

EFFECT OF PLANT EXTRACTS ON THE GROWTH AND DEVELOPMENT OF THE MULBERRY SILKWORM *BOMBYX MORI* L



A THESIS

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DEDICATED
TO
THE MEMORY OF MY LATE FATHER
AND
TO MY BELOVED MOTHER

DECLARATION

I hereby declare that the research work submitted as the thesis entitled "EFFECT OF PLANT EXTRACTS ON THE GROWTH AND DEVELOPMENT OF THE MULBERRY SILKWORM *BOMBYX MORI* L" in the Department of Zoology, University of Rajshahi for the degree of Doctor of Philosophy is the result of my own investigation and has not ever been submitted before in any form for any other degree at any place. I further declare that the whole of the work submitted for the degree of Doctor of Philosophy to the University of Rajshahi is based on my original investigation except when due reference is made in the text of the thesis.

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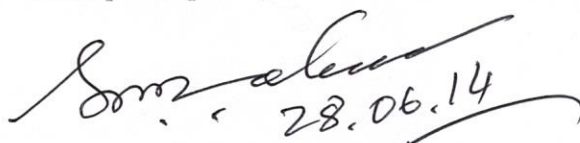
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CERTIFICATE

We do hereby certify that Hosna Ara Banu carried out the investigation on "EFFECT OF PLANT EXTRACTS ON THE GROWTH AND DEVELOPMENT OF THE MULBERRY SILKWORM *BOMBYX MORI* L" under our supervision. She fulfilled all the requirements and regulations relating to the nature and period of research. This thesis embodies the results of original investigation carried out in the Sericulture Research Laboratory of Zoology Department, Rajshahi University We forward this dissertation to be examined for the degree of Doctor of Philosophy.

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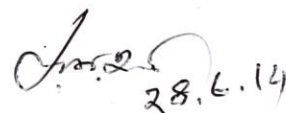
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-The Authoress-

Abstract

An attempt was initiated for the utilization of different plant materials as food supplement for the improvement of different economic traits of *Bombyx mori* L. For this purpose initially an experiment was conducted to screen out different parts of *Abroma augusta*, *Centella asiatica*, *Neolamarckia cadamba*, *Solanum tuberosum*, *Persicaria acuminata* and *Andrographis paniculata* plant with respect to their toxic effect on silkworm, *Bombyx mori* L. Relative toxicity by probit analysis for different parts of six plants extracts at different feeding schedules against silkworm larvae have been found out. Results on the mean mortality percentage of the larvae indicated that all the parts of *P. acuminata* and *A. paniculata* extracts showed toxic effect. With the increase of the dose of the extracts of the plant materials mortality of the larvae were increased. The LD₅₀ values for different parts extracts at different feeding schedules also implied that different parts of those plant extracts produced higher mortality so that fruitful results could not be achieved with the supplementation in the feeding of silkworm larvae.

On the other hand, results on the mean mortality percentage of the larvae indicated that all the parts of *A. augusta*, *C. asiatica*, *N. cadamba*, *S. tuberosum* plant extracts were not toxic. The LD₅₀ values also reported the same effect.

After screening, the effects of the supplementation of different parts, viz. leaf, stem, root extracts of *A. augusta*, *C. asiatica*, *N. cadamba*, *S. tuberosum* on growth and development of *B. mori* at different feeding schedules, viz. fed only in 1st feeding of 3rd to 5th instar larvae (FS-1), fed everyday in 1st feeding of 3rd to 5th instar larvae (FS-2), fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae (FS-3) were conducted.

Leaf extract of *A. augusta* increased the WML, LML, BML at different doses compare to control while fed in FS-1, FS-2 and FS-3. The highest and the lowest results for these parameters were observed at 500 ppm and control respectively.

Similar results were also recorded for stem and root extract. In case of FS-1, FS-2 and FS-3, leaf, stem and root extract slightly increased the PW at different doses, viz. at 100 ppm, 500 ppm, 1000 ppm, 1500 ppm in comparison to control.

Effects of different parts extracts of *A. augusta* on SP of *B. mori* at different feeding schedules were significant. In case of LD and PD, the results of leaf, stem and root extracts were significant at FS-1, FS-2 and FS-3. Leaf, stem and root extracts of *A. augusta* significantly increased the CW, SW, TEL and HP of *B. mori* at different feeding schedules. Generally the highest and the lowest results for these parameters were observed at 500 ppm and control respectively. Similar results were also recorded for stem and root extract.

The results of analysis of variance indicated that the items feeding schedules, plant parts and doses showed highly significant differences at 1% level of significance. The effectiveness of different plant parts on different characters under study followed the order stem > leaf > root and in respect of feeding schedule FS-2 > FS-3 > FS-1. The most effective dose of the plant extracts was found to be 500 ppm followed by 1000 ppm, 1500 ppm and 100 ppm. But in case of SP it was found to be 1000 ppm followed by 1500 ppm, 500 ppm and 100 ppm.

C. asiatica leaf extract increased the WML, LML, BML at different doses compare to control while fed in FS-1, FS-2 and FS-3. Similar results were also recorded for stem and root extracts. In case of FS-1, FS-2 and FS-3, leaf, stem and root extract also increased the PW at different doses, viz. at 100 ppm, 500 ppm, 1000 ppm, 1500 ppm in comparison to control.

Effects of different parts extracts of *C. asiatica* on SP of *B. mori* at different feeding schedules were significant. In case of LD and PD, the results of leaf, stem, root extracts of *C. asiatica* were significant at FS-1, FS-2 and FS-3, and the most effective dose of the plant extracts in this cases were 1000 ppm followed by 1500 ppm, 500 ppm and 100 ppm. Leaf, stem, root extracts of *C. asiatica*

significantly increased the CW, SW TEL and HP of *B. mori* at different feeding schedules, viz. FS-1, FS-2, FS-3.

In majority cases, the results of analysis of variance indicated that the items feeding schedules, plant parts and doses showed highly significant differences at 1% level of significance. The effective concentration of this plant extracts in respect of their efficacy as a food supplement with mulberry leaves for majority characters under study followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm. When pp was evaluated, the most effective PP was leaf followed by stem and root. For FS the efficacy followed the order FS-2 > FS-3 > FS-1.

Different parts, viz. leaf, stem and root extract of *N. cadamba* increased the WML, LML, BML at different doses compare to control while fed in FS-1, FS-2 and FS-3. In case of FS-1, FS-2 and FS-3, leaf, stem and root extract slightly increased the PW at different doses, viz. at 100 ppm, 500 ppm, 1000 ppm, 1500 ppm in comparison to control. The results of ANOVA indicated that only item plant parts revealed significant results ($P < 0.05$).

In case of SP, LD, PD, CW, SW, TEL and HP the results of leaf extracts of *N. cadamba* were significant at different feeding schedules, viz. FS-1, FS-2 and FS-3. Generally the highest and the lowest results for these parameters were observed at 500 ppm and control respectively. Similar results were also recorded for stem and root extract. The results of analysis of variance indicated that the majority items showed highly significant differences at 1% level of significance.

The efficacy of different plant parts on majority characters under study followed the order stem > leaf > root and for feeding schedule the effectiveness in this regard was FS-2 > FS-3 > FS-1. The most effective dose of the plant extracts in majority of the cases was 500 ppm followed by 1000 ppm, 1500 ppm and 100 ppm.

Leaf extract of *S. tuberosum* increased the WML, LML, BML at different doses compare to control while fed in FS-1, FS-2 and FS-3. The highest and the lowest

results for these parameters were observed at 500 ppm and control respectively. Similar results were also recorded for stem and root extract. In case of FS-1, FS-2 and FS-3, leaf, stem and root extract slightly increased the PW at different doses, viz. at 100 ppm, 500 ppm, 1000 ppm, 1500 ppm in comparison to control. Although the results of ANOVA revealed insignificant results for all the items.

Effects of different parts extracts of *S. tuberosum* on SP of *B. mori* at different feeding schedules were significant. For LD, PD, CW, SW, TEL and HP the results of leaf, stem, root extracts of this plant were also significant at FS-1, FS-2, FS-3. Generally the highest and the lowest results for these parameters were observed at 500 ppm and control respectively. Similar results were also recorded for stem and root extract.

The effective concentration of plant extracts in respect of their efficacy as a food supplement with mulberry leaves for larval growth, pupal growth, SP, cocoon characters, fecundity and fertility followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm but for developmental period the order were 1000 ppm > 1500 ppm > 500 ppm > 100 ppm. When pp was evaluated, the most effective PP was stem followed by root and leaf. For FS the efficacy followed the order FS-2 > FS-3 > FS-1.

Results on the effects of the supplementation of different parts of different plants extracts on *B. mori* at different feeding schedules clearly indicated that different plant parts supplementation play an important role on the growth and development of the mulberry silkworm, *B. mori*.

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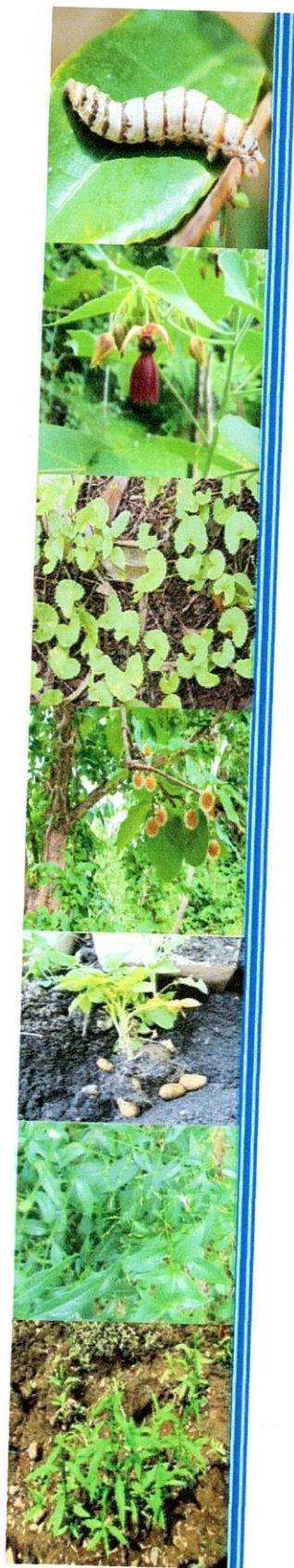
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ABBREVIATIONS USED

WML	= Wight of mature larvae
LML	= Length of mature larvae
BML	= Breadth of mature larvae
PW	= Pupal weight
LD	= Larval duration
PD	= Pupal duration
SP	= Surviving percentage
CW	= Cocoon weight
SW	= Shell weight
TEL	= Total number of eggs laid
EHP	= Egg hatching percentage
d	= Day
P	= Probability
SS	= Sum of squares
MS	= Mean sum of squares
F	= Variance ratio
df	= Degree of freedom
FS	= Feeding schedules
PP	= Plant parts
FS-1	= Fed only in 1 st feeding of 3 rd to 5 th instars larvae
FS-2	= Fed everyday in 1 st feeding of 3 rd to 5 th instars larvae
FS-3	= Fed everyday in 1 st and 3 rd feeding of 3 rd to 5 th instars larvae.
%	= Percentage
<	= Less then
>	= Getter then
B.	= <i>Bombyx</i>
DF	= Degree of freedom
P	= probability

SS	= Sum of square
MS	= Mean of square
F	= Variance ratio
i.e.	= That is
mm	= Millimeter
gm	= Gram
SE	= Standard Error
χ^2	= Chi- square
*	= Significant at 5% to level
**	= Significant at 1% level



CHAPTER-1

Introduction

1. Introduction

Mulberry silkworm, *Bombyx mori* L., the most important source of natural silk, is a bio-tool that converts mulberry leaf into a superb textile fibre. This conversion route from leaf to silk is achieved through silkworm rearing, which has now developed into a practical and well integrated basic science. *Bombyx mori* is a beneficial insect producing the supreme quality natural textile fibre. For the use of this fine natural filament, the wild silkworm was brought under domestication for centuries and it becomes completely domesticated.

The word sericulture is originated from the Greek word 'sericos' meaning 'silk' and the English word 'culture' meaning 'rearing'. The art and science at the back of natural silk manufacture is recognized as sericulture. In other words, sericulture denotes the commercial rearing of silk producing insects in large magnitude to acquire silk from them. The entire process is completed through different tiers of activity like host plant cultivation, silkworm rearing, spinning, reeling, weaving and finally the artistic work of dying and printing.

Silk generates unconstrained fervour and feelings of contentment among the textiles of all ages since its discovery. Silk being the most discriminating fabric, carry on its inimitable place hardly ever confronted any challenge by other textiles because of its natural attributes. The silk is rightly called as the "Queen of textiles" for its graceful lustier, suppleness combined with softness and resilience, delicacy, elasticity, crispness and the aesthetic appeal. These outstanding features create a centre of attraction of the consumers at the first sight. Silk has been woven into comfortable tapestries, blankets, carpets and other accessories. Silk items for consumptions give the impression of material comfort that no other textiles can be analogous with it. In recent years, the popularity of artificial fabrics in the fashion craze amplified to a large extent, nonetheless, nature's reward "the silk" bestowed to make a glamorous human civilization continues to hold top rank in the world of textiles.

As the foundation of sericulture, the silkworm has meant economic survival for farmers and workers in the textile industry. Silk and the trade of silk have enriched human endeavour through art and culture, contributing to an early form of globalization for nearly 2000 years during the Silk Road Era (Kurin, 2002). The main objective of silkworm rearing is the progressive improvement of economic traits to produce quantity and quality silk. Beginning in the nineteenth century, the silkworm became a model for scientific discovery in microbiology, physiology, and genetics at a period when enormous conceptual changes took place in our understanding of biology (Willis, Wilkins, Goldsmith., 1995). Today the silkworm plays roles in three major areas: basic research, sericulture, and biotechnology.

Sericulture is an age-old land-based rural industry with high employment potential and economic benefits to agrarian families, which is highly suitable to the socio-economic condition of underdeveloped countries where unemployment and underemployment persist to be a unresolved problem. Importance of the silk industry in the economy of Bangladesh can be observed in the light of its rural employment perspectives, establishment of cottage industries in the remote villages and distribution wealth to the downward stream as well as development of the neglected area. The nature of work in all the stages of sericulture is very light in nature. Thus the woman folk in rural area can participate not only in rearing but also in reeling, spinning, weaving, printing, finishing and processing of silk fibres. It is estimated that about 60 percentages of activities in sericulture industry could be carried out by women (Datta and Kumar, 1988). Sericulture provides great opportunities for human resource development, which can effectively check migration of people to urban area. Under this context, sericulture has emerged as an economically viable agrarian industry in Bangladesh. Reports have tended to convey the impression that environmental conditions of Bangladesh offer ideal situations for the development of sericulture (Anonymous, 1994). A more realistic analysis would be that Bangladesh could offer a wide range of areas, which can support the production of quality silk that will satisfy domestic demand. Various researches have been undertaken to develop the sericulture for better production of silk.

1.1 Silk and the silkworm

Silk is a natural protein fibre of animal origin produced by many insects, principally in the form of cocoon or covering within which creatures are enclosed during the period of their principal transformation in metamorphosis. These cocoons provide shelter and protection to silkworm during their inactive and the most critical pupal stage. After 20-25 days of feeding silkworm larvae attain maturity and begin to eject the silk fluid from the two glands through a spinneret at its mouth. The glands occupy between 4th to 8th segments of the body and are the second largest organs of the body, which occupy 40% of its body weight and volume. The silk fluid thrown by the ripe silkworm larvae coming in contact with air solidifies into a fine silk filament. In case of *Bombyx mori*, larva spins cocoons moving their head in the shape of figure of eight '8' from exterior to the interior. In order to complete whole structure of the cocoon the worms need to rotate around 60,000 to 3,00,000 times inside the cocoon depending upon the size of the larva.

The silk fibre is composed of two proteins, explicitly, sericin (20%) and fibroin (80%). The sericin is a sticky and paste like substance which encircle core of the filament, i.e. fibroin coming out from two silk glands. These proteins are synthesized by the silkworm from mulberry leaves in two silk glands which spread along the body on either side of the silkworm. By cooking in warm water sericin component dissolve and thus facilitates separation of the silk fibre during the process of reeling. The quality of silk is also dependent on the quantity of sericin. This could not be fully washed out during cooking. Fibroin is the core of the filament and is stretchable.

The individual polypeptide chains of fibroin are unstable and frequently assume a helical configuration or aggregate side by side to form a sheet-like structure. The

Table 1. Different kinds of silk and silk producing organism

Type of silk	Scientific name of silk producing organism	Name of major host food plants		
		Scientific name	Common name	English name
I. Mulberry silkworm	<i>Bombyx mn ori</i> L <i>Bombyx mandarina</i> <i>Theophila religiosae</i>	<i>Morus indica</i> <i>Morus alba</i> <i>Morus serrata</i> <i>Morus nigra</i>	Tut	Mulberry
II. Non mulberry silkworm				
1. Eri, endi or errandi silkworm	<i>Philosamia cynthia</i> <i>Semia Cynthia ricini</i>	<i>Ricinus communis</i>	Varenda	Castor
		<i>Heteropanax fragrans</i>	Kesseru	Kesseru
		<i>Manihot utilissama</i>	Cassava	Tapioca or cassava
2. Tasar silkworm				
a. Indian tropical tasar	<i>Antheraea mylitta</i> Dury	<i>Terminalia arjuna</i>	Arjun	Arjun
		<i>Shorea robusta</i>	Sal	Sal
		<i>Terminalia tomentosa</i>	Asan	Asan
		<i>Zizyphus jujube</i>	Kul / Boro	Jujube
		<i>Terminalia catappa</i>	Katbadam	Almound
		<i>Terminalia chebula</i>	Haritaki	Myrobalan
b. Indian temperate tasar	<i>Antheraea proylei</i>	<i>Quercus serrata</i>	Uyung	Oak
		<i>Quercus incana</i>	Banj	Oak
		<i>Quercus dealbata</i>	Sahi	Oak
		<i>Quercus himalayana</i>	Moru	Oak
c. Chinese tasar	<i>Antheraea pernyi</i>	<i>Quercus</i> sp.		Oak
d. Japanese tasar	<i>Antheraea yamamai</i>	<i>Quercus</i> sp.		Oak
3. Muga silkworm	<i>Antheraea assamensis</i>	<i>Machilus bombycina</i> <i>Litsaea polyantha</i> <i>Litsaea citrate</i>	Som Soalu Mezankari	
4. Anaphe silk	<i>Anaphe ventra</i>	<i>Triplochiton scleroxylon</i>		
5. Gonometa silkworm	<i>Gonometa</i>	<i>Acacia torilis</i>		
6. Fragra silk	<i>Attacus atlas</i>			
7. Coan silkworm	<i>Pachypasa otus</i> <i>Pachypasa lineosa</i>			Pine, juniper and oak
8. Mussel silk	<i>Pinna squamosa</i>			
9. Spider silk	<i>Nephila madagascarensis</i> <i>Miranda aurentia</i> <i>Eperia</i> sp.			

determinative factor which leads to the formation of either of the forms deepens on carboxyl (C=O) and amino (N-H) groups that flank the peptide bond. Fibroin polypeptide chains make hydrogen bonds between lateral extensions and ultimately form a pleated structure, called beta-sheets. The beta-sheets are specially favoured by the presence of a large number of glycine residues.

In addition to mulberry silkworm, *Bombyx mori* L., a number of other organisms produce silk which are known as non-mulberry silk. Nearly 400-500 species are known to produce silk but only very few are commercially viable. Mulberry silkworm is completely domesticated whereas non-mulberry silkworm is mostly wild type or forest variety or semi domesticated. Further, the non-mulberry variety of silk is classified as insect and non-insect type. Insect type of silk is obtained from six different types of insects and the silk is named as: (i) Eri silk (ii) Tasar silk (iii) Muga silk (iv) Anaphe silk (v) Fagara silk and (vi) Coan silk. Both the mulberry and non-mulberry silk producing insects set up a protective covering to entomb themselves in the cocoon. The non-insect type silk are produced by mussels for anchorage to fix them on some objects and Spiders to catch up their prey. The name different kinds of silk and silk producing organism along with the name of their host plants have been included in the Table 1.

The majority of silk producing insect belong to the Order-Lepidoptera, Superfamily-Bombycoide and Families-Bombycidae and Saturniidae. Among these silk producing organisms mulberry silkworm, *Bombyx mori* is most important, which adds as much as 95% of world production, therefore, the term "silk" generally refers to mulberry silk (Krishnaswami, *et al.* 1973; Ganga and Chetty, 1999).

1.2 History of sericulture

The origin of sericulture, silk production and weaving is ancient and clouded with legend. It was first discovered in China as long as 2640 B.C. by Xi Ling shi, wife of the then Emperor, Huang Ti (Copper, 1964). It is supposed that one day 14 year old queen was getting pleasure from a tea ceremony in her palace garden with her

friends and maids under mulberry trees. All of a sudden a golden coloured cocoon dropped in her tea cup. When she attempted to take away the cocoon from the tea cup, an end of the filament came out of the cocoon and it was a continuous and non-stop one. Then she collected some more cocoons, took them to her palace, preserved them till emergence and reared in the next generation and later discovered the method of reeling (Sarkar, 1958). For centuries the techniques of silkworm rearing and fabrication of silk products were jealously guarded by the Chinese (Krishnaswami *et al.*, 1973). In China, the birthplace of silk and the silk-weaving art, the silk fibre was so treasured that it became a measure of currency and reward.

From China, the technology and art of silk production had spread first to Korea through Chinese immigrants in about 1200 B.C. (Krishnaswami *et al.*, 1973). Afterwards it spread to Japan, when Semiramus, the Japanese General occupied Korea and took as slaves and prisoners-of-war farmers and artisans of this trade. The industry is said to have spread to Tibet when a Chinese Princess married the king of Khotan in Tibet, carrying silkworm eggs and mulberry tree seeds in her headdress. From Tibet the industry spread slowly to India and Persia. Sericulture in the Indian sub-continent is as old as its ancient culture, but the precise origin is not clear. According to the Western historian, silk industry was brought to India from China through the famous "Silk Road" via Tibet in 140 B.C.

1.2.1 History of sericulture in Bangladesh

Bangladesh sericulture has a long-established glory. It shares the same tradition of sericulture heritage with the undivided Bengal of the pre-independence day. The silk industry flourished in our territory in the beginning of the seventeenth century. During the regime of Emperor Kanisk, there was flourishing trade of Bengal silk with Rome and Greece. The then Bengal was acknowledged as the "store house of silk" (Sarkar, 1958). During that time a quantum of 250 metric tonnes of silk yarn was exported from undivided Bengal to various parts of Mughal Empire, to the neighbouring countries and to Europe. During the middle of the 18th century

varieties of silk cloths and raw silk were exported to Europe and to the markets of Western Asia including Basra, Mecca, Jeddah and Malacca.

Silk industry in Bangladesh suffered following the partition of India in 1947. After the partition the then East Pakistan (Bangladesh after 1971) received only two ill equipped sericulture nurseries. One of them was located at Bogra and the other at Mirgonj (Rajshahi). Some traditional silk growing areas of Bholahat and Shibgonj were also fallen in this part. Most of the expert growers involved with sericulture migrated to Indian part. At that time, the industry was at the verge of extinction. Records showed that only a little more than 100 lbs of raw silk was produced from a few villages in Rajshahi District. From 1947 to June, 1961 the Directorate of Industry looked after sericulture in the country. In July, 1961 sericulture project was transferred to the East Pakistan Small and Cottage Industries Corporation (EPSCIC after 1971 BSCIC) and some schemes were chalked out and put under implementation.

Under this new initiative in addition to the re-organization of two existing nurseries (Bogra and Mirganj), ten new nurseries, were set up at Bholahat, Chapai Nawabganj, Ishwardi, Rangpur, Dinajpur, Konabari, Mainamati, Khadimnagar (Sylhet), Bhatiari and Chondraghona. Twenty two extension centres, one silk factory and one sericulture research and training institute were also established. Before independence of Bangladesh and also within the First Five Year Plan (1973-1978) period of Bangladesh, sericulture could not show any substantial progress. At that time BSCIC was a very big Sector Corporation shouldering a number of developmental projects, therefore, BSCIC manage only routine work and does not take any initiative for the development of sericulture. This period was a critical phase of this industry when enthusiastic institutional endeavour was necessary to gear up the activities and to uphold the potentials of sericulture. The progress achieved from 1971-72 to 1977-78 is shown in Table 2.

Table 2. Progress achieved before establishment of Bangladesh Sericulture Board.

Item	1971-72	1975-76	1976-77	1977-78
Mulberry plantation (acre)	850	1124	995	1250
DFLs production (nos.)	649130	1369280	1039557	1160000
Cocoon production (kg)	136116	229292	246824	273223
Silk yarn production (kg)	8686	14330	15426	18003
Silk fabrics (m)	130302	214950	231390	270045

It was felt necessary to make the activities more efficiently of the sector; Bangladesh Sericulture Board (BSB) was established in 1978 under a presidential ordinance. BSB was assigned with some specific functions to render the welfare service to the persons engaged in sericulture and silk industry.

At the initial stage of BSB, Swiss-Bangladesh Bilateral Project in Sericulture played a key role for the expansion of sericulture throughout the country and intensifying the research activities. Meticulous efforts were made to improve the state of affairs supplemented by the ADP schemes of the Government of Bangladesh. Consequently, mulberry acreage increased considerably during 1978-81 from 1250 acres to 4100 acres, still then the motivation work in the extension area held-up due to some unavoidable reasons. Many of the farmers entering this occupation failed to keep up cultivation of mulberry. A number of them expressed their disinclination to continue in this field. For short of expertise in mulberry cultivation and silkworm rearing they could not grow mulberry and rear silkworm as looked-for. Thus achievements in this respect were much below the anticipation. Total production of raw silk rose from 14.52 tons in 1978-79 to 25.72 tons in 1980-81 (Anonymous, 1994). The highest raw silk production in the history of sericulture in Bangladesh was reported 58.45 metric tons during the year 1995-96 (Anonymous, 2003). In contrast to the world production Bangladesh shares only 0.06 per cent raw silk.

After that it suffered once more and the production of raw silk turned down. However, the employment opening in this sector rose from 35000 in 1979-80 to 600000 in 2001-2002 (Anonymous, 2005). In the year 2013 Bangladesh Sericulture Board was further renamed and restructured once again under the name Bangladesh Sericulture Development Board (Act No. 13, 7 March 2013).

Bangladesh Sericulture Research and Training Institute (BSRTI) is the only national institute for research and training in the field of sericulture. This institute was established on 3rd January, 1962 comprising of two units- silk cum lac institute and silk technological institute under the then East Pakistan Small and Cottage Industries Corporation. In 1974 the two units were combined together and named as Silk Research and Training Institute. After some times, the Presidential Ordinance no. of L12 of 1977 was published in an extra ordinary gazette on the 30th December with the order that the head office of Bangladesh Sericulture Board will be at the ancient silk producing city Rajshahi. The board started functioning from 1st of February, 1978. In this time sericulture research and training institute was brought under the control of BSB as a technical component and named as Bangladesh Sericulture Research and Training Institute (BSRTI) in 1980. But in the 2003, government separated BSRTI from BSB and established as an independent institute through the Act no. 25. Again in 7 March 2013 (Act No. 13) again BSRTI is under the administrative control of BSDB.

1.3 Global scenario of silk production

The mulberry silkworm, *Bombyx mori* has been domesticated for silk production for 5,000 years and provides the major source of income for 30 million families. Among all the continents, Asia is the main manufacturer of mulberry silk in the world and produces over 98 % of the total output. Despite the fact that about 50 countries are engaged in silk, ranging from a very small producers like France (400 kg of raw silk/annum) to the largest producer like China yielding 126000 tones which is 83.00% of total world raw silk production. India is the second largest silk producing country yielding 16.00% of total raw silk production of the world. The major

producers in the order are - China, India, Uzbekistan, Brazil, Vietnam, North Korea, Iran and Japan (Table 3).

Table 3. World mulberry raw silk production in metric tonnes]

Country	2008	2009	2010	2011	2012
China	98620	84000	115000	104000	126000
India	18370	19690	21005	23060	23679
Uzbekistan	770.5	780	940	940	940
Thailand	1100	665	655	655	655
Brazil	1177	811	770	558	614
Vietnam			550	500	450
North Korea				300	300
Iran	180	82	75	120	123
Japan	96	72	54	42	30
Turkey	15	20	18	22	22
Indonesia	37	19	20	20	20
Madagascar	15	16	16	16	18
Bulgaria	7.5	6.3	9.4	6	8.5
Tunisia	0.08	0.04	0.12	3	3.95
South Korea	3	3	3	3	1.5
Philippines	1	1	1	1	0.89
Egypt	3	3	0.3	0.7	0.7
Colombia	0.6	0.6	0.6	0.6	0.6
Syria	0.4	0.6	0.6	0.5	0.5
Total	120396	106169	139118	129684	152868

[ISC web-site update as on January, 2013]

Since the silk industry is highly labour intensive, therefore, production cost of silk is becoming very high in the industrialized countries. As a result of which the industrialised countries like France, Italy, Spain, and even Japan etc., are almost giving up the sericulture.

1.4 Back ground information on the host and test plants

1.4.1 Host plant

The Mulberry plant: The systematic cultivation of mulberry, the food plant of *Bombyx mori*, is the first step in the production of mulberry silk. Mulberry plant is considered as the most suitable food plant of *Bombyx mori*. Therefore, this is known as a monophagous insect. Mulberry plant fall under the genus *Morus* of family Moraceae. Several species of the genus are known to be important for the sericulture industry. In Bangladesh *M. indica* and *M. alba* species are commonly found. Presently most of the high yielding varieties under cultivation belong to the species *M. alba*. A brief description of this species are summerize below:

Mulberry plant, *Morus alba*, known as white mulberry, is a short-lived, fast-growing, small to medium sized mulberry tree, which grows to 10–20 m tall. The species is native to northern China, and is widely cultivated and naturalized elsewhere.^{[3][4]} It is known as Toot in Hindi, *Tuta* in Sanskrit, *Tuti* in Marathi and *Toot* in Persian and in Armenian, In Bengali, it is popularly known as “Tut gach”. The white mulberry is widely cultivated to feed the silkworms employed in the commercial production of silk. It is also notable for the rapid release of its pollen, which is launched at over half the speed of sound.

► Systemic position of *Morus alba*

Kingdom: Plantae

Division: Magnoliophyta

Class: Eudicots

Order: Rosales

Family: Moraceae

Genus: *Morus*

Species: *M. alba* L.



Plate 1: *M. alba* plant. L.

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► Description

On young, vigorous shoots, the leaves may be up to 30 cm long, and deeply and intricately lobed, with the lobes rounded. On older trees, the leaves are generally 5–15 cm long, unlobed, cordate at the base and rounded to acuminate at the tip, and serrated on the margins. The trees are generally deciduous in temperate regions, but trees grown in tropical regions can be evergreen. The flowers are single-sex catkins; male catkins are 2–3.5 cm long, and female catkins 1–2 cm long. Male and female flowers are usually on separate trees although they may occur on the same tree. The fruit is 1–2.5 cm long; in the species in the wild it is deep purple, but in many cultivated plants it varies from white to pink; it is sweet but bland, unlike the more intense flavor of the red mulberry and black mulberry. The seeds are widely dispersed by birds, which eat the fruit and excrete the seeds.

The white mulberry is scientifically notable for the rapid plant movement involved in pollen release from its catkins. The stamens act as catapults, releasing stored elastic energy in just 25 μ s. The resulting movement is approximately 350 miles per hour (560 km/h), over half the speed of sound, making it the fastest known movement in the plant kingdom.

► Medical uses

White mulberry leaves are the preferred feedstock for silkworms, and are also cut for food for livestock (cattle, goats, etc.) in areas where dry seasons restrict the availability of ground vegetation. The fruit are also eaten, often dried or made into wine.

In traditional Chinese medicine, the fruit is used to treat prematurely grey hair, to "tonify" the blood, and treat constipation and diabetes. The bark is used to treat cough, wheezing, edema, and to promote urination. It is also used to treat fever, headache, red dry and sore eyes.

The root bark of *Morus alba* (Moraceae) has been used as a traditional medicine in Asian countries and exhibits antibacterial activity against food poisoning micro-organisms. Hypolipidemic and antioxidant effects from freeze-dried powder of mulberry (*Morus alba* L.) fruit.

Albanol A, isolated from the root bark extract of *M. alba*, may be a promising lead compound for developing an effective drug for treatment of leukemia.

Moracin M, steppogenin-4'-O- β -D-glucoside and mulberroside A were isolated from the root bark of *Morus alba* L. and all produced hypoglycemic effects. Mulberroside A, a glycosylated stilbenoid, can be useful in the treatment of hyperuricemia and gout.

► The major chemical composition of mulberry leaf

- i) **Flavone and Flavone Glycosides:** The mulberry leaf contains compounds of rutin, quercetin, isoquercitrin and Quercetin-3- Triglucoside, etc.
- ii) **Steroids:** Including β - sitosterol, stigmasterol, campesterol, β -sitosteryl- β -D-glucoside, mesoinositol and metamorphic hormone such as inokosteron and ecdysterone.
- iii) **Volatile Oils:** Acetic acid, propionic acid, butyric acid, isobutyric acid, valeric acid, isovaleric acid, caproic acid, isocaproic acid, methyl salicylate, guaiacol. phenol, o-cresol, m-cresol, eugenol, etc., also containing oxalic acid, fumarate, tartaric acid, citric acid, succinic acid, palmitic acid, ethyl palmitate, hentriacontane and hydroxycoumarin, etc.
- iv) **Saccharides and amino acids:** Including sucrose, fructose, glucose and 17 kinds of amino acids such as aspartic acid and glutamic acid. The content of blood level-decrease component γ -amino butanoic acid is up to 226mg/100g. For γ -amino butanoic acid is converted from glutamic acid, so the glutamic acid in mulberry leaf is up to 2323mg/100g.

v) **Vitamins and trace elements:** Containing vitamin A, B1, C, nicotinic acid, carotene and food fibres, also with zinc, copper, boron, manganese, iron, etc. In addition, mulberry leaf contains alkaloids, especially one

1.4.2 Test plants

The present study was taken on to assess the potential growth regulatory properties of six indigenous plants, viz. *Abroma augusta*, *Andrographis paniculata*, *Centella asiatica*, *Neolamarckia cadamba*, *Persicaria acuminata* and *Solanum tuberosum* on the growth and development and for enhancing the major economic traits of silkworm, *Bombyx mori*. A brief review on the available information of these plants are summarized below:

1.4.2.1 *Abroma augusta*

Abroma augusta Linn f. (*Ambroma*) syn. commonly known as Ulatkambal in Hindi and Bengali, and Devil's cotton in English. A number of names is given to this plant in Sanskrit, viz. Pisacha karpus, Pivari, Ritumati, Ucchat and Yonipushpa. In Assami: Ulat kambal and Bon kopashi; Tamil: Sivapputtutti. Gujarati: Ulat kambal, Olakatbol Marathi: Ulat kambal, Olakatambol; Telugu: Gogu, Kondagogu. *A. augusta* is found in tropical Asia, South and eastern Africa, and Australia. It is found in both wild and cultivated, throughout the hot and moister parts of India from Punjab and Uttar Pradesh eastwards to Arunachal Pradesh, Assam, Meghalaya and Tripura, ascending to 1,200 m, and southwards in peninsular India; it is also cultivated for ornament.

► Morphological attributes of *A. augusta*

A. augusta is a shrubs and small tree, attaining a height of 3-5 meters with horizontal and velvety branches. The branches and branch lets are downy. The leaves are alternate. The dry roots have 0.5-1.0 mm thick, highly fibrous, brown barks; the thickness of the bark varies according to the age and girth of the root. When freshly cut the root produces a thick gummy substance. The outer surface of the bark is dull brown and longitudinally wrinkled with small warty markings; the outer surface is whitish yellow and finely longitudinally striate. The root bark is test less, slimy, odorless, and tough, but not brittle. When soaked in cold water for 3-4 days, the bark produces slimy mucilage which can be extracted. Leaves are polymorphous about 10-30 cm. long and

successively. In case, where the pain precedes the flow, it is given two days previous to its appearance. The utility of *A. augusta* in uterine haemorrhage might be due to the presence of the magnesium salts. The leaves are reported to be useful in treating uterine disorders, diabetes, rheumatic pains of joints, and headache with sinusitis. The cold aqueous infusion of the fresh leaves and twigs is reported to be demulcent and very efficacious in gonorrhoea. It is also mention that the leaves are used aphrodisiac as a sex stimulant. 50g. Juice obtained from crushed leaves is taken with honey twice daily for 14 days.

The roots and bark of pivari are other uses of the plant are used in stomachache, diabetes, dermatitis, and also in whitish discharge in urine in men; uterine and nervous dysmenorrhoea, ammenorrhoea, sterility and other menstrual disorder. Powdered root act as an abortifacient and anti-fertility agent. Leaves are useful in treating uterine disorders, diabetes, rheumatic pain of joints, and headache with sinusitis. Leaves and stem are demulcent and an infusion of fresh leaves and stem in cold water is very efficacious in gonorrhoea. The root-bark is used as an emmenagogue and uterine tonic. The action of dried roots as well as the sap of the fresh root has been studied.

► Traditional uses

A. augusta has a long history of medicinal use in Ayurvedic system. It is highly effective in gynecological disorders. It regulates the menstrual flow and also used as abortifacient and anti-fertility agent. In India it is used in dymenorrhea but in Indonesia it is used in scabies. It is used in dermatitis, anti- inflammatory and analgesics. The leaves and stems of *A. augusta* were used by the traditional healers of Bogra district, but the bark of roots were used by the traditional healers of Jessore district.

► Chemistry

Primarily the plants consist of alkaloid. The root bark of the plant has the following constituents: mixed oils; resins; alkaloids; in minute quantities; water soluble base. The root part contains abromine ($C_6H_{12}NO_2$), mp 283-2850; a sterol ($C_{30}H_{52}O_2$), mp 153-1570; friedelin, abromasterol a mp 125.50. choline, betaine, β -sitosterol, stigmasterol, a basic compound and a fixed oil. Maslinic acid and α -amyrin isolated from root bark. Protocalechuic , vanillic and caffeic acids in their free glycosidic

and ester forms identified in root bark extract, a water soluble polysaccharide fraction isolated from root bark and found to contain rhamnose, arabinose, xylose, mannose, galactose, glucose, galacturonic acid and glucuronic acid an acidic.

1.4.2.2 *Centella asiatica*

Centella asiatica, commonly known as centella, is a small, herbaceous, annual plant and is native to wetlands in Asia. Centella grows in tropical swampy areas. Centella grows along ditches and in low, wet areas. In Indian and Southeast Asian centella, the plant frequently suffers from high levels of bacterial contamination, possibly from having been harvested from sewage ditches. Because the plant is aquatic, it is especially sensitive to pollutants in the water, which are easily incorporated into the plant. In South Asia, other common names of centella include sarswathi aku in Telugu; kudavan, muththil, or kudangal in Malayalam; thankuni in Bengali; gotu kola in Sinhala; mandukaparni in Sanskrit; brahmi in Marathi; ondelaga in Kannada; vallaarai in Tamil; brahmi booti in Hindi; perook in Manipuri; manimuni in Assamese; brahmabuti or ghod-tapre in Nepali and Asiatic pennywort or Indian pennywort in English

C. asiatica is called *brahmi* particularly in north India (Daniel, 2005; Warriar *et. al*, 1996) although that may be a case of mistaken identity introduced during the 16th century, when *brahmi* was confused with *mandukaparni*, a name for *C. asiatica* (Khare, 2003) probably the earliest study of *mandookaparni* as *medya rasayana* (improving the mental ability) was carried out at the Dr. A. Lakshmipathy Research Centre (Appa Rao MVR *et. al*, 1973). In Southeast Asia, it is known as (*sleuk tracheakkranh*) in Khmer; (*mying khwar*) in Burmese; (*bai bua bok*) in Thai; *rau má* ("mother vegetable") in Vietnamese; *pegagan* or *antanan* in Indonesian; *takip-kohol* (literally "snail lid") or *yahong yahong* ("little bowl") in Filipino; and *pegagan* or *pegaga* in Malay. In East Asia, it is known as (*lei gong gen*; literally "thunder god's root") or ("chipped big bowl") in Chinese; and (*byeong-pul*, literally "bottle/jar plant") in Korean.

► **Systemic position of *C. asiatica***

Kingdom: Plantae

Division: Angiosperms

Class: Eudicots

Order: Apiales

Family: Apiaceae

Genus: *Centella*

Species: *C. asiatica* (Linn.)



Plate 3: *C. asiatica*

► **Morphological attributes of *Centella asiatica***

The stems are slender, creeping stolons, green to reddish-green in color, connecting plants to each other. It has long-stalked, green, reniform leaves with rounded apices which have smooth texture with palmately netted veins. The leaves are borne on pericladial petioles, around 2 cm. The rootstock consists of rhizomes, growing vertically down. They are creamish in color and covered with root hairs.

The flowers are pinkish to red in color, born in small, rounded bunches (umbels) near the surface of the soil. Each flower is partly enclosed in two green bracts. The hermaphrodite flowers are minute in size (less than 3 mm), with 5-6 corolla lobes per flower. Each flower bears five stamens and two styles. The fruits are densely reticulate, distinguishing it from species of *Hydrocotyle* which have smooth, ribbed or warty fruit. The crop matures in three months, and the whole plant, including the roots, is harvested manually.

► **Social utilities and folk medicinal use**

It is used as a medicinal herb in Ayurvedic medicine, traditional African medicine, and traditional Chinese medicine. According to the American Cancer Society, although centella is promoted for its health benefits, "available scientific evidence does not support claims of its effectiveness for treating cancer or any other disease in humans.

Thankuni has been used for centuries as a medicinal herb in the ancient traditional Chinese medicines from about 2000 years ago, as well in Indian Ayurvedic medicine from about 3,000 years ago. In Ayurvedic medicine it has been used for healing wounds, as a mild diuretic, for increasing concentration and alertness, as well as an anti-anxiety and anti-stress medicament. In China it is called the Fountain of Youth. In traditional African healthcare it has been used for the treatment of leprosy, bronchitis, asthma, syphilis and wound healing. Yogis have used this herb to increase their meditation abilities through better concentration, focus and alertness. This herb has also shown great promise in improving mental retardation and increasing IQ. In general, it has been used by the traditional healers for wound healing, better circulation, memory enhancement, cancer treatment, increasing vitality, as a general tonic, treatment of respiratory ailments, for detoxifying the body, treatment of skin disorders (such as psoriasis and eczema), revitalising connective tissue, burn and scar treatment, clearing up skin infections, slimming and edema, for arthritis and rheumatism, treatment of liver and kidneys, treatment of periodontal disease, strengthening of veins (varicose veins), blood purifier, treatment of high blood pressure, as a sedative, as a anti-stress and anti-anxiety medicine, as an aphrodisiac, and an immunity booster. Thankuni is a rich source of vitamin K, and also contains magnesium, calcium and other nutritional properties. For these reasons this plant is also widely consumed by the sub continental people as a vegetable.

Centella is used as a leafy green in Sri Lankan cuisine, where it is called *gotu kola*. In Sinhalese, *gotu* is translated as "conical shape" and *kola* as "leaf". It is most often prepared as *malluma*, a traditional accompaniment to rice and curry, and goes especially well with vegetarian dishes, such as *dhal*, and jackfruit or pumpkin curry. It is considered quite nutritious. In addition to finely chopped *gotu kola*, *malluma* almost always contains grated coconut, and may also contain finely chopped green chilis, chili powder, turmeric powder and lime (or lemon) juice. A variation of the nutritious porridge known as *kola kenda* is also made with *gotu kola* by the Sinhalese people of Sri Lanka. *Kola Kenda* is made with very well-boiled red rice (with extra liquid), coconut milk and *gotu kola*, which is pureed. The porridge is accompanied with jaggery for sweetness. Centella leaves are also used in sweet "pennywort" drinks.

In Indonesia, the leaves are used for *sambai oi peuga-ga*, an Aceh type of salad, and are also mixed into *asinan* in Bogor. In Vietnam and Thailand, this leaf is used for preparing a drink or can be eaten in raw form in salads or cold rolls. In Bangkok, vendors in the famous Chatuchak Weekend Market sell it alongside coconut, roselle, chrysanthemum, orange and other health drinks. In Malay cuisine the leaves of this plant are used for *ulam*, a type of Malay salad. It is one of the constituents of the Indian summer drink *thandaayyee*. In Bangladeshi cuisine mashed centella is eaten with rice and is popular for its medicinal properties.

1.4.2.3 *Neolamarckia cadamba*

Neolamarckia cadamba, commonly called **Kadam** in Bengali is an evergreen, tropical tree native to South and Southeast Asia. The genus name honours French naturalist Jean-Baptiste Lamarck. The species has been widely but incorrectly called *Anthocephalus chinensis*. It has scented orange flowers in dense globe-shaped clusters. The flowers are used in perfumes. The tree is grown as an ornamental plant and for timber and paper-making. Kadam features in Indian mythology and religion.

► Distribution

Neolamarckia cadamba is stated to be one of the most frequently planted trees in the tropics. Kadamba is distributed to Southern China, Indian ; Bangladesh; Nepal; Sri Lanka; Cambodia; Laos; Myanmar; Thailand; Vietnam, Indonesia; Malaysia; Papua New Guinea and Australia

► Systemic position of *N. cadamba*

Kingdom: Plantae

Division: Angiosperms

Class: Eudicots

Order: Gentianales

Family: Rubiaceae

Genus: *Neolamarckia*

Species: *N. cadamba* (Roxb.)



Plate 4: *N. cadamba* plant.

► Morphological attributes of *N. cadamba*

A fully mature *N. cadamba* tree can reach up to 45 m in height. It is a large tree with a broad crown and straight cylindrical bole. It is quick growing, with broad spreading branches and grows rapidly in the first 6–8 years. The trunk has a diameter of 100–160 cm. Leaves glossy green, opposite, simple more or less sessile to petiolate, ovate to elliptical with dimensions of 15–50 cm by 8–25 cm. Flowers inflorescence in clusters; terminal globose heads without bracteoles, subsessile fragrant, orange or yellow flowers; Flowers bisexual, 5-merous, calyx tube funnel-shaped, corolla gamopetalous saucer-shaped with a narrow tube, the narrow lobes imbricate in bud. Stamens 5, inserted on the corolla tube, filaments short, anthers basifixed. Ovary inferior, bi-locular, sometimes 4-lobular in the upper part, style exerted and a spindle-shaped stigma. Flowering usually begins when the tree is 4–5 years old. Kadam flowers are sweetly fragrant, red to orange in colour, occurring in dense, globular heads of approximately 5.5 cm diameter. The fruit of *N. cadamba* occur in small, fleshy capsules packed closely together to form a fleshy yellow-orange inflorescence containing approximately 8000 seeds. On maturing, the fruit splits apart, releasing the seeds, which are then dispersed by wind or rain. Stamens 5, inserted on the corolla tube, filaments short, anthers basifixed. Ovary inferior, bi-locular, sometimes 4-locular in the upper part, style exerted and a spindle-shaped stigma.

► Social utilities and medicinal use

The fruit and inflorescences are reportedly edible to humans. The fresh leaves are fed to cattle. The fragrant orange flowers attract pollinators. Its sapwood is white with a light yellow tinge becoming creamy yellow on exposure and is not clearly differentiated from the heartwood. *N. lamarckia* is grown as an ornamental, and for low-grade timber and paper. The timber is used for plywood, light construction, pulp and paper, boxes and crates, dug-out canoes, and furniture components. Kadamba yields a pulp of satisfactory brightness and performance as a hand sheet. The wood can be easily impregnated with synthetic resins to increase its density and compressive strength. The wood has a density of 290–560 kg/cu m at 15% moisture content, a fine to medium texture; straight grain; low luster and has no characteristic odor or taste. It is easy to work with hand and machine tools, cuts cleanly, gives a very good surface and is easy to nail. The timber air

dries rapidly with little or no degrades. Kadamba wood is very easy to preserve using either open tank or pressure-vacuum systems. A yellow dye is obtained from the root bark. Kadamba flowers are an important raw material in the production of 'attar', which is Indian perfume with sandalwood (*Santalum* spp.) base in which one of the essences is absorbed through hydro-distillation. The flowers exhibit slight anti-implantation activity in test animals. Kadamba extracts exhibit nematocidal effects on *Meloidogyne incognita*. The dried bark is used to relieve fever and as a tonic. An extract of the leaves serves as a mouth gargle.

The tree is grown along avenues, roadsides and villages for shade. Kadamba are suitable for reforestation programs. It sheds large amounts of leaf and non-leaf litter which on decomposition improves some physical and chemical properties of soil under its canopy. This reflects an increase in the level of soil organic carbon, cation exchange capacity, available plant nutrients and exchangeable bases.

► Chemistry

Phytochemical investigations have resulted in the isolation of saponins, indole and quinoline alkaloids, secoiridoids and triterpenes from this plant (Banerji, 1977; 1978; Brown and Chapple, 1976; Handa *et al.*, 1984; Kitagawa *et al.*, 1996; Sahu *et al.*, 1999).

1.4.2.4 *Solanum tuberosum*

Solanum tuberosum commonly known as **potato** is a starchy, tuberous crop. The word "potato" may refer to the plant itself in addition to the edible tuber. Potato has become an integral part of much of the world's food supply. It is the world's fourth-largest food crop, following maize, wheat and rice. The English word *potato* comes from Spanish *patata* (the name used in Spain). The Spanish Royal Academy says the Spanish word is a compound of the Taino *batata* (sweet potato) and the Quechua *papa* (potato). The name potato originally referred to a type of sweet potato rather than the other way around, although there is actually no close relationship between the two plants. The English confused the two plants one for the other. In many of the chronicles detailing agriculture and plants, no distinction is made between the two (Weatherford, 1988). The

16th-century English herbalist John Gerard used the terms "bastard potatoes" and "Virginia potatoes" for this species, and referred to sweet potatoes as "common potatoes". Potatoes are occasionally referred to as "Irish potatoes" or "white potatoes" in the United States, to distinguish them from sweet potatoes (Simpson and Weiner, 1989)

► Distribution

In the Andes, where the species is indigenous, there are some other closely related cultivated potato species. Potatoes were introduced outside the Andes region four centuries ago. Wild potato species occur throughout the Americas, from the United States to southern Chile (Hijmans and Robert, 2001). The potato was originally believed to have been domesticated independently in multiple locations, but later genetic testing of the wide variety of cultivars and wild species proved a single origin for potatoes in the area of present-day southern Peru and extreme northwestern Bolivia (from a species in the *Solanum brevicaule* complex), where they were domesticated 7,000–10,000 years ago (Spooner *et al.*, 2005). Following centuries of selective breeding, there are now over a thousand different types of potatoes. Over 99% of the presently cultivated potatoes worldwide are descended from varieties that originated in the lowlands of south-central Chile, which have displaced formerly popular varieties from the Andean highlands (Miller, 2008; Ames and Spooner, 2008). The annual diet of an average person in the first decade of the 21st century included about 33 kg of potato. However, the local importance of potato is extremely variable and rapidly changing. It remains an essential crop in Europe (especially eastern and central Europe), where per capita production is still the highest in the world, but the most rapid expansion over the past few decades has occurred in southern and eastern Asia. China is now the world's largest potato-producing country, and nearly a third of the world's potatoes are harvested in China and India (Hijmans and Robert, 2001).

► **Systemic position of *S. tuberosum***

Kingdom: Plantae

Division: Angiosperms

Class: Asterids

Order: Solanales

Family: Solanaceae

Genus: *Solanum*

Species: *S. tuberosum* (Linn.)



Plate 5: *S. tuberosum* plant.

► **Morphological attributes and pagation of *Solanum tuberosum***

Potato plants are herbaceous perennials that grow about 60 cm high, depending on variety. They bear white, pink, red, blue, or purple flowers with yellow stamens. In general, the tubers of varieties with white flowers have white skins, while those of varieties with colored flowers tend to have pinkish skins. Potatoes are cross-pollinated mostly by insects, including bumblebees, which carry pollen from other potato plants, but a substantial amount of self-fertilizing occurs as well. Tubers form in response to decreasing day length, although this tendency has been minimized in commercial varieties.

After potato plants flower, some varieties produce small green fruits that resemble green cherry tomatoes, each containing up to 300 true seeds. Potato fruit contains large amounts of the toxic alkaloid solanine and is therefore unsuitable for consumption. All new potato varieties are grown from seeds, also called "true seed" or "botanical seed" to distinguish it from seed tubers. By finely chopping the fruit and soaking it in water, the seeds separate from the flesh by sinking to the bottom after about a day (the remnants of the fruit float). Any potato variety can also be propagated vegetatively by planting tubers, pieces of tubers, cut to include at least one or two eyes, or also by cuttings, a practice used in greenhouses for the production of healthy seed tubers. Some commercial potato varieties do not produce seeds at all (they bear imperfect flowers)

and are propagated only from tuber pieces. Confusingly, these tubers or tuber pieces are called "seed potatoes," because the potato itself functions as "seed".

► Uses

Potatoes are used to brew alcoholic beverages such as vodka, potcheen, or akvavit. They are also used as food for domestic animals. Potato starch is used in the food industry as, for example, thickeners and binders of soups and sauces, in the textile industry, as adhesives, and for the manufacturing of papers and boards (Grant *et al.*, 1997; Jai Gopal *et al.*, 2006). Companies are exploring the possibilities of using waste potatoes to obtain polylactic acid for use in plastic products; other research projects seek ways to use the starch as a base for biodegradable packaging (Jai Gopal *et al.*, 2006).

Potato skins, along with honey, are a folk remedy for burns in India. Burn centers in India have experimented with the use of the thin outer skin layer to protect burns while healing. The consistent parenchyma tissue, the clonal nature of the plant and the low metabolic activity provide a very nice "model tissue" for experimentation. Wound-response studies are often done on potato tuber tissue, as are electron transport experiments. In this respect, potato tuber tissue is similar to *Drosophila melanogaster*, *Caenorhabditis elegans* and *Escherichia coli*: they are all "standard" research organisms.

► Chemistry

Aerial parts contain a number of biologically active terpenoids and flavones. Leaves contain flavonoids, quercetin, rhamnetin, quercitrin, avicularin, rutin; pigments, delphinidin-3,5-diglucoside, cyanidin-3,5-diglucoside and quercetin. Stem contains vanillic, syringic, *p*-hydroxybenzoic, protocatechuic, gallic and coumaric acids, kaempferol, quercetin and hyperin.

1.4.2.5 *Persicaria acuminata*

Persicaria acuminata is known as biskathali in Bangladesh.

► Habitat and distribution

Marshy areas Indo-Malesia and east Asia.

► Systemic position of *P. acuminata*

Kingdom: Plantae

Division: Magnoliophyta

Class: Magnoliatae

Order: Polygonales

Family: Polygonaceae

Genus: *Persicaria*

Species: *P. acuminata* (Franch.)

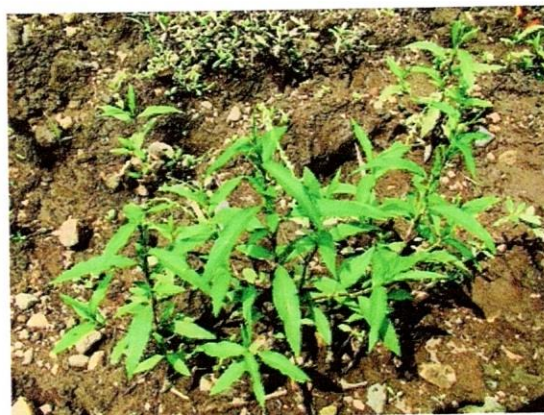


Plate 6: *P. acuminata*.

► Morphological attributes of *Persicaria acuminata*

Stout herbs; stems sometimes decumbent at base. Leaves 13 x 2 cm, elliptic to linear-lanceolate, acuminate, hispid below and along the nerves above; ochrea 15 mm long, adpressed-hairy, strongly bristled at mouth. Racemes 6-10 cm long, slender; bracts obovate, ciliate, glabrous. Flowers paired, pedicellate; tepals 5, oblong, obtuse, glandular-pubescent, stamens 10; style 3-fid, stigmas globose. Nut trigonous.

► Uses

The juice of the herb is used as a remedy for fever. Infusion of leaves is used to relieve colic pain. Fresh juice of the leaves possesses poisonous properties

► Chemistry

Primarily the plants consist of alkaloid. The root of the plant has the following constituents: mixed oils; resins; alkaloids; in minute quantities; water soluble base.

The root part contains, sterol, friedelin, choline, betaine, β -sitosterol, stigmasterol, a basic compound and a fixed oil. Maslinic acid and α -amyrin isolated from root and stem. Protocatechuic, vanillic and caffeic acids in their free glycosidic and ester forms identified in root bark extract, a water soluble polysaccharide fraction isolated from root and found to contain rhamanose, arabinose, xylose, mannose, galactose, glucose, galacturonic acid and glucuronic acid.

1.4.2.6 *Andrographis paniculata*

Andrographis paniculata is an annual herbaceous plant in the family *Acanthaceae*, native to India and Sri Lanka. It is widely cultivated in Southern and Southeastern Asia, where it has been traditionally used to treat infections and some diseases. Mostly the leaves and roots were used for medicinal purposes. The plant is known in north-eastern India as *Maha-tita*, literally "king of bitters", and known by various vernacular names. As an Ayurveda herb it is known as *Kalmegh* or *Kalamegha*, meaning "dark cloud". It is also known as *Bhui-neem*, meaning "neem of the ground", since the plant, though being a small annual herb, has a similar strong bitter taste as that of the large Neem tree (*Azadirachta indica*). In Malaysia, it is known as *Hempedu Bumi*, which literally means 'bile of earth' since it is one of the bitterest plants. The genus *Andrographis* consists of 28 species of small annual shrubs essentially distributed in tropical Asia. Only a few species are medicinal, of which *A. paniculata* is the most popular.

► Distribution

A. paniculata is distributed in tropical Asian countries, often in isolated patches. It can be found in a variety of habitats, such as plains, hillsides, coastlines, and disturbed and cultivated areas such as roadsides, farms, and wastelands. Native populations of *A. paniculata* are spread throughout south India and Sri Lanka which perhaps represent the center of origin and diversity of the species. The herb is an introduced species in northern parts of India, Java, Malaysia, Indonesia, the West Indies, and elsewhere in the Americas. The species also occurs in Hong Kong, Thailand, Brunei, Singapore, and other parts of Asia where it may or may not be native. The plant is cultivated in many

areas, as well. Unlike other species of the genus, *A. paniculata* is of common occurrence in most places in India, including the plains and hilly areas up to 500 m, which accounts for its wide use.

► Morphological attributes of *Andrographis paniculata*

Andrographis paniculata is an erect annual herb grows to a height of 30–110 cm in moist, shady places. The slender stem is dark green, squared in cross-section with longitudinal furrows and wings along the angles. The lance-shaped leaves have hairless blades measuring up to 8 cm long by 2.5 wide. The small flowers are borne in spreading racemes. The fruit is a capsule around 2 centimetres long and a few mm wide. It contains many yellow-brown seeds.

► Systemic position of *Andrographis paniculata*

Kingdom: Plantae

Division: Angiosperms

Class: Asterids

Order: Lamiales

Family: Acanthaceae

Genus: *Andrographis*

Species: *A. paniculata* (Burm.f.)

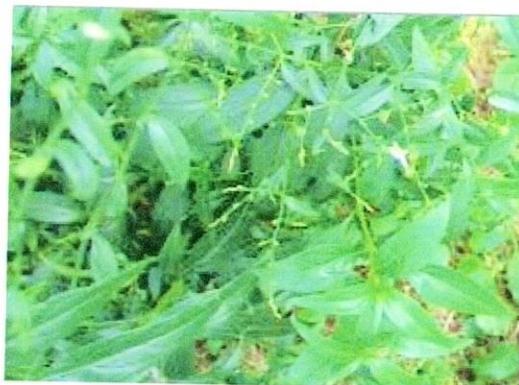


Plate 7: *A. paniculata*

► Medicinal use

Since ancient times, *A. paniculata* is used in traditional Siddha and Ayurvedic systems of medicine as well as in tribal medicine in India and some other countries for multiple clinical applications. The herb has a number of purported medicinal uses, although research has found evidence of its effectiveness is limited to treatment of upper respiratory infection, ulcerative colitis and rheumatic symptoms; in particular, there is no evidence of its effectiveness in cancer treatment.

According to the *Mayo Clinic Book of Alternative Medicine* (2010), "A specific product (andrographis combined with *Eleutherococcus senticosus*) may shorten the duration and

lessen the symptoms of common cold." It also says, "Pregnant women shouldn't use andrographis because it could terminate pregnancy."

In one Chilean study from 1999, the herb had a significant drying effect on the nasal secretions of cold sufferers who took 1,200 milligrams of andrographis extract daily for five days (Caceres *et al.*, 1999). A 2012 study suggested that *Andrographis paniculata* extracts may have the potential to be used as a mosquito repellent (Govindarajan *et al.*, 2011). A 2006 study reported that extracts of Andrographis exhibited potent anti-inflammatory effects and antioxidant actions in mice (Sheeja *et al.*, 2006).

► Chemistry

Andrographolide, an active ingredient in Andrographis, has been shown to be responsible for the herb's inflammatory modulating actions, including the reduction of cytokine and peritoneal deposition of neutrophils, and modulation of lung inflammation *in vivo* (Xia *et al.*, 2004). Andrographolide is the major constituent extracted from the leaves of the plant which is a bicyclic diterpenoid lactone. This bitter principle was isolated in pure form by Gorter (1911). Such other activities as liver protection under various experimental conditions of treatment with galactosamine, paracetamol etc. are also attributed to andrographolide. The hepatoprotective action of andrographolide is related to the activity of certain metabolic enzymes. Systematic studies on chemistry of *A. paniculata* have been carried out by Chao and Lin (2010). Some known constituents of *An. paniculata* are 14-Deoxy-11-dehydroandrographolide, 14-Deoxy-11-oxoandrographolide, Paniculide-A, Paniculide-B, 5-Hydroxy-7,8,2',3'-Tetramethoxyflavone, Andrographolide, Neoandrographolide, Paniculide-C (Plant); Andrographine (Root); Panicoline (Rlkjlkjoot); 5-Hydroxy-7,8,2'-Trimethoxyflavone, (Tissue Culture).

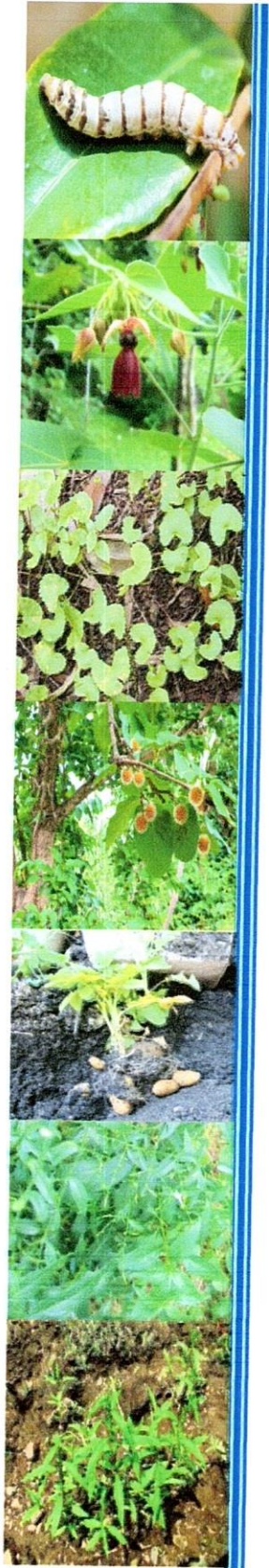
1.5 Objectives of the present work

Successful cocoon crops in sericulture depend mostly on a healthy larval growth. It is obvious that the study of nutritional effect on the larval growth and development,

and economic traits is an important aspect of research for silkworm cocoon production. The supplementation and fortification of mulberry leaves is a recent technique in sericulture research. Quite a good number of plants have been identified and utilized as food supplement and medicinal purpose till to date. But it is true that a large number of plants have still been untouched or less investigated from which significant results can be obtained in this regard. So the present study is undertaken to determine the effects of some plant materials, viz. *Abroma augusta*, *Centella asiatica*, *Neolamarckia cadamba*, *Solanum tuberosum* *Persicaria acuminata* and *Andrographis paniculata*, on the growth and development of *B. mori* L.

These plant materials have been studied a lot phytochemically. But in details a very few studies have been done till to date with its medicinal properties and on its use as food supplement with mulberry leaves in enhancing the growth and development, and cocoon characters of silkworm *Bombyx mori* L. Keeping this in mind the present investigations were undertaken to fulfil the following objectives

- ❖ Screening of different parts of *A. augusta*, *C. asiatica*, *N. cadamba*, *S. tuberosum*, *P. acuminata* and *A. paniculata* plant with respect to their toxic effect on silkworm, *Bombyx mori* L.
- ❖ To study the efficacy of the selected plant materials in enhancing the growth parameters and cocoon characters of *B. mori*.
- ❖ To observe the efficacy of the test plants as food supplement with mulberry leaves on the 'biological efficiency' of *B. mori*, such as fecundity, fertility and rate of survivality.
- ❖ To comment on the future prospects of the test plants for their commercial utilization as a food supplement to gear up the economic traits of silkworm, *Bombyx mori* L. based on the results achieved.



CHAPTER-2

Review of Literature

2. Review of literature

Since the legendary fall and disentanglement of a cocoon in the teacup of Chinese princess Xi Ling Shi five thousand years ago (Kurin, 2002), the mulberry silkworm, *Bombyx mori* L., has been intimately connected with humans. As the only truly domesticated insect, it is completely dependent on the care of man for their survival and reproduction (Hubbell, 2001). Silkworm nutrition is to be considered as the major area of research in sericulture from the scientific point of view. The silkworm became a model for scientific discovery in microbiology, physiology, and genetics at a period when enormous conceptual changes took place in our understanding of biology (Willis, *et al.*, 1995).

Unlike other insects, silkworm is deriving almost all the constituents required for its growth from the mulberry leaves. Different species of mulberry may have compositional differences and might lead to varying effects on *B. mori* growth and silk productions. Qader *et al.* (1993) investigated the nutritive effects of leaves of three mulberry varieties on larval growth and cocoon characters of three *B. mori* races. It is known that there is high correlation between leaf protein level and production efficiency of cocoon shell, which means cocoon shell weight to the total amount of mulberry leaves consumed by the *B. mori*. Therefore, increase in protein level may lead to improvement in productivity of cocoons and silk. Addition of extra nutrients to the mulberry leaf food in the silkworm enhanced their growth and cocoon yield (Sharda *et al.*, 1956; Ito, 1960; Li and Chiang, 1982).

Research conducted worldwide revealed the fact that the use of mineral and salts, vitamins, hormones, protein and amino acids, and additives in the natural food of silkworm *Bombyx mori* L., improve the growth rate of larvae, protein and mineral content of haemolymph, the protein content, DNA and RNA content of the sericigen glands, and the quality parameters of cocoon. Improvement in quality

and quantity of silk by mulberry leaves enriched with plant extracts has also been tried by many workers. The important works relevant to this study are reviewed here under the following heads:

2.1 Effect of mineral and salt supplementation

The role of nutrients, minerals and a variety of exogenous modulators on the growth and metabolism of silkworm and its impact on the economic parameters of sericulture has been well documented. All insects require a variety of minerals and trace elements as micronutrients (Muniandy, 1995). Known trace elements essential for insects include iron, copper, manganese, zinc, cobalt, nickel and iodine (Trager, 1953). Specifically, the minerals essential for the nutrition of silkworms include potassium, phosphorus, magnesium and zinc (Horie and Watanabe, 1980). Requirements of different minerals in insects have been investigated (House, 1965). Horie *et al.* (1967) studied on the effect of foliar application of different levels of various micronutrients to mulberry on the quality of bivoltine cocoon and silk. The minimum optimal levels of these minerals in the diet have been determined (Ito, 1964). Lakshmi Devi and Yellamma (2013) suggested that zinc induced active turnover of all profiles of protein metabolic events in the posterior silk gland, creating the conditions that are highly congenial for growth and silk production.

Cocoon parameters in the silkworm, *Bombyx mori* on exposure to trace element and nutrients was traced by Lakshmi Devi and Yellamma (2013). The larvae fed with mulberry leaves supplemented with multiminerals showed a greater body weight at the end of larval stage comparative with the larva that didn't received supplements. Total proteins present a significant increase in all treatments with multiminerals (Etebari and Fazilati, 2003). The supplementation of food with potassium permanganate leads to an increase of proteins from hemolymph and

insect's fat body (Bhattacharya and Kaliwal, 2004). Similar results had been reported with potassium nitrate supplementation (Goudar, 2001).

Further, recent experimental findings suggests that cofactor functions of iron and Zinc, for example are considered as the most universal importance to organisms and trace elements can be essential for insects in general (Nichol *et al.*, 2002). Apart from the organic nutrients for the optimal growth of larvae, micro-nutrients, especially zinc are required. Severe zinc deficiency is reported to cause growth retardation (Underwood, 1971). Zinc plays an important role in protein synthesis and carbohydrate, nucleic acid and lipid metabolism (Vallee, 1976).

Several researchers have documented the beneficial effects of mineral supplementation on silkworms (Ito and Niminura, 1966a,b; Horie *et al.*, 1967; Chakrobari and Medda, 1977, 1978a,b; Miyoshi *et al.*, 1978; Bhattacharya and Medda, 1981a,b, 1983; Majumdar, 1982; Narasimhamurthy and Gobindappa, 1988; Thangavelu and Bania, 1990; Magadum *et al.*, 1992; Islam and Khan, 1993). Iwanari (1976) reported that a quantitative decrease of potassium, calcium, magnesium and phosphorus resulted in a decrease in body weight in *B. mori*.

Salt may constitute a limiting factor in the growth of insects upon some diets (Wigglesworth, 1972). The modulatory effect of zinc chloride, nickel chloride, ascorbic acid, magnesium sulphate, ferrous chloride, potassium sulphate, thyroxin (Majumdar and Medda, 1995), on the silkworm metabolism, immune response and silk production has been extensively studied.

Feeding of mulberry leaves treated with cobalt chloride enhanced that larval and cocoon shell weight and egg productivity in the Nistari race of *B. mori* (Chakrobari and Medda, 1977, 1978a,b) and the worms fed on leaves treated with potassium iodide increased the economic parameters and reduced the larval duration (Majumdar, 1982). Khan and Talukder (1985, 1986) assessed the effect of addition of potassium, sodium, magnesium and ammonium chlorides to castor leaves on the eri silkworm, *Samia Cynthia ricini* (Boisd). Thangavelu and Bania

(1990) recorded that trace amounts of minerals, e.g. calcium, magnesium, iron, and their salts present in rain water presumably stimulated metabolic activity in *B. mori* resulting in the shorter larval duration and increase in the effective rearing rate, oviposition and silk content of cocoons.

It has been reported that in some adult insect's requirement of salts may be related to the reproductive function of the female (Bracken, 1965; Sing and Brown, 1957). An increase in the larval weight has been reported in the eri silkworm by feeding leaves treated with mineral salts such as cupric chloride, magnesium sulphate and cobalt chloride (Padki, 1991). Khan and Saha (1996) observed that the supplementation of potassium dichromate, significantly increased the weight of larvae, pupae and adults; enhanced the cocoon characters; decreased the developmental periods and increased the reproductive potential of *B. mori* at 0.10, 0.20 and 0.40% concentration. However, worms treated with 0.80% potassium dichromate had deleterious effects on the parameters of the silkworm studied. Miyoshi *et al.* (1978) reported that feeding of copper in artificial diet was toxic to young *B. mori* larvae. Magadum *et al.* (1992) noted that supplementation of feed with copper sulphate significantly increased the larval and female cocoon shell weight but decreased the larval period, cocooning and moth emergence in *B. mori*.

Arnaudo (1954) recorded higher silk yields when included 0.08-0.22 mg cobalt per larvae in silkworm diet. Takahashi (1955, 1956) showed that cobalt exerts favorable effect on the growth of silkworm. Narsimhamurthy and Govindappa (1988) observed that cobalt treatment significantly increased the economic characteristics of cocoon crop, viz. single cocoon weight and shell weight.

It is reported that the dietary supplementation of iodinate compounds improved some of the economic characters of silkworm. Potassium iodide fed to the silkworm through the mulberry leaves improved the cocoon weight and silk percentage (Chakrobari and Medda, 1978b; Majumdar, 1982; Magadum, 1987). Chakrobari and Medda, (1978a) found that 20 µg/ml potassium iodide increased shell weight over the control treatment. Majumdar (1982) recorded that a high

concentration of potassium iodide produced higher larval and pupal mortalities in the Nistari race of *B. mori*. However, a high concentration of potassium iodide decreased fecundity, increased silk gland weight, enhanced metabolic activity, acid and alkaline phosphatase activity and decreased the glycogen content of the silk gland (Bhattachayya and Medda, 1981a,b; 1983). Quader *et al.* (1993) found that 500 ppm concentration of iodized salt significantly increased larval weight, single cocoon weight and shell percentage and 40 ppm concentration of iodized salt increased shell weight, length of filament and size of cocoon filament. Srinivasababu *et al.* (1992) observed that dietary supplementation of iodophore significantly increased the larval weight, cocoon weight, shell weight, pupation rate and fecundity and decreased the duration of 5th instar larvae. Quader *et al.* (1993) found that iodized salt (sodium chloride containing 35 ppm potassium iodide) significantly increased the larval weight over potassium iodide and control treatments and they suggested the use of iodized salt as a growth stimulator of the silkworm, *B. mori*.

Islam and Khan (1993) recorded that supplementation of mulberry leaves with lower concentrations of manganese sulphate significantly increased the larval, pupal and adult growth, decreased the total developmental period, enhanced the cocoon characters and the reproductive potential of the mulberry silkworm.

It has been reported that supplementation of magnesium sulphate and ferrous sulphate significantly increased various economic parameters of silkworm. Nirwani and Kaliwal (1996) reported that the supplementation of feed with ferrous and magnesium sulphate produced beneficial effects on the economic characters of *B. mori*. Balamani *et al.* (1995) showed that zinc treatment up to 100 ppm level produced no adverse effects on the nutritional indices, economic characters of cocoon and quality of silk produced, instead improvement was observed in them in more than 50% of the concentrations tested. He also reported that oral supplementation of potassium, magnesium and ferrous sulphates to bivoltine NB₄D₂ race of *B. mori* showed significant increase in the larval, cocoon and post-

cocoon traits. Saha and Khan (1995) observed that supplementation of diet with magnesium nitrate enhanced the economic parameters of the silkworm.

Magadum (1987) found that feeding 15, 30 and 45 μg nickel chloride increased cocoon shell weight in females in polyvoltine pure Mysore breed of *B. mori*. Saha and Khan (1995) recorded that lower concentrations of nickel chloride significantly increased the growth of larvae, pupae and adults, enhanced the cocoon characters, reduced the larval and pupal periods and decreased the mortalities and enhanced reproductive potential of *B. mori*. Hugar *et al.* (1998) found that lower concentration of nickel chloride supplementation significantly increased the silk gland weight, female and male cocoon weight and the length, weight and denier of the silk filament in all the treated groups.

Supplementation of calcium and magnesium chlorides showed an increase in cocoon shell weight and shell-ratio in *B. mori* (Subbu Rathinam *et al.*, 1990). Feeding of mulberry leaves with supplements of potassium iodide, cobalt chloride and calcium chloride increase the quantity of proteins in the sericigene gland (Dasmahapatra *et al.*, 1989). Administering of potassium sulfate in the food determines protein decrease in the fat body and the hemolymph (Nirwani and Kaliwal, 1996), but zinc chloride causes a significant decrease of fat body protein content and a significant increase in hemolymph protein content (Hugar *et al.*, 1998). Implicitly, the mineral salts of potassium and magnesium present in lemon juice could have significantly contributed to the rise in the levels of fat body protein (Bhattacharya and Kaliwal, 2004).

Islam, *et al.*, (2004) suggested that the Nickel chloride can be used at low concentrations for enhancing the economic characters of silkworm, *B. mori* L. Administration of additional copper sulphate, nickel chloride and potassium iodide in the food increased economic parameters of the silkworms. Islam *et al.*, (2004) mentioned that the cocoon weight, shell weight, and shell/cocoon ratio of silkworm increased when treated with various combinations of urea, ascorbic acid, and nickel chloride.

The mineral enrichment studies concentrated on the application of salts of cobalt, potassium, magnesium, calcium and zinc (Bhattacharya and Kaliwal, 2005a, 2005b, 2005c, 2005d; Kavitha *et al.*, 2012), often with mixed results on economic traits of silkworm.

Ashfaq *et al.* (2009), studied the toxic effect of food contamination with cobalt (Co(II)), observing that although the mulberry tree is not a powerful cobalt accumulator and the larvae eliminate a significant part of the Co (II) contents in their excrements, the negative effect is easily observable – the larvae length in each life stadium, their growth and the mortality rate gets worse proportionally with increased concentration of cobalt used in irrigation of mulberry trees. Cobalt, in particular Co(II), is not a recommendable nutritive supplement.

The zinc salt and its effect on silkworm metabolism substantiates that the two tissues i.e., silk gland and fat body of silkworm respond to opposing concentrations/doses of exogenous factors provided through the mulberry diet. While fat body responds well to higher doses of zinc, silk gland and haemolymph respond at low concentrations (Kavitha *et al.*, 2011).

2.2 Effect of hormone supplementation

A number of experiments have been carried out on the effects of hormones on the growth and development of *B. mori* by Padki (1991), Magadum *et al.* (1992), Trivedy *et al.* (1993), Saha and Khan (1997a), Reddy *et al.* (1994) and Magadum and Hooli (1989). The effect of vitamin supplementation on the growth of *B. mori* have been investigated by many researchers (Majumdar and Medda, 1995; Bhattacharyya and Medda, 1981a,b; Das and Medda, 1998; Faruki, 1990, 1998, 2005; Babu *et al.*, 1992; Khan and Saha, 1996a,b; Nirwani and Kaliwal, 1996; Nirwani *et al.*, 1998; Mosallanejad, 2002; Etebari *et al.*, 2004; Rajabi *et al.*, 2006a, 2006b). The requirements of vitamin in silkworm, *B. mori* were confirmed by different experiments by Saha and Khan (1996).

Morimoto *et al.* (1968) reported that posterior silk gland and larval body weight increases logarithmically in the early stage of 4th instars. Daillie (1979) also reported that development of silk gland remarkably differed in different days of 5th instars due to the effect of different doses of juvenile hormone on silkworm. The cocoon weight increased when the silkworm larvae were fed with blood meal fortified mulberry leaves (Majumdar and Medda 1995; Isaiarasu and Ganga, 2000).

The ecdysone has been noticed to influence the reproductive potential of *Bombyx mori* (Pondeville *et al.*, 2008; Parlak *et al.*, 1992; Kawaguchi *et al.*, 1993 and Okuda *et al.*, 1993). Ecdysteroids play key role in moulting and metamorphosis in insects. Plant-produced insects moulting hormones, known as phytoecdysteroids (PEs), assume the functions of defense against insects by acting either as feeding deterrents or as agents that induce developmental disruption (Schmulz *et al.*, 2002). The moulting hormones are hydrophilic in nature because of a number of hydroxy group present in the molecules (Sehnal, 1989; Sehnal and Akai, 1990). Effects of phytoecdysteroids on weight of ovary and weight of egg (Srivastava and Upadhyay, 2012a); on length of silk filament and non breakable filament of multivoltine mulberry silkworm (Srivastava and Upadhyay, 2012b); on the spinning duration (Pandey and Upadhyay, 2014); changes of protein content in the larvae of silkworm (Srivastava and Upadhyay, 2013a); on silk producing potential (Srivastava and Upadhyay, 2013a) and on incubation period and percent fertilized egg of multivoltine silkworm (Srivastava and Upadhyay, 2013b) have been studied extensively with an aim to utilize the results for commercial cocoon production. The plant like *Achyranthes aspera* (Lal jeera) and *Cassia tora* (Choti chakwar) have been identified to have phytoecdysteroids (Lafont and Horn, 2004). In China, various plant sources were identified which contained moderate to high amounts of PE and used them in sericulture to manage the silkworm rearing during the last stage of larval development (Wong *et al.*, 1979 and Chou and Lu, 1980).

2.3 Effects of vitamin supplementation

Vitamins play a major role in the organism in physiological processes, being considered biocatalyst, with an important role in processes like growth, reproduction, metabolism, etc. Studies of Ito (1978) determined that generally vitamins present in the mulberry leaves satisfy minimum needs of silkworm but the amount of vitamins present in mulberry leaves varies on the basis of environmental conditions; usage of fertilizers in field and mulberry varieties and other field practices.

The enrichment of mulberry leaves with riboflavin at 77 ppm enhanced certain economic characters of silkworm, and improves silk production in the climatic conditions of Iran (Rajabi *et al.*, 2006a). Folic acid plays a major role in cellular metabolism including the synthesis of some of the components of DNA and pigment precursor (Chapman 1998). Yasuhiro and Sholchi (1971) noted that the silkworm growth decreased when folic acid was eliminated from artificial diet. Nirwani and kaliwal (1996) determined that folic acid has phagostimulatory effects with significant increase in female and male cocoon weight and shell weight. Multi-vitamin compounds as diet factors prouce extensive effects of on growth and cocoon characteristics. Evanglista *et al.* (1997) have also reported that the larval and cocoon length, width and weight increase under multi-vitamin treatment. It is showed that multi-vitamin and mineral compounds could increase the food intake, growth and conversion efficiency of silkworm (Muniandy *et al.*, 1995). Application of multi-vitamins as supplementary nutrients on biological and economical characteristics of silk worm, *Bombyx mori* L. had radically changed the results based on the concentration they were administered (Etebari and Matindoost, 2005). Chang and Li (2004) reported that nutritional interactions exist between vitamin B3 and other groups of vitamin B. A number of researchers have worked on the effects of vitamin enriched food on the reproduction of *B. mori* females (Faruki and Khan, 1992 and Saha and Khan, 1996). Application of multi-

vitamins as supplementary nutrients on biological and economical characteristics of silk worm have also been reported by Etebari and Matindoost, 2005.

Saha and Khan (1996) described the extensive effects of multi-vitamin compounds as diet factors on growth interruption and the decrease of cocoon characteristics. It is showed that multi-vitamin and mineral compounds could increase the food intake, growth and conversion efficiency of silkworm (Muniandy *et al.*, 1995). Evanglista *et al.* (1997) reported that the larval and cocoon weight increase under multi-vitamin compound treatment, but did not have any positive effects on cocoon shell weight. Enrichment of mulberry leaves with E vitamin did not have significant effect on food consumption in silkworm larvae (Mosallanejad *et al.*, 2002).

Para-amino benzoic acid (PABA) is one of the substances belonging to the vitamin B-complex group supports vital function in insects and especially in silkworm (Pai *et al.*, 1988). PABA supplementation has no significant effects on adult weight where as it caused deleterious effects on their length ($P < 0.001$) and Fe-PLUS (ferrus fumarate + folic acid) supplementation significantly increased larval, pupal and adult weight in comparison with controls with lowest and highest growth obtained at the concentrations of 0.32 and 0.64% respectively (Khan and Saha, 1996a).

Banerjee and Khan (1992) observed that vitamin B₆ enhances the oviposition of the silkworm infected by *Bacillus thuringiensis* var. *Kurstaki* but the rate was lower than the control. Das and Medda (1998) reported that supplementation of mulberry leaves with B₁₂ vitamin could increase the synthesis of nucleic acid and protein in the silk glands of the silkworm.

Horie and Ito (1965) showed the required level of niacin for silkworm is highly regulated to the most appropriate level of 33 µg/L of dry weight and the increase of niacin reduced the larval weight. Cocoon parameters such as cocoon weight, pupal weight and cocoon shell weight also showed significant decrease in all

treatments (Etebari and Matindoost, 2004). High doses (20 and 30 g/l) of nicotinamide killed all larvae before entering the 5 instars (Etebari and Matindoost, 2004). Niacin with 0.5 g/L acted as an antifeedants for silkworm larvae and decreased their metabolism (Etebari and Matindoost, 2004). Nirwani *et al.*, (1998) reported that the weight of larvae and silk glands in all the thiamin fed groups had not shown any significant changes. Faruki (1998) reported that the thiamine derivative thianomin enhanced the growth of silkworm larvae, pupae and adults at all concentration used (50,100, 500, and 1000 ppm).

Other researchers administered mulberry leaves treated with vitamins (ascorbic acid, panthothenic acid, folic acid and multivitamins) in silk worm food (Etebari and Matindoost, 2005; Cappellozza *et al.*, 2005). Pyridoxine is reported to be involved in amino acid metabolism in insects (Friedrich, 1988). Faruki (2005) reported that mulberry leaf fortification by pyrol (Pyridoxine hydrochloride) in various concentrations from the third instars significantly reduced the fecundity and fertility of silkworm. Etebari and Matindoost, (2005) administered a vitamin complex (ascorbic acid, thiamin, riboflavin, pyridoxine, B₁₂, niacin, calcium panthotenate, vitamins A and D₃) to silk worm, in concentrations of 1, 2.5 and 5% in the 4th and 5th larval stages, supplementation being executed by pulverizing the vitamin substances on to the leaves. This treatment led to significant increases in the larvae body mass, cocoon mass, chrysalis weight and egg productivity compared to the control group. Cappellozza *et al.* (2005) recorded the negative effect of Vitamin C on the development and productivity of the silkworm, as a result of diet supplementation with ascorbic acid followed by the assumption that Vitamin C has adverse effects on the silkworm. Etebari *et al.* (2004) studied the effects of hypervitaminosis with vitamin B₃ on the biology of silk worm *Bombyx mori*, following: larva weight, cocoon weight, silk cover weight and of pupa, total proteins, glycerol and some minerals like K, Na and Ca. The high quantity of vitamin B₃ administered in larval food leads to a feeding interruption in larva and to an increase mortality during shedding. Larva presents indigestion, darkening

integument and ejections in form of a brown liquid. Larval stage increased to 31 days and only a few larvae turned into pupae.

Ascorbic acid had effect on the growth of silkworm (Javed and Gondal, 2002) and combination of 0.2% of N which enhances the growth of silk production (Hussain and Javed, 2002). Balasundaram *et al.* (2008) have reported that the larval length, width and weight have been improved when the larvae fed with the supplementation of vitamin C treated mulberry leaves.

Antioxidant activity of ascorbic acid decreases reactive oxygen species and oxidative pressure, and as a result, the absorption of nutritious substances in the mid gut would increase (Felton and Summers, 1995). Ascorbic acid is an indispensable vitamin in the diet of silkworm and other polyphagous insect (Ito and Arai, 1965a,b). Supplementation of vitamin C to mulberry leaves improved economic traits in the silkworm as studied by Chauhan and Singh (1992) and Prasad (1994). Several research demonstrated phagostimulatory effect of ascorbic acid for insects (Ito, 1978). Prasad *et al.* (1994) found significantly higher silk productivity on 2% ascorbic acid supplemented diet in Pure Mysore, NB₄D₂ and PM×NB₄D₂ breeds. In silkworm a gustatory stimulating activity have been observed to some extent due to effect of ascorbic acid (Ito, 1961). Gomma *et al.* (1977) observed that ascorbic acid significantly increased the weight of silkworm larvae). Etebari *et al.* (2004) reported the yield decrease, when ascorbic acid concentration is enhanced in silk worm diet. Chang and Li (2004) reported that nutritional interactions exist between vitamin B₃ and other groups of vitamin B.

Babu *et al.* (1992) observed that the first and second instar larvae reared on 1.5% ascorbic acid enriched mulberry leaves resulted in higher silk filament length, weight and denier values. Sengupta *et al.* (1972) reported that silk production increased with 1% ascorbic acid in the diet of silkworm. Etebari *et al.* (2004) demonstrated that feeding on mulberry leaves enriched with ascorbic acid at 3% concentration decreased larval weight due to hypervitaminosis. Chauhan and

Singh (1992) showed that 1% ascorbic acid could increase the number of eggs in the silkworm.

2.4 Effect of proteins, amino acids and enzymes

The economic characters of the silk cocoon were reported to improve by feeding the silkworm with mulberry leaves treated with amino acids (Subbu Rathinam *et al.*, 1990). The requirements of amino acids in *B. mori* have been also confirmed by Qadar *et al.*, (1994); Eid *et al.* (1989); Saha and Khan, (1995) and Saha *et al.* (1994).

Among the 20 haemolymph free amino acid (FAA) glycine, alanine, serine and tyrosine are reported to being actively utilized for silk production in the sericigenous insects, *B. mori* (Tashiro *et al.*, 1968; Bose *et al.*, 1989). The variation in the concentration of these amino acids may be related to the amino acid contents of the food, leaves of the silkworms. This view conforms to that of Inokuchi (1970) who suggested that the variation in free amino acid concentration may be due to the dietary amino acids which play an influential role in the concentration of the haemolymph amino acids. Further, it has been reported by various workers that some weed plants influence the growth and metabolic activity of silk gland in sericigenous insects (Mane and Patil, 2000a and b; Mamadapur, 1994). Radjabi (2010) mentioned that asparagine and alanine amino acids could not improve silk production in sericulture significantly.

An experiment was carried out by Rezina laz (2010) to determine the effects of methionine and tryptophan on some quantitative traits of silkworm, *B. mori* L. Mulberry leaves were treated with 250, 500, 750 and 1000 ppm of amino acids and were provided to the worms as food. Compared to the controls amino acids (especially 500 and 750 ppm) significantly increased the fecundity, fertility, adult emergence, developmental periods and longevity of *B. mori* adults but decreased

the mortality. Babu (1994) observed an increased silk productivity when the silkworms were reared on glycine supplemented leaves during their fifth instars.

According to Horie and Watanabe (1983) amino acids can influence the development of the whole organism. In *B. mori*, in particular, up to 65% of digested nitrogen is utilized for silk production during the last instar and the level of dietary protein and limiting amino acids in the diet strongly affects larval growth and silk production. Leonardi *et al.* (2001) demonstrated that intestinal amino acid absorption is an important step in nitrogen metabolism and directs the biological development of the whole organism. They also showed that leucine-methyl-ester (Leu-Ome) can greatly increase the activity of the transport system responsible for absorption of most essential amino acids in the larval midgut of *B. mori*. They recorded the leucine uptake activation by Leu-Ome in brush border membrane vesicles and in the apical membrane of epithelial cells in the midgut incubated *in vitro* and observed that the addition of this strong activator of amino acid absorption to diet significantly affected the larval development.

Amway is the best supplement protein for the production of good qualified cocoon and silk suggested by Amla Rani *et al.* (2011). Amway Nutrile is a protein supplement and it contains a balanced amount of important amino acids. Amway protein with a concentration of 10% was very effective, when compared to control. Mulberry leaves treated with Amway protein (10%) fed larvae recorded a maximum cocoon length (3.69 ± 0.12), cocoon width (1.98 ± 2.4), shell ratio (18.25 ± 0.14), filament length (888 ± 7.2), filament weight (3.2 ± 0.57), Denier (2.87 ± 0.02) and fibroin content (43.99 ± 0.02). They noticed that the growth rate and protein utilization of silkworm are high as a result of the supplementation of Miraculan, a plant growth regulator.

Amylase is one of the key enzymes involved in digestion and carbohydrate metabolism in insect (Horie and Watanabe, 1980). Probably most of study of characteristics of an insect digestive enzyme has been made on amylase of silkworm. The economic characters of the silk cocoon were reported to improve

by feeding the silkworm with mulberry leaves treated with amino acids. Subbu Rathinam *et al.* (1990) observed the enrichment of mulberry leaves with calcium chloride to increase the cocoon characters like cocoon weight, shell weight cocoon /shell ratio and silk proteins. The cocoon weight increased when the silkworm larvae were fed with blood meal fortified mulberry leaves. Majumdar and Medda (1995) reported the supplementation of tyrosine to enhance the cocoon weight due to the increased synthesis of DNA, RNA and proteins in silk gland. The weight and the size of cocoon, shell ratio and fibroin content of the shell increased with the supplementation of the amino acid, glycine (Isaiarasu and Ganga, 2000)

Bose and Majumder (1989) studied amino acid requirements in silkworm nutrition. Effect of dietary levels of protein and pyridoxine the on growth of younger larvae of *B. mori*. observed by Krishnappa (1987) and also observed the influence of amino acid supplementation on growth and development of *B. mori*.

2.5 Effect of artificial diet with different nutrients

The effect of artificial diets with different nutrients on better production of cocoon crops and silk were investigated by many workers (Fukuda and Higuchi, 1963; Yokoyama, 1964; Hamamura, 1964; Ito, 1964; Legay and Pascal, 1964; Ito and Arai, 1965a,b; Yanagawa, 1973; Gomma *et al.*, 1976, 1977; El-Shaarawy *et al.*, 1976; 1977a,b). Tsuchida and Yoshitaka (1983). A number of feeding experiments have been attempted for the formulation of artificial diets in silkworms and other insects by several researchers in different parts of the world (Babu *et al.*, 1992; Boisvert and Auclari, 1981; Bounias, 1980; Faruki 1990; Gomma, 1978; Gour, 1975; Haque, 1991; Jayanth and Nagarkath, 1981; Junnikala, 1980; Kamano, 1980; Khilistovskii and Alfimov, 1979; Khan and Saha 1995, 1996a,b; Kieinjan and Dadd, 1977; Klein and Beck, 1979; Mc Farlane, 1983; Pant and Dang, 1967; Pant and Srivastava, 1975; Pant and Anand, 1975; Rahman *et al.*, 1990; Saha *et al.*, 1994; Saha and Khan, 1996; Siddiqui and Sarup, 1981; Siddiqui *et al.*, 1983;

Srivastava and Pant, 1977; Toth, 1981; Tsiropoulos, 1981; Turunen, 1978) which seemed to be relevant to the present study.

Cappellozza *et al.* (2005) showed that the lack of ascorbic acid in larva food fed with artificial feed especially during the first and the last larval stage produces beneficial effects regarding cocoon production without influences on the survival percentage and larva cycle. The artificial diet administered to the larvae contained dry mulberry leaves, but the main effect of the leaf drying process is the degradation of the ascorbic acid. The effect of the ascorbic acid on the larvae was determined by introducing only this vitamin in the silkworm's diet, at a level of 2% pure ascorbic acid (Sigma, Italy, 99% purity).

2.6 Effect of plant extract supplementation

The plant extracts phytochemicals could benefit sericulture by improving the silk yield of *B. mori* and commercial silk production (Rajasekaragouda *et al.*, 1997). Various extracts of medicinal plants have been tested by supplementation in the silkworm, *Bombyx mori* and were seen to influence the body weight, silk gland weight and the silk thread length in *Bombyx mori* (Murugan *et al.*, 1998). Dietary supplementation of the leaf, flower and pod extracts of *Moringa oleifera* (Rajeswari and Isaiarasu, 2004) and chitosan solution elicited varied responses in the final instar larvae of *Bombyx mori*.

Murugan *et al.* (1998) noticed a strong correlation between the growth of silkworm and the silk production in the silkworm after the treatment with plant extracts and attributed the growth promoting effect of the plant extracts to the stimulation of biochemical processes leading to protein synthesis. Saravanan *et al.* (2011) suggested that the co-administration of *Vigna unguiculata* with mulberry leaves at a concentration of 7.5% enhanced the biochemical reaction involved in the silk production in the silkworm.

Aloe vera herbal tonic 'Iogen' (Balamurugan and Isaiarasu, 2007); 'alloe' (Manimutha and Isaiarasu, 2010) and 'Aloe' (Deshmukh and Khyade, 2013) tonic treated mulberry leaves influence the cocoons, pupal and growth parameters of *B. mori*. Numerous scientific studies on *Aloe vera* had demonstrated its analgesic, anti-inflammatory, wound healing, immune modulating and anti-tumor activities as well as antiviral, antibacterial and antifungal properties. Besides, *Aloe vera* products are also used in pharmaceutical and food industries. *Aloe vera* contains over 75 nutrients and 200 active compounds, including vitamins, enzymes, minerals, sugars, lignin, anthraquinones, saponins, salicylic acid and amino acids (Park and Jo, 2006). Preparations of *Aloe* are, therefore, used both topically and as dietary supplement.

The influence of the dietary supplementation of the herbal tonic "Alloe" containing principally the extract of *Aloe vera* Linne. on the growth and the cocoon characteristics of the mulberry silkworm *Bombyx mori* L. commercial cross breed race L x CSR2 during its fifth instar was experimented. This, in general, elicited better response of the growth and the cocoon characteristics of this silkworm. Specifically, the *Aloe vera* tonic at 2.0 per cent concentration resulted higher larval growth and increased the weight of cocoon. The mean larval weight, relative growth rate, effective rearing rate, larval consumption index of the final instar larvae of *B. mori* increased with this supplementation of *Aloe vera* tonic. The average pupal weight and mother moth weight also increased as a result of this supplementation. Maximum shell weight and shell ratio were noted in the experimental sets treated with the *Aloe vera* tonic. In addition, the fibroin content of the cocoon shell produced by this silkworm in response to the dietary supplementation of *Aloe vera* tonic treatment also showed significant increase over the control. The growth and the cocoon parameters could be improved with the supplementation of *A. vera* commercial preparations (Manimuthu and Isaiarasu, 2010).

The application of *Aloe vera* oil on the silkworm has been proved to be significant in sericulture industry. Recently Tiwari *et al.* (2014) have reported that if applied tactfully, may boost up the formation of good cocoons at commercial scale. There experiments were conducted with *A. vera* oil in 0.25, 0.50, 0.75 and 1.0 ml as single, double and triple treatment against 3rd, 4th and 5th instar larvae. The maximum fecundity ($409.66 \pm 3.31\%$) and hatchability ($96.75 \pm 1.22\%$) (Sing *et al.*, 2014) and the maximum larval weight (1.807 ± 0.094 g) and larval length (6.728 ± 0.567 cm) have been observed in case of triple treatment with 0.75 ml amount of *A. vera* oil.

Fortification of mulberry leaves with the flour of black gram and red gram to improve the larval growth and cocoon characteristics in *B. mori*. Subburathinam and Krishnan, (1998) have noticed soya bean meal to accelerate the larval growth significantly at certain level when supplemented along with food to the silkworm *B. mori*. Sarkar *et al.* (1993) reported that growth of larvae *B. mori* significantly improved when they were fed on mulberry leaves supplemented with different nutrients such as soya milk, milk powder, sugars, vitamins and amino acids. Supplementation of mulberry leaves with potato leaf extracts at growth stage, at 1:4 concentrations significantly improved the economic parameters (higher mature larval weight, cocoon weight, shell weight and shell percentage) of silkworm.

Ganesh Bhawane *et al.* (2014) evaluated the lysosomal and microsomal acid phosphatase activity in midgut tissue of silkworm larvae, *Bombyx mori* L. after induced oxidative stress by D-galactose. The larvae were simultaneously treated with ethanolic extracts of *Bacopa monniera* and *Lactuca sativa* to study their antioxidant properties. Lipid peroxidation and fluorescence was measured to analyze extent of oxidative stress. The ethanolic extract of *Lactuca sativa* was found to be more effective in protecting membranes against oxidative stress than *Bacopa monniera*.

Impact of feeding of Japanese weed leaves (*Mikania micrantha*) on amino acid concentrations of silk fiber of eri silkworm, *Samia ricinii* Donovan has been

investigated by Devi (2012). In Devi's investigation, the improvement of alanine, glycine, and tyrosine in the larvae fed with *Mikania micrantha* from III instar till maturity were 1.65%, 2.68% and 8.31% over control. The increased amino acid concentration in silk fiber may be due to *Mikania micrantha* for its role on growth and metabolic activity in the silk gland of *Samia ricini* Donovan.

Amirmohammadi *et al.* (2013) evaluated the methanol extract of the plant *Pteridium aquilinum* (Dennstaedtiaceae), was used in 3 concentrations (i.e. 1.25, 2.5 and 5%) dissolved in distilled water and sprayed on leaves fed on first two days of 3rd, 4th, and 5th instar larvae of *Bombyx mori* in 3 replications of 100 insects in each replicate and a control with distilled water treatment. Results showed that, the highest silk gland weight belonged to control (0.45 ± 0.15 g), the highest cocoon weight (60.235 ± 6.98 g), cocoon shell weight (19.5 ± 2.59 g), number of best cocoon (53) was that of 2.5% concentration.

Senthamarai Selvi *et al.* (2014) mentioned that the treatment of *Spinacia oleracea* at the concentration of 25% may have beneficial effects on the growth of the silkworm larval and pupal length, width and weight and also increased the quantity of silk production by enhancing the feed efficacy than control. So, this supplementation could be prescribed to the farmers to get more quantity of silk.

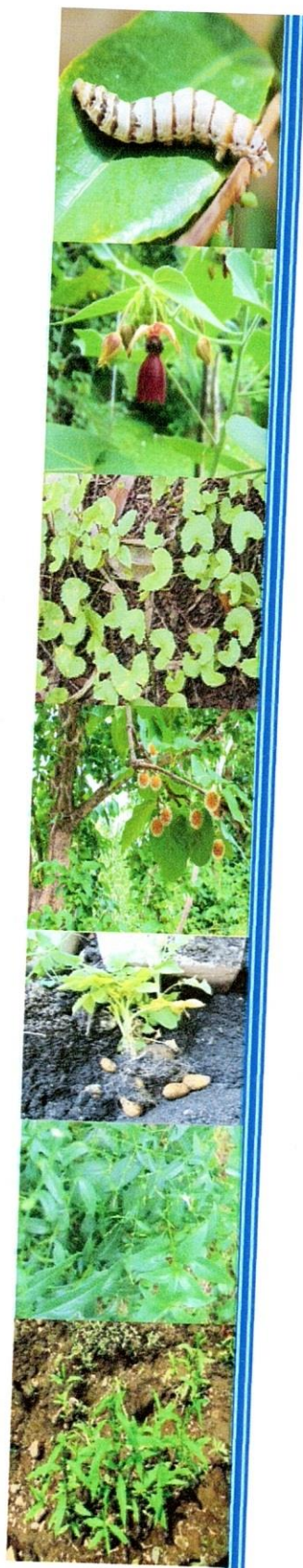
Ganesh Bhawane *et al.* (2014) studied on the Effect of ethanolic plant extracts on BmNPV inoculated silkworm *Bombyx mori* in relation with midgut antioxidant enzymes, acid phosphatase and non-specific esterase. The weed plants are being tried to increase the silk and egg production in mulberry silk worm *Bombyx mori* as well as eri silk worm, *Samia cynthia ricini* Bois. Shivkumar *et al.* (1995) reported weed plant *Cassipourea* extracts in accelerating the maturity of *Bombyx mori*. Similarly, dusting of *Lantana camara* and *Clearodendron inermae* at 5% has increased silk and fecundity by eri silk worm (Mamadapur, 1994). The leaves of weed plant *Mikania micrantha* had been found to have significant effect on growth, development and yield of eri silk worm, *Samia cynthia ricini* Donovan (Devi, 2010).

The effect of plant extract containing phytoecdysteroids (β -ecdysone) on the spinning behavior of silkworms (NB4D2 $\times$ SH6) and (SK28 $\times$ SK30) was investigated by Rufaie *et al.* (2012). Fully grown larvae of 5th instar were fed with mulberry leaves sprayed with different concentrations of methanol extracts of leaves of the plant *Taxus wallichiana* Zucc. (Himalayan Yew), *Cupressus tularosa* Linn (Cupreous) and *Datura stramonium* Linn. (Datura) also with control batches and a group receiving mounting hormone (branded hormone SAMPOORNA), were maintained in similar conditions. These hybrids treated silkworms showed spinning behavior within 6-10 hours where as mounting process took 24 hours in plant extract sprayed batches and also branded hormone sprayed batches.

A new approach has captured worldwide from *Hyalophora cecropia*, attention in the control of growth and development in insects. Delay in moulting is probably due to the inhibitory action of JH on ecdysone synthesis in *B. mori* (Parlak *et al.*, 1992; Trivedy *et al.*, 1997). Some plants like *Pinus longifolia*, *Abies balsamea*, *Psoralea corylifolia* and *Azadirachta indica* act on *Bombyx mori* larvae as bioactive juvenoid compounds (Nair *et al.*, 2009).

Thulasi and Sivaprasad (2014) suggested lemon juice (LJ) as a profitable supplementary diet for silkworm. Minimum effective concentration of LJ was determined and its positive impact demonstrated on *B. mori*, with reference to larval growth, protein profiles and economic parameters of sericulture. LJ works well at a concentration of 3% in distilled water and stimulates growth rates in silkworm larvae during fourth and fifth instar developmental stages, but more effectively during fifth instar. It stimulates fibroin (core silk protein) synthesis and retards floss protein synthesis in silk gland, more particularly in its anterior region. Further, lemon juice promotes protein mobilization from fat body to silk gland via haemolymph. In doing so, it contributes to sericulture industry by causing improvements in profit making economic traits such as gland-body ratio, cocoon weight, shell weight, raw silk weight, denier and renditta and by reducing the production of floss, which contributes to loss in the sericulture industry.

From the above review it is crystal clear that plants are the richest source of organic chemicals on earth and phytochemicals have been reported to influence the life and behaviour of different insects. Different plant parts supplementation play an important role on the growth and development of the mulberry silkworm. Various extracts of medicinal plants have been tested by supplementation in the silkworm feed and were seen to influence the body weight, silk gland weight and the silk thread length. It is also evident from this review that not a single attempt has been initiate for the utilization of different plant materials as food supplement for the improvement of ifferent economic traits of *Bombyx mori* in Banglaesh.



CHAPTER-3

Materials and Methods

3. Materials and Methods

The materials of the present experiments comprised of an indigenous multivoltine variety of silkworm, *Bombyx mori* L., popularly known as Nistari. Other materials include host plant of silkworm, i.e. mulberry leaves of *Morus alba* species maintained in the garden of Zoology Department of Rajshahi University. Six test plants selected for food supplementation, which are *Abroma augusta*, *Centella asiatica*, *Neolamarckia cadamba*, *Solanum tuberosum*, *Persicaria acuminata* and *Andrographis paniculata*. Description of the selected silkworm variety, host plant and test plants are given below:

3.1 Description of Nistari variety of *B. mori*

3.1.1 Nistari

This variety is also called as Nistri or Madrassi. It is a long-established variety of indigenous origin (Jolly, 1983a) supposed to be introduced in this region of sub-continent during the nineteenth century (Datta, 1984). This multivoltine race is continuously being reared not only for producing Cross Breed hybrids, but also as a commercial indigenous race. It was introduced in 1881 from China and continues to dominate commercial rearing in the entire North India, especially in the then Bengal (Ganga and Chetty, 1999). The larvae are small and spin spindle-shaped, soft and flossy cocoons of golden-yellow colour. In spite of the introduction of several high-yielding crossbreed varieties, it continues to hold its status as a commercial breed. The ease with which it can be handled, its ability to tolerate poor quality leaves, its low consumption rate enabling rearing of more worms from the same amount of leaves, its lesser space requirements so that more worms can be accommodated and harvested from the same rearing house, are factors that weigh with the rearers.

Unlike the cross-breeds, it can withstand the high humidity of heavy rainy season and the dry spells which are characteristic of Bangladesh. It is more resistant to diseases than the cross-breeds. Farmers have experienced less crop failures with this race and prefer to rear this race from March to September and only from October to February they are prepared to try out the high yielding commercial hybrids.

The main demerits of this race are-poor cocoon weight, thin shell and inferior quality of silk fibre. Yet from 100 dfls of this race following traditional method 10-15kg of cocoons is sure to be harvested and the yield can be increased to 15-20 kgs by adopting no technology of rearing.

3.2 Description of host plant and test plants

Host species of mulberry plant selected for the present investigation is *Morus alba* L. The detailed description of host plants and six test plants, viz. *A. augusta*, *C. asiatica*, *N. cadamba*, *S. tuberosum*, *P. acuminate* and *A. paniculata*. are included in the Introduction Chapter, Section 1.4.1 for mulberry plant, *M. alba* and in the Section 1.4.2 for six selected test plants.

3.3 Silkworm rearing:

Silkworm rearing is a complicated process which requires various technical aspects, specific management skill, due understanding and experience. The practice of sericulture consists of two major activities, viz. cultivation of mulberry plant for producing disease free leaf crop to feed the silkworm larvae and the rearing of silkworm larvae to produce the cocoon which is the raw material for the silk reeling industry. For silkworm rearing a model scientific rearing house is a pre-requisite for a good harvest of quality cocoon crop. The description of the rearing house and the environmental control in the rearing house during the course of rearing in the present investigation are given as follows:.

3.3.1 Rearing house: Rearing of silkworm needs certain environmental requirements in respect of temperature and humidity. The rearing of present experiment was conducted in the Sericulture Research Laboratory, Department of Zoology, University of Rajshahi, which satisfies all the requirements of an ideal rearing house. The length and breadth of the rearing house is 7 and 5 meters respectively. It has 4 windows and one door which are fitted with wire nets and glass. The ceiling of the room was quite high (4.5m) and wide fluctuations in environmental conditions outside the room did not affect seriously the room conditions.

Environmental control in the rearing house: During summer, when the dry temperature prevailed, the windows of the laboratory were kept open during night and during winter the door and windows were kept closed at night. To check humidity in dry season the floor was moistened with water.

3.3.2 Rearing appliances:

In the rearing house following equipment were used for rearing and maintaining silkworms:

Rearing almirahs: Netted almirah (1.5×0.7×2.5 m) was used for the rearing of silkworm. Each almirah consists of five racks, on which rearing trays were placed containing the silkworm. It protected the larvae, pupae and adults from the attack of parasites and predators like Tachinid flies, ants, lizards, rats etc.

Rearing trays: Rearing trays are portable receptacles for keeping worms during rearing. There are many kinds of trays differing from one another in materials, shape and size. During the rearing of the present experiment rearing trays made of wooden frame having a hard board at bottom (25×40×6) was utilized so that they were light and easy to handle.

Foam pads: Long foam pads (2.5×2.5cm²) thick dipped in water were kept around the silkworm rearing beds during first and second instars for maintaining optimum humidity in the rearing beds (Krishna swami, 1979).

Leaf chamber: A simple leaf chamber made up of a frame work of wooden strips was used for the preservation of harvested mulberry leaves as fresh as possible. Storing of leaves in the chamber prevent the withering and quality deterioration. Wet gunny mats were used on the chamber. The gunny mats were sprayed with water periodically to keep them wet.

Feathers: White bird feathers were used for bushing newly hatched larvae and also changing beds in the early stages. The use of feather during brushing saved the worms from the injurious contact of hand.

Chopsticks: Chopsticks are made of bamboo or wood about 17.5 cm long with the girth and tapering at one end. They were used for picking the young stage larvae. This ensures hygienic handling of delicate worms, and also prevents damage to them.

Chopping board, knives and mats etc: For feeding the young silkworm larvae mulberry leaves should be chopped. For this reason a chopping board made of soft wood with size of (40×40×3.5 cm.) and a sharp chopping knife were used for cutting mulberry leaves in different sizes as to feed silkworm larvae. Mats were used at the time of chopping leaves. A plastic basin or use as receptacle for chopped leaves for young stage worms was also used.

Cleaning nets: To remove old mulberry leaves, facial matters of silkworm, and dead worms, cleaning nets were spread on the bed before feeding. Bed cleaning nets made of cotton thread with different meshes suit to the size of the silkworms were used. Following mesh size were used for cleaning beds in different instar. Uses of cleaning nets saved the time during transfer of larvae from one tray to another tray and protect the larvae from rough handling as practiced in the traditional method of rearing.

Age of silkworms	Net mesh
1 st instar	2mm × 2mm
2 nd instar	2mm × 2mm
3 rd instar	10mm × 10mm
4 th instar	20mm × 20mm
5 th instar	20mm × 20mm

Mountages: Mountages were used for the mature larvae to pain cocoons. In the present experiment locally made “Chandraki” was used as mountage. This comprises a rectangular bamboo mat on which a spiral of bamboo tape is fixed. The tap is 4 cm. wide and the gap between the spirals was 4 cm. The size of the “Chandraki” was 90cm × 60 cm.

Polythene paper and bags: Thick polythene paper was used for keeping the beds of early age silkworm (1st and 2nd instar)covered, so as to prevent withering of chopped leaves and also to maintain the desired humidity in rearing bed in the low relative condition (<86°C). Polythene bags were used for collecting fresh mulberry leaves and also to keep the treated leaves as fresh as possible and to avoid mixing with other treatment.

Thermometers and hygrometers: Dry and wet bulb thermometers and hygrometers were used to record daily temperature and relative humidity.

Ant wells: Ants are a serious menace of silkworms. As such it is necessary to rest the rearing almirahs on ant wells. During the rearing of the present experiment cement concrete ant wells were used, in which half of the wells is filled with water and kerosene.

Other appliances: Feeding stands with small wooden contrivances having cross legs about 0.95 meters high were used for keeping the trays during feeding, cleaning etc. Some breakers were used to prepare solution. Aluminium lids for mating, white

egg-cards etc. were used. An electronic balance was used for weighting the developmental stages of the silkworm.

3.3.3 Rearing techniques:

The silkworm rearing techniques followed in the present investigation were as follows:

Disinfection: Since silkworms are very much susceptible to diseases, they must be reared under a germ free condition. To prevent diseases and to maintain good sanitation the rearing room and other rearing appliances were disinfected with a 2% formaldehyde solution and sometimes with bleaching powder (1% chlorine) solution following the procedure suggested by Ullah and Narasimhanna (1978).

Incubation and disinfection of eggs: The eggs were incubated at $25^{\circ}\pm 1^{\circ}\text{C}$ and humidity $80\%\pm 5\%$. Normal daylight and dark in the night were maintained throughout the incubation period. A black pin-like spot appeared on the egg two days before hatching and on the next day it turned completely blue called body pigmentation of the egg. The eggs at this stage were disinfected with 2% formaldehyde solution for five minutes (Jolly, 1983). Immediately after washing and drying, eggs were transferred to the rearing house.

Hatching and brushing: The worms hatch out generally in the morning. During the blue head stage, eggs were preserved in dark until several newly-hatched worms were obtained. On the day of hatching eggs were exposed suddenly to a bright light at 8 am, which ensured uniform hatching.

The process of transferring of the newly hatched silkworms to rearing tray is called "brushing", which was performed with a feather following the brushing technique of Ullal and Narashimhanna (1978). Very finely chopped tender mulberry leaves were spread over the worm for feeding worms. Hatching in first two days were used for rearing.

Feeding of the silkworm larvae: The newly hatched larvae are very active. They constantly use to move until they find mulberry leaves for feeding. On no account the worms were fed on wet, dirty, dusty, diseased, fermented, dried or ripe, yellow leaves nor were the worms given too many leaves at a time.

For feeding the silkworm larvae, fresh and succulent leaves were harvested from the mulberry garden of Department of Zoology, Rajshahi University. Feeding was provided a per feeding schedule the present experiment supplemented with different plant materials

The recommended size of the chopped leaves by Krishnaswami (1979) was followed for feeding early three instars. The fourth and final instar larvae were fed with whole mature leaves. At all stages, the worms were fed four times a day at an interval of six hours, i.e. at 4 am, 10 am, 4 pm and 10 pm. There was no feeding during moulting periods. The recommended size of the chopped leaves by Krishnaswami (1979) for feeding early three instars are given below:

Age	Size of leaf
1 st instar	0.5cm – 2.0cm
2 nd instar	2.0cm – 4.0cm
3 rd instar	4.0cm – 6.0cm

Bed cleaning: As the larvae grow, the unconsumed mulberry leaves exuvae, dead larvae etc. in the bed increases, which make the bed feverish. This may cause the multiplication of pathogen and release obnoxious gases. Hence periodic cleaning of the larval bed is necessary. The removing of these unwanted matters from the rearing bed is known as bed cleaning. For maintaining the sanitation in the rearing bed, it would appear that more frequent the cleaning, the better would be the health of silkworm larvae. Since cleaning involves labour, therefore frequent cleaning would not be economic for silkworm rearing. Moreover, frequent cleaning will inevitably causes the loss of worms especially in the early stages. Considering the

above point, the following schedule of bed cleaning was adapted in the rearing of the present investigation:

Age	No. of bed cleaning	Time of bed cleaning
1 st instar	1	Before first moult.
2 nd instar	2	Just after first moult and again before setting for second moult.
3 rd instar	3	Just after moult, in the middle of the age and again before setting for next moult.
4 th and 5 th instar		Daily in the morning.

Instead of the traditional method of bed cleaning, scientific methods i.e. "combined husk and net method" and sometimes "net method" were followed as suggested by Ullal and Narasimhanna (1978).

Care at moulting: Moulting is a critical and delicate phase in the larval life. Rearing management during this period is therefore very important for the growth and development of larvae. During the entire larval period the worms moult four times and gradually grow bigger and bigger in size. When at moult, they stop feeding, become motionless, raise head a little and the body becomes shortened. This stage may last for 24-48 hours in different insters. Towards the end the head and foreparts are gradually lowered and finally, the worms begin to stretch their body in an effort to cast their old skin off. By adulatory movements and wriggling, the body completely casts off the skin and becomes free.

At the time of moulting, the worms require comparatively dry conditions. To achieve this, bed was kept thin through spreading the bed with choop stick. Leaves were also cut to a smaller size for feeds just prior to moulting. Feeding was stopped as soon as 90-95% of the worms have settled down for moult. Lime powder was sprinkled on the bed after the last feed. This prevents the worms to start feeding which have come out of moult early and thus maintaining uniformty in growth.

Unsettled worms are separated and rejected before dusting the lime. The treatment of lime powder also helps to reduce the bed humidity and dries the left over leaves quickly. Resumption of feeding was done only after more than 95% of the worms have come out of moult. Tender leaf is given at the time of resumption after applying bed disinfectant and waiting for 30 minutes.

Spacing: Silkworm is a very fast growing insect. The larvae of which show a fantastic rate of growth and exhibit a many fold increase both in weight and size. With the advancement of the larval age, the bed becomes narrow and over crowded. Therefore, it is necessary to extent the rearing beds from time to time in order to avoid over crowding of the worms and to afford orderly growth of the larvae. During the present study bed spacing suggest by Sengupta (1978) was followed.

Age of the worms	Bed spacing
1 st instar and 2 nd instar	Length× Breadth × no. of worm × 1.02
3 rd instar	Length× Breadth × no. of worm × 2.02
4 th and	Length× Breadth × no. of worm × 3.00
5 th instar	Length× Breadth × no. of worm × 4.00

Mounting and harvesting: At the end of 5th instar larvae reduce consuming leaf, Shrink in size, body becomes translucent and release soft wet excreta. At that time the larvae start crawling and search suitable place for spinning cocoons raising their head. Larvae showing these symptoms are collected from the rearing bed and were placed on the bamboo-made mountages called "Chandraki". Soft and watery faces from the mountage were removed by keeping the mountage in an inclined position for two hours. Cocoons were harvested after 4-5 days of mounting.

Segregation of male and female insects: Pupae are the most convenient stage to identify and to separate males and females. The cocoons were cut open obliquely at one end and the sexes were separated by observing the genital marking at the postero-vental side of the pupae. The presence of a v-shaped genital marking at the

ventral side of the last abdominal segment indicates a female pupa and on the other hand, in males a pair of very close dots is found in the same place. Normally the female pupae are larger and heavier than the males. The sexed pupae with their shells were kept separately in the trays to avoid their mixing.

Emergence of moths: The duration of pupal period depends on the breeds as well as temperature conditions, i.e. moth emerges after 9-14 days from the day of spinning. Before emergence of moth some changes are evident in the pupa, such as, darkening of the eyes, demarcation of legs and wings and softening of the pupal body. When the pupae show these symptoms, the cocoon preservation trays kept dark one day prior to emergence. On the day of emergence bright light was provided in the early morning by about 4.00 am. The male moths started emerging earlier than the female. The adults come out by dissolving one end of the shell as moths. Not more than 5-8 minutes was taken for their emergence and within 45 minutes to an hour, they become fully active and were prepared for mating.

Coupling: After emergence the fresh moths were allowed to mate. Coupled moths were transferred to another tray, and left undistributed under a semi-dark condition. Coupling normally took place between 16-18 hours of emergence and the natural duration for coupling was 24 hours although 3-6 hours are adequate (Ullal and Narasimhanna, 1978). Each couple was then placed on a clean rough paper and covered with an aluminum lid to check them from vivid light and other environmental disturbances.

Egg laying: After 3-4 hours of mating the moths were separated by holding the female moth gently sliding the male anticlock wise with fingers. The female moths were then kept under plastic lids. After completion of egg-laying they were discarded and egg-cards were preserved for next rearing and counting of the ggs to record fecundity and fertility.

Incubation and disinfection of eggs: The eggs were incubated under controlled temperature $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and humidity $80 \pm 5\%$ condition. Normal day light and dark in

night was maintained throughout the incubation period. A black pinhead on the egg two days before hatching and next day it turned completely blue called body pigmentation stage. The eggs at this stage were disinfected with 2% formaldehyde solution for five minutes. Immediately after washing and drying eggs was transferred to the rearing house.

Hatching and brushing of larvae: During the body pigmentation stage or blue head stage, the eggs were preserved in dark condition until several newly hatched worms came out of eggs. On the day of hatching, eggs were exposed suddenly to bright light at 8.00 am which ensured a uniform hatching of the eggs. The hatched larvae are called "Keego" or "Ant". The processes of transferring the silkworm to rearing tray is called "brushing" which was performed around 9.00 am. with a feather following the brushing technique of Ullal and Narasimhanna (1978). During transforming of the newly hatched larvae to a rearing tray very fine chopped larvae (0.5 sq. cm.) were spread over the eggs cards. When the larvae crawled into it and started feeding, the newly hatched larvae were separated from the egg cards to the rearing tray by gentle strokes with a feather and tapping the egg cards at 10.00 am.

3.4 Record of experimental data:

Following characters were selected for the present investigation. Method of data collection of these traits has been described as follows:

Weight of mature larvae (WML): The weight of mature larva was taken at the end of the 5th instar, *i.e.* one day before spinning. Fifteen larvae were collected at random from each rearing-bed. Individual weight of these larvae was taken in gram on an electronic balance. A mean of 15 observations for each replication was used for statistical analysis.

Length of mature larvae (LML): The length of mature larva was taken at the end of the 5th instar, *i.e.* one day before spinning. Fifteen larvae were collected at random from each rearing-bed. Individual length of these larvae was taken in

millimetre. A mean of 15 observations for each replication was used for statistical analysis.

Breadth of mature larvae (BML): The breadth of larva was also taken at fully mature stage, *i.e.* one day before spinning in the mid abdominal segment. Fifteen larvae were collected at random from each rearing-bed. Breadth of randomly picked individual larvae was taken in millimetre. A mean of 15 observations for each replication was used for statistical analysis.

Pupal weight (PW): The weights of pupa were taken at the end of pupal period, *i.e.*, two days before emergence. Individual pupal weight for 15 pupas per replication was taken in gram by an electronic balance. Mean weight of 15 pupae per replication was used for statistical analysis.

Larval period (LP): Larval period was calculated from the date of brushing to date of pre pupa formation, which was recorded in days from the log sheet of rearing for each replication separately.

Pupal period (PP): Pupal period constitute the days between the date of pupa formation in the cocoon and emergence of moth from the cocoon. The data collected from 15 individual pupa for each replication separately are used for statistical analysis.

Surviving percentage (SP): Collection of data on surviving percentage Is based on the record of larval count at the third instar just after the second moult. and the larvae survived up to spinning. This was thought reasonable due to less larval mortality in the first two larval instars and most of the larvae survived spin cocoons. The surviving percentage is computed by using the following formula:

$$SP = \frac{\text{Total no. of cocoons harvestd}}{\text{Total no. of larvae selected in the early 3rd instar}} \times 100$$

The data collected in percentage for SP were transformed into corresponding angles before statistical analysis (Bliss, 1937).

Cocoon weight (CW): Cocoons were selected randomly from each replication. Individual weight of cocoons was taken in gram by an electric balance. For each replication mean of 15 cocoons weight was used for analysis.

Shell weight (SW): To observe the shell weight cocoons were cut at one end to isolate shell from pupa. Shell weight was then measured from the cocoons selected for cocoon weight. For each replicate, individual weight of 15 shells was taken and the mean over male and female shell weight was used for statistical analysis.

Total number of eggs laid (TED): The total number of eggs laid by the individual female moth was counted. A mean of 15 layings for each replication was used for statistical analysis.

Egg hatching percentage (EHP): For evaluating the fertility of the silkworm, hatching percentage was recorded and following formula is employed for estimating EHP.

$$\text{EHP} = \frac{\text{Total no. of eggs hatched in a laying}}{\text{Total no. of eggs in a laying}} \times 100$$

The data collected in percentage for EHP were transformed into corresponding angles before statistical analysis (Bliss, 1937).

3.5 Collection and extraction of plant materials

3.5.1 Collection of plant materials

The present investigation was undertaken to evaluate growth regulatory properties of six indigenous plant materials as a food supplement in the diet of silkworm

Bombyx mori. The materials of the present investigation comprised of leaf, stem and root of *Abroma augusta*, *Centella asiatica*, *Neolamarckia cadamba*, *Solanum tuberosum*, *Persicaria acuminata* and *Andrographis paniculata*, which were collected from Rajshahi University campus and near by area of the Rajshahi city. For taxonomical identification, it was authenticated by the taxonomist of Department of Botany, Rajshahi University.

After collection the plant parts *i.e.*, leaves, stems and roots were processed through the following way:

Leaves: Leaves were spread out to dry without heaping the material together. It was done under the shade avoiding direct sunshine.

Stems: Stems were processed by cutting into small pieces as thin as possible and thoroughly dried in a well-ventilated room.

Root: Roots were collected by digging up without damaging them and shook and brushed away excess soil without washing them with water. After that the roots were cut into small pieces as thin as possible, and were spread out to dry thoroughly under a shade.

3.5.2 Aqueous extraction of the plant materials

After collection the plant parts were cut into small pieces and dried in a well-ventilated room under shade from 3 to 7 days depending on weather conditions and finally dried in an incubator at 40°C for 12 hours.

The dried plant material is disintegrated by feeding it into a disc pulverizer which has built-in sieves. The particle size is controlled by varying the speed of the rotor clearance between the hammers and the lining of the grinder and also by varying the opening of the discharge of the mill. The plant material is reduced to a size of 40 mesh. The objective for powdering the plant material is to rupture its organ, tissue and cell structures so that its ingredients are exposed to the extraction. Furthermore, size reduction maximizes the surface area, which in turn enhances the mass transfer

of active ingredients from plant material to the solvent. The 30-40 mesh size is optimal, while smaller particles may become slimy during extraction and create difficulty during filtration. The powdered material thus obtained after grinding were stored in an air tight container in the laboratory.

In the next step the powdered material is macerated with water in conical flasks. Cold water is added until the powdered material is completely immersed. It is allowed to stand at room temperature for a period of at least 48 hours with frequent agitation until the soluble matter has dissolved so that water-soluble ingredients attain equilibrium in the water. The mixture is then clarified by filtration through Whatman filter paper and thus the output extracts were collected.

The enriched filtered aqueous extract were then dried in a Vacuum Rotary Evaporator to get dry powder (Plate 8). Evaporated materials are labelled for different plant materials and their parts separately. Finally they are stored in a refrigerator at 4°C.



Plate 8: Vacuum Rotary Evaporator

3.6 Treatment procedure and experimental design

3.6.1 Preparation different doses of plant extracts

Extracts collected from different parts of *A. augusta*, *C. asiatica*, *N. cadamba*, *S. tuberosum*, *P. acuminata* and *A. paniculata* were weighed and dissolved in distilled water according to the proportion of dry weight with a target to prepare 1500 ppm solution. This was considered as stock solution. From this stock solution other dose, viz. 1000 ppm, 500 ppm and 100 ppm selected for the present experiments with each plants were prepared by mixing the requisite quantities of stock solution and distilled water.

3.6.2 Silkworm rearing schedule for experiments with plant extracts

To begin with an experiment was conducted to evaluate the toxicity of the six plants as a food supplement with mulberry leaves. To serve the purpose six consecutive silkworm rearing was conducted separately for each plant to find out their effect on the larval mortality. The rearing schedule has been shown in the following table:

Name of the plant used as food supplement with mulberry leaf	Name of the rearing season corresponding with commercial crop	Date of brushing of silkworm larvae
Potato, <i>Solanum tuberosum</i>	Early Chaita	10 – 15 February, 2010
Biskathali, <i>Persicaria acuminata</i>	Late Chaita	05 – 10 March, 2010
Kadom, <i>Neolamarckia cadamba</i>	Early Jaistha	10 – 15 May, 2010
Kalomegh, <i>Andrographis paniculata</i>	Late Jaistha	01 – 05 June, 2010
Thankuni, <i>Centella asiatica</i>	Bhaduri	03 – 08 August, 2010
Ulot kombol <i>Abroma augusta</i>	Agrahyani	20 – 27 October, 2010

On the basis of the results of larval mortality *Persicaria acuminata* and *Andrographis paniculata* are discarded and the rest four plants, viz. *A. augusta*, *C. asiatica*, *N. cadamba*, *S. tuberosum*, *P. acuminata* and *A. paniculata* were selected for the experiments on food supplementation with mulberry leaves. The rearing schedule for which has been shown in the following table:

Name of the plant used as food supplement with mulberry leaf	Name of the rearing season corresponding with commercial crop	Date of brushing of silkworm larvae
Potato, <i>Solanum tuberosum</i>	Chaita	10 – 15 February, 2011
Kadom, <i>Neolamareckia cadamba</i>	Jaistha	10 – 15 May, 2011
Thankuni, <i>Centella asiatica</i>	Bhaduri	03 – 08 August, 2011
Ulot kombol <i>Abroma augusta</i>	Agrahyani	20 – 27 October, 2012

To study the effect of different plant extracts collected powdered materials were weighed and mixed with required quantity of distilled water. Fresh mulberry leaves were treated by dipping in these solutions and after that these were dried by fanning. Four concentrations of the extracts, i.e., 100 ppm, 500 ppm, 1000 ppm and 1500 ppm were prepared. After then the larvae were fed with mulberry leaves treated by different doses of extracted materials of *A. augusta*, *An. Paniculata*, *C. asiatica*, *N. cadamba*, *P. acuminata* and *S. tuberosum* 3rd to 5th instar. A control batch was also reared treated by distilled water only.

3.6.3 Experimental design

In the present investigation, after disinfection and incubation of collected eggs, the newly hatched larvae were brushed in the rearing trays (25 × 40 cm) and reared up to second instar on fresh mulberry leaves. After second moulting the fresh mulberry leaves were dipped in different concentrations (100 ppm, 500 ppm, 1000 ppm and

1500 ppm) and fed the larvae under three feeding schedules. The feeding schedules are as follows:

Schedule	Code name	Feeding schedule
Feeding schedule-1	FS-1	Fed only in 1st feeding of 3rd to 5th instar larvae
Feeding schedule-2	FS-2	Fed everyday in 1st feeding of 3rd to 5th instar larvae
Feeding schedule-3	FS-3	Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae

The leaves were then dried up by fanning and were supplied to the worms on the respective rearing trays according to concentration of the solution and rearing and feeding schedule. A control batch was also maintained where larvae were reared by mulberry leaves dipped in distilled water only. There were three replications per concentration and in each replication 60 healthy larvae were selected at the end of 2nd instar.

3.6.4 Statistical analyses:

In the experiment on larval mortality when control batch had any mortality, the mortality percentage was corrected using Abbott's formula (Abbott, 1925) as follows.

$$P_t = \frac{P_o - P_c}{100 - P_c} \times 100$$

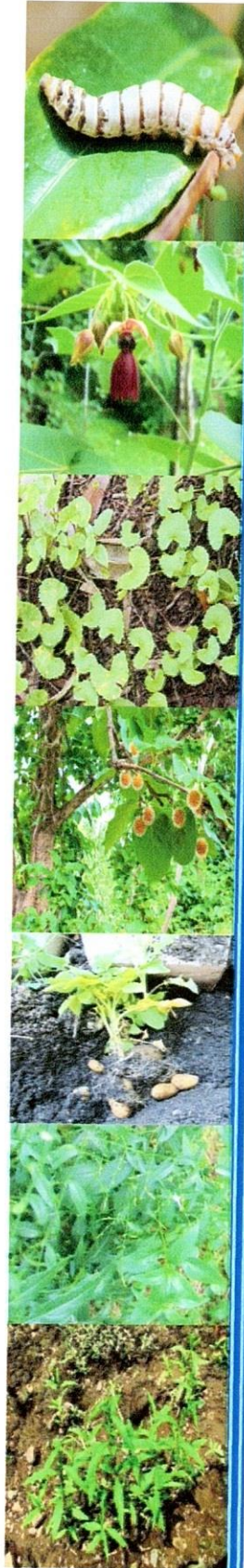
Where, P_t = Corrected mortality % P_o = observed mortality % and P_c = Control mortality %.

The observed data are then subjected to probit analysis according to Finny (1947) and Busvine (1971) using a software developed in the Department of Agricultural and Environmental Science, University of Newcastle Upon Tyne, United Kingdom, which involve different steps of calculations to automatic computation. No

provisional graph or tables are required in this programme. Heterogeneity is tested by a chi-square test. If the probability is greater than 5% an automatic correction of heterogeneity is introduced. Automatic computation of confidence limits for LD_{50} was also a part of this software.

As input of this software data is entered into a linear regression programme, which fits a regression line onto a probit log dose concentration graph. Percentage mortality and dose concentration can be determined from this graph using the probit transformation table. Regression lines were drawn using the Microsoft Excel.

For testing the significance of different parameter on the effect of food supplementation, the collected data were statistically analysed (ANOVA) using Microsoft Excel in a microcomputer.



CHAPTER-4

Results

4. Results

4.1 Effect of different plant extracts on the larval mortality of *Bombyx mori* L.

Initial bioassays were carried out to establish the effect of six plant materials, viz. *Abroma augusta*, *Centella asiatica*, *Neolamarckia cadamba*, *Solanum tuberosum*, *Persicaria acuminata* and *Andrographis paniculata* on silkworm larvae. Relative toxicity by probit analysis for different parts of six plant extracts at different feeding schedules against silkworm larvae have been conducted and are described as follows:

4.1.1 Effect of *Abroma augusta* extract

The mean larval mortality percentage of silkworm due to the effect of three parts, viz. leaf, stem and root of *A. augusta* extracts at different feeding schedules, viz. fed only in 1st feeding of 3rd to 5th instar larvae (FS-1), fed everyday in 1st feeding of 3rd to 5th instar larvae (FS-2), and fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae (FS-3) are presented in the Table 4. Results on the mean mortality percentage of the larvae indicated that all the parts of plant extracts were not effective. Negligible mortality was recorded in the control as well as different treatments.

The LC_{50} values, 95% confidence limit, regression equation and χ^2 values have been presented in Table 10. The detailed dose mortality data of probit analysis are shown in Appendix tables I-IX. The calculated LC_{50} values due to effect of leaf extract were $1.083E+07$ ppm, $6.193E+09$ ppm and $1.985E+09$ ppm at FS-1, FS-2 and FS-3 respectively. For stem extract these values were $5.987E+05$ ppm, $7.229E+06$ ppm and $2.956E+06$ ppm at FS-1, FS-2 and FS-3 respectively. It was also observed that

LC₅₀ values due to effect of root extract were 3.538E+07 ppm, 7.229E+06 ppm and 3.785E+11 ppm at FS-1, FS-2 and FS-3 respectively (Table 10).

The regression lines for the toxicity of *Abroma augusta* leaf, stem and root extracts against silkworm larvae at different feeding schedules are shown in Fig. 1.1 – 1.9.9.

The LC₅₀ values for different parts extracts at different feeding schedules implied that different parts of *Abroma augusta* extract showed negligible larval mortality.

4.1.2 Effect of *Centella asiatica* extract

The mean larval mortality percentage of silkworm due to the effect of three parts, viz. leaf, stem and root of *C. asiatica* extracts at different feeding schedules, viz. FS-1, FS-2 and FS-3 are presented in the Table 11. Results on the mean mortality percentage of the larvae indicated that all the parts of plant extracts were not effective.

The LC₅₀ values, 95% confidence limit, regression equation and χ^2 values have been presented in Table 11. The detailed dose mortality data of probit analysis are shown in Appendix tables X-XVIII. The calculated LC₅₀ values due to effect of leaf extract were 3.538E+07 ppm, 3.627E+07 ppm and 4.004E+10 ppm at FS-1, FS-2 and FS-3 respectively. For stem extract these values were 1.655E+09 ppm, 1.084E+11 ppm and 4.938E+10 ppm at FS-1, FS-2 and FS-3 respectively. It was also observed that LC₅₀ values due to effect of root extract were 1.109E+09 ppm, 3.538E+07 ppm and 2.808E+08 ppm at FS-1, FS-2 and FS-3 respectively (Table 11).

The regression lines for the toxicity of *C. asiatica* leaf, stem and root extracts against silkworm larvae at different feeding schedules are shown in Fig. 2.1-2.9.

The LC₅₀ values for different parts extracts at different feeding schedules indicated that different parts of *C. asiatica* extract showed no effective mortality.

4.1.3 Effect of *Neolamarckia cadamba*. extract

The mean larval mortality percentage of silkworm due to the effect of three parts, viz. leaf, stem and root of *N. cadamba* extracts at different feeding schedules, viz. FS-1, FS-2 and FS-3 are presented in the Table 6. Results on the mean mortality percentage of the larvae indicated that all the parts of plant extracts were not effective to induce mortality. Negligible mortality was recorded in the control as well as different treatments.

The LC_{50} values, 95% confidence limit, regression equation and χ^2 values have been presented in Table 12. The detailed dose mortality data of probit analysis are shown in Appendix tables XIX-XXVII. The calculated LC_{50} values due to effect of leaf extract were $3.275E+12$ ppm, $4.938E+10$ ppm and $4.639E+06$ ppm at FS-1, FS-2 and FS-3 respectively. For stem extract these values were $1.084E+11$ ppm, $1.109E+09$ ppm and $1.108E+09$ ppm at FS-1, FS-2 and FS-3 respectively. It was also observed that LC_{50} values due to effect of root extract were $5.902E+06$ ppm, $4.925E+09$ ppm and $3.538E+07$ ppm at FS-1, FS-2 and FS-3 respectively (Table 12).

The regression lines for the toxicity of *N. cadamba*. leaf, stem and root extracts against silkworm larvae at different feeding schedules are shown in Fig. 3.1-3.9.

The LC_{50} values for different parts extracts at different feeding schedules implied that different parts of *Neolamarckia cadamba* extract showed very low mortality.

4.1.4 Effect of *Solanum tuberosum* extract

The mean larval mortality percentage of silkworm due to the effect of three parts, viz. leaf, stem and root of *S. tuberosum* extracts at different feeding schedules, viz. FS-1, FS-2 and FS-3 are presented in the Table 4. Results on the mean mortality percentage of the larvae indicated that all the parts of plant extracts were not effective. With the increase of the dose of the extracts of all the plant materials

mortality of the larvae were not increased and negligible mortality was recorded in the control as well as different treatments.

The LC_{50} values, 95% confidence limit, regression equation and χ^2 values have been presented in Table 13. The detailed dose mortality data of probit analysis are shown in Appendix tables XXVIII-XXXVI. The calculated LC_{50} values due to effect of leaf extract were $3.317E+08$ ppm, $4.522E+08$ ppm and $3.538E+07$ ppm at FS-1, FS-2 and FS-3 respectively. For stem extract these values were $7.229E+06$ ppm, $7.912E+07$ ppm and $8.428E+06$ ppm at FS-1, FS-2 and FS-3 respectively. It was also observed that LC_{50} values due to effect of root extract were $6.816E+08$ ppm, $8.884E+07$ ppm and $1.749E+06$ ppm at FS-1, FS-2 and FS-3 respectively (Table 13).

The regression lines for the toxicity of *S. tuberosum* leaf, stem and root extracts against silkworm larvae at different feeding schedules are shown in Fig. 4.1-4.9.

The LC_{50} values for different parts extracts at different feeding schedules implied that different parts of *S. tuberosum* extract showed no effective mortality.

4.1.5 Effect of *Persicania acuminata* extract

The mean larval mortality percentage of silkworm due to the effect of three parts, viz, leaf, stem, root of *P. acuminata* extracts at different feeding schedules, viz. FS-1, FS-2 and FS-3 are presented in the Table 5. Results on the mean mortality percentage of the larvae indicated that all the plant extracts were effective. With the increase of the dose of the extracts of all the plant materials mortality of the larvae increased. A few mortality was recorded in the control at different treatment.

The LC_{50} values, 95% confidence limit, regression equation and χ^2 values have been presented in Table 14. The detailed dose mortality data of probit analysis are shown in Appendix tables XXXVII-VL. The calculated LC_{50} values due to effect of leaf extract were $2.073E+04$ ppm, $1.726E+04$ ppm and $2.129E+03$ ppm at FS-1, FS-2 and FS-3 respectively. For stem extract these values were $1.935E+05$ ppm,

1.697E+06 ppm and 1.009E+05 ppm at FS-1, FS-2 and FS-3 respectively. It was also observed that LC_{50} values due to effect of root extract were 7.539E+04 ppm, 1.966 E+04 ppm and 1.094E+05 ppm at FS-1, FS-2 and FS-3 respectively (Table 8).

The regression lines for the toxicity of *P. acuminata* leaf, stem and root extracts against silkworm larvae at different feeding schedules are shown in Fig. 5.1-5.9

The LC_{50} values for different parts extracts at different feeding schedules implied that different parts of *P. acuminata* extract produced the highest mortality in comparison to mortality caused by *A. paniculata* extract produced the higher mortality than *A. augusta*, *C. asiatica*, *N. cadamba* and *S. tuberosum*..

4.1. 6 Effect of *Andrographis paniculata* extract

The mean larval mortality percentage of silkworm due to the effect of three parts, viz. leaf, stem and root of *A. paniculata* extracts at different feeding schedules, viz. FS-1, FS-2 and FS-3 are presented in the Table 6. Results on the mean mortality percentage of the larvae indicated that all the parts of plant extracts were effective. With the increase of the dose of the extracts of all the plant materials, mortality of the larvae increased. Little mortality was recorded in the control at different treatment.

The LC_{50} values, 95% confidence limit, regression equation and χ^2 values have been presented in Table 14. The detailed dose mortality data of probit analysis are shown in Appendix tables IVL-LIV. The calculated LC_{50} values due to effect of leaf extract were 8.035E+04 ppm, 3.881E+05 ppm and 3.800E+05 ppm at FS-1, FS-2 and FS-3 respectively. For stem extract these values were 2.692E+05, 6.102E+05 ppm and 2.302E+05 ppm at FS-1, FS-2 and FS-3 respectively. It was also observed that LC_{50} values due to effect of root extract were 7.995E+04 ppm, 9.838E+05 ppm and 9.067E+05 ppm at FS-1, FS-2 and FS-3 respectively (Table 15).

The regression lines for the toxicity of *A. paniculata* leaf, stem and root extracts against silkworm larvae at different feeding schedules are shown in Fig. 6.1-6.9

The LC_{50} values for different parts extracts at different feeding schedules implied that different parts of *A. paniculata* extract produced the higher mortality than *A. augusta*, *C. asiatica*, *N. cadamba* and *S. tuberosum*.

From the results of the present investigation, it is evident that among the selected plants *P. acuminata* and *A. paniculata* are not fit for silkworm rearing as they take a heavy toll of larval mortality during rearing. For that reason, they are discarded at this stage. On the other hand, *A. augusta*, *C. asiatica*, *N. cadamba* and *S. tuberosum* have the potentiality in silkworm rearing as food supplement with mulberry leaves, therefore, they are selected for further investigation.

Table 4. Mean mortality percentage of different parts of *Abroma augusta* water extract under different schedules of feeding on the larval mortality of *Bombyx mori*.

Feeding Schedule	Dose (ppm)	Mean $\pm$ SE		
		Leaf	Stem	Root
FS-1	Control	3.89 $\pm$ 0.56	3.89 $\pm$ 0.56	3.89 $\pm$ 0.56
	100	5.56 $\pm$ 1.47	5.00 $\pm$ 0.96	7.22 $\pm$ 1.47
	500	8.33 $\pm$ 0.00	5.56 $\pm$ 1.47	8.89 $\pm$ 1.47
	1000	8.89 $\pm$ 1.11	6.11 $\pm$ 1.47	10.00 $\pm$ 0.96
	1500	9.44 $\pm$ 1.47	3.89 $\pm$ 0.56	10.56 $\pm$ 0.56
FS-2	Control	3.89 $\pm$ 0.56	3.89 $\pm$ 0.56	3.89 $\pm$ 0.56
	100	8.33 $\pm$ 0.96	6.67 $\pm$ 0.96	6.67 $\pm$ 1.92
	500	8.89 $\pm$ 1.47	8.33 $\pm$ 0.96	8.89 $\pm$ 2.22
	1000	10.00 $\pm$ 0.96	10.00 $\pm$ 0.00	10.00 $\pm$ 1.92
	1500	12.22 $\pm$ 1.47	11.67 $\pm$ 0.96	11.11 $\pm$ 2.00
FS-3	Control	3.89 $\pm$ 0.56	3.89 $\pm$ 0.56	3.89 $\pm$ 0.56
	100	10.56 $\pm$ 0.56	7.22 $\pm$ 1.47	8.33 $\pm$ 0.96
	500	11.67 $\pm$ 0.96	8.33 $\pm$ 0.96	8.89 $\pm$ 1.47
	1000	13.33 $\pm$ 0.96	9.44 $\pm$ 1.47	10.00 $\pm$ 0.96
	1500	14.44 $\pm$ 2.42	12.22 $\pm$ 2.00	11.67 $\pm$ 0.96

FS- 1: Feeding Schedule-1

FS- 2: Feeding Schedule- 2

FS- 3: Feeding Schedule-3

Table 5. Mean mortality percentage of different parts of *Centella asiatica* water extract under different schedules of feeding on the larval mortality of *Bombyx mori*.

Feeding Schedule	Dose (ppm)	Mean $\pm$ SE		
		Leaf	Stem	Root
FS-1	Control	2.78 $\pm$ 1.11	2.78 $\pm$ 1.11	2.78 $\pm$ 1.11
	100	5.56 $\pm$ 0.56	7.22 $\pm$ 0.56	7.22 $\pm$ 1.47
	500	7.78 $\pm$ 1.11	9.44 $\pm$ 1.11	8.89 $\pm$ 1.47
	1000	8.89 $\pm$ 0.56	9.44 $\pm$ 1.47	10.00 $\pm$ 0.96
	1500	9.44 $\pm$ 1.47	11.11 $\pm$ 1.11	11.11 $\pm$ 1.11
FS-2	Control	2.78 $\pm$ 1.11	2.78 $\pm$ 1.11	2.78 $\pm$ 1.11
	100	7.22 $\pm$ 0.56	8.33 $\pm$ 0.96	6.11 $\pm$ 0.56
	500	8.33 $\pm$ 1.67	10.00 $\pm$ 1.67	7.22 $\pm$ 0.56
	1000	10.56 $\pm$ 1.47	10.56 $\pm$ 1.47	8.89 $\pm$ 0.56
	1500	12.22 $\pm$ 1.11	11.67 $\pm$ 1.67	9.44 $\pm$ 0.56
FS-3	Control	2.78 $\pm$ 1.11	2.78 $\pm$ 1.11	2.78 $\pm$ 1.11
	100	9.44 $\pm$ 1.11	7.78 $\pm$ 1.47	6.67 $\pm$ 2.55
	500	10.00 $\pm$ 0.96	8.89 $\pm$ 1.47	7.78 $\pm$ 2.78
	1000	10.56 $\pm$ 0.56	9.44 $\pm$ 2.22	8.89 $\pm$ 2.22
	1500	13.33 $\pm$ 0.00	10.56 $\pm$ 1.47	10.56 $\pm$ 1.47

FS- 1: Feeding Schedule-1

FS- 2: Feeding Schedule- 2

FS- 3: Feeding Schedule-3

Table 6. Mean mortality percentage of different parts of *Neolamarckia cadamba* water extract under different schedules of feeding on the larval mortality of *Bombyx mori*.

Feeding Schedule	Dose (ppm)	Mean $\pm$ SE		
		Leaf	Stem	Root
FS-1	Control	3.33 $\pm$ 0.96	3.33 $\pm$ 0.96	3.33 $\pm$ 0.96
	100	8.89 $\pm$ 1.11	8.89 $\pm$ 0.56	8.33 $\pm$ 0.96
	500	10.00 $\pm$ 0.96	10.56 $\pm$ 1.47	10.00 $\pm$ 0.96
	1000	10.56 $\pm$ 1.47	11.11 $\pm$ 0.56	11.67 $\pm$ 0.96
	1500	12.22 $\pm$ 1.47	12.22 $\pm$ 0.56	13.89 $\pm$ 0.56
FS-2	Control	3.33 $\pm$ 0.96	3.33 $\pm$ 0.96	3.33 $\pm$ 0.96
	100	8.33 $\pm$ 0.00	8.33 $\pm$ 0.96	8.89 $\pm$ 1.47
	500	9.17 $\pm$ 0.68	12.78 $\pm$ 1.47	9.44 $\pm$ 2.00
	1000	9.17 $\pm$ 0.68	6.67 $\pm$ 0.96	10.56 $\pm$ 1.11
	1500	10.00 $\pm$ 1.36	12.22 $\pm$ 1.11	11.11 $\pm$ 0.56
FS-3	Control	3.33 $\pm$ 0.96	3.33 $\pm$ 0.96	3.33 $\pm$ 0.96
	100	5.56 $\pm$ 0.56	8.33 $\pm$ 0.96	6.67 $\pm$ 0.96
	500	6.67 $\pm$ 0.96	9.44 $\pm$ 1.47	7.78 $\pm$ 0.56
	1000	8.33 $\pm$ 0.96	10.56 $\pm$ 2.00	8.89 $\pm$ 2.00
	1500	8.89 $\pm$ 1.47	12.22 $\pm$ 0.56	10.00 $\pm$ 1.92

FS- 1: Feeding Schedule-1

FS- 2: Feeding Schedule- 2

FS- 3: Feeding Schedule-3

Table 7. Mean mortality percentage of different parts of *Solanum tuberosum* water extract under different schedules of feeding on the larval mortality of *Bombyx mori*.

Feeding Schedule	Dose (ppm)	Mean $\pm$ SE		
		Leaf	Stem	Root
FS-1	Control	2.22 $\pm$ 0.56	2.22 $\pm$ 0.56	2.22 $\pm$ 0.56
	100	3.89 $\pm$ 1.47	5.56 $\pm$ 0.56	5.00 $\pm$ 0.00
	500	4.44 $\pm$ 1.11	6.67 $\pm$ 0.96	6.11 $\pm$ 0.56
	1000	5.00 $\pm$ 0.00	7.78 $\pm$ 0.56	7.22 $\pm$ 2.00
	1500	6.67 $\pm$ 0.96	10.00 $\pm$ 0.00	8.33 $\pm$ 1.67
FS-2	Control	2.22 $\pm$ 0.56	2.22 $\pm$ 0.56	2.22 $\pm$ 0.56
	100	5.00 $\pm$ 0.96	8.33 $\pm$ 0.96	4.44 $\pm$ 0.56
	500	5.56 $\pm$ 0.56	9.44 $\pm$ 2.22	5.56 $\pm$ 1.47
	1000	6.67 $\pm$ 1.67	10.56 $\pm$ 0.56	6.11 $\pm$ 1.47
	1500	8.33 $\pm$ 0.00	13.33 $\pm$ 0.96	6.67 $\pm$ 1.67
FS-3	Control	2.22 $\pm$ 0.56	2.22 $\pm$ 0.56	2.22 $\pm$ 0.56
	100	5.00 $\pm$ 0.96	6.67 $\pm$ 0.96	6.11 $\pm$ 0.56
	500	7.22 $\pm$ 1.47	7.78 $\pm$ 0.56	8.33 $\pm$ 0.96
	1000	7.78 $\pm$ 1.47	10.00 $\pm$ 1.67	10.56 $\pm$ 2.00
	1500	9.44 $\pm$ 3.89	12.78 $\pm$ 2.00	12.22 $\pm$ 1.47

FS- 1: Feeding Schedule-1

FS- 2: Feeding Schedule- 2

FS- 3: Feeding Schedule-3

Table 8. Mean mortality percentage of different parts of *Persicaria acuminata* water extract under different schedules of feeding on the larval mortality of *Bombyx mori*.

Feeding Schedule	Dose (ppm)	Mean $\pm$ SE		
		Leaf	Stem	Root
FS-1	Control	5.56 $\pm$ 0.56	5.56 $\pm$ 0.56	5.56 $\pm$ 0.56
	100	31.67 $\pm$ 3.33	27.78 $\pm$ 2.42	33.33 $\pm$ 0.96
	500	33.89 $\pm$ 3.09	28.89 $\pm$ 3.09	32.78 $\pm$ 3.09
	1000	36.67 $\pm$ 3.33	35.00 $\pm$ 2.55	30.00 $\pm$ 0.96
	1500	46.11 $\pm$ 2.00	36.67 $\pm$ 0.96	35.00 $\pm$ 4.41
FS-2	Control	5.56 $\pm$ 0.56	5.56 $\pm$ 0.56	5.56 $\pm$ 0.56
	100	36.11 $\pm$ 1.47	32.22 $\pm$ 2.00	30.56 $\pm$ 1.47
	500	38.89 $\pm$ 2.00	35.00 $\pm$ 1.92	35.00 $\pm$ 1.92
	1000	39.44 $\pm$ 2.42	35.00 $\pm$ 1.92	40.56 $\pm$ 2.42
	1500	48.33 $\pm$ 1.92	39.44 $\pm$ 1.47	41.11 $\pm$ 2.42
FS-3	Control	5.56 $\pm$ 0.56	5.56 $\pm$ 0.56	5.56 $\pm$ 0.56
	100	40.00 $\pm$ 0.96	31.67 $\pm$ 1.92	27.78 $\pm$ 1.11
	500	42.78 $\pm$ 0.56	34.44 $\pm$ 3.64	30.56 $\pm$ 2.22
	1000	45.00 $\pm$ 2.89	38.33 $\pm$ 2.55	35.56 $\pm$ 1.47
	1500	51.67 $\pm$ 3.33	40.56 $\pm$ 1.47	37.78 $\pm$ 2.22

FS- 1: Feeding Schedule-1

FS- 2: Feeding Schedule- 2

FS- 3: Feeding Schedule-3

Table 9. Mean mortality percentage of different parts of *Andrographis paniculata* water extract under different schedules of feeding on the larval mortality of *Bombyx mori*.

Feeding Schedule	Dose (ppm)	Mean $\pm$ SE		
		Leaf	Stem	Root
FS-1	Control	6.67 $\pm$ 1.92	6.67 $\pm$ 1.92	6.67 $\pm$ 1.92
	100	25.00 $\pm$ 0.96	22.22 $\pm$ 0.56	26.67 $\pm$ 0.96
	500	26.67 $\pm$ 0.96	25.00 $\pm$ 0.96	29.44 $\pm$ 1.47
	1000	28.33 $\pm$ 2.55	30.00 $\pm$ 0.96	30.56 $\pm$ 2.42
	1500	29.44 $\pm$ 2.00	30.56 $\pm$ 0.56	31.67 $\pm$ 3.47
FS-2	Control	6.67 $\pm$ 1.92	6.67 $\pm$ 1.92	6.67 $\pm$ 1.92
	100	23.33 $\pm$ 2.55	22.22 $\pm$ 0.56	26.11 $\pm$ 0.56
	500	25.56 $\pm$ 2.00	24.44 $\pm$ 1.11	28.89 $\pm$ 0.56
	1000	27.22 $\pm$ 2.00	28.33 $\pm$ 0.96	32.22 $\pm$ 0.56
	1500	28.89 $\pm$ 2.00	30.56 $\pm$ 1.11	33.33 $\pm$ 0.96
FS-3	Control	6.67 $\pm$ 1.92	6.67 $\pm$ 1.92	6.67 $\pm$ 1.92
	100	25.00 $\pm$ 1.67	23.89 $\pm$ 1.11	32.78 $\pm$ 1.47
	500	27.22 $\pm$ 1.47	27.22 $\pm$ 0.56	28.89 $\pm$ 1.47
	1000	29.44 $\pm$ 0.56	28.33 $\pm$ 2.55	32.78 $\pm$ 1.47
	1500	30.00 $\pm$ 1.67	33.89 $\pm$ 1.47	33.33 $\pm$ 0.96

FS- 1: Feeding Schedule-1

FS- 2: Feeding Schedule- 2

FS- 3: Feeding Schedule-3

Table 10. χ^2 values, regression equation, LC_{50} and fiducial limits of *Abroma augusta* plant extracts against *Bombyx mori* larvae.

Plant parts	FS	χ^2 (df=2)	Regression equation	LC_{50}	Fiducial limits	
					Lower	Upper
Leaf	FS-1	0.432	$Y = 2.205 + 0.397X$	1.083E+07	267.797	4.383E+11
	FS-2	1.438	$Y = 2.865 + 0.218X$	6.193E+09	5.798E-02	6.616E+20
	FS-3	0.262	$Y = 3.103 + 0.204X$	1.985E+09	0.168	2.350E+19
Stem	FS-1	2.930	$Y = 1.249 + 0.649X$	5.987E+05	1909.427	1.877E+08
	FS-2	0.149	$Y = 2.317 + 0.391X$	7.229 E+06	804.813	6.495E+10
	FS-3	0.666	$Y = 2.238 + 0.427X$	2.956 E+06	1114.832	7.839E+09
Root	FS-1	0.003	$Y = 2.439 + 0.339X$	3.538E+07	167.284	7.481E+12
	FS-2	0.149	$Y = 2.317 + 0.391X$	7.229 E+06	804.813	6.495E+10
	FS-3	0.674	$Y = 2.965 + 0.176X$	3.785E+11	2.188E-06	6.546E+28

FS- 1: Feeding Schedule-1

FS- 2: Feeding Schedule- 2

FS- 3: Feeding Schedule-3

Table 11. χ^2 values, regression equation, LC_{50} and fiducial limits of *Centella asiatica* plant extracts against *Bombyx mori* larvae.

Plant parts	FS	χ^2 (df=2)	Regression equation	LC_{50}	Fiducial limits	
					Lower	Upper
Leaf	FS-1	0.003	$Y = 2.439 + 0.339X$	3.538E+07	167.284	7.481E+12
	FS-2	0.636	$Y = 2.705 + 0.304X$	3.627E+07	185.528	7.091E+12
	FS-3	1.342	$Y = 3.134 + 0.176X$	4.004E+10	2.052E-04	7.812E+24
Stem	FS-1	0.285	$Y = 2.896 + 0.228X$	1.655E+09	0.507	5.405E+18
	FS-2	0.115(2)	$Y = 3.085 + 0.174X$	1.084E+11	5.553E-05	2.115E+26
	FS-3	0.090	$Y = 2.963 + 0.191X$	4.938E+10	2.865E-04	8.510E+24
Root	FS-1	0.434	$Y = 2.856 + 0.237X$	1.109E+09	0.952	1.292E+18
	FS-2	0.003	$Y = 2.439 + 0.339X$	3.538E+07	167.284	7.481E+12
	FS-3	0.359	$Y = 2.661 + 0.277X$	2.808E+08	11.499	6.859E+15

FS- 1: Feeding Schedule-1

FS- 2: Feeding Schedule- 2

FS- 3: Feeding Schedule-3

Table 12. χ^2 values, regression equation, LC_{50} and fiducial limits of *Neolamarckia cadamba* plant extracts against *Bombyx mori* larvae.

Plant parts	FS	χ^2 (df=2)	Regression equation	LC_{50}	Fiducial limits	
					Lower	Upper
Leaf	FS-1	0.383	$Y = 3.134 + 0.149X$	3.275E+12	2.732E-09	3.926E+33
	FS-2	0.090	$Y = 2.963 + 0.191X$	4.938E+10	2.865E-04	8.510E+24
	FS-3	0.339	$Y = 1.988 + 0.452X$	4.639 E+06	925.216	2.327E+10
Stem	FS-1	0.115	$Y = 3.085 + 0.174X$	1.084E+11	5.553E-05	2.115E+26
	FS-2	0.434	$Y = 2.856 + 0.237X$	1.109E+09	0.952	1.292E+18
	FS-3	0.433	$Y = 2.855 + 0.236X$	1.108E+09	0.951	1.291E+18
Root	FS-1	0.278	$Y = 2.627 + 0.350X$	5.902 E+06	998.705	3.488E+10
	FS-2	0.080	$Y = 2.341 + 0.397X$	4.925 E+09	1112.847	2.179E+10
	FS-3	0.003	$Y = 2.439 + 0.339X$	3.538E+07	167.284	7.481E+12

FS- 1: Feeding Schedule-1

FS- 2: Feeding Schedule- 2

FS- 3: Feeding Schedule-3

Table 13. χ^2 values, regression equation, LC_{50} and fiducial limits of *Solanum tuberosum* plant extracts against *Bombyx mori* larvae.

Plant parts	FS	χ^2 (df=2)	Regression equation	LC_{50}	Fiducial limits	
					Lower	Upper
Leaf	FS-1	1.351	$Y = 2.215 + 0.327X$	3.317E+08	1.204	9.133E+16
	FS-2	0.945	$Y = 2.475 + 0.292X$	4.522E+08	1.911	1.070E+17
	FS-3	0.003	$Y = 2.439 + 0.339X$	3.538E+07	167.284	7.481E+12
Stem	FS-1	0.149	$Y = 2.317 + 0.391X$	7.229 E+06	804.813	6.495E+10
	FS-2	0.546	$Y = 2.871 + 0.269X$	7.912E+07	74.028	8.457E+13
	FS-3	1.190	$Y = 2.607 + 0.346X$	8.428 E+06	773.121	9.187E+10
Root	FS-1	0.121	$Y = 2.536 + 0.279X$	6.816E+08	2.601	1.786E+17
	FS-2	0.107	$Y = 2.214 + 0.351X$	8.884E+07	26.944	2.929E+14
	FS-3	0.299	$Y = 2.373 + 0.421X$	1.749 E+06	2492.717	1.229E+09

FS- 1: Feeding Schedule-1

FS- 2: Feeding Schedule- 2

FS- 3: Feeding Schedule-3

Table 14 χ^2 values, regression equation, LC_{50} and fiducial limits of *Persicania acuminata* plant extracts against *Bombyx mori* larvae.

Plant parts	FS	χ^2 (df=2)	Regression equation	LC_{50}	Fiducial limits	
					Lower	Upper
Leaf	FS-1	4.104	$Y = 3.821 + 0.273X$	2.073 E+04	1017.621	4.224E+05
	FS-2	2.564	$Y = 4.057 + 0.223X$	1.726 E+04	538.704	5.531 E+05
	FS-3	1.229	$Y = 4.294 + 0.212X$	2.129 E+03	395.659	1.146 E+04
Stem	FS-1	0.919	$Y = 3.799 + 0.227X$	1.935 E+05	544.955	6.868E+07
	FS-2	0.742	$Y = 4.123 + 0.141X$	1.697 E+06	6.311	4.561E+11
	FS-3	0.385	$Y = 3.999 + 0.199X$	1.009 E+05	326.529	3.119E+07
Root	FS-1	0.555	$Y = 3.641 + 0.279X$	7.539E+04	242.549	4.574E+05
	FS-2	0.452	$Y = 3.769 + 0.287X$	1.966 E+04	1156.429	3.344 E+05
	FS-3	0.639	$Y = 3.769 + 0.244X$	1.094 E+05	791.698	1.512E+07

FS- 1: Feeding Schedule-1

FS- 2: Feeding Schedule- 2

FS- 3: Feeding Schedule-3

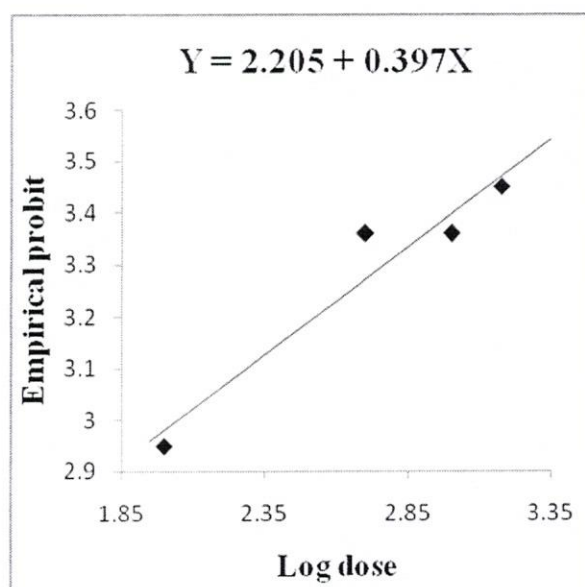
Table 15. χ^2 values, regression equation, LC_{50} and fiducial limits of *Andrographis paniculata* plant extracts against *Bombyx mori* larvae.

Plant parts	FS	χ^2 (df=2)	Regression equation	LC_{50}	Fiducial limits	
					Lower	Upper
Leaf	FS-1	1.751	$Y = 3.694 + 0.266X$	8.035E+04	1126.906	5.729E+06
	FS-2	2.165	$Y = 3.634 + 0.244X$	3.881E+05	736.131	2.046E+08
	FS-3	2.005	$Y = 3.637 + 0.240X$	3.800E+05	730.131	2.000E+08
Stem	FS-1	1.295	$Y = 3.437 + 0.288X$	2.692 E+05	1552.212	4.669E+07
	FS-2	0.594	$Y = 3.484 + 0.262X$	6.102 E+05	992.912	3.750E+08
	FS-3	1.114	$Y = 3.487 + 0.282X$	2.302 E+05	1361.656	3.890E+07
Root	FS-1	0.027	$Y = 3.574 + 0.291X$	7.995E+04	1452.794	4.399E+06
	FS-2	0.181	$Y = 3.787 + 0.202X$	9.838 E+05	180.786	5.354E+09
	FS-3	0.256	$Y = 3.798 + 0.202X$	9.067 E+05	211.996	3.878E+10

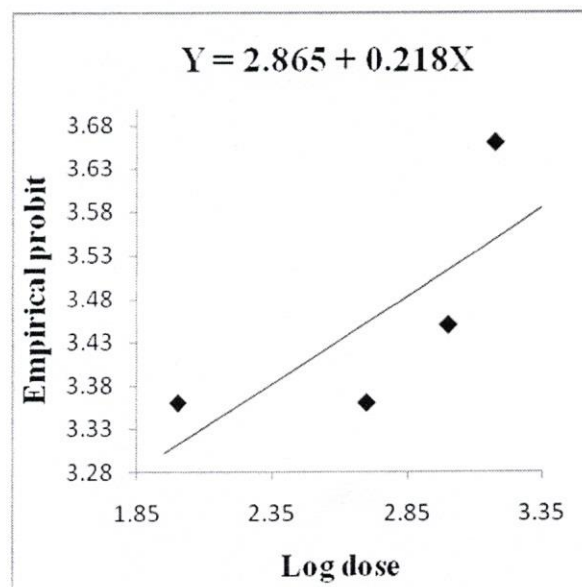
FS- 1: Feeding Schedule-1

FS- 2: Feeding Schedule- 2

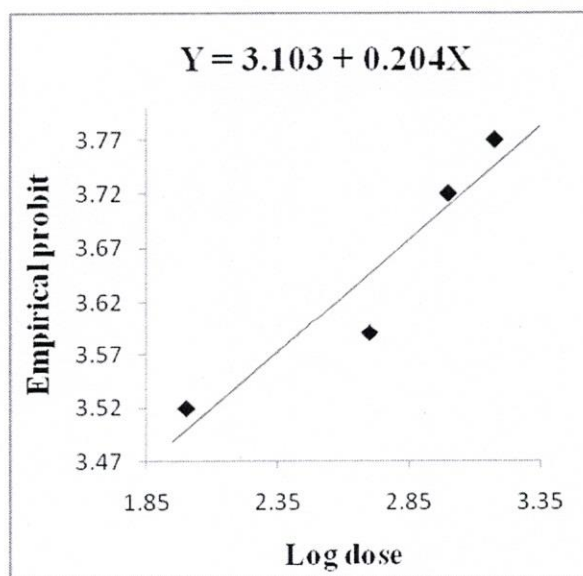
FS- 3: Feeding Schedule-3



FS-1



FS-2



FS-3

Fig 1.1-1.3: Probit mortality line of *A. angusta* leaf extract against *B. mori* larvae at different feeding schedules (FS-1, FS-2 and FS-3).

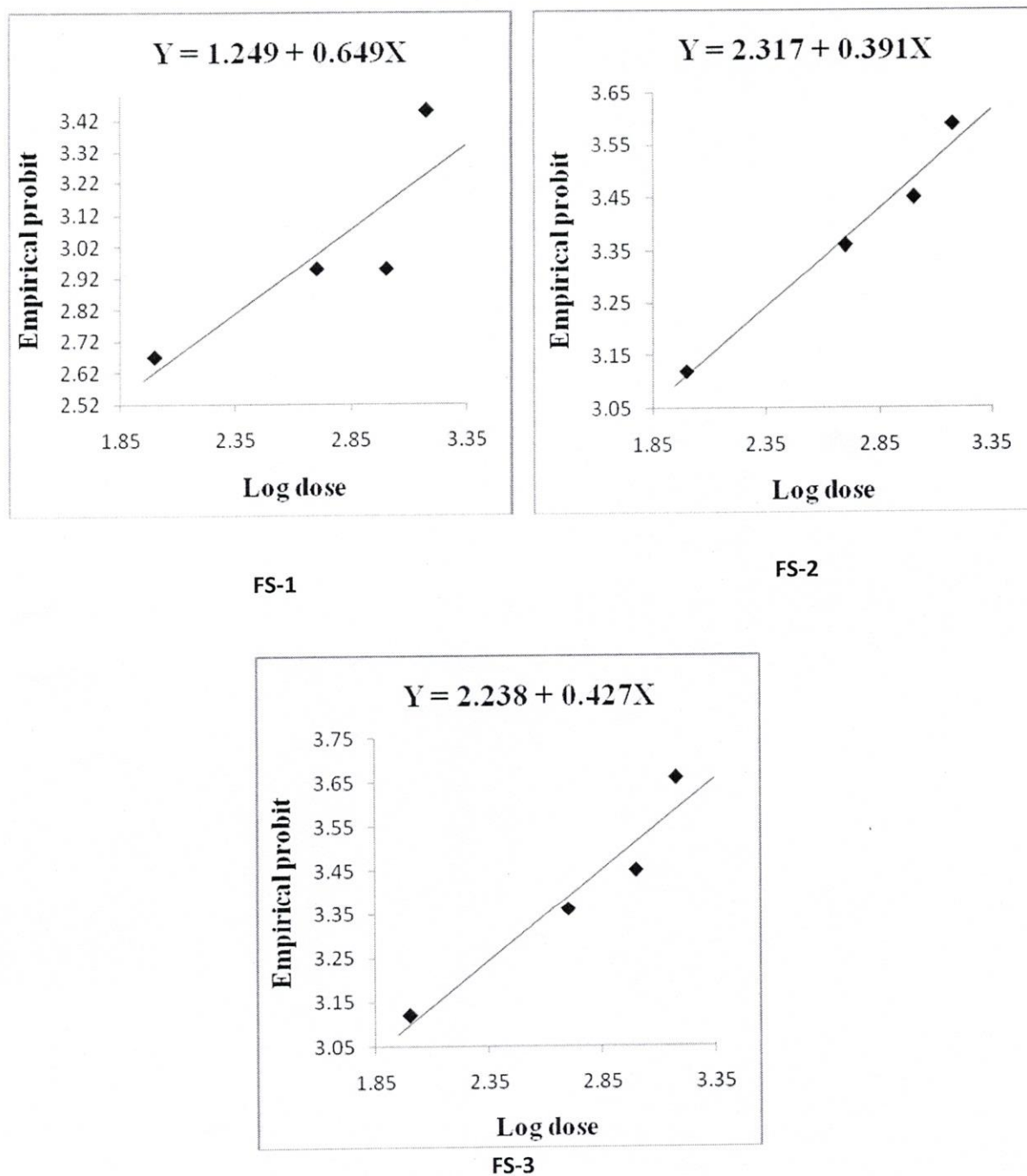


Fig 1.4-1.6: Probit mortality line of *A. angusta* stem extract against *B. mori* larvae at different feeding schedules (FS-1, FS-2 and FS-3).

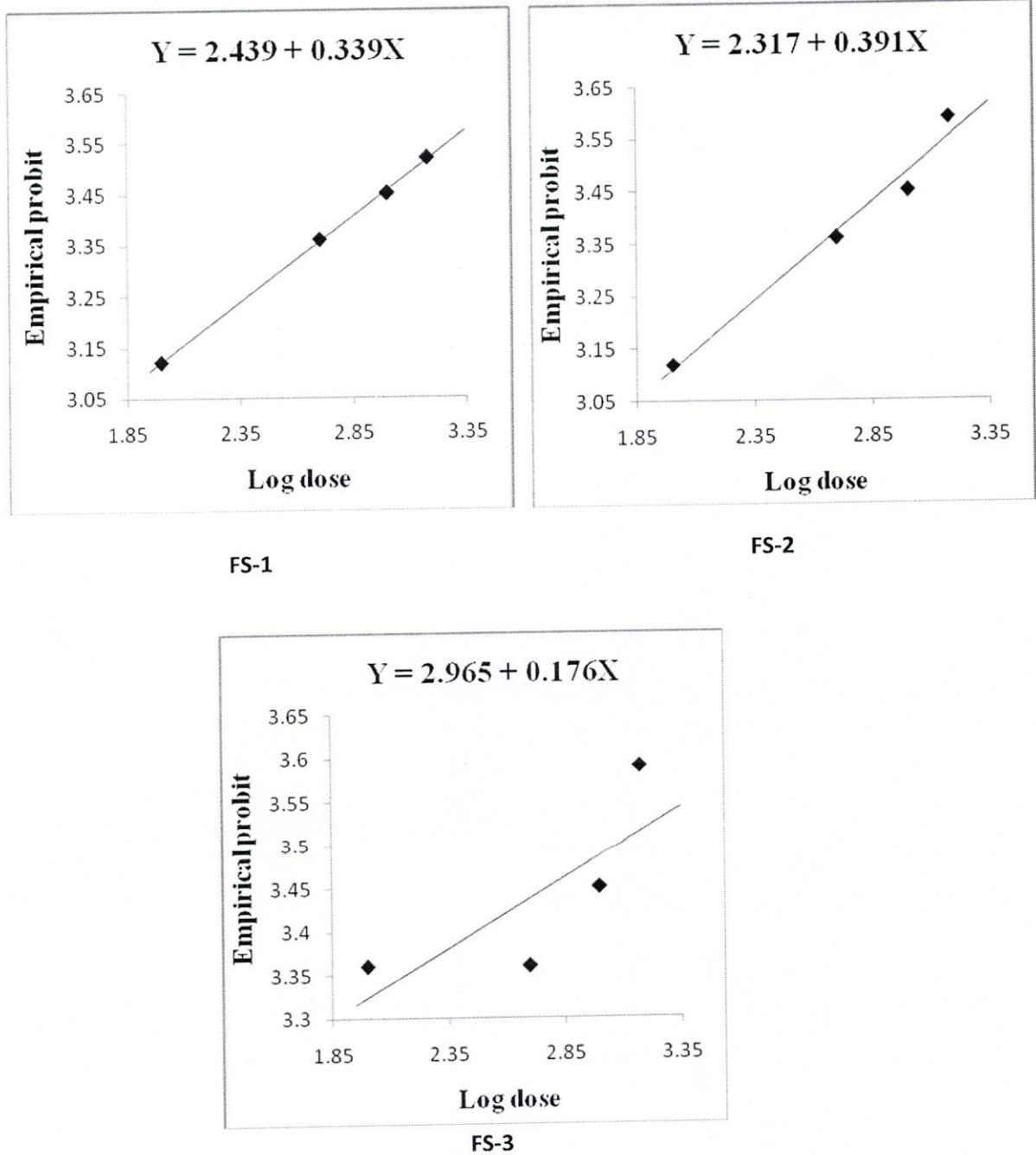
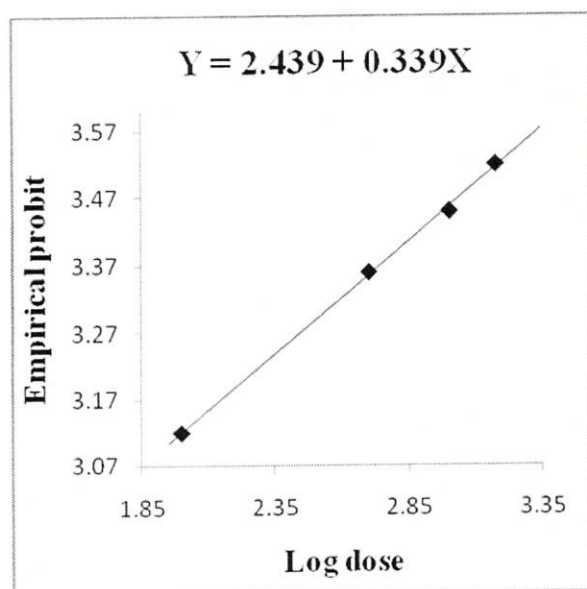
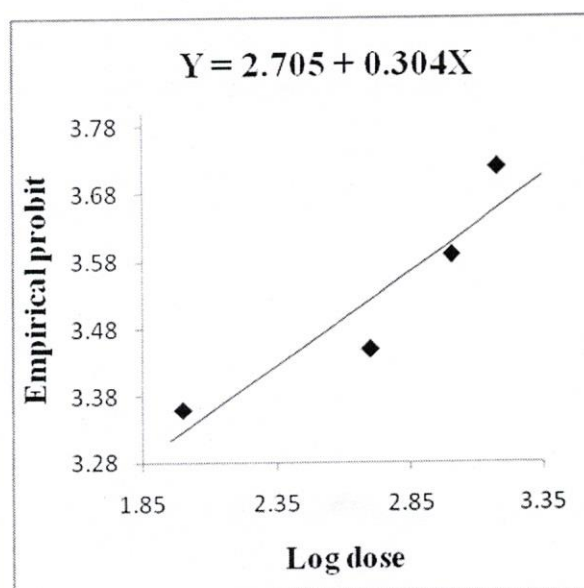


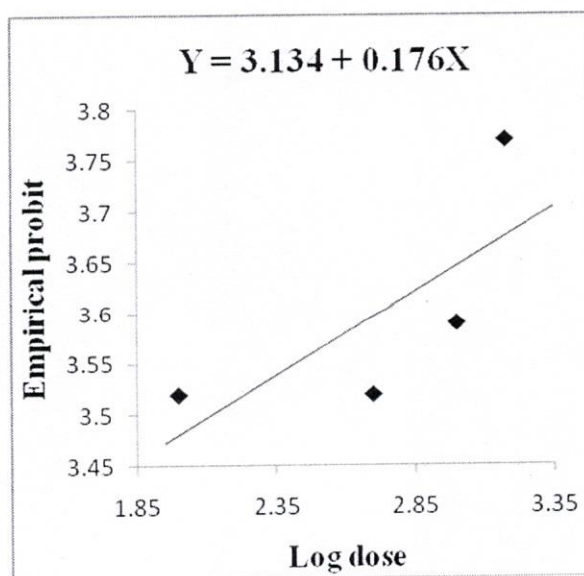
Fig 1.7-1.9: Probit mortality line of *A. angusta* root extract against *B. mori* larvae at different feeding schedules (FS-1, FS-2 and FS-3).



FS-1

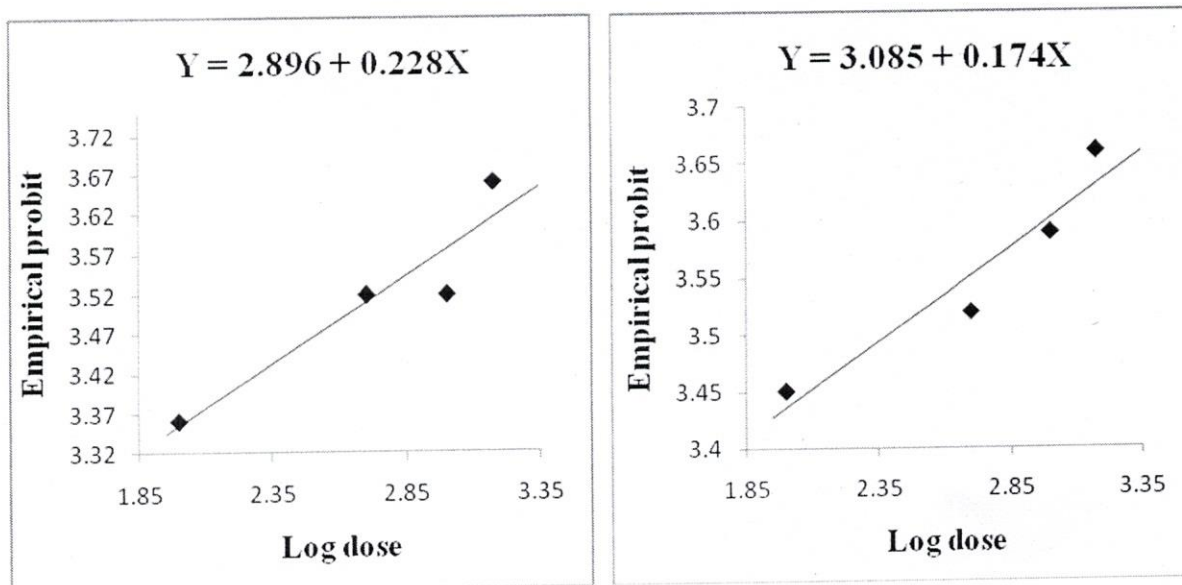


FS-2



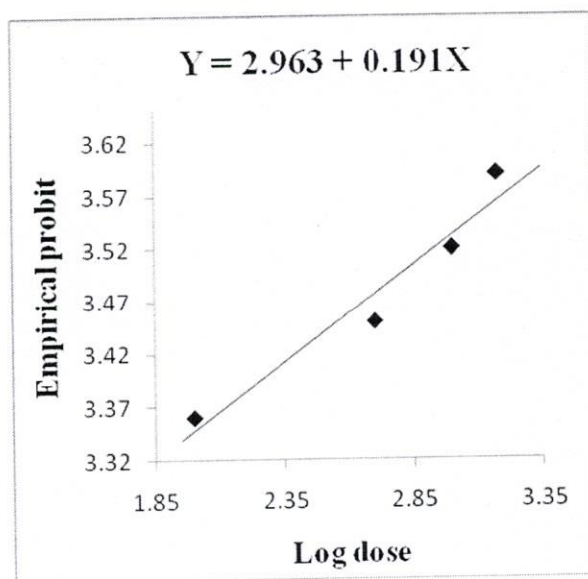
FS-3

Fig 2.1-2.3: Probit mortality line of *C. asiatica* leaf extract against *B. mori* larvae at different feeding schedules (FS-1, FS-2 and FS-3).



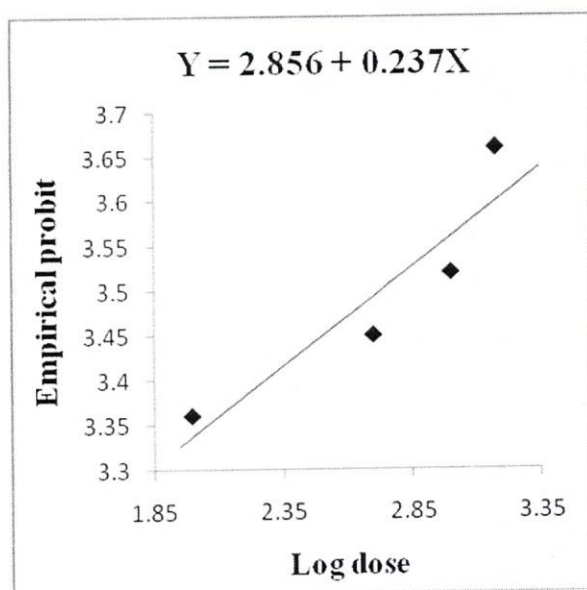
FS-1

FS-2

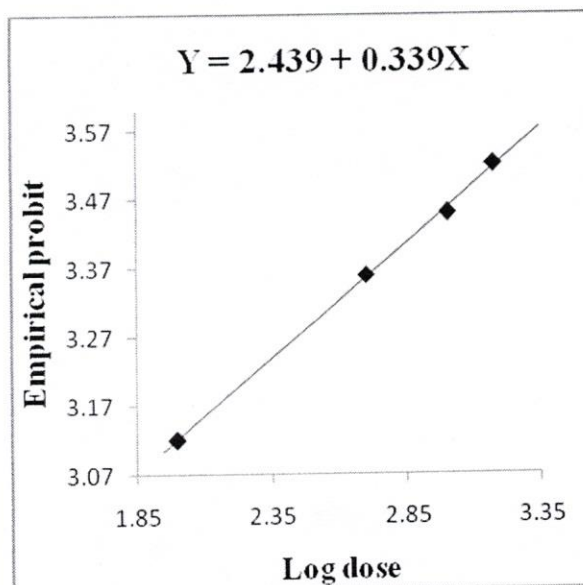


FS-3

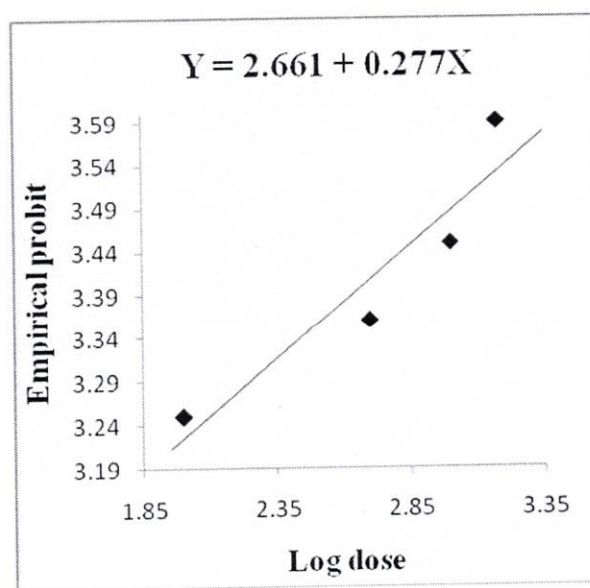
Fig 2.4-2.6: Probit mortality line of *C. asiatica* stem extract against *B. mori* larvae at different feeding schedules (FS-1, FS-2 and FS-3).



FS-1

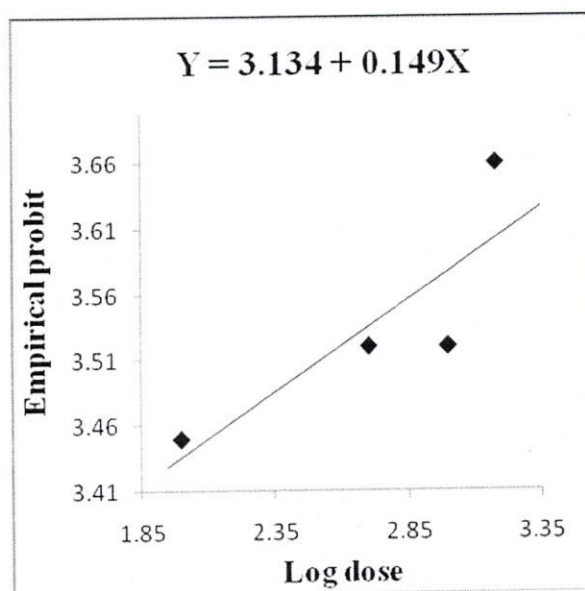


FS-2

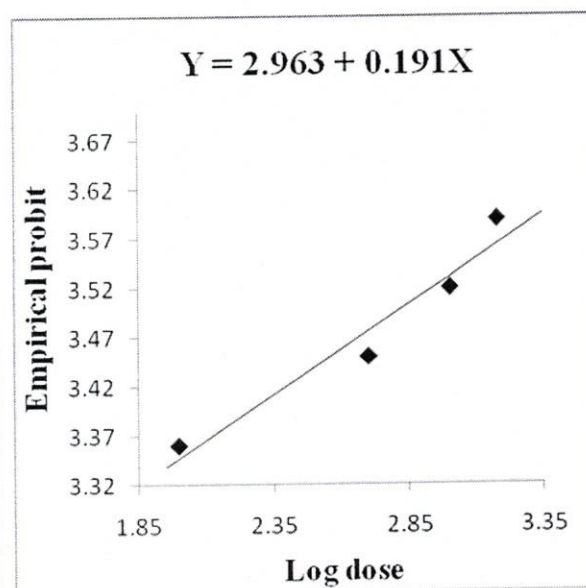


FS-3

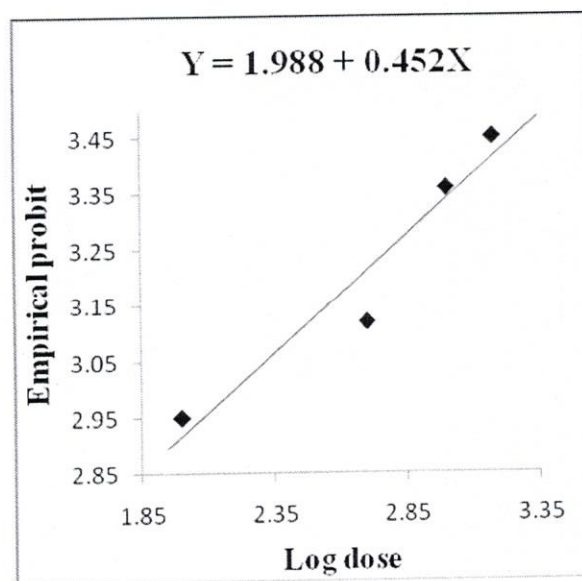
Fig 2.7-2.9: Probit mortality line of *C. asiatica* root extract against *B. mori* larvae at different feeding schedules (FS-1, FS-2 and FS-3).



FS-1

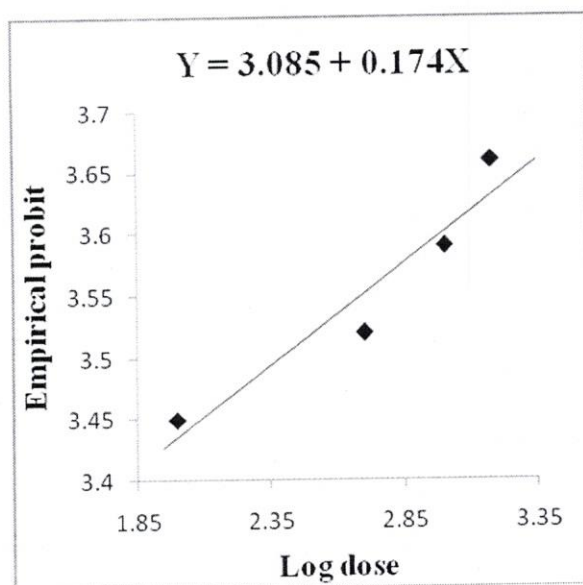


FS-2

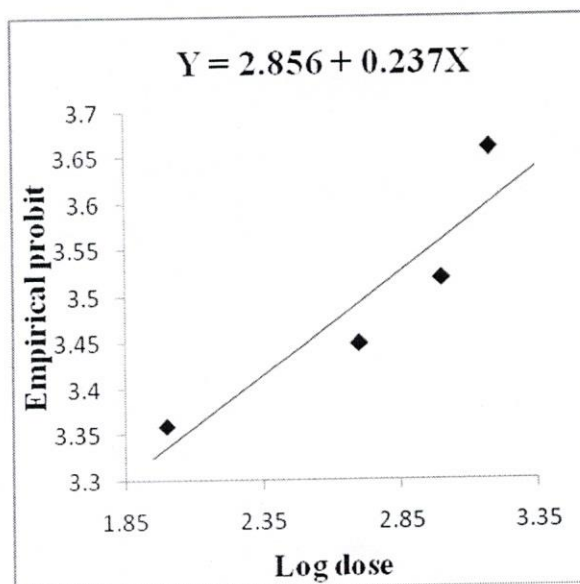


FS-3

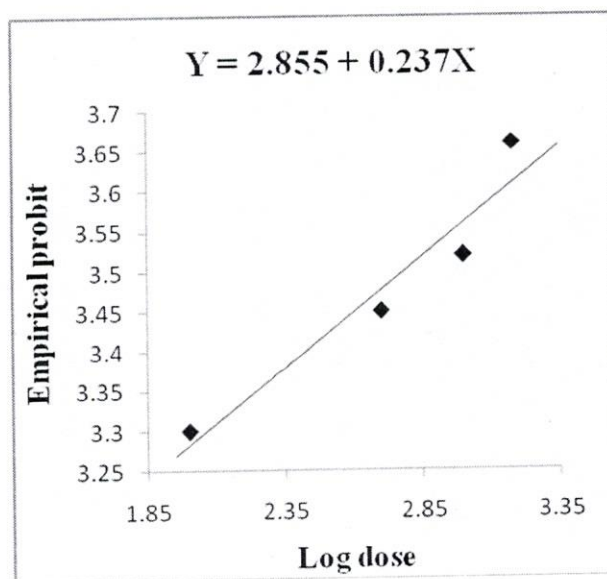
Fig 3.1-3.3: Probit mortality line of *N. cadamba* leaf extract against *B. mori* larvae at different feeding schedules (FS-1, FS-2 and FS-3).



FS-1

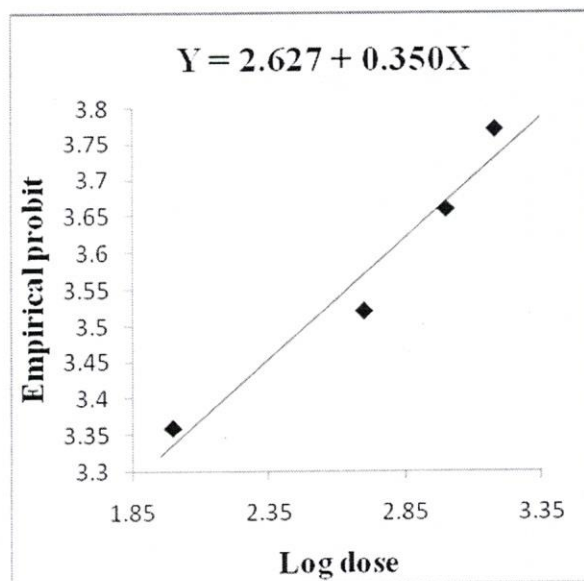


FS-2

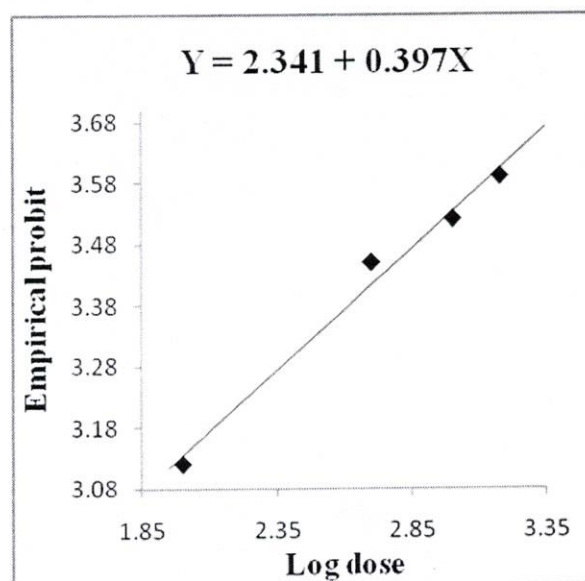


FS-3

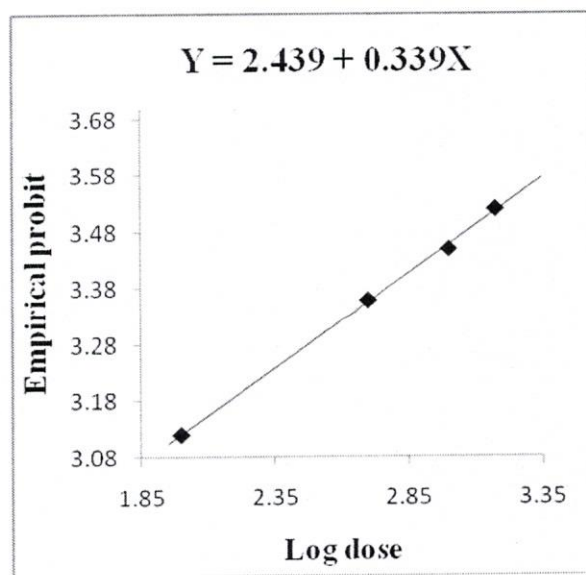
Fig 3.4-3.6: Probit mortality line of *N. cadamba* stem extract against *B. mori* larvae at different feeding schedules (FS-1, FS-2 and FS-3).



FS-1



FS-2



FS-3

Fig 3.7-3.9: Probit mortality line of *N. cadamba* root extract against *B. mori* larvae at different feeding schedules (FS-1, FS-2 and FS-3).

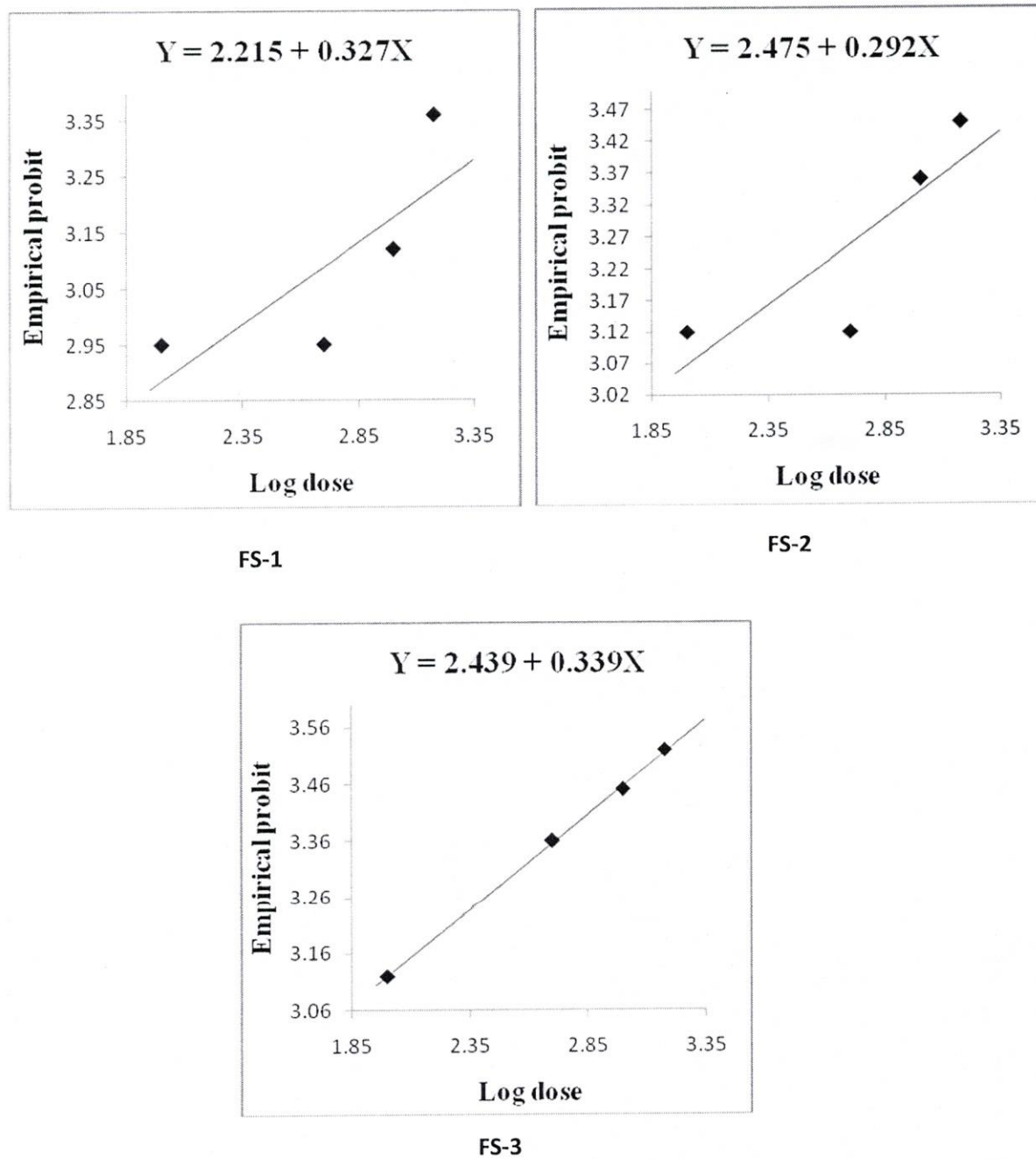
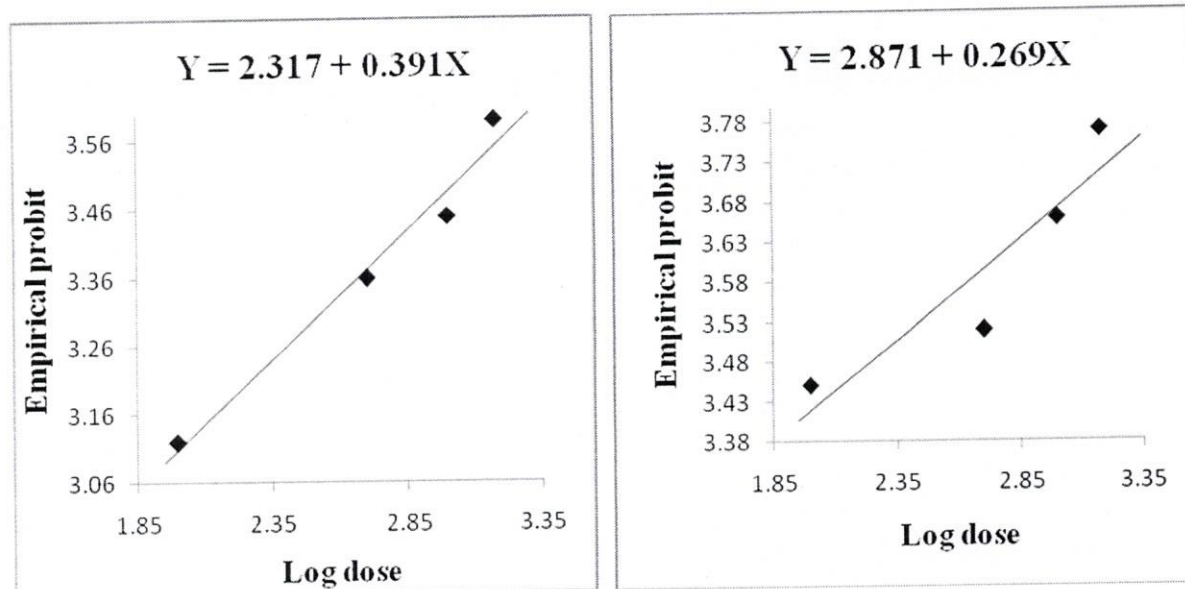
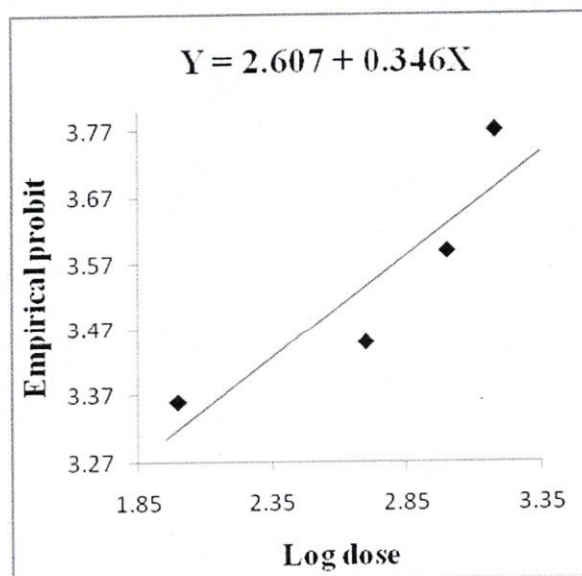


Fig 4.1-4.3: Probit mortality line of *S. tuberosum* leaf extract against *B. mori* larvae at different feeding schedules (FS-1, FS-2 and FS-3).



FS-1

FS-2



FS-3

Fig 4.4-4.6: Probit mortality line of *S. tuberosum* stem extract against *B. mori* larvae at different feeding schedules (FS-1, FS-2 and FS-3).

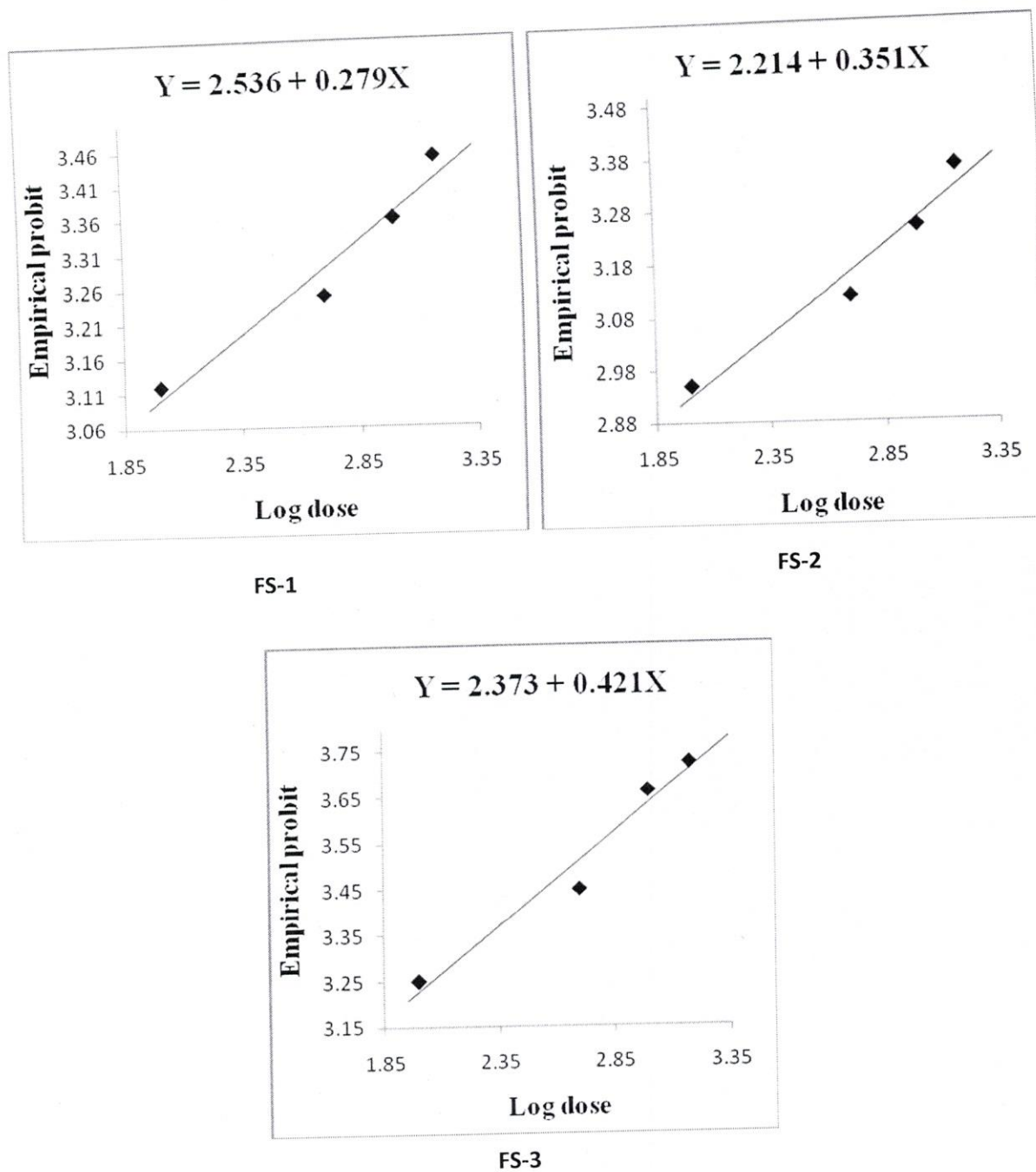
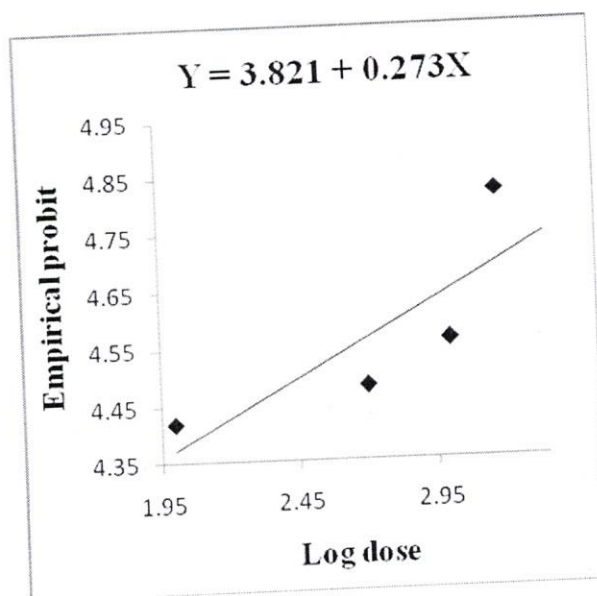
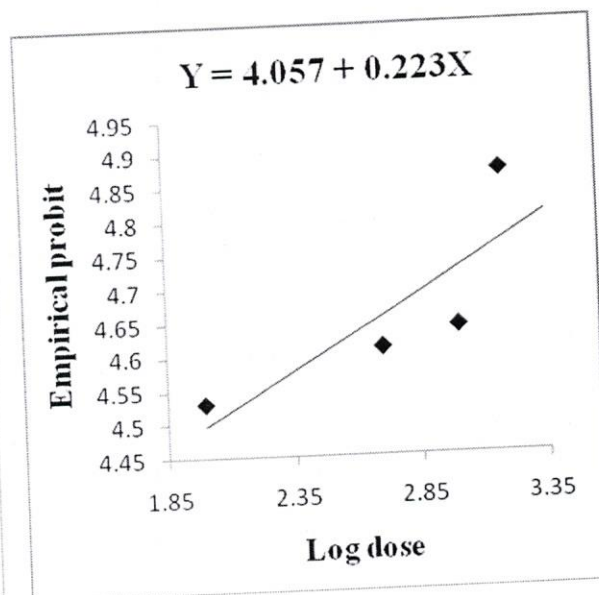


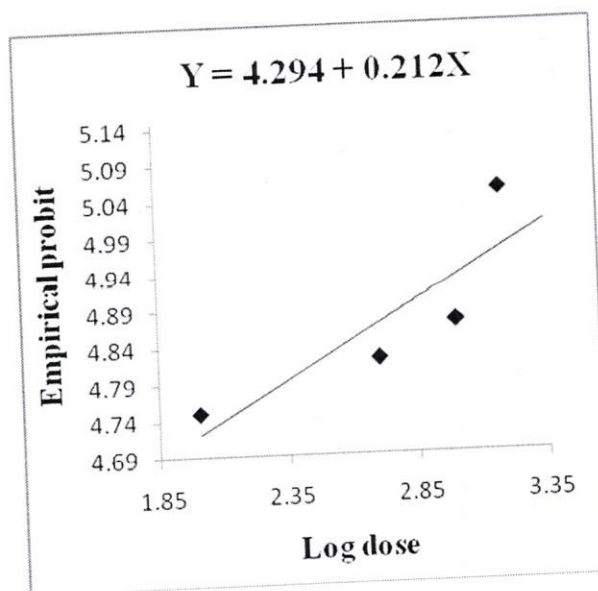
Fig 4.7-4.9: Probit mortality line of *S. tuberosum* root extract against *B. mori* larvae at different feeding schedules (FS-1, FS-2 and FS-3).



FS-1

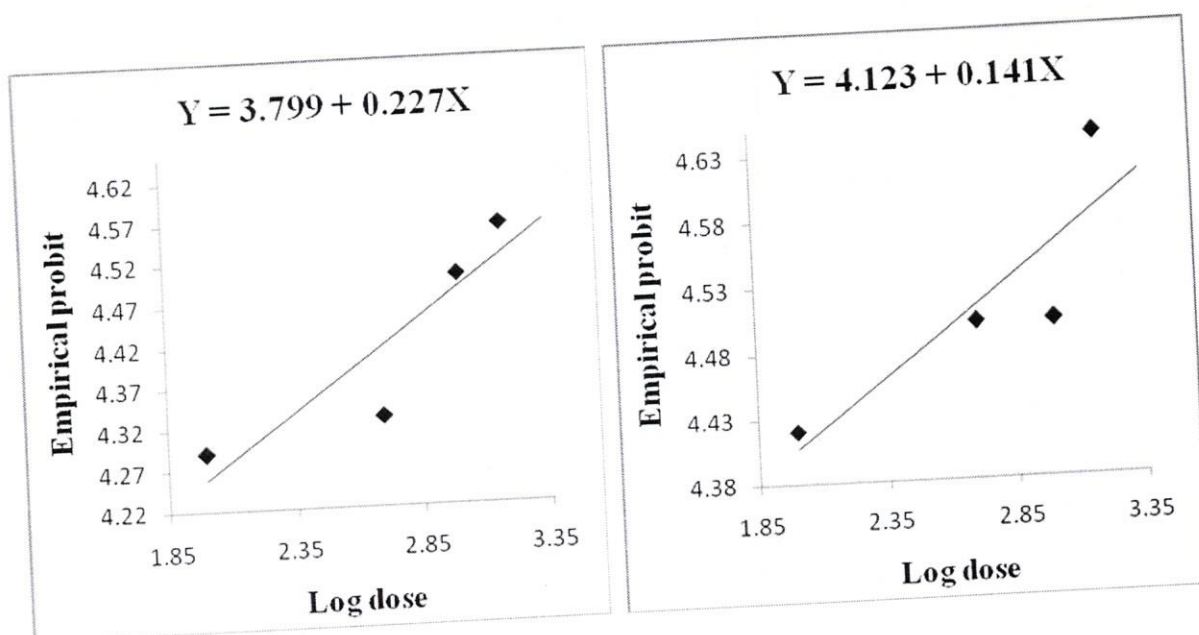


FS-2



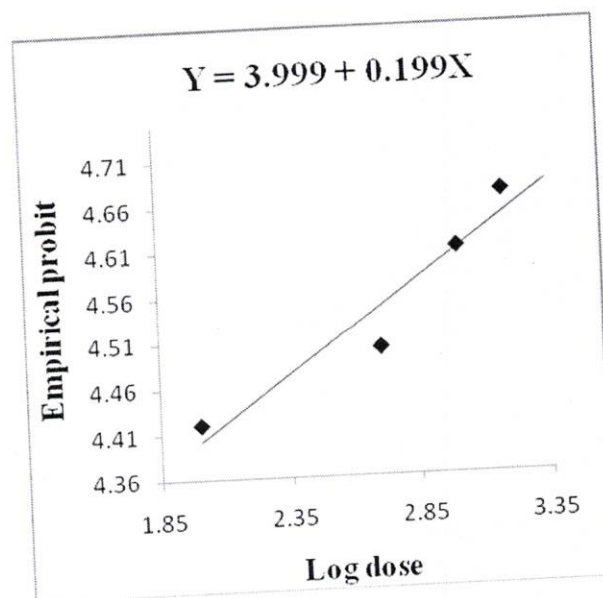
FS-3

Fig 5.1-5.3: Probit mortality line of *P. acuminata* leaf extract against *B. mori* larvae at different feeding schedules (FS-1, FS-2 and FS-3).



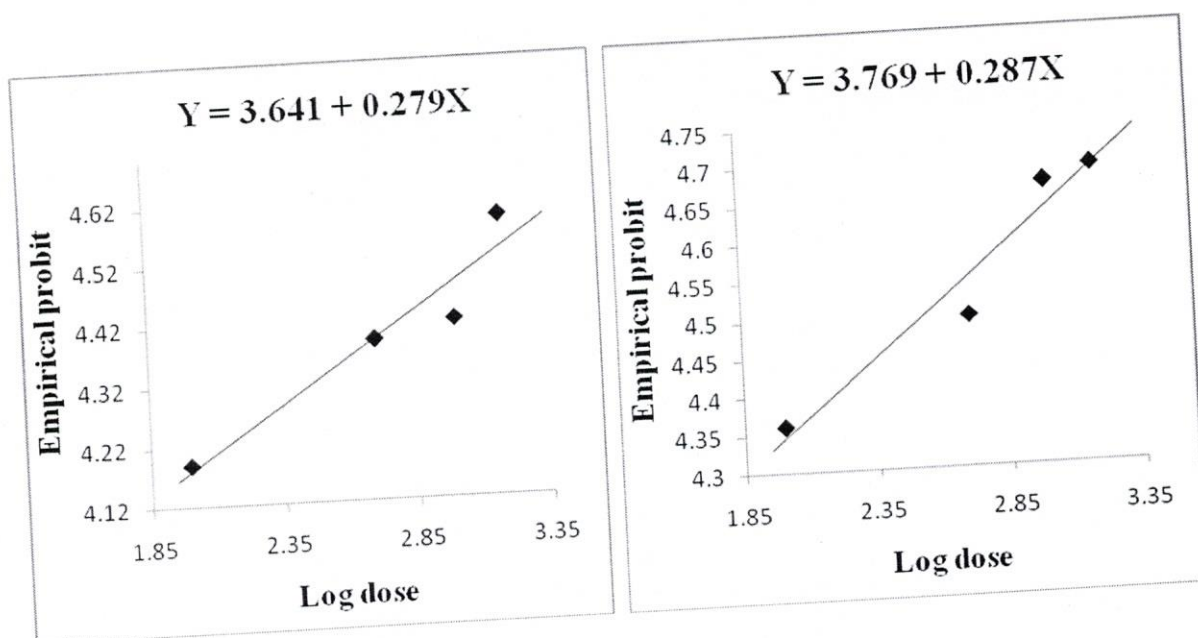
FS-1

FS-2



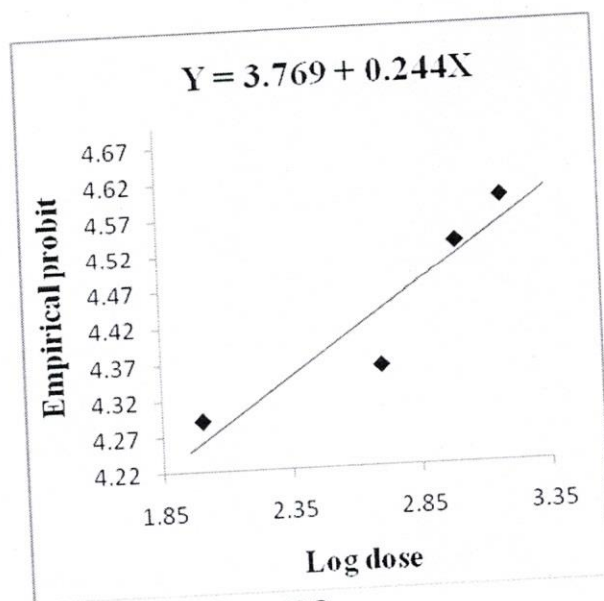
FS-3

Fig 5.4-5.6: Probit mortality line of *P. acuminata* stem extract against *B. mori* larvae at different feeding schedules (FS-1, FS-2 and FS-3).



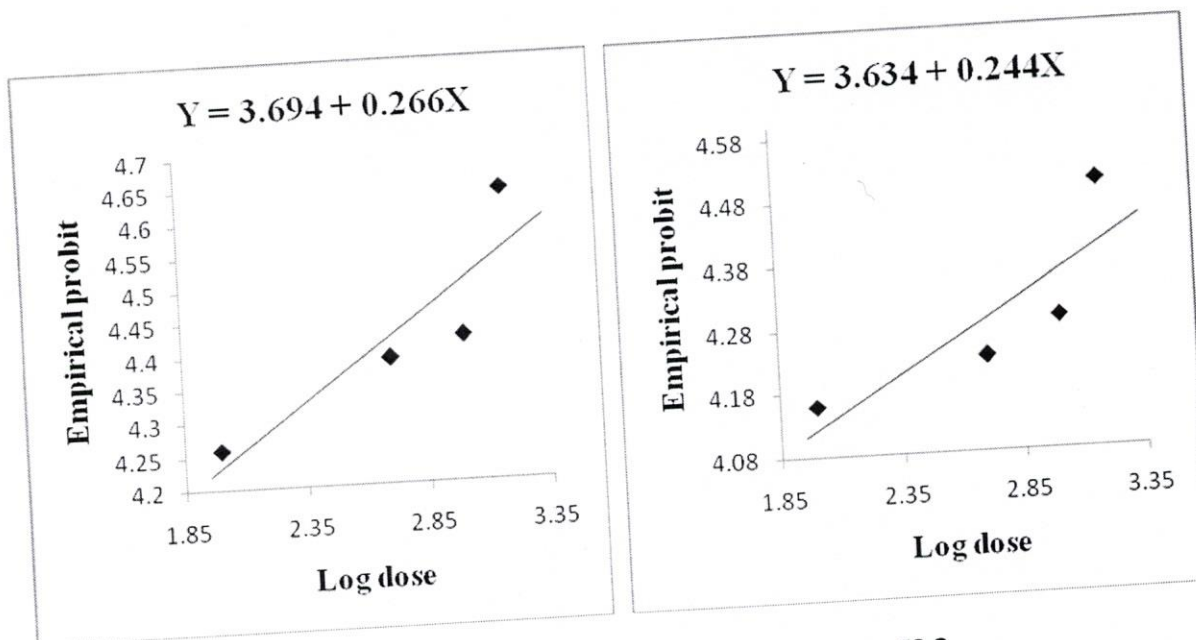
FS-1

FS-2



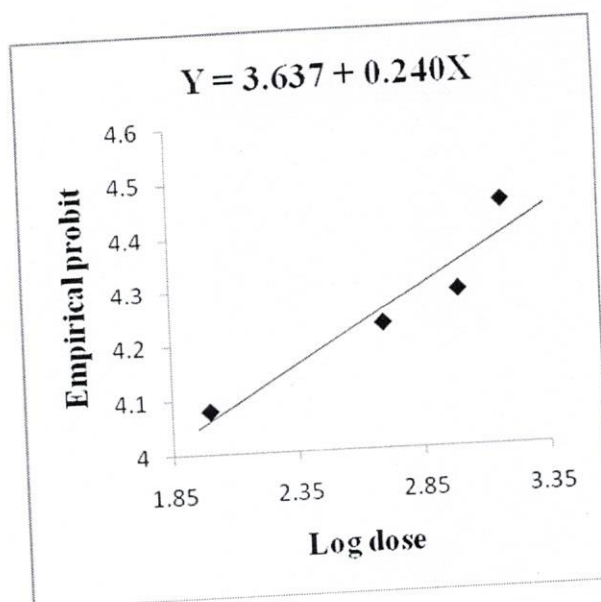
FS-3

Fig 5.7-5.9: Probit mortality line of *P. acuminata* root extract against *B. mori* larvae at different feeding schedules (FS-1, FS-2 and FS-3).



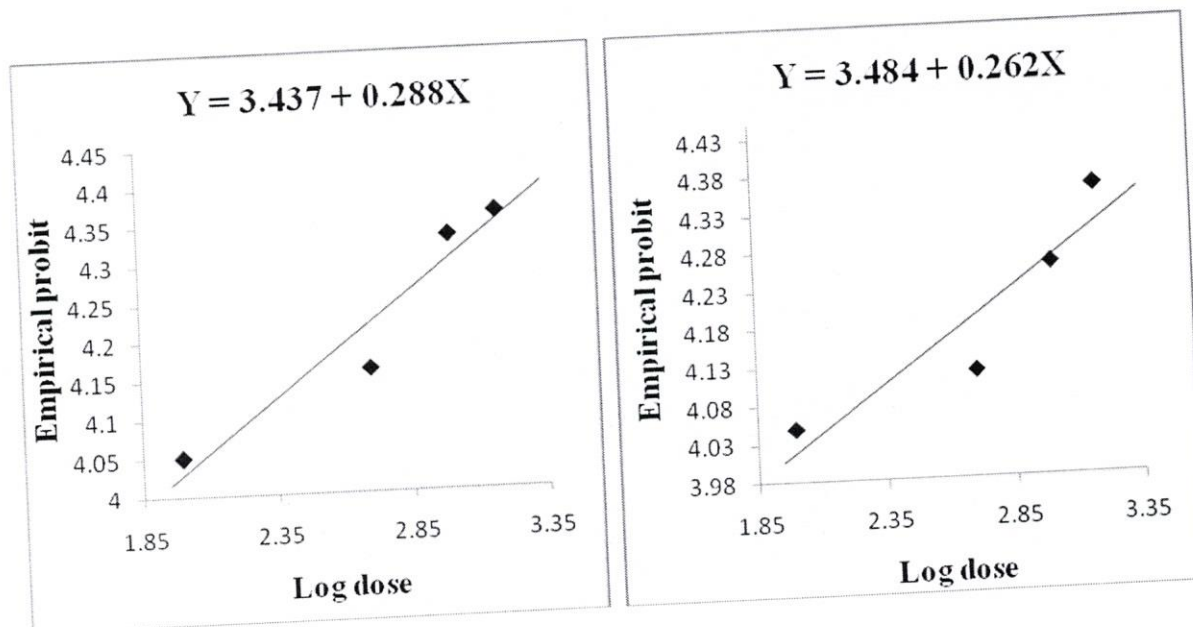
FS-1

FS-2



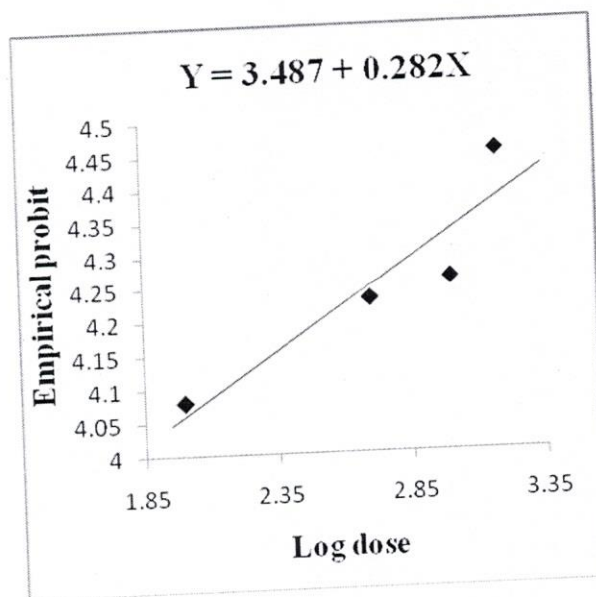
FS-3

Fig 6.1-6.3: Probit mortality line of *An. paniculata* leaf extract against *B. mori* larvae at different feeding schedules (FS-1, FS-2 and FS-3).



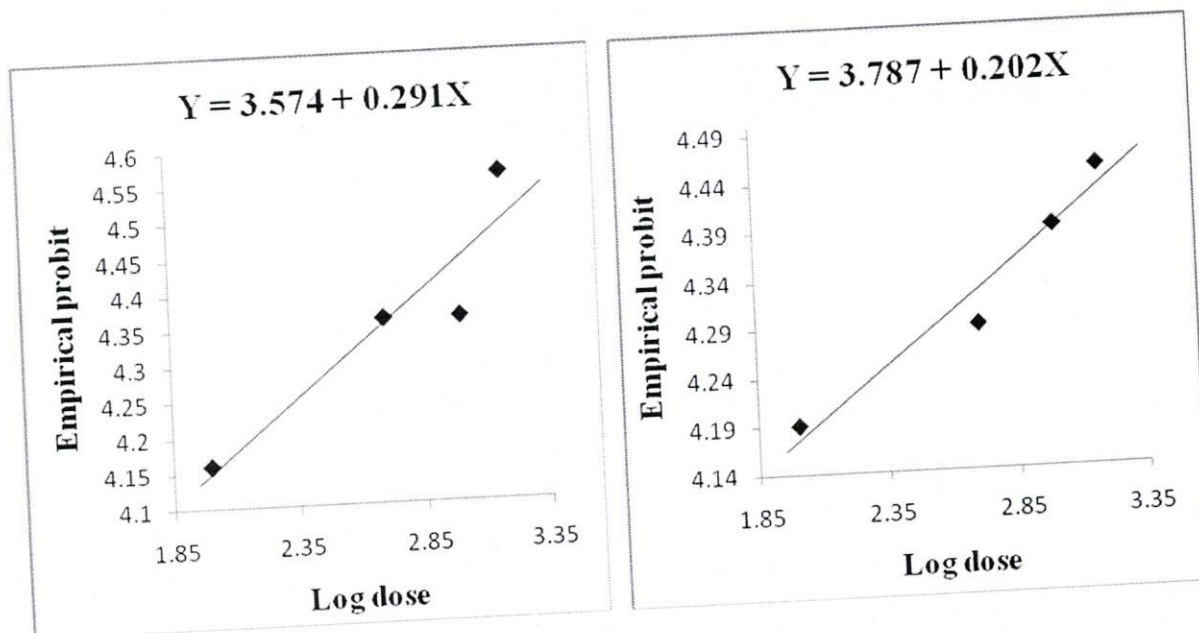
FS-1

FS-2



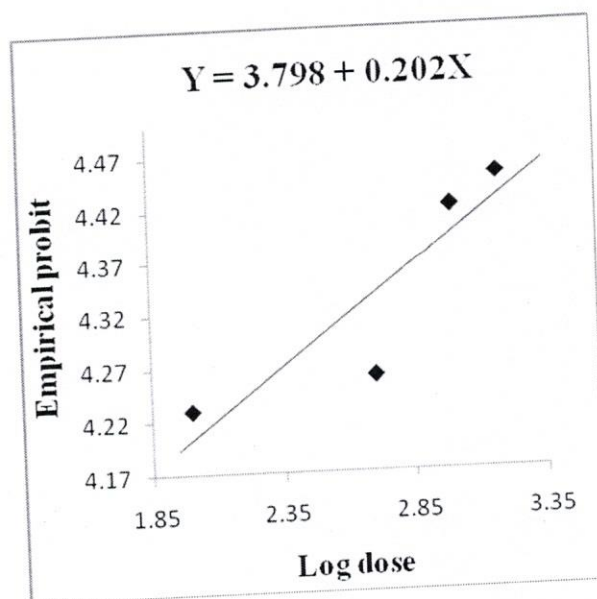
FS-3

Fig 6.4-6.6: Probit mortality line of *An. paniculata* stem extract against *B. mori* larvae at different feeding schedules (FS-1, FS-2 and FS-3).



FS-1

FS-2



FS-3

Fig 6.7-6.9: Probit mortality line of *An. paniculata* root extract against *B. mori* larvae at different feeding schedules (FS-1, FS-2 and FS-3).

4.2 Effect of different plant extracts with mulberry leaves on

Bombyx mori L.

4.2.1 Effect of *Abroma augusta* extracts supplementation with mulberry leaves on *Bombyx mori*

The effects of the supplementation of different parts, viz. leaf, stem and root extracts of *A. augusta* on *B. mori* at different feeding schedules, viz. fed only in 1st feeding of 3rd to 5th instar larvae (FS-1), fed everyday in 1st feeding of 3rd to 5th instar larvae (FS-2), fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae (FS-3) were conducted and are presented in Tables 16-26. The data for different characters were subjected to analysis of variance to determine the variations among doses and plant parts, feeding schedules are presented in Table 27-37. The results obtained in the present experiments are discussed as follows:

4.2.1.1 Effect of *A. augusta* extracts on the larval growth of *B. mori*

The results of the supplementation of different parts, viz. leaf, stem and root extracts of *A. augusta* on growth of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 are given below:

Weight of mature larvae (WML):

Effect of different parts, viz. leaf, stem and root extracts of *A. augusta* on WML of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 16 and their statistical analysis is presented in Table 27.

Leaf extract of *A. augusta* increased the WML at different doses compare to control while fed in FS-1. The highest and the lowest mean WML were observed at 500 ppm (2.95 ± 0.009 gm) and control (2.83 ± 0.014 gm) respectively. While fed according to FS-2 the heaviest and the lightest larvae were produced at 500 ppm (2.97 ± 0.006 gm) and at control (2.84 ± 0.011 gm) respectively. In case of FS-3, leaf extract also increased the WML at different doses, viz. at 100 ppm

(2.93 ± 0.012 gm), 500 ppm (2.96 ± 0.019 gm), 1000 ppm (2.95 ± 0.014 gm) and 1500 ppm (2.94 ± 0.003 gm) compare to control (2.87 ± 0.021 gm).

In case of stem extract, the mean values of WML in different concentrations for different feeding schedules were significantly increased. While fed according to FS-1, the heaviest and the lightest larvae were produced at 500 ppm (2.97 ± 0.017 gm) and at control (2.83 ± 0.014 gm) respectively. In case of FS-2, leaf extract increased the WML at different doses, viz. at 100 ppm (2.96 ± 0.019 gm), 500 ppm (3.00 ± 0.014 gm), 1000 ppm (2.97 ± 0.003 gm), 1500 ppm (2.97 ± 0.005 gm) compare to control (2.84 ± 0.014 gm). The highest and the lowest mean WML were observed at 500 ppm (2.98 ± 0.018 gm) and control (2.87 ± 0.020 gm) respectively at FS-3.

In different feeding schedules, the mean values of WML were significantly increased at different concentrations for root extract of *A. augusta*. The highest and lowest mean WML were observed at 500 ppm (2.96 ± 0.011 gm) and at control (2.83 ± 0.014 gm) for FS-1, at 500 ppm (2.98 ± 0.0115 gm) and at control (2.84 ± 0.021 gm) for FS-2 and at 500 ppm (2.97 ± 0.106 gm) and at control (2.87 ± 0.120 gm) for FS-3.

Results of analyses of variance are presented in Table 27. All the items showed highly significant differences at 1% level of significance. The effectiveness of different plant parts on WML followed the order stem > root > leaf and in respect of feeding schedule FS-2 > FS-3 > FS-1. The most effective dose of the plant extracts was found to be 500 ppm followed by 1000 ppm, 1500 ppm and 100 ppm.

Length of mature larvae (LML):

Effect of different parts extracts of *A. augusta* on LML of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 17 and their statistical analysis is presented in Table 28.

In case of leaf extract, the mean values of LML increased at different doses compare to control while fed in FS-1. The highest and the lowest mean LML were

observed at 500 ppm ($78.42 \pm 0.95\text{mm}$) and at control ($72.19 \pm 0.003\text{mm}$) respectively. While maintaining schedules FS-2, the highest and the lowest LML were observed at 500 ppm ($80.98 \pm 0.86\text{mm}$) and at control ($74.59 \pm 0.32\text{mm}$) respectively. In case of FS-3, leaf extract also increased the LML at different doses viz. at 100 ppm ($76.25 \pm 1.77\text{mm}$), 500 ppm ($78.89 \pm 0.30\text{mm}$), 1000 ppm ($78.58 \pm 0.43\text{mm}$), 1500 ppm ($77.10 \pm 0.58\text{mm}$) compare to control ($77.10 \pm 0.58\text{mm}$).

For stem extract, the mean values of LML in different concentrations for different feeding schedules and plant parts were significantly increased. While fed according to FS-1, the highest and the lowest LML were recorded at 500 ppm ($80.72 \pm 0.42\text{mm}$) and at control ($72.19 \pm 0.30\text{mm}$) respectively. In case of FS-2, leaf extract increased the LML at different doses, viz. at 100 ppm ($78.46 \pm 0.48\text{mm}$), 500 ppm ($81.75 \pm 0.50\text{mm}$), 1000 ppm ($81.44 \pm 0.54\text{mm}$), 1500 ppm ($79.82 \pm 0.33\text{mm}$) compare to control ($74.59 \pm 0.32\text{mm}$). The highest and the lowest mean LML were observed at 500 ppm ($80.02 \pm 0.59\text{mm}$) and control ($73.18 \pm 0.37\text{mm}$) respectively while fed according to FS-3.

In different feeding schedules, the mean values of LML were significantly increased at different concentrations for root extract of *A. augusta*. The highest and the lowest mean LML were observed at 500 ppm ($79.41 \pm 0.61\text{mm}$) and at control ($72.19 \pm 0.30\text{mm}$) for FS-1, at 500 ppm ($81.57 \pm 0.54\text{mm}$) and at control ($74.59 \pm 0.32\text{mm}$) for FS-2 and at 500 ppm ($80.02 \pm 0.59\text{mm}$) and at control ($73.18 \pm 0.37\text{mm}$) for FS-3 respectively.

The results of ANOVA have been presented in the Table-28. The items, viz. feeding schedules ($F=66.76$), plant parts ($F=37.58$), dose ($F=315.24$) revealed significant results ($P<0.01$).

The efficacy of different plant parts on LML followed the order stem > root > leaf and for feeding schedule the effectiveness in this regard was FS-2 > FS-3 > FS-1.

The most effective dose of the plant extracts in majority of the cases was 500 ppm followed by 1000 ppm, 1500 ppm and 100 ppm.

Breadth of mature larvae (BML):

Effect of different parts, viz. leaf, stem, root extracts of *A. augusta* on BML of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table-18 and their statistical analysis is presented in Table 29.

Results of leaf extract of *A. augusta* showed that the BML increased at different doses in comparison to control while fed in FS-1. The highest and the lowest mean BML were observed at 500 ppm ($23.38 \pm 1.17\text{mm}$) and control ($17.25 \pm 0.28\text{mm}$) respectively. While fed according to FS-2 the highest and the lowest BML were recorded at 500 ppm ($25.13 \pm 0.37\text{mm}$) and at control ($18.29 \pm 0.93\text{mm}$) respectively. In case of FS-3, leaf extract also increased the BML at different doses, viz. at 100 ppm ($21.33 \pm 1.12\text{mm}$), 500 ppm ($24.50 \pm 0.70\text{mm}$), 1000 ppm ($23.22 \pm 0.65\text{mm}$), 1500 ppm ($22.49 \pm 0.80\text{mm}$) compared with control ($16.60 \pm 0.33\text{mm}$).

In case of stem extract, the mean values of BML in different concentrations for different feeding schedules and plant parts were significantly increased. For FS-1, the highest and the lowest BML were recorded at 500 ppm ($25.45 \pm 0.51\text{mm}$) and at control ($17.25 \pm 0.28\text{mm}$) respectively. In case of FS-2, stem extract increased the BML at different doses, viz. at 100 ppm ($22.91 \pm 0.79\text{mm}$), 500 ppm ($26.79 \pm 0.61\text{mm}$), 1000 ppm ($23.44 \pm 0.53\text{mm}$) and 1500 ppm ($24.27 \pm 0.40\text{mm}$) compare to control ($18.29 \pm 0.33\text{mm}$). The highest and the lowest mean BML were observed at 500 ppm ($26.00 \pm 0.32\text{mm}$) and control ($16.60 \pm 0.33\text{mm}$) respectively while fed according to FS-3.

In different feeding schedules, the mean values of BML were significantly increased at different concentrations for root extract of *A. augusta*. The highest and the lowest mean BML were observed at 500 ppm ($24.66 \pm 0.56\text{mm}$) and at

control ($17.25 \pm 0.28 \text{ mm}$) for FS-1, at 500 ppm ($26.40 \pm 0.93 \text{ mm}$) and at control ($18.29 \pm 0.33 \text{ mm}$) and at 500 ppm ($25.07 \pm 0.27 \text{ mm}$) and at control ($16.60 \pm 0.33 \text{ mm}$) for FS-3 respectively.

Analysis of variance showed highly significant differences among feeding schedules ($F=43.81$), among plant parts ($F=37.21$), among doses ($F=291.88$) at 1% level of significance but dose $\times$ plant parts ($F=1.52$) showed non-significant results (Table 29).

The effectiveness of different plant extracts with respect to plant parts followed the order stem > root > leaf while in respect of feeding schedule this trend was FS-2 > FS-3 > FS-1. In most of the results for both PP and FS effective dose of the plant extracts followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm.

4.2.1.2 Effect of *A. augusta* extracts on growth of pupae of *B. mori*

The results of the supplementation of different parts, viz. leaf, stem and root extracts of *A. augusta* on growth of pupae of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 are given below:

Pupal weight (PW):

Effect of different parts extracts of *A. augusta* on PW of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 19 and their statistical analysis is presented in Table 30.

In case of leaf extract, the mean values of PW increased at different doses when compared with control in respect FS-1. The highest and the lowest mean PW were observed at 500 ppm ($1.17 \pm 0.004 \text{ gm}$) and control ($1.12 \pm 0.004 \text{ gm}$) respectively. While maintaining scheduled FS-2, the highest and the lowest PW were observed at 500 ppm, ($1.16 \pm 0.006 \text{ gm}$), and at control ($1.12 \pm 0.004 \text{ gm}$) respectively. In case of FS-3, leaf extract also increased the PW at different doses, viz. at 100 ppm ($1.16 \pm 0.000 \text{ gm}$), 500 ppm ($1.18 \pm 0.005 \text{ gm}$), 1000 ppm ($1.18 \pm 0.002 \text{ gm}$) and 1500 ppm ($1.17 \pm 0.004 \text{ gm}$) compare to control ($1.15 \pm 0.002 \text{ gm}$).

For stem extract, the mean values of PW in different concentrations for different feeding schedules and plant parts were significantly increased. While fed according to FS-1, the highest and the lowest PW were recorded at 500 ppm ($1.17 \pm 0.004 \text{ gm}$) and at control ($1.12 \pm 0.004 \text{ gm}$) respectively. In case of FS-2, leaf extract increased the PW at different doses, viz. at 100 ppm ($1.14 \pm 0.006 \text{ gm}$), 500 ppm ($1.17 \pm 0.005 \text{ gm}$), 1000 ppm ($1.10 \pm 0.004 \text{ gm}$) and 1500 ppm ($1.16 \pm 0.009 \text{ gm}$) against the control value ($1.12 \pm 0.004 \text{ gm}$). The highest and the lowest mean PW were observed at 500 ppm ($1.20 \pm 0.003 \text{ gm}$) and control ($1.15 \pm 0.002 \text{ gm}$) respectively while fed according to FS-3.

In different feeding schedules, the mean values of PW were significantly increased at different concentrations for root extract of *A. augusta*. The highest and the lowest mean PW were observed at 500 ppm ($1.17 \pm 0.002 \text{ gm}$) and at control ($1.12 \pm 0.004 \text{ gm}$) for FS-1, at 500 ppm ($1.19 \pm 0.004 \text{ gm}$) and at control ($1.12 \pm 0.004 \text{ gm}$) for FS-2 and at 500 ppm ($1.18 \pm 0.004 \text{ gm}$) and at control ($1.15 \pm 0.002 \text{ gm}$) for FS-3 respectively.

The results of ANOVA have been presented in the Table 30. The items dose and feeding schedules revealed significant results.

The effectiveness of different plant extracts with respect to plant parts followed the order stem > root > leaf while in respect of feeding schedule this trend was FS-3 > FS-2 > FS-1. In most of the results for both PP and FS effective dose of the plant extracts followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm.

4.2.1.3 Effect of *A. augusta* extract on the survival of *B. mori* larvae.

The results of the supplementation of different parts, viz. leaf, stem and root extracts of *A. augusta* on survival of *B. mori* larvae at different feeding schedules, viz. FS-1, FS-2 and FS-3 are given bellow:

Surviving percentage (SP):

Effect of different extracts from different parts of *A. augusta* on SP of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 20 and their statistical analysis is presented in Table 31.

In case of leaf extract, the mean values of SP increased at different dose against control while fed in FS-1. The highest and the lowest mean SP were observed at 500 ppm ($63.00 \pm 1.20\%$) and control ($55.00 \pm 0.53\%$) respectively. While maintaining schedules FS-2 the highest and the lowest SP were observed at 500 ppm ($65.33 \pm 0.88\%$) and at control ($56.67 \pm 0.67\%$) respectively. In case of FS-3, leaf extract also increased the SP at different doses, viz. at 100 ppm ($61.67 \pm 0.86\%$), 500 ppm ($64.00 \pm 0.54\%$), 1000 ppm ($62.00 \pm 0.55\%$) and 1500 ppm ($62.33 \pm 0.49\%$) when compared with control ($56.00 \pm 0.58\%$).

For stem extract, the mean values of SP in different concentrations for different feeding schedules and plant parts increased significantly. While fed according to FS-1, the highest and the lowest SP were recorded at 500 ppm ($64.67 \pm 0.44\%$) and at control ($55.00 \pm 0.53\%$) respectively. In case of FS-2, stem extract increased the SP at different doses, viz. at 100 ppm ($63.00 \pm 0.51\%$), 500 ppm ($66.00 \pm 0.52\%$), 1000 ppm ($65.33 \pm 0.49\%$) and 1500 ppm ($64.00 \pm 0.51\%$) against control ($56.67 \pm 0.67\%$). The highest and the lowest mean SP were observed at 500 ppm ($65.33 \pm 0.42\%$) and control ($56.00 \pm 0.58\%$) respectively while fed according to FS-3.

In different feeding schedules, the mean values of SP increased significantly at different concentrations for root extract of *A. augusta*. The highest and the lowest mean SP were observed at 500 ppm ($63.00 \pm 0.51\%$) and at control ($55.00 \pm 0.53\%$) for FS-1, at 500 ppm ($65.33 \pm 0.76\%$) and at control ($56.67 \pm 0.66\%$) for FS-2 and at 500 ppm ($64.00 \pm 0.69\%$) and at control ($56.00 \pm 0.58\%$) for FS-3 respectively.

The results of ANOVA have been presented in the Table 31. It indicated highly significant differences among feeding schedules ($F=140.46$), plant parts

($F=45.43$), doses ($F=679.04$) at 1% level of significance. The result was insignificant for the interaction item doses $\times$ plant parts.

The effectiveness of different plant parts on SP followed the order stem > root > leaf and in respect of feeding schedule FS-2 > FS-3 > FS-1. The most effective dose of the plant extracts was found to be 500 ppm followed by 1000 ppm, 1500 ppm and 100 ppm.

4.2.1.4 Effect of *A. augusta* extracts on the developmental period of *B. mori*

The results of the supplementation of different parts, viz. leaf, stem and root extracts of *A. augusta* on the developmental period of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 are given below:

Larval duration (LD):

Effect of different parts of *A. augusta* extract on LD of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 21 and their statistical analysis is presented in Table 32.

In case of leaf extract, the mean values of LD increased at different doses against control while fed in FS-1. The highest and the lowest mean LD were observed at 500 ppm ($22.99\pm0.82d$) and control ($23.05\pm0.66d$) respectively. While maintaining schedules FS-2 the highest and the lowest LD were observed at 5000 ppm, ($23.10\pm0.29d$), and at control ($22.90\pm0.79d$) respectively. In case of FS-3, leaf extract also increased the LD at different doses, viz. at 100 ppm ($23.05\pm0.66d$), 500 ppm ($23.11\pm0.56d$), 1000 ppm ($23.14\pm0.42d$) and 1500 ppm ($23.12\pm0.26d$) in comparison to control ($22.99\pm0.82d$).

In case of stem extract, the mean values of LD in different concentrations were significantly increased. While fed according to FS-1, the highest and the lowest LD were recorded at 1000 ppm ($23.20\pm0.07d$) and at control ($23.05\pm0.66d$) respectively. For FS-1, stem extract increased the LD at different doses, viz. at 100

ppm ($23.10 \pm 0.37d$), 500 ppm ($23.17 \pm 0.27d$), 1000 ppm ($23.25 \pm 0.25d$) and 1500 ppm ($23.20 \pm 0.40d$) against control ($22.90 \pm 0.79d$). For FS-2 the highest and the lowest mean LD were observed at 500 ppm ($23.16 \pm 0.55d$) and control ($22.99 \pm 0.82d$) respectively while fed according to FS-3.

In different feeding schedules, the mean values of LD were significantly increased at different concentrations for root extract of *A. augusta*. The highest and the lowest mean LD were observed at 500 ppm ($23.20 \pm 0.78d$) at control ($23.05 \pm 0.66d$) for FS-1, at 500 ppm ($23.12 \pm 0.25d$) at control ($22.90 \pm 0.79d$) for FS-2, at 500 ppm ($23.15 \pm 0.55d$) for FS-3 compare to control ($22.99 \pm 0.82d$).

The results of ANOVA have been presented in the Table 32. All the items revealed significant results ($P < 0.01$). The efficacy of different plant parts on LD followed the order stem > root > leaf and for feeding schedule the effectiveness in this regard was FS-2 > FS-3 > FS-1. The most effective dose of the plant extracts in majority of the cases was 1000 ppm followed by 1500 ppm, 500 ppm and 100 ppm.

Pupal duration (PD):

Result on the effect of *A. augusta* extracts on PD of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 22 and their statistical analysis is presented in Table 33.

In case of leaf extract, the mean values of PD increased at different doses as compared to control while fed in FS-1. The highest and the lowest PD were observed at 1000 ppm ($9.20 \pm 0.052d$) and control ($8.99 \pm 0.009d$) respectively. While maintaining schedules FS-2 the highest and the lowest PD were observed at 1000 ppm ($9.26 \pm 0.015d$) and at control ($9.15 \pm 0.015d$) respectively. In case of FS-3, leaf extract also increased the PD at different doses, viz. at 100 ppm ($9.12 \pm 0.006d$), 500 ppm ($9.15 \pm 0.0115d$), 1000 ppm ($9.23 \pm 0.009d$), 1500 ppm ($9.22 \pm 0.075d$) against control ($9.10 \pm 0.009d$).

In case of stem extract, the mean values of PD in different concentrations increased significantly. While fed according to FS-1, the highest and the lowest PD were recorded at 1000 ppm ($9.36 \pm 0.05d$) and at control ($8.99 \pm 0.009d$) respectively. For FS-2, stem extract increased the PD at different doses, viz. at 100 ppm ($9.23 \pm 0.02d$), 500 ppm ($9.30 \pm 0.045d$), 1000 ppm ($9.41 \pm 0.037d$) and 1500 ppm ($9.35 \pm 0.048d$) against control ($9.15 \pm 0.015d$). The highest and the lowest PD were observed at 500 ppm ($9.22 \pm 0.018d$) and control ($9.10 \pm 0.009d$) respectively while fed according to FS-3.

In different feeding schedules, the mean values of PD were significantly increased at different concentrations for root extract of *A. augusta*. The highest PD were observed at 1000 ppm ($9.30 \pm 0.044d$) for FS-1, at 1000 ppm ($9.38 \pm 0.042d$) for FS-2, at 1000 ppm ($9.30 \pm 0.059d$) for FS-3. On the other hand lowest PD was recorded in control for all the cases.

For all the items except dose $\times$ plant parts ($F=1.58$), analyses of variance showed highly significant differences among feeding schedules ($F=40.57$), plant parts ($F=30.25$), doses ($F=52.56$) at 1% level of significance (Table 33).

The effectiveness of different plant extracts with respect to plant parts followed the order stem > root > leaf while in respect of feeding schedule this trend was FS-2 > FS-3 > FS-1. In most of the results for both PP and FS effective dose of the plant extracts followed the order 1000 ppm > 1500 ppm > 500 ppm > 100 ppm.

4.2.1.5 Effect of *A. augusta* extracts on the cocoon characters of *B. mori*

The results of the supplementation of different parts of *A. augusta* extracts, viz. leaf, stem and root on the cocoon characters of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 are given bellow:

Cocoon weight (CW):

Effect of different parts, viz. leaf, stem and root extracts of *A. augusta* on CW of *B. mori* at different feeding schedules, viz. FS-1, FS-2, and FS-3 has been in Table 23 and their statistical analysis is included in Table 34.

Leaf extract of *A. augusta* increased the CW at different doses compare to control while fed in FS-1. The highest and the lowest mean CW were observed at 500 ppm ($1.32 \pm 0.010\text{gm}$) and control ($1.25 \pm 0.009\text{gm}$) respectively. While fed according to FS-2 the heaviest and the lightest cocoon were produced at 500 ppm ($1.34 \pm 0.012\text{gm}$), and at control ($1.27 \pm 0.015\text{gm}$) respectively. In case of FS-3, leaf extract also increased the CW at different doses, viz. at 100 ppm ($1.32 \pm 0.006\text{gm}$), 500 ppm ($1.35 \pm 0.009\text{gm}$), 1000 ppm ($1.34 \pm 0.011\text{gm}$) and 1500 ppm ($1.32 \pm 0.009\text{gm}$) against control ($1.29 \pm 0.012\text{gm}$).

In case of stem extract, the mean values of CW in different concentrations for different feeding schedules increased significantly. While fed according to FS-1, the heaviest and the lightest cocoons were produced at 500 ppm ($1.34 \pm 0.007\text{gm}$) and at control ($1.25 \pm 0.009\text{gm}$) respectively. In case of FS-2, stem extract increased the CW at different doses, viz. at 100 ppm ($1.29 \pm 0.015\text{gm}$), 500 ppm ($1.35 \pm 0.012\text{gm}$), 1000 ppm ($1.26 \pm 0.009\text{gm}$) and 1500 ppm ($1.33 \pm 0.015\text{gm}$) compare to control ($1.27 \pm 0.015\text{gm}$). The highest and the lowest mean CW were recorded at 500 ppm ($1.37 \pm 0.006\text{gm}$) and control ($1.29 \pm 0.012\text{gm}$) respectively at FS-3.

In different feeding schedules, the mean values of CW increased significantly at different concentrations for root extract of *A. augusta*. The highest mean CW were observed at 500 ppm ($1.33 \pm 0.013\text{gm}$) for FS-1, at 500 ppm ($1.36 \pm 0.012\text{gm}$) for FS-2 and at 500 ppm ($1.36 \pm 0.010\text{gm}$) FS-3 and the lowest at control i.e. ($1.25 \pm 0.009\text{gm}$) FS-1, ($1.27 \pm 0.015\text{gm}$) in FS-2 and ($1.29 \pm 0.012\text{gm}$) in FS-3.

Results of analyses of variance are presented in Table 34. The items feeding schedules and doses showed highly significant differences at 1% level of significance.

The effective concentration of plant extracts in respect of their efficacy as a food supplement with mulberry leaves followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm. When pp was evaluated, the most effective PP was stem followed by root and leaf. For FS the efficacy followed the order FS-2 > FS-3 > FS-1.

Shell weight (SW): Effect of different parts, viz. leaf, stem and root extracts of *A. augusta* on SW of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 24 and their statistical analysis is presented in Table 35.

Leaf extract of *A. augusta* increased the SW at different doses compare to control while fed in FS-1. The highest and the lowest mean SW were observed at 500 ppm (0.15 ± 0.006 gm) and control (0.13 ± 0.005 gm) respectively. While fed according to FS-2 the heaviest and the lightest shell were produced at 500 ppm, (0.18 ± 0.006 gm), and at control (0.15 ± 0.011 gm) respectively. In case of FS-3, leaf extract also increased the SW at different doses, viz. at 100 ppm (0.16 ± 0.006 gm), 500 ppm (0.17 ± 0.003 gm), 1000 ppm (0.16 ± 0.009 gm), 1500 ppm (0.15 ± 0.005 gm) compare to control (0.14 ± 0.010 gm).

In case of stem extract, the mean values of SW in different concentrations for different feeding schedules increased significantly. While fed according to FS-1, the heaviest and the lightest shell were produced at 500 ppm (0.17 ± 0.003 gm) and at control (0.13 ± 0.005 gm) respectively. In case of FS-2, stem extract increased the SW at different doses, viz. at 100 ppm (0.16 ± 0.009 gm), 500 ppm (0.18 ± 0.007 gm), 1000 ppm (0.17 ± 0.005 gm) and 1500 ppm (0.17 ± 0.007 gm) against control (0.15 ± 0.011 gm). The highest and the lowest mean SW were observed at 500 ppm (0.17 ± 0.003 gm) and control (0.14 ± 0.010 gm) respectively at FS-3.

In different feeding schedules, the mean values of SW were significantly increased at different concentrations for root extract of *A. augusta*. The highest mean SW

was observed at 500 ppm (0.16 ± 0.011 gm) for FS-1, at 500 ppm (0.17 ± 0.008 gm) for FS-2 and at 500 ppm (0.18 ± 0.006 gm) FS-3 and the lowest at control for all the cases. i.e. (0.13 ± 0.005 gm) for FS-1, (0.15 ± 0.011 gm) for FS-2 and (0.14 ± 0.010 gm) for FS-3 in respect.

Results of analyses of variance are presented in Table 35. The items doses ($F=33.38$) and feeding schedules ($F=9.46$) showed highly significant differences at 1% level of significance.

The effectiveness of different plant extracts with respect to plant parts followed the order stem > root > leaf while in respect of feeding schedule this trend was FS-2 > FS-3 > FS-1. In most of the results for both PP and FS effective dose of the plant extracts followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm.

4.2.1.6 Effect of *A. augusta* on the fecundity and fertility of *B. mori*

In the present investigation fecundity was evaluated on the basis of egg laying potential, i.e. total number of eggs laid by individual female moth of *B. mori* and for fertility parameter egg hatching percentage was computed.

The results of the supplementation of different parts, viz. leaf, stem and root extracts of *A. augusta* on the fecundity and fertility of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 are given bellow:

Total number of eggs laid per female (TEL):

Effect of different parts, viz. leaf, stem and root extracts of *A. augusta* on fecundity, i.e. total number of eggs by individual female of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 25 and their statistical analysis is presented in Table 36.

Leaf extract of *A. augusta* increased the TEL at different doses compare to control while fed in FS-1. The highest and the lowest TEL were observed at 500 ppm (446.33 ± 0.67) and control (440.11 ± 1.04) respectively. While fed according to FS-

2 the highest and the lowest TEL were produced at 500 ppm (448.00 ± 1.00) and at 100 ppm (445.00 ± 1.73) respectively. In case of FS-3, leaf extract also increased the TEL at different doses, viz. at 100 ppm (444.67 ± 1.33), 500 ppm (447.67 ± 0.88), 1000 ppm (446.00 ± 0.58) and 1500 ppm (445.67 ± 0.88) against to control (428.56 ± 1.05).

In case of stem extract, the mean values of TEL in different concentrations for different feeding schedules were significantly increased. While fed according to FS-1, the heaviest and the lightest TEL were produced at 500 ppm (448.67 ± 1.45) and at control (440.11 ± 1.04) respectively. In case of FS-2, stem extract increased the TEL at different doses, viz. at 100 ppm (447.33 ± 0.33), 500 ppm (450.67 ± 0.88), 1000 ppm (449.67 ± 0.88), 1500 ppm (448.33 ± 1.20) compare to control (445.00 ± 1.01). The highest and the lowest TEL were observed at 500 ppm (449.67 ± 1.20) and the control (428.56 ± 1.05) respectively at FS-3.

In different feeding schedules, the mean values of TEL increased significantly at different concentrations for root extract of *A. augusta*. The highest and lowest value of TEL was observed at 500 ppm (447.33 ± 1.20) and at control (440.11 ± 1.04) for FS-1, at 500 ppm (449.00 ± 0.58) and at control (445.00 ± 1.01) for FS-2 and at 500 ppm (448.00 ± 0.58) and at control (428.56 ± 1.05) for FS-3 respectively.

Results of analyses of variance are presented in Table 36. All the items showed highly significant differences at 1% level of significance. The effectiveness of different plant extracts with respect to plant parts followed the order stem > root > leaf while in respect of feeding schedule this trend was FS-2 > FS-3 > FS-1. In most of the results for both PP and FS effective dose of the plant extracts followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm.

Egg hatching percentage (EHP):

Effect of different parts viz. leaf, stem, root extracts of *A. augusta* on EHP of *B. mori* at different feeding schedules viz. FS-1, FS-2 and FS-3 is shown in Table 26 and their statistical analysis is presented in Table 37.

Leaf extract of *A. augusta* increased the EHP at different doses compare to control while fed in FS-1. The highest and the lowest EHP were observed at 500 ppm ($92.00 \pm 0.56\%$) and control ($86.0 \pm 0.58\%$) respectively. While fed according to FS-2 the highest and the lowest EHP were produced at 500 ppm ($94.00 \pm 0.58\%$) and at control ($87.00 \pm 0.55\%$) respectively. In case of FS-3, leaf extract also increased the EHP at different doses, viz. at 100 ppm ($80.00 \pm 0.54\%$), 500 ppm ($93.00 \pm 0.67\%$), 1000 ppm ($91.00 \pm 0.55\%$), 1500 ppm ($91.00 \pm 0.60\%$) compare to control ($84.00 \pm 0.33\%$).

In case of stem extract, the mean values of EHP in different concentrations for different feeding schedules increased significantly. While fed according to FS-1, the highest and the lowest EHP were produced at 500 ppm and at control ($86.00 \pm 0.58\%$) respectively. In case of FS-2, stem extract increased the EHP at different doses, viz. at 100 ppm ($90.00 \pm 0.52\%$), 500 ppm ($97.00 \pm 0.59\%$), 1000 ppm ($96.00 \pm 0.62\%$) and 1500 ppm ($95.00 \pm 0.54\%$) against control ($87.00 \pm 0.55\%$). The highest and the lowest EHP were observed at 500 ppm ($90.00 \pm 0.84\%$) and control ($84.00 \pm 0.33\%$) respectively at FS-3.

In different feeding schedules, the mean values of EHP were significantly increased at different concentrations for root extract of *A. augusta*. The highest mean EHP were observed at 500 ppm ($94.00 \pm 0.51\%$) for FS-1, at 500 ppm ($96.00 \pm 0.59\%$) for FS-2 and at 500 ppm ($95.00 \pm 0.39\%$) for FS-3 and the lowest at control for all the cases, i.e. ($86.0 \pm 0.58\%$) in FS-1, ($87.00 \pm 0.55\%$) in FS-2 and ($84.00 \pm 0.33\%$) in FS-3.

Results of analyses of variance are presented in Table 37. The items feeding schedules ($F=5.14$), plant parts ($F=6.91$) and doses ($F=16.11$) showed significant

differences. The effectiveness of different plant extracts with respect to plant parts followed the order stem > root > leaf while in respect of feeding schedule this trend was FS-2 > FS-3 > FS-1. In most of the results for both PP and FS effective dose of the plant extracts followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm.

4.2.2 Effects of *C. asiatica* extracts supplementation with mulberry leaves on *Bombyx mori*

The effects of the supplementation of different parts, viz. leaf, stem and root extracts of *C. asiatica* on *B. mori* at different feeding schedules, viz. fed only in 1st feeding of 3rd to 5th instar larvae (FS-1), fed everyday in 1st feeding of 3rd to 5th instar larvae (FS-2) and fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae (FS-3) were conducted and are presented in Tables 38-48. The data for different characters were subjected to analysis of variance to determine the variations among doses and plant parts, feeding schedules and are presented in Table 49-59. The results obtained in the present experiments are discussed as follow:

4.2.2.1 Effect of *C. asiatica* extracts on the larval growth of *B. mori*.

The results of the supplementation of different parts, viz. leaf, stem and root extracts of *C. asiatica* on growth of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 are given bellow:

Weight of mature larvae (WML):

Effect of different parts, viz. leaf, stem and root extracts of *C. asiatica* on WML of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 38 and their statistical analysis is presented in Table 49.

Leaf extract of *C. asiatica* increased the WML at different doses compare to control while fed in FS-1. The highest and the lowest mean WML were observed at 500 ppm ($2.58 \pm 0.121 \text{ gm}$) and control ($2.48 \pm 0.012 \text{ gm}$) respectively. While fed according to FS-2 the heaviest and the lightest larvae were produced at 500 ppm ($2.59 \pm 0.015 \text{ gm}$) and at control ($2.54 \pm 0.010 \text{ gm}$) respectively. In case of FS-3, leaf extract also increased the WML at different doses viz. at 100 ppm ($2.51 \pm 0.008 \text{ gm}$), 500 ppm ($2.57 \pm 0.016 \text{ gm}$), 1000 ppm ($2.54 \pm 0.014 \text{ gm}$), 1500 ppm ($2.56 \pm 0.012 \text{ gm}$) compare to control ($2.52 \pm 0.015 \text{ gm}$).

In case of stem extract, the mean values of WML in different concentrations for different feeding schedules were significantly increased. While fed according to FS-1, the heaviest and the lightest larvae were produced at 500 ppm ($2.57 \pm 0.011 \text{ gm}$) and at control ($2.48 \pm 0.0012 \text{ gm}$) respectively. In case of FS-2, leaf extract increased the WML at different doses, viz. at 100 ppm ($2.56 \pm 0.014 \text{ gm}$), 500 ppm ($2.59 \pm 0.007 \text{ gm}$), 1000 ppm ($2.97 \pm 0.01 \text{ gm}$), 1500 ppm ($2.57 \pm 0.013 \text{ gm}$) compare to control ($2.54 \pm 0.010 \text{ gm}$). The highest and the lowest mean WML were observed at 500 ppm ($2.58 \pm 0.007 \text{ gm}$) and control ($2.52 \pm 0.015 \text{ gm}$) respectively at FS-3.

In different feeding schedules, the mean values of WML were significantly increased at different concentrations for root extract of *C. asiatica*. The highest mean WML were observed at 500 ppm ($2.56 \pm 0.017 \text{ gm}$) at control ($2.48 \pm 0.012 \text{ gm}$) for FS-1, at 500 ppm ($2.58 \pm 0.009 \text{ gm}$) at control ($2.54 \pm 0.010 \text{ gm}$) for FS-2 and at 500 ppm ($2.57 \pm 0.013 \text{ gm}$) FS-3 and the lowest at control ($2.52 \pm 0.015 \text{ gm}$).

Results of analyses of variance are presented in Table 49. All the items showed highly significant differences at least 5% level of significance. The effectiveness of different plant extracts with respect to plant parts followed the order leaf > stem > root while in respect of feeding schedule this trend was FS-2 > FS-3 > FS-1. In most of the results for both PP and FS effective dose of the plant extracts followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm.

Length of mature larvae (LML):

Effect of different parts extracts of *C. asiatica* on LML of *B. mori* at different feeding schedules viz. FS-1, FS-2 and FS-3 is shown in Table 39 and their statistical analysis is presented in Table 50.

In case of leaf extract, the mean values of LML increased at different doses compare to control while fed in FS-1. The highest and the lowest mean LML were observed at 500 ppm ($72.31 \pm 0.68\text{mm}$) and at control ($64.77 \pm 0.040\text{mm}$) respectively. While maintaining schedules FS-2 the highest and the lowest LML were observed at 500 ppm ($74.15 \pm 0.36\text{mm}$) and at control ($66.86 \pm 0.51\text{mm}$) respectively. In case of FS-3, leaf extract also increased the LML at different doses, viz. at 100 ppm ($70.58 \pm 0.43\text{m}$), 500 ppm ($73.23 \pm 0.54\text{mm}$), 1000 ppm ($72.30 \pm 0.17\text{mm}$), 1500 ppm ($71.15 \pm 0.17\text{mm}$) compare to control ($66.11 \pm 0.23\text{mm}$).

For stem extract, the mean values of LML in different concentrations for different feeding schedules and plant parts were significantly increased. While fed according to FS-1, the highest and the lowest LML were recorded at 500 ppm ($71.63 \pm 0.62\text{mm}$) and at control ($64.77 \pm 0.40\text{mm}$) respectively. In case of FS-2, leaf extract increased the LML at different doses, viz. at 100 ppm ($70.21 \pm 0.95\text{mm}$), 500 ppm ($73.02 \pm 0.81\text{mm}$), 1000 ppm ($72.55 \pm 0.55\text{mm}$), 1500 ppm ($71.60 \pm 1.05\text{mm}$) compare to control ($66.86 \pm 0.51\text{mm}$). The highest and the lowest mean LML were observed at 500 ppm ($72.47 \pm 0.71\text{mm}$) and control ($66.11 \pm 0.23\text{mm}$) respectively while fed according to FS-3.

In different feeding schedules, the mean values of LML were significantly increased at different concentrations for root extract of *C. asiatica*. The highest and the lowest mean LML were observed at 500 ppm (70.45 ± 0.41) and at control (64.77 ± 0.40) for FS-1, at 500 ppm (72.83 ± 1.21) and at control (66.86 ± 0.51) for FS-2 and at 500 ppm (71.71 ± 1.38) and at control ($66.11 \pm 0.23\text{mm}$) for FS-3 respectively.

The results of ANOVA have been presented in the Table 50. The items, viz. feeding schedules ($F=129.98$), plant parts ($F=78.81$), dose ($F=222.07$) revealed significant results ($P<0.01$). The efficacy of different plant parts on LML followed the order leaf > stem > root and for feeding schedule the effectiveness in this regard was FS-2 > FS-3 > FS-1. The most effective dose of the plant extracts in majority of the cases was 1000 ppm followed by 1500 ppm, 500 ppm and 100 ppm.

Breadth of mature larvae (BML):

Effect of different parts, viz. leaf, stem and root extracts of *C. asiatica* on BML of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 40 and their statistical analysis is presented in Table 51.

Results of leaf extract of *C. asiatica* showed that the BML increased at different doses in comparison to control while fed in FS-1. The highest and the lowest mean BML were observed at 500 ppm (22.61 ± 0.61 mm) and control (14.48 ± 0.27 mm) respectively. While fed according to FS-2 the highest and the lowest BML were recorded at 500 ppm (24.61 ± 0.55 mm) and at control (16.29 ± 0.32 mm) respectively. In case of FS-3, leaf extract also increased the BML at different doses, viz. at 100 ppm (20.55 ± 0.67 mm), 500 ppm (23.12 ± 0.75), 1000 ppm (22.32 ± 0.61 mm), 1500 ppm (21.15 ± 0.67 mm) compared with control (15.02 ± 0.25 mm).

In case of stem extract, the mean values of BML in different concentrations for different feeding schedules and plant parts were significantly increased. For FS-1, the highest and the lowest BML were recorded at 500 ppm (21.56 ± 0.72 mm) and at control (14.48 ± 0.27 mm) respectively. In case of FS-2, stem extract increased the BML at different doses, viz. at 100 ppm (20.48 ± 0.53 mm), 500 ppm (23.09 ± 0.119 mm), 1000 ppm (22.14 ± 0.78 mm) and 1500 ppm (21.28 ± 0.64 mm) compare to control (16.29 ± 0.32 mm). The highest and the lowest mean BML were

observed at 500 ppm (22.10 ± 1.14 mm) and control (15.02 ± 0.25 mm) respectively while fed according to FS-3.

In different feeding schedules, the mean values of BML were significantly increased at different concentrations for root extract of *C. asiatica*. The highest and the lowest mean BML were observed at 500 ppm (20.91 ± 0.78 mm) and at control (14.48 ± 0.27 mm) for FS-1, at 500 ppm (22.53 ± 1.17 mm) and at control (16.29 ± 0.32 mm) and at 500 ppm (21.94 ± 0.27 mm) and at control (15.02 ± 0.25 mm) for FS-3 respectively. Analysis of variance showed highly significant differences among feeding schedules ($F=129.89$), among plant parts ($F=71.49$), among doses ($F=311.68$) at 1% level of significance but dose $\times$ plant parts ($F=0.76$) showed non-significant results (Table 51).

The effective concentration of plant extracts in respect of their efficacy as a food supplement with mulberry leaves followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm. When pp was evaluated, the most effective PP was leaf followed by stem and root. For FS the efficacy followed the order FS-2 > FS-3 > FS-1.

4.2.2.2 Effect of *C. asiatica* extracts on the growth of pupae of *B. mori*

The results of the supplementation of different parts, viz. leaf, stem and root extracts of *C. asiatica* on growth of pupae of *B. mori* at different feeding schedules viz. FS-1, FS-2 and FS-3 are given bellow:

Pupal weight (PW):

Effect of different parts extracts of *C. asiatica* on PW of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 41 and their statistical analysis is presented in Table 52.

In case of leaf extract, the mean values of PW increased at different doses when compared with control in FS-1. The highest and the lowest mean mature pupal

weight of respect were observed at 500 ppm ($1.04 \pm 0.002 \text{ gm}$) and control ($0.97 \pm 0.007 \text{ gm}$) respectively. While maintaining scheduled FS-2, the highest and the lowest pupal weight were observed at 500 ppm, ($1.02 \pm 0.005 \text{ gm}$), and at control ($0.98 \pm 0.009 \text{ gm}$) respectively. In case of FS-3, leaf extract also increased the pupal weight at different doses, viz. at 100 ppm ($0.92 \pm 0.003 \text{ gm}$), 500 ppm ($1.02 \pm 0.002 \text{ gm}$), 1000 ppm ($0.96 \pm 0.003 \text{ gm}$) and 1500 ppm ($0.96 \pm 0.002 \text{ gm}$) compare to control ($0.99 \pm 0.010 \text{ gm}$).

For stem extract, the mean values of PW in different concentrations for different feeding schedules and plant parts were significantly increased. While fed according to FS-1, the highest and the lowest pupal weight were recorded at 500 ppm ($1.01 \pm 0.010 \text{ gm}$) and at control ($0.97 \pm 0.007 \text{ gm}$) respectively. In case of FS-2, leaf extract increased the pupal weight at different doses, viz. at 100 ppm ($0.99 \pm 0.009 \text{ gm}$), 500 ppm ($1.02 \pm 0.005 \text{ gm}$), 1000 ppm ($1.00 \pm 0.006 \text{ gm}$) and 1500 ppm ($1.00 \pm 0.002 \text{ gm}$) against the control value ($0.98 \pm 0.009 \text{ gm}$). The highest and the lowest mean pupal weight were observed at 500 ppm ($1.02 \pm 0.009 \text{ gm}$) and control ($0.99 \pm 0.010 \text{ gm}$) respectively while fed according to FS-3.

In different feeding schedules, the mean values of mature PW were significantly increased at different concentrations for root extract of *C. asiatica*. The highest and the lowest mean pupal weight were observed at 500 ppm ($1.03 \pm 0.006 \text{ gm}$) and at control ($0.97 \pm 0.007 \text{ gm}$) for FS-1, at 500 ppm ($1.02 \pm 0.004 \text{ gm}$) and at control ($0.98 \pm 0.009 \text{ gm}$) for FS-2 and at 500 ppm ($1.02 \pm 0.004 \text{ gm}$) and at control ($0.99 \pm 0.010 \text{ gm}$) for FS-3 respectively.

The results of ANOVA have been presented in the Table 52. Only one item dose revealed significant results ($P < 0.01$). The effectiveness of different plant parts on PW followed the order leaf > stem > root and in respect of feeding schedule FS-1 > FS-2 > FS-3. The most effective dose of the plant extracts was found to be 500 ppm followed by 1000 ppm, 1500 ppm and 100 ppm.

4.2.2.3 Effect of *C. asiatica* extract on the survival of *B. mori* larvae.

The results of the supplementation of different parts, viz. leaf, stem and root extracts of *C. asiatica* on the developmental period of *B. mori* at different feeding schedules viz. FS-1, FS-2 and FS-3 are given below:

Surviving percentage (SP):

The results of *C. asiatica* extracts on the larval survival of *B. mori* supplemented with mulberry leaves under different schedules of feeding have been discussed for the following draft:

Effect of different parts extracts from different parts of *C. asiatica* on surviving percentage SP of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 42 and their statistical analysis is presented in Table 53.

In case of leaf extract, the mean values of surviving percentage increased at different dose against control while fed in FS-1. The highest and the lowest mean SP were observed at 500 ppm ($61.00 \pm 0.78\%$) and control ($52.00 \pm 0.58\%$) respectively. While maintaining schedules FS-2 the highest and the lowest surviving percentage were observed at 500 ppm ($63.00 \pm 0.73\%$) and at control ($54.00 \pm 0.67\%$) respectively. In case of FS-3, leaf extract also increased the SP at different doses, viz. at 100 ppm ($59.00 \pm 0.75\%$), 500 ppm ($62.33 \pm 0.48\%$), 1000 ppm ($61.00 \pm 0.55\%$) and 1500 ppm ($60.33 \pm 0.86\%$) when compared with control ($52.67 \pm 0.33\%$).

For stem extract, the mean values of SP in different concentrations for different feeding schedules and plant parts were increased significantly. While fed according to FS-1, the highest and the lowest SP were recorded at 500 ppm ($59.00 \pm 0.59\%$) and at control ($52.00 \pm 0.58\%$) respectively. In case of FS-2, stem extract increased the surviving percentage at different doses, viz. at 100 ppm ($58.00 \pm 0.98\%$), 500 ppm ($61.33 \pm 0.90\%$), 1000 ppm ($59.33 \pm 0.52\%$) and 1500 ppm ($59.00 \pm 0.52\%$) against control ($54.00 \pm 0.67\%$). The highest and the lowest mean

SP were observed at 500 ppm ($60.67 \pm 1.20\%$) and control ($52.67 \pm 0.33\%$) respectively while fed according to FS-3.

In different feeding schedules, the mean values of SP were significantly increased at different concentrations for root extract of *C. asiatica*. The highest and the lowest mean SP were observed at 500 ppm ($58.33 \pm 1.20\%$) and at control ($52.00 \pm 0.58\%$) for FS-1, at 500 ppm ($60.67 \pm 0.95\%$) and at control ($54.00 \pm 0.67\%$) for FS-2 and at 500 ppm ($59.00 \pm 0.50\%$) and at control ($52.67 \pm 0.33\%$) for FS-3 respectively.

The results of ANOVA have been presented in the Table 53. It indicated highly significant differences among feeding schedules ($F=56.70$), plant parts ($F=71.34$), doses ($F=138.83$) at 1% level of significance. The result was insignificant for the interaction item doses $\times$ plant parts.

The effectiveness of different plant extracts with respect to plant parts followed the order leaf > stem > root while in respect of feeding schedule this trend was FS-2 > FS-3 > FS-1. In most of the results for both PP and FS effective dose of the plant extracts followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm.

4.2.2.4. Effect of *C. asiatica* extracts on the developmental period of *B. mori*

The results of the supplementation of different parts, viz. leaf, stem and root extracts of *C. asiatica* on the developmental period of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 are given below:

Larval duration (LD):

Effect of different parts of *C. asiatica* extract on LD of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 43 and their statistical analysis is presented in Table 54.

In case of leaf extract, the mean values of larval duration increased at different doses against control while fed in FS-1. The highest and the lowest mean mature

larval length were observed at 1000 ppm ($22.19 \pm 0.243d$) and control ($22.08 \pm 0.040d$) respectively. While maintaining schedules FS-2 the highest and the lowest larval duration were observed at 1000 ppm, ($22.32 \pm 0.046d$), and at control ($22.20 \pm 0.026d$) respectively. In case of FS-3, leaf extract also increased the larval duration at different doses, viz. at 100 ppm ($22.21 \pm 0.213d$), 500 ppm ($22.26 \pm 0.230d$), 1000 ppm ($22.41 \pm 0.036d$) and 1500 ppm ($22.32 \pm 0.116d$) in comparison to control ($22.12 \pm 0.252d$).

In case of stem extract, the mean values of mature larval larval duration in different concentrations were significantly increased. While fed according to FS-1, the highest and the lowest larval duration were recorded at 1000 ppm ($22.50 \pm 0.030d$) and at control ($22.08 \pm 0.040d$) respectively. For FS-2, stem extract increased the larval duration at different doses, viz. at 100 ppm ($22.40 \pm 0.210d$), 500 ppm ($22.49 \pm 0.030d$), 1000 ppm ($22.61 \pm 0.015d$) and 1500 ppm ($22.52 \pm 0.123d$) against control ($22.20 \pm 0.026d$). The highest and the lowest mean larval duration were observed at 500 ppm ($22.45 \pm 0.204d$) and control ($22.12 \pm 0.252d$) respectively while fed according to FS-3.

In different feeding schedules, the mean values of larval duration were significantly increased at different concentrations for root extract of *C. asiatica*. The highest and the lowest mean larval duration were observed at 1000 ppm ($22.35 \pm 0.044d$) and at control ($22.08 \pm 0.040d$) for FS-1, 1000 ppm ($22.46 \pm 0.039d$) and at control ($22.20 \pm 0.026d$) for FS-2, 1000 ppm ($22.35 \pm 0.229d$) and at control ($22.12 \pm 0.252d$) for FS-3.

The results of ANOVA have been presented in the Table 54. All the items except dose $\times$ plant parts revealed significant results ($P < 0.01$). The efficacy of different plant parts on LD followed the order leaf > stem > root and for feeding schedule the effectiveness in this regard was FS-2 > FS-3 > FS-1. The most effective dose of the plant extracts in majority of the cases was 1000 ppm followed by 1500 ppm, 500 ppm and 100 ppm.

Pupal duration (PD):

Result on the effect of *C. asiatica* extracts PD of *B. mori* at different feeding schedules viz. FS-1, FS-2 and FS-3 is shown in Table 44 and their statistical analysis is presented in Table 55.

In case of leaf extract, the mean values of PD increased at different doses as compared to control while fed in FS-1. The highest and the lowest PD were observed at 500 ppm ($8.32 \pm 0.117d$) and control ($8.12 \pm 0.262d$) respectively. While maintaining schedules FS-2 the highest and the lowest PD were observed at 500 ppm ($8.51 \pm 0.015d$) and at control ($8.37 \pm 0.129d$) respectively. In case of FS-3, leaf extract also increased the pupal duration at different doses, viz. at 100 ppm ($8.29 \pm 0.286d$), 500 ppm ($8.37 \pm 0.127d$), 1000 ppm ($8.58 \pm 0.095d$), 1500 ppm ($8.46 \pm 0.091d$) against control ($8.21 \pm 0.173d$).

In case of stem extract, the mean values of PD in different concentrations increased significantly. While fed according to FS-1, the highest and the lowest PD were recorded at 1000 ppm ($8.60 \pm 0.322d$) and at control ($8.12 \pm 0.262d$) respectively. For FS-2, stem extract increased the pupal duration at different doses, viz. at 100 ppm ($8.39 \pm 0.176d$), 500 ppm ($8.55 \pm 0.021d$), 1000 ppm ($8.80 \pm 0.207d$) and 1500 ppm ($8.68 \pm 0.217d$) against control ($8.37 \pm 0.129d$). The highest and the lowest PD were observed at 1000 ppm ($8.62 \pm 0.084d$) and control ($8.21 \pm 0.173d$) respectively while fed according to FS-3.

In different feeding schedules, the mean values of PD were significantly increased at different concentrations for root extract of *C. asiatica*. The highest PD were observed at 1000 ppm ($8.55 \pm 0.328d$) for FS-1, at 1000 ppm ($8.79 \pm 0.172d$) for FS-2, at 1000 ppm ($8.60 \pm 0.084d$) for FS-3. On the other hand lowest PD were recorded in control

For all the items, analysis of variance showed highly significant differences at least 5% level of significance (Table 55). The efficacy of different plant parts on LD followed the order leaf > stem > root and for feeding schedule the

effectiveness in this regard was FS-2 > FS-3 > FS-1. The most effective dose of the plant extracts in majority of the cases was 1000 ppm followed by 1500 ppm, 500 ppm and 100 ppm.

4.2.2.5 Effect of *C. asiatica* extracts on the cocoon characters of *B. mori*

The results of the supplementation of different parts of *C. asiatica*, extracts viz. leaf, stem and root on the cocoon characters of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 are given below:

Cocoon weight (CW):

Effect of different parts, viz. leaf, stem and root extracts of *C. asiatica* on the weight of cocoon of *B. mori* at different feeding schedules, viz. FS-1, FS-2, FS-3 has been in Table 45 and their statistical analysis is included in Table 56.

Leaf extract of *C. asiatica* increased the cocoon weight at different doses compare to control while fed in FS-1. The highest and the lowest mean cocoon weight were observed at 500 ppm ($1.25 \pm 0.006\text{gm}$) and control ($1.13 \pm 0.015\text{gm}$) respectively. While fed according to FS-2 the heaviest and the lightest cocoon were produced at 500 ppm ($1.25 \pm 0.009\text{gm}$), and at control ($1.15 \pm 0.012\text{gm}$) respectively. In case of FS-3, leaf extract also increased the cocoon weight at different doses, viz. at 100 ppm ($1.09 \pm 0.012\text{gm}$), 500 ppm ($1.24 \pm 0.006\text{gm}$), 1000 ppm ($1.17 \pm 0.009\text{gm}$) and 1500 ppm ($1.15 \pm 0.006\text{gm}$) against control ($1.10 \pm 0.014\text{gm}$).

In case of stem extract, the mean values of cocoon weight in different concentrations for different feeding schedules increased significantly. While fed according to FS-1, the heaviest and the lightest cocoons were produced at 500 ppm ($1.20 \pm 0.016\text{gm}$) and at control ($1.13 \pm 0.015\text{gm}$) respectively. In case of FS-2, stem extract increased the cocoon weight at different doses, viz. at 100 ppm ($1.17 \pm 0.015\text{gm}$), 500 ppm ($1.22 \pm 0.007\text{gm}$), 1000 ppm ($1.19 \pm 0.015\text{gm}$) and 1500 ppm ($1.18 \pm 0.006\text{gm}$) compare to control ($1.15 \pm 0.012\text{gm}$). The highest and the

lowest mean cocoon weight were recorded at 500 ppm (1.21 ± 0.012 gm) and control (1.10 ± 0.014 gm) respectively at FS-3.

In different feeding schedules, the mean values of cocoon weight increased significantly at different concentrations for root extract of *C. asiatica*. The highest mean cocoon weight were observed at 500 ppm (1.22 ± 0.009 gm) for FS-1, at 500 ppm (1.21 ± 0.009 gm) for FS-2 and at 500 ppm (1.20 ± 0.006 gm) for FS-3 and the lowest at control (1.13 ± 0.015 gm) for all the cases, i.e. (1.13 ± 0.015 gm) FS-1, (1.15 ± 0.012 gm) in FS-2 and (1.10 ± 0.014) in FS-3.

Results of analyses of variance are presented in Table 56. Only one item, dose showed highly significant differences at 1% level of significance. The effective concentration of plant extracts in respect of their efficacy as a food supplement with mulberry leaves followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm. When pp was evaluated, the most effective PP was leaf followed by root and stem. For FS the efficacy followed the order FS-2 > FS-1 > FS-3.

Shell weight (SW):

Effect of different parts, viz. leaf, stem and root extracts of *C. asiatica* on SW of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 46 and their statistical analysis is presented in Table 57.

Leaf extract of *C. asiatica* increased the shell weight at different doses compare to control while fed in FS-1. The highest and the lowest mean shell weight were observed at 500 ppm (0.21 ± 0.003 gm) and control (0.16 ± 0.008 gm) respectively. While fed according to FS-2 the heaviest and the lightest shell were produced at 500 ppm, (0.23 ± 0.004 gm), and at control (0.17 ± 0.003 gm) respectively. In case of FS-3, leaf extract also increased the shell weight at different doses, viz. at 100 ppm (0.17 ± 0.009 gm), 500 ppm (0.22 ± 0.003 gm), 1000 ppm (0.21 ± 0.006 gm), 1500 ppm (0.19 ± 0.003 gm) compare to control (0.11 ± 0.003 gm).

In case of stem extract, the mean values of SW in different concentrations for different feeding schedules increased significantly. While fed according to FS-1, the heaviest and the lightest shell were produced at 500 ppm (0.19 ± 0.006 gm) and at control (0.16 ± 0.008 gm) respectively. In case of FS-2, stem extract increased the shell weight at different doses, viz. at 100 ppm (0.18 ± 0.006 gm), 500 ppm (0.20 ± 0.006 gm), 1000 ppm (0.19 ± 0.009 gm) and 1500 ppm (0.18 ± 0.003 gm) against control (0.17 ± 0.003 gm). The highest and the lowest mean SW were observed at 500 ppm (0.20 ± 0.003 gm) and control (0.11 ± 0.003 gm) respectively at FS-3.

In different feeding schedules, the mean values of shell weight were significantly increased at different concentrations for root extract of *C. asiatica*. The highest mean shell weight were observed at 500 ppm (0.19 ± 0.003 gm) for FS-1, at 500 ppm (0.19 ± 0.005 gm) for FS-2 and at 500 ppm (0.18 ± 0.002 gm) FS-3 and the lowest at control (0.11 ± 0.003 gm) for all the cases. ie (0.16 ± 0.008 gm) FS-1, (0.17 ± 0.003 gm) FS-2 and (0.11 ± 0.003 gm) gm in FS-3 respectively.

Results of analyses of variance are presented in Table 57. All the items showed significant differences at least 5% level of significance. The effectiveness of different plant extracts with respect to plant parts followed the order leaf > stem > root while in respect of feeding schedule this trend was FS-2 > FS-3 > FS-1. In most of the results for both PP and FS effective dose of the plant extracts followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm.

4.2.2.6. Effect of *C. asiatica* on the fecundity and fertility of *B. mori*

In the present investigation fecundity was evaluated on the basis of egg laying potential, ie. total number of eggs laid by individual female moth of *B. mori* and for fertility parameter egg hatching percentage was computed.

The results of the supplementation of different parts, viz. leaf, stem and root extracts of *C. asiatica* on the fecundity and fertility of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 are given bellow:

Total number of eggs laid per female (TEL):

Effect of different parts, viz. leaf, stem and root extracts of *C. asiatica* on fecundity, i.e. total number of eggs by individual female of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 47 and their statistical analysis is presented in Table 58.

Leaf extract of *C. asiatica* increased the fecundity at different doses compare to control while fed in FS-1. The highest and the lowest fecundity were observed at 500 ppm (408.67 ± 0.88) and control (400.33 ± 1.14) respectively. While fed according to FS-2 the highest and the lowest no. of egg were produced at 500 ppm (410.33 ± 0.53) and at control (402.00 ± 1.11). In case of FS-3, leaf extract also increased the fecundity at different doses, viz. at 100 ppm (406.00 ± 1.15), 500 ppm (409.33 ± 1.16), 1000 ppm (408.67 ± 0.98) and 1500 ppm (407.33 ± 0.79) against to control (401.67 ± 2.19).

In case of stem extract, the mean values of TEL in different concentrations for different feeding schedules were significantly increased. While fed according to FS-1, the heaviest and the lightest fecundity were produced at 500 ppm (407.00 ± 1.15) and at control (400.33 ± 1.14) respectively. In case of FS-2, stem extract increased the fecundity at different doses, viz. at 100 ppm (404.67 ± 0.82), 500 ppm (409.67 ± 0.78), 1000 ppm (408.00 ± 0.68), 1500 ppm (407.00 ± 1.15) compare to control (402.00 ± 1.11). The highest and the lowest fecundity were observed at 500 ppm (408.00 ± 1.13) and the control (401.67 ± 2.19) respectively at FS-3.

In different feeding schedules, the mean values of TEL increased significantly at different concentrations for root extract of *C. asiatica*. The highest and lowest value of TEL were observed at 500 ppm (406.33 ± 1.20) and at control (400.33 ± 1.14) for FS-1, at 500 ppm (408.67 ± 0.97) and at control (402.00 ± 1.11) for FS-2 and at 500 ppm (407.33 ± 1.20) and at control (401.67 ± 2.19) for FS-3 respectively.

Results of analyses of variance are presented in Table 58. All the items except dose $\times$ plant parts showed highly significant differences at 1% level of significance. The effectiveness of different plant parts on TEL followed the order leaf > stem > root and in respect of feeding schedule FS-2 > FS-3 > FS-1. The most effective dose of the plant extracts was found to be 500 ppm followed by 1000 ppm, 1500 ppm and 100 ppm.

Egg hatching percentage (EHP)

Effect of different parts viz. leaf, stem, root extracts of *C. asiatica* on fertility of *B. mori* at different feeding schedules viz. FS-1, FS-2, FS-3 is shown in Table 48 and their statistical analysis is presented in Table 59.

Leaf extract of *C. asiatica* increased the fertility at different doses compare to control while fed in FS-1. The highest and the lowest fertility were observed at 500 ppm ($90.67 \pm 1.09\%$) and control ($82.00 \pm 1.15\%$) respectively. While fed according to FS-2 the highest and the lowest fertility were produced at 500 ppm ($91.00 \pm 1.25\%$) and at control ($83.00 \pm 0.58\%$) respectively. In case of FS-3, leaf extract also increased the fertility at different doses, viz. at 100 ppm ($85.00 \pm 0.35\%$), 500 ppm ($92.00 \pm 0.87\%$), 1000 ppm ($94.00 \pm 0.66\%$), 1500 ppm ($89.00 \pm 0.88\%$) compare to control ($82.00 \pm 0.33\%$).

In case of stem extract, the mean values of fertility in different concentrations for different feeding schedules increased significantly. While fed according to FS-1, the highest and the lowest fertility were produced at 500 ppm ($89.00 \pm 0.88\%$) and at control ($88.00 \pm 0.85\%$) respectively. In case of FS-2, stem extract increased the fertility at different doses, viz. at 100 ppm ($88.00 \pm 1.52\%$), 500 ppm ($97.00 \pm 1.51\%$), 1000 ppm ($95.00 \pm 0.59\%$) and 1500 ppm ($89.00 \pm 1.15\%$) against control ($83.00 \pm 0.58\%$). The highest and the lowest fertility were observed at 500 ppm ($91.00 \pm 0.88\%$) and control ($82.00 \pm 0.33\%$) respectively at FS-3.

In different feeding schedules, the mean values of fertility were significantly increased at different concentrations for root extract of *C. asiatica*. The highest

mean cocoon weight were observed at 500 ppm ($88.00 \pm 0.85\%$) for FS-1, at 500 ppm ($90.00 \pm 1.77\%$) for FS-2 and at 500 ppm ($89.00 \pm 0.98\%$) FS-3 and the lowest at control ($82.00 \pm 1.15\%$) for all the cases, i.e. ($82.00 \pm 1.15\%$) in FS-2, ($83.00 \pm 0.58\%$) in FS-2 and ($82.00 \pm 0.33\%$) in FS-3.

Results of analyses of variance are presented in Table 59. The items feeding schedules ($F=167.53$), plant parts ($F=185.40$) and doses ($F=229.8$) showed highly significant differences at 1% level of significance. The effectiveness of different plant extracts with respect to plant parts followed the order stem > leaf > root while in respect of feeding schedule this trend was FS-2 > FS-3 > FS-1. In most of the results for both PP and FS effective dose of the plant extracts followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm.

4.2.3 Effects of *N. cadamba* extracts supplementation with mulberry leaves on *Bombyx mori*

The effects of the supplementation of different parts, viz. leaf, stem and root extracts of *N. cadamba* on *B. mori* at different feeding schedules, viz. fed only in 1st feeding of 3rd to 5th instar larvae (FS-1), fed everyday in 1st feeding of 3rd to 5th instar larvae (FS-2) and fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae (FS-3) were conducted and are presented in Tables 60-70. The data for different characters were subjected to analysis of variance to determine the variations among doses and plant parts, feeding schedules and are presented in Table 71-81. The results obtained in the present experiments are discussed as follows:

4.2.3.1 Effect of *N. cadamba* extracts on the larval growth of *B. mori*.

The results of the supplementation of different parts, viz. leaf, stem and root extracts of *N. cadamba* on growth of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 are given bellow:

Weight of mature larvae (WML):

Effect of different parts, viz. leaf, stem and root extracts of *N. cadamba* on WML of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 60 and their statistical analysis is presented in Table 71.

Leaf extract of *N. cadamba* increased the WML at different doses compare to control while fed in FS-1. The highest and the lowest mean WML were observed at 500 ppm (2.95 ± 0.008 gm) and control (2.86 ± 0.011 gm) respectively. While fed according to FS-2 the heaviest and the lightest larvae were produced at 500 ppm (2.97 ± 0.005 gm) and at control (2.84 ± 0.005 gm) respectively. In case of FS-3, leaf extract also increased the WML at different doses viz. at 100 ppm (2.92 ± 0.004 gm), 500 ppm (2.96 ± 0.007 gm), 1000 ppm (2.95 ± 0.005 gm), 1500 ppm (2.93 ± 0.01 gm) compare to control (2.87 ± 0.012 gm).

In case of stem extract, the mean values of WML in different concentrations for different feeding schedules were significantly increased. While fed according to FS-1, the heaviest and the lightest larvae were produced at 500 ppm (2.95 ± 0.013 gm) and at control (2.86 ± 0.011 gm) respectively. In case of FS-2, leaf extract increased the WML at different doses viz. at 100 ppm (2.94 ± 0.009 gm), 500 ppm (2.98 ± 0.006 gm), 1000 ppm (2.97 ± 0.01 gm), 1500 ppm (2.95 ± 0.009 gm) compare to control (2.84 ± 0.005 gm). The highest and the lowest mean WML were observed at 500 ppm (2.96 ± 0.008 gm) and control (2.87 ± 0.012 gm) respectively at FS-3.

In different feeding schedules, the mean values of WML were significantly increased at different concentrations for root extract of *N. cadamba*. The highest mean WML were observed at 500 ppm (2.94 ± 0.05 gm) for FS-1, at 500 ppm (2.97 ± 0.06 gm) for FS-2 and at 500 ppm (2.95 ± 0.013 gm) FS-3 and the lowest at control (2.86 ± 0.011 gm) in FS-1, (2.92 ± 0.04 gm) in FS-2, (2.87 ± 0.012 gm) in FS-3.

Results of analyses of variance are presented in Table 71. All the items showed highly significant differences at 1% level of significance. The effectiveness of

different plant parts on WML followed the order stem > leaf > root and in respect of feeding schedule FS-> 2FS-3 > FS-1. The most effective dose of the plant extracts was found to be 500 ppm followed by 1000 ppm, 1500 ppm and 100 ppm.

Length of mature larvae (LML):

Effect of different parts extracts of *N. cadamba* on LML of *B. mori* at different feeding schedules viz. FS-1, FS-2 and FS-3 is shown in Table 61 and their statistical analysis is presented in Table 72.

In case of leaf extract, the mean values of LML increased at different doses compare to control while fed in FS-1. The highest and the lowest mean LML were observed at 500 ppm ($72.94 \pm 0.84\text{mm}$) and at control ($65.47 \pm 0.034\text{mm}$) respectively. While maintaining schedules FS-2 the highest and the lowest LML were observed at 500 ppm ($73.35 \pm 0.80\text{mm}$) and at control ($67.63 \pm 0.55\text{mm}$) respectively. In case of FS-3, leaf extract also increased the LML at different doses viz. at 100 ppm ($70.58 \pm 0.87\text{mm}$), 500 ppm ($73.91 \pm 0.56\text{mm}$), 1000 ppm ($72.69 \pm 0.52\text{mm}$), 1500 ppm ($71.80 \pm 0.68\text{mm}$) compare to control ($66.38 \pm 0.39\text{mm}$).

For stem extract, the mean values of LML in different concentrations for different feeding schedules and plant parts were significantly increased. While fed according to FS-1, the highest and the lowest LML were recorded at 500 ppm ($73.38 \pm 0.74\text{mm}$) and at control ($65.47 \pm 0.34\text{mm}$) respectively. In case of FS-2, leaf extract increased the LML at different doses viz. at 100 ppm ($72.63 \pm 0.73\text{mm}$), 500 ppm ($75.22 \pm 0.79\text{mm}$), 1000 ppm ($74.50 \pm 0.54\text{mm}$), 1500 ppm ($73.08 \pm 1.05\text{mm}$) compare to control ($67.63 \pm 0.55\text{mm}$). The highest and the lowest mean LML were observed at 500 ppm ($74.70 \pm 0.72\text{mm}$) and control ($66.38 \pm 0.39\text{mm}$) respectively while fed according to FS-3.

In different feeding schedules, the mean values of LML were significantly increased at different concentrations for root extract of *N. cadamba*. The highest and the lowest mean LML were observed at 500 ppm ($71.94 \pm 0.59\text{mm}$) and at

control (65.47 ± 0.34 mm) for FS-1, at 500 ppm (73.50 ± 0.59 mm) and at control (67.63 ± 0.55 mm) for FS-2 and at 500 ppm (72.22 ± 0.66 mm) and at control (66.38 ± 0.39 mm) for FS-3 respectively.

The results of ANOVA have been presented in the Table 72. The items, viz. feeding schedules, plant parts, dose revealed significant results ($P < 0.01$). The efficacy of different plant parts on LML followed the order stem > leaf > root and for feeding schedule the effectiveness in this regard was FS-2 > FS-3 > FS-1. The most effective dose of the plant extracts in majority of the cases was 500 ppm followed by 1000 ppm, 1500 ppm and 100 ppm.

Breadth of mature larvae (BML):

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Effect of different parts, viz. leaf, stem and root extracts of *N. cadamba* on BML of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 62 and their statistical analysis is presented in Table 73.

Results of leaf extract of *N. cadamba* showed that the BML increased at different doses in comparison to control while fed in FS-1. The highest and the lowest mean BML were observed at 500 ppm (21.74 ± 0.59 mm) and control (14.91 ± 0.19 mm) respectively. While fed according to FS-2 the highest and the lowest BML were recorded at 500 ppm (23.49 ± 0.55 mm) and at control ($16.33 \pm 0.55.36$ mm) respectively. In case of FS-3, leaf extract also increased the BML at different doses, viz. at 100 ppm (19.35 ± 0.42 mm), 500 ppm (22.70 ± 0.62), 1000 ppm (21.27 ± 0.81 mm), 1500 ppm (20.20 ± 0.32 mm) compared with control (15.16 ± 0.12 mm).

In case of stem extract, the mean values of BML in different concentrations for different feeding schedules and plant parts were significantly increased. For FS-1, the highest and the lowest BML were recorded at 500 ppm (22.42 ± 0.47 mm) and at control (14.91 ± 0.19 mm) respectively. In case of FS-2, stem extract increased the BML at different doses, viz. at 100 ppm (21.09 ± 0.73 mm), 500 ppm

($24.19 \pm 0.44 \text{ mm}$), 1000 ppm ($23.44 \pm 0.53 \text{ mm}$) and 1500 ppm ($22.06 \pm 0.43 \text{ mm}$) compare to control ($16.33 \pm 0.36 \text{ mm}$) The highest and the lowest mean BML were observed at 500 ppm ($23.75 \pm 0.60 \text{ mm}$) and control ($15.16 \pm 0.12 \text{ mm}$) respectively while fed according to FS-3.

In different feeding schedules, the mean values of BML were significantly increased at different concentrations for root extract of *N. cadamba*. The highest and the lowest mean BML were observed at 500 ppm ($20.59 \pm 0.86 \text{ mm}$) and at control ($14.91 \pm 0.19 \text{ mm}$) for FS-1, at 500 ppm ($22.25 \pm 0.9 \text{ mm}$) and at control ($16.33 \pm 0.33 \text{ mm}$) and at 500 ppm ($21.94 \pm 1.15 \text{ mm}$) and at control ($15.16 \pm 0.12 \text{ mm}$) for FS-3 respectively.

Analysis of variance showed highly significant differences among feeding schedules ($F=247.07$), among plant parts ($F=157.42$), among doses ($F=363.16$) at 1% level of significance but dose $\times$ plant parts ($F=0.99$) showed non-significant results (Table 73).

The effectiveness of different plant extracts with respect to plant parts followed the order stem > leaf > root while in respect of feeding schedule this trend was FS-2 > FS-3 > FS-1. In most of the results for both PP and FS effective dose of the plant extracts followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm.

4.2.3.2 Effect of *N. cadamba* extracts on the growth of pupae of *B. mori*

The results of the supplementation of different parts, viz. leaf, stem and root extracts of *N. cadamba* on growth of pupae of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 are given below:

Pupal weight (PW):

Effect of different parts extracts of *N. cadamba* on PW of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 63 and their statistical analysis is presented in Table 74.

In case of leaf extract, the mean values of PW increased at different doses when compared with control in FS-1. The highest and the lowest mean mature pw of respect were observed at 500 ppm ($1.01 \pm 0.010\text{gm}$) and control ($0.98 \pm 0.001\text{gm}$) respectively. While maintaining scheduled FS-2, the highest and the lowest pw were observed at 500 ppm, ($1.03 \pm 0.009\text{gm}$), and at control ($1.00 \pm 0.001\text{gm}$) respectively. In case of FS-3, leaf extract also increased the pupal weight at different doses, viz. at 100 ppm (1.03 ± 0.004), 500 ppm (1.05 ± 0.011), 1000 ppm (1.05 ± 0.002) and 1500 ppm (1.05 ± 0.002) compare to control (0.99 ± 0.001).

For stem extract, the mean values of PW in different concentrations for different feeding schedules and plant parts were significantly increased. While fed according to FS-1, the highest and the lowest pupal weight were recorded at 500 ppm ($1.03 \pm 0.005\text{g}$) and at control (0.98 ± 0.001) respectively. In case of FS-2, leaf extract increased the pupal weight at different doses, viz. at 100 ppm (1.02 ± 0.005), 500 ppm (1.04 ± 0.002), 1000 ppm (1.04 ± 0.001) and 1500 ppm (1.03 ± 0.001) against the control value (1.00 ± 0.001). The highest and the lowest mean pupal weight were observed at 500 ppm (1.05 ± 0.002) and control (0.99 ± 0.001) respectively while fed according to FS-3.

In different feeding schedules, the mean values of mature PW were significantly increased at different concentrations for root extract of *N. cadamba*. The highest and the lowest mean pupal weight were observed at 500 ppm (1.01 ± 0.002) and at control (0.98 ± 0.001) for FS-1, at 500 ppm (1.02 ± 0.003) and at control (1.00 ± 0.001) for FS-2 and at 500 ppm (1.02 ± 0.005) and at control (0.99 ± 0.001) for FS-3 respectively.

The results of ANOVA have been presented in the Table 74. Only item, plant parts revealed significant results ($P < 0.05$). The effectiveness of different plant extracts with respect to plant parts followed the order leaf > stem > root while in respect of feeding schedule this trend was FS-3 > FS-2 > FS-1. In most of the results for both PP and FS effective dose of the plant extracts followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm.

4.2.3.3 Effect of *N. cadamba* extract on the survival of *B. mori* larvae.

The results of the supplementation of different parts, viz. leaf, stem and root extracts of *N. cadamba* on the formation and duration of developmental stages of *B. mori* at different feeding schedules viz. FS-1, FS-2, FS-3 are given bellow:

Surviving percentage (SP):

The results of *N. cadamba* extracts on the larval survival of *B. mori* supplemented with mulberry leaves under different schedules of feeding have been discussed for the following drait:

Effect of different parts extracts from different parts of *N. cadamba* on surviving percentage SP of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 64 and their statistical analysis is presented in Table 75.

In case of leaf extract, the mean values of surviving percentage increased at different dose against control while fed in FS-1. The highest and the lowest mean SP were observed at 500 ppm (59.00 ± 1.15) and control (54.33 ± 1.76) respectively. While maintaining schedules FS-2 the highest and the lowest surviving percentage were observed at 500 ppm (61.67 ± 0.88) and at control ($56.33 \pm 1.20\%$) respectively. In case of FS-3, leaf extract also increased the SP at different doses, viz. at 100 ppm (57.00 ± 1.15), 500 ppm (60.33 ± 0.88), 1000 ppm (59.67 ± 0.88) and 1500 ppm (58.33 ± 0.88) when compared with control (55.67 ± 1.86).

For stem extract, the mean values of SP in different concentrations for different feeding schedules and plant parts were increased significantly. While fed according to FS-1, the highest and the lowest SP were recorded at 500 ppm (59.67 ± 0.33) and at control (54.33 ± 1.76) respectively. In case of FS-2, stem extract increased the surviving percentage at different doses, viz. at 100 ppm (58.00 ± 0.58), 500 ppm (62.00 ± 0.58), 1000 ppm (61.00 ± 0.58) and 1500 ppm (59.00 ± 0.58) against control (56.33 ± 1.20). The highest and the lowest mean SP were observed at 500 ppm (59.00 ± 0.58) and control (55.67 ± 1.86) respectively while fed according to FS-3.

In different feeding schedules, the mean values of SP were significantly increased at different concentrations for root extract of *N. cadamba*. The highest and the lowest mean SP were observed at 500 ppm (60.33 ± 0.88) and at control (55.00 ± 0.53) for FS-1, at 500 ppm (65.33 ± 0.76) and at control (54.33 ± 1.76) for FS-2 and at 500 ppm (60.67 ± 0.88) and at control (55.67 ± 1.86) for FS-3 respectively.

The results of ANOVA have been presented in the Table 75. It indicated highly significant differences doses at 1% level of significance. The effective concentration of plant extracts in respect of their efficacy as a food supplement with mulberry leaves followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm. When pp were evaluated, the most effective PP was stem followed by leaf and root. For FS the efficacy followed the order FS-2 > FS-3 > FS-1.

4.2.3.4 Effect of *N. cadamba* extracts on the developmental period stages of *B. mori*

The results of the supplementation of different parts, viz. leaf, stem and root extracts of *N. cadamba* on the formation and duration of developmental stages of *B. mori* at different feeding schedules viz. FS-1, FS-2, FS-3 are given below:

Larval duration (LD):

Effect of different parts of *N. cadamba* extract on LD of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 65 and their statistical analysis is presented in Table 76.

In case of leaf extract, the mean values of larval duration increased at different doses against control while fed in FS-1. The highest and the lowest mean mature larval length were observed at 500 ppm (22.2 ± 0.044) and control (21.85 ± 0.033) respectively. While maintaining schedules FS-2 the highest and the lowest larval duration were observed at 1000 ppm, (22.33 ± 0.043), and at control (22.03 ± 0.241) respectively. In case of FS-3, leaf extract also increased the larval duration at

different doses, viz. at 100 ppm (22.05 ± 0.061), 500 ppm (22.16 ± 0.409), 1000 ppm (22.37 ± 0.056) and 1500 ppm (22.28 ± 0.110) in comparison to control (22.1 ± 0.069).

In case of stem extract, the mean values of mature larval larval duration in different concentrations were significantly increased. While fed according to FS-1, the highest and the lowest larval duration were recorded at 1000 ppm (22.25 ± 0.048) and at control (21.85 ± 10.033) respectively. For FS-2, stem extract increased the larval duration at different doses, viz. at 100 ppm (22.150 ± 0.083), 500 ppm (22.24 ± 0.038), 1000 ppm (2.396 ± 0.43) and 1500 ppm (22.320 ± 0.170) against control (22.030 ± 0.241). The highest and the lowest mean larval duration were observed at 1000 ppm (22.210 ± 0.419) and control (22.100 ± 0.069) respectively while fed according to FS-3.

In different feeding schedules, the mean values of larval duration were significantly increased at different concentrations for root extract of *N. cadamba*. The highest and the lowest mean larval duration were observed at 1000 ppm (22.170 ± 0.040) at control (21.850 ± 0.033) for FS-1, at 1000 ppm (22.340 ± 0.059) for FS-2, at 1000 ppm (22.300 ± 0.060) at control (22.100 ± 0.069) for FS-3 compare to control (22.99 ± 0.82).

The results of ANOVA have been presented in the Table 76. All the items revealed significant results ($P < 0.01$). The effectiveness of different plant parts on SP followed the order stem > leaf > root and in respect of feeding schedule FS-2 > FS-3 > FS-1. The most effective dose of the plant extracts was found to be 500 ppm followed by 1000 ppm, 1500 ppm and 100 ppm.

Pupal duration (PD):

Result on the effect of *N. cadamba* extracts PD of *B. mori* at different feeding schedules viz. FS-1, FS-2, FS-3 is shown in Table 66 and their statistical analysis is presented in Table 77.

In case of leaf extract, the mean values of PD increased at different doses as compared to control while fed in FS-1. The highest and the lowest PD were observed at 1000 ppm (8.120 ± 0.233) and control (7.750 ± 0.287) respectively. While maintaining schedules FS-2 the highest and the lowest PD were observed at 1000 ppm (8.380 ± 0.167) and at control (7.990 ± 0.182) respectively. In case of FS-3, leaf extract also increased the pupal duration at different doses, viz. at 100 ppm (7.990 ± 0.257), 500 ppm (18.000 ± 0.260), 1000 ppm (8.320 ± 0.172), 1500 ppm (8.220 ± 0.185) against control (7.910 ± 0.228).

In case of stem extract, the mean values of PD in different concentrations increased significantly. While fed according to FS-1, the highest and the lowest PD were recorded at 1000 ppm (8.290 ± 0.177) and at control (7.750 ± 0.287) respectively. For FS-2, stem extract increased the pupal duration at different doses, viz. at 100 ppm (8.080 ± 0.227), 500 ppm (8.140 ± 0.247), 1000 ppm (8.390 ± 0.168) and 1500 ppm (8.240 ± 0.198) against control (7.99 ± 0.182). The highest and the lowest PD were observed at 1000 ppm (8.330 ± 0.173) and control (7.910 ± 0.228) respectively while fed according to FS-3.

In different feeding schedules, the mean values of PD were significantly increased at different concentrations for root extract of *N. cadamba*. The highest PD were observed at 1000 ppm (8.270 ± 0.173) for FS-1, at 1000 ppm (8.340 ± 0.168) for FS-2, at 1000 ppm (8.300 ± 0.173) for FS-3. On the other hand lowest PD were recorded in control

Analyses of variance showed highly significant differences among feeding schedules and doses at 1% level of significance (Table 77). The effectiveness of different plant extracts with respect to plant parts followed the order stem > leaf > root while in respect of feeding schedule this trend was FS-2 > FS-3 > FS-1. In most of the results for both PP and FS effective dose of the plant extracts followed the order 1000 ppm > 1500 ppm > 500 ppm > 100 ppm.

4.2.3.5 Effect of *N. cadamba* extracts on the cocoon characters of *B. mori*

The results of the supplementation of different parts of *N. cadamba*, extracts viz. leaf, stem and root on the cocoon characters of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 are given bellow:

Cocoon weight (CW):

Effect of different parts, viz. leaf, stem and root extracts of *N. cadamba* on the weight of cocoon of *B. mori* at different feeding schedules, viz. FS-1, FS-2, FS-3 has been in Table 67 and their statistical analysis is included in Table 78.

Leaf extract of *N. cadamba* increased the cocoon weight at different doses compare to control while fed in FS-1. The highest and the lowest mean cocoon weight were observed at 500 ppm (1.20 ± 0.012 g) and control (1.13 ± 0.014) respectively. While fed according to FS-2 the heaviest and the lightest cocoon were produced at 500 ppm (1.21 ± 0.015), and at control (1.15 ± 0.016) respectively. In case of FS-3, leaf extract also increased the cocoon weight at different doses, viz. at 100 ppm (1.18 ± 0.009), 500 ppm (1.21 ± 0.014), 1000 ppm (1.20 ± 0.018) and 1500 ppm (1.19 ± 0.011) against control (1.11 ± 0.017).

In case of stem extract, the mean values of cocoon weight in different concentrations for different feeding schedules increased significantly. While fed according to FS-1, the heaviest and the lightest cocoons were produced at 500 ppm (1.21 ± 0.018) and at control (1.13 ± 0.014) respectively. In case of FS-2, stem extract increased the cocoon weight at different doses, viz. at 100 ppm (1.18 ± 0.015), 500 ppm (1.23 ± 0.016), 1000 ppm (1.22 ± 0.011) and 1500 ppm (1.21 ± 0.014) compare to control (1.15 ± 0.016). The highest and the lowest mean cocoon weight were recorded at 500 ppm (1.22 ± 0.017) and control (1.11 ± 0.017) respectively at FS-3.

In different feeding schedules, the mean values of cocoon weight increased significantly at different concentrations for root extract of *N. cadamba*. The

highest mean cocoon weight were observed at 500 ppm (1.19 ± 0.008) for FS-1, at 500 ppm (1.21 ± 0.009) for FS-2 and at 500 ppm (1.20 ± 0.009) FS-3 and the lowest at control for all the cases, i.e. (1.13 ± 0.014 gm) in FS-1, (1.15 ± 0.016) in FS-2 and (1.11 ± 0.017) in FS-3.

Results of analyses of variance are presented in Table 78. All the items showed significant differences. The effective concentration of plant extracts in respect of their efficacy as a food supplement with mulberry leaves followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm. When pp were evaluated, the most effective PP was stem followed by leaf and root. For FS the efficacy followed the order FS-2 > FS-3 > FS-1.

Shell weight (SW):

Effect of different parts, viz. leaf, stem and root extracts of *N. cadamba* on SW of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 68 and their statistical analysis is presented in Table 79.

Leaf extract of *N. cadamba* increased the shell weight at different doses compare to control while fed in FS-1. The highest and the lowest mean shell weight were observed at 500 ppm (0.19 ± 0.002 g) and control (0.15 ± 0.013) respectively. While fed according to FS-2 the heaviest and the lightest shell were produced at 500 ppm, (0.18 ± 0.006), and at control (0.15 ± 0.015) respectively. In case of FS-3, leaf extract also increased the shell weight at different doses, viz. at 100 ppm (0.15 ± 0.005), 500 ppm (0.16 ± 0.003), 1000 ppm (0.15 ± 0.016), 1500 ppm (0.14 ± 0.009) compare to control (0.12 ± 0.016).

In case of stem extract, the mean values of SW in different concentrations for different feeding schedules increased significantly. While fed according to FS-1, the heaviest and the lightest shell were produced at 500 ppm (0.18 ± 0.013) and at control (0.15 ± 0.013) respectively. In case of FS-2, stem extract increased the shell weight at different doses, viz. at 100 ppm (0.16 ± 0.01), 500 ppm (0.19 ± 0.014), 1000 ppm (0.18 ± 0.010) and 1500 ppm (0.18 ± 0.013) against control (0.15 ± 0.015).

The highest and the lowest mean SW were observed at 500 ppm (0.17 ± 0.015) and control (0.12 ± 0.016) respectively at FS-3.

In different feeding schedules, the mean values of shell weight were significantly increased at different concentrations for root extract of *N. cadamba*. The highest mean shell weight were observed at 500 ppm (0.18 ± 0.006) for FS-1, at 500 ppm (0.19 ± 0.006) for FS-2 and at 500 ppm (0.19 ± 0.003) FS-3 and the lowest at control (0.12 ± 0.016) for all the cases. ie 0.15 ± 0.013 gm in FS-1, 0.15 ± 0.015 gm in FS-2 and 0.12 ± 0.016 gm in FS-3 respectively.

Results of analyses of variance are presented in Table 79. The item doses ($F=4.17$) showed highly significant differences at 1% level of significance. The effectiveness of different plant extracts with respect to plant parts followed the order stem > leaf > root while in respect of feeding schedule this trend was FS-2 > FS-3 > FS-1. In most of the results for both PP and FS effective dose of the plant extracts followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm.

4.2.3.6 Effect of *N. cadamba* on the fecundity and fertility of *B. mori*

In the present investigation fecundity was evaluated on the basis of egg laying potential, i.e. total number of eggs laid by individual female moth of *B. mori* and for fertility parameter egg hatching percentage was computed.

The results of the supplementation of different parts, viz. leaf, stem and root extracts of *N. cadamba* on the fecundity and fertility of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 are given bellow:

Total number of eggs laid per female (TEL):

Effect of different parts, viz. leaf, stem and root extracts of *N. cadamba* on fecundity, i.e. total number of eggs by individual female of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 69 and their statistical analysis is presented in Table 80.

Leaf extract of *N. cadamba* increased the fecundity at different doses compare to control while fed in FS-1. The highest and the lowest fecundity were observed at 500 ppm (409.67 ± 0.33) and control (401.00 ± 3.79) respectively. While fed according to FS-2 the highest and the lowest no. of egg were produced at 500 ppm (414.00 ± 1.00) and at control (409.67 ± 3.98) respectively. In case of FS-3, leaf extract also increased the fecundity at different doses, viz. at 100 ppm (406.33 ± 0.88), 500 ppm (409.00 ± 1.15), 1000 ppm (408.00 ± 2.65) and 1500 ppm (407.67 ± 1.67) against to control (403.33 ± 1.20).

In case of stem extract, the mean values of TEL in different concentrations for different feeding schedules were significantly increased. While fed according to FS-1, the heaviest and the lightest fecundity were produced at 500 ppm (409.00 ± 1.53) and at control (401.00 ± 3.79) respectively. In case of FS-2, stem extract increased the fecundity at different doses, viz. at 100 ppm (408.00 ± 1.53), 500 ppm (411.00 ± 0.58), 1000 ppm (410.33 ± 1.45), 1500 ppm (409.33 ± 1.20) compare to control (409.67 ± 3.93). The highest and the lowest fecundity were observed at 500 ppm (410.33 ± 0.33) and the control (403.33 ± 1.20) respectively at FS-3.

In different feeding schedules, the mean values of TEL increased significantly at different concentrations for root extract of *N. cadamba*. The highest and lowest value of TEL were observed at 500 ppm (407.33 ± 0.88) and at control (401.00 ± 3.79) for FS-1, at 500 ppm (409.33 ± 1.45) and at control (409.67 ± 3.93) for FS-2 and at 500 ppm (408.33 ± 1.33) and at control (403.33 ± 1.20) for FS-3 respectively.

Results of analyses of variance are presented in Table 80. All the items showed highly significant differences at 1% level of significance. The effectiveness of different plant extracts with respect to plant parts followed the order leaf > stem > root while in respect of feeding schedule this trend was FS-2 > FS-3 > FS-1. In most of the results for both PP and FS effective dose of the plant extracts followed the order 1000 ppm > 1500 ppm > 500 ppm > 100 ppm.

Egg hatching percentage (EHP)

Effect of different parts viz. leaf, stem, root extracts of *N. cadamba* on fertility of *B. mori* at different feeding schedules viz. FS-1, FS-2, FS-3 is shown in Table 70 and their statistical analysis is presented in Table 81.

Leaf extract of *N. cadamba* increased the fertility at different doses compare to control while fed in FS-1. The highest and the lowest fertility were observed at 500 ppm (90.33 ± 0.88) and control (83.0 ± 0.58) respectively. While fed according to FS-2 the highest and the lowest fertility were produced at 500 ppm (92.33 ± 0.88) and at control (84.00 ± 0.58) respectively. In case of FS-3, leaf extract also increased the fertility at different doses, viz. at 100 ppm (88.67 ± 0.88), 500 ppm (91.00 ± 1.53), 1000 ppm (90.00 ± 0.58), 1500 ppm (89.33 ± 0.88) compare to control (83.67 ± 0.33).

In case of stem extract, the mean values of fertility in different concentrations for different feeding schedules increased significantly. While fed according to FS-1, the highest and the lowest fertility were produced at 500 ppm (91.33 ± 0.88) and at control (83.00 ± 0.58) respectively. In case of FS-2, stem extract increased the fertility at different doses, viz. at 100 ppm (90.00 ± 0.58), 500 ppm (93.00 ± 0.58), 1000 ppm (92.00 ± 0.58) and 1500 ppm (91.00 ± 1.15) against control (84.00 ± 0.58). The highest and the lowest fertility were observed at 500 ppm (92.00 ± 0.58) and control (83.67 ± 0.33) respectively at FS-3.

In different feeding schedules, the mean values of fertility were significantly increased at different concentrations for root extract of *N. cadamba*. The highest mean EHP were observed at 500 ppm (89.00 ± 1.53) for FS-1, at 500 ppm (91.67 ± 1.20) for FS-2 and at 500 ppm (90.00 ± 1.53) for FS-3 and the lowest at control for all the cases, i.e. (83.00 ± 0.58) in FS-1, (84.00 ± 0.58) in FS-2 and (83.67 ± 0.33) in FS-3.

Results of analyses of variance are presented in Table 81. The items feeding schedules ($F=193.96$), plant parts ($F=147.04$) and doses ($F=303.64$) showed highly

significant differences at 1% level of significance. The effectiveness of different plant extracts with respect to plant parts followed the order stem > leaf > root while in respect of feeding schedule this trend was FS-2 > FS-3 > FS-1. In most of the results for both PP and FS effective dose of the plant extracts followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm.

4.2.4 Effects of *S. tuberosum* extracts supplementation with mulberry leaves on *Bombyx mori*

The effects of the supplementation of different parts, viz. leaf, stem and root extracts of *S. tuberosum* on *B. mori* at different feeding schedules, viz. fed only in 1st feeding of 3rd to 5th instar larvae (FS-1), fed everyday in 1st feeding of 3rd to 5th instar larvae (FS-2) and fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae (FS-3) were conducted and are presented in Tables 82-92. The data for different characters were subjected to analysis of variance to determine the variations among doses and plant parts, feeding schedules and are presented in Table 93-103. The results obtained in the present experiments are discussed as follows:

4.2.4.1 Effect of *S. tuberosum* extracts on the larval growth of *B. mori*.

The results of the supplementation of different parts, viz. leaf, stem and root extracts of *S. tuberosum* on growth of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 are given bellow:

Weight of mature larvae (WML):

Effect of different parts, viz. leaf, stem and root extracts of *S. tuberosum* on WML of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 82 and their statistical analysis is presented in Table 93.

Leaf extract of *S. tuberosum* increased the WML at different doses compare to control while fed in FS-1. The highest and the lowest mean WML were observed at 500 ppm ($2.81 \pm 0.009\text{gm}$) and control ($2.78 \pm 0.012\text{gm}$) respectively. While fed according to FS-2 the heaviest and the lightest larvae were produced at 500 ppm ($2.83 \pm 0.008\text{gm}$) and at control ($2.80 \pm 0.008\text{gm}$) respectively. In case of FS-3, leaf extract also increased the WML at different doses, viz. at 100 ppm ($2.80 \pm 0.011\text{gm}$), 500 ppm ($2.82 \pm 0.005\text{gm}$), 1000 ppm ($2.81 \pm 0.006\text{gm}$), 1500 ppm ($2.81 \pm 0.005\text{gm}$) compare to control ($2.78 \pm 0.009\text{gm}$).

In case of stem extract, the mean values of WML in different concentrations for different feeding schedules were significantly increased. While fed according to FS-1, the heaviest and the lightest larvae were produced at 500 ppm ($2.84 \pm 0.0003\text{gm}$) and at control ($2.78 \pm 0.012\text{gm}$) respectively. In case of FS-2, leaf extract increased the WML at different doses viz. at 100 ppm ($2.83 \pm 0.003\text{gm}$), 500 ppm ($2.86 \pm 0.008\text{gm}$), 1000 ppm ($2.85 \pm 0.005\text{gm}$), 1500 ppm ($2.84 \pm 0.003\text{gm}$) compare to control. The highest and the lowest WML were observed at 500 ppm ($2.85 \pm 0.006\text{gm}$) and control ($2.78 \pm 0.009\text{gm}$) respectively at FS-3.

In different feeding schedules, the mean values of WML were significantly increased at different concentrations for root extract of *S. tuberosum*. The highest mean WML were observed at 500 ppm ($2.83 \pm 0.008\text{gm}$) for FS-1, at 500 ppm ($2.85 \pm 0.005\text{gm}$) for FS-2 and at 500 ppm ($2.84 \pm 0.006\text{gm}$) FS-3 and the lowest at control for all the cases, i.e. ($2.78 \pm 0.012\text{gm}$) for FS-1, ($2.80 \pm 0.008\text{gm}$) for FS-2 and ($2.78 \pm 0.008\text{gm}$) for FS-3.

Results of analyses of variance are presented in Table 93. All the items except dose $\times$ plant parts showed highly significant differences at 1% level of significance. The effectiveness of different plant parts on WML followed the order stem > root > leaf and in respect of feeding schedule FS-2 > FS-3 > FS-1. The most effective dose of the plant extracts was found to be 500 ppm followed by 1000 ppm, 1500 ppm and 100 ppm.

Length of mature larvae (LML):

Effect of different parts extracts of *S. tuberosum* on LML of *B. mori* at different feeding schedules viz. FS-1, FS-2 and FS-3 is shown in Table 83 and their statistical analysis is presented in Table 94.

In case of leaf extract, the mean values of LML increased at different doses compare to control while fed in FS-1. The highest and the lowest mean LML were observed at 500 ppm (78.60 ± 0.63 mm) and at control (73.60 ± 0.47 mm) respectively. While maintaining schedules FS-2 the highest and the lowest LML were observed at 500 ppm (80.17 ± 0.81 mm) and at control (74.78 ± 0.27 mm) respectively. In case of FS-3, leaf extract also increased the LML at different doses viz. at 100 ppm (70.58 ± 0.87 m), 500 ppm (79.30 ± 0.78 mm), 1000 ppm (78.93 ± 10.56 mm), 1500 ppm (77.34 ± 1.09 mm) compare to control (73.85 ± 1.02 mm).

For stem extract, the mean values of LML in different concentrations for different feeding schedules and plant parts were significantly increased. While fed according to FS-1, the highest and the lowest larval length were recorded at 500 ppm (80.29 ± 0.66 mm) and at control (73.60 ± 0.47 mm) respectively. In case of FS-2, leaf extract increased the LML at different doses, viz. at 100 ppm (79.11 ± 0.24 mm), 500 ppm (82.17 ± 0.92 mm), 1000 ppm (81.41 ± 0.95 mm), 1500 ppm (80.37 ± 0.59 mm) compare to control (74.78 ± 0.27 mm). The highest and the lowest mean LML were observed at 500 ppm (81.45 ± 0.77 mm) and control (73.85 ± 1.02 mm) respectively while fed according to FS-3.

In different feeding schedules, the mean values of LML were significantly increased at different concentrations for root extract of *S. tuberosum*. The highest and the lowest mean LML were observed at 500 ppm (79.55 ± 0.34 mm) and at control (73.60 ± 0.47 mm) for FS-1, at 500 ppm (81.53 ± 0.45 mm) and at control (74.78 ± 0.27 mm) for FS-2 and at 500 ppm (80.35 ± 0.45 mm) and at control (73.85 ± 1.02 mm) for FS-3 respectively.

The results of ANOVA have been presented in the Table 94. The items, viz. feeding schedules ($F=180.28$), plant parts ($F=188.46$), dose ($F=203.19$) revealed significant results ($P<0.01$). The efficacy of different plant parts on LML followed the order stem > root > leaf and for feeding schedule the effectiveness in this regard was FS-2 > FS-3 > FS-1. The most effective dose of the plant extracts in

majority of the cases was 500 ppm followed by 1000 ppm, 1500 ppm and 100 ppm.

Breadth of mature larvae (BML):

Effect of different parts, viz. leaf, stem and root extracts of *S. tuberosum* on BML of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 84 and their statistical analysis is presented in Table 95.

Results of leaf extract of *S. tuberosum* showed that the BML increased at different doses in comparison to control while fed in FS-1. The highest and the lowest mean BML were observed at 500 ppm (23.62 ± 0.88 mm) and control (17.70 ± 0.26 mm) respectively. While fed according to FS-2 the highest and the lowest BML were recorded at 500 ppm (25.27 ± 0.35 mm) and at control (18.55 ± 0.43 mm) respectively. In case of FS-3, leaf extract also increased the BML at different doses viz. at 100 ppm (21.63 ± 0.87 mm), 500 ppm (24.87 ± 1.49), 1000 ppm (23.28 ± 0.89 mm), 1500 ppm (22.93 ± 1.52 mm) compared with control (16.12 ± 0.30 mm).

In case of stem extract, the mean values of BML in different concentrations for different feeding schedules and plant parts were significantly increased. For FS-1, the highest and the lowest BML were recorded at 500 ppm (24.21 ± 0.91 mm) and at control (17.70 ± 0.26 mm) respectively. In case of FS-2, stem extract increased the BML at different doses, viz. at 100 ppm (23.60 ± 0.51 mm), 500 ppm (26.08 ± 0.54 mm), 1000 ppm (25.48 ± 0.52 mm) and 1500 ppm (24.48 ± 0.50 mm) compare to control (25.48 ± 0.52 mm). The highest and the lowest mean BML were observed at 500 ppm (25.73 ± 0.45 mm) and control (16.12 ± 0.30 mm) respectively while fed according to FS-3.

In different feeding schedules, the mean values of BML were significantly increased at different concentrations for root extract of *S. tuberosum*. The highest and the lowest mean BML were observed at 500 ppm (24.21 ± 0.91 mm) and at control (17.70 ± 0.26 mm) for FS-1, at 500 ppm (26.08 ± 0.54 mm) and at control

(16.55 ± 0.43 mm) for FS-2 and at 500 ppm (25.73 ± 0.45 mm) and at control (16.12 ± 0.30 mm) for FS-3 respectively.

Analysis of variance showed highly significant differences among doses at 1% level of significance (Table 95). The effectiveness of different plant extracts with respect to plant parts followed the order leaf > stem > root while in respect of feeding schedule this trend was FS-2 > FS-3 > FS-1. In most of the results for both PP and FS effective dose of the plant extracts followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm.

4.2.4.2 Effect of *S. tuberosum* extracts on the growth of pupae of *B. mori*

The results of the supplementation of different parts, viz. leaf, stem and root extracts of *S. tuberosum* on growth of pupae of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 are given bellow:

Pupal weight (PW):

Effect of different parts extracts of *S. tuberosum* on PW of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 85 and their statistical analysis is presented in Table 96.

In case of leaf extract, the mean values of PW increased at different doses when compared with control in FS-1. The highest and the lowest mean PW of respect were observed at 500 ppm (1.10 ± 0.01 gm) and control (1.07 ± 0.001 gm) respectively. While maintaining scheduled FS-2, the highest and the lowest PW were observed at 500 ppm, (1.16 ± 0.006 gm), and at control (1.10 ± 0.004 gm) respectively. In case of FS-3, leaf extract also increased the PW at different doses, viz. at 100 ppm (1.06 ± 0.007 gm), 500 ppm (1.07 ± 0.008 gm), 1000 ppm (1.06 ± 0.002 gm) and 1500 ppm (1.04 ± 0.004 gm) compare to control (1.05 ± 0.001 gm).

For stem extract, the mean values of PW in different concentrations for different feeding schedules and plant parts were significantly increased. While fed

according to FS-1, the highest and the lowest PW were recorded at 500 ppm ($1.14 \pm 0.010 \text{ gm}$) and at control ($1.07 \pm 0.001 \text{ gm}$) respectively. In case of FS-2, leaf extract increased the PW at different doses, viz. at 100 ppm ($1.13 \pm 0.012 \text{ gm}$), 500 ppm ($1.15 \pm 0.01 \text{ gm}$), 1000 ppm ($1.14 \pm 0.007 \text{ gm}$) and 1500 ppm ($1.12 \pm 0.006 \text{ gm}$) against the control value ($1.10 \pm 0.004 \text{ gm}$). The highest and the lowest mean PW were observed at 500 ppm ($1.15 \pm 0.008 \text{ gm}$) and control ($1.05 \pm 0.001 \text{ gm}$) respectively while fed according to FS-3.

In different feeding schedules, the mean values of PW were significantly increased at different concentrations for root extract of *S. tuberosum*. The highest and the lowest mean pupal weight were observed at 500 ppm ($1.11 \pm 0.002 \text{ gm}$) and at control ($1.07 \pm 0.001 \text{ gm}$) for FS-1, at 500 ppm ($1.15 \pm 0.002 \text{ gm}$) and at control ($1.10 \pm 0.004 \text{ gm}$) for FS-2 and at 500 ppm ($1.14 \pm 0.000 \text{ gm}$) and at control ($1.05 \pm 0.001 \text{ gm}$) for FS-3 respectively.

The results of ANOVA have been presented in the Table 96. All the items revealed insignificant results ($P < 0.01$). The effectiveness of different plant extracts with respect to plant parts followed the order stem > root > leaf while in respect of feeding schedule this trend was FS-2 > FS-3 > FS-1. In most of the results for both PP and FS effective dose of the plant extracts followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm.

4.2.4.3 Effect of *S. tuberosum* extract on the survival of *B. mori* larvae.

The results of the supplementation of different parts, viz. leaf, stem and root extracts of *S. tuberosum* on the developmental period of *B. mori* at different feeding schedules viz. FS-1, FS-2 and FS-3 are given bellow:

Surviving percentage (SP):

The results of *S. tuberosum* extracts on the larval survival of *B. mori* supplemented with mulberry leaves under different schedules of feeding have been discussed as follows:

Effect of different parts extracts from different parts of *S. tuberosum* on surviving percentage SP of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 86 and their statistical analysis is presented in Table 97.

In case of leaf extract, the mean values of sp increased at different dose against control while fed in FS-1. The highest and the lowest mean SP were observed at 500 ppm ($60.00 \pm 0.58\%$) and control ($54.67 \pm 0.33\%$) respectively. While maintaining schedules FS-2 the highest and the lowest surviving percentage were observed at 500 ppm ($62.33 \pm 1.20\%$) and at control ($55.67 \pm 0.30\%$) respectively. In case of FS-3, leaf extract also increased the SP at different doses, viz. at 100 ppm ($58.33 \pm 1.21\%$), 500 ppm ($61.00 \pm 0.55\%$), 1000 ppm ($62.33 \pm 1.45\%$) and 1500 ppm ($58.33 \pm 1.24\%$) when compared with control ($55.33 \pm 1.32\%$).

For stem extract, the mean values of SP in different concentrations for different feeding schedules and plant parts were increased significantly. While fed according to FS-1, the highest and the lowest SP were recorded at 500 ppm ($63.00 \pm 0.51\%$) and at control ($54.67 \pm 0.33\%$) respectively. In case of FS-2, stem extract increased the surviving percentage at different doses, viz. at 100 ppm ($59.67 \pm 0.36\%$), 500 ppm ($65.33 \pm 0.83\%$), 1000 ppm ($64.00 \pm 1.58\%$) and 1500 ppm ($62.00 \pm 1.15\%$) against control ($55.67 \pm 0.30\%$). The highest and the lowest mean SP were observed at 500 ppm ($64.00 \pm 0.59\%$) and control ($55.33 \pm 1.32\%$) respectively while fed according to FS-3.

In different feeding schedules, the mean values of SP were significantly increased at different concentrations for root extract of *S. tuberosum*. The highest and the lowest mean SP were observed at 500 ppm (61.00 ± 0.57) and at control ($54.67 \pm 0.33\%$) for FS-1, at 500 ppm ($63.33 \pm 1.33\%$) and at control ($59.33 \pm 0.38\%$) for FS-2 and at 500 ppm ($62.33 \pm 1.30\%$) and at control ($55.33 \pm 1.32\%$) for FS-3 respectively.

The results of ANOVA have been presented in the Table 97. It indicated highly significant differences among feeding schedules ($F=289.79$), plant parts

($F=57.25$), doses ($F=121.3$) at 1% level of significance. The result was insignificant for the interaction item doses $\times$ plant parts.

The effective concentration of plant extracts in respect of their efficacy as a food supplement with mulberry leaves followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm. When pp was evaluated, the most effective PP was stem followed by root and leaf. For FS the efficacy followed the order FS-2 > FS-3 > FS-1.

4.2.4.4 Effect of *S. tuberosum* extracts on the developmental period stages of *B. mori*

The results of the supplementation of different parts, viz. leaf, stem and root extracts of *S. tuberosum* on the formation and duration of developmental stages of *B. mori* at different feeding schedules viz. FS-1, FS-2, FS-3 are given bellow:

Larval duration (LD):

Effect of different parts of *S. tuberosum* extract on LD of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 87 and their statistical analysis is presented in Table 98.

In case of leaf extract, the mean values of LD increased at different doses against control while fed in FS-1. The highest and the lowest mean LD were observed at 1000 ppm ($22.46 \pm 0.086d$) and control ($22.20 \pm 0.085d$) respectively. While maintaining schedules FS-2 the highest and the lowest larval duration were observed at 1000 ppm, ($22.55 \pm 0.143d$), and at control ($22.31 \pm 0.064d$) respectively. In case of FS-3, leaf extract also increased the larval duration at different doses, viz. at 100 ppm ($22.30 \pm 0.068d$), 500 ppm ($22.36 \pm 0.034d$), 1000 ppm ($22.52 \pm 0.128d$) and 1500 ppm ($22.40 \pm 0.042d$) in comparison to control ($22.37 \pm 0.135d$).

In case of stem extract, the mean values of LD in different concentrations were significantly increased. While fed according to FS-1, the highest and the lowest larval duration were recorded at 1000 ppm ($22.56 \pm 0.065d$) and at control ($22.20 \pm 0.085d$) respectively. For FS-2, stem extract increased the larval duration at different doses, viz. at 100 ppm ($22.47 \pm 0.035d$), 500 ppm ($22.49 \pm 0.033d$), 1000 ppm ($22.64 \pm 0.168d$) and 1500 ppm ($22.56 \pm 0.015d$) against control ($22.31 \pm 0.064d$). The highest and the lowest mean larval duration were observed at 1000 ppm ($22.60 \pm 0.102d$) and control ($22.37 \pm 0.135d$) respectively while fed according to FS-3.

In different feeding schedules, the mean values of LD were significantly increased at different concentrations for root extract of *S. tuberosum*. The highest and the lowest mean LD were observed at 1000 ppm ($22.50 \pm 0.045d$) for FS-1, at 1000 ppm ($22.60 \pm 0.168d$) for FS-2, at 1000 ppm ($22.55 \pm 0.094d$) for FS-3 compare to control.

The results of ANOVA have been presented in the Table 98. All the items revealed significant results ($P < 0.01$). The effectiveness of different plant parts on LD followed the order stem > root > leaf and in respect of feeding schedule FS-2 > FS-3 > FS-1. The most effective dose of the plant extracts was found to be 1000 ppm followed by 1500 ppm, 500 ppm and 100 ppm.

Pupal duration (PD):

Result on the effect of *S. tuberosum* extracts PD of *B. mori* at different feeding schedules viz. FS-1, FS-2, FS-3 is shown in Table 88 and their statistical analysis is presented in Table 99.

In case of leaf extract, the mean values of PD increased at different doses as compared to control while fed in FS-1. The highest and the lowest PD were observed at 1000 ppm ($8.45 \pm 0.447d$) and control ($8.18 \pm 0.177d$) respectively. While maintaining schedules FS-2 the highest and the lowest PD were observed at

1000 ppm ($8.55 \pm 0.304d$) and at control ($8.38 \pm 0.111d$) respectively. In case of FS-3, leaf extract also increased the PD at different doses, viz. at 100 ppm ($8.30 \pm 0.095d$), 500 ppm ($8.38 \pm 0.208d$), 1000 ppm ($8.52 \pm 0.226d$), 1500 ppm ($8.48 \pm 0.377d$) against control ($8.32 \pm 0.369d$).

In case of stem extract, the mean values of PD in different concentrations increased significantly. While fed according to FS-1, the highest and the lowest PD were recorded at 1000 ppm ($8.43 \pm 0.451d$) and at control ($8.18 \pm 0.177d$) respectively. For FS-2, stem extract increased the pupal duration at different doses, viz. at 100 ppm ($8.48 \pm 0.213d$), 500 ppm ($8.56 \pm 0.325d$), 1000 ppm ($8.65 \pm 0.337d$) and 1500 ppm ($8.59 \pm 0.453d$) against control (8.38 ± 0.111). The highest and the lowest PD were observed at 1000 ppm ($8.62 \pm 0.209d$) and control ($8.32 \pm 0.369d$) respectively while fed according to FS-3.

In different feeding schedules, the mean values of PD were significantly increased at different concentrations for root extract of *S. tuberosum*. The highest PD were observed at 1000 ppm ($8.43 \pm 0.451d$) for FS-1, at 1000 ppm ($8.59 \pm 0.349d$) for FS-2, at 1000 ppm ($8.58 \pm 0.215d$) for FS-3. On the other hand lowest PD were recorded in control

For all the items, analyses of variance showed highly significant differences (Table 99). The efficacy of different plant parts on LML followed the order stem > root > leaf and for feeding schedule the effectiveness in this regard was FS-2 > FS-3 > FS-1. The most effective dose of the plant extracts in majority of the cases was 1000 ppm followed by 1500 ppm, 500 ppm and 100 ppm.

4.2.4.5 Effect of *S. tuberosum* extracts on the cocoon characters of *B. mori*

The results of the supplementation of different parts of *S. tuberosum*, extracts, viz. leaf, stem and root on the cocoon characters of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 are given bellow:

Cocoon weight (CW):

Effect of different parts, viz. leaf, stem and root extracts of *S. tuberosum* on the weight of cocoon of *B. mori* at different feeding schedules, viz. FS-1, FS-2, FS-3 has been in Table 89 and their statistical analysis is included in Table 100.

Leaf extract of *S. tuberosum* increased the cw at different doses compare to control while fed in FS-1. The highest and the lowest mean cw were observed at 500 ppm ($1.35 \pm 0.015\text{gm}$) and control ($1.27 \pm 0.01\text{gm}$) respectively. While fed according to FS-2 the heaviest and the lightest cocoon were produced at 500 ppm ($1.37 \pm 0.013\text{gm}$), and at control ($1.29 \pm 0.009\text{gm}$) respectively. In case of FS-3, leaf extract also increased the cocoon weight at different doses, viz. at 100 ppm ($1.32 \pm 0.011\text{gm}$), 500 ppm ($1.34 \pm 0.014\text{gm}$), 1000 ppm ($1.31 \pm 0.009\text{gm}$) and 1500 ppm ($1.28 \pm 0.015\text{gm}$) against control ($1.25 \pm 0.010\text{gm}$).

In case of stem extract, the mean values of cocoon weight in different concentrations for different feeding schedules increased significantly. While fed according to FS-1, the heaviest and the lightest cocoons were produced at 500 ppm ($1.37 \pm 0.016\text{gm}$) and at control ($1.27 \pm 0.010\text{gm}$) respectively. In case of FS-2, stem extract increased the cw at different doses, viz. at 100 ppm ($1.35 \pm 0.021\text{gm}$), 500 ppm ($1.39 \pm 0.019\text{gm}$), 1000 ppm ($1.37 \pm 0.016\text{gm}$) and 1500 ppm ($1.33 \pm 0.012\text{gm}$) compare to control ($1.29 \pm 0.009\text{gm}$). The highest and the lowest mean cocoon weight were recorded at 500 ppm ($1.39 \pm 0.013\text{gm}$) and control ($1.25 \pm 0.01\text{gm}$) respectively at FS-3.

In different feeding schedules, the mean values of cw increased significantly at different concentrations for root extract of *S. tuberosum*. The highest mean cw were observed at 500 ppm ($1.37 \pm 0.012\text{gm}$) for FS-1, at 500 ppm ($1.38 \pm 0.006\text{gm}$) for FS-2 and at 500 ppm (1.37gm) FS-3 and the lowest at control for all the cases, i.e. ($1.27 \pm 0.010\text{gm}$) in FS-1, ($1.29 \pm 0.009\text{gm}$) in FS-2 and ($1.25 \pm 0.010\text{gm}$) in FS-3.

Results of analyses of variance are presented in Table 100. All the items showed insignificant results. The effectiveness of different plant extracts with respect to plant parts followed the order stem > root > leaf while in respect of feeding schedule this trend was FS-3 > FS-1 > FS-2. In most of the results for both PP and FS effective dose of the plant extracts followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm.

Shell weight (SW):

Effect of different parts, viz. leaf, stem and root extracts of *S. tuberosum* on SW of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 90 and their statistical analysis is presented in Table 101.

Leaf extract of *S. tuberosum* increased the sw at different doses compare to control while fed in FS-1. The highest and the lowest mean sw were observed at 500 ppm (0.25 ± 0.005 gm) and control (0.20 ± 0.009 gm) respectively. While fed according to FS-2 the heaviest and the lightest shell were produced at 500 ppm, (0.21 ± 0.007 gm), and at control (0.19 ± 0.005 gm) respectively. In case of FS-3, leaf extract also increased the sw at different doses, viz. at 100 ppm (0.26 ± 0.004 gm), 500 ppm (0.27 ± 0.006 gm), 1000 ppm (0.25 ± 0.007 gm), 1500 ppm (0.24 ± 0.011 gm) compare to control (0.20 ± 0.009 gm).

In case of stem extract, the mean values of SW in different concentrations for different feeding schedules increased significantly. While fed according to FS-1, the heaviest and the lightest shell were produced at 500 ppm (0.23 ± 0.006 gm) and at control (0.20 ± 0.009 gm) respectively. In case of FS-2, stem extract increased the shell weight at different doses, viz. at 100 ppm (0.22 ± 0.009 gm), 500 ppm (0.24 ± 0.009 gm), 1000 ppm (0.23 ± 0.009 gm) and 1500 ppm (0.21 ± 0.006 gm) against control (0.19 ± 0.005 gm). The highest and the lowest mean SW were observed at 500 ppm (0.24 ± 0.006) and control (0.20 ± 0.009) respectively at FS-3.

In different feeding schedules, the mean values of SW were significantly increased at different concentrations for root extract of *S. tuberosum*. The highest mean shell weight were observed at 500 ppm (0.26 ± 0.01) for FS-1, at 500 ppm (0.23 ± 0.003) for FS-2 and at 500 ppm (0.23 ± 0.01) for FS-3 and the lowest at control for all the cases. i.e 0.20 ± 0.009 gm in FS-1, 0.19 ± 0.005 gm in FS-2 and 0.20 ± 0.009 gm in FS-3 respectively.

Results of analyses of variance are presented in Table 101. Only one item doses showed highly significant differences at 1% level of significance. The effectiveness of different plant extracts with respect to plant parts followed the order stem > root > leaf while in respect of feeding schedule this trend was FS-2 > FS-3 > FS-1. In most of the results for both PP and FS effective dose of the plant extracts followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm.

4.2.4.6 Effect of *S. tuberosum* on the fecundity and fertility of *B. mori*

In the present investigation fecundity was evaluated on the basis of egg laying potential, i.e. total number of eggs laid by individual female moth of *B. mori* and for fertility parameter egg hatching percentage was computed.

The results of the supplementation of different parts, viz. leaf, stem and root extracts of *S. tuberosum* on the fecundity and fertility of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 are given below:

Total number of eggs laid per female (TEL):

Effect of different parts, viz. leaf, stem and root extracts of *S. tuberosum* on fecundity, i.e. total number of eggs by individual female of *B. mori* at different feeding schedules, viz. FS-1, FS-2 and FS-3 is shown in Table 91 and their statistical analysis is presented in Table 102.

Leaf extract of *S. tuberosum* increased the fecundity at different doses compare to control while fed in FS-1. The highest and the lowest fecundity were observed at 500 ppm (453.33 ± 1.32) and control (447.11 ± 4.92) respectively. While fed

according to FS-2 the highest and the lowest no. of egg were produced at 500 ppm (455.67 ± 0.33) and at control (450.67 ± 10.35) respectively. In case of FS-3, leaf extract also increased the fecundity at different doses, viz. at 100 ppm ($4.51.67 \pm 2.03$), 500 ppm (455.00 ± 0.58), 1000 ppm (453.33 ± 0.88) and 1500 ppm (452.00 ± 3.51) against to control (444.33 ± 5.35).

In case of stem extract, the mean values of TEL in different concentrations for different feeding schedules were significantly increased. While fed according to FS-1, the heaviest and the lightest fecundity were produced at 500 ppm (455.33 ± 0.88) and at control (447.11 ± 4.92) respectively. In case of FS-2, stem extract increased the fecundity at different doses, viz. at 100 ppm (451.67 ± 0.80), 500 ppm (457.67 ± 0.90), 1000 ppm (456.33 ± 0.41), 1500 ppm (455.33 ± 0.89) compare to control (450.67 ± 10.35). The highest and the lowest fecundity were observed at 500 ppm (457.00 ± 1.19) and the control (444.33 ± 5.35) respectively at FS-3.

In different feeding schedules, the mean values of TEL increased significantly at different concentrations for root extract of *S. tuberosum*. The highest and lowest value of TEL were observed at 500 ppm (454.33 ± 1.45) and at control (447.11 ± 4.92) for FS-1, at 500 ppm (456.00 ± 1.16) and at control (450.67 ± 10.35) for FS-2 and at 500 ppm (456.33 ± 0.67) and at control (444.33 ± 5.35) for FS-3 respectively.

Results of analyses of variance are presented in Table 102. All the items showed highly significant differences at 1% level of significance. The effective concentration of plant extracts in respect of their efficacy as a food supplement with mulberry leaves followed the order 500 ppm > 1000 ppm > 1500 ppm > 100 ppm. When pp was evaluated, the most effective PP was stem followed by root and leaf. For FS the efficacy followed the order FS-2 > FS-3 > FS-1.

Egg hatching percentage (EHP)

Effect of different parts viz. leaf, stem, root extracts of *S. tuberosum* on fertility of *B. mori* at different feeding schedules viz. FS-1, FS-2, FS-3 is shown in Table 92 and their statistical analysis is presented in Table 103.

Leaf extract of *S. tuberosum* increased the fertility at different doses compare to control while fed in FS-1. The highest and the lowest fertility were observed at 500 ppm (93.00 ± 0.59) and control (87.00 ± 0.58) respectively. While fed according to FS-2 the highest and the lowest fertility were produced at 500 ppm (95.00 ± 0.56) and at control (88.00 ± 0.58) respectively. In case of FS-3, leaf extract also increased the fertility at different doses, viz. at 100 ppm (91.33 ± 1.01), 500 ppm (94.00 ± 1.14), 1000 ppm (93.00 ± 1.02), 1500 ppm (92.67 ± 0.60) compare to control (54.67 ± 0.33).

In case of stem extract, the mean values of fertility in different concentrations for different feeding schedules increased significantly. While fed according to FS-1, the highest and the lowest fertility were produced at 500 ppm (95.67 ± 1.03) and at control (87.00 ± 0.58) respectively. In case of FS-2, stem extract increased the fertility at different doses, viz. at 100 ppm (94.00 ± 0.54), 500 ppm (97.33 ± 0.67), 1000 ppm (96.00 ± 1.08) and 1500 ppm (95.00 ± 1.17) against control (88.00 ± 0.58). The highest and the lowest fertility were observed at 500 ppm (96.00 ± 0.52) and control (87.67 ± 0.33) respectively at FS-3.

In different feeding schedules, the mean values of fertility were significantly increased at different concentrations for root extract of *S. tuberosum*. The highest mean cocoon weight were observed at 500 ppm (94.00 ± 1.18) for FS-1, at 500 ppm (96.00 ± 0.48) for FS-2 and at 500 ppm (95.00 ± 0.60) for FS-3 and the lowest at control for all the cases, i.e. (87.00 ± 0.58) in FS-1, (88.00 ± 0.58) in FS-2 and (87.67 ± 0.33) in FS-3.

Results of analyses of variance are presented in Table 103. The items feeding schedules ($F=45.92$), plant parts ($F=59.01$) and doses ($F=171.95$) showed highly significant differences at 1% level of significance. The effectiveness of different plant parts on EHP followed the order stem > root > leaf and in respect of feeding schedule FS-2 > FS-3 > FS-1. The most effective dose of the plant extracts was found to be 500 ppm followed by 1000 ppm, 1500 ppm and 100 ppm.

Table 16. Effect of different parts of *Abroma augusta* water extracts under different schedules of feeding on the weight of mature larvae of *B. mori* L.

Feeding schedule	Dose (ppm)	Mean $\pm$ SE (gm)		
		Leaf	Stem	Root
FS-1	Control	2.83 $\pm$ 0.014	2.83 $\pm$ 0.014	2.83 $\pm$ 0.014
	100	2.92 $\pm$ 0.012	2.94 $\pm$ 0.008	2.93 $\pm$ 0.015
	500	2.95 $\pm$ 0.009	2.97 $\pm$ 0.017	2.96 $\pm$ 0.112
	1000	2.94 $\pm$ 0.018	2.95 $\pm$ 0.013	2.95 $\pm$ 0.105
	1500	2.93 $\pm$ 0.008	2.94 $\pm$ 0.020	2.93 $\pm$ 0.103
FS-2	Control	2.84 $\pm$ 0.011	2.84 $\pm$ 0.014	2.84 $\pm$ 0.021
	100	2.94 $\pm$ 0.015	2.96 $\pm$ 0.019	2.95 $\pm$ 0.102
	500	2.97 $\pm$ 0.006	3.00 $\pm$ 0.014	2.98 $\pm$ 0.115
	1000	2.96 $\pm$ 0.010	2.97 $\pm$ 0.003	2.97 $\pm$ 0.104
	1500	2.95 $\pm$ 0.016	2.97 $\pm$ 0.005	2.96 $\pm$ 0.101
FS-3	Control	2.87 $\pm$ 0.021	2.87 $\pm$ 0.020	2.87 $\pm$ 0.120
	100	2.93 $\pm$ 0.012	2.93 $\pm$ 0.016	2.93 $\pm$ 0.107
	500	2.96 $\pm$ 0.019	2.98 $\pm$ 0.018	2.97 $\pm$ 0.106
	1000	2.95 $\pm$ 0.014	2.96 $\pm$ 0.023	2.96 $\pm$ 0.016
	1500	2.94 $\pm$ 0.003	2.96 $\pm$ 0.016	2.94 $\pm$ 0.080

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 17. Effect of different parts of *Abroma augusta* water extract under different schedules of feeding on the length of mature larvae of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(mm)		
		Leaf	Stem	Root
FS-1	Control	72.19 $\pm$ 0.30	72.19 $\pm$ 0.30	72.19 $\pm$ 0.30
	100	75.74 $\pm$ 0.63	77.93 $\pm$ 0.28	76.69 $\pm$ 0.58
	500	78.42 $\pm$ 0.95	80.72 $\pm$ 0.42	79.41 $\pm$ 0.61
	1000	77.47 $\pm$ 0.64	79.66 $\pm$ 0.39	78.96 $\pm$ 0.33
	1500	76.38 $\pm$ 1.04	78.67 $\pm$ 0.41	77.79 $\pm$ 0.51
FS-2	Control	74.59 $\pm$ 0.32	74.59 $\pm$ 0.32	74.59 $\pm$ 0.32
	100	77.56 $\pm$ 1.36	78.46 $\pm$ 0.48	78.78 $\pm$ 1.75
	500	80.98 $\pm$ 0.86	81.75 $\pm$ 0.50	81.57 $\pm$ 0.54
	1000	79.62 $\pm$ 0.94	81.44 $\pm$ 0.54	80.85 $\pm$ 0.96
	1500	78.04 $\pm$ 0.47	79.82 $\pm$ 0.33	79.06 $\pm$ 0.69
FS-3	Control	73.18 $\pm$ 0.37	73.18 $\pm$ 0.37	73.18 $\pm$ 0.37
	100	76.25 $\pm$ 1.77	78.05 $\pm$ 0.43	77.05 $\pm$ 1.43
	500	78.89 $\pm$ 0.30	80.02 $\pm$ 0.59	80.02 $\pm$ 0.59
	1000	78.58 $\pm$ 0.43	80.24 $\pm$ 0.28	79.51 $\pm$ 0.89
	1500	77.10 $\pm$ 0.58	79.09 $\pm$ 0.22	78.31 $\pm$ 0.85

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 18. Effect of different parts of *Abroma augusta* water extract under different schedules of feeding on the breadth of mature larvae of *B. mori* L. L.

FS	Dose (ppm)	Mean $\pm$ SE(mm)		
		Leaf	Stem	Root
FS-1	Control	17.25 $\pm$ 0.28	17.25 $\pm$ 0.28	17.25 $\pm$ 0.28
	100	20.18 $\pm$ 0.79	21.09 $\pm$ 0.66	21.92 $\pm$ 0.30
	500	23.38 $\pm$ 1.17	25.45 $\pm$ 0.51	24.66 $\pm$ 0.56
	1000	22.44 $\pm$ 1.14	24.87 $\pm$ 0.56	23.47 $\pm$ 0.45
	1500	21.27 $\pm$ 0.88	23.44 $\pm$ 0.65	22.64 $\pm$ 0.28
FS-2	Control	18.29 $\pm$ 0.33	18.29 $\pm$ 0.33	18.29 $\pm$ 0.33
	100	22.04 $\pm$ 0.81	22.91 $\pm$ 0.79	23.51 $\pm$ 0.35
	500	25.13 $\pm$ 0.37	26.79 $\pm$ 0.61	26.40 $\pm$ 0.93
	1000	24.22 $\pm$ 0.88	25.29 $\pm$ 0.73	25.28 $\pm$ 0.33
	1500	23.14 $\pm$ 1.14	24.27 $\pm$ 0.40	24.05 $\pm$ 0.25
FS-3	Control	16.60 $\pm$ 0.33	16.60 $\pm$ 0.33	16.60 $\pm$ 0.33
	100	21.33 $\pm$ 1.12	21.78 $\pm$ 0.56	22.32 $\pm$ 0.37
	500	24.50 $\pm$ 0.70	26.00 $\pm$ 0.32	25.07 $\pm$ 0.27
	1000	23.22 $\pm$ 0.65	25.87 $\pm$ 0.64	24.34 $\pm$ 1.06
	1500	22.49 $\pm$ 0.80	24.72 $\pm$ 0.44	23.61 $\pm$ 0.65

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 19. Effect of different parts of *Abroma augusta* water extract under different schedules of feeding on the pupal weight of *B. mori*.

FS	Dose (ppm)	Mean $\pm$ SE(gm)		
		Leaf	Stem	Root
FS-1	Control	1.12 $\pm$ 0.004	1.12 $\pm$ 0.004	1.12 $\pm$ 0.004
	100	1.14 $\pm$ 0.003	1.16 $\pm$ 0.006	1.16 $\pm$ 0.009
	500	1.17 $\pm$ 0.004	1.17 $\pm$ 0.004	1.17 $\pm$ 0.002
	1000	1.16 $\pm$ 0.003	1.16 $\pm$ 0.010	1.13 $\pm$ 0.006
	1500	1.15 $\pm$ 0.001	1.14 $\pm$ 0.001	1.14 $\pm$ 0.008
FS-2	Control	1.12 $\pm$ 0.004	1.12 $\pm$ 0.004	1.12 $\pm$ 0.004
	100	1.15 $\pm$ 0.001	1.14 $\pm$ 0.006	1.18 $\pm$ 0.055
	500	1.16 $\pm$ 0.006	1.17 $\pm$ 0.005	1.19 $\pm$ 0.004
	1000	1.15 $\pm$ 0.003	1.10 $\pm$ 0.004	1.17 $\pm$ 0.003
	1500	1.14 $\pm$ 0.004	1.16 $\pm$ 0.009	1.14 $\pm$ 0.002
FS-3	Control	1.15 $\pm$ 0.002	1.15 $\pm$ 0.002	1.15 $\pm$ 0.002
	100	1.16 $\pm$ 0.000	1.18 $\pm$ 0.002	1.16 $\pm$ 0.005
	500	1.18 $\pm$ 0.005	1.20 $\pm$ 0.003	1.18 $\pm$ 0.004
	1000	1.18 $\pm$ 0.002	1.17 $\pm$ 0.042	1.17 $\pm$ 0.006
	1500	1.17 $\pm$ 0.004	1.18 $\pm$ 0.005	1.17 $\pm$ 0.005

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 20. Effect of different parts of *Abroma augusta* water extract under different schedules of feeding on the surviving percentage of *B. mori*.

FS	Dose (ppm)	Mean $\pm$ SE(%)		
		Leaf	Stem	Root
FS-1	Control	55.00 $\pm$ 0.53	55.00 $\pm$ 0.53	55.00 $\pm$ 0.53
	100	60.33 $\pm$ 0.88	61.33 $\pm$ 0.80	60.33 $\pm$ 0.82
	500	63.00 $\pm$ 1.20	64.67 $\pm$ 0.44	63.00 $\pm$ 0.51
	1000	62.00 $\pm$ 1.15	63.67 $\pm$ 0.38	62.00 $\pm$ 1.15
	1500	61.33 $\pm$ 0.65	62.67 $\pm$ 0.81	61.33 $\pm$ 0.67
FS-2	Control	56.67 $\pm$ 0.67	56.67 $\pm$ 0.67	56.67 $\pm$ 0.66
	100	62.67 $\pm$ 0.33	63.00 $\pm$ 0.51	62.67 $\pm$ 0.35
	500	65.33 $\pm$ 0.88	66.00 $\pm$ 0.52	65.33 $\pm$ 0.76
	1000	64.00 $\pm$ 0.50	65.33 $\pm$ 0.49	64.00 $\pm$ 0.60
	1500	63.00 $\pm$ 0.62	64.00 $\pm$ 0.51	63.00 $\pm$ 0.61
FS-3	Control	56.00 $\pm$ 0.58	56.00 $\pm$ 0.58	56.00 $\pm$ 0.58
	100	61.67 $\pm$ 0.86	62.33 $\pm$ 0.81	61.67 $\pm$ 0.82
	500	64.00 $\pm$ 0.54	65.33 $\pm$ 0.42	64.00 $\pm$ 0.69
	1000	62.00 $\pm$ 0.55	64.00 $\pm$ 0.56	62.00 $\pm$ 0.61
	1500	62.33 $\pm$ 0.49	63.00 $\pm$ 0.40	62.33 $\pm$ 0.43

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 21. Effect of different parts of *Abroma augusta* water extract under different schedules of feeding on the larval duration of *B. mori*.

FS	Dose (ppm)	Mean $\pm$ SE(d)		
		Leaf	Stem	Root
FS-1	Control	23.05 $\pm$ 0.66	23.05 $\pm$ 0.66	23.05 $\pm$ 0.66
	100	22.91 $\pm$ 0.27	22.98 $\pm$ 0.25	22.95 $\pm$ 0.24
	500	22.99 $\pm$ 0.82	23.08 $\pm$ 0.80	23.20 $\pm$ 0.78
	1000	23.15 $\pm$ 0.10	23.20 $\pm$ 0.07	23.15 $\pm$ 0.23
	1500	23.06 $\pm$ 0.27	23.15 $\pm$ 0.25	23.12 $\pm$ 0.24
FS-2	Control	22.90 $\pm$ 0.79	22.90 $\pm$ 0.79	22.90 $\pm$ 0.79
	100	23.03 $\pm$ 0.38	23.10 $\pm$ 0.37	23.09 $\pm$ 0.36
	500	23.10 $\pm$ 0.29	23.17 $\pm$ 0.27	23.12 $\pm$ 0.25
	1000	23.21 $\pm$ 0.26	23.25 $\pm$ 0.25	23.21 $\pm$ 0.23
	1500	23.14 $\pm$ 0.44	23.20 $\pm$ 0.40	23.17 $\pm$ 0.39
FS-3	Control	22.99 $\pm$ 0.82	22.99 $\pm$ 0.82	22.99 $\pm$ 0.82
	100	23.05 $\pm$ 0.66	23.10 $\pm$ 0.65	23.07 $\pm$ 0.64
	500	23.11 $\pm$ 0.56	23.16 $\pm$ 0.55	23.15 $\pm$ 0.55
	1000	23.14 $\pm$ 0.42	23.23 $\pm$ 0.40	23.20 $\pm$ 0.39
	1500	23.12 $\pm$ 0.26	23.19 $\pm$ 0.25	23.15 $\pm$ 0.23

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 22. Effect of different parts of *Abroma augusta* water extract under different schedules of feeding on the pupal duration of *B. mori*.

FS	Dose (ppm)	Mean $\pm$ SE(d)		
		Leaf	Stem	Root
FS-1	Control	8.99 $\pm$ 0.009	8.99 $\pm$ 0.009	8.99 $\pm$ 0.009
	100	9.06 $\pm$ 0.015	9.00 $\pm$ 0.021	9.10 $\pm$ 0.035
	500	9.10 $\pm$ 0.009	9.21 $\pm$ 0.031	9.16 $\pm$ 0.015
	1000	9.20 $\pm$ 0.052	9.36 $\pm$ 0.050	9.30 $\pm$ 0.044
	1500	9.16 $\pm$ 0.007	9.30 $\pm$ 0.037	9.25 $\pm$ 0.023
FS-2	Control	9.15 $\pm$ 0.015	9.15 $\pm$ 0.015	9.15 $\pm$ 0.015
	100	9.15 $\pm$ 0.015	9.23 $\pm$ 0.020	9.19 $\pm$ 0.012
	500	9.17 $\pm$ 0.003	9.30 $\pm$ 0.045	9.20 $\pm$ 0.012
	1000	9.26 $\pm$ 0.015	9.41 $\pm$ 0.037	9.38 $\pm$ 0.042
	1500	9.20 $\pm$ 0.052	9.35 $\pm$ 0.048	9.26 $\pm$ 0.041
FS-3	Control	9.10 $\pm$ 0.009	9.10 $\pm$ 0.009	9.10 $\pm$ 0.009
	100	9.12 $\pm$ 0.006	9.17 $\pm$ 0.012	9.13 $\pm$ 0.003
	500	9.15 $\pm$ 0.015	9.22 $\pm$ 0.018	9.20 $\pm$ 0.018
	1000	9.23 $\pm$ 0.009	9.38 $\pm$ 0.042	9.30 $\pm$ 0.059
	1500	9.22 $\pm$ 0.075	9.30 $\pm$ 0.078	9.26 $\pm$ 0.041

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 23. Effect of different parts of *Abroma augusta* water extract under different schedules of feeding on the cocoon weight of *B. mori*.

FS	Dose (ppm)	Mean $\pm$ SE(gm)		
		Leaf	Stem	Root
FS-1	Control	1.25 $\pm$ 0.009	1.25 $\pm$ 0.009	1.25 $\pm$ 0.009
	100	1.27 $\pm$ 0.007	1.30 $\pm$ 0.012	1.30 $\pm$ 0.012
	500	1.32 $\pm$ 0.010	1.34 $\pm$ 0.007	1.33 $\pm$ 0.013
	1000	1.30 $\pm$ 0.015	1.32 $\pm$ 0.015	1.28 $\pm$ 0.015
	1500	1.28 $\pm$ 0.008	1.28 $\pm$ 0.009	1.29 $\pm$ 0.011
FS-2	Control	1.27 $\pm$ 0.015	1.27 $\pm$ 0.015	1.27 $\pm$ 0.015
	100	1.29 $\pm$ 0.010	1.29 $\pm$ 0.015	1.33 $\pm$ 0.067
	500	1.34 $\pm$ 0.012	1.35 $\pm$ 0.012	1.36 $\pm$ 0.012
	1000	1.32 $\pm$ 0.009	1.26 $\pm$ 0.009	1.32 $\pm$ 0.014
	1500	1.30 $\pm$ 0.013	1.33 $\pm$ 0.015	1.30 $\pm$ 0.017
FS-3	Control	1.29 $\pm$ 0.012	1.29 $\pm$ 0.012	1.29 $\pm$ 0.012
	100	1.32 $\pm$ 0.006	1.33 $\pm$ 0.011	1.31 $\pm$ 0.009
	500	1.35 $\pm$ 0.009	1.37 $\pm$ 0.006	1.36 $\pm$ 0.010
	1000	1.34 $\pm$ 0.011	1.33 $\pm$ 0.048	1.33 $\pm$ 0.012
	1500	1.32 $\pm$ 0.009	1.34 $\pm$ 0.009	1.34 $\pm$ 0.012

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 24. Effect of different parts of *Abroma augusta* water extract under different schedules of feeding on the shell weight of *B. mori*.

FS	Dose (ppm)	Mean $\pm$ SE(gm)		
		Leaf	Stem	Root
FS-1	Control	0.13 $\pm$ 0.005	0.13 $\pm$ 0.005	0.13 $\pm$ 0.005
	100	0.13 $\pm$ 0.003	0.14 $\pm$ 0.006	0.14 $\pm$ 0.003
	500	0.15 $\pm$ 0.006	0.17 $\pm$ 0.003	0.16 $\pm$ 0.011
	1000	0.14 $\pm$ 0.012	0.16 $\pm$ 0.006	0.15 $\pm$ 0.009
	1500	0.13 $\pm$ 0.007	0.14 $\pm$ 0.008	0.15 $\pm$ 0.003
FS-2	Control	0.15 $\pm$ 0.011	0.15 $\pm$ 0.011	0.15 $\pm$ 0.011
	100	0.14 $\pm$ 0.009	0.16 $\pm$ 0.009	0.15 $\pm$ 0.012
	500	0.18 $\pm$ 0.006	0.18 $\pm$ 0.007	0.17 $\pm$ 0.008
	1000	0.17 $\pm$ 0.006	0.17 $\pm$ 0.005	0.15 $\pm$ 0.011
	1500	0.16 $\pm$ 0.009	0.17 $\pm$ 0.007	0.16 $\pm$ 0.015
FS-3	Control	0.14 $\pm$ 0.010	0.14 $\pm$ 0.010	0.14 $\pm$ 0.010
	100	0.16 $\pm$ 0.006	0.15 $\pm$ 0.009	0.15 $\pm$ 0.003
	500	0.17 $\pm$ 0.003	0.17 $\pm$ 0.003	0.18 $\pm$ 0.006
	1000	0.16 $\pm$ 0.009	0.16 $\pm$ 0.007	0.16 $\pm$ 0.006
	1500	0.15 $\pm$ 0.005	0.15 $\pm$ 0.003	0.17 $\pm$ 0.007

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 25. Effect of different parts of *Abroma augusta* water extract under different schedules of feeding on the total number of eggs laid of *B. mori*.

FS	Dose (ppm)	Mean $\pm$ SE		
		Leaf	Stem	Root
FS-1	Control	440.11 $\pm$ 1.04	440.11 $\pm$ 1.04	440.11 $\pm$ 1.04
	100	443.67 $\pm$ 1.76	445.33 $\pm$ 0.33	444.00 $\pm$ 1.53
	500	446.33 $\pm$ 0.67	448.67 $\pm$ 1.45	447.33 $\pm$ 1.20
	1000	445.00 $\pm$ 0.58	447.00 $\pm$ 1.15	446.67 $\pm$ 0.88
	1500	444.33 $\pm$ 0.88	446.67 $\pm$ 0.88	445.33 $\pm$ 1.20
FS-2	Control	445.00 $\pm$ 1.01	445.00 $\pm$ 1.01	445.00 $\pm$ 1.01
	100	445.00 $\pm$ 1.73	447.33 $\pm$ 0.33	446.67 $\pm$ 0.88
	500	448.00 $\pm$ 1.00	450.67 $\pm$ 0.88	449.00 $\pm$ 0.58
	1000	447.67 $\pm$ 0.33	449.67 $\pm$ 0.88	448.67 $\pm$ 0.33
	1500	446.00 $\pm$ 0.58	448.33 $\pm$ 1.20	447.67 $\pm$ 0.33
FS-3	Control	428.56 $\pm$ 1.05	428.56 $\pm$ 1.05	428.56 $\pm$ 1.05
	100	444.67 $\pm$ 1.33	446.67 $\pm$ 1.45	445.00 $\pm$ 1.15
	500	447.67 $\pm$ 0.88	449.67 $\pm$ 1.20	448.00 $\pm$ 0.58
	1000	446.00 $\pm$ 0.58	448.33 $\pm$ 0.88	447.00 $\pm$ 1.15
	1500	445.67 $\pm$ 0.88	447.67 $\pm$ 0.67	446.33 $\pm$ 0.88

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 26. Effect of different parts of *Abroma augusta* water extract under different schedules of feeding on the egg hatching percentage of *B. mori*.

FS	Dose (ppm)	Mean $\pm$ SE(%)		
		Leaf	Stem	Root
FS-1	Control	86.00 $\pm$ 0.58	86.00 $\pm$ 0.58	86.00 $\pm$ 0.58
	100	82.00 $\pm$ 1.15	94.00 $\pm$ 0.62	89.00 $\pm$ 0.57
	500	92.00 $\pm$ 0.56	95.00 $\pm$ 0.70	94.00 $\pm$ 0.51
	1000	90.00 $\pm$ 0.88	94.00 $\pm$ 0.88	93.00 $\pm$ 0.35
	1500	89.00 $\pm$ 0.33	93.00 $\pm$ 0.53	92.00 $\pm$ 0.38
FS-2	Control	87.00 $\pm$ 0.55	87.00 $\pm$ 0.55	87.00 $\pm$ 0.55
	100	88.00 $\pm$ 0.67	90.00 $\pm$ 0.52	95.00 $\pm$ 0.53
	500	94.00 $\pm$ 0.58	97.00 $\pm$ 0.59	96.00 $\pm$ 0.59
	1000	93.00 $\pm$ 0.58	96.00 $\pm$ 0.62	95.00 $\pm$ 0.60
	1500	90.00 $\pm$ 1.20	95.00 $\pm$ 0.54	94.00 $\pm$ 0.66
FS-3	Control	84.00 $\pm$ 0.33	84.00 $\pm$ 0.33	84.00 $\pm$ 0.33
	100	80.00 $\pm$ 0.54	91.00 $\pm$ 0.64	92.00 $\pm$ 0.38
	500	93.00 $\pm$ 0.67	90.00 $\pm$ 0.84	95.00 $\pm$ 0.39
	1000	91.00 $\pm$ 0.55	90.00 $\pm$ 0.81	96.00 $\pm$ 0.52
	1500	91.00 $\pm$ 0.60	89.00 $\pm$ 0.67	90.00 $\pm$ 0.51

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 27. ANOVA for different plant parts of *Abroma augusta* water extracts under different schedules of feeding on the WML of *B. mori*.

Source	df	SS	MS	F
FS	2	0.029	0.015	54.58**
PP	2	0.009	0.004	16.22**
Error-1	4	0.001	0.000	
Dose	4	0.803	0.201	695.17**
Dose×PP	8	0.025	0.003	10.78**
Error-2	24	0.007	0.000	
Total	44	0.874		

WML=Weight of mature larvae, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 28. Anova for different plant parts of *Abroma augusta* water extracts under different schedules of feeding on the LML of *B. mori* L.

Source	df	SS	MS	F
FS	2	235.39	117.69	66.76**
PP	2	132.52	66.26	37.58**
Error-1	4	7.05	1.76	
Dose	4	2380.30	595.07	315.24**
Dose×PP	8	15.08	1.88	1.00
Error-2	24	45.30	1.88	
Total	44	2815.66		

LML=Length of mature larvae, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 29. Anova for different plant parts *Abroma augusta*. water extracts under different schedules of feeding on the BML of *B. mori* L.

Source	df	SS	MS	F
FS	2	138.18	69.09	43.81**
PP	2	117.38	58.69	37.21**
Error-1	4	6.31	1.58	
Dose	4	3092.65	773.16	291.88**
Dose×PP	8	32.25	4.03	1.52
Error-2	24	63.57	2.65	
Total	44	3450.35		

BML=Breadth of mature larvae, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 30. Anova for different plant parts of *Abroma augusta* water extracts under different schedules of feeding on the PW of *B. mori* L.

Source	df	SS	MS	F
FS	2	0.046	0.023	6.49*
PP	2	0.001	0.000	0.11
Error-1	4	0.014	0.004	
Dose	4	0.090	0.022	14.50**
Dose×PP	8	0.007	0.001	0.58
Error-2	24	0.037	0.002	
Total	44	0.196		

PW=Pupal weight, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 31. Anova for different plant parts of *Abroma augusta* water extracts under different schedules of feeding on the SP of *B. mori*.

Source	df	SS	MS	F
FS	2	230.978	115.489	140.46**
PP	2	74.711	37.356	45.43**
Error-1	4	3.289	0.822	
Dose	4	3621.556	905.389	679.04**
Dose×PP	8	15.244	1.906	1.43
Error-2	24	32.000	1.333	
Total	44	3977.778		

SP=Surviving Percentage, PP= Plant parts, df=Degree of freedom, SS=Sum of squares, MS=Mean sum of square, F=Variance ratio

Table 32. Anova for different plant parts of *Abroma augusta* water extracts under different schedules of feeding on the LD of *B. mori*.

Source	df	SS	MS	F
FS	2.00	0.02	0.01	131.15**
PP	2.00	0.02	0.01	141.21**
Error-1	4.00	0.00	0.00	
Dose	4.00	0.26	0.07	184.90**
Dose×PP	8.00	0.08	0.01	27.79**
Error-2	24.00	0.01	0.00	
Total	44.00	0.39		

LD=Larval Duration, PP= Plant parts, df=Degree of freedom, SS=Sum of squares, MS=Mean sum of square, F=Variance ratio

Table 33. Anova for different plant parts of *Abroma augusta* water extracts under different schedules of feeding on the PD of *B. mori*.

Source	df	SS	MS	F
FS	2	0.065	0.033	40.57**
PP	2	0.049	0.024	30.25**
Error-1	4	0.003	0.001	
Dose	4	0.318	0.079	52.56**
Dose×PP	8	0.019	0.002	1.58
Error-2	24	0.036	0.002	
Total	44	0.490		

PD=Pupal duration, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 34. Anova for different plant parts of *Abroma augusta* water extracts under different schedules of feeding on the CW of *B. mori*.

Source	df	SS	MS	F
FS	2	0.088	0.044	20.62**
PP	2	0.004	0.002	1.04
Error-1	4	0.009	0.002	
Dose	4	0.247	0.062	31.09**
Dose×PP	8	0.009	0.001	0.56
Error-2	24	0.048	0.002	
Total	44	0.404		

CW=Cocoon weight, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 35. Anova for different plant parts of *Abroma augusta* water extracts under different schedules of feeding on the SW of *B. mori* L.

Source	df	SS	MS	F
FS	2	0.021	0.011	9.46**
PP	2	0.002	0.001	0.70
Error-1	4	0.004	0.001	
Dose	4	0.043	0.011	33.38**
Dose×PP	8	0.003	0.000	1.08
Error-2	24	0.008	0.000	
Total	44	0.081		

SW=Shell weight PP= Plant parts, df=Degree of freedom, SS=Sum of squares, MS=Mean sum of square, F=Variance ratio

Table 36. Anova for different plant parts *Abroma augusta* water extracts under different schedules of feeding on the TEL of *B. mori* L.

Source	df	SS	MS	F
FS	2	1156.31	578.16	515.19**
PP	2	203.51	101.76	90.67**
Error-1	4	4.49	1.12	
Dose	4	5634.53	1408.63	533.80**
Dose×PP	8	2922.80	365.35	138.45**
Error-2	24	63.33	2.64	
Total	44	9984.98		

TEL=Total no. of eggs laid, PP= Plant parts, df=Degree of freedom, SS=Sum of squares, MS=Mean sum of square, F=Variance ratio

Table 37. Anova for different plant parts of *Abroma augusta* water extracts under different schedules of feeding on the EHP of *B. mori* L.

Source	df	SS	MS	F
FS	2	600.400	300.200	5.14*
PP	2	806.800	403.400	6.91**
Error-1	4	233.600	58.400	
Dose	4	3682.800	920.700	16.11**
Dose×PP	8	39.600	4.950	0.09
Error-2	24	1371.600	57.150	
Total	44	6734.800		

EHP=Egg hatching percentage, PP= Plant parts, df=Degree of freedom, SS=Sum of squares, MS=Mean sum of square, F=Variance ratio

Table 38. Effect of different parts of *Centela asiatica* water extract under different schedules of feeding on the weight of mature larvae of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE		
		Leaf	Stem	Root
FS-1	Control	2.48 $\pm$ 0.012	2.48 $\pm$ 0.012	2.48 $\pm$ 0.012
	100	2.55 $\pm$ 0.210	2.54 $\pm$ 0.007	2.53 $\pm$ 0.011
	500	2.58 $\pm$ 0.121	2.57 $\pm$ 0.011	2.56 $\pm$ 0.017
	1000	2.57 $\pm$ 0.404	2.56 $\pm$ 0.021	2.55 $\pm$ 0.012
	1500	2.56 $\pm$ 0.009	2.55 $\pm$ 0.020	2.54 $\pm$ 0.017
FS-2	Control	2.54 $\pm$ 0.010	2.54 $\pm$ 0.010	2.54 $\pm$ 0.010
	100	2.56 $\pm$ 0.051	2.56 $\pm$ 0.014	2.55 $\pm$ 0.023
	500	2.59 $\pm$ 0.015	2.59 $\pm$ 0.007	2.58 $\pm$ 0.009
	1000	2.58 $\pm$ 0.013	2.58 $\pm$ 0.017	2.57 $\pm$ 0.014
	1500	2.57 $\pm$ 0.017	2.57 $\pm$ 0.013	2.56 $\pm$ 0.023
FS-3	Control	2.52 $\pm$ 0.015	2.52 $\pm$ 0.015	2.52 $\pm$ 0.015
	100	2.51 $\pm$ 0.008	2.55 $\pm$ 0.012	2.54 $\pm$ 0.011
	500	2.57 $\pm$ 0.016	2.58 $\pm$ 0.007	2.57 $\pm$ 0.013
	1000	2.54 $\pm$ 0.014	2.57 $\pm$ 0.016	2.56 $\pm$ 0.020
	1500	2.56 $\pm$ 0.012	2.56 $\pm$ 0.014	2.55 $\pm$ 0.030

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 39. Effect of different parts of *Centela asiatica* water extract under different schedules of feeding on the length of mature larvae of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(mm)		
		Leaf	Stem	Root
FS-1	Control	64.77 $\pm$ 0.40	64.77 $\pm$ 0.40	64.77 $\pm$ 0.40
	100	69.92 $\pm$ 0.27	68.24 $\pm$ 0.51	67.29 $\pm$ 0.83
	500	72.31 $\pm$ 0.68	71.63 $\pm$ 0.62	70.45 $\pm$ 0.41
	1000	71.94 $\pm$ 0.36	70.14 $\pm$ 0.85	69.33 $\pm$ 0.56
	1500	70.50 $\pm$ 0.38	69.24 $\pm$ 0.28	68.01 $\pm$ 0.96
FS-2	Control	66.86 $\pm$ 0.51	66.86 $\pm$ 0.51	66.86 $\pm$ 0.51
	100	71.67 $\pm$ 0.76	70.21 $\pm$ 0.95	69.36 $\pm$ 0.28
	500	74.15 $\pm$ 0.36	73.02 $\pm$ 0.81	72.83 $\pm$ 1.21
	1000	73.24 $\pm$ 0.55	72.55 $\pm$ 0.55	71.48 $\pm$ 0.60
	1500	72.27 $\pm$ 1.08	71.60 $\pm$ 1.05	70.60 $\pm$ 0.50
FS-3	Control	66.11 $\pm$ 0.23	66.11 $\pm$ 0.23	66.11 $\pm$ 0.23
	100	70.68 $\pm$ 0.43	69.37 $\pm$ 1.05	68.27 $\pm$ 0.89
	500	73.23 $\pm$ 0.54	72.47 $\pm$ 0.71	71.71 $\pm$ 1.38
	1000	72.30 $\pm$ 0.17	71.44 $\pm$ 0.72	70.45 $\pm$ 0.40
	1500	71.15 $\pm$ 0.17	70.58 $\pm$ 0.59	69.98 $\pm$ 1.32

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 40. Effect of different parts of *Centela asiatica* water extract under different schedules of feeding on the breadth of mature larvae of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(mm)		
		Leaf	Stem	Root
FS-1	Control	14.48 $\pm$ 0.27	14.48 $\pm$ 0.27	14.48 $\pm$ 0.27
	100	19.44 $\pm$ 0.65	18.44 $\pm$ 0.48	17.24 $\pm$ 0.61
	500	22.61 $\pm$ 0.61	21.56 $\pm$ 0.72	20.91 $\pm$ 0.78
	1000	21.16 $\pm$ 0.68	20.19 $\pm$ 0.95	19.56 $\pm$ 0.31
	1500	20.57 $\pm$ 0.64	19.49 $\pm$ 0.46	18.23 $\pm$ 0.34
FS-2	Control	16.29 $\pm$ 0.32	16.29 $\pm$ 0.32	16.29 $\pm$ 0.32
	100	21.63 $\pm$ 0.63	20.48 $\pm$ 0.53	19.26 $\pm$ 0.38
	500	24.61 $\pm$ 0.55	23.09 $\pm$ 1.19	22.53 $\pm$ 1.17
	1000	23.30 $\pm$ 0.64	22.14 $\pm$ 0.78	21.87 $\pm$ 0.65
	1500	22.33 $\pm$ 0.65	21.28 $\pm$ 0.64	20.27 $\pm$ 0.31
FS-3	Control	15.02 $\pm$ 0.25	15.02 $\pm$ 0.25	15.02 $\pm$ 0.25
	100	20.55 $\pm$ 0.67	19.44 $\pm$ 0.43	18.27 $\pm$ 0.53
	500	23.12 $\pm$ 0.75	22.10 $\pm$ 1.14	21.94 $\pm$ 0.98
	1000	22.32 $\pm$ 0.61	21.91 $\pm$ 0.62	21.83 $\pm$ 1.05
	1500	21.15 $\pm$ 0.67	20.12 $\pm$ 0.86	19.61 $\pm$ 1.23

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 41. Effect of different parts of *Centela asiatica* water extract under different schedules of feeding on the pupal weight of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(gm)		
		Leaf	Stem	Root
FS-1	Control	0.97 $\pm$ 0.007	0.97 $\pm$ 0.007	0.97 $\pm$ 0.007
	100	1.01 $\pm$ 0.011	1.00 $\pm$ 0.006	1.01 $\pm$ 0.001
	500	1.04 $\pm$ 0.002	1.01 $\pm$ 0.010	1.03 $\pm$ 0.006
	1000	1.07 $\pm$ 0.010	0.94 $\pm$ 0.003	1.01 $\pm$ 0.003
	1500	0.99 $\pm$ 0.008	1.00 $\pm$ 0.006	1.02 $\pm$ 0.008
FS-2	Control	0.98 $\pm$ 0.009	0.98 $\pm$ 0.009	0.98 $\pm$ 0.009
	100	1.01 $\pm$ 0.001	0.99 $\pm$ 0.009	1.00 $\pm$ 0.003
	500	1.02 $\pm$ 0.005	1.02 $\pm$ 0.001	1.02 $\pm$ 0.004
	1000	0.99 $\pm$ 0.010	1.00 $\pm$ 0.006	1.00 $\pm$ 0.003
	1500	1.01 $\pm$ 0.007	1.00 $\pm$ 0.002	0.99 $\pm$ 0.003
FS-3	Control	0.99 $\pm$ 0.010	0.99 $\pm$ 0.010	0.99 $\pm$ 0.010
	100	0.920 $\pm$ 0.003	1.01 $\pm$ 0.005	1.01 $\pm$ 0.002
	500	1.02 $\pm$ 0.002	1.02 $\pm$ 0.009	1.02 $\pm$ 0.004
	1000	0.96 $\pm$ 0.003	0.99 $\pm$ 0.002	0.99 $\pm$ 0.003
	1500	0.96 $\pm$ 0.002	1.00 $\pm$ 0.005	0.98 $\pm$ 0.003

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 42. Effect of different parts of *Centela asiatica* water extract under different schedules of feeding on the surviving percentage of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(%)		
		Leaf	Stem	Root
FS-1	Control	52.00 $\pm$ 0.58	52.00 $\pm$ 0.58	52.00 $\pm$ 0.58
	100	58.33 $\pm$ 0.81	56.67 $\pm$ 0.68	55.33 $\pm$ 0.88
	500	61.00 $\pm$ 0.78	59.00 $\pm$ 0.59	58.33 $\pm$ 1.20
	1000	60.00 $\pm$ 0.80	58.67 $\pm$ 0.44	57.67 $\pm$ 0.88
	1500	59.33 $\pm$ 1.20	57.00 $\pm$ 0.65	56.00 $\pm$ 0.12
FS-2	Control	54.00 $\pm$ 0.67	54.00 $\pm$ 0.67	54.00 $\pm$ 0.67
	100	60.00 $\pm$ 0.54	58.00 $\pm$ 0.98	57.67 $\pm$ 0.88
	500	63.00 $\pm$ 0.73	61.33 $\pm$ 0.90	60.67 $\pm$ 0.95
	1000	62.00 $\pm$ 0.68	59.33 $\pm$ 1.16	59.33 $\pm$ 1.15
	1500	61.33 $\pm$ 0.72	59.00 $\pm$ 0.52	58.33 $\pm$ 0.40
FS-3	Control	52.67 $\pm$ 0.33	52.67 $\pm$ 0.33	52.67 $\pm$ 0.33
	100	59.00 $\pm$ 0.75	57.00 $\pm$ 1.15	56.67 $\pm$ 1.15
	500	62.33 $\pm$ 0.84	60.67 $\pm$ 1.20	59.00 $\pm$ 0.50
	1000	61.00 $\pm$ 0.55	59.33 $\pm$ 1.45	58.67 $\pm$ 0.56
	1500	60.33 $\pm$ 0.86	58.67 $\pm$ 0.85	57.33 $\pm$ 1.20

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 43. Effect of different parts of *Centela asiatica* water extract under different schedules of feeding on the larval duration of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(d)		
		Leaf	Stem	Root
FS-1	Control	22.08 $\pm$ 0.040	22.08 $\pm$ 0.040	22.08 $\pm$ 0.040
	100	22.10 $\pm$ 0.046	22.18 $\pm$ 0.028	22.15 $\pm$ 0.019
	500	22.19 $\pm$ 0.243	22.27 $\pm$ 0.228	22.29 $\pm$ 0.215
	1000	22.35 $\pm$ 0.044	22.50 $\pm$ 0.030	22.45 $\pm$ 0.026
	1500	22.13 $\pm$ 0.255	22.39 $\pm$ 0.211	22.38 $\pm$ 0.207
FS-2	Control	22.20 $\pm$ 0.026	22.20 $\pm$ 0.026	22.20 $\pm$ 0.026
	100	22.26 $\pm$ 0.230	22.40 $\pm$ 0.210	22.32 $\pm$ 0.183
	500	22.32 $\pm$ 0.046	22.49 $\pm$ 0.030	22.41 $\pm$ 0.021
	1000	22.46 $\pm$ 0.039	22.61 $\pm$ 0.015	22.52 $\pm$ 0.020
	1500	22.40 $\pm$ 0.143	22.52 $\pm$ 0.123	22.47 $\pm$ 0.106
FS-3	Control	22.12 $\pm$ 0.252	22.12 $\pm$ 0.252	22.12 $\pm$ 0.252
	100	22.21 $\pm$ 0.213	22.35 $\pm$ 0.193	22.28 $\pm$ 0.170
	500	22.26 $\pm$ 0.230	22.45 $\pm$ 0.204	22.35 $\pm$ 0.229
	1000	22.41 $\pm$ 0.036	22.57 $\pm$ 0.038	22.49 $\pm$ 0.026
	1500	22.32 $\pm$ 0.116	22.41 $\pm$ 0.093	22.37 $\pm$ 0.080

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae

Table 44. Effect of different parts of *Centela asiatica* water extract under different schedules of feeding on the pupal duration of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(d)		
		Leaf	Stem	Root
FS-1	Control	8.12 $\pm$ 0.262	8.12 $\pm$ 0.262	8.12 $\pm$ 0.262
	100	8.15 $\pm$ 0.163	8.23 $\pm$ 0.139	8.15 $\pm$ 0.117
	500	8.32 $\pm$ 0.117	8.29 $\pm$ 0.112	8.28 $\pm$ 0.115
	1000	8.52 $\pm$ 0.296	8.60 $\pm$ 0.322	8.55 $\pm$ 0.328
	1500	8.41 $\pm$ 0.090	8.46 $\pm$ 0.076	8.35 $\pm$ 0.044
FS-2	Control	8.37 $\pm$ 0.129	8.37 $\pm$ 0.129	8.37 $\pm$ 0.129
	100	8.40 $\pm$ 0.176	8.39 $\pm$ 0.176	8.43 $\pm$ 0.167
	500	8.51 $\pm$ 0.015	8.55 $\pm$ 0.021	8.52 $\pm$ 0.015
	1000	8.75 $\pm$ 0.213	8.80 $\pm$ 0.207	8.79 $\pm$ 0.172
	1500	8.62 $\pm$ 0.199	8.68 $\pm$ 0.217	8.65 $\pm$ 0.225
FS-3	Control	8.21 $\pm$ 0.173	8.21 $\pm$ 0.173	8.21 $\pm$ 0.173
	100	8.29 $\pm$ 0.286	8.35 $\pm$ 0.274	8.32 $\pm$ 0.264
	500	8.37 $\pm$ 0.127	8.46 $\pm$ 0.097	8.40 $\pm$ 0.093
	1000	8.58 $\pm$ 0.095	8.62 $\pm$ 0.084	8.60 $\pm$ 0.084
	1500	8.46 $\pm$ 0.091	8.56 $\pm$ 0.061	8.49 $\pm$ 0.042

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 45. Effect of different parts of *Centela asiatica*. water extract under different schedules of feeding on the cocoon weight of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(gm)		
		Leaf	Stem	Root
FS-1	Control	1.13 $\pm$ 0.015	1.13 $\pm$ 0.015	1.13 $\pm$ 0.015
	100	1.18 $\pm$ 0.017	1.18 $\pm$ 0.013	1.19 $\pm$ 0.007
	500	1.25 $\pm$ 0.006	1.20 $\pm$ 0.016	1.22 $\pm$ 0.009
	1000	1.23 $\pm$ 0.016	1.12 $\pm$ 0.011	1.18 $\pm$ 0.009
	1500	1.17 $\pm$ 0.014	1.17 $\pm$ 0.012	1.17 $\pm$ 0.015
FS-2	Control	1.15 $\pm$ 0.012	1.15 $\pm$ 0.012	1.15 $\pm$ 0.012
	100	1.19 $\pm$ 0.015	1.17 $\pm$ 0.015	1.18 $\pm$ 0.009
	500	1.25 $\pm$ 0.009	1.22 $\pm$ 0.007	1.21 $\pm$ 0.009
	1000	1.20 $\pm$ 0.019	1.19 $\pm$ 0.015	1.18 $\pm$ 0.007
	1500	1.20 $\pm$ 0.013	1.18 $\pm$ 0.006	1.17 $\pm$ 0.007
FS-3	Control	1.10 $\pm$ 0.014	1.10 $\pm$ 0.014	1.10 $\pm$ 0.014
	100	1.09 $\pm$ 0.012	1.18 $\pm$ 0.011	1.17 $\pm$ 0.007
	500	1.24 $\pm$ 0.006	1.21 $\pm$ 0.012	1.20 $\pm$ 0.006
	1000	1.17 $\pm$ 0.009	1.20 $\pm$ 0.006	1.16 $\pm$ 0.009
	1500	1.15 $\pm$ 0.006	1.19 $\pm$ 0.009	1.15 $\pm$ 0.006

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 46. Effect of different parts of *Centela asiatica*. water extract under different schedules of feeding on the shell weight of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(gm)		
		Leaf	Stem	Root
FS-1	Control	0.16 $\pm$ 0.008	0.16 $\pm$ 0.008	0.16 $\pm$ 0.008
	100	0.17 $\pm$ 0.006	0.18 $\pm$ 0.007	0.18 $\pm$ 0.006
	500	0.21 $\pm$ 0.003	0.19 $\pm$ 0.006	0.19 $\pm$ 0.003
	1000	0.16 $\pm$ 0.006	0.18 $\pm$ 0.008	0.17 $\pm$ 0.006
	1500	0.18 $\pm$ 0.006	0.17 $\pm$ 0.006	0.15 $\pm$ 0.007
FS-2	Control	0.17 $\pm$ 0.003	0.17 $\pm$ 0.003	0.17 $\pm$ 0.003
	100	0.18 $\pm$ 0.013	0.18 $\pm$ 0.006	0.18 $\pm$ 0.006
	500	0.23 $\pm$ 0.004	0.20 $\pm$ 0.006	0.19 $\pm$ 0.005
	1000	0.21 $\pm$ 0.009	0.19 $\pm$ 0.009	0.18 $\pm$ 0.003
	1500	0.19 $\pm$ 0.006	0.18 $\pm$ 0.003	0.18 $\pm$ 0.004
FS-3	Control	0.11 $\pm$ 0.003	0.11 $\pm$ 0.003	0.11 $\pm$ 0.003
	100	0.17 $\pm$ 0.009	0.17 $\pm$ 0.006	0.16 $\pm$ 0.005
	500	0.22 $\pm$ 0.003	0.20 $\pm$ 0.003	0.18 $\pm$ 0.002
	1000	0.21 $\pm$ 0.006	0.21 $\pm$ 0.003	0.17 $\pm$ 0.006
	1500	0.19 $\pm$ 0.003	0.19 $\pm$ 0.003	0.17 $\pm$ 0.003

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 47. Effect of different parts of *Centela asiatica* water extract under different schedules of feeding on the total number of eggs laid of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE		
		Leaf	Stem	Root
FS-1	Control	400.33 $\pm$ 1.14	400.33 $\pm$ 1.14	400.33 $\pm$ 1.14
	100	405.33 $\pm$ 1.20	404.00 $\pm$ 0.58	403.67 $\pm$ 0.43
	500	408.67 $\pm$ 0.88	407.00 $\pm$ 1.15	406.33 $\pm$ 1.20
	1000	407.00 $\pm$ 1.18	406.33 $\pm$ 0.35	405.67 $\pm$ 0.67
	1500	406.33 $\pm$ 0.87	405.33 $\pm$ 0.42	404.33 $\pm$ 0.88
FS-2	Control	402.00 $\pm$ 1.11	402.00 $\pm$ 1.11	402.00 $\pm$ 1.11
	100	406.00 $\pm$ 0.59	404.67 $\pm$ 0.82	403.33 $\pm$ 1.20
	500	410.33 $\pm$ 0.53	409.67 $\pm$ 0.78	408.67 $\pm$ 0.97
	1000	409.67 $\pm$ 0.80	408.00 $\pm$ 0.68	407.00 $\pm$ 1.15
	1500	408.33 $\pm$ 0.75	407.00 $\pm$ 1.15	406.33 $\pm$ 1.04
FS-3	Control	401.67 $\pm$ 2.19	401.67 $\pm$ 2.19	401.67 $\pm$ 2.19
	100	406.00 $\pm$ 1.15	405.67 $\pm$ 0.881.12	404.00 $\pm$ 1.15
	500	409.33 $\pm$ 1.16	408.00 $\pm$ 1.13	407.33 $\pm$ 1.20
	1000	408.67 $\pm$ 0.98	407.00 $\pm$ 1.00	406.00 $\pm$ 0.95
	1500	407.33 $\pm$ 0.79	406.00 $\pm$ 1.12	405.00 $\pm$ 1.20

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 48. Effect of different parts of *Centela asiatica* water extract under different schedules of feeding on the egg hatching percentage of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(%)		
		Leaf	Stem	Root
FS-1	Control	82.00 $\pm$ 1.15	82.00 $\pm$ 1.15	82.00 $\pm$ 1.15
	100	87.00 $\pm$ 1.22	86.00 $\pm$ 0.99	85.00 $\pm$ 1.16
	500	90.67 $\pm$ 1.09	89.00 $\pm$ 0.88	88.00 $\pm$ 0.85
	1000	89.67 $\pm$ 1.41	88.00 $\pm$ 1.32	87.00 $\pm$ 1.15
	1500	88.00 $\pm$ 0.56	87.00 $\pm$ 0.88	86.00 $\pm$ 1.20
FS-2	Control	83.00 $\pm$ 0.58	83.00 $\pm$ 0.58	83.00 $\pm$ 0.58
	100	89.33 $\pm$ 1.18	88.00 $\pm$ 1.52	87.00 $\pm$ 1.20
	500	91.00 $\pm$ 1.25	97.00 $\pm$ 1.51	90.00 $\pm$ 1.77
	1000	90.00 $\pm$ 0.68	95.00 $\pm$ 0.59	81.00 $\pm$ 0.86
	1500	97.00 $\pm$ 1.25	89.00 $\pm$ 1.15	88.00 $\pm$ 1.33
FS-3	Control	82.00 $\pm$ 0.33	82.00 $\pm$ 0.33	82.00 $\pm$ 0.33
	100	85.00 $\pm$ 0.35	80.00 $\pm$ 0.51	86.00 $\pm$ 0.82
	500	92.00 $\pm$ 0.87	91.00 $\pm$ 0.80	89.00 $\pm$ 0.98
	1000	94.00 $\pm$ 0.66	79.00 $\pm$ 1.45	82.00 $\pm$ 1.31
	1500	89.00 $\pm$ 0.88	98.00 $\pm$ 0.87	96.00 $\pm$ 1.15

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table-49. Anova for different plant parts of *Centela asiatica* water extracts under different schedules of feeding on the WML of *B. mori* L.

Source	df	SS	MS	F
FS	2	0.046	0.023	39.15**
PP	2	0.006	0.003	5.03*
Error-1	4	0.002	0.001	
Dose	4	0.194	0.049	83.24**
Dose×PP	8	0.030	0.004	6.49**
Error-2	24	0.014	0.001	
Total	44	0.293		

WML=Weight of mature larva, PP= Plant parts, df=Degree of freedom, SS=Sum of squares, MS=Mean sum of square, F=Variance ratio

Table 50. Anova for different plant parts of *Centela asiatica* water extracts under different schedules of feeding on the LML of *B. mori* L.

Source	df	SS	MS	F
FS	2	276.51	138.26	129.98**
PP	2	167.65	83.82	78.81**
Error-1	4	4.25	1.06	
Dose	4	2032.62	508.15	222.07**
Dose×PP	8	2.66	0.33	0.15
Error-2	24	54.92	2.29	
Total	44	2538.62		

LML=Length of mature larva, PP= Plant parts, df=Degree of freedom, SS=Sum of squares, MS=Mean sum of square, F=Variance ratio

Table 51. Anova for different plant parts of *Centela asiatica* water extracts under different schedules of feeding on the BML of *B. mori* L.

Source	df	SS	MS	F
FS	2	249.07	124.54	129.89**
PP	2	137.09	68.54	71.49**
Error-1	4	3.83	0.96	
Dose	4	2549.81	637.45	311.68**
Dose×PP	8	12.39	1.55	0.76
Error-2	24	49.08	2.04	
Total	44	3001.29		

BML=Breadth of mature larva, PP= Plant parts, df=Degree of freedom, SS=Sum of squares, MS=Mean sum of square, F=Variance ratio

Table 52. Anova for different plant parts of *Centela asiatica* water extracts under different schedules of feeding on the pw of *B. mori* L.

Source	df	SS	MS	F
FS	2	0.012	0.006	0.47
PP	2	0.0034	0.002	0.13
Error-1	4	0.049	0.012	
Dose	4	0.0761	0.019	4.67*
Dose×PP	8	0.023	0.003	0.72
Error-2	24	0.097	0.004	
Total	44	0.262		

PW=Pupal weight, PP= Plant parts, df=Degree of freedom, SS=Sum of squares, MS=Mean sum of square, F=Variance ratio

Table 53. Anova for different plant parts of *Centela asiatica* water extracts under different schedules of feeding on the SP of *B. mori* L.

Source	df	SS	MS	F
FS	2	202.84	101.42	56.70**
PP	2	255.24	127.62	71.34**
Error-1	4	7.16	1.789	
Dose	4	2915.91	728.98	137.83**
Dose×PP	8	21.16	2.64	0.50
Error-2	24	126.93	5.29	
Total	44	3529.24		

SP= Surviving perentage, PP= Plant parts, df=Degree of freedom, SS=Sum of squares, MS=Mean sum of square, F=Variance ratio

Table 54. Anova for different plant parts of *Centela asiatica* water extracts under different schedules of feeding on the LD of *B. mori* L.

Source	df	SS	MS	F
FS	2	0.156	0.078	72.42**
PP	2	0.102	0.051	47.10**
Error-1	4	0.004	0.001	
Dose	4	0.632	0.158	82.92**
Dose×PP	8	0.013	0.002	0.87
Error-2	24	0.046	0.002	
Total	44	0.953		

LD= Larval duration, PP= Plant parts, df=Degree of freedom, SS=Sum of squares, MS=Mean sum of square, F=Variance ratio

Table 55. Anova for different plant parts of *Centela asiatica* water extracts under different schedules of feeding on the PD of *B. mori* L.

Source	df	SS	MS	F
FS	2	0.419	0.210	213.55**
PP	2	0.013	0.007	6.86**
Error-1	4	0.004	0.001	
Dose	4	0.989	0.247	421.92**
Dose×PP	8	0.011	0.001	2.40*
Error-2	24	0.014	0.001	
Total	44	1.451		

PD= Pupal duration, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 56. Anova for different plant parts of *Centela asiatica* water extracts under different schedules of feeding on the CW of *B. mori* L.

Source	df	SS	MS	F
FS	2	0.0443200	0.0222	2.0424
PP	2	0.00652	0.0033	0.3005
Error-1	4	0.04340	0.0109	
Dose	4	0.3754	0.0938	22.239**
Dose×PP	8	0.02228	0.0028	0.66
Error-2	24	0.101280	0.0042	
Total	44	0.5932		

CW=cocoon weight, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 57. Anova for different plant parts of *Centela asiatica* water extracts under different schedules of feeding on the SW of *B. mori* L.

Source	df	SS	MS	F
FS	2	0.018	0.009	7.55**
PP	2	0.015	0.007	6.2**
Error-1	4	0.005	0.001	
Dose	4	0.129	0.032	35.83**
Dose×PP	8	0.058	0.008	8.022**
Error-2	24	0.022	0.0009	
Total	44	0.247		

SW=Shell weight, PP= Plant parts, df=Degree of freedom, SS=Sum of squares, MS=Mean sum of square, F=Variance ratio

Table 58. Anova for different plant parts of *Centela asiatica* water extracts under different schedules of feeding on the TEL of *B. mori* L.

Source	df	SS	MS	F
FS	2	901.20	450.60	10.96**
PP	2	457.20	228.60	5.56**
Error-1	4	164.40	41.10	
Dose	4	3323.20	830.80	11.77**
Dose×PP	8	576.80	72.10	1.02
Error-2	24	1694.40	70.60	
Total	44	7117.20		

TEL=Total no. of egg laid, PP= Plant parts, df=Degree of freedom, SS=Sum of squares, MS=Mean sum of square, F=Variance ratio

Table 59. Anova for different plant parts of *Centela asiatica* water extracts under different schedules of feeding on the EHP of *B. mori* L.

Source	df	SS	MS	F
FS	2	174.978	87.489	167.53**
PP	2	193.644	96.822	185.40**
Error-1	4	2.089	0.522	
Dose	4	2410.311	602.578	229.80**
Dose×PP	8	42.356	5.294	2.02
Error-2	24	62.933	2.622	
Total	44	2886.311		

EHP= Egg hatching percentage, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 60. Effect of different parts of *Neolamarckia cadamba* water extract under different schedules of feeding on the weight of mature larvae of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(gm)		
		Leaf	Stem	Root
FS-1	Control	2.86 $\pm$ 0.011	2.86 $\pm$ 0.011	2.86 $\pm$ 0.011
	100	2.91 $\pm$ 0.009	2.92 $\pm$ 0.03	2.91 $\pm$ 0.01
	500	2.95 $\pm$ 0.008	2.95 $\pm$ 0.013	2.94 $\pm$ 0.05
	1000	2.94 $\pm$ 0.003	2.95 $\pm$ 0.007	2.93 $\pm$ 0.008
	1500	2.92 $\pm$ 0.0056	2.93 $\pm$ 0.08	2.92 $\pm$ 0.03
FS-2	Control	2.84 $\pm$ 0.005	2.84 $\pm$ 0.005	2.84 $\pm$ 0.005
	100	2.93 $\pm$ 0.007	2.94 $\pm$ 0.009	2.92 $\pm$ 0.04
	500	2.97 $\pm$ 0.005	2.98 $\pm$ 0.006	2.97 $\pm$ 0.06
	1000	2.97 $\pm$ 0.006	2.97 $\pm$ 0.01	2.95 $\pm$ 0.02
	1500	2.94 $\pm$ 0.002	2.95 $\pm$ 0.009	2.94 $\pm$ 0.004
FS-3	Control	2.87 $\pm$ 0.012	2.87 $\pm$ 0.012	2.87 $\pm$ 0.012
	100	2.92 $\pm$ 0.004	2.93 $\pm$ 0.01	2.92 $\pm$ 0.008
	500	2.96 $\pm$ 0.007	2.96 $\pm$ 0.008	2.95 $\pm$ 0.0013
	1000	2.95 $\pm$ 0.005	2.96 $\pm$ 0.007	2.94 $\pm$ 0.009
	1500	2.93 $\pm$ 0.001	2.94 $\pm$ 0.006	2.93 $\pm$ 0.06

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 61. Effect of different parts of *Neolamarckia cadamba* water extract under different schedules of feeding on the length of mature larvae of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(mm)		
		Leaf	Stem	Root
FS-1	Control	65.47 $\pm$ 0.34	65.47 $\pm$ 0.34	65.47 $\pm$ 0.34
	100	69.38 $\pm$ 0.75	70.41 $\pm$ 0.89	68.52 $\pm$ 0.79
	500	72.94 $\pm$ 0.84	73.38 $\pm$ 0.74	71.94 $\pm$ 0.59
	1000	71.85 $\pm$ 0.51	72.16 $\pm$ 0.39	70.84 $\pm$ 0.63
	1500	70.69 $\pm$ 0.12	71.44 $\pm$ 0.31	69.24 $\pm$ 0.32
FS-2	Control	67.63 $\pm$ 0.55	67.63 $\pm$ 0.55	67.63 $\pm$ 0.55
	100	71.88 $\pm$ 1.52	72.63 $\pm$ 0.73	70.28 $\pm$ 0.31
	500	73.35 $\pm$ 0.80	75.22 $\pm$ 0.79	73.50 $\pm$ 0.59
	1000	73.17 $\pm$ 0.49	74.50 $\pm$ 0.54	72.82 $\pm$ 0.45
	1500	72.19 $\pm$ 0.79	73.08 $\pm$ 1.05	71.56 $\pm$ 1.19
FS-3	Control	66.38 $\pm$ 0.39	66.38 $\pm$ 0.39	66.38 $\pm$ 0.39
	100	70.58 $\pm$ 0.87	71.17 $\pm$ 0.84	69.91 $\pm$ 0.57
	500	73.91 $\pm$ 0.56	74.70 $\pm$ 0.72	72.22 $\pm$ 0.66
	1000	72.69 $\pm$ 0.52	73.00 $\pm$ 0.81	71.35 $\pm$ 0.66
	1500	71.80 $\pm$ 0.68	72.41 $\pm$ 0.65	70.85 $\pm$ 0.67

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 62. Effect of different parts of *Neolamarckia cadamba* water extract under different schedules of feeding on the breadth of mature larvae of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(mm)		
		Leaf	Stem	Root
FS-1	Control	14.91 $\pm$ 0.19	14.91 $\pm$ 0.19	14.91 $\pm$ 0.19
	100	18.72 $\pm$ 0.52	19.35 $\pm$ 0.63	17.88 $\pm$ 0.58
	500	21.74 $\pm$ 0.59	22.42 $\pm$ 0.47	20.59 $\pm$ 0.89
	1000	20.59 $\pm$ 0.50	21.37 $\pm$ 0.45	19.05 $\pm$ 0.56
	1500	19.49 $\pm$ 1.17	20.16 $\pm$ 0.80	18.35 $\pm$ 0.33
FS-2	Control	16.33 $\pm$ 0.36	16.33 $\pm$ 0.36	16.33 $\pm$ 0.36
	100	20.30 $\pm$ 0.76	21.09 $\pm$ 0.73	19.21 $\pm$ 0.62
	500	23.49 $\pm$ 0.55	24.19 $\pm$ 0.44	22.25 $\pm$ 0.90
	1000	22.72 $\pm$ 0.51	23.44 $\pm$ 0.53	21.77 $\pm$ 1.70
	1500	21.25 $\pm$ 0.70	22.06 $\pm$ 0.43	20.52 $\pm$ 0.59
FS-3	Control	15.16 $\pm$ 0.12	15.16 $\pm$ 0.12	15.16 $\pm$ 0.12
	100	19.35 $\pm$ 0.42	20.04 $\pm$ 1.27	18.79 $\pm$ 0.57
	500	22.70 $\pm$ 0.62	23.75 $\pm$ 0.60	21.94 $\pm$ 1.15
	1000	21.27 $\pm$ 0.81	22.45 $\pm$ 0.24	20.33 $\pm$ 0.95
	1500	20.20 $\pm$ 0.32	21.39 $\pm$ 0.86	19.63 $\pm$ 0.41

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 63. Effect of different parts of *Neolamarekia cadamba* water extract under different schedules of feeding on the larval pupal weight of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(gm)					
		Leaf		Stem		Root	
FS-1	Control	0.98	0.001	0.98	0.001	0.98	0.001
	100	1.00	0.002	1.02	0.003	1.00	0.011
	500	1.01	0.010	1.03	0.005	1.01	0.002
	1000	0.99	0.003	1.03	0.003	1.00	0.006
	1500	1.00	0.004	1.02	0.006	1.00	0.002
FS-2	Control	1.00	0.001	1.00	0.001	1.00	0.001
	100	1.02	0.001	1.02	0.005	1.01	0.009
	500	1.03	0.009	1.04	0.002	1.02	0.003
	1000	1.01	0.004	1.04	0.001	0.99	0.001
	1500	1.00	0.004	1.03	0.001	0.98	0.003
FS-3	Control	0.99	0.001	0.99	0.001	0.99	0.001
	100	1.03	0.004	1.18	0.002	0.99	0.004
	500	1.05	0.011	1.05	0.002	1.02	0.005
	1000	1.05	0.002	1.05	0.003	0.99	0.003
	1500	1.05	0.002	1.04	0.008	1.01	0.044

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 64. Effect of different parts of *Neolamarckia cadamba* water extract under different schedules of feeding on the surviving percentage of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(%)		
		Leaf	Stem	Root
FS-1	Control	54.33 $\pm$ 1.76	54.33 $\pm$ 1.76	54.33 $\pm$ 1.76
	100	56.00 $\pm$ 1.15	56.33 $\pm$ 0.33	57.67 $\pm$ 0.33
	500	59.00 $\pm$ 1.15	59.67 $\pm$ 0.33	60.33 $\pm$ 0.88
	1000	58.33 $\pm$ 0.33	58.00 $\pm$ 0.58	59.00 $\pm$ 0.58
	1500	57.33 $\pm$ 0.33	57.00 $\pm$ 0.58	58.00 $\pm$ 0.58
FS-2	Control	56.33 $\pm$ 1.20	56.33 $\pm$ 1.20	56.33 $\pm$ 1.20
	100	58.00 $\pm$ 0.58	58.00 $\pm$ 0.58	57.00 $\pm$ 1.15
	500	61.67 $\pm$ 0.88	62.00 $\pm$ 0.58	60.67 $\pm$ 0.88
	1000	60.33 $\pm$ 0.88	61.00 $\pm$ 0.58	59.33 $\pm$ 0.88
	1500	59.33 $\pm$ 0.88	59.00 $\pm$ 0.58	57.67 $\pm$ 0.33
FS-3	Control	55.67 $\pm$ 1.86	55.67 $\pm$ 1.86	55.67 $\pm$ 1.86
	100	57.00 $\pm$ 1.15	56.67 $\pm$ 0.88	56.33 $\pm$ 0.67
	500	60.33 $\pm$ 0.88	59.00 $\pm$ 0.58	60.33 $\pm$ 0.88
	1000	59.67 $\pm$ 0.88	58.00 $\pm$ 0.58	58.33 $\pm$ 0.33
	1500	58.33 $\pm$ 0.88	57.67 $\pm$ 1.67	57.33 $\pm$ 0.88

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 65. Effect of different parts of *Neolamarckia cadamba* water extract under different schedules of feeding on the larval duration of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(d)		
		Leaf	Stem	Root
FS-1	Control	21.85 $\pm$ 0.033	21.85 $\pm$ 0.033	21.85 $\pm$ 0.033
	100	21.95 $\pm$ 0.490	22.00 $\pm$ 0.497	21.92 $\pm$ 0.486
	500	22.20 $\pm$ 0.044	22.08 $\pm$ 0.069	21.99 $\pm$ 0.046
	1000	22.05 $\pm$ 0.078	22.25 $\pm$ 0.048	22.17 $\pm$ 0.040
	1500	22.13 $\pm$ 0.028	22.15 $\pm$ 0.032	22.12 $\pm$ 0.027
FS-2	Control	22.03 $\pm$ 0.241	22.03 $\pm$ 0.241	22.03 $\pm$ 0.241
	100	22.12 $\pm$ 0.090	22.15 $\pm$ 0.083	22.10 $\pm$ 0.096
	500	22.18 $\pm$ 0.043	22.24 $\pm$ 0.038	22.22 $\pm$ 0.032
	1000	22.31 $\pm$ 0.043	22.39 $\pm$ 0.043	22.34 $\pm$ 0.059
	1500	22.25 $\pm$ 0.182	22.32 $\pm$ 0.170	22.29 $\pm$ 0.175
FS-3	Control	22.10 $\pm$ 0.069	22.10 $\pm$ 0.069	22.10 $\pm$ 0.069
	100	22.05 $\pm$ 0.061	22.12 $\pm$ 0.041	22.10 $\pm$ 0.043
	500	22.16 $\pm$ 0.409	22.21 $\pm$ 0.419	22.18 $\pm$ 0.429
	1000	22.37 $\pm$ 0.056	22.38 $\pm$ 0.059	22.30 $\pm$ 0.060
	1500	22.28 $\pm$ 0.110	22.25 $\pm$ 0.100	22.23 $\pm$ 0.094

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 66. Effect of different parts of *Neolamarckia cadamba* water extract under different schedules of feeding on the pupal duration of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(d)		
		Leaf	Stem	Root
FS-1	Control	7.750 $\pm$ 0.287	7.750 $\pm$ 0.287	2.583 $\pm$ 0.287
	100	7.860 $\pm$ 0.285	7.950 $\pm$ 0.255	7.910 $\pm$ 0.248
	500	7.920 $\pm$ 0.305	8.060 $\pm$ 0.258	8.030 $\pm$ 0.253
	1000	8.120 $\pm$ 0.233	8.290 $\pm$ 0.177	8.270 $\pm$ 0.173
	1500	8.020 $\pm$ 0.242	8.150 $\pm$ 0.198	8.120 $\pm$ 0.193
FS-2	Control	7.990 $\pm$ 0.182	7.990 $\pm$ 0.182	2.663 $\pm$ 0.182
	100	8.050 $\pm$ 0.237	8.080 $\pm$ 0.227	8.100 $\pm$ 0.220
	500	8.140 $\pm$ 0.247	8.140 $\pm$ 0.247	8.190 $\pm$ 0.230
	1000	8.380 $\pm$ 0.167	8.390 $\pm$ 0.168	8.340 $\pm$ 0.168
	1500	8.210 $\pm$ 0.208	8.240 $\pm$ 0.198	8.240 $\pm$ 0.198
FS-3	Control	7.910 $\pm$ 0.228	7.910 $\pm$ 0.228	2.637 $\pm$ 0.228
	100	7.990 $\pm$ 0.257	8.030 $\pm$ 0.243	7.750 $\pm$ 0.238
	500	8.100 $\pm$ 0.260	8.150 $\pm$ 0.269	8.110 $\pm$ 0.263
	1000	8.320 $\pm$ 0.172	8.330 $\pm$ 0.173	8.300 $\pm$ 0.173
	1500	8.220 $\pm$ 0.185	8.220 $\pm$ 0.185	8.180 $\pm$ 0.198

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 67. Effect of different parts of *Neolamarckia cadamba* water extract under different schedules of feeding on the larval cocoon weight of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(gm)		
		Leaf	Stem	Root
FS-1	Control	1.13 $\pm$ 0.014	1.13 $\pm$ 0.014	1.13 $\pm$ 0.014
	100	1.17 $\pm$ 0.017	1.18 $\pm$ 0.015	1.16 $\pm$ 0.017
	500	1.20 $\pm$ 0.012	1.21 $\pm$ 0.018	1.19 $\pm$ 0.008
	1000	1.15 $\pm$ 0.011	1.20 $\pm$ 0.014	1.17 $\pm$ 0.012
	1500	1.18 $\pm$ 0.008	1.19 $\pm$ 0.013	1.16 $\pm$ 0.007
FS-2	Control	1.15 $\pm$ 0.016	1.15 $\pm$ 0.016	1.15 $\pm$ 0.016
	100	1.18 $\pm$ 0.011	1.18 $\pm$ 0.015	1.17 $\pm$ 0.012
	500	1.21 $\pm$ 0.015	1.23 $\pm$ 0.016	1.21 $\pm$ 0.009
	1000	1.18 $\pm$ 0.013	1.22 $\pm$ 0.011	1.18 $\pm$ 0.007
	1500	1.17 $\pm$ 0.007	1.21 $\pm$ 0.014	1.16 $\pm$ 0.009
FS-3	Control	1.11 $\pm$ 0.017	1.11 $\pm$ 0.017	1.11 $\pm$ 0.017
	100	1.18 $\pm$ 0.009	1.19 $\pm$ 0.013	1.17 $\pm$ 0.010
	500	1.21 $\pm$ 0.014	1.22 $\pm$ 0.017	1.20 $\pm$ 0.009
	1000	1.20 $\pm$ 0.018	1.21 $\pm$ 0.012	1.15 $\pm$ 0.006
	1500	1.19 $\pm$ 0.011	1.20 $\pm$ 0.014	1.18 $\pm$ 0.050

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 68. Effect of different parts of *Neolamarckia cadamba* water extract under different schedules of feeding on the larval shell weight of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(gm)		
		Leaf	Stem	Root
FS-1	Control	0.15 $\pm$ 0.013	0.15 $\pm$ 0.013	0.15 $\pm$ 0.013
	100	0.17 $\pm$ 0.015	0.16 $\pm$ 0.012	0.16 $\pm$ 0.006
	500	0.19 $\pm$ 0.002	0.18 $\pm$ 0.013	0.18 $\pm$ 0.006
	1000	0.16 $\pm$ 0.008	0.17 $\pm$ 0.011	0.17 $\pm$ 0.006
	1500	0.18 $\pm$ 0.004	0.17 $\pm$ 0.007	0.16 $\pm$ 0.005
FS-2	Control	0.15 $\pm$ 0.015	0.15 $\pm$ 0.015	0.15 $\pm$ 0.015
	100	0.16 $\pm$ 0.010	0.16 $\pm$ 0.010	0.16 $\pm$ 0.003
	500	0.18 $\pm$ 0.006	0.19 $\pm$ 0.014	0.19 $\pm$ 0.006
	1000	0.17 $\pm$ 0.009	0.18 $\pm$ 0.010	0.19 $\pm$ 0.006
	1500	0.17 $\pm$ 0.003	0.18 $\pm$ 0.013	0.18 $\pm$ 0.006
FS-3	Control	0.12 $\pm$ 0.016	0.12 $\pm$ 0.016	0.12 $\pm$ 0.016
	100	0.15 $\pm$ 0.005	0.01 $\pm$ 0.011	0.18 $\pm$ 0.006
	500	0.16 $\pm$ 0.003	0.17 $\pm$ 0.015	0.19 $\pm$ 0.003
	1000	0.15 $\pm$ 0.016	0.16 $\pm$ 0.009	0.16 $\pm$ 0.003
	1500	0.14 $\pm$ 0.009	0.16 $\pm$ 0.006	0.17 $\pm$ 0.006

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 69. Effect of different parts of *Neolamarckia cadamba* water extract under different schedules of feeding on the total number of eggs laid of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE		
		Leaf	Stem	Root
FS-1	Control	401.00 $\pm$ 3.79	401.00 $\pm$ 3.79	401.00 $\pm$ 3.79
	100	403.33 $\pm$ 1.20	406.67 $\pm$ 0.67	402.67 $\pm$ 2.33
	500	409.67 $\pm$ 0.33	409.00 $\pm$ 1.53	407.33 $\pm$ 0.88
	1000	407.00 $\pm$ 1.15	408.00 $\pm$ 0.58	406.00 $\pm$ 1.15
	1500	405.33 $\pm$ 0.33	407.33 $\pm$ 1.86	405.00 $\pm$ 3.06
FS-2	Control	409.67 $\pm$ 3.93	409.67 $\pm$ 3.93	409.67 $\pm$ 3.93
	100	407.33 $\pm$ 0.88	408.00 $\pm$ 1.53	406.00 $\pm$ 1.53
	500	414.00 $\pm$ 1.00	411.00 $\pm$ 0.58	409.33 $\pm$ 1.45
	1000	409.33 $\pm$ 0.88	410.33 $\pm$ 1.45	408.33 $\pm$ 0.67
	1500	410.00 $\pm$ 0.58	409.33 $\pm$ 1.20	407.67 $\pm$ 0.33
FS-3	Control	403.33 $\pm$ 1.20	403.33 $\pm$ 1.20	403.33 $\pm$ 1.20
	100	406.33 $\pm$ 0.88	407.67 $\pm$ 0.88	404.00 $\pm$ 3.61
	500	409.00 $\pm$ 1.15	410.33 $\pm$ 0.33	408.33 $\pm$ 1.33
	1000	408.00 $\pm$ 2.65	409.67 $\pm$ 0.88	407.33 $\pm$ 2.60
	1500	407.67 $\pm$ 1.67	408.67 $\pm$ 0.88	406.67 $\pm$ 3.93

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 70. Effect of different parts of *Neolamarckia cadamba* water extract under different schedules of feeding on the larval egg hatching percentage of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(%)		
		Leaf	Stem	Root
FS-1	Control	83.00 $\pm$ 0.58	83.00 $\pm$ 0.58	83.00 $\pm$ 0.58
	100	87.67 $\pm$ 0.33	88.00 $\pm$ 0.58	86.00 $\pm$ 0.58
	500	90.33 $\pm$ 0.88	91.33 $\pm$ 0.88	89.00 $\pm$ 1.53
	1000	89.00 $\pm$ 0.58	90.33 $\pm$ 0.88	88.67 $\pm$ 1.86
	1500	88.00 $\pm$ 1.53	89.33 $\pm$ 0.88	87.00 $\pm$ 0.58
FS-2	Control	84.00 $\pm$ 0.58	84.00 $\pm$ 0.58	84.00 $\pm$ 0.58
	100	89.33 $\pm$ 0.88	90.00 $\pm$ 0.58	88.00 $\pm$ 0.58
	500	92.33 $\pm$ 0.88	93.00 $\pm$ 0.58	91.67 $\pm$ 1.20
	1000	91.33 $\pm$ 0.88	92.00 $\pm$ 0.58	90.33 $\pm$ 0.88
	1500	90.33 $\pm$ 0.88	91.00 $\pm$ 1.15	89.00 $\pm$ 1.53
FS-3	Control	83.67 $\pm$ 0.33	83.67 $\pm$ 0.33	83.67 $\pm$ 0.33
	100	88.67 $\pm$ 0.88	89.33 $\pm$ 1.45	87.00 $\pm$ 1.15
	500	91.00 $\pm$ 1.53	92.00 $\pm$ 0.58	90.00 $\pm$ 1.53
	1000	90.00 $\pm$ 0.58	91.67 $\pm$ 0.88	89.33 $\pm$ 1.45
	1500	89.33 $\pm$ 0.88	90.67 $\pm$ 1.86	89.33 $\pm$ 0.88

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 71. ANOVA for different plant parts of *Neolamarckia cadamba* water extracts under different schedules of feeding on the WML of *B. mori* L.

Source	df	SS	MS	F
FS	2	0.009	0.005	263.06**
PP	2	0.007	0.004	203.41**
Error-1	4	0.00008	1.889	
Dose	4	0.538	0.134	737.57**
Dose×PP	8	0.023	0.002	15.93**
Error-2	24	0.004	0.0002	
Total	44	0.582		

WML= Weight of mature larva, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 72. ANOVA for different plant parts of *Neolamarckia cadamba* water extracts under different schedules of feeding on the LML of *B. mori* L.

Source	df	SS	MS	F
FS	2	233.0998933	116.5499467	111.50**
PP	2	133.5214533	66.76072667	63.87**
Error-1	4	4.18097	1.045243333	
Dose	4	2347.087844	586.7719611	279.15**
Dose×PP	8	11.18566222	1.398207778	0.66
Error-2	24	50.447373	2.101973889	
Total	44	2779.5232		

LML=Length of mature larvae, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 73. ANOVA for different plant parts of *Neolamarckia cadamba* water extracts under different schedules of feeding on the breadth of mature larvae of *B. mori* L.

Source	df	SS	MS	F
FS	2	216.44	108.22	247.07**
PP	2	137.91	68.95	157.42**
Error-1	4	1.75	0.438	
Dose	4	2393.78	598.44	363.16**
Dose×PP	8	13.014	1.62	0.9872
Error-2	24	39.54	1.64	
Total	44	2802.46		

PP= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 74. ANOVA for different plant parts of *Neolamarckia cadamba* water extracts under different schedules of feeding on the PW of *B. mori* L.

Source	df	SS	MS	F
FS	2	0.00007	0.00004	0.08
PP	2	0.00486	0.00243	5.18*
Error-1	4	0.00188	0.00047	
Dose	4	0.00137	0.00034	2.37
Dose×PP	8	0.00368	0.00046	3.19
Error-2	24	0.00347	0.00014	
Total	44	0.01532		

PW= Pupal weight, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 75. ANOVA for different plant parts of *Neolamarckia cadamba* water extracts under different schedules of feeding on the surviving percentage of *B. mori* L.

Source	df	SS	MS	F
FS	2	174.71	87.35	5.55
PP	2	4.04	2.02	0.13
Error-1	4	62.89	15.72	
Dose	4	1150.75	287.68	186.27**
Dose×PP	8	22.18	2.77	1.79
Error-2	24	37.07	1.54	
Total	44	1451.64444		

PP= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 76. ANOVA for different plant parts of *Neolamarckia cadamba* water extracts under different schedules of feeding on the LD of *B. mori* L.

Source	df	SS	MS	F
FS	2	0.26	0.128	167.27**
PP	2	0.02	0.0064	8.448**
Error-1	4	0.003	0.0008	
Dose	4	0.55	0.138	256.72**
Dose×PP	8	0.019	0.002	4.6165**
Error-2	24	0.012	0.0005	
Total	44	0.86		

LD=Larval duration, **d**=day, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 77. ANOVA for different plant parts of *Neolamarckia cadamba* water extracts under different schedules of feeding on the PW of *B. mori* L.

Source	df	SS	MS	F
FS	2	0.221	0.111	26.07**
PP	2	0.017	0.008	1.99
Error-1	4	0.017	0.004	
Dose	4	0.946	0.237	347.53**
Dose×PP	8	0.012	0.002	2.26
Error-2	24	0.016	0.001	
Total	44	1.230		

PW=Pupal weight, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 78. ANOVA for different plant parts of *Neolamarckia cadamba* water extracts under different schedules of feeding on the CW of *B. mori* L.

Source	df	SS	MS	F
FS	2	0.017	0.009	10.90*
PP	2	0.019	0.010	12.10**
Error-1	4	0.003	0.001	
Dose	4	0.286	0.072	94.14**
Dose×PP	8	0.021	0.003	3.51*
Error-2	24	0.018	0.001	
Total	44	0.366		

CW= Cocoon weight, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 79. ANOVA for different plant parts of *Neolamarckia cadamba* water extracts under different schedules of feeding on the SW of *B. mori* L.

Source	df	SS	MS	F
FS	2	0.059	0.029	4.07
PP	2	0.013	0.007	0.92
Error-1	4	0.029	0.007	
Dose	4	0.098	0.024	4.17*
Dose×PP	8	0.021	0.003	0.45
Error-2	24	0.141	0.006	
Total	44	0.361		

SW = Shell weight, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 80. ANOVA for different plant parts of *Neolamarckia cadamba* water extracts under different schedules of feeding on the TEL of *B. mori* L.

Source	df	SS	MS	F
FS	2	1203.73	601.87	31.46**
PP	2	249.73	124.87	6.53**
Error-1	4	76.53	19.13	
Dose	4	1385.42	346.36	45.24**
Dose×PP	8	408.04	51.01	6.66**
Error-2	24	183.73	7.66	
Total	44	3507.20		

TEL= Total number of egg laid, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 81. ANOVA for different plant parts of *Neolamarckia cadamba* water extracts under different schedules of feeding on the EHP of *B. mori* L.

Source	df	SS	MS	F
FS	2	215.51	107.75	193.96**
PP	2	163.38	81.69	147.04**
Error-1	4	2.22	0.55	
Dose	4	2888	722	303.64**
Dose×PP	8	18.93	2.37	0.99
Error-2	24	57.06	2.38	
Total	44	3345.11		

EHP= Egg hatching percentage, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 82. Effect of different parts of *Solanum tuberosum* water extract under different schedules of feeding on the weight of mature larvae of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(gm)		
		Leaf	Stem	Root
FS-1	Control	2.78 $\pm$ 0.01202	2.78 $\pm$ 0.01202	2.78 $\pm$ 0.01202
	100	2.78 $\pm$ 0.00577	2.81 $\pm$ 0.00333	2.80 $\pm$ 0.00882
	500	2.81 $\pm$ 0.00882	2.84 $\pm$ 0.00333	2.83 $\pm$ 0.00882
	1000	2.80 $\pm$ 0.00333	2.83 $\pm$ 0.01453	2.82 $\pm$ 0.00882
	1500	2.79 $\pm$ 0.00333	2.82 $\pm$ 0.00577	2.81 $\pm$ 0.00882
FS-2	Control	2.80 $\pm$ 0.00882	2.80 $\pm$ 0.00882	2.80 $\pm$ 0.00882
	100	2.80 $\pm$ 0.00882	2.83 $\pm$ 0.00333	2.82 $\pm$ 0.00882
	500	2.83 $\pm$ 0.00882	2.86 $\pm$ 0.00882	2.85 $\pm$ 0.00577
	1000	2.82 $\pm$ 0.00667	2.85 $\pm$ 0.00577	2.84 $\pm$ 0.01202
	1500	2.81 $\pm$ 0.00577	2.84 $\pm$ 0.00333	2.83 $\pm$ 0.00577
FS-3	Control	2.78 $\pm$ 0.00882	2.78 $\pm$ 0.00882	2.78 $\pm$ 0.00882
	100	2.80 $\pm$ 0.01155	2.82 $\pm$ 0.01202	2.81 $\pm$ 0.00577
	500	2.82 $\pm$ 0.00577	2.85 $\pm$ 0.00667	2.84 $\pm$ 0.00667
	1000	2.81 $\pm$ 0.00667	2.84 $\pm$ 0.01202	2.83 $\pm$ 0.00882
	1500	2.81 $\pm$ 0.00577	2.83 $\pm$ 0.00882	2.82 $\pm$ 0.01528

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 83. Effect of different parts of *Solanum tuberosum* water extract under different schedules of feeding on the length of mature larvae of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(mm)		
		Leaf	Stem	Root
FS-1	Control	73.60 $\pm$ 0.47	73.60 $\pm$ 0.47	73.60 $\pm$ 0.47
	100	75.69 $\pm$ 0.60	77.54 $\pm$ 0.30	76.52 $\pm$ 0.36
	500	78.60 $\pm$ 0.63	80.29 $\pm$ 0.66	79.55 $\pm$ 0.34
	1000	77.55 $\pm$ 0.67	79.74 $\pm$ 0.43	78.74 $\pm$ 0.79
	1500	76.35 $\pm$ 1.40	78.17 $\pm$ 0.50	77.64 $\pm$ 0.57
FS-2	Control	74.78 $\pm$ 0.27	74.78 $\pm$ 0.27	74.78 $\pm$ 0.27
	100	76.12 $\pm$ 0.65	79.11 $\pm$ 0.24	78.20 $\pm$ 0.60
	500	80.17 $\pm$ 0.81	82.17 $\pm$ 0.92	81.53 $\pm$ 0.45
	1000	79.52 $\pm$ 0.33	81.41 $\pm$ 0.95	80.00 $\pm$ 0.16
	1500	78.59 $\pm$ 0.58	80.37 $\pm$ 0.59	79.17 $\pm$ 0.42
FS-3	Control	73.85 $\pm$ 1.02	73.85 $\pm$ 1.02	73.85 $\pm$ 1.02
	100	76.13 $\pm$ 0.56	78.32 $\pm$ 0.64	77.11 $\pm$ 0.37
	500	79.30 $\pm$ 0.78	81.45 $\pm$ 0.77	80.35 $\pm$ 0.45
	1000	78.93 $\pm$ 0.54	80.40 $\pm$ 1.07	79.02 $\pm$ 0.21
	1500	77.34 $\pm$ 1.09	79.45 $\pm$ 0.46	78.27 $\pm$ 0.45

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 84. Effect of different parts of *Solanum tuberosum* water extract under different schedules of feeding on the breadth of mature larvae of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE		
		Leaf	Stem	Root
FS-1	Control	17.70 $\pm$ 0.26	17.70 $\pm$ 0.26	17.70 $\pm$ 0.26
	100	20.93 $\pm$ 0.59	21.34 $\pm$ 0.63	21.34 $\pm$ 0.63
	500	23.62 $\pm$ 0.88	24.21 $\pm$ 0.91	24.21 $\pm$ 0.91
	1000	22.28 $\pm$ 0.85	23.63 $\pm$ 0.45	23.63 $\pm$ 0.45
	1500	21.28 $\pm$ 0.32	22.07 $\pm$ 0.32	22.07 $\pm$ 0.32
FS-2	Control	18.55 $\pm$ 0.43	18.55 $\pm$ 0.43	18.55 $\pm$ 0.43
	100	22.55 $\pm$ 0.30	23.60 $\pm$ 0.51	23.60 $\pm$ 0.51
	500	25.27 $\pm$ 0.35	26.08 $\pm$ 0.54	26.08 $\pm$ 0.54
	1000	24.91 $\pm$ 0.40	25.48 $\pm$ 0.52	25.48 $\pm$ 0.52
	1500	23.16 $\pm$ 1.18	24.48 $\pm$ 0.50	24.48 $\pm$ 0.50
FS-3	Control	16.12 $\pm$ 0.30	16.12 $\pm$ 0.30	16.12 $\pm$ 0.30
	100	21.63 $\pm$ 0.87	22.21 $\pm$ 0.94	22.21 $\pm$ 0.94
	500	24.87 $\pm$ 1.49	25.73 $\pm$ 0.45	25.73 $\pm$ 0.45
	1000	23.28 $\pm$ 0.89	24.05 $\pm$ 0.94	24.05 $\pm$ 0.94
	1500	22.93 $\pm$ 1.52	23.11 $\pm$ 1.25	23.11 $\pm$ 1.25

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 85. Effect of different parts of *Solanum tuberosum* water extract under different schedules of feeding on the Pupal weight of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(gm)		
		Leaf	Stem	Root
FS-1	Control	1.07 $\pm$ 0.001	1.07 $\pm$ 0.001	1.07 $\pm$ 0.001
	100	1.08 $\pm$ 0.006	1.13 $\pm$ 0.003	1.08 $\pm$ 0.007
	500	1.10 $\pm$ 0.010	1.14 $\pm$ 0.010	1.11 $\pm$ 0.002
	1000	1.09 $\pm$ 0.002	1.10 $\pm$ 0.010	1.10 $\pm$ 0.001
	1500	1.09 $\pm$ 0.004	1.08 $\pm$ 0.003	1.09 $\pm$ 0.007
FS-2	Control	1.10 $\pm$ 0.004	1.10 $\pm$ 0.004	1.10 $\pm$ 0.004
	100	1.11 $\pm$ 0.001	1.13 $\pm$ 0.012	1.14 $\pm$ 0.003
	500	1.16 $\pm$ 0.006	1.15 $\pm$ 0.010	1.15 $\pm$ 0.002
	1000	1.15 $\pm$ 0.002	1.14 $\pm$ 0.007	1.14 $\pm$ 0.003
	1500	1.13 $\pm$ 0.002	1.12 $\pm$ 0.006	1.14 $\pm$ 0.002
FS-3	Control	1.05 $\pm$ 0.001	1.05 $\pm$ 0.001	1.05 $\pm$ 0.001
	100	1.06 $\pm$ 0.007	1.14 $\pm$ 0.012	1.13 $\pm$ 0.007
	500	1.07 $\pm$ 0.008	1.15 $\pm$ 0.008	1.14 $\pm$ 0.000
	1000	1.06 $\pm$ 0.002	1.14 $\pm$ 0.006	1.13 $\pm$ 0.009
	1500	1.04 $\pm$ 0.004	1.13 $\pm$ 0.009	1.13 $\pm$ 0.003

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 86. Effect of different parts of *Solanum tuberosum* water extract under different schedules of feeding on the larval Surviving percentage of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(%)		
		Leaf	Stem	Root
FS-1	Control	54.67 $\pm$ 0.33	54.67 $\pm$ 0.33	54.67 $\pm$ 0.33
	100	57.33 $\pm$ 0.88	60.33 $\pm$ 0.80	58.67 $\pm$ 0.81
	500	60.00 $\pm$ 0.58	63.00 $\pm$ 0.51	61.00 $\pm$ 0.57
	1000	59.33 $\pm$ 0.80	62.00 $\pm$ 1.25	60.67 $\pm$ 0.86
	1500	58.00 $\pm$ 1.52	61.33 $\pm$ 0.67	59.33 $\pm$ 0.38
FS-2	Control	55.67 $\pm$ 0.30	55.67 $\pm$ 0.30	55.67 $\pm$ 0.30
	100	59.33 $\pm$ 1.33	59.67 $\pm$ 0.36	60.33 $\pm$ 1.20
	500	62.33 $\pm$ 1.20	65.33 $\pm$ 0.83	63.33 $\pm$ 1.33
	1000	61.00 $\pm$ 1.00	64.00 $\pm$ 1.58	62.67 $\pm$ 1.67
	1500	60.00 $\pm$ 1.15	62.00 $\pm$ 1.15	61.00 $\pm$ 1.05
FS-3	Control	55.33 $\pm$ 1.32	55.33 $\pm$ 1.32	55.33 $\pm$ 1.32
	100	58.33 $\pm$ 1.21	61.67 $\pm$ 1.28	59.33 $\pm$ 1.35
	500	61.00 $\pm$ 0.55	64.00 $\pm$ 0.59	62.33 $\pm$ 1.30
	1000	60.33 $\pm$ 1.45	62.00 $\pm$ 0.57	61.00 $\pm$ 1.58
	1500	58.33 $\pm$ 1.24	62.33 $\pm$ 0.34	59.67 $\pm$ 1.80

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 87. Effect of different parts of *Solanum tuberosum* water extract under different schedules of feeding on the larval duration of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(d)		
		Leaf	Stem	Root
FS-1	Control	22.20 $\pm$ 0.085	22.20 $\pm$ 0.085	22.20 $\pm$ 0.085
	100	22.27 $\pm$ 0.084	22.36 $\pm$ 0.088	22.31 $\pm$ 0.105
	500	22.30 $\pm$ 0.097	22.40 $\pm$ 0.064	22.37 $\pm$ 0.058
	1000	22.46 $\pm$ 0.086	22.56 $\pm$ 0.065	22.50 $\pm$ 0.045
	1500	22.38 $\pm$ 0.046	22.48 $\pm$ 0.057	22.43 $\pm$ 0.029
FS-2	Control	22.31 $\pm$ 0.064	22.31 $\pm$ 0.064	22.31 $\pm$ 0.064
	100	22.39 $\pm$ 0.055	22.47 $\pm$ 0.035	22.38 $\pm$ 0.006
	500	22.43 $\pm$ 0.043	22.49 $\pm$ 0.033	22.46 $\pm$ 0.041
	1000	22.55 $\pm$ 0.143	22.64 $\pm$ 0.168	22.60 $\pm$ 0.168
	1500	22.48 $\pm$ 0.042	22.56 $\pm$ 0.015	22.51 $\pm$ 0.032
FS-3	Control	22.37 $\pm$ 0.135	22.37 $\pm$ 0.135	22.37 $\pm$ 0.135
	100	22.30 $\pm$ 0.068	22.39 $\pm$ 0.038	22.35 $\pm$ 0.038
	500	22.36 $\pm$ 0.034	22.46 $\pm$ 0.038	22.41 $\pm$ 0.035
	1000	22.52 $\pm$ 0.128	22.60 $\pm$ 0.102	22.55 $\pm$ 0.094
	1500	22.40 $\pm$ 0.042	22.51 $\pm$ 0.037	22.47 $\pm$ 0.031

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 88. Effect of different parts of *Solanum tuberosum* water extract under different schedules of feeding on the pupal duration of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(d)		
		Leaf	Stem	Root
FS-1	Control	8.18 $\pm$ 0.177	8.18 $\pm$ 0.177	8.18 $\pm$ 0.177
	100	8.17 $\pm$ 0.311	8.21 $\pm$ 0.324	8.15 $\pm$ 0.304
	500	8.30 $\pm$ 0.127	8.29 $\pm$ 0.127	8.26 $\pm$ 0.136
	1000	8.45 $\pm$ 0.447	8.43 $\pm$ 0.451	8.43 $\pm$ 0.451
	1500	8.37 $\pm$ 0.218	8.38 $\pm$ 0.222	8.50 $\pm$ 0.225
FS-2	Control	8.38 $\pm$ 0.111	8.38 $\pm$ 0.111	8.38 $\pm$ 0.111
	100	8.40 $\pm$ 0.186	8.48 $\pm$ 0.213	8.42 $\pm$ 0.225
	500	8.48 $\pm$ 0.298	8.56 $\pm$ 0.325	8.52 $\pm$ 0.332
	1000	8.55 $\pm$ 0.304	8.65 $\pm$ 0.337	8.59 $\pm$ 0.349
	1500	8.53 $\pm$ 0.433	8.59 $\pm$ 0.453	8.56 $\pm$ 0.443
FS-3	Control	8.32 $\pm$ 0.369	8.32 $\pm$ 0.369	8.32 $\pm$ 0.369
	100	8.30 $\pm$ 0.095	8.36 $\pm$ 0.075	8.35 $\pm$ 0.073
	500	8.38 $\pm$ 0.208	8.48 $\pm$ 0.242	8.42 $\pm$ 0.252
	1000	8.52 $\pm$ 0.226	8.62 $\pm$ 0.209	8.58 $\pm$ 0.215
	1500	8.48 $\pm$ 0.377	8.57 $\pm$ 0.358	8.50 $\pm$ 0.335

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 89. Effect of different parts of *Solanum tuberosum* water extract under different schedules of feeding on the cocoon weight of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(gm)		
		Leaf	Stem	Root
FS-1	Control	1.27 $\pm$ 0.010	1.27 $\pm$ 0.010	1.27 $\pm$ 0.010
	100	1.30 $\pm$ 0.012	1.33 $\pm$ 0.012	1.31 $\pm$ 0.012
	500	1.35 $\pm$ 0.015	1.37 $\pm$ 0.016	1.37 $\pm$ 0.012
	1000	1.31 $\pm$ 0.015	1.30 $\pm$ 0.015	1.35 $\pm$ 0.018
	1500	1.28 $\pm$ 0.010	1.30 $\pm$ 0.012	1.32 $\pm$ 0.012
FS-2	Control	1.29 $\pm$ 0.009	1.29 $\pm$ 0.009	1.29 $\pm$ 0.009
	100	1.33 $\pm$ 0.014	1.35 $\pm$ 0.021	1.35 $\pm$ 0.012
	500	1.37 $\pm$ 0.013	1.39 $\pm$ 0.019	1.38 $\pm$ 0.006
	1000	1.35 $\pm$ 0.011	1.37 $\pm$ 0.016	1.37 $\pm$ 0.009
	1500	1.34 $\pm$ 0.006	1.33 $\pm$ 0.012	1.36 $\pm$ 0.009
FS-3	Control	1.25 $\pm$ 0.010	1.25 $\pm$ 0.010	1.25 $\pm$ 0.010
	100	1.32 $\pm$ 0.011	1.35 $\pm$ 0.015	1.34 $\pm$ 0.019
	500	1.34 $\pm$ 0.014	1.39 $\pm$ 0.013	1.37 $\pm$ 0.010
	1000	1.31 $\pm$ 0.009	1.37 $\pm$ 0.012	1.36 $\pm$ 0.012
	1500	1.28 $\pm$ 0.015	1.36 $\pm$ 0.012	1.35 $\pm$ 0.012

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 90. Effect of different parts of *Solanum tuberosum* water extract under different schedules of feeding on the shell weight of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(gm)		
		Leaf	Stem	Root
FS-1	Control	0.20 $\pm$ 0.009	0.20 $\pm$ 0.009	0.20 $\pm$ 0.009
	100	0.22 $\pm$ 0.006	0.20 $\pm$ 0.009	0.23 $\pm$ 0.005
	500	0.25 $\pm$ 0.005	0.23 $\pm$ 0.006	0.26 $\pm$ 0.010
	1000	0.22 $\pm$ 0.013	0.20 $\pm$ 0.006	0.25 $\pm$ 0.017
	1500	0.19 $\pm$ 0.006	0.22 $\pm$ 0.009	0.23 $\pm$ 0.005
FS-2	Control	0.19 $\pm$ 0.005	0.19 $\pm$ 0.005	0.19 $\pm$ 0.005
	100	0.22 $\pm$ 0.013	0.22 $\pm$ 0.009	0.21 $\pm$ 0.009
	500	0.21 $\pm$ 0.007	0.24 $\pm$ 0.009	0.23 $\pm$ 0.003
	1000	0.20 $\pm$ 0.009	0.23 $\pm$ 0.009	0.23 $\pm$ 0.006
	1500	0.21 $\pm$ 0.003	0.21 $\pm$ 0.006	0.22 $\pm$ 0.007
FS-3	Control	0.20 $\pm$ 0.009	0.20 $\pm$ 0.009	0.20 $\pm$ 0.009
	100	0.26 $\pm$ 0.004	0.21 $\pm$ 0.003	0.21 $\pm$ 0.012
	500	0.27 $\pm$ 0.006	0.24 $\pm$ 0.006	0.23 $\pm$ 0.010
	1000	0.25 $\pm$ 0.007	0.23 $\pm$ 0.006	0.22 $\pm$ 0.003
	1500	0.24 $\pm$ 0.011	0.22 $\pm$ 0.003	0.21 $\pm$ 0.009

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 91. Effect of different parts of *Solanum tuberosum* water extract under different schedules of feeding on the total number of eggs laid of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE		
		Leaf	Stem	Root
FS-1	Control	447.11 $\pm$ 4.92	447.11 $\pm$ 4.92	447.11 $\pm$ 4.92
	100	450.67 $\pm$ 1.45	452.00 $\pm$ 1.15	451.33 $\pm$ 0.88
	500	453.33 $\pm$ 1.32	455.33 $\pm$ 0.88	454.33 $\pm$ 1.45
	1000	452.33 $\pm$ 1.48	454.67 $\pm$ 1.40	453.33 $\pm$ 0.84
	1500	451.33 $\pm$ 3.84	453.67 $\pm$ 0.85	452.33 $\pm$ 1.86
FS-2	Control	450.67 $\pm$ 10.35	450.67 $\pm$ 10.35	450.67 $\pm$ 10.35
	100	452.67 $\pm$ 3.48	451.67 $\pm$ 0.80	453.33 $\pm$ 1.20
	500	455.67 $\pm$ 0.33	457.67 $\pm$ 0.90	456.00 $\pm$ 1.16
	1000	454.67 $\pm$ 1.86	456.33 $\pm$ 0.41	455.00 $\pm$ 0.58
	1500	453.33 $\pm$ 2.60	455.33 $\pm$ 0.89	454.00 $\pm$ 0.50
FS-3	Control	444.33 $\pm$ 5.35	444.33 $\pm$ 5.35	444.33 $\pm$ 5.35
	100	451.67 $\pm$ 2.03	453.00 $\pm$ 1.00	452.33 $\pm$ 0.31
	500	455.00 $\pm$ 0.58	457.00 $\pm$ 1.19	456.33 $\pm$ 0.67
	1000	453.33 $\pm$ 0.88	455.00 $\pm$ 1.15	454.33 $\pm$ 0.80
	1500	452.00 $\pm$ 3.51	454.00 $\pm$ 0.56	453.00 $\pm$ 0.58

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 92. Effect of different parts of *Solanum tuberosum* water extract under different schedules of feeding on the egg hatching percentage of *B. mori* L.

FS	Dose (ppm)	Mean $\pm$ SE(%)		
		Leaf	Stem	Root
FS-1	Control	87.00 $\pm$ 0.58	87.00 $\pm$ 0.58	87.00 $\pm$ 0.58
	100	90.33 $\pm$ 0.80	92.33 $\pm$ 1.20	91.00 $\pm$ 1.16
	500	93.00 $\pm$ 0.59	95.67 $\pm$ 1.03	94.00 $\pm$ 1.18
	1000	92.67 $\pm$ 1.45	94.00 $\pm$ 1.15	93.00 $\pm$ 1.53
	1500	91.00 $\pm$ 0.52	93.00 $\pm$ 0.50	92.67 $\pm$ 0.30
FS-2	Control	88.00 $\pm$ 0.58	88.00 $\pm$ 0.58	88.00 $\pm$ 0.58
	100	89.67 $\pm$ 0.33	94.00 $\pm$ 0.54	93.00 $\pm$ 0.51
	500	95.00 $\pm$ 0.56	97.33 $\pm$ 0.67	96.00 $\pm$ 0.48
	1000	94.33 $\pm$ 0.81	96.00 $\pm$ 1.08	95.00 $\pm$ 0.69
	1500	93.00 $\pm$ 1.15	95.00 $\pm$ 1.17	93.33 $\pm$ 0.86
FS-3	Control	87.67 $\pm$ 0.33	87.67 $\pm$ 0.33	87.67 $\pm$ 0.33
	100	91.33 $\pm$ 1.01	93.33 $\pm$ 0.83	92.00 $\pm$ 0.17
	500	94.00 $\pm$ 1.14	96.00 $\pm$ 0.52	95.00 $\pm$ 0.60
	1000	93.00 $\pm$ 1.02	94.00 $\pm$ 0.51	94.33 $\pm$ 0.78
	1500	92.67 $\pm$ 0.84	94.33 $\pm$ 0.85	93.00 $\pm$ 0.53

FS-1=Fed only in 1st feeding of 3rd to 5th instar larvae.

FS-2=Fed everyday in 1st feeding of 3rd to 5th instar larvae.

FS-3=Fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Table 93. Anova for different plant parts of *Solanum tuberosum* water extracts under different schedules of feeding on the WML of *B. mori* L.

Source	df	SS	MS	F
FS	2	0.023	0.012	21.21**
PP	2	0.047	0.023	43.31**
Error-1	4	0.002	0.0005	
Dose	4	0.154	0.038	196.51**
Dose×PP	8	0.0018	0.0002	1.175
Error-2	24	0.0047	0.0002	
Total	44	0.234		

WML=Weight of mature larva, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 94. Anova for different plant parts of *Solanum tuberosum* water extracts under different schedules of feeding on the LML of *B. mori* L.

Source	df	SS	MS	F
FS	2	167.072	83.536	180.28**
PP	2	174.655	87.327	188.46**
Error-1	4	1.853	0.463	
Dose	4	1941.881	485.470	203.19**
Dose×PP	8	8.268	1.033	0.43
Error-2	24	57.342	2.389	
Total	44	2351.074		

LML=Length of mature larva, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 95. Anova for different plant parts of *Solanum tuberosum* water extracts under different schedules of feeding on the BML of *B. mori* L.

Source	df	SS	MS	F
FS	2	516.858	258.429	2.72
PP	2	136.022	68.0112	0.71
Error-1	4	379.873	94.9682	
Dose	4	2523.778	630.944	7.07**
Dose×PP	8	816.661	102.083	1.14
Error-2	24	2142.788	89.2828	
Total	44	6515.981		

BML=Breadth of mature larva, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 96. Anova for different plant parts of *Solanum tuberosum* of water extracts under different schedules of feeding on the PW of *B. mori* L.

Source	df	SS	MS	F
FS	2	0.071	0.036	0.10
PP	2	0.256	0.128	0.38
Error-1	4	1.358	0.339	
Dose	4	0.933	0.233	0.87
Dose×PP	8	1.973	0.247	0.92
Error-2	24	6.466	0.269	
Total	44	11.057		

PW=Pupal weight **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 97. Anova for different plant parts of *Solanum tuberosum* water extracts under different schedules of feeding on the SP of *B. mori* L.

Source	df	SS	MS	F
FS	2	158.71	79.35	28.79**
PP	2	315.51	157.75	57.25**
Error-1	4	11.02	2.755	
Dose	4	2523.022	630.756	121.3**
Dose×PP	8	28.178	3.522	0.677
Error-2	24	124.800	5.2	
Total	44	3161.244		

SP=Serving percentage, PP= Plant parts, df=Degree of freedom, SS=Sum of squares, MS=Mean sum of square, F=Variance ratio

Table 98. Anova for different plant parts of *Solanum tuberosum* water extracts under different schedules of feeding on the LD of *B. mori* L.

Source	df	SS	MS	F
FS	2	0.075	0.037	206.87**
PP	2	0.039	0.019	106.88**
Error-1	4	0.0007	0.00018	
Dose	4	0.362	0.0903	176.91**
Dose×PP	8	0.025	0.0031	6.025**
Error-2	24	0.0121	0.0005	
Total	44	0.513		

LD=Larval duration, PP= Plant parts, df=Degree of freedom, SS=Sum of squares, MS=Mean sum of square, F=Variance ratio

Table 99. Anova for different plant parts of *Solanum tuberosum*. of water extracts under different schedules of feeding on the PD of *B. mori* L.

Source	df	SS	MS	F
FS	2	0.345	0.173	92.66**
PP	2	0.017	0.008	4.504*
Error-1	4	0.007	0.0018	
Dose	4	0.389	0.0974	248.8**
Dose×PP	8	0.0101	0.0012	3.2326*
Error-2	24	0.009400	0.00039	
Total	44	0.779		

PD=Pupal duration **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 100. Anova for different plant parts of *Solanum tuberosum* water extracts under different schedules of feeding on the CW of *B. mori* L.

Source	df	SS	MS	F
FS	2	1.039	0.520	1.58
PP	2	1.037	0.519	1.58
Error-1	4	1.314	0.328	
Dose	4	1.636	0.409	1.20
Dose×PP	8	2.846	0.356	1.04
Error-2	24	8.215	0.342	
Total	44	16.089		

CW=Cocoon weight **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 101. Anova for different plant parts of *Solanum tuberosum* water extracts under different schedules of feeding on the SW of *B. mori* L.

Source	df	SS	MS	F
FS	2	0.0120	0.0060	0.61
PP	2	0.0026	0.0013	0.13
Error-1	4	0.0393	0.0098	
Dose	4	0.0799	0.0200	17.30
Dose×PP	8	0.0040	0.0005	0.43
Error-2	24	0.0277	0.0012	
Total	44	0.1655		

SW=Shell weight, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table102. Anova for different plant parts of *Solanum tuberosum* water extracts under different schedules of feeding on the TEL of *B. mori* L.

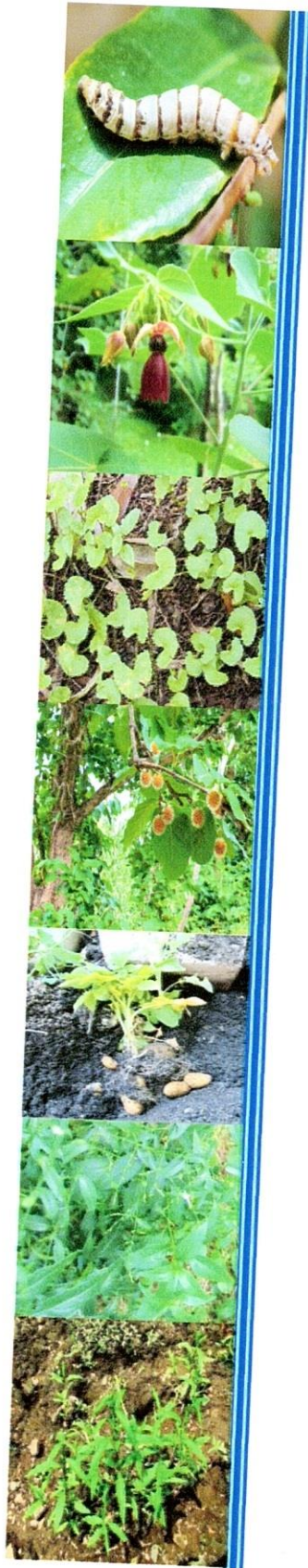
Source	df	SS	MS	F
FS	2	356.84	178.42	122.58**
PP	2	116.04	58.02	39.86**
Error-1	4	5.822	1.455	
Dose	4	3253.644	813.41	254.19**
Dose×PP	8	373.155	46.64	14.57**
Error-2	24	76.800	3.2	
Total	44	4182.311		

TEL=Total number of eggs laid, **WML**=Weight of mature larvae, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio

Table 103. Anova for different plant parts of *Solanum tuberosum* water extracts under different schedules of feeding on the EHP of *B. mori* L.

Source	df	SS	MS	F
FS	2	145.91	72.955	45.92**
PP	2	187.51	93.755	59.01**
Error-1	4	6.35	1.589	
Dose	4	2774.09	693.522	171.95**
Dose×PP	8	20.31	2.539	0.63
Error-2	24	96.80	4.033	
Total	44	3230.97		

EHP=Egg hatching percentage, **PP**= Plant parts, **df**=Degree of freedom, **SS**=Sum of squares, **MS**=Mean sum of square, **F**=Variance ratio



CHAPTER-5

Discussion

5. Discussion

Silkworms are well known industrial insects which produce natural silk. Because of economic importance for silk yarn, the main objective of silkworm rearing is the progressive improvement of economic traits to produce quantity and quality silk. Feeding of nutritionally enriched leaves showed better growth and development of silkworms as well as gain in economic characters of cocoons (Krishnaswami *et al.*, 1971). Fortification of mulberry leaves with supplementary food to increase the larval growth and development of *B. mori* has been carried out by many researchers. These include the effect of vitamins (Saha and Khan 1996; Nirwani and Kaliwal, 1996; Nirwani *et al.*, 1998; Khan and Saha, 2003; Etebari *et al.*, 2004; Rahmathulla *et al.*, 2007), hormones (Magadum *et al.*, 1992; Trivedy *et al.*, 1993; Saha and Khan, 1997), amino acid (Khan and Faruki, 1990; Qadar *et al.*, 1994; Saha *et al.*, 1994) and minerals (Magadum *et al.*, 1992; Islam and Khan, 1993; Saha and Khan, 1996). Nutritional background of the larval stage significantly influences the status of the resulting larva, pupa and fibre (Ahmed *et al.*, 1998; Rahmathulla *et al.*, 2002; Khan and Saha, 2003; Etebari and Matindoost, 2004). Although the mulberry leaves constitute a complete diet for the mulberry silkworm, however, nutritional deficiencies occur due to different reasons.

In the present study an experiment was conducted to screen out different parts of *Abroma augusta*, *Centella asiatica*, *Neolamarckia cadamba*, *Solanum tuberosum*, *Persicaria acuminata* and *Andrographis paniculata* plant extract with respect to their toxic effect on silkworm, *Bombyx mori* L. Relative toxicity by probit analysis for different parts of six plant extracts at different feeding schedules against silkworm larvae have been worked out. Results on the mean mortality percentage of the larvae indicated that all the parts of *P. acuminata* and *A. paniculata* extracts showed very high toxic effect. With the increase of the dose of the extracts of all the plant materials mortality of the larvae were increased. The LC_{50} values for different parts extracts at different feeding schedules implied that different parts of

those plants extract also produced very high mortality in comparison to other four test plants of the present investigation. Jahan *et al.* (1989) reported the toxic effect of Bishkatali, Nishinda and Akanda on larval mortality of *T. confusum* and found that Bishkatali was more effective toxicant followed by Nishinda and Akanda. A large number of scientific papers and reports cover the subject of naturally occurring antifeedants or feeding deterrents in plants (Gill and Lewis, 1971; Girish and Jain, 1974; Jacobson *et al.*, 1975; Bernays and Chapman, 1977; Golob and Webley 1980; Malik and Naqvi, 1984; Gujar, 1990; Thangam and Kathiresan 1991; Ahmed and Ahamad 1992; Ramjan *et al.*, 1993; Nawrot and Harmatha, 1994; Howlader *et al.*, 1995). Several authors also reported the antifeedant, repellency and growth inhibiting effects of some plant materials against stored product pests (Mukherjee and Ramachandran, 1989; Qureshi *et al.*, 1988; Rani and Jamil, 1989; Mondal and Begum, 1991; Parveen and Mondal, 1992; Talukder and Howse, 1993).

On the other hand, results on the mean mortality percentage of the larvae indicated that all the parts of *A. augusta*, *C. asiatica*, *N. cadamba*, *S. tuberosum* plant extracts were not toxic. The LC_{50} values did not show toxic effect. Murugan *et al.* (1998) noticed a strong correlation between the growth of silkworm and the silk production in the silkworm after the treatment with plant extracts and attributed the growth promoting effect of the plant extracts to the stimulation of biochemical processes leading to protein synthesis. Saravanan *et al.* (2011) suggested that the co-administration of *Vigna unguiculata* with mulberry leaves at a concentration of 7.5% enhanced the biochemical reaction involved in the silk production in the silkworm.

After screening with respect to relative toxicity of the test plants, investigations were carried out separately to determine the effects of *A. augusta*, *C. asiatica*, *N. cadamba*, and *S. tuberosum* extracts on the growth and development of silkworm, *B. mori*. The effects of the supplementation of different parts, viz. leaf, stem and root extracts on *B. mori* at different feeding schedules, viz. fed only in 1st feeding

of 3rd to 5th instar larvae (FS-1), fed everyday in 1st feeding of 3rd to 5th instar larvae (FS-2), fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae (FS-3) were conducted. Leaf extract of *A. augusta*, *C. asiatica*, *N. cadamba*, *S. tuberosum* increased different parameter under study at different doses in comparison to control under different feeding schedules. Similar results were also recorded for stem and root extract. The results of analysis of variance also indicated that there was a highly significant difference among plant parts. Many researchers found that the growth rate of larvae, protein and mineral content of haemolymph, the protein content, DNA and RNA content of the sericigen glands, and the quality parameters of cocoon was improved by different nutrients such as ascorbic acid, folic acid, thiamin, vitamin B complex, etc. (Saha and Khan, 1996; Nirwani and Kaliwal, 1996; Etebari *et al.*, 2004, Rahmathulla *et al.*, 2007; El-Karaksy and Idris, 2009). Improvement in the growth and development, and quality and quantity of silk by mulberry leaves enriched with plant extracts has also been achieved by many workers (Amirmohammadi *et al.*, 2013; Senthamarai Selvi *et al.*, 2014; Tiwari *et al.*, 2014).

All insects require a variety of minerals and trace elements as micronutrients (Muniandy *et al.*, 2001). Known trace elements essential for insects include iron, copper, manganese, zinc, cobalt, nickel and iodine (Trager, 1953). Specifically, the minerals essential for the nutrition of silkworms include potassium, phosphorus, magnesium and zinc (Horie and Watanabe, 1980). Bose and Majumdar (1989), studied the effect of foliar application of different levels of various micronutrients to mulberry on the quality of bivoltine cocoon and silk and achieved positive results. Cocoon parameters in the silkworm, *Bombyx mori* on exposure to trace element have also been improve as reported by Lakshmi Devi and Yellamma (2013).

Several researchers have documented the beneficial effects of mineral supplementation on silkworms (Ito and Niminura, 1966a,b; Horie *et al.*, 1967; Chakrobarti and Medda, 1977, 1978a,b; Miyoshi *et al.*, 1978; Bhattacharrya and

Medda, 1981, 1983; Majumder, 1982; Vishwanath and Krishnamurthy, 1982; Narasimhamurthy and Gobindappa, 1988; Thangavelu and Bania, 1990; Magadum *et al.*, 1992; Islam and Khan, 1993). Thangavelu and Bania (1990) recorded that trace amounts of minerals, e.g. calcium, magnesium, iron, and their salts present in rain water presumably stimulated metabolic activity in *B. mori* resulting in the shorter larval duration and increase in the effective rearing rate, oviposition and silk content of cocoons.

The modulatory effect of zinc chloride, nickel chloride, ascorbic acid, magnesium sulphate, ferrous chloride, potassium sulphate (Nirvani and Kaliwal, 1996b), thyroxin (Majumdar and Medda, 1995), on the silkworm metabolism, immune response and silk production has been extensively studied. Feeding of mulberry leaves treated with cobalt chloride enhanced that larval and cocoon shell weight and egg productivity in the Nistari race of *B. mori* (Chakrobarti and Medda, 1977, 1978a,b) and the worms fed on leaves treated with potassium iodide increased the economic parameters and reduced the larval duration (Majumder, 1982). Khan and Saha (1996) observed that the supplementation of potassium dichromate, significantly increased the weight of larvae, pupae and adults; enhanced the cocoon characters; decreased the developmental periods and increased the reproductive potential of *B. mori* at 0.10, 0.20 and 0.40% concentration. Quader, *et al.*, (1990) found that 500 ppm concentration of iodized salt significantly increased larval weight, single cocoon weight and shell percentage and 40 ppm concentration of iodized salt increased shell weight, length of filament and size of cocoon filament. Srinivasababu *et al.* (1992) observed that dietary supplementation of iodophore significantly increased the larval weight, cocoon weight, shell weight, pupation rate and fecundity and decreased the duration of 5th instar larvae. Quader *et al.* (1993) found that iodized salt (sodium chloride containing 35 ppm potassium iodide) significantly increased the larval weight over potassium iodide and control treatments and they suggested the use of iodized salt as a growth stimulator of the silkworm, *B. mori*.

A number of experiments have been carried out on the effects of hormones on the growth and development of *B. mori* by Magadum and Hooli (1989), Padki (1991), Trivedy *et al.* (1993), Magadum *et al.* (1994), Reddy *et al.* (1994), and Saha and Khan (1997a). The ecdysone has been noticed to influence the reproductive potential of *Bombyx mori* (Pondeville *et al.*, 2008; Parlak *et al.*, 1992; Kawaguchi *et al.*, 1993 and Okuda *et al.*, 1993). Ecdysteroids play key role in moulting and metamorphosis in insects. Plant-produced insects moulting hormones, known as phytoecdysteroids (PEs), assume the functions of defense against insects by acting either as feeding deterrents or as agents that induce developmental disruption (Schmulz *et al.*, 2002). Effects of phytoecdysteroids on weight of ovary and weight of egg (Srivastava and Upadhyay, 2012a); on length of silk filament and non breakable filament of multivoltine mulberry silkworm (Srivastava and Upadhyay, 2012b); on the spinning duration (Pandey and Upadhyay, 2014); changes of protein content in the larvae of silkworm (Srivastava and Upadhyay, 2013a); on silk producing potential (Srivastava and Upadhyay, 2013a) and on incubation period and percent fertilized egg of multivoltine silkworm (Srivastava and Upadhyay, 2013b) have been studied extensively with an aim to utilize the results for commercial cocoon production. The plant like *Achyranthes aspera* (Lal jeera) and *Cassia tora* (Choti chakwar) have been identified to have phytoecdysteroids (Lafont and Horn, 2004). In China, various plant sources were identified which contained moderate to high amounts of PE and used them in sericulture to manage the silkworm rearing during the last stage of larval development (Wong *et al.*, 1979 and Chou and Lu, 1980).

The effect of vitamin supplementation on the growth of *B. mori* have been investigated by many researchers (Majumdar and Medda, 1995; Bhattacharyya and Medda, 1981a,b; Das and Medda, 1988; Faruki, 1990, 1998, 2005; Babu *et al.*, 1992; Faruki *et al.*, 1992; Khan and Saha, 1996a,b; Nirwani and Kaliwal, 1996; Nirwani *et al.*, 1998; Mosallanejad, 2002; Etebari *et al.*, 2004; Rajabi *et al.*, 2006a,b). The requirements of vitamin in silkworm, *B. mori* were confirmed by different experiments by Saha and Khan (1996). Evangelista *et al.* (1997) have also

reported that the larval and cocoon length, width and weight increase under multi-vitamin treatment. It is showed that multi-vitamin and mineral compounds could increase the food intake, growth and conversion efficiency of silkworm (Muniandy *et al.*, 2001). Application of multi-vitamins as supplementary nutrients on biological and economical characteristics of silk worm, *Bombyx mori* L. had radically changed the results based on the concentration they were administered (Etebari and Matindoost, 2005). Chang and Li (2004) reported that nutritional interactions exist between vitamin B3 and other groups of vitamin B. A number of researchers have worked on the effects of vitamin enriched food on the reproduction of *B. mori* females (Faruki *et al.*, 1992 and Saha and Khan, 1996). Application of multi-vitamins as supplementary nutrients on biological and economical characteristics of silk worm have also been reported by Etebari *et al.* (2005). Nirwani *et al.*, (1998) reported that the weight of larvae and silk glands in all the thiamin fed groups had not shown any significant changes. Faruki (1998) reported that the thiamine derivative thianomin enhanced the growth of silkworm larvae, pupae and adults at all concentration used (50,100, 500, and 1000 ppm). Cocoon parameters such as cocoon weight, pupal weight and cocoon shell weight also showed significant decrease in all treatments (Etebari and Matindoost. 2004). High doses (20 and 30 g/l) of nicotinamide killed all larvae before entering the 5 instars (Etebari and Matindoost, 2004). Niacin with 0.5 g/L acted as an antifeedants for silkworm larvae and decreased their metabolism (Etebari and Matindoost, 2004). Faruki (2005) reported that mulberry leaf fortification by pyrol (Pyridoxine hydrochloride) in various concentrations from the third instars significantly reduced the fecundity and fertility of silkworm. Etebari *et al.* (2005) administered a vitamin complex (ascorbic acid, thiamin, riboflavin, pyridoxine, B₁₂, niacin, calcium panthotenate, vitamins A and D₃) to silk worm, in concentrations of 1, 2.5 and 5% in the 4th and 5th larval stages, supplementation being executed by pulverizing the vitamin substances on to the leaves. This treatment led to significant increases in the larvae body mass, cocoon mass, chrysalis weight and egg productivity compared to the control group. Several research demonstrated phagostimulatory effect of ascorbic acid for insects (Ito,

1978). Prasad *et al.* (1994) found significantly higher silk productivity on 2% ascorbic acid supplemented diet in Pure Mysore, NB₄D₂ and PM×NB₄D₂ breeds. Etebari *et al.* (2004) reported the yield decrease, when ascorbic acid concentration is enhanced in silk worm diet. Chang and Li (2004) reported that nutritional interactions exist between vitamin B3 and other groups of vitamin B. Babu *et al.* (1992) observed that the first and second instar larvae reared on 1.5% ascorbic acid enriched mulberry leaves resulted in higher silk filament length, weight and denier values. Cappellozza *et al.* (2005) showed that the lack of ascorbic acid in larva food fed with artificial feed especially during the first and the last larval stage produces beneficial effects regarding cocoon production without influences on the survival percentage and larva cycle.

Various extracts of medicinal plants have been tested by supplementation in the silkworm, *Bombyx mori* and were seen to influence the body weight, silk gland weight and the silk thread length in *Bombyx mori* (Murugan *et al.*, 1998). Dietary supplementation of the leaf, flower and pod extracts of *Moringa oleifera* (Rajeswari and Isaiarasu, 2004) and chitosan solution (Bin Li *et al.*, 2010) elicited varied responses in the final instar larvae of *Bombyx mori*. Saravanan *et al.* (2011) suggested that the co-administration of *Vigna unguiculata* with mulberry leaves at a concentration of 7.5% enhanced the biochemical reaction involved in the silk production in the silkworm. *Aloe vera* herbal tonic 'Iogen' (Balamurugan and Isaiarasu, 2007); 'alloe' (Manimutha and Isaiarasu, 2010) and 'Aloe' (Deshmukh and Khyade, 2013) tonic treated mulberry leaves influence the cocoons, pupal and growth parameters of *B. mori*. *Aloe vera* contains over 75 nutrients and 200 active compounds, including vitamins, enzymes, minerals, sugars, lignin, anthraquinones, saponins, salicylic acid and amino acids (Park and Jo, 2006). Preparations of *Aloe* are, therefore, used both topically and as dietary supplement (Buen, 2006). There experiments were conducted with *A. vera* oil in 0.25, 0.50, 0.75 and 1.0 ml as single, double and triple treatment against 3rd, 4th and 5th instar larvae. The maximum fecundity ($409.66 \pm 3.31\%$) and hatchability ($96.75 \pm 1.22\%$) (Sing *et al.*, 2014) and the maximum larval weight (1.807 ± 0.094 g)

and larval length (6.728 ± 0.567 cm) (Tiwari *et al.*, 2014) have been observed in case of triple treatment with 0.75 ml amount of *A. vera* oil.

Supplementation of mulberry leaves with potato leaf extracts at growth stage, at 1:4 concentrations significantly improved the economic parameters (higher mature larval weight, cocoon weight, shell weight and shell percentage) of silkworm (Krishna Prasad *et al.*, 2000). Gaikwad *et al.* (2010) evaluated the lysosomal and microsomal acid phosphatase activity in midgut tissue of silkworm larvae, *Bombyx mori* L. after induced oxidative stress by D-galactose. Impact of feeding of Japanese weed leaves (*Mikania micrantha*) on amino acid concentrations of silk fiber of eri silkworm, *Samia ricinii* Donovan has been investigated by Devi (2012). In Devi's investigation, the improvement of alanine, glycine, and tyrosine in the larvae fed with *Mikania micrantha* from III instar till maturity were 1.65%, 2.68% and 8.31% over control. The increased amino acid concentration in silk fiber may be due to *Mikania micrantha* for its role on growth and metabolic activity in the silk gland of *Samia ricini* Donovan.

Amirmohammadi *et al.* (2013) evaluated the methanol extract of the plant *Pteridium aquilinum* (Dennstaedtiaceae), was used in 3 concentrations (i.e. 1.25, 2.5 and 5%) dissolved in distilled water and sprayed on leaves fed on first two days of 3rd, 4th, and 5th instar larvae of *Bombyx mori* in 3 replications of 100 insects in each replicate and a control with distilled water treatment. Results showed that, the highest silk gland weight belonged to control (0.45 ± 0.15 g), the highest cocoon weight (60.235 ± 6.98 g), cocoon shell weight (19.5 ± 2.59 g), number of best cocoon (53) was that of 2.5% concentration. Senthamarai Selvi *et al.* (2014) mentioned that the treatment of *Spinacia oleracea* at the concentration of 25% may have beneficial effects on the growth of the silkworm larval and pupal length, width and weight and also increased the quantity of silk production by enhancing the feed efficacy than control.

Ganesh Bhawane *et al.* (2014) studied on the Effect of ethanolic plant extracts on BmNPV inoculated silkworm *Bombyx mori* in relation with midgut antioxidant

enzymes, acid phosphatase and non-specific esterase. The dusting of *Lantana camara* and *Clearodendron inermae* at 5% has increased silk and fecundity by eri silk worm (Mamadapur, 1994 and Santosh Kumar, 1997). The leaves of weed plant *Mikania micrantha* had been found to have significant effect on growth, development and yield of eri silk worm, *Samia cynthia ricini* Donovan (Devi , 2010).

Carroll Williams (1956) from *Hyalophora cecropia*, a new approach has captured worldwide attention in the control of growth and development in insects. Delay in moulting is probably due to the inhibitory action of JH on ecdysone synthesis in *B. mori* (Sakurai *et al.*, 1986; Trivedy *et al.*, 1997). Some plants like *Pinus longifolia*, *Abies balsamea*, *Psoralea corylifolia* and *Azadirachta indica* act on *Bombyx mori* larvae as bioactive juvenoid compounds (Nair *et al.*, 1999).

Thulasi and Sivaprasad (2014) suggested lemon juice (LJ) as a profitable supplementary diet for silkworm. Minimum effective concentration of LJ was determined and its positive impact demonstrated on *B. mori*, with reference to larval growth, protein profiles and economic parameters of sericulture. LJ works well at a concentration of 3% in distilled water and stimulates growth rates in silkworm larvae during fourth and fifth instar developmental stages, but more effectively during fifth instar. It stimulates fibroin (core silk protein) synthesis and retards floss protein synthesis in silk gland, more particularly in its anterior region. Further, lemon juice promotes protein mobilization from fat body to silk gland via haemolymph. In doing so, it contributes to sericulture industry by causing improvements in profit making economic traits such as gland-body ratio, cocoon weight, shell weight, raw silk weight, denier and renditta and by reducing the production of floss, which contributes to loss in the sericulture industry.

From the above discussion it is evident that plants are the richest source of organic chemicals on earth and phytochemicals have been reported to influence the life and behaviour of different insects. Different plant parts supplementation play an important role on the growth and development of the mulberry silkworm. Various

extracts of plants under study have been tested by supplementation in the silkworm feed and were seen to influence the body weight, cocoon characters, developmental period, fecundity and fertility. Therefore, it is concluded that potential, economic advantages are expected to be gained through utilizing different plant materials of *Abroma augusta*, *Centella asiatica*, *Neolamarckia cadamba* and *Solanum tuberosum* as food supplement with mulberry leaves. Further research are, however, needed on the isolation and identification of active ingredients responsible for the growth regulatory activity and their possible mechanism of action in ilkworm.



CHAPTER-6

Literature cited

6. Literature cited

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CHAPTER-7

Appendices

Appendix Table LII. Dose mortality data of *Bombyx mori* larva treated with *Centella asiatica*. root extract in water fed with mulberry leaves fed only in 1st feeding of 3rd to 5th instar larvae.

Dose (ppm)	Log dose	Insects used	Number killed	Killed (%)	Corrected mortality (%)	Empirical probit	Expected probit	Working probit	Weight	Final probit
1500.000	3.176	180	19	10.556	9	3.66	3.631	3.663	54.36	3.636
1000.000	3.000	180	18	10.000	8	3.59	3.602	3.596	54.36	3.606
500.000	2.699	180	16	8.889	7	3.52	3.552	3.519	48.42	3.554
100.000	2.000	180	13	7.222	6	3.45	3.435	3.450	42.84	3.432

$Y = 3.085 + 0.173X$
 CHI-SQUARED IS 0.114 WITH 2 DEGREES OF FREEDOM
 LC₅₀ IS 1.083E+11
 95% CONF LIMITS ARE 5.553E-05 TO 2.115E+26

Appendix Table LIII. Dose mortality data of *Bombyx mori* larva treated with *Centella asiatica*. root extract in water fed with mulberry leaves fed everyday in 1st feeding of 3rd to 5th instar larvae.

Dose (ppm)	Log dose	Insects used	Number killed	Killed (%)	Corrected mortality (%)	Empirical probit	Expected probit	Working probit	Weight	Final probit
1500.000	3.176	180	20	11.111	10	3.72	3.707	3.720	60.48	3.710
1000.000	3.000	180	18	10.000	9	3.66	3.668	3.663	54.36	3.671
500.000	2.699	180	16	8.889	8	3.59	3.601	3.596	54.36	3.603
100.000	2.000	180	12	6.667	6	3.45	3.445	3.450	42.84	3.445

$Y = 2.993 + 0.225X$
 CHI-SQUARED IS 1.243E-02 WITH 2 DEGREES OF FREEDOM
 LC₅₀ IS 7.758E+08
 95% CONF LIMITS ARE 2.029 TO 2.965E+17

Appendix Table LIV. Dose mortality data of *Bombyx mori* larva treated with *Centella asiatica*. root extract in water fed with mulberry leaves fed everyday in 1st and 3rd feeding of 3rd to 5th instar larvae.

Dose (ppm)	Log dose	Insects used	Number killed	Killed (%)	Corrected mortality (%)	Empirical probit	Expected probit	Working probit	Weight	Final probit
1500.000	3.176	180	21	11.667	10	3.72	3.662	3.730	54.36	3.671
1000.000	3.000	180	18	10.000	8	3.59	3.626	3.596	54.36	3.634
500.000	2.699	180	16	8.889	7	3.52	3.566	3.519	48.42	3.569
100.000	2.000	180	15	8.333	6	3.45	3.426	3.450	42.84	3.420

$Y = 2.992 + 0.213X$
 CHI-SQUARED IS 0.425 WITH 2 DEGREES OF FREEDOM
 LC₅₀ IS 2.442E+09
 95% CONF LIMITS ARE 0.278 TO 2.138E+19

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