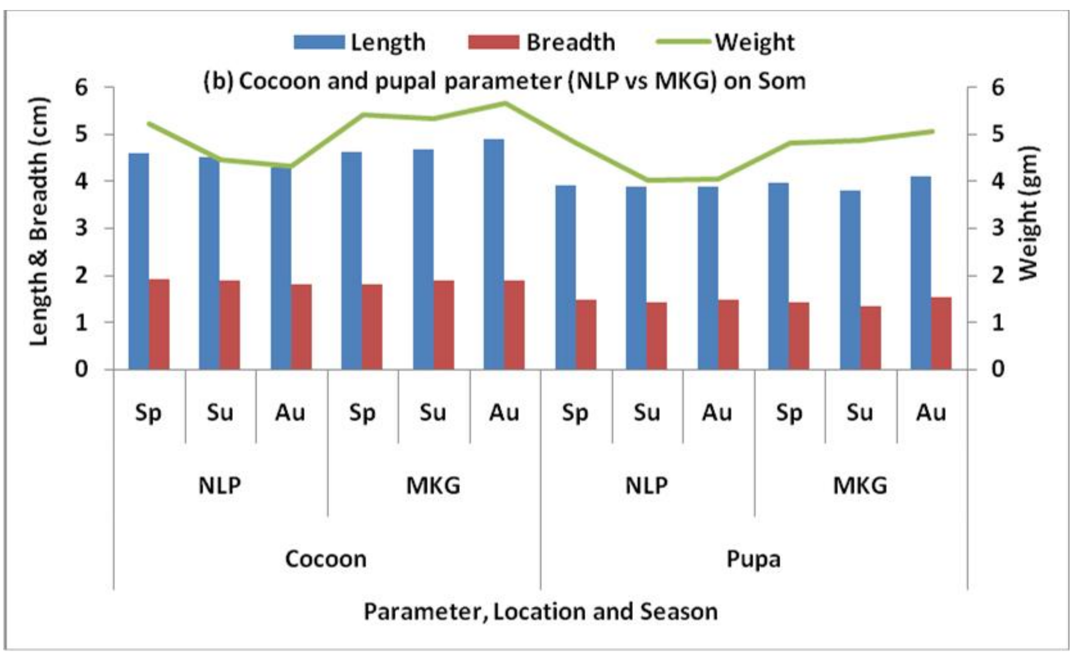
Location	Sex	Season	Parameters (Mean±SE)		
			Length	**Breadth**	**Weight**
North Lakhimpur	**Male**	Spring	3.78±0.032	1.64±0.025	4.24±0.063
		Summer	3.69±0.122	1.60±0.061	3.66±0.262
		Autumn	3.45±0.074	1.45±0.054	3.55±0.187
		Mean	**3.64±0.171**	**1.56±0.100**	**3.82±0.371**
	Female	Spring	5.35±0.023	2.18±0.017	6.20±0.041
		Summer	5.30±0.105	2.17±0.029	5.22±0.556
		Autumn	5.12±0.119	2.15±0.066	5.09±0.260
		Mean	**5.25±2.613**	**2.17±0.015**	**5.50±0.607**
	Seasonal mean	Spring	4.57±1.110	1.91±0.382	5.22±1.386
		Summer	4.49±1.138	1.88±0.403	4.44±1.103
		Autumn	4.29±1.181	1.80±0.495	4.32±1.089
	Total mean		**4.45±0.144**	**1.86±0.057**	**4.66±0.489**
Mokok-Chung	Male	Spring	4.17±0.299	1.56±0.048	4.84±0.147
		Summer	4.30±0.190	1.61±0.149	4.87±0.201
		Autumn	4.63±0.217	1.72±0.163	5.12±0.220
		Mean	**4.37±0.237**	**1.63±0.082**	**4.95±0.154**
	Female	Spring	5.06±0.127	2.03±0.164	5.98±0.146
		Summer	5.02±0.157	2.16±0.159	5.80±0.230
		Autumn	5.12±0.240	2.04±0.182	6.19±0.348
		Mean	**5.07±0.050**	**2.08±0.072**	**5.99±0.195**
	Seasonal mean	Spring	4.61±0.629	1.80±0.332	5.42±0.806
		Summer	4.66±0.509	1.89±0.389	5.34±0.658
		Autumn	4.88±0.346	1.88±0.226	5.66±0.757
	Total mean		**4.72±0.144**	**1.86±0.049**	**5.47±0.167**
Average of Location	Male	Spring	3.98±0.276	1.60±0.057	4.55±0.424
		Summer	4.00±0.431	1.61±0.007	4.27±0.856
		Autumn	4.04±0.834	1.59±0.191	4.34±1.110
		Mean	**4.01±0.031**	**1.60±0.010**	**4.39±0.146**
	Female	Spring	5.21±0.205	2.11±0.106	6.09±0.156
		Summer	5.16±0.198	2.17±0.007	5.51±0.410
		Autumn	5.12±0.000	2.10±0.078	5.64±0.778
		Mean	**5.16±0.045**	**2.13±0.038**	**5.75±0.304**
Total average for season		Spring	4.59±0.870	1.86±0.361	5.32±1.089
		Summer	4.58±0.820	1.89±0.396	4.89±0.877
		Autumn	4.58±0.764	1.85±0.361	4.99±0.919
Grand Mean			**4.58±0.006**	**1.87±0.021**	**5.07±0.225**
F	Season		0.149***	3.815*	88.636***
	Location		193.426***	0.697NS	860.446***
	Sex		3604.367***	1544.175***	2439.751***
	Sex X Location		564.430***	30.662*	136.582***
	Season X Sex		4.638*	1.664NS	11.101***
	Season X Location		71.364***	17.614***	144.602***
	Season X Location X Sex		13.778***	17.428***	3.890*
CV%			**3.25**	**5.57**	**4.22**

Table 23: Altitudinal effect on pupal parameters of *A. assama* (C) (between North Lakhimpur and Mokokchung) (*= Significant; ** & *= Highly Significant at the 5 % level of probability, NS= Non significant)**

Location	Sex	Season	Parameters		
			Length (cm)	Breadth (cm)	Weight (gm)
North Lakhimpur	**Male**	Spring	3.33±0.045	1.48±0.068	3.86±0.055
		Summer	3.27±0.088	1.41±0.056	3.30±0.234
		Autumn	3.31±0.076	1.47±0.066	3.81±0.227
		Mean	**3.30±0.031**	**1.45±0.038**	**3.66±0.310**
	Female	Spring	4.47±0.025	1.45±0.029	5.75±0.075
		Summer	4.48±0.080	1.44±0.047	4.71±0.401
		Autumn	4.46±0.030	1.44±0.032	4.84±0.266
		Mean	**4.47±0.010**	**1.44±0.006**	**5.10±0.567**
	Seasonal mean	Spring	3.90±0.806	1.47±0.021	4.81±1.336
		Summer	3.88±0.856	1.43±0.021	4.01±0.997
		Autumn	3.88±0.813	1.46±0.021	4.05±0.728
	Total mean		**3.88±0.012**	**1.45±0.021**	**4.29±0.451**
Mokok chung	Male	Spring	3.69±0.099	1.37±0.057	4.33±0.099
		Summer	3.45±0.284	1.35±0.095	4.45±0.199
		Autumn	3.88±0.263	1.49±0.081	4.61±0.218
		Mean	**3.67±0.215**	**1.40±0.076**	**4.46±0.140**
	Female	Spring	4.23±0.056	1.44±0.064	5.27±0.148
		Summer	4.12±0.332	1.32±0.088	5.25±0.235
		Autumn	4.27±0.298	1.54±0.109	5.50±0.342
		Mean	**4.21±0.078**	**1.43±0.110**	**5.34±0.139**
	Seasonal mean	Spring	3.96±0.382	1.41±0.049	4.80±0.665
		Summer	3.79±0.474	1.34±0.021	4.85±0.566
		Autumn	4.08±0.276	1.52±0.035	5.06±0.629
	Total mean		**3.94±0.146**	**1.42±0.091**	**4.90±0.138**
Average of Location	Male	Spring	3.51±0.255	1.43±0.078	4.09±0.332
		Summer	3.36±0.127	1.38±0.042	3.88±0.813
		Autumn	3.59±0.403	1.48±0.014	4.21±0.566
		Mean	**3.49±0.117**	**1.43±0.050**	**4.06±0.167**
	Female	Spring	4.35±**0.170**	1.45±**0.007**	5.51±**0.339**
		Summer	4.30±**0.255**	1.38±**0.085**	4.98±**0.382**
		Autumn	4.37±**0.134**	1.49±**0.071**	5.30±**0.283**
		Mean	**4.34±0.036**	**1.44±0.056**	**5.26±0.267**
Total average for season		Spring	3.93±0.594	1.44±0.014	4.88±1.004
		Summer	3.83±0.665	1.38±0.000	4.43±0.778
		Autumn	3.98±0.552	1.49±0.007	4.68±0.877
Grand Mean			**3.91±0.076**	**1.44±0.055**	**4.60±0.233**
F	Season		15.293	57.872	88.633
	Location		6.104	16.270	713.571
	Sex		1475.148	1.967	2940.428
	Sex X Location		206.816	6.306	258.974
	Season X Sex		4.612	0.454	15.302
	Season X Location		13.327	33.475	185.359
	Season X Location X Sex		2.219	10.014	5.164
CV%			**4.39**	**4.15**	**3.88**



(a)



(b)

Fig. 46 Altitudinal morphometric variation of *Antheraea assama* (cultivated) on *P. bombycina* (Som) between North Lakhimpur and Mokokchung

CHAPTER V

ALTITUDINAL EFFECT AND HOST PLANT PREFERENCE ON REARING PERFORMANCE OF *ANTHERAEA ASSAMA* Westwood

REARING ON HIGHER ALTITUDE

Rearing of *Antheraea assama* (Cultivated) on primary and secondary host plants in higher altitude

Muga silkworm (*Antheraea assama* Ww) is semi domesticated which is reared outdoor on trees, while spinning and seed production activities are accomplished indoor. Rearing of muga silkworm is generally conducted for five to six crops annually in traditional way in the state of Assam **(Table 24)**, however, muga culture in Nagaland has not reached the commercial level.

Table 24 Muga crop schedule prevalent in Assam

Crop number	Crop name	Nature of crop	Rearing period
1	Jarua (winter)	Pre seed	Dec-Jan
2	Chatua (Late winter)	Seed	Mar-May
3	Jethua (spring)	Commercial	May-Jun
4	Aherua (summer)	Pre seed	Jun-Jul
5	Bhodia (late summer)	Seed	Aug-Sep
6	Kotia (Autumn)	Commercial	Oct-Nov

Materials and Method

Having considered various region specific factors, it was felt necessary to develop a separate rearing schedule for Nagaland climatic condition and rearing of muga silkworm was conducted in Ungma Sericulture farm, Mokokchung, Nagaland. Disease free muga layings were collected from Muga Silkworm Seed Organization, P4 Unit, Tura, Meghalaya and rearing was initiated during Spring crop (April-June), 2007 by brushing equal number of newly hatched larvae on the selected bush plantation of *P. bombycina* and *L. citrata* (in triplicate) which were covered with nylon net to protect the silkworms from predators and other enemies. The rearing was continued in the subsequent crops i.e. Pre-summer (July-mid of August) Crop, Summer (August-September) Crop, Autumn (October-December) Crop and Winter (January-March) Crop taking all together five crops in the first year of experiment from May, 2007 to March, 2008. It was however observed that, inspite of taking all precautions, the rearing conducted during pre-summer and winter crop were not satisfactory, the reasons for which were mainly attributed to very high and low temperature during summer and winter respectively, fluctuation of relative humidity, high rainfall (pre summer crop), high prevalence of pest and predators like Uzi fly and wasps and various diseases. Hence rearing and grainage of muga silk worm in the second year i.e. 2008 was limited only to Spring (April-June), Summer (July-September) and Autumn season (October-December) and the experimental data on rearing and subsequent grainage conducted for two consecutive years during 2007 and 2008 in six seasons i.e. Spring - season I (April-June), Summer - season II (July-September) and Autumn - season III (October-December) was recorded for further analysis. The worms which crawled down to the base of the tree on exhaustion of leaves were transferred to new host plants. On maturity, the larvae were handpicked and kept in mountage for spinning of cocoons which were harvested after 8-10 days of pupation. The grainage operation was conducted at the muga seed grainage centre, Govt. sericulture farm, Ungma, Mokokchung at room temperature of 19^{o}–21^{o} C and relative humidity of 68-78% during different seasons.

The data were recorded and analyzed for study of biology, which included the parameters such as morphometric characters (length, breadth and weight), life cycle, and production and cocoon parameter taking ten replicates for each treatment on both host plants in different seasons. The mean and standard error (SE) were calculated from the computed values. Randomized block design and completely randomized block design were used to analyse the field and laboratory data respectively (Gomez and Gomez, 1984). Further, critical differences were calculated by using *F*-test as described by Snedechor and Cochran (1967). The measurement and commercial characters of cocoons was carried out by conventional method.

For reeling, muga cocoons were softened by cooking in open pan with 5 gm of sodium carbonate in 3 litres of water for 10-15 minutes. Cocoons were individually deflossed by hand for taking out continuous filament. Reeling was done by Muga reeling-cum-twisting machine (developed by Central Silk Board, Bangalore, India) at Central Muga Eri Research & Training Institute, Central silk board, Jorhat, Assam (India).

The seasonal climatic variation recorded during rearing period is given in **Table 25.** The maximum temperature ranged from 24.33±3.32^{0}C (autumn) to 31.3±0.76^{0}C (summer) while the minimum temperature fluctuated between 10.5±2.78 ^{0}C (autumn) and 19.73±0.48 ^{0}C (summer). Similarly, average maximum and minimum relative humidity (%) was recorded as 89.06±0.51 and 49.25±7.46 in spring season during the study period. The highest rainfall/day was recorded in summer (11.80±3.68 mm) and lowest in autumn (2.60±2.96mm). The maximum and minimum rainy days were recorded during summer (22.67±1.53) and autumn (8.33±9.29) season respectively.

Table 25: Mean seasonal meteorological data during rearing period at Mokokchung

Season	Parameter and value (Mean±SE)					
	Temp.^{0}C		R.H. (%)		Rainfall/ Day (mm)	Rainy days/ month
	Max.	Min.	Max.	Min.		
Spring (Apr-Jun)	30.56± 0.58	15.67± 2.36	89.06± 0.51	49.25± 7.46	7.67± 0.48	21.33± 0.21
Summer (Jul-Aug)	31.33± 0.76	19.73± 0.48	88.86± 1.30	61.06± 5.42	11.80± 3.68	22.67± 1.53
Autumn (Oct-Dec)	24.33± 3.32	10.50± 2.78	87.14± 0.24	51.81± 2.78	2.60± 2.96	8.33± 9.29

Results and Discussion

Variation on life cycle parameters: Rearing performance of *A. assama* in two host plants exhibited strong seasonality on growth and development in different stages **(Table 26).** The incubation period was significantly short on both the host plants (9.58±0.20 and 10.38±0.12 days in *P.bombycina* and *L.citrata* respectively) during second season, i.e. summer and was long on *L.citrata* (13.90±0.15 days) during third rearing season (autumn). Similarly total larval duration was significantly shorter in *P.bombycina* (28.20±0.65, 34.90±0.72, and 37.40±0.99 days) in comparison to *L.citrata* (33.40±0.66, 39.70±0.73, and 45.20±1.61 days) having the sequence of second < first< third season respectively. The minimum pupal period was recorded in *P. bombycina* during summer season (20.70±0.17 days) while the maximum was recorded in *L.citrata* in autumn season (38.50±1.08).The maximum adult longevity was recorded as 8.40±0.15 and 10.96±0.27 days in male and female respectively on *P.bombycina* during 1st rearing season whereas, minimum was recorded as 7.2±0.16 (*L.citrata*) and 7.5±0.11 (*P.bombycina*) days in male and female respectively during 2nd and 3rd rearing season. Thus muga silk worm took 62.5±5.9 days to complete its life cycle in *P. bombycina*, while in *L. citrata* it was 73.3±6.78 days in different seasons.

The shortest period of life cycle during summer season (season II) was correlated with the higher temperature and optimum humidity, which ensured faster growth and development in different stages. The larval and pupal duration were longer in autumn in both host plants and the extended pupal duration in winter and pre-spring indicated the diapausing character in Nagaland climatic condition. The non significant difference in pupal duration on different host plants might be due to the optimum temperature, relative humidity, maintained during rearing period and it also indicated that host plants did not exhibit any influence on pupal period. The longer larval duration in *L.citrata* in different seasons might be due to slow eating habit of muga silk worm, since for generations together muga silk worm were not accustomed with feeding on it (Saikia *et al.*, 2004). The extension of larval span on *L. citrata* might also be due to low nutrition levels (Reddy *et al*., 2012) which reflected on the poor feeding behaviour of muga silkworm **(Table 27)**. Yadav and Goswami (1992) and Choudhury *et al*. (2000) found a negative effect of crude fibre on larval development of muga silkworm on different host plants. Dutta *et al.* (1997) revealed that with the high amount of total nitrogen and protein, Som leaves were more nutritive than Mejankari. Evaluation of suitable food plants in relation to growth, development and reproductive potential of other silk worm species like *Bombyx mori* Linn. (Saratchandra *et al*., 1992), *Antheraea mylitta* Drury (Rath, 2000), *Samia ricini* Donovan (Jayaramaiah and Sannapa, 2000) have also been made earlier. The longer larval period on feeding with *L.citrata* leaf compared to *P. bombycina* might contribute negatively in terms of lesser hatching and ERR with the probability of longer exposure to environmental vagaries, diseases, pests and predators. The quantitative as well as qualitative nutrition is highly essential and specific for sericigenous insects to control the physiological status (Chapman, 1998; Kumar *et al*., 2010) and under the lack of such required nutrition in *L. citrata,* the muga silkworm might have extended its larval span.

Effect on production parameters: The minimum and maximum fecundity (Nos.) was recorded during second season while rearing on *P. bombycina* (152.30$\pm$7.95) and *L. citrata* (198.33$\pm$7.50) respectively indicating the effect of host plants **(Table 28).** While hatching percentage was higher in *P. bombycina* than *L. citrata*, effective rate of rearing (ERR) was better in *L. citrata* than the former except for third season. Similarly cocoons per dfl were also recorded to be maximum in *L. citrata* than *P. bombycina* in 1st and 2nd season. In 3rd season cocoon: dfl ratio was more in *P. bombycina*. While mean annual value of fecundity and cocoon: dfl was found to be better in *L. citrata*, hatching percentage and ERR was higher in *P. bombycina*. However, the present investigation indicated that 1st and 2nd seasons were more suitable for rearing of *A. assama* in *L. citrata* than *P. bombycina* highlighting the effect of host plants as well as seasons on production parameters. The differences in production parameters may be due to variation in nutrient composition of food plants, because the amount, rate and quality of food consumed by larvae influenced the fecundity, growth rate, development time and survival of adults (Slanky and Scriber, 1985). Mc Caffery (1975) also pointed out that egg production in insects was influenced by the host plant selection.

Effect of host plants on cocoon production: Interaction effect on morphometric character and commercial traits of cocoons of *A. assama* due to host plant, season and sex showed significant difference in green cocoon weight, shell weight, shell ratio and raw silk recovery **(Table 29).** Maximum of green cocoon weight (gm) was recorded in female (6.19±0.35) on *P. bombycina* and minimum in male (4.33±0.49) on *L. citrata* during autumn season. The dimensions of creamy white cocoon were 6.55±0.11 cm^2 in male and 9.43±0.14 cm^2 in female with an average weight of 4.58±0.21 to 5.44±0.49 gm respectively when fed on the leaves of *L. citrata*. Barah *et al.* (1988) also observed that weight of muga cocoons produced during autumn season was significantly higher than the cocoons produced in other seasons. Shell weight (gm) of both male (0.53±0.14) and female (0.71±0.06) cocoon was maximum in *P. bombycina* during 1st rearing season while minimum in *L. citrata* (0.32±0.10 and 0.32±0.17 respectively) during 3rd rearing season. Silk ratio (%) was recorded to be higher in Som than Mejankari in both sexes in all seasons. However it was interesting to note that, the mean value of SR% was found to be more in female cocoon (10.85±1.24) than male (9.83±1.13) in Som, while the reverse trend of having more in male (8.40±0.89) than female (8.11±1.23) was observed in Mejankari. The food plant nutrition highly influences the larval rate of growth, metamorphosis and the reproductive efficiency in many insects (Pattanayak and Dash, 2000; Rath *et al.*, 2006; Reddy *et al.*, 2009) and thus the male cocoons have better silk while female cocoons have better pupae with their prioritized budgeting of food reserves (Hazarika *et* *al*., 2003; Radjabi *et al*., 2009). The 1st season exhibited maximum filament length (409.2±19.36 m) in *P. bombycina*, however, the same was maximum in *L. citrata* (366.76±5.40 m) during 2nd season **(Table 30).** Filament denier was comparatively higher in *P. bombycina* than *L. citrata* in all seasons. Raw silk recovery was more in *L. citrata* during 1st (49.43%) and 2nd (43.14%) season than *P. bombycina* which produced 47.26% during 3rd season. It has been reported that cocoons of *Antheraea assama* (muga) reared on different host plants and in different seasons in Assam, vary greatly in characters like cocoon weight, shell weight, silk filament length and shell ratio (Thangavelu *et al*., 1988; Baruah *et al*., 2000). Ghose *et al*. (2000) observed that cocoons and silk yarn of *Antheraea assama* reared on *Litsea citrata* were more lustrous due to more sericin (gum) content in the cocoon shell and in the raw silk. The rearing performance of muga silkworm on *L. citrata* food plant was found to be positive with better production and cocoon parameters which were comparable to that of *P. bombycina* in Nagaland. The higher pupation in the cocoons raised on *L.citrata* food plant can anticipate the possibility for better silkworm seed recovery, being the important commercial trait associated with the number of live cocoons available in total cocoons harvested. The significant positive increase in pupation, cocoon weight, shell weight and silk ratio further indicate the commercial prospective of *L. citrata* as alternative food plant of *A. assama* and the low production or any other negative trend in other commercial traits can be compensated by the higher market price of Mejankari silk. Saikia and Goswami

(1997) observed that, due to non-availability of pure line seed for Mejankari rearing, silkworms sometimes showed reluctance to devour Mejankari leaves after III/IV instar, which could be safely transferred to Som plants without incurring any commercial loss and the product so produced had better quality yarn than the pure Som cocoons. Further as the white Mejankari silk is derived from the leaves of immature tree of two to three years old (Choudhury, 2005b), it is suggested to take up Mejankari silk farming along with Som plantation to ensure more value added production. Therefore it is highly imperative to conserve the natural plantation of *L. citrata* as well as its propagation on scientific lines in degraded area along with Som in higher altitude to boost the Mejankari silk production which can create a new horizon for the muga silk industry in Nagaland.

Table 26 : Seasonality and impact of host plants on life cycle parameters (Mean ± SE) of *A. assama* (Cultivated) at Mokokchung

Seasons	Host Plants	Stages (in days)								
		Egg	1st	2nd	3rd	4th	5th	Pupa	Adult	
									Male	Female
Season I	Som	10.37±0.348	5.60±0.323	5.30±0.211	6.48±0.215	6.68±0.155	10.78±0.175	24.69±0.228	8.40±0.149	10.96±0.267
	Mejankari	11.79±0.160	6.70±0.163	5.50±0.189	7.50±0.163	7.70±0.156	12.30±0.156	26.60±0.133	8.00±0.163	10.90±0.141
	Seasonal mean	**11.08±1.004**	**6.15±0.778**	**5.40±0.141**	**6.99±0.721**	**7.10±0.863**	**11.54±1.075**	**25.65±1.351**	**8.20±0.283**	**10.93±0.042**
Season II	Som	9.58±0.198	4.50±0.125	4.30±0.115	5.29±0.166	5.30±0.125	8.79±0.137	20.70±0.170	7.30±0.170	9.30±0.149
	Mejankari	10.38±0.123	5.70±0.149	5.30±0.163	6.40±0.115	6.40±0.133	9.60±0.149	22.80±0.133	7.20±0.156	9.10±0.149
	Seasonal mean	**9.98±0.566**	**5.10±0.849**	**4.80±0.707**	**5.85±0.785**	**5.85±0.778**	**9.20±0.573**	**21.75±1.485**	**7.25±0.071**	**9.20±0.141**
Season-III	Som	12.10±0.294	6.10±0.133	6.50±0.141	6.69±0.145	6.80±0.236	11.30±0.149	35.30±0.163	7.40±0.125	7.50±0.105
	Mejankari	13.90±0.149	7.60±0.115	7.80±0.163	8.20±0.221	8.30±0.823	13.30±0.949	38.50±1.080	7.50±0.850	9.30±0.675
	Seasonal mean	**13.00±1.273**	**6.85±1.061**	**7.15±0.919**	**7.45±1.068**	**7.55±1.068**	**12.30±1.414**	**36.90±2.263**	**7.45±0.071**	**8.40±1.273**
Host plant mean	Som	10.68±1.289	5.40±0.819	5.37±1.102	6.15± 0.755	6.26±0.834	10.29±1.325	26.90±7.546	7.70±0.608	9.25±1.730
	Mejankari	12.02±1.772	6.67±0.950	6.20±1.389	7.37±0.907	7.47±0.971	11.73±1.914	29.30±8.191	7.57±0.404	9.77±0.987
Grand mean		**11.35±0.948**	**6.04±0.898**	**5.79±0.587**	**6.76±0.863**	**6.87±0.856**	**11.01±1.018**	**28.10±1.697**	**7.63±0.094**	**9.51±0.363**
F	Host plant	799.466***	1110.614***	502.266***	999.852***	177.569***	206.940***	291.589***	2.023NS	3.825NS
	Season	1386.851***	716.059***	1437.657***	618.125***	130.496***	346.967***	4166.160***	38.088***	32.366***
	H x S	37.815***	10.014**	77.965***	9.947**	2.691NS	11.868***	11.109***	2.402*	6.032**
CV%		**1.62**	**2.44**	**2.49**	**2.14**	**5.11**	**3.53**	**1.94**	**4.76**	**3.53**

Total Larval Duration (Days)	**Host plants**	
	Som	**Mejankari**
Season-I (May-Jun)	**34.9±0.72**	**39.7±0.73**
Season-II (Aug- Sep)	**28.2±0.65**	**33.4±0.66**
Season-III (Oct-Dec)	**37.4±0.99**	**45.2±1.61**

*** = significant at 5% level, ** = significant at 1% at level, ***= significant at 0.1% level of probability, NS= Not significant)**

Table 27 : Mean values of nutrient content (Mean ± SE) in the leaves of *Persea bombycina* and *Litsea citrata* in Mokokchung

Content (%)	***P. bombycina***	***L. citrata***
Moisture	60.47± 0.49	64.45± 0.91
Total carbohydrate	17.36± 0.24	12.61± 0.42
Total soluble sugar	4.50± 0.13	2.08± 0.28
Total reducing sugar	2.39± 0.06	0.72± 0.03
Crude fibre	7.05± 0.83	6.98± 1.01
Total nitrogen	2.82± 0.11	2.73± 0.07
Crude protein	17.63± 0.71	17.10± 0.44
Total ash	7.17± 0.11	4.97± 0.07

Table 28 : Seasonal variation of production parameters of *Antheraea assama* (Cultivated) on Som and Mejankari at Mokokchung

Host plant	Season	Parameters **(Mean ± SE)**			
		Fecundity (Nos)	Hatching (%)	ERR (%)	Cocoons/Dfl
Som	Spring	180.80±11.341	77.30±0.949	56.00±1.491	46.70±4.596
	Summer	152.30±7.945	65.90±1.595	41.90±0.876	42.00±1.333
	Autumn	189.60±6.653	70.50±1.434	50.00±1.700	67.00±4.028
	Mean	**174.23±19.498**	**71.23±5.735**	**49.30±7.076**	**51.90±13.286**
Mejankari	Spring	171.50±9.925	71.30±1.160	57.40±0.966	70.00±3.399
	Summer	198.30±7.499	60.10±1.595	45.40±0.843	54.00±1.491
	Autumn	188.60±8.784	69.50±1.269	40.80±1.619	53.00±3.266
	Mean	**186.13±13.569**	**66.97±6.014**	**47.87±8.570**	**59.00±9.539**
Host plant mean	Spring	176.15±6.576	74.30±4.243	56.70±0.990	58.35±16.476
	Summer	175.30±32.527	63.00±4.101	43.65±2.475	48.00±8.485
	Autumn	189.10±0.707	70.00±0.707	45.40±6.505	60.00±9.899
	Grand mean	**180.18±7.734**	**69.10±5.704**	**48.58±7.083**	**55.45±6.504**
F	Host plant	109.543	172.282	32.202	190.706
	Season	61.689	410.473	1048.607	213.405
	Host plant x Season	229.315	25.279	242.129	461.324
CV%		**2.44**	**1.82**	**2.01**	**3.59**
CD%	Host plant	4.459***	1.275***	0.991***	2.016***
	Season	5.461***	1.561***	1.213***	2.470***
	Host plant x Season	4.138*	2.208***	1.716***	3.493***

*** = significant at 5% level, ** = significant at 1% at level, ***= significant at 0.1% level of probability, NS= Non significant**

Table 29 : Seasonality and impact of host plants on cocoon characteristics of *A.assama* (Cultivated) at Mokokchung

Host plant	Sex	Season	Parameters (Mean ± SE)			
			Cocoon Wt gm)	**Pupal Wt gm)**	**Shell wt (gm)**	**SR %**
Som	**Male**	Spring	4.85±0.147	4.33±0.099	0.53±0.137	10.87±2.539
		Summer	4.87±0.201	4.45±0.199	0.42±0.009	8.63±0.343
		Autumn	5.12±0.220	4.61±0.218	0.51±0.015	9.98±0.477
		Mean	**4.96±0.179**	**4.46±0.140**	**0.49±0.059**	**9.83±1.128**
	Female	Spring	5.98±0.146	5.27±0.148	0.71±0.058	11.92±0.970
		Summer	5.80±0.230	5.25±0.235	0.55±0.015	9.49±0.563
		Autumn	6.19±0.348	5.50±0.342	0.69±0.018	11.11±0.589
		Mean	**5.99±0.195**	**5.34±0.139**	**0.65±0.087**	**10.85±1.237**
	Seasonal mean	Spring	5.42±0.799	4.80±0.665	0.62±0.127	11.40±0.742
		Summer	5.34±0.658	4.85±0.566	0.49±0.092	9.06±0.608
		Autumn	5.66±0.757	5.06±0.629	0.60±0.127	10.55±0.799
	Total mean		**5.47±0.167**	**4.90±0.138**	**0.57±0.070**	**10.33±1.184**
Mejan Kari	Male	Spring	4.71±0.156	4.28±0.158	0.43±0.015	9.17±0.461
		Summer	4.69±0.130	4.29±0.131	0.40±0.011	8.58±0.333
		Autumn	4.33±0.488	4.010±0.458	0.32±0.101	7.42±2.153
		Mean	**4.58±0.214**	**4.19±0.159**	**0.39±0.057**	**8.40±0.890**
	Female	Spring	5.78±0.215	5.24±0.220	0.54±0.014	9.35±0.491
		Summer	5.67±0.138	5.21±0.136	0.46±0.015	8.10±0.295
		Autumn	4.88±0.888	4.55±0.897	0.32±0.169	6.89±4.149
		Mean	**5.440±0.491**	**5.00±0.390**	**0.44±0.111**	**8.11±1.230**
	Seasonal mean	Spring	5.25±0.757	4.76±0.679	0.49±0.078	9.27±0.127
		Summer	5.18±0.693	4.75±0.651	0.43±0.042	8.34±0.339
		Autumn	4.61±0.389	4.28±0.381	0.32±0.00	7.16±0.375
	Total mean		**5.01±0.351**	**4.60±0.274**	**0.41±0.086**	**8.26±1.057**
Average of host plant	Male	Spring	4.78±0.099	4.31±0.035	0.48±0.071	10.02±1.202
		Summer	4.78±0.127	4.37±0.113	0.41±0.014	8.61±0.035
		Autumn	4.74±0.544	4.31±0.424	0.42±0.134	8.70±1.810
		Mean	**4.77±0.023**	**4.33±0.035**	**0.44±0.038**	**9.11±0.789**
	Female	Spring	5.88±0.141	5.26±0.021	0.63±0.120	10.64±1.817
		Summer	5.74±0.092	5.232±0.028	0.51±0.064	8.80±0.983
		Autumn	5.54±0.926	5.03±0.672	0.51±0.262	9.00±2.984
		Mean	**5.72±0.171**	**5.17±0.125**	**0.55±0.069**	**9.48±1.010**
Total average for season		Spring	5.33±0.778	4.79±0.672	0.56±0.106	10.38±0.438
		Summer	5.26±0.679	4.80±0.608	0.46±0.071	8.71±0.134
		Autumn	5.14±0.566	4.67±0.509	0.47±0.064	8.86±0.212
Grand Mean			**5.30±0.096**	**4.75±0.072**	**0.49±0.055**	**9.32±0.924**
F	Season		19.447***	8.066**	38.775***	20.207***
	Host plant		302.507***	113.403***	239.308***	81.692***
	Sex		1286.971***	854.675***	120.486***	2.713NS
	Season x host plant		122.984***	66.292***	42.436***	12.653***
	Season x Sex		9.813***	5.518**	3.273*	0.331NS
	Host plant x Sex		11.208***	1.454NS	29.289***	8.316**
	Season x Host plant x Sex		11.019***	6.2**	2.739NS	0.225NS
CV%			**3.93**	**4.7**	**15.82**	**19.13**

(* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Non significant)**

Table 30 : Yarn characteristics (Single cocoon) of *A.assama* (cultivated) in Mokokchung **(Mean ± SE)**

Seasons	Host plants	Filament length (m)	Filament denier (d)	Raw silk recovery (%)
Season-I (Apr-Jun)	A	409.20± 19.60	5.76±0.1	45.14±1.24
	B	365.48± 3.57	5.1±0.21	49.43±0.92
Season-II (Aug-Sep)	A	303.20± 4.39	6.15±0.17	38.37±0.96
	B	366.78± 5.40	4.80±0.15	43.15±0.88
Season-III (Oct-Dec)	A	407.30± 9.13	5.63±0.12	47.26±0.83
	B	255.04± 5.52	4.60±0.01	35.20±1.10
Mean± SE	A	373.24±10.95	5.85±0.13	43.59±1.01
	B	329.10± 9.97	4.83±0.12	42.59±0.97

A = *Persea bombycina* B= *Litsea citrata*

Rearing of *Antheraea assama* (Wild) on primary and secondary host plants in higher altitude

Materials and Method

Fifteen cocoons of wild variety of *A. assama*, ten from *P. bombycina* and five from *L. citrata* plants were collected from Mokokchung area during last week of August 2006 and kept in a wooden cage until their emergence in the muga seed grainage centre, Govt. Sericulture Farm, Ungma, Mokokchung, Nagaland. On emergence, male (six) and female (four) moths were kept in moth coupling cage for pairing and there after, the four fertile females were tied in khorikas (wooden bend stick) for egg laying. After egg laying, the females were tested for disease freeness and the layings along with khorika were kept for hatching at room temperature of 17^{o}–19^{o} C and relative humidity 78-84 %. On hatching four khorikas were placed separately on two selected bush plants of *P. bombycina* (Som) and *L. citrata* (Mejankari) and covered with nylon net to protect the worms from natural enemies. Successive outdoor rearing was taken up separately in both host plants i.e. Som and Mejankari using fifteen disease free layings (dfls) in triplicate and grainage was conducted thereafter as practiced in cultivated variety taking all prophylactic measures, for six seasons Spring (April-June), summer (July-September and autumn (October-December) during 2007 and 2008. The data were recorded and analyzed for study of biology, which included the parameters such as morphometric characters (length, breadth and weight), life cycle, and production and cocoon parameter taking ten replicates for each treatment on both host plants in different seasons. The statistical procedures and methodology for analysis of cocoon and yarn characteristics are similar to that of cultivated population as described earlier.

Results and Discussion

Seasonality and effect of host plants on life cycle parameter: Biology and rearing performance of *A. assama* (Wild) on two different host plants exhibited strong seasonality on growth and development in different stages. April-June (spring or commencing onset of monsoon), with average minimum and maximum temperatures of 16.84±3.26^{o}C and 31.34±1.27°C respectively was the earliest breeding season for this insect. The relative humidity ranged from 51.32+10.86 to 89.83±1.15%. Second and third breeding periods corresponded to summer (July-September) and autumn (October-December) seasons respectively **(Table 25).** The incubation period (days) was shorter in *P. bombycina* (8.40±1.08 days) during summer season and was longer in *L. citrata* (11.50±0.85 days) during autumn rearing season. Similarly total larval duration was significantly shorter in *P. bombycina* (25.50±0.91, 32.50±1.04, and 37.5o±1.00 days) in comparison to *L. citrata* (30.50±0.78, 37.50±1.43, and 42.50±0.94 days) having the sequence of second < first < third season respectively. While pupal period was slightly less during summer (20.50±1.27 days) than spring (21.50±0.85 days) season in Som, no observable difference was noticed between these two seasons (22.50±0.50 days) in Mejankari. Further, pupa entered in diapause from November to next spring due to the prolong winter months in Nagaland **(Table 31)** exhibiting trivoltinism. The variation in larval and pupal duration was due to changes in climatic conditions particularly in temperature and relative humidity which increased from spring to summer and thereafter decreased towards autumn. The maximum adult longevity was recorded as 6.50±0.53 and 10.50±1.08 days in male and female respectively during the 1st rearing season, whereas the minimum was recorded as 4.50±0.53 (2nd season) and 7.50±1.18 (3rd season) days in male and female respectively. The present investigation indicated that 1st (spring) and 3rd (autumn) seasons were more suitable for rearing of wild variety of *A. assama* in *P. bombycina* than *L. citrata* highlighting the interaction effect of host plants and seasons on growth and development.

Effect on production parameters: The maximum and minimum fecundity (nos.) was recorded during first (205.40±10.37) and second (188.70±6.57) seasons while rearing in *P. bombycina* indicating the effect of seasonal variation **(Table 32).** While hatching percentage, effective rate of rearing (ERR) and Cocoons per disease free laying (Cocoons: dfl) was higher (79.90±1.45, 66.01±1.16 and 103.60±2.99 respectively) in *P. bombycina* during first rearing season, the minimum was recorded in *L. citrata* (71.30±1.95, 28.40±1.17 and 39.90±1.60 respectively) during third rearing season. The present investigation indicated that rearing performance was better during 1st and 3rd seasons in *P. bombycina* than *L. citrata* highlighting the interaction effect of host plants and seasons on production parameters. The variation in production parameters between the two host plants in different seasons may be due variation in mean values of nutrient content of two host plants that reflected on the feeding behaviors of muga silk worm. While *P. bombycina* had higher moisture content, *L. citrata* possessed higher percentage of total carbohydrate, total soluble sugar and crude fibre than *P. bombycina*. However percentage of total reducing sugar, total nitrogen, crude protein and total ash was higher in *P. bombycina* than *L. citrata* **(Table 27).** Slanky and Scriber (1985) described that the quality of food consumed by larvae influenced the fecundity, growth rate, development time and survival of adults. Similar observation has also been made by Yadav and Goswami (1992) who studied the nutritional contribution of *Machilus bombycina* and *Litsea polyantha* in relation to rearing of cultivated variety of muga silkworm. It has been clearly established that the quality of leaves particularly their moisture content, mineral content, protein content and sugar content play a significant role in proper growth and development of Silkworm. Dietary water played a very important role in silkworm metabolism as it regulated the rate of ingestion by muga silkworm (Delvi *et al*., 1988). Hazarika *et al*. (1994) 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. The nutritive value of leaf has a considerable influence on the growth and development of silkworms. The quantitative and qualitative nutrition controls the physiological status and the productivity of silk insect in terms of silk and egg yields (Mohanty and Mitra, 1991; Ojala *et al*., 2005)

Effect of host plant on cocoon parameter: Interaction effect of host plant and season on morphometric character and commercial traits of cocoons of wild variety did not show significant difference; however there was significant variation in certain parameters among the three seasons **(Table 33).** While seasonal cocoon dimension (cm^2) ranged from 5.35±0.06 (male during summer) to 9.22±0.14 (female during autumn) in *P. bombycina*, mean dimension was recorded maximum in both sex in *L. citrtata*. Minimum and maximum weight (gm) of green cocoon was recorded in male (4.04±0.16) during summer and female (8.27±0.18) during spring season in *L. citrata* and *P. bombycina* respectively. Wild variety of *A. assama* was conspicuous of having long peduncle. Shell weight (gm) of both male (0.64±0.02) and female (0.74±0.02) cocoon was maximum in *P. bombycina* during first rearing season while minimum was in male (0.37+0.02) and female (0.43±0.02) in *P. bombycina* and *L. citrata* respectively during second rearing season. While shell ratio in female was higher in Mejankari than Som during spring season, both sex had higher mean shell weight and shell ratio in Som. The qualitative and quantitative characters of the cocoon greatly varied according to the type of food plants used (Sharma *et al*., 1995). The requirement and balancing of nutrients is essential for larval metamorphosis to pupa with necessary shell formation to construct the nest (Reddy *et al*., 2012) and the varied levels of availability of such nutrition among two food plants might resulted to insignificant change in the cocoon weight with significant change in shell weight among the cocoons raised on *L. citrata* and

P.bombycina. Krishnaswamy *et al.* (1971) also observed that growth, development, and the economic characters of the cocoons were greatly influenced by the nutritional content of mulberry leaves. Rajadurai and Thangavelu (2000) while studying the biology of *Actias selene* in three different host plants observed strong influence of host plants on colour and morphometry of immature stages and adults, life cycle parameters, larval duration, reproductive programming and commercial characters of cocoons. Filament length (m) was maximum (373.00$\pm$25.46) in *L. citrata* during 1st season and minimum (236.93$\pm$16.83) during 2nd season in *P.bombycina*. However, filament denier was comparatively higher in *P.bombycina* than *L.citrata* in all seasons. Raw silk recovery was more in *L.citrata* during 1st (49.40%) and 2nd season (43.15%) than *P. bombycina* which exhibited maximum (47.27%) during 3rd season **(Table 34).** It was observed from the present investigation that cocoons and yarn produced from Mejankari were much stronger, thicker, glossy and durable and were at par with Som, the primary host plant. Mokokchung, a higher altitudinal area, favoured muga production in Spring (1st), Summer (2nd) and Autumn (3rd) season and could be potential seed zone particularly in summer season by producing healthy and vigorous seed cocoons for using during autumn crop in Assam. Photographs depicting rearing and grainage operation, host plant maintenance, cocoon and yarn diversity of both cultivated and wild variety are presented in **Figure 46 to 50**.

Muga silkworms crawl to top of the tree for feeding

Net rearing to protect the silkworms

(a)

(b)

Transfer of muga silkworm to new trees on exhaustion of foliages (a & b)

Indigenous device (Bows & Arrows) to to scare predators

Mature silkworms accumulated at the base of the tree

Fig. 46 Rearing of *Antheraea assama*

Traditional mountage (Dry leaves) Improved mountage

Cocooning of mature worm

Harvesting Cocoons

Selected cocoons for grainage operation

Fig.47 a Mounting of mature worms and harvesting of Cocoons shifting from tradition to improvised but low cost devise

Seed cocoon in racks

Garlanding of cocoons

Moth emergence

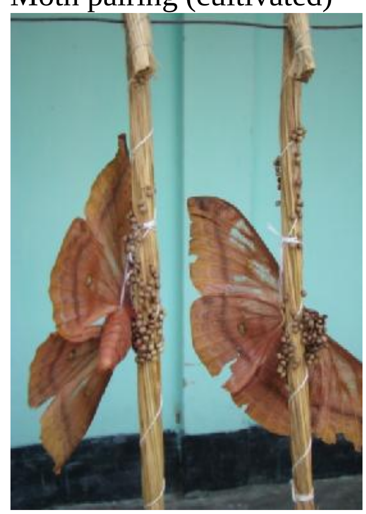
Moth pairing (wild)

Moth emergence

Moth pairing (cultivated)

Female moths for egg laying (cultivated)

Female moths for egg laying (wild)



Oviposition

Fig. 47 b Grainage operation is a crucial activity in muga culture

Female moths kept ready for examination

Looking of disease

Egg Harvesting

Disease free layings after mass grainage

Fig. 47 c Preparation of disease free layings - pre requiste for successful commercial crop

Intercropping provides additional income during gestation period of host plants

complete defoliation by muga silkworm is a sign of good crop

(a)

(b)

(c)

(d)

Pollarding and pruning helps to maintain host plants to manageable height with new foliages

Fig. 48 Host plant maintenance is important for muga culture

Som fed – cultivated (NLP)

Soalu fed- cultivated (NLP)

Som fed- cultivated (MKG)

Mejankari fed-cultivated (MKG)

Som fed –wild (MKG)

Mejankari fed- wild (MKG)

Som and Mejankari fed wild cocoon showing long peduncle

Fig. 49 Cocoon diversity of *Antheraea assama*

Muga yarn (a) Som (b) Soalu fed

Som fed muga yarn of a private rearer

At North Lakhimpur

Muga yarn of Som fed

Muga yarn of Mejankari fed

At Mokokchung Cultivated variety

(a)

(b)

Muga yarn of wild variety of *A. assama* (a) Som fed (b) Mejankari fed cocoon

Fig. 50 Yarn diversity of *A. assama*

Table 31 : Seasonality and impact of host plants on life cycle parameters (Mean ± SE) of *A. assama* (Wild) at Mokokchung

Seasons	Host Plants	Stages (in days)								
		Egg	1st	2nd	3rd	4th	5th	Pupa	Adult	
									Male	Female
Season I	Som	9.50±0.527	5.50±0.527	4.50±0.527	6.50±0.527	6.50±0.527	9.50±0.707	21.50±0.850	6.50±0.527	9.50±0.527
	Mejankari	10.50±0.850	6.50±0.707	5.50±0.527	6.50±0.527	7.50±0.707	11.50±0.972	22.50±0.850	6.50±0.850	10.50±1.080
	Seasonal mean	**10.00±0.707**	**6.00±0.707**	**5.00±0.707**	**6.50±0.00**	**7.00±0.707**	**10.50±1.414**	**22.00±0.707**	**6.65**±0.000	**10.00**±0.710
Season II	Som	8.40±1.075	4.50±0.527	3.50±0.527	4.50±0.527	4.50±0.527	8.50±0.527	20.50±1.269	5.50±0.850	8.50±0.707
	Mejankari	9.50±0.850	5.50±0.527	4.50±0.707	5.50±0.850	5.50±0.850	9.50±0.850	22.50±0.850	4.50±0.527	8.50±0.707
	Seasonal mean	**8.95±0.778**	**5.00±0.707**	**4.00±0.707**	**5.00±0.707**	**5.00±0.707**	**9.00±0.707**	**21.50±1.414**	**5.00±0.707**	**8.50**±0.000
Season-III	Som	10.50±0.850	6.50±0.527	6.50±0.527	6.50±0.850	6.50±0.527	11.50±0.707	Diapause	6.50±0.850	8.50±0.527
	Mejankari	11.50±0.850	7.50±1.080	7.50±0.850	8.50±0.850	7.50±0.850	11.50±0.972		5.50±0.707	7.50±1.179
	Seasonal mean	**11.00±0.707**	**7.00±0.707**	**7.00±0.707**	**7.50±1.414**	**7.00±0.707**	**11.50±0.000**		**6.00±0.707**	**8.00±0.707**
Host plant mean	Som	9.45±1.485	5.50±1.000	4.83±1.528	5.83±1.155	5.83±1.155	9.83±1.528	--	6.17±0.577	8.83±0.577
	Mejankari	10.50±1.000	6.50±1.000	5.83±1.528	6.83±1.528	6.83±1.155	10.83±1.155	--	5.50±1.000	8.83±1.528
Grand mean		**9.98±0.742**	**6.00±0.707**	**5.33±0.707**	**6.33±0.707**	**6.33±0.707**	**10.33±0.707**	**--**	**5.84±0.474**	**8.83±0.000**
F	Host plant	50.020***	62.469***	190.48***	115.607***	204.250***	70.265***	23.824***	5.612*	2.309NS
	Season	8.003**	9.996**	68.784***	12.846***	32.681***	19.675***	501.882***	13.247***	36.935***
	H x S	8.004**	9.996**	47.619***	38.536***	32.681***	19.675***	7.941**	2.624NS	9.234**
CV%		**8.83**	**8.83**	**9.62**	**10.50**	**6.77**	**7.22**	**5.47**	**11.71**	**9.8**

Total Larval Duration (Days)	**Host plants**	
	Som	**Mejankari**
Season-I (April-June)	**32.5±1.04**	**37.5±1.43**
Season-II (August-September)	**25.5±0.91**	**30.5±0.78**
Season-III (October-December)	**37.5±1.00**	**42.5±0.94**

***= Significant and ***= Highly Significant at the 5% level of probability, NS= Non Significant**

Table 32 : Seasonal variation of production parameters of *Antheraea assama* (Wild) on Som and Mejankari at Mokokchung

Host plant	Season	PARAETERS **(Mean ± SE)**			
		Fecundity (Nos)	Hatching (%)	ERR (%)	Cocoons/Dfl
Som	Spring	205.4±7.058	79.90±1.449	66±1.155	103.60±2.989
	Summer	188.7±4.923	71.60±1.350	33±1.333	44.02±1.476
	Autumn	197.6±5.103	76.00±1.491	54.30±1.418	81.90±4.254
	Mean	**197.23±8.356**	**75.83±4.153**	**51.10±16.731**	**76.57±30.154**
Mejankari	Spring	200.2±5.329	74.50±1.581	58.80±1.229	87.40±3.658
	Summer	199.1±6.420	76.20±1.619	30.10±1.449	45.40±1.776
	Autumn	199.5±6.115	71.30±1.947	28.40±1.174	39.90±1.595
	Mean	**199.60±0.557**	**74±2.488**	**39.10±17.082**	**57.57±25.982**
Host plant mean	Spring	202.80±3.677	77.20±3.818	62.40±5.091	95.50±11.455
	Summer	193.90±7.354	73.90±3.259	31.55±2.051	44.71±0.976
	Autumn	198.55±1.344	73.65±3.322	41.35±18.314	60.90±29.698
	Grand mean	**198.42±4.451**	**74.92±1.878**	**45.06±15.811**	**67.07±25.945**
F	Host plant	4.736	43.128	2983.425	2461.364
	Season	22.342	67.166	6864.019	6101.303
	Host plant x Season	17.195	133.291	1032.666	1073.727
CV%		**2.12**	**1.44**	**1.89**	**2.21**
CD%	Host plant	2.285*	1.095***	0.862***	1.502***
	Season	5.224***	1.341***	1.055***	1.840***
	Host plant x Season	7.387***	1.896***	1.492***	2.602***

*** = significant at 5% level, ** = significant at 1% at level, ***= significant at 0.1% level of probability, NS= Non significant.**

Table 33: Seasonality and impact of host plants on cocoon characteristics of *A.assama* (Wild) at Mokokchung (* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Non significant)**

Host plant	**Sex**	**Season**	**Parameters (Mean ± SE)**			
			Cocoon Wt (gm)	**Pupal Wt (gm)**	**Shell Wt (gm)**	**SR %**
Som	**Male**	Spring	5.13±0.148	4.49±0.121	0.64±0.02	12.69±0.60
		Summer	4.87±0.201	4.50±0.202	0.37±0.02	9.81±0.52
		Autumn	5.12±0.259	4.59±0.255	0.53±0.01	10.34±0.22
		Mean	**5.04±0.143**	**4.53±0.055**	**0.51±0.02**	**10.95±0.35**
	Female	Spring	8.27±0.181	7.53±0.182	0.74±0.02	8.96±0.32
		Summer	5.05±0.242	4.56±0.236	0.49±0.03	9.76±0.59
		Autumn	6.09±0.283	5.47±0.279	0.62±0.03	10.24±0.6
		Mean	**6.47±1.643**	**5.85±1.522**	**0.62±0.02**	**9.65±0.28**
	Seasonal mean	Spring	6.70±2.220	6.01±2.150	0.69±0.07	10.83±2.64
		Summer	4.96±0.127	4.53±0.042	0.43±0.08	9.795±0.04
		Autumn	5.61±0.686	5.03±0.622	0.585±0.06	10.29±0.07
	Total mean		**5.76±0.879**	**5.19±0.933**	**0.565±0.13**	**10.30.52**
Mejankari	Male	Spring	5.65±0.128	5.06±0.126	0.59±0.03	10.78±0.64
		Summer	4.04±0.160	3.66±0.163	0.38±0.01	9.56±0.31
		Autumn	5.28±0.170	4.78±0.169	0.50±0.01	9.49±0.26
		Mean	**4.99±0.843**	**4.50±0.74**	**0.49±0.02**	**9.94±0.27**
	Female	Spring	7.34±0.131	6.61±0.131	0.73±0.01	10.04±0.3
		Summer	4.76±0.105	4.33±0.100	0.43±0.02	9.07±0.29
		Autumn	6.49±0.265	5.86±0.261	0.63±0.03	9.74±0.28
		Mean	**6.20±1.315**	**5.60±1.162**	**0.60±0.03**	**9.62±0.18**
	Seasonal mean	Spring	6.50±1.195	5.83±1.096	0.66±0.10	10.41±0.52
		Summer	4.40±0.509	3.99±0.474	0.41±0.04	9.32±0.35
		Autumn	5.89±0.856	5.32±0.764	0.57±0.09	9.62±0.18
	Total mean		**5.60±1.080**	**5.05±0.778**	**0.55**±0.13	**9.78**±0.56
Average of host plant	Male	Spring	5.39±0.37	4.78±**0.40**	0.62±**0.04**	11.74±**1.35**
		Summer	4.46±0.59	4.08±0.59	0.38±0.01	9.69±0.18
		Autumn	5.20±0.11	4.69±0.13	0.52±0.02	9.92±0.60
		Mean	5.02±0.49	4.52±0.38	0.51±0.12	10.45±1.12
	Female	Spring	7.81±0.66	7.07±0.65	0.74±0.01	9.50±0.76
		Summer	4.91±0.21	4.45±0.16	0.46±0.04	9.42±0.49
		Autumn	6.29±0.28	5.67±0.28	0.63±0.01	9.99±0.35
		Mean	6.34±1.45	5.73±1.31	0.61±0.14	9.64±0.31
Total average for season		Spring	6.60±1.71	5.93±1.62	0.68±0.08	10.62±1.58
		Summer	4.69±0.32	4.27±0.26	0.42±0.06	9.56±0.19
		Autumn	5.75±0.77	5.18±0.69	0.58±0.08	9.96±0.05
Grand Mean			**5.67**±1.34	**5.12**±0.75	**0.56**±0.08	**9.79**±1.03
F	Season		251.979***	191.786***	326.739***	30.654***
	Host plant		5.338*	4.094*	6.556*	1.537NS
	Sex		356.060***	306.687***	160.309***	5.662*
	Season X host plant		90.340***	91.039***	0.303NS	12.315***
	Season X Sex		513.060***	513.103***	0.082NS	2.236NS
	Host plant X Sex		18.974***	20.503***	0.082NS	2.236NS
	Season X Host plant X Sex		148.395***	164.210***	4.583*	45.692***
CV%			**9.53**	**10.47**	**11.54**	**12.63**

Table 34: Yarn characteristics (Single cocoon) of *A.assama* (wild) in Mokokchung (Mean ± SE)

Seasons	Host plants	Filament length (m)	Filament denier (d)	Raw silk recovery (%)
Season-I (Apr-Jun)	A	327.65±31.82	4.87±0.20	45.13±0.51
	B	373.00±80.46	4.20±0.22	49.40±2.76
Season-II (Aug-Sep)	A	236.93±54.54	4.62±0.20	38.71±1.08
	B	261.80±54.59	4.56±0.11	43.15±1.66
Season-III (Oct-Dec)	A	363.27±58.64	4.71±0.16	47.27±1.42
	B	312.66±77.39	3.06±0.21	35.24±0.56
Mean± SE	A	309.28±22.47	4.73±0.19	43.70±1.00
	B	315.82±22.48	3.94±0.18	42.60±1.66

A = *Persea bombycina* B= *Litsea citrata*

Comparative rearing performance of *A. assama* (cultivated and wild) on Som

Variation on life cycle parameters: The incubation period was significantly shorter in wild population than cultivated one in different seasons. While mean larval period in 1st instar was slightly higher in wild than the cultivated population, the reverse trend was observed from 2nd to 5th stages which were due to voracious feeding habit of wild population that ensured faster growth and development. In both populations larval period was longer during autumn season followed by spring and summer season **(Table 35).** While total larval duration during spring and summer was significantly shorter in wild population (32.5±1.04 and 25.5±0.91 days respectively) than that of cultivated one (34.9±0.72 and 28.2±0.65 days respectively), both population required almost equal days to complete larval period during autumn season. The shortest period of life cycle during summer season was correlated with the higher temperature and optimum humidity. Similarly minimum pupal period for both populations was recorded during summer season; however wild variety had undergone diapauses during autumn season up to the next spring season due to prolong winter in Mokokchung. The mean maximum adult longevity of male (7.70±0.61 days) and female (9.25±1.73 days) was recorded in cultivated variety as compared to wild variety (6.17±0.58 and 8.83±0.58 days in male and female respectively).

Variation in production parameters: While minimum fecundity (nos.) of both populations was recorded during summer season, the maximum in cultivated and wild variety was recorded during autumn (189.60±6.65) and spring (205.4±7.06) season respectively **(Table 36).** Hatching percentage and effective rate of rearing (ERR) was recorded minimum and maximum during summer and spring season respectively in both varieties. Singh *et al.* (2007) opined that the presence of unfertilized eggs would in no way affect the fertilized ones and quality directly, yet the frequency of their occurrence underrated the quality and brought down the hatching percentage. Autumn season was found to be more suitable for cultivated variety which produced more cocoons per disease free laying (67±4.03) followed by spring (46.7±4.60) and summer (42±1.33). However, in wild variety, maximum production of cocoon was recorded during spring (103.6±2.99) followed by autumn (81.9±4.25) and summer (44.02±1.48) season. The present investigation indicated that spring and autumn seasons were more suitable for rearing of *A. assama* which emphasized on the effect of seasons on production parameters. It was observed that, in spite of having seasonal differences, annual mean of different production parameters was higher in wild variety than cultivated one highlighting better rearing performance of wild variety

Variation in cocoon production: Total mean of green cocoon weight was higher in wild (5.76±0.88) than the cultivated one (5.47±0.17), with the record of maximum weight (gm) in female-wild (8.27±0.18) and minimum in male-cultivated (4.85±0.15) during spring season **(Table 37).** While seasonal green cocoon weight in wild population was found to be maximum during spring (6.7±2.22) followed by autumn (5.61±0.69) and summer (4.96±0.13) season, in cultivated one it was found be maximum during autumn (5.66±0.76) followed by spring (5.42±0.80) and summer (5.34±0.66) season. No apparent difference was observed on total mean of shell weight (gm) and silk ratio (%) between wild and cultivated variety and followed the same seasonal pattern of spring>autumn>summer except for SR% in female-wild exhibiting maximum during autumn followed by summer and spring. However it was interesting to note that shell weight and SR% was recorded maximum in female of cultivated population than the wild one which was found to be reversed in male cocoons. Filament length and filament denier were found to be maximum in cultivated variety than wild one in all seasons, however there was apparently no difference in raw silk recovery (%) in between the two populations in different seasons **(Table 38).**

Table 35 : Seasonal variation of Life cycle parameter (Mean ± SE) of cultivated and wild population of *Antheraea assama* on Som host plant in Mokokchung

Variety	**Season**	**Stages (in days)**								
		Egg	**1st**	**2nd**	**3rd**	**4th**	**5th**	**Pupa**	**Adult**	
									Male	**Female**
Cultivated	Season I	10.37±0.348	5.60±0.323	5.30±0.211	6.48±0.215	6.68±0.155	10.78±0.175	24.69±0.228	8.40±0.149	10.96±0.267
	Season-II	9.58±0.198	4.50±0.125	4.30±0.115	5.29±0.166	5.30±0.125	8.79±0.137	20.70±0.170	7.30±0.170	9.30±0.149
	Season III	12.10±0.294	6.10±0.133	6.50±0.141	6.69±0.145	6.80±0.236	11.30±0.149	35.30±0.163	7.40±0.125	7.50±0.105
	Mean	10.68±1.289	5.40±0.819	5.37±1.102	6.15± 0.755	6.26±0.834	10.29±1.325	26.90±7.546	7.70±0.608	9.25±1.730
Wild	Season I	9.50±0.527	5.50±0.527	4.50±0.527	6.50±0.527	6.50±0.527	9.50±0.707	21.50±0.850	6.50±0.527	9.50±0.527
	Season-II	8.40±1.075	4.50±0.527	3.50±0.527	4.50±0.527	4.50±0.527	8.50±0.527	20.50±1.269	5.50±0.850	8.50±0.707
	Season III	10.50±0.850	6.50±0.527	6.50±0.527	6.50±0.850	6.50±0.527	11.50±0.707	Diapause	6.50±0.850	8.50±0.527
	Mean	9.45±1.485	5.50±1.000	4.83±1.528	5.83±1.155	5.83±1.155	9.83±1.528	--	6.17±0.577	8.83±0.577
F	Variety	52.249***	0.927*	28.098***	6.714*	17.647***	13.903***	6132.389***	44.198***	13.681**
	Season	64.443***	101.018***	226.537***	79.335***	127.575***	169.146***	365.224***	2.565NS	130.154***
	V X S	1.757NS	2.162NS	7.024**	3.862*	3.494*	12.637***	4563.835***	3.414*	41.912***
CV%		**6.28**	**7.39**	**7.64**	**7.98**	**6.51**	**4.71**	**3.12**	**15.10**	**4.86**

Total Larval Duration (Days)	**Variety**	
	Cultivated	**Wild**
Season-I (May-Jun)	**34.9±0.72**	**32.5±1.04**
Season-II (Aug- Sep)	**28.2±0.65**	**25.5±0.91**
Season-III (Oct-Dec)	**37.4±0.99**	**37.5±1.00**

(* = significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Non significant)**

Table 36 : Comparative seasonal variation of production parameter of cultivated and wild population of *Antheraea assama* on Som host plant in Mokokchung

Variety	Season	PARAMETERS (Mean ± SE)			
		Fecundity (Nos)	Hatching (%)	ERR (%)	Cocoons/Dfl
Cultivated	Spring	180.80±11.341	77.30±0.949	56.00±1.491	46.70±4.596
	Summer	152.30±7.945	65.90±1.595	41.90±0.876	42.00±1.333
	Autumn	189.60±6.653	70.50±1.434	50.00±1.700	67.00±4.028
	Mean	**174.23±19.498**	**71.23±5.735**	**49.30±7.076**	**51.90±13.286**
Wild	Spring	205.4±7.058	79.90±1.449	66±1.155	103.60±2.989
	Summer	188.7±4.923	71.60±1.350	33±1.333	44.02±1.476
	Autumn	197.6±5.103	76.00±1.491	54.30±1.418	81.90±4.254
	Mean	**197.23±8.356**	**75.83±4.153**	**51.10±16.731**	**76.57±30.154**
F	Variety	141.650***	163.546***	26.509***	801.366***
	Season	62.159***	250.583***	1543.664***	588.443***
	Variety x Season	18.169***	7.755**	256.336***	359.808***
CV%		**4.03**	**1.89**	**2.70**	**5.25**

*** = significant at 5% level, ** = significant at 1% at level, ***= significant at 0.1% level of probability, NS= Non significant.**

Table 37 Comparative seasonal variation of cocoon characteristics of cultivated and wild population *A.assama* on Som host plant at Mokokchung

Population	Sex	Season	Parameters (Mean ± SE)			
			Cocoon Wt (gm)	**Pupal Wt (gm)**	**Shell wt (gm)**	**SR %**
Cultivated	**Male**	Spring	4.85±0.147	4.33±0.099	0.53±0.137	10.87±2.539
		Summer	4.87±0.201	4.45±0.199	0.42±0.009	8.63±0.343
		Autumn	5.12±0.220	4.61±0.218	0.51±0.015	9.98±0.477
		Mean	**4.96±0.179**	**4.46±0.140**	**0.49±0.059**	**9.83±1.128**
	Female	Spring	5.98±0.146	5.27±0.148	0.71±0.058	11.92±0.970
		Summer	5.80±0.230	5.25±0.235	0.55±0.015	9.49±0.563
		Autumn	6.19±0.348	5.50±0.342	0.69±0.018	11.11±0.589
		Mean	**5.99±0.195**	**5.34±0.139**	**0.65±0.087**	**10.85±1.237**
	Seasonal mean	Spring	5.42±0.799	4.80±0.665	0.62±0.127	11.40±0.742
		Summer	5.34±0.658	4.85±0.566	0.49±0.092	9.06±0.608
		Autumn	5.66±0.757	5.06±0.629	0.60±0.127	10.55±0.799
	Total mean		**5.47±0.167**	**4.90±0.138**	**0.57±0.070**	**10.33±1.184**
Wild	Male	Spring	5.13±0.148	4.49±0.121	0.64±0.02	12.69±0.60
		Summer	4.87±0.201	4.50±0.202	0.37±0.02	9.81±0.52
		Autumn	5.12±0.259	4.59±0.255	0.53±0.01	10.34±0.22
		Mean	**5.04±0.143**	**4.53±0.055**	**0.51±0.02**	**10.95±0.35**
	Female	Spring	8.27±0.181	7.53±0.182	0.74±0.02	8.96±0.32
		Summer	5.05±0.242	4.56±0.236	0.49±0.03	9.76±0.59
		Autumn	6.09±0.283	5.47±0.279	0.62±0.03	10.24±0.6
		Mean	**6.47±1.643**	**5.85±1.522**	**0.62±0.02**	**9.65±0.28**
	Seasonal mean	Spring	6.70±2.220	6.01±2.150	0.69±0.07	10.83±2.64
		Summer	4.96±0.127	4.53±0.042	0.43±0.08	9.79±0.04
		Autumn	5.61±0.686	5.03±0.622	0.58±0.06	10.29±0.07
	Total mean		**5.76±0.879**	**5.19±0.933**	**0.57±0.13**	**10.30±0.52**
Average of population	Male	Spring	4.99±0.20	4.41±0.11	0.59±0.08	11.78±1.29
		Summer	4.87±0.20	4.48±0.04	0.40±0.04	9.22±0.83
		Autumn	5.12±0.22	4.60±0.01	0.52±0.01	10.16±0.25
		Mean	**4.99±0.13**	**4.50±0.10**	**0.50±0.10**	**10.39±1.29**
	Female	Spring	7.13±1.62	6.40±1.60	0.73±0.02	10.44±2.09
		Summer	5.43±0.53	4.91±0.49	0.52±0.04	9.63±0.19
		Autumn	6.14±0.07	5.49±0.02	0.66±0.05	10.68±0.62
		Mean	**6.23±0.55**	**5.60±0.75**	**0.64±0.11**	**10.25±0.55**
Total average for season		Spring	6.06±1.51	5.41±1.41	0.66±0.10	11.11±0.95
		Summer	5.15±0.40	4.70±0.30	0.46±0.08	9.42±0.29
		Autumn	5.63±0.72	5.05±0.63	0.59±0.10	10.42±0.37
Grand Mean			**5.61±0.46**	**5.05±0.36**	**0.57±0.10**	**10.32±0.84**
F	Season		325.350***	208.930***	139.144***	70.713***
	Variety		95.372***	102.030***	0.074NS	8.228**
	Sex		1808.418***	1511.214***	183.562***	2.508NS
	Season X Variety		304.402***	275.063***	14.010***	0.875NS
	Season X Sex		261.054***	267.009***	0.408NS	24.804***
	Variety X Sex		44.277***	62.515***	9.841**	26.653***
	Season X Variety X Sex		207.664***	225.913***	1.448NS	29.121***
CV%			**3.98**	**4.34**	**13.46**	**11.81**

*** = significant at 5% level, ** = significant at 1% at level, ***= significant at 0.1% level of probability, NS= Non significant.**

Table 38 Comparative yarn characteristics (Single cocoon) of cultivated and wild population of *A. assama* on Som host plant in Mokokchung (Mean±SE)

Seasons	Population	Filament length (m)	Filament denier (d)	Raw silk recovery (%)
Season-I (Apr-Jun)	Cultivated	409.20± 19.60	5.76±0.10	45.14±1.24
	Wild	327.65±31.82	4.87±0.20	45.13±0.51
Season-II (Aug-Sep)	Cultivated	303.20± 4.39	6.15±0.17	38.37±0.96
	Wild	236.93±54.54	4.62±0.20	38.71±1.08
Season-III (Oct-Dec)	Cultivated	407.30± 9.13	5.63±0.12	47.26±0.83
	Wild	363.27±58.64	4.71±0.16	47.27±1.42
Mean± SE	Cultivated	373.24±10.95	5.85±0.13	43.59±1.01
	Wild	309.28±22.47	4.73±0.19	43.70±1.00

Comparative rearing performance of *A. assama* (cultivated and wild) on Mejankari

Variation on life cycle parameters: The incubation period was significantly higher in cultivated population than wild one in different seasons. Wild population having the voracious feeding habit exhibited faster growth and development than cultivated one in all larval instars in different seasons except for slight decrease in 3rd instar level during autumn season. Total larval duration (days) was significantly shorter in summer season (30.5±0.78 and 33.4±0.66) followed by spring (37.5±1.43 and 39.7±0.73) and autumn (42.5±0.94 and 45.2±1.61) season in wild and cultivated population respectively **(Table-39).** The shortest period of life cycle during summer season was correlated with the higher temperature and optimum humidity. Pupal period was recorded to be minimum during summer (22.80±0.13) and followed by spring (26.60±0.13) and autumn (38.50±1.08) season in cultivated variety. However, exhibiting the same pupal period of 22.50± 0.85 days both in spring and summer season, pupa of the wild variety had undergone diapauses during winter months until the onset of next spring season due to prolong winter in Mokokchung. Adult longevity of wild population was shorter than cultivated one in all seasons. The mean adult longevity of male (5.50±1.00 days) and female (8.83±1.53 days) was recorded minimum in wild variety as compared to cultivated variety (7.57±0.40 and 9.77±0.99 in male and female respectively.

Variation in production parameters: Both cultivated and wild population exhibited mean and seasonal variation on various production parameters **(Table 40).** Fecundity (nos.) in cultivated variety was maximum in summer season (198.30±7.50) followed by autumn (188.60±8.78) and spring (171.50±9.93) season, however, maximum and minimum fecundity in wild population was recorded in spring (200.20±5.33) and summer (199.10±6.42) season respectively. Total mean fecundity in wild population (199.60±0.56) was recorded to be higher than cultivated one (186.13±13.57). Average hatching percentage was found to be higher in wild (74.00± 2.49) than cultivated (66.97±6.01) variety having shown no definite seasonal trend in both populations. Spring (71.30±1.16) and summer (76.20±1.62) season recorded maximum hatching percentage for cultivated and wild variety respectively. Mean effective rate of rearing (ERR) and cocoons per dfl was recorded higher in cultivated than wild population except for spring season in wild variety showing higher value than cultivated one. Further there was a decreasing trend of ERR and Cocoons/dfl from spring to autumn seasons in both varieties. The present investigation indicated that spring and summer seasons were more suitable for rearing of both varieties of *A. assama* on Mejankari which emphasized on the effect of seasons on production parameters. It was observed that, in spite of having seasonal differences, annual mean on various production parameters between cultivated and wild varieties highlighted an equitable rearing performance on Mejankari.

Variation in cocoon production: Total mean of green cocoon weight (gm) was higher in wild (5.76±0.88) than the cultivated one (5.47±0.17), with the record of maximum weight in female-wild (8.27±0.18) and minimum in male-cultivated (4.85±0.15) during spring season **(Table 41).** While seasonal green cocoon weight in wild population was found to be maximum during spring (6.7±2.22) followed by autumn (5.61±0.69) and summer (4.96±0.13) season, in cultivated one it was found be maximum during autumn (5.66±0.76) season followed by spring (5.42±0.80) and summer (5.34±0.66) season. No apparent difference was observed on total mean of shell weight (gm) and silk ratio (%) between wild and cultivated variety and followed the same seasonal pattern of spring>autumn>summer except for SR% in female-wild exhibiting maximum during autumn followed by summer and spring. Shell weight and SR% was recorded to be maximum in female of cultivated population than the wild ones which had been found to be reversed in male cocoons. Filament length (m) and filament denier were found to be maximum in cultivated variety than wild one in all seasons; however there was apparently no difference in raw silk recovery (%) between the two populations in different seasons **(Table-42).**

Table 39: Seasonal variation of Life cycle parameter (Mean±SE) of cultivated and wild population of *Antheraea assama* on Mejankari host plant in Mokokchung

Variety	Season	Stages (in days)								
		Egg	**1st**	**2nd**	**3rd**	**4th**	**5th**	**Pupa**	**Adult**	
									Male	**Female**
Cultivated	Season I	11.79±0.160	6.70±0.163	5.50±0.189	7.50±0.163	7.70±0.156	12.30±0.156	26.60±0.133	8.00±0.163	10.90±0.141
	Season-II	10.38±0.123	5.70±0.149	5.30±0.163	6.40±0.115	6.40±0.133	9.60±0.149	22.80±0.133	7.20±0.156	9.10±0.149
	Season III	13.90±0.149	7.60±0.115	7.80±0.163	8.20±0.221	8.30±0.823	13.30±0.949	38.50±1.080	7.50±0.850	9.30±0.675
	Mean	**12.02±1.772**	**6.67±0.950**	**6.20±1.389**	**7.37±0.907**	**7.47±0.971**	**11.73±1.914**	**29.30±8.191**	**7.57±0.404**	**9.77±0.987**
Wild	Season I	10.50±0.850	6.50±0.707	5.50±0.527	6.50±0.527	7.50±0.707	11.50±0.972	22.50±0.850	6.50±0.850	10.50±1.080
	Season-II	9.50±0.850	5.50±0.527	4.50±0.707	5.50±0.850	5.50±0.850	9.50±0.850	22.50±0.850	4.50±0.527	8.50±0.707
	Season III	11.50±0.850	7.50±1.080	7.50±0.850	8.50±0.850	7.50±0.850	11.50±0.972	Diapause	5.50±0.707	7.50±1.179
	Mean	**10.50±1.000**	**6.50±1.000**	**5.83±1.528**	**6.83±1.528**	**6.83±1.155**	**10.83±1.155**	**--**	**5.50±1.000**	**8.83±1.528**
F	Variety	93.678***	1.246NS	7.615**	12.423**	13.549**	20.490***	6953.690***	169.091***	22.064***
	Season	103.054***	56.860***	157.909***	91.822***	49.654***	78.111***	326.902***	25.909***	50.994***
	V X S	8.322**	0.050NS	3.084NS	10.104***	1.614NS	6.156**	5019.591***	4.795NS	4.841*
CV%		**5.42**	**8.78**	**8.56**	**7.76**	**9.32**	**6.83**	**3.00**	**9.42**	**8.27**

Total Larval Duration (Days)	**Variety**	
	Cultivated	**Wild**
Season-I (May-Jun)	**39.7±0.73**	**37.5±1.43**
Season-II (Aug- Sep)	**33.4±0.66**	**30.5±0.78**
Season-III (Oct-Dec)	**45.2±1.61**	**42.5±0.94**

*** = significant at 5% level, ** = significant at 1% at level, ***= significant at 0.1% level of probability, NS= Non significant**

Table 40: Comparative seasonal variation of production parameter of cultivated and wild population of *Antheraea assama* on Mejankari plant in Mokokchung

Variety	Season	PARAMETERS (Mean ± SE)			
		Fecundity (Nos)	Hatching (%)	ERR (%)	Cocoons/Dfl
Cultivated	I	171.50±9.925	71.30±1.160	57.40±0.966	70.00±3.399
	II	198.30±7.499	60.10±1.595	45.40±0.843	54.00±1.491
	III	188.60±8.784	69.50±1.269	40.80±1.619	53.00±3.266
	Mean	**186.13±13.569**	**66.97±6.014**	**47.87±8.570**	**59.00±9.539**
Wild	I	200.2±5.329	74.50±1.581	58.80±1.229	87.40±3.658
	II	199.1±6.420	76.20±1.619	30.10±1.449	45.40±1.776
	III	199.5±6.115	71.30±1.947	28.40±1.174	39.90±1.595
	Mean	**199.60±0.557**	**74±2.488**	**39.10±17.082**	**57.57±25.982**
F	Variety	48.162***	308.935***	747.324***	4.248*
	Season	14.989***	47.012***	2109.641***	869.269***
	Variety x Season	17.664***	129.365***	258.083***	186.859***
CV%		**3.90**	**2.20**	**2.86**	**4.62**

*** = significant at 5% level, ** = significant at 1% at level, ***= significant at 0.1% level of probability, NS= Non significant**

Table 41: Comparative seasonal variation of cocoon characteristics of cultivated and wild population *A.assama* on Mejankari host plant at Mokokchung

Variety	Sex	Season	Parameters (Mean± SE)			
			CocoonWt (gm)	**Pupal Wt (gm)**	**Shell Wt (gm)**	**SR %**
Cultivated	**Male**	Spring	4.71±0.156	4.28±0.158	0.43±0.015	9.17±0.461
		Summer	4.69±0.130	4.29±0.131	0.40±0.011	8.58±0.333
		Autumn	4.33±0.488	4.010±0.458	0.32±0.101	7.42±2.153
		Mean	**4.58±0.214**	**4.19±0.159**	**0.39±0.057**	**8.40±0.890**
	Female	Spring	5.78±0.215	5.24±0.220	0.54±0.014	9.35±0.491
		Summer	5.67±0.138	5.21±0.136	0.46±0.015	8.10±0.295
		Autumn	4.88±0.888	4.55±0.897	0.32±0.169	6.89±4.149
		Mean	**5.440±0.491**	**5.00±0.390**	**0.44±0.111**	**8.11±1.230**
	Seasonal mean	Spring	5.25±0.757	4.76±0.679	0.49±0.078	9.27±0.127
		Summer	5.18±0.693	4.75±0.651	0.43±0.042	8.34±0.339
		Autumn	4.61±0.389	4.28±0.381	0.32±0.00	7.16±0.375
	Total mean		**5.01±0.351**	**4.60±0.274**	**0.41±0.086**	**8.26±1.057**
Wild	Male	Spring	5.65±0.128	5.06±0.126	0.59±0.03	10.78±0.64
		Summer	4.04±0.160	3.66±0.163	0.38±0.01	9.56±0.31
		Autumn	5.28±0.170	4.78±0.169	0.50±0.01	9.49±0.26
		Mean	**4.99±0.843**	**4.50±0.74**	**0.49±0.02**	**9.94±0.27**
	Female	Spring	7.34±0.131	6.61±0.131	0.73±0.01	10.04±0.3
		Summer	4.76±0.105	4.33±0.100	0.43±0.02	9.07±0.29
		Autumn	6.49±0.265	5.86±0.261	0.63±0.03	9.74±0.28
		Mean	**6.20±1.315**	**5.60±1.162**	**0.60±0.03**	**9.62±0.18**
	Seasonal mean	Spring	6.50±1.195	5.83±1.096	0.66±0.10	10.41±0.52
		Summer	4.40±0.509	3.99±0.474	0.41±0.04	9.32±0.35
		Autumn	5.89±0.856	5.32±0.764	0.57±0.09	9.62±0.18
	Total mean		**5.60±1.08**	**5.05±0.778**	**0.55±0.13**	**9.78±0.56**
Average of population	Male	Spring	5.18±0.66	4.67±0.55	0.51±0.11	9.98±1.14
		Summer	4.37±0.46	3.98±0.45	0.39±0.01	9.07±0.69
		Autumn	4.81±0.67	4.40±0.54	0.41±0.13	8.46±1.46
		Mean	**4.79±0.41**	**4.35±0.35**	**0.44±0.06**	**9.17±0.76**
	Female	Spring	6.56±1.10	5.93±0.97	0.64±0.13	9.70±0.49
		Summer	5.22±0.64	4.77±0.62	0.45±0.02	8.59±0.69
		Autumn	5.69±1.14	5.21±0.93	0.48±0.22	8.32±2.02
		Mean	**5.82±0.68**	**5.30±0.59**	**0.52±0.10**	**8.87±0.73**
Total average for season		Spring	5.87±0.98	5.30±0.89	0.58±0.09	9.84±0.20
		Summer	4.80±0.60	4.38±0.56	0.42±0.04	8.83±0.34
		Autumn	5.25±0.62	4.81±0.57	0.45±0.05	8.39±0.10
Grand Mean			**5.30±0.75**	**4.82±0.75**	**0.48±0.06**	**8.97±0.30**
F	Season		215.611***	158.603***	161.507***	19.876***
	Variety		188.585***	114.618***	302.475***	63.448***
	Sex		591.301***	506.997***	116.581***	1.863NS
	Season X Variety		256.999***	203.616***	114.012***	8.085***
	Season X Sex		16.153***	12.558***	7.937***	0.27NS
	Variety X Sex		16.117***	11.753**	11.610**	0.450NS
	Season X Variety X Sex		12.483***	10.287***	7.203**	1.408NS
CV%			**6.23**	**6.78**	**12.17**	**15.54**

***= significant at 5% level, ** = significant at 1% at level, ***= significant at 0.1% level of probability, NS= Non significant.**

Table 42 Comparative yarn characteristics (Single cocoon) of cultivated and wild population of *A. assama* on Mejankari host plant in Mokokchung (Mean ± SE)

Seasons	Population	Filament length (m)	Filament denier (d)	Raw silk recovery (%)
Season-I (Apr-Jun)	Cultivated	365.48± 3.57	5.10±0.21	49.43±0.92
	Wild	373.00±80.46	4.20±0.22	49.40±2.76
Season-II (Aug-Sep)	Cultivated	366.78± 5.40	4.80±0.15	43.15±0.88
	Wild	261.80±54.59	4.56±0.11	43.15±1.66
Season-III (Oct-Dec)	Cultivated	255.04± 5.52	4.60±0.09	35.20±1.10
	Wild	312.66±77.39	3.06±0.21	35.24±0.56
Mean± SE	Cultivated	329.10±9.97	4.83±0.12	42.59±0.97
	Wild	315.82±22.48	3.94±0.18	42.60±1.66

REARING AT LOWER ALTITUDE

Rearing of *Antheraea assama* (Cultivated) on Primary host plants at lower altitude

Materials and Method

Lakhimpur district of Assam is a commercial zone of muga culture and rearing of muga silkworm is conducted for five to six crops particularly in two commercial crops namely Jethua and Kotia crop **(Table 24).** While *Persea bombycina* (Som), the most prevalent primary host plant is first choice among the rearers in Lakhimpur, the other primary host plant, *Litsea polyantha* (Soalu) also finds equal importance in both seed and commercial crop. Following the established rearing schedule in relation to seasonal pattern in Assam climatic condition, the present rearing and grainage of muga silk worm was conducted only in three seasons i.e. spring, summer and autumn to have comparative analysis along with the rearing conducted in higher altitude in Nagaland. Accordingly rearing and subsequent grainage of muga silk worm was conducted in Japisajia muga farm, North Lakhimpur, Assam for two consecutive years during 2007 and 2008 in six seasons (3 seasons in each year) i.e. Spring- season I (May-June), Summer-season II (August-September) and Autumn- season III (October-December). Disease free muga layings were initially collected from Muga Silkworm Seed Organization, P4 Unit, Tura, Meghalaya and equal number of newly hatched larvae were brushed on the selected bush plantation of *Persea bombycina* and *Litsea polyantha* (in triplicate) which were covered with nylon nets to protect the silkworms from predators and other enemies. The worms which crawled down to the base of the tree on exhaustion of leaves were transferred to new host plants. On maturity, the larvae were handpicked and kept in mountage for spinning of cocoons which were harvested after 8-10 days of pupation. The grainage operation was conducted at the muga seed grainage centre, Japisajia muga farm, North Lakhimpur at room temperature of 20^{o}–31^{o} C and relative humidity of 61-91%.

All the rearing and grainage data were recorded and analyzed for study of biology, which included the parameters such as morphometric characters (length, breadth and weight), life cycle, and production and cocoon parameter taking ten replicates for each treatment on both host plants in different seasons. The measurement and commercial character of cocoons was carried out by conventional method. The mean and standard error (SE) were calculated from the computed values. Randomized block design and completely randomized block design were used to analyse the field and laboratory data respectively (Gomez and Gomez, 1984). Further, critical differences were calculated by using *F*-test as described by Snedechor and Cochran (1967).

For reeling, muga cocoons were softened by cooking in open pan with 5 gm of sodium carbonate in 3 litres of water for 10-15 minutes. Cocoons were individually deflossed by hand for taking out continuous filament. Reeling was done by Muga reeling-cum-twisting machine (developed by Central Silk Board, Bangalore, India) at Central Muga Eri Research & Training Institute, Central silk board, Jorhat, Assam (India).

The seasonal climatic variation recorded during rearing period is given in **Table 43.** The maximum temperature ranged from 26.07±4.56 ^{0}C (autumn) to 32.23±0.71^{0}C (summer) while the minimum temperature fluctuated between 18.80±4.97 ^{0}C (autumn) and 25.00±1.51^{0}C (summer). Similarly, average maximum and minimum relative humidity (%) was recorded as 91.30±2.38 and 59.80±11.00 in spring and autumn season respectively during the study period. The highest rainfall/day was recorded in summer (15.01±3.14 mm) and lowest in autumn (2.90±2.65 mm). The maximum and minimum rainy days were recorded during summer (15.00±5.00) and autumn (4.70±4.16) season respectively.

Table 43 : Mean seasonal meteorological data during rearing period at North Lakhimpur

Season	Parameter and value (Mean±SE)					
	Temp.^{0}C		R.H. (%)		Rainfall/ Day (mm)	Rainy days/ Month
	Max.	Min.	Max.	Min.		
Spring (Apr-Jun)	31.1± 4.41	23.4± 3.57	91.3± 2.38	64.4± 8.06	8.91± 5.00	8.7± 3.79
Summer (Jul-Aug)	32.2± 0.71	25.0± 1.51	91.0± 3.28	81.8± 0.88	15.0± 3.14	15.0± 5.0
Autumn (Oct-Dec)	26.1± 4.56	18.8± 4.97	90.5± 5.64	59.8± 11.0	2.9± 2.65	4.7± 4.16

Results and Discussion

Variation on life cycle parameters: The incubation period was significantly short during second season, i.e. summer on both the host plants (7.30±0.48 and 7.10± 0.32 days in *P.bombycina* and *L. polyantha* respectively) and was long during autumn rearing season (10.50±0.53 and 10.30±0.48 days respectively in *P.bombycina* and *L.polyantha*). Similarly total larval duration was significantly shorter in *L.polyantha* (20.1±1.34, 23.0±1.54, and 33.0±2.19 days) in comparison to *P. bombycina* (21.2±1.37, 24.1±1.62, and 34.0±2.11 days) having the sequence of summer < spring< autumn season respectively. The minimum pupal period was recorded in *L. polyantha* during summer season (18.30±0.48 days) while the maximum was recorded in *P. bombycina* in autumn season (31.00±0.67). The maximum adult longevity was recorded as 9.1±0.74 and 11.9±0.57 days in male and female respectively on *L. polyantha* during spring rearing season whereas, minimum was recorded as 7.0±0.67(male) and 9.0±0.94 (female) days in *P.bombycina* during summer rearing season. The shortest period of life cycle during summer season (season II) was correlated with the higher temperature and optimum humidity, which ensured faster growth and development in different stages. The longer larval and pupal duration in both host plants during autumn might be due to the lower temperature and dry season with onset of winter **(Table 44).**

Effect on production parameters: The minimum and maximum fecundity (nos.) was recorded during spring in *L. polyantha* (178.00±8.93) and summer in *P. bombycina* (204.00±10.59), however, the annual mean of fecundity was higher in

P. bombycina (195.67±9.71) than *L. polyantha* (188.00±10.00) exhibiting highly significant effect of host plant as well as seasons **(Table 45).** While hatching percentage was higher in *P. bombycina* (82.33±6.43) than *L. polyantha* (81.00±5.57), effective rate of rearing (ERR) was better in *L. polyantha* (48.20±17.05) than the former (42.73±17.47) except for summer season. Mean annual production of cocoons per dfl was slightly higher in *P. bombycina* (46.67±20.82) than *L. polyantha* (45.67±27.68) however, on seasonal basis cocoon production was more in later than former during spring and autumn season. In summer season cocoon: dfl ratio was more in *P. bombycina*. In general, fecundity, hatching percentage and cocoon: dfl was found to be better in *P.bombycina*, however, ERR was slightly higher in *L. polyantha.* While there was highly significant seasonal difference in all production parameters, difference was not significant between two host plants except for ERR%. Further interaction effect of host plant x season was highly significant only for cocoons: dfl ratio. The differences in life cycle and production parameters may be due to variation in nutrient composition of food plants **(Table 46)** because the amount, rate and quality of food consumed by larvae influenced the fecundity, growth rate, development time and survival of adults (Slanky and Scriber, 1985). Yadav and Goswami (1992) and Choudhury *et al*. (2000) found a negative effect of crude fibre on larval development of muga silkworm on different host plants. *L. polyantha* with slightly less percentage of crude fibre and total carbohydrate might be more palatable to muga silk worm. However, Dutta *et al*. (1997) revealed that with the high amount of total nitrogen and protein, Som leaves were more nutritive. Mc Caffery (1975) also pointed out that egg production in insects was influenced by the host plant selection.

Effect of host plants on cocoon production: Maximum green cocoon weight (gm) was recorded in female (7.59±0.37) on *L. polyantha* during summer season while minimum was recorded in male (3.55±0.18) on *P.bombycina* during autumn season **(Table 47).** Barah *et al.* (1988) however observed that weight of muga cocoons produced during autumn season was higher than the cocoons produced in other season. In *P.bombycina,* shell weight (gm) of both male (0.38±01) and female (0.51±0.02) cocoon was maximum during spring and summer season respectively, however in *L. polyantha,* summer season only exhibited maximum shell weight for both male (0.45±0.02) and female (0.62±0.02) . Both sexes had higher mean silk ratio in Som than Soalu having maximum contribution during summer followed by spring and autumn season. Mean filament length (cm) was higher in *P. bombycina* (411.10±10.95) than *L. polyantha* (383.38± 9.97) exhibiting a seasonal trend of autumn > spring> summer season in the former and spring>autumn >summer in later. Filament denier was comparatively higher in *L. polyantha* (5.55) than *P. bombycina* (5.17) exhibiting maximum record of former in all seasons. While spring season has a higher record for both host plants, it was calculated to be same in respective host plants in summer and autumn seasons. Mean raw silk recovery was maximum in *P. bombycina* (48.08%) than *L. polyantha* (44.67%) having maximum recovery during spring season for both host plants. *P. bombycina* exhibited the seasonal trend of spring>autumn> summer, however, *L. polyantha* contributed equally during summer and autumn seasons

(Table 48). Thangavelu *et al*. (1988) and Baruah *et al*. (2000) reported that cocoons of *Antheraea assama* reared on different host plants and in different seasons in Assam varied greatly in characters like cocoon weight, shell weight, silk filament length and shell ratio The result suggested individual and combined effect of seasons, host plants and sexes highlighting significant to highly significant difference on various cocoon parameters.

Table 44: Seasonality and impact of host plants on life cycle parameters (Mean± SE) of *A. assama* (Cultivated) at North Lakhimpur

Season	Host plants	Stages(in days)								
		Egg	1st	2nd	3rd	4th	5th	pupa	Adult	
									Male	Female
Season-I	Som	8.2±0.422	3±0.000	3.75±0.540	4.5±0.527	5.7±0.483	7.1±0.316	22±0.667	8±0.667	11.1±0.876
	Soalu	8±0.000	2.7±0.483	3.7±0.483	4.5±0.527	5.4±0.516	6.7±0.483	21±0.471	9.1±0.738	11.9±0.568
	Seasonal mean	8.1±0.141	2.85±0.212	3.725±0.035	4.5±0.000	5.55±0.212	6.9±0.283	21.5±0.707	8.55±0.778	11.5±0.566
Season-II	Som	7.30±0.483	2.70±0.483	3.20±0.422	4.20±0.422	5.0±0.471	6.10±0.316	19±0.667	7±0.667	9±0.943
	Soalu	7.10±0.316	2.70±0.483	3.10±0.316	3.60±0.516	4.70±0.483	6.00±0.000	18.30±0.48	8±0.816	10±0.667
	Seasonal mean	7.20±0.141	2.70±0.000	3.15±0.071	3.90±0.424	4.85±0.212	6.05±0.071	18.65±0.495	7.5±0.707	9.5±0.707
Season-III	Som	10.50±0.527	4.60±0.516	5.90±0.568	6.10±0.316	7.20±0.422	10.20±0.422	31±0.667	8±0.667	10±0.667
	Soalu	10.30±0.483	4.20±0.422	5.80±0.422	6.00±0.000	6.90±0.316	10.10±0.316	30±0.667	9±0.667	11±0.816
	Seasonal mean	10.4±0.141	4.4±0.283	5.85±0.071	6.05±0.071	7.05±0.212	10.15±0.071	30.5±0.707	8.5±0.707	10.50.707
Host plant Mean	Som	8.67±1.650	3.43±1.021	4.28±1.427	4.93±1.021	5.97±1.124	7.80±2.138	24±6.245	7.67±0.577	10.03±1.050
	Soalu	8.47±1.650	3.20±0.866	4.20±1.418	4.70±1.212	5.67±1.124	7.60±2.193	23.10±6.126	8.70±0.608	10.97±0.950
Grand .mean		8.57	3.31	4.24	4.82	5.82	7.70	23.55	8.18	10.50
F	Host plant	3.652NS	4.261*	0.497NS	4.183*	6.811*	5.015*	33.353***	33.302***	22.914***
	Season	331.536***	92.435***	193.077***	126.085***	127.471***	782.746***	2100.412***	14.589***	35.075***
	H x S	28.453**	23.640**	5.093NS	16.107***	2.54NS	9.176**	453.574***	6.78NS	3.735*
CV%		**4.73**	**13.21**	**10.80**	**9.17**	**7.65**	**4.50**	**2.56**	**8.48**	**7.19**

Total Larval Duration (Days)	**Host plant**	
	Som	**Soalu**
Season-I (May-Jun)	**24.1±1.62**	**23.0±1.54**
Season-II (Aug- Sep)	**21.2 ±1.37**	**20.1±1.34**
Season-III (Oct-Dec)	**34.0 ±2.11**	**33.0±2.19**

significant at 5% level, ** = significant at 1% at level, *= significant at 0.1% level of probability, NS= Non significant.**

Table 45: Seasonal variation of production parameters of *Antheraea assama* on Som and Soalu at North Lakhimpur

Host plant	Season	Parameters (Mean ± SE)			
		Fecundity (Nos)	Hatching (%)	ERR (%)	Cocoons/Dfl
Som	I	185±7.817	85±3.018	61±6.182	70±5.395
	II	204±10.593	75±8.641	41±4.372	40±3.496
	III	198±6.848	87±2.582	26.2±3.490	30±6.092
	Mean	**195.67±9.713**	**82.33±6.429**	**42.73±17.465**	**46.67±20.817**
Soalu	I	178±8.932	82±5.457	67.8±11.351	75±1.491
	II	198±10.975	75±8.485	40±5.055	20±2.160
	III	188±14.384	86±8.287	36.8±7.146	42±5.033
	Mean	**188±10.000**	**81.00±5.568**	**48.20±17.049**	**45.67±27.683**
Host plant mean	I	181.50±4.950	83.50±2.121	64.40±4.808	72.50±3.536
	II	201±4.243	75±0.000	40.50±0.707	30±14.142
	III	193±7.071	86.50±0.707	31.50±7.495	36±8.485
	Grand mean	**191.83±9.802**	**81.67±5.965**	**45.47±17.003**	**46.17±23.002**
F	Host plant	8.678**	0.630NS	12.836***	0.220
	Season	18.915***	16.806***	107.299***	154.881***
	Host plant x Season	0.190	0.277	3.986	134.047
CV%		**5.25**	**7.97**	**15.35**	**17.90**
CD%	Host plant	5.80*	NS	4.922**	NS
	Season	13.259***	8.055***	8.214***	4.030***
	Host plant x Season	NS	NS	6.223*	5.699***

*** = significant at 5% level, ** = significant at 1% at level,**
*****= significant at 0.1% level of probability, NS= Non significant**

Table 46 : Mean values of nutrient content in the leaves of *Persea bombycina* and *Litsea polyantha* in North Lakhimpur (Mean±SE)

Content (%)	***P. bombycina***	***L. polyantha***
Moisture	68.89± 0.74	64.84± 1.29
Total carbohydrate	11.78± 0.84	9.01± 0.67
Total soluble sugar	4.36± 0.66	4.09± 0.66
Total reducing sugar	2.35± 0.77	2.12± 0.31
Crude fibre	13.95± 0.85	11.87± 1.21
Total nitrogen	3.63± 0.43	3.10± 0.87
Crude protein	22.65± 0.57	19.24± 0.66
Total ash	4.33± 0.54	4.13± 0.65

Table 47 Seasonality and impact of host plants on cocoon characteristics of *A. assama* (Cultivated) at North Lakhimpur

Host plant	Sex	Season	Parameters (Mean±SE)			
			CocoonWt (gm)	**Pupal Wt (gm)**	**Shell wt (Gm)**	**SR %**
Som	**Male**	Spring	4.24±0.063	3.86±0.055	0.38±0.077	8.93±1.714
		Summer	3.66±0.262	3.30±0.234	0.36±0.072	9.69±1.736
		Autumn	3.55±0.187	3.27±0.227	0.28±0.084	7.91±2.427
		Mean	**3.82±0.371**	**3.48±0.332**	**0.34±0.053**	**8.84±0.893**
	Female	Spring	6.20±0.041	5.75±0.075	0.46±0.092	7.39±1.416
		Summer	5.22±0.556	4.71±0.401	0.51±0.403	9.35±6.542
		Autumn	5.09±0.260	4.84±0.266	0.25±0.077	4.94±1.502
		Mean	**5.50±0.607**	**5.10±0.567**	**0.41±0.138**	**7.23±2.210**
	Seasonal mean	Spring	5.22±1.386	4.81±1.336	0.42±0.057	8.16±1.089
		Summer	4.44±1.103	4.01±0.997	0.44±0.106	9.52±0.240
		Autumn	4.32±1.089	4.06±1.110	0.27±0.021	6.425±2.100
	Total mean		**4.66±1.188**	**4.29±0.446**	**0.38±0.093**	**8.04±1.549**
Soalu	Male	Spring	4.82±0.200	4.44±0.076	0.42±0.108	8.54±2.126
		Summer	4.92±0.193	4.48±0.214	0.45±0.133	9.08±2.653
		Autumn	4.65±0.046	4.34±0.092	0.31±0.078	6.56±1.667
		Mean	**4.80±0.137**	**4.42±0.072**	**0.39±0.074**	**8.06±1.327**
	Female	Spring	6.04±0.085	5.61±0.114	0.43±0.069	7.17±1.154
		Summer	7.59±0.281	7.20±0.252	0.62±0.094	7.89±1.310
		Autumn	6.00±0.088	5.68±0.097	0.32±0.089	5.37±1.462
		Mean	**6.54±0.907**	**6.162±0.898**	**0.46±0.152**	**6.81±1.298**
	Seasonal mean	Spring	5.43±0.863	5.03±0.827	0.43±0.007	7.86±0.969
		Summer	6.26±1.888	5.84±1.923	0.52±0.141	8.54±0.764
		Autumn	5.33±0.955	5.01±0.948	0.32±0.007	5.97±0.841
	Total mean		**5.67±1.230**	**5.29±0.474**	**0.42±0.100**	**7.46±1.332**
Average of host plant	Male	Spring	4.53±0.410	4.15±0.410	0.40±0.028	8.74±0.276
		Summer	4.29±0.891	3.89±0.834	0.41±0.064	9.39±0.431
		Autumn	4.10±0.778	3.81±0.757	0.30±0.021	7.24±0.955
		Mean	**4.31±0.215**	**3.95±0.178**	**0.36±0.061**	**8.46±1.103**
	Female	Spring	6.12±0.113	5.68±0.099	0.45±0.028	7.28±0.156
		Summer	6.41±1.676	5.96±1.761	0.57±0.078	8.62±1.032
		Autumn	5.54±0.643	5.26±0.594	0.29±0.049	5.16±0.304
		Mean	**6.02±0.443**	**5.26±0.198**	**0.44±0.140**	**7.02±1.745**
Total average for season		Spring	5.33±1.124	4.92±1.082	0.43±0.035	8.01±1.032
		Summer	5.35±1.499	4.93±1.464	0.44±0.191	9.01±0.544
		Autumn	4.82±1.018	4.54±1.025	0.30±0.007	6.20±1.471
Grand Mean			**5.17±0.300**	**4.74±0.276**	**0.38±0.061**	**7.74±1.424**
F	Season		198.732***	134.211***	22.331***	14.436***
	Host plant		1708.82***	2040.898***	0.467NS	9.444**
	Sex		4838.727***	5719.723***	2588NS	29.870***
	Season X host plant		347.381***	437.859***	1.005NS	3.896*
	Season X Sex		69.653***	76.596***	0.877NS	0.413NS
	Host plant X Sex		0.926NS	7.869**	4.164*	0.687NS
	Season X Host plant X Sex		128.997***	192.03***	3.93*	5.325*
CV%			**3.69**	**3.59**	**38.64**	**35.79**

*** = significant at 5% level, ** = significant at 1% at level, ***= significant at 0.1% level of probability, NS= Non significant**

Table 48 : Yarn characteristics (Single cocoon) of *A.assama* (cultivated) in North Lakhimpur (Mean ± SE)

Seasons	Host plants	Filament length (m)	Filament denier (d)	Raw silk recovery (%)
Season-I (Apr-Jun)	A	435.00± 10.85	5.50±0.14	50.23±1.51
	B	410.00± 7.25	5.8±0.07	46.00±1.49
Season-II (Aug-Sep)	A	350.00± 3.87	5.00±0.16	46.00±0.77
	B	340.15± 10.74	5.42±0.23	44.00±0.80
Season-III (Oct-Dec)	A	448.30± 14.92	5.00±0.12	48.01±1.20
	B	400.00± 11.40	5.43±0.21	44.00±1.49
Mean± SE	A	411.10±10.95	5.17±0.14	48.08±1.16
	B	383.38± 9.97	5.55±0.17	44.67±1.26

A = *Persea bombycina* B= *Litsea polyantha*

Altitudinal effect of rearing performance of *Antheraea assama* (Cultivated) on primary host plant

Variation on life cycle parameters: The incubation period was significantly shorter in North Lakhimpur than Mokokchung in different seasons and year. Except for the slightly longer larval period in 4th instar during autumn season, seasonal and mean larval period in all instars were shorter in North Lakhimpur than Mokokchung. In both places larval period was longer during autumn season followed by spring and summer season **(Table 49).** While total larval duration during summer and spring was significantly shorter in North Lakhimpur (21.2±1.37 and 24.1±1.62 days respectively) than Mokokchung (28.2±0.65 and 34.9±0.72 days respectively), no significant difference was observed between lower (34.0±2.11) and higher (37.4± 0.99) altitude during autumn season. The shortest period of life cycle in lower altitude was correlated with the higher temperature and optimum humidity **(Table 50).** Similarly seasonal and mean pupal period was recorded to be shorter in North Lakhimpur than Mokokchung, however difference was not significant except for autumn season during which pupal growth was slower in Mokokchung due to lower temperature particularly in December. While mean adult longevity of male was slightly shorter in North Lakhimpur (7.67±0.58 days) than Mokokchung (7.70±0.61 days), the reverse had been recorded in female exhibiting longer life in North Lakhimpur (10.03±1.05 days) than Mokokchung (9.25±1.73 days).

Variation in production parameters: The mean fecundity (nos.) of muga silk moth in North Lakhimpur (195.67±9.71) was higher than Mokokchung (174.23±19.50), exhibiting higher record in the former in all respective seasons also. However no consistency and uniformity was noticed in different seasons in two places. While fecundity in North Lakhimpur was recorded to be maximum during summer (204.00±10.59), it was found to be maximum (189.60±6.65) during autumn in Mokokchung. Summer season recorded minimum (152.30±7.95) fecundity in Mokokchung **(Table 51).** Hatching percentage was also recorded to be higher in North Lakhimpur than Mokokchung in respective seasons. However there was difference in seasonality between the two places having variable seasonal trend of autumn>spring>summer in North Lakhimpur and spring>autumn>summer in Mokokchung. Effective rate of rearing (ERR) was recorded minimum and maximum in North Lakhimpur (42.33±17.47) and Mokokchung (49.30±7.08) respectively. With the maximum record in both places during spring season (61.6±6.18 and 56.0±1.49), ERR was been found to be highly variable in other seasons having the least record during autumn (26.2±3.49) and summer (41.9±0.88) in North Lakhimpur and Mokokchung respectively. Spring season was found to be more suitable for rearing of muga silk worm in lower altitude which produced more cocoons per disease free laying (70.00±5.40) followed by summer (40.00±3.50) and autumn (30.00±6.09). However, in high altitude, maximum production of cocoon was recorded during autumn (67.00±4.03) followed by spring (46.70±4.60) and summer (42.00±1.33 season. The average annual production was found to be more in Mokokchung (51.90±13.29) than North Lakhimpur (46.67±20.82). The difference in life cycle and present observation of higher fecundity and hatching percentage in lower altitude and maximum ERR and cocoon production in higher altitude emphasized on variation of nutrient composition of the host plant (*P.bombycina*) in both places **(Table 52)** which may be due to climatic and altitudinal effect. Further season to season analysis on rearing and cocoon production between the two places highlighted the fact that rearing performance in higher altitude was comparatively better than lower altitude during summer and autumn season and also showed highly significant difference between locations, seasons and interaction effect due to location x season

Variation in cocoon production: Interaction effect on morphometric character and commercial traits of cocoons of *A. assama* due to season, location and sex showed significant difference in green cocoon weight, shell weight, shell ratio and raw silk recovery **(Table 53).** Total mean of green cocoon weight (gm) was higher in Mokokchung (5.47±0.17) than North Lakhimpur (4.66±0.19), with the record of maximum weight in female (6.20±0.04) during spring and minimum in male (3.55±0.19) during autumn season in North Lakhimpur. It was observed that weight of both male and female cocoon were recorded to be higher in Mokokchung than North Lakhimpur in the corresponding seasons except for the female cocoon during spring season having higher weight in North Lakhimpur (6.20±0.04) than Mokokchung (5.98±0.15). While seasonal green cocoon weight in Mokokchung was found to be maximum during autumn (5.66±2.22) followed by spring (5.42±0.80) and summer (5.34±0.66) season, in North Lakhimpur it was found be maximum during spring (5.22±1.39) followed by summer (4.44±1.10) and spring (4.32±1.09) season. Mean shell weight was higher in Mokokchung (0.57±0.07) than North Lakhimpur (0.38±0.09). In Mokokchung, shell weight of both male (0.53±0.14) and female (0.71±0.06) cocoon was recorded to be maximum only during spring season, however, in North Lakhimpur, maximum weight in male (0.38±0.08) and female (0.51±0.40) cocoon was obtained in spring and summer season respectively. Silk ratio (%) was recorded to be higher in Mokokchung than North Lakhimpur in both sexes in all seasons. The mean value of SR% in female cocoon (10.85±1.24) was found to be more than male (9.83±1.13) counterpart in Mokokchung, while the reverse trend of having more in male (8.84±0.89) than female (7.23±2.21) was observed in North Lakhimpur.

Filament length (m) was recorded to be higher in North Lakhimpur (411.1±10.95) than Mokokchung (373.24±9.97). Seasonally, its length was maximum during autumn (448.30±14.92) in North Lakhimpur, while in Mokokchung it was maximum during spring season (409.22±19.60) exhibiting minimum in summer season for both places **(Table 54).** Average filament denier was comparatively higher in Mokokchung (5.85) than North Lakhimpur (5.17) and also in all seasons. While filament denier in North Lakhimpur was maximum during summer season, it was found to be maximum in Mokokchung during summer season. Mean raw silk recovery was more in North Lakhimpur (48.08) than Mokokchung (43.59). Raw silk recovery in North Lakhimpur was maximum during spring (50.23±1.51) followed by autumn (48.01±1.20) and summer (46.00±0.77), however in Mokokchung it was found to be maximum during autumn (47.26± 0.83) followed by spring (45.14±1.24) and summer (38.37± 0.96) season.

Table 49 Altitudinal variation on life cycle parameter (Mean ± SE) of *Antheraea assama* (cultivated) between North Lakhimpur and Mokokchung

Location	Season	Stages (in days)								
		Egg	1st	2nd	3rd	4th	5th	Pupa	Adult	
									Male	Female
North Lakhimpur	Season I	8.2±0.422	3±0.000	3.75±0.540	4.5±0.527	5.7±0.483	7.1±0.316	22±0.667	8±0.667	11.1±0.876
	Season-II	7.30±0.483	2.70±0.483	3.20±0.422	4.20±0.422	5.0±0.471	6.10±0.316	19±0.667	7±0.667	9±0.943
	Season III	10.50±0.527	4.60±0.516	5.90±0.568	6.10±0.316	7.20±0.422	10.20±0.422	31±0.667	8±0.667	10±0.667
	Mean	8.67±1.650	3.43±1.021	4.28±1.427	4.93±1.021	5.97±1.124	7.80±2.138	24±6.245	7.67±0.577	10.03±1.050
Mokokchung	Season I	10.37±0.348	5.60±0.323	5.30±0.211	6.48±0.215	6.68±0.155	10.78±0.175	24.69±0.228	8.40±0.149	10.96±0.267
	Season-II	9.58±0.198	4.50±0.125	4.30±0.115	5.29±0.166	5.30±0.125	8.79±0.137	20.70±0.170	7.30±0.170	9.30±0.149
	Season III	12.10±0.294	6.10±0.133	6.50±0.141	6.69±0.145	6.80±0.236	11.30±0.149	35.30±0.163	7.40±0.125	7.50±0.105
	Mean	10.68±1.289	5.40±0.819	5.37±1.102	6.15± 0.755	6.26±0.834	10.29±1.325	26.90±7.546	7.70±0.608	9.25±1.730
F	Location	350.723***	362.065***	97.769***	115.647***	6.386*	248.169***	233.466***	0.060NS	12.020**
	Season	248.246***	96.835***	174.179***	70.733***	85.112***	146.179***	1763.715***	19.761***	39.044***
	L x S	4.278*	15.209***	7.792**	22.863***	19.609***	113.08**	35.851***	6.5**	30.848**
CV%		**4.31**	**9.06**	**8.79**	**7.93**	**7.35**	**6.77**	**2.88**	**6.87**	**9.03**

Total Larval Duration (Days)	**Location**	
	North Lakhimpur	**Mokokchung**
Season-I (May-Jun	**24.1±1.62**	**34.9±0.72**
Season-II (Aug- Sep)	**21.2 ±1.37**	**28.2±0.65**
Season-III (Oct-Dec)	**34.0 ± 2.11**	**37.4±0.99**

*** = significant at 5% level, ** = significant at 1% at level, ***= significant at 0.1% level of probability, NS= Non significant**

Table 50: Mean altitudinal climatic variation between North Lakhimpur and Mokokchung during study period

Season	Local-tin	Parameter and value (Mean±SE)					
		Temp. ^{0}C		R.H. (%)		Rainfall/ day (mm)	Rainy days/ month
		Max.	Min.	Max.	Min.		
Spring	NLP	31.1± 4.41	23.4± 3.57	91.3± 2.38	64.4± 8.06	8.91± 5.00	8.7± 3.79
	MKG	30.6± 0.58	15.7± 2.36	89.1± 0.51	49.3± 7.46	7.7± 0.48	21.3± 0.21
Summer	NLP	32.2± 0.71	25.0± 1.51	91.0± 3.28	81.8± 0.88	15.0± 3.14	15.0± 5.0
	MKG	31.3± 0.76	19.7± 0.48	88.9± 1.30	61.1± 5.42	11.8± 3.68	22.7± 1.53
Autumn	NLP	26.1± 4.56	18.8± 4.97	90.5± 5.64	59.8± 11.0	2.9± 2.65	4.7± 4.16
	MKG	24.3± 3.32	10.5± 2.78	87.1± 0.24	51.8± 2.78	2.6± 2.96	8.3± 9.29

Table 51: Altitudinal variation on production parameters of *Antheraea assama* (Cultivated) (between North Lakhimpur and Mokokchung)

Location	Season	Parameters (Mean+SE)			
		Fecundity (Nos)	Hatching (%)	ERR (%)	Cocoons/Dfl
North Lakhimpur	Spring	185±7.817	85±3.018	61±6.182	70±5.395
	Summer	204±10.593	75±8.641	41±4.372	40±3.496
	Autumn	198±6.848	87±2.582	26.2±3.490	30±6.092
	Mean	**195.67±9.713**	**82.33±6.429**	**42.73±17.47**	**46.67±20.82**
Mock-chug	Spring	180.80±11.341	77.30±0.949	56±1.491	46.70±4.596
	Summer	152.30±7.945	65.90±1.595	41.90±0.876	42±1.333
	Autumn	189.60±6.653	70.50±1.434	50±1.700	67±4.028
	Mean	**174.23±19.50**	**71.23±5.74**	**49.30±7.08**	**51.90±13.29**
Location mean	Spring	182.90±2.970	81.15±5.445	58.50±3.536	58.35±16.48
	Summer	178.15±36.56	70.45±6.435	41.45±0.636	41±1.414
	Autumn	193.80±5.940	78.75±11.67	38.10±16.83	48.50±26.160
	Grand mean	**184.95±8.024**	**76.78±5.615**	**46.02±10.940**	**49.28±8.701**
F	Location	149.433	102.55	40.675	29.380
	Season	27.924	34.983	150.523	108.297
	Location x Season	74.975	6.204	72.772	327.849
CV%		**3.67**	**5.53**	**8.67**	**7.59**
CD%	Location	6.877***	4.299***	4.038***	3.787***
	Season	8.422***	5.265***	4.946***	4.638***
	Location x Season	11.911***	5.464**	6.994***	6.559***

*** = significant at 5% level, ** = significant at 1% at level, ***= significant at 0.1% level of probability, NS= Non significant.**

Table 52 : Altitudinal variation of mean foliar nutrient content in *Persea bombycina* between North Lakhimpur and Mokokchung (Mean + SE)

Content (%)	**North Lakhimpur**	**Mokokchung**
Moisture	68.89+ 0.74	60.47+ 0.49
Total carbohydrate	11.78+ 0.84	17.36+ 0.24
Total soluble sugar	4.36+ 0.66	4.50+ 0.13
Total reducing sugar	2.35+ 0.77	2.39+ 0.06
Crude fibre	13.95+ 0.85	7.05+ 0.83
Total nitrogen	3.63+ 0.43	2.82+ 0.11
Crude protein	22.65+ 0.57	17.63+ 0.71
Total ash	4.33+ 0.54	7.17+ 0.11

Table 53: Altitudinal variation on cocoon parameters of *Antheraea assama* (Cultivated) (between North Lakhimpur (NLP) and Mokokchung (MKG) (* = significant at 5% level, ** = significant at 1% at *level, *= significant at 0.1% level of probability, NS= Non significant.***

Location	**Sex**	**Season**	**Parameters** (Mean ± SE)			
			CocoonWt(gm)	**Pupal Wt (gm)**	**Shell Wt (gm)**	**SR %**
NLP	**Male**	Spring	4.24±0.063	3.86±0.055	0.38±0.077	8.93±1.714
		Summer	3.66±0.262	3.30±0.234	0.36±0.072	9.69±1.736
		Autumn	3.55±0.187	3.27±0.227	0.28±0.084	7.91±2.427
		Mean	**3.82±0.371**	**3.48±0.332**	**0.34±0.053**	**8.84±0.893**
	Female	Spring	6.20±0.041	5.75±0.075	0.46±0.092	7.39±1.416
		Summer	5.22±0.556	4.71±0.401	0.51±0.403	9.35±6.542
		Autumn	5.09±0.260	4.84±0.266	0.25±0.077	4.94±1.502
		Mean	**5.50±0.607**	**5.10±0.567**	**0.41±0.138**	**7.23±2.210**
	Seasonal mean	Spring	5.22±1.386	4.81±1.336	0.42±0.057	8.16±1.089
		Summer	4.44±1.103	4.01±0.997	0.44±0.106	9.52±0.240
		Autumn	4.32±1.089	4.06±1.110	0.27±0.021	6.43±2.100
	Total mean		**4.66±1.188**	**4.29±0.446**	**0.38±0.093**	**8.04±1.549**
MKG	Male	Spring	4.85±0.147	4.33±0.099	0.53±0.137	10.87±2.539
		Summer	4.87±0.201	4.45±0.199	0.42±0.009	8.63±0.343
		Autumn	5.12±0.220	4.61±0.218	0.51±0.015	9.98±0.477
		Mean	**4.96±0.179**	**4.46±0.140**	**0.49±0.059**	**9.83±1.128**
	Female	Spring	5.98±0.146	5.27±0.148	0.71±0.058	11.92±0.970
		Summer	5.80±0.230	5.25±0.235	0.55±0.015	9.49±0.563
		Autumn	6.19±0.348	5.50±0.342	0.69±0.018	11.11±0.589
		Mean	**5.99±0.195**	**5.34±0.139**	**0.65±0.087**	**10.85±1.237**
	Seasonal mean	Spring	5.42±0.799	4.80±0.665	0.62±0.127	11.40±0.742
		Summer	5.34±0.658	4.85±0.566	0.49±0.092	9.06±0.608
		Autumn	5.66±0.757	5.06±0.629	0.60±0.127	10.55±0.799
	Total mean		**5.47±0.167**	**4.90±0.138**	**0.57±0.070**	**10.33±1.184**
Average of location	Male	Spring	4.55±0.431	4.10±0.332	0.46±0.106	9.90±1.372
		Summer	4.27±0.856	3.88±0.813	0.39±0.042	9.16±0.750
		Autumn	4.34±1.110	3.94±0.948	0.40±0.163	8.95±1.464
		Mean	**4.39±0.146**	**3.97±0.114**	**0.42±0.038**	**9.34±0.499**
	Female	Spring	6.09±0.156	5.51±0.339	0.59±0.177	9.66±3.203
		Summer	5.51±0.410	4.98±0.382	0.53±0.028	9.42±0.099
		Autumn	5.64±0.778	5.17±0.467	0.47±0.311	8.03±4.363
		Mean	**5.75±0.304**	**5.22±0.269**	**0.53±0.060**	**9.04±0.880**
Total average for season		Spring	5.32±1.089	4.81±0.997	0.53±0.092	9.78±0.170
		Summer	4.89±0.877	4.43±0.778	0.46±0.099	9.29±0.184
		Autumn	4.99±0.919	4.56±0.870	0.44±0.049	8.49±0.651
Grand Mean			**5.07±0.225**	**4.60±0.193**	**0.48±0.047**	**9.19±0.651**
F	Season		76.194**	54.925***	29.385***	14.759***
	Location		738.013***	440.792***	418.983***	127.538***
	Sex		2085.751***	1809.063***	148.983***	1.167NS
	Season x Location		123.861***	114.425***	72.473***	56.221***
	Season x Sex		9.608***	9.564***	4.802**	4.068***
	Location x Sex		116.305***	158.828***	24.734***	40.606***
	Season x Location x Sex		3.329*	3.239*	12.150***	6.080**
CV%			**4.54**	**4.95**	**15.78**	**16.51**

Table 54 Altitudinal variation of yarn characteristics (Single cocoon) of *Antheraea assama* (cultivated) fed on Som between North Lakhimpur (NLP) and Mokokchung (MKG) (Mean $\pm$ SE)

Seasons	Location	Filament length (m)	Filament denier (d)	Raw silk recovery (%)
Season-I (Apr-Jun)	NLP	435.00± 10.85	5.50±0.14	50.23±1.51
	MKG	409.20±19.60	5.76±0.10	45.14±1.24
Season-II (Aug-Sep)	NLP	350.00± 3.87	5.00±0.16	46.00±0.77
	MKG	303.20± 4.39	6.15±0.17	38.37± 0.96
Season-III (Oct-Dec)	NLP	448.30± 14.92	5.00±0.12	48.01±1.20
	MKG	407.30± 9.13	5.63± 0.12	47.26± 0.83
Mean± SE	NLP	411.10±10.95	5.17±0.14	48.08±1.16
	MKG	373.24±10.95	5.85±0.13	43.59±1.01

Rearing of muga silk worm even on same host plant in different seasons and locations resulted in variability among different characters like ERR, cocoon weight, shell weight, silk filament length and shell ratio and indicated a promising future in terms of producing novel silk with high economic value for the region. The variability in qualitative and quantitative characters of the cocoon and silk content between both cultivated and wild population was dependent on the larval development which was largely influenced by host plants and abiotic factors (Chowdhury *et al.,* 2000). The superiority of the autumn cocoon crop to other seasonal crops, particularly in higher altitude might be due to prevalent lower average temperature, humidity and drier atmosphere (low rainfall) which facilitated increased spinning of cocoons (Dash *et al*., 1992). The lowest cocoon quality during the rainy season might be due to high temperatures, RH and rainfall. Yokoyama (1963) reported that *Bombyx mori* yielded superior quality cocoons at optimum temperatures (22-23^{o}C) and humidity (60-70%). Tanaka (1964) remarked that the rainy season was unsuitable for rearing of *B. mori* due to high RH and changing temperature. Krishnaswami *et al.* (1973) reported that temperature and RH exceeding 20-26^{o}C and 60-70% respectively affected cocoon quality of *B. mori*. They also remarked about poor silk content of rainy cocoon crop and superior silk content of autumn cocoon crop of *A. mylitta*. Jolly *et al.* (1974) observed that heavy rainfall disrupted spinning of *A. mylitta* resulting in inferior cocoons. Sarkar (1980) stated that sudden variation in temperature was harmful to rearing *Philosamia ricini* larvae. Sengupta (1986) observed better quality of cocoon production by *A. mylitta* during September- October (autumn). Ullal and Narasimhanna (1987) reported that high temperature followed by strong fluctuation resulted in poor quality cocoons of *B. mori*.

The food plant leaf quality in terms of nutrition influenced the health and growth of larvae, effective rate of rearing (ERR) and crop yields the correlation of which was observed with the weight of silk cocoon and cocoon shell and silk ratio (Dash *et al.,* 1992; Yadav and Mahobia, 2010) and could influence the crop economics (Muthukrishnan *et al.,* 1987; Reddy, 2011). The leaf nutrient status of food plant was fundamental not only for silk productivity, but also for its metamorphosis during life cycle and subsequent parental moth reproductive efficiency (Pattanayak and Dash, 2000; Rath *et al*., 2006).

An analysis of rearing performance of muga silk worm revealed that the salubrious climatic conditions in Mokokchung, Nagaland assured better production of the cocoons in three different seasons. While spring and autumn seasons were the best suited for commercial crop production, cocoons produced during summer season could be used for seed purpose in ensuing autumn crop. Further, the diapausing character of *A. assama* indicated its adaptability to severe winter at higher altitude and would provide enormous opportunities for rearing of wild variety which may be cross breed with cultivated one for hybrid vigour and production of disease resistant high yielding variety. One of the basic problems of muga culture in this state was the lack of quality seed for which the rearers had to depend on neighbouring state of Assam. Thus these rearing schedules and techniques adopted for different rearing seasons would be able to solve the problem of seed cocoons which can be further utilized during commercial crop within and outside of the state. Having shown the better performance in growth and development of different pre-imaginal stages, it is suggested that Mokokchung may be considered as alternative eco-pocket for rearing of muga silk worm particularly during pre-seed and seed crop which are most important for any successful commercial crop. Nagaland has vast tract of vacant land, abandoned after Jhoom (slash and burn) cultivation which can be brought under systematic plantation of muga food plants. To boost the muga culture in Nagaland, cluster plantation of Som trees on a large scale should be promoted by the state government on degraded area to take up muga silk moth farming to ensure increased production of silk cocoons. While taking up silk worm rearing on commercial basis, various activities of the production process could be clustered together in traditionally sericulture-rich pockets which would provide new opportunities in silk production for thousands of families. However training and skill up gradation should be imparted to rural farmers particularly women and younger generation for pre and post cocoon technology. With the research based transfer of technology and effective extension programme, the state could be a prospective seed cocoon zone in all three seasons by producing healthy and vigorous seed cocoons which may be used during succeeding commercial crops in Assam.

Present status of muga culture in Nagaland

Problems and prospects: While eri culture has been practiced since time immemorial by different tribes and sub tribes in both the plains and the hills of Nagaland, muga culture is comparatively new to the state having only two muga farms, one nursery, two seed grainages and one training cum demonstration centre. The state has brought 410 hectares of private land under plantation of two primary host plants *Persea bombycina* (Som) and *Litsea polyantha* (Soalu) involving 515 nos. of family and produced only 95 lakhs of reeling cocoon (2 MT of raw silk) by using 2 lakhs of disease free layings during 2011-2012 (Source: Department of Sericulture, Govt. of Nagaland). It is felt that transfer of technology, based upon proper coordination between traditional working efficiency and modern working technique is not yet reach to grass root level.

The basic problems and constrains that hinder the speedy progress are absence of systematic plantation for steady supply of leaves; lack of well defined seed organization for adequate production and supply of seed; unorganized cocoon and yarn market; lack of appropriate rearing/grainage house; lack of knowledge of farmers on modern rearing technology and product diversification; occurrence of disease; weak extension support and inadequate research support. However there are tremendous prospects for all round improvement of muga culture through formulating certain farmer friendly strategies which can be easily adopted by user groups. Nagaland has vast tract of vacant land abandoned after Jhoom cultivation which can be brought under systematic plantation of muga food plants. During the gestation period of host plants for silk worm rearing the concept intercropping with seasonal vegetables and other leguminous plants should be stressed upon to generate additional income from the land as well keeping a balance in nutrient content of the soil. Infrastructural facilities and technical know how can be dissipated to the farmers to encourage them to take up muga culture on commercial basis. Muga based ecological farming system can be mooted for ecological restoration and sustainable economic development particularly in rural area. Further, establishment of grainage center for steady production and supply of seed to rearers and imparting training for skill up gradation for rural farmers particularly women for product diversifion would develop muga silk industry in the state.

SWOT analysis: The strength and weakness of the muga silk industry are analysed on the basis of internal factors while opportunities and threats are analysed considering the external factors (Kakati, 2006). Certain aspects like sustainability, economic impact, market attractiveness, competitiveness, community support and interest, entrepreneurship, business capacity, labour capacity, availability of resources (man power, raw material) implementations, investment, impact on environment, transport and communication are considered as important factors for success of muga culture in the state. While the state has ample scope for large scale farming through host plant raising and silk worm rearing with eco friendly nature of production process, the industry itself can create a great market demand within and outside of the state. Further all the labour intensive activities can be timely completed by suitably engaging small marginal farmers especially women, children and old aged people. However certain factors like inadequate infrastructure, poor technology transfer, lack of proper marketing system, inadequate emphasis on quality commercial seed sector and lack of package of practice for high productivity are attributed as weakness of the industry. The industry would provide vast opportunity by uplifting the living condition of rural people through rural employment. It is revealed that uncertain crop output due to fluctuation of climatic condition and lack of production of quality seeds are identified as great threat to the industry.

Socioeconomic perspective and employment generation: Being agro based industry; muga culture can be an alternative viable for upliftment of socioeconomic condition of the rural tribal for sustainable economic growth. It provides more employment opportunity within very short gestation period with less capital investment both on farm and off farm activities. It is estimated that the industry results in employment rate of 13 persons/ha/year out of which 60% to women because of nature of works involved such as rearing of silk worms, spinning and reeling of silk yarn and weaving which can be done by women and young child staying at village during day time when men folk are out for different activities. The higher proportion of women participation is a natural and self regulated phenomenon in sericulture. Considering the high potentiality of muga culture to provide year round employment and to alleviate the poverty of farmers of rural areas, especially that of women, effort should be taken introduce muga culture as a subsidiary farm enterprise under the concept of integrated farming system.

To augment the muga culture in the state, Govt of India has launched certain ambitious projects like United Nation Development Programme (UNDP) and Catalytic Development Programme (CDP). Success of these projects lies in establishment of backward and forward linkages at each level, so that the production process continues unhindered till the end product is marketed (Teotia *et al.,* 2000). This has led to formation of self sustainable production in muga culture to provide a sustainable income to the marginal farmers and weaker section of the society. It has immense potential for rural development, income generation, poverty alleviation and employment generation. These projects empower the tribal and women to take up independent and self-sustaining economic activities.

CHAPTER VI

SUMMARY

Sustainability of muga silk industry, which is prerogative of North Eastern Region, particularly the Brahmaputra valley of Assam, has been facing serious threat in recent years due to global warming and various anthropogenic reasons. The traditional commercial muga growers of Assam generally visit foot hills as well as higher altitudinal areas of neighbouring hill states to collect wild, healthy seed cocoon for conducting commercial crop which emphasize that altitudinal effect, climatic variation and host plant preference play a great role in muga cocoon production. In this context, rearing schedule and technology of muga crops has to be standardized to suitably adjust the local conditions particularly in high altitude so that the crucial gap between production of seed cocoons and their requirement for each commercial crop is minimized. Hence a systematic study of rearing has been undertaken on three host plants (*Persea bombycina*, *Litsea polyantha* and *Litsea citrata*) in two locations at North Lakhimpur, Assam (low altitude) and Mokokchung, Nagaland (High altitude) for two consecutive years to have comparative analysis of altitudinal effect and host plant preference on growth and production of *A. assama* Ww.

The experimental sites selected for present study was located in Ungma of Mokokchung (Mokokchung district) in Nagaland at higher altitude (1325m amsl) and Japisajia of North Lakhimpur (Lakhimpur district) in Assam at lower altitude 135m amsl). Rearing of *Antheraea assama* Westwood was conducted simultaneously in three different seasons i.e. spring (April-June), summer (July-September) and autumn (October-December) on three host plants namely *Persea* *bombycina* Kost (Som), *Litsea polyantha* Juss (Soalu) and *Litsea citrata* Blume (Mejankari). *Persea bombycina* (Som) was common to both places, whereas *Litsea polyantha* (Soalu), the another primary host plant was utilized in lower altitude and *Litsea citrata* (Mejankari), the important secondary host plant which grows abundantly in Nagaland was used in higher altitude.

Nagaland is largely a mountainous state rising from the Brahmaputra Valley in Assam to about 2,000 feet (610 m) and rise further to the southeast, as high as 6,000 feet (1,800 m). The hilly terrain of Nagaland with the forest cover of about 52% is instrumental in shaping the cool and pleasant climatic conditions. Nagaland may be divided in to four distinct seasons. The four distinct seasons prevailing in Nagaland are cold (winter), hot (pre-monsoon), rainy (monsoon) and cool dry season (retreating monsoon). Mokokchung district which lies at $26^{o}17^{'}$-$26^{o}39^{'}$ N latitude and $94^{o}18^{'}$-$94^{o}37^{'}$ E longitude covers an area of 1615 Km^{2} and has an altitude of 1325 m above mean sea level. The location of Assam within the rain shadow zone lies between 26°30' N and 29°30' N latitude and between 91°30' E and 97°30' E longitude at an average altitude of 135 m above mean sea level. Persistent high humidity and moderate temperature throughout the year, extensive water bodies, local depressions, elevations and extensive forests play important role for shaping veritable climatic conditions of Assam**.** Climate wise the year in Assam can be divided broadly into the wet (March to September) and cool dry season (October to February) period. Lakhimpur district is located in north-east corner of Assam at 26°48'-27°53' N latitude and 93°42'-94°20' E longitude covering 2953 Km^2 at an altitude of 135m amsl.

While variation in mean maximum temperature was not much evident, mean minimum temperature was considerably variable during different rearing seasons between Mokokchung and North Lakhimpur. The range of maximum and minimum temperature in all seasons was higher in Mokokchung than North Lakhimpur indicating colder climatic regime on the former. Persistent high humidity in North Lakhimpur than Mokokchung was mostly influenced by high rainfall and moderately high temperature throughout the year. Both locations in lower and higher altitude represent an ideal sub-tropical climate, however, Lakhimpur district of Assam exhibits certain self regulating mechanisms of occasional winter rain and summer drought while Mokokchung district witnesses prolong winter. The mean annual rainfall for last 20 years in Mokokchung was lower than North Lakhimpur

Persea bombycina Kost (Som) and *Litsea polyantha* Juss (Soalu) are the primary food plant of muga silk worm mostly used for production of commercial and seed cocoons in upper and lower Assam. Sixteen ecotypes of Som and ten ecotypes of Soalu are described. The cocoons produced in Som and Soalu are golden brown in colour. *Litsea citrata* (Mejankari) is the most important secondary host plant whose distribution in plains of Assam is very sparse but grown naturally in Mokokchung, wokha and Tuensang district of Nagaland. Muga silk worm fed on *Litsea citrata* produces a kind of silk known as Mejankari silk which is admired for its durability, luster and creamy white shade.

Analysis of physico-chemical characteristics of soil in different seasons between North Lakhimpur and Mokokchung (moisture Content % = spring : 15.03±0.68 and 27.79±1.01, summer: 37.83±4.02 and 31.36±0.78, autumn:17.83±2.32 and 18.05±0.58; soil pH = spring: 5.61±0.11 and 5.15±0.10, 5.35±0.06 and 5.14±0.14, autumn:4.91±0.09 and 4.90±0.09; organic carbon % = spring season:1.18±0.13 and 1.70±0.19, summer:1.04±0.09 and 1.68±0.14, autumn:0.87±0.02 and 1.52±0.05; total nitrogen kg/ha= spring:501.76±76.02 and 456.55±49.52 kg/ha, summer: 522.14±27.89 and 515.21±23.14 kg/ha, autumn: 397.23±11.84 and 399.00±11.90 kg/ha; available phosphorus (kg/ha)= spring:37.61±0.81 kg/ha, summer:25.00±1.66 kg/ha, autumn season (31.72±0.40 kg/ha); available potassium kg/ha=spring: 238.11±1.84 and 343.40±2.66 kg/ha; summer: 229.55±5.32 and 373.50±8.65 kg/ha; autumn: 217.61±8.83 and 372.50±15.11 kg/ha) reveal that the soil quality in both sites are suitable for growth of muga silkworm food plants with balanced amount of these nutrients. Total nitrogen and phosphorus decreased with the increase in altitude, while organic carbon and potassium exhibited an opposite trend which might be due to various factors such as temperature, rainfall, altitudinal aspect, vegetation cover, land use etc.

In North Lakhimpur, Assam (Low altitude), highly significant variation in nutrient content among different leaf types of two primary food plants i.e. *Persea bombycina* (Som) and *Litsea polyantha* (Soalu) have been observed exhibiting a trend of tender>medium>mature in moisture, nitrogen, crude protein content, while the reverse trend i.e. mature>medium>tender was seen in crude fibre, carbohydrate and total ash. However no definite trend was seen in soluble and reducing sugar in both host plants. In Som, all the foliar contents were found to be maximum during summer season followed by autumn and spring, however in Soalu, different trend was observed i.e. spring>autumn>summer in case of nitrogen, crude protein, crude fibre, carbohydrate, reducing sugar; summer>autumn>spring in moisture; autumn>spring>summer in soluble sugar and autumn>summer>spring in total ash. The annual mean (percentage) of all foliar constituents were found to be higher in Som than Soalu i.e. moisture (68.89± 0.74 and 64.84± 1.29) , nitrogen (3.63± 0.43and 3.10± 0.87), crude protein (22.65± 0.57 and 19.24± 0.66), crude fibre (13.95± 0.85 and 11.87± 1.21), carbohydrate (11.78± 0.84 and 9.01± 0.67), soluble sugar (4.36± 0.66 and 4.09± 0.66), reducing sugar (2.35± 0.77 and 2.12± 0.31) and total ash (4.33± 0.54 a4.13± 0.65) respectively. The results suggest both individual and combined effect of leaf types, seasons and host plants on the nutritive value of leaves which greatly influences the silk worm feeding from initial to maturation stage to produce healthier cocoons in different rearing seasons.

In Mokokchung, Nagaland (high altitude) seasonal variation of foliar constituents viz. moisture content, nitrogen, crude protein, crude fibre, carbohydrate, soluble and reducing sugar and total ash in different leaf types of primary (*Persea bombycina*) and secondary (*Litsea citrata*) food plants were found to be highly significant. Moisture content was recorded be minimum during spring and autumn season in Som than Mejankari, however the trend is found to be reverse in case of nitrogen, crude protein and crude fibre which are found to be less during summer in Som than Mejankari. Further percentage of carbohydrate, soluble sugar, reducing sugar and total ash are recorded to be maximum in all seasons in Som than Mejankari. While nitrogen, Crude protein, crude fibre, carbohydrate, soluble sugar and total ash were higher in Som during autumn, Mejankari retained higher percentage of these constituents during summer season except for carbohydrate which is maximum in spring season. The annual mean (percentage) of all foliar constituents were found to be higher in Som than Mejankari except for moisture content i.e. moisture (60.47± 0.49 and 64.45± 0.91) , nitrogen (2.82± 0.11 and 2.73± 0.07), crude protein (17.63± 0.71and 17.10± 0.44), crude fibre (7.05± 0.83and 6.98± 1.01), carbohydrate (17.36± 0.24 and 12.61± 0.42), soluble sugar (4.50± 0.13and 2.08± 0.28), reducing sugar (2.39± 0.06and 0.72± 0.03) and total ash (7.17± 0.11 and 4.97± 0.07) respectively. The comparative studies on seasonal variations between leaf type of both *P.bombycina* (Som) and *L.citrata* (Mejankari) revealed significant differences for moisture, total carbohydrate, soluble sugar, total nitrogen and crude protein whereas difference were insignificant for reducing sugar, crude fibre and total ash. The results suggest both individual and combined effect of leaf types, seasons and host plants on the nutritive value of leaves which greatly influences the silk worm feeding on different larval stages and highlight the importance of Mejankari at par with Som and Soalu host plant on rearing performance and cocoon production in different season.

Foliar constituents of *Persea bombycina* in both locations of lower and higher altitude, showed a declining trend in the moisture, nitrogen, and protein content from tender to mature leaves, however the reverse trend i.e. mature>medium>tender was found in respect of crude fibre, carbohydrate, reducing sugar and total ash in all seasons except for slightly higher amount of soluble sugar content in medium leaves highlighting significant altitudinal influence on the chemical composition in different maturity of leaves. Mean seasonal value of moisture, nitrogen, protein and crude fibre was more in lower altitude (North Lakhimpur) and carbohydrate, soluble and reducing sugar and total ash was more in higher altitude (Mokokchung) in respective seasons except for slight decrease of soluble and reducing sugar during summer season. The mean annual moisture content, nitrogen, crude protein and crude fibre in North Lakhimpur (68.89±0.74, 3.63± 0.43, 22.65± 0.57 and 13.95± 0.85 respectively) was recorded to be higher than Mokokchung (60.47±14.65, 2.82± 0.11, 17.63± 0.71 and 7.05± 0.83 respectively); however a reverse trend having higher amount in Mokokchung than North Lakhimpur has been observed in case of carbohydrate

(17.36± 0.24 and 11.78± 0.84), soluble sugar (4.50± 0.13 and 4.36± 0.66) reducing sugar (2.39± 0.06 and 2.35± 0.77) and (7.17± 0.11and 4.33± 0.54) respectively. On average, foliage in higher altitude exhibited comparatively higher values for carbohydrate, soluble sugar, reducing sugar and total ash whereas, the foliages of lower altitude revealed higher value for moisture, total nitrogen, crude protein and crude fibre content. Based on the present findings, it is suggested that *Persea bombycina* located in higher altitude i.e. Mokokchung, the non traditional zone is nutritionally at par with the traditional zone of located in Lower altitude i.e. North Lakhimpur and suitable for muga silkworm rearing.

Although North Lakhimpur, Assam, the low altitudinal area is a traditional zone for muga culture, the present rearing and grainage of muga silk worm was conducted on *Persea bombycina* and *Litsea polyantha* in three seasons i.e. spring, summer and autumn only. Seasonal mean of larval length ranges from 1.12±0.12 to 1.22±0.08 cm (1st instar) to 9.53±0.26 to 10.25±0.06 cm (5th instar) in *P.bombicina* and *L.polyantha* respectively. The weight of in 5th instar larval was higher in Soalu (7.59±0.15 gm) than Som (6.88±0.83 gm). Length breadth and weight of female cocoons and pupa was higher than its male counterpart in both host plants and respective seasons. Further total mean cocoon and pupal parameters in Soalu was found to be better that that of Som. It takes 24.1±1.62 to 34.0±2.11 days to complete its larval period on *P.bombycina*, while on *L.polyantha* the duration is 23.0±1.54 to 33.0±2.19 days in indifferent seasons. The total mean production parameters viz. Fecundity, hatching percentage, ERR and cocoon:dfl in Som and Soalu are 195.67±9.71 and 188±10.00, 82.33±6.43 and81.00±5.57, 42.73±17.47and 48.20±17.05, 46.67±20.82 and 45.67±27.68 respectively. Shell ratio (8.04±1.55 and 7.46±1.33%), filament length (411.10±10.95 and 383.38± 9.97 m), filament denier (5.17 and 5.55) and raw silk recovery (48.08% and 44.67%) as recorded in *P.bombycina* and *Litsea polyantha* respectively did not show significant difference.

Muga silkworm rearing is comparatively new to Nagaland and generally conducted only on Som plants. The larvae also produce luster and creamy white shaded silk known as Mejankari silk while feeding on *Litsea citrata* Blume (Mejankari) the secondary host plants grown naturally in Mokokchung, Nagaland. A comparative rearing experiment on Som and Mejankari in a muga producing area of Mokokchung showed that seasonal mean of larval length ranges from 0.97±0.09 cm to 1.11±0.08 cm (1st instar) to 7.94±0.88 cm to 9.32±0.27 cm (5th instar) respectively in *L.citrata* and *P.bombycina*. While larval volume is found to be higher in Som than Mejankari, no significant different has been observed in larval weight between the two host plants. It takes 34.9±0.72 to37.4± 0.99 days to complete its larval period on *P.bombycina* while on *L.citrata* the duration is 39.7±0.73 to 45.2±1.61 days in indifferent seasons. The important economic characters viz. fecundity (nos.), hatching percentage, ERR (%) and cocoon:dfl ratio in *Litsea citrata* ranges from 171.50±9.63 to 198.33±8.64, 60.12±2.66 to 71.25±1.71, 40.77±1.02 to 57.37±1.26 and 53.0±1.89 to70.0±4.56 respectively in different seasons. The mean dimension of creamy white cocoon in *L.citrata* ranges from 6.50±0.48 to 8.10±0.56 with an average weight ranging from 4.61±0.38 to 5.24±0.76 in different seasons which are comparable with that of *P. Bombycina*. Shell ratio (8.26±1.057 % and 10.33±1.184%), filament length (329.09± 9.97 cm and 373.33±10.95 cm), filament denier (4.8 and 5.8) and raw silk recovery (42.6% and 43.58%) in *L. citrata* and *P. bombycina* respectively are at par with each other and the rearing potentiality is also quite encouraging on *L. citrata* which produces much stronger, thicker, glossy and durable cocoons. Thus it is highly essential to conserve natural plantation of *Litsea citrata* as well as to take up Mejankari silk farming along with Som in higher altitude to boost Mejankari silk production which can create a new horizon for the muga silk industry.

Rearing of Wild population of *Antheraea assama* in three different seasons on two host plants in Mokokchung, Nagaland exhibited strong seasonality and host plant effect on growth and development in different larval stages, cocoon and pupa. Each larval instar exhibited distinguishing colour variation and tubercular arrangement. The seasonal mean of larval length ranges from 0.94±0.07 - 1.07± 0.10 cm (1st instar) to 9.77±0.28 - 8.45±0.4 cm (5th instar) respectively in *Persea bombycina* and *Litsea citrata*. The volume (Length x Breadth) and weight of the larva during first instar was comparatively less in Som than Mejankari which was however getting reverse along with developmental stages and attained maximum volume and weight of 14.99 cm and 11.56 gm in Som and 11.35 cm and 10.74 gm in Mejankari respectively. Cocoons colour varied in host plants and seasons. Length breadth and weight of female cocoons and pupa was higher than its male counterpart in both host plants and respective seasons. While cocoon and pupal parameters in Som was found to be better that that of Mejankari, spring season was more favourable followed by autumn and summer season showing significant interaction effect due to host plants x seasons. The moths of wild variety which is larger in size and deeper in colour than cultivated variety have wing span of 142- 153 mm in male and 153 -172mm in female. It takes 28.2±0.91 to 37.2±1.00 days to complete its larval period on *P. bombycina* while on *L. citrata,* the duration is 33.4±0.78 to 45.2±0.94 days in different seasons. The important economic characters viz. fecundity (Nos.), hatching %, effective rate of rearing and cocoon:dfl ratio in *L. citrata* range from 199.10±9.63 to 200.20±8.64, 71.28±2.66 to 76.21±1.71, 28.35±1.02 to 58.87±1.26 and 39.90±1.89 to 87.40±4.56 respectively in different seasons. The golden to pinkish white and tough texture cocoons measure a length of 3.78±0.11 to 4.42±0.12 in male and 4.31±0.14 to 5.04±0.12 in female and a breadth of 1.44±0.04 to 1.56±0.06 in male and 1.64±0.06 to 1.68±0.07 in female when fed on the leaves of *L. citrata*. Shell ratio (%), filament length (cm), filament denier and raw silk recovery (%) of *L. citrata* fed cocoons are at par with that of *P. bombycina.*

Comparative rearing analysis of both cultivated and wild variety of muga silk worm on Som have shown strong seasonality in larval duration having the sequence of summer<spring<autumn season with 28.2±0.65 to 25.5±0.91, 34.9±0.72to 32.5± 1.04 and 37.4±0.99 to 37.5±1.0 days respectively and was correlated with the higher temperature and optimum humidity. While mean values for all production parameters have been recorded to be less in cultivated variety than the wild ones, both varieties exhibited seasonal fluctuation of all production parameters with a minimum record during summer. Maximum green cocoon weight (gm) for both cultivated and wild variety was recorded in female during autumn (6.19±0.37) and spring (8.27±0.17) season respectively. While total mean of shell weight, silk ratio and raw silk recovery did not show any significant difference, the filament length (373.33±10.95 and 309.28±22.47 m) and denier (5.8 and 4.7) respectively between cultivated and wild variety differed significantly.

Larval duration of cultivated and wild population on Mejankari also exhibited strong seasonality with temperature and humidity having the sequence of summer < spring< autumn season with 39.7±0.73 to 37.5±1.43, 33.4±0.66 to 30.5±0.78 and 45.2±1.61 to 42.5±0.94 days respectively. Total mean fecundity in wild population (199.60±0.56) was recorded to be higher than cultivated one (186.13±13.57).Average hatching percentage was found to be higher in wild (74.00± 2.49) than cultivated (66.97±6.01) variety having shown no definite seasonal trend in both populations. Mean effective rate of rearing (ERR) and cocoons per dfl was recorded higher in cultivated (47.87±8.570 and 59.00±9.539) than wild population (39.10±17.082 and57.57±25.982) except for spring season in wild variety showing higher value than cultivated ones. Total mean of green cocoon weight (gm) was higher in wild (5.76±0.88) than the cultivated one (5.47±0.17), with the record of maximum weight in female-wild (8.27±0.18) and minimum in male-cultivated (4.85±0.15) during spring season Shell weight and SR% was recorded to be maximum in female of cultivated population than the wild ones which had been found to be reversed in male cocoons. Filament length (m) and filament denier were found to be maximum in cultivated variety than wild one in all seasons; however there was apparently no difference in raw silk recovery (%) between the two populations in different seasons.

Rearing conducted on *Persea bombycina* Kost in two locations i.e. North Lakhimpur, Assam (low altitude-high temperature) and Mokokchung, Nagaland (high altitude-low temperature) simultaneously for three seasons has shown significant effect of altitudinal and climatic variation on morphometric characteristics during different development stages of muga silk worm. The significant differences in length, breadth and weight in larval stages from first to fifth instars in different seasons highlighted the effect of climatic variation between Lakhimpur and Mokokchung. While difference in length of 5th stage worms is not significant, the mean difference on breadth and weight is highly significant between the two sites. Morphometric parameters of female cocoon and pupa are higher than its male counterpart in respective seasons in both sites. The length, breadth and weight of cocoon and pupa is maximum during spring season with a decreasing trend through summer and autumn in lower altitude, however a seasonal fluctuation is observed in higher altitude exhibiting maximum during autumn. The volume and weight of cocoon and pupa during summer and autumn season in Mokokchung is higher than Lakhimpur and exhibits a strong interaction effect due to seasons, sites and sex. Total larval duration during summer and spring was significantly shorter in North Lakhimpur (21.2$\pm$1.37 and 24.1$\pm$1.62 days respectively) than Mokokchung (28.2$\pm$0.65 and 34.9$\pm$0.72 days respectively), however no significant difference was observed between lower (34.0$\pm$2.11) and higher (37.4$\pm$ 0.99) altitude during autumn season. Seasonal and mean pupal period was recorded to be shorter in North Lakhimpur than Mokokchung. Higher fecundity and hatching percentage in lower altitude and maximum ERR and cocoon production in higher altitude emphasized strong altitudinal effect on production parameters due to climatic variation in both places. Further season to season analysis on rearing and cocoon production between the two places highlighted the fact that rearing performance in higher altitude was comparatively better than lower altitude during summer and autumn season and also showed highly significant difference between locations, seasons and interaction effect due to location x season. Total mean of green cocoon weight (gm) was higher in Mokokchung (5.47$\pm$0.17) than North Lakhimpur (4.66$\pm$0.19), with the record of maximum weight in female (6.20$\pm$0.04) during spring and minimum in male (3.55$\pm$0.19) during autumn season in North Lakhimpur. Silk ratio (%) was recorded to be higher in Mokokchung than North Lakhimpur in both sexes in all seasons. While filament length and raw silk recovery was higher in North Lakhimpur (411.1$\pm$10.95 m and 48.08%) than Mokokchung (373.24$\pm$9.97 m and 43.59%), denier was recorded to be higher in Mokokchung (5.85) than North Lakhimpur (5.17).

Rearing of muga silk worm even on same host plant in different seasons and locations resulted in variability among different characters like ERR, cocoon weight, shell weight, silk filament length and shell ratio and indicated a promising future in terms of producing novel silk with high economic value for the region. While spring and autumn seasons were the best suited for commercial crop production, cocoons produced during summer season could be used for seed purpose in ensuing autumn crop. Further, the diapason character of *A. assama* indicated its adaptability to severe winter at higher altitudes and would provide enormous opportunities for rearing of wild variety which may be cross breed with cultivated one for hybrid vigor and production of disease resistant high yielding variety.

The congenial climatic condition in Nagaland state particularly during spring, summer and autumn seasons is highly suitable for muga culture which may have tremendous potentialities to emerge as important subsidiary crop next to agriculture for livelihood. However the knowledge of muga silk production is very poor among farmers due to lack of transfer of technology, which is yet to reach grass root level. In spite of having certain problems like weak research and extension support, inadequate infrastructure, processing and market facilities of seed and commercial cocoons, inadequate package of practice for plantation, rearing and grainage, adjustment to the climatic fluctuation etc., muga culture has high prospect in this state for large scale development due to its great market demand particularly for seed cocoons, availability of vast track of vacant land for plantation, employment opportunity to skilled and unskilled manpower etc. A critical SWOT analysis is made towards upliftment of muga silk industry that requires the complete package from egg production to finished cloth to assist muga farmers, revelers, weavers and traders to generate income from the sale of their respective raw materials. Having seen the socioeconomic perspective of muga silk industry towards contributing renewal interest among marginal farmers, women and unemployed youths, it is suggested that Mokokchung may be considered as an alternative eco-pocket for rearing of muga silk worm particularly during pre-seed and seed crops which are most important for any successful commercial crop.

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