In India, sericulture is one of the most important agro and forest based cottage industry, earning a foreign exchange of Rs. 400 crores / annum and providing gainful employment to over six million people. Technically sericulture is rearing of silkworms either on mulberry or non-mulberry plants for production of silk. Today India is the second largest silk producer of raw silk and also has the distinction of being the world’s largest consumer of silk. In developing countries such as India, agriculture and agro-based industries play a vital role in the improvement of rural economy. The limited availability of land, the limited cash returns and agriculture being confirmed to one or two seasons in the year, have made villages to look for supporting rural industries and one of them is sericulture. It is a cottage agro based industry and provides ample work for the women folk in the rural areas in rearing silk worms, while the male members work in the fields. Recently with the invention of new technologies by research institutions both in mulberry cultivation and silkworm handling among sericulturists, the industry is now practiced as main profession and as a major cash crop of the country. Sericulture has been identified as an occupation of low investments, high output source of employment and income. The industry holds high promise as an employment intensive occupation especially in rural and semi-urban areas (Benchamin and Jolly, 1986).

Sericulture has important socio-cultural implications. Studies have established large scale employment generation potential and high income generation potential of sericulture (Hanumappa, 1986). Jayaram et al., (1998) showed that every acre of sericulture practiced under irrigated conditions had a potential to employ 247 men and 193 women round the year. They have also shown that the small scale mulberry farms provided ample scope for employment of owned family labour and suggested its potential to solve the problem of seasonal unemployment. Lakshmanan et al., (1999) found that female labour is quite dominant in all sericultural activities, to an extent of nearly 50%. Saraswathi and Sumangala (2001) observed that in the indoor activity of silkworm rearing women participation was as high as 94.67 % and that except for the peak period the entire sericultural activity is conducted using family labour.

Most of the activities in silk production are in the informal sector and menial in nature. Thus about 90% of the employment goes either to the landless or to the marginal
farming families that hire out these labour, or to the sericulture families (Sinha, 1989). While considering the price spread in the whole industry, it can be seen that 48% of it goes to farming sector. Sericulture and silk production are labour-intensive at the village level, employing both men and women at all stages of production. In China, it occupies some 20 million farmers, as well as 5 lakh people in the silk processing industry. In India, sericulture is a cottage industry in 59,000 villages, providing full and part-time employment to some six million people from the farm sector, and silk processing industry (ITC silk review 2001).

Rural economy in India is largely dependent on agriculture. There is a considerable scope to increase employment and income in rural areas through labour intensive remunerative enterprises like sericulture. Sericulture industry is unique in its advantages and suitability to the rural setup. The reduction of rural poverty continues to be a paramount goal of the developing countries like India as the majority of the poor population still resides in the countryside. The World Bank, for example, estimates that more than 70% of the world’s poor live in rural areas. So far, various strategies have been pursued to address this concern and among the major ones is rural employment creation. The agriculture sector, however, has been contending with a number of factors that have limited its potential for generating new jobs in rural areas. Those factors may include the small land holding size, insufficient capital and investment incentives, the inadequate farm infrastructure, limited market and stagnant prices of agricultural products. It is therefore necessary to focus on a broader spectrum of the rural economy. The establishment of rural based industries like sericulture, in particular, can be very effective in creating new job opportunities and providing supplemental income. Being a rural agro-based labour intensive industry this sector can also play vibrant role in checking migration from rural to urban areas.

Silk is one of the most mysterious creations of Mother Nature. Its history is as often said, “Shrouded in mystery and legend.” Both Indian and Chinese versions of history exist. There are references of the fabric in ancient scriptures of both the countries. However it is generally believed that silk found its origins in China, more than four thousand years ago. The Chinese legend says that it was the teen aged Chinese empress “Hsi-Ling-Chi” of the yellow emperor “Huang Te” who brought the secrets of
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silk to light. Historic relics unearthed from China support this legend. The Chinese still worship the empress as the “Silk Goddess”. “SILK” the very name itself evokes delicate feelings. Till date no fabric in the world has conquered this Queen of Textiles and this is the magic of silk. Silk is not just another fabric in India. If fashion is a fine art, then silk is its biggest canvas, and if silk is the canvas, then all its weavers, dyers, designers, embroiderers are the greatest artists. Indian silk has enthralled fashion watchers and all categories of consumers across the world with its vast repertoire of motifs, techniques and brilliant hues. India’s traditional and culture bound domestic market and an amazing diversity of silk garments that reflect ‘geographic specificity’ has helped the country to achieve a leading position in silk industry (Silkworm online blog, 2010).

Silk is a very unique fabric and has always been a luxury product. If cotton is king, silk is the queen of the textiles. Silk signifies liberty, life, sensuality, pleasure, tenderness, warmth, purity, serenity/ nature and universalism. Silk is of ancient origin and silk fabrics had been used during Ramayana and Mahabharata period. The Japanese carried off four Chinese maidens, who knew the secret of silk, along with mulberry shoots and silk moth eggs. Today Japan is the leading producer of silk! Another story is that a Chinese princess married an Indian prince. She carried silkworm eggs and mulberry shoots in her elaborate headdress and the secret of raising silkworms in her head, thus spreading the culture of silk to India. Finally, two poor monks told Emperor Justinian of Constantinople that they had learned the secret of silk. Justinian sends them back to China to get some eggs and mulberry shoots for him. They returned many years later with the eggs and shoots hidden inside their hollowed-out walking sticks. Since Justinian was the emperor of Constantinople, a crossroads city, the secret soon spread throughout Europe. There are many more interesting stories about the history of silk (Silkworm online blog, 2010).

Sericulture Industry in India

The silk trade flourished in India during the medieval period. Under the Moughals, silks from Kashmir and Bengal were exported mainly by the Moors, who during the 14th and 15th centuries transmitted it to Europe (Nanavaty, 1990). The British had identified the qualitative shortcoming with Indian silk and tried to improve it by bringing experts to modernize the rearing and reeling techniques. In 1771, the
'China worm’ was introduced with the idea of improving cocoon quality. The government promoted the extension of land under sericulture. Rent was slashed by half for those lands, and that too was exempt for the first two years of cultivation. The government also promoted a higher wage structure for processing raw silk (Ray Indrajit, 2005). Technology was substantially improved in conformity with the European know-how and practices so that British weavers accepted raw silk of Bengal. In fact, the overseas market responded very favorably to the first consignment of the new technology in 1772 (Ray Indrajit, 2005). The government was also successful in diffusing Chinese worms in sericulture. Another breakthrough was achieved in the sphere of the production system. The government successfully organized sericulture as a cottage industry. The industry’s technology and organization were thus thoroughly reformed by the close of the eighteenth century in tandem with the requirements of the European market. Consequent to the abolition of British East India Company’s monopoly on private trade the company wound up its silk trade in 1833, leaving it to private entrepreneurs. During the last quarter of 19th century Bengal silk began to decline due to lack of proper organization, husbanding authority and the absence of technical know how (Ray Indrajit, 2005).

Hanumappa and Erappa (1988) cites sericulture development in the princely state of Mysore as an example of the crucial role the state can play in augmenting the sources of rural income. Sericulture flourished in Mysore during the 18th century under Tipu Sultan. The technology was transferred from Bengal. Japanese and Italian silkworm strains were imported and experts hired from these countries (Nanavaty, 1990). Spread of diseases during 1866 and the world depression in 1929 along with competition from imported silk and rayon lead to downfall of Indian silk industry on the eve of World War II. A tariff protection commenced from 1934 to save the industry from cheap imports of silk (National Commission of Agriculture, 1976). During the World War II, the Indian silk industry again surged, mainly due to demand from the Allies for silk for manufacture of parachutes.

The first authentic inquiry into the conditions of Indian silk industry was undertaken in 1914-15 by H. Maxwell Lefroy and E. C. Ansorge (Lefroy and Ansorge, 1915). In a report they observed that the industry was scattered and unorganized.
producers were subjected to exploitation. They suggested formation of a central organization to address the needs of the industry (Lefroy and Ansorge, 1915). Subsequent recommendations by a Silk Panel in 1946 lead to the formation of the Central Silk Board in 1949. Central Silk Board (CSB) is a statutory body, under the administrative control of the Ministry of Textiles, Government of India. One of the earliest commodity boards to be constituted by the Government of India, the Board coordinates the development of sericulture and advises the Government on policies governing export and import. It has the responsibility for pre-shipment inspection of silk goods exported from the country. The Board is also responsible for organizing sericultural research, training, basic seed (egg) production and collection of statistics pertaining to sericulture and silk industry (National Commission of Agriculture, 1976 and Gopalachar, 1978).

The Central Silk Board (CSB) established a number of sericulture research institutions in 1960s. With systematic efforts, it became possible in 1970s to develop a technology suitable for tropics. New mulberry varieties coupled with agronomical practices were made available to the farmers. Packages of practice were developed for silkworm rearing, besides realizing new bivoltine races. Popularization of the bivoltine hybrids was given priority. Since seed preparers started using bivoltine as a male parent for the preparation of cross breeds, the traditional poor yield crosses have been replaced to the extent of 85%. Consequent to this, mulberry sericulture was spread to non-traditional states like Kerala, Maharashtra, Rajasthan and Gujarat in the 1980s. While other crops (grains) perish due to very little precipitation, mulberry survives such acute situation where ground water is also not available for raising the crops, thus providing subsistence to a large number of farmers (National Commission of Agriculture, 1976).

Currently in India mulberry silk is chiefly produced in 5 states viz. Karnataka, Andhra Pradesh, Tamil Nadu, West Bengal and Jammu and Kashmir, contributing to about 99% of the total mulberry silk produced. Interestingly, the states of A.P and T.N with almost no silk production during 1960 (Vasumathi, 2000), currently occupy the second and fourth position respectively. West Bengal at present contributes about 11.8% of the total cocoon / silk production, while Karnataka contributes the lion's share (43.95%) with Andhra Pradesh and Tamil Nadu contributing 38 % and 4 % respectively.
Whereas consumption of Sericulture in Maharashtra is practiced in 1441 villages of 22 districts, (Kalantri and Jadhav, 2006), consumption of dils increased form 2.17 lakhs (1988-89) to 18.40 lakhs in 2007. Cocoon production increased from 34.62 MTs (1988-89) to 766 MTs in 2007, (Kalantri, et al., 2007). But it is about 200 MTs in 2008-09 and 218 MTs in 2009-10 (Vigneshwara Varmudy, 2011).

India is the second largest producer of raw silk after China and the biggest consumer of raw silk and silk fabrics. An analysis of trends in international silk production suggests that sericulture has better prospects for growth in the developing countries rather than in the advanced countries. Silk production in temperate countries like Japan, South Korea, USSR etc., is declining steadily not only because of the high cost of labour and heavy industrialization in these countries, but also due to climatic restrictions imposed on mulberry leaf availability that allows only two cocoon crops per annum. Thus, India has a distinct advantage of practicing sericulture all through the year, yielding a stream of about 4 – 6 crops as a result of its tropical climate. In India, sericulture is not only a tradition but also a living culture. It is a farm-based, labour intensive and commercially attractive economic activity falling under the cottage and small-scale sector. It particularly suits rural-based farmers, entrepreneurs and artisans, as it requires low investment but, with potential for relatively higher returns. It provides income and employment to the rural poor especially farmers with small land-holdings and the marginalized and weaker sections of the society. Several socio-economic studies have affirmed that the benefit-cost ratio in sericulture is highest among comparable agricultural crops.

**Present status:**

At present, approximately 8 million families (of these 80% are rural poor) are involved in silk production as part of their livelihood, engaging in sericulture as an agro-based cottage industry. Due to favorable agro-climatic conditions (suitable temperature and humidity), traditional skills and market potential, silk production is mostly confined to states like Karnataka, Andhra Pradesh, West Bengal and Jammu and Kashmir. The predicted demand growth for silk could generate self-employment and remunerative livelihood opportunities for the most disadvantaged sections of society, especially for
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small and marginal farmers and the landless poor through silk worm rearing, reeling of yarn, weaving of fabric, and value-addition as non-farm activities (Patil et al., 2009).

Currently, the domestic demand for silk, considering all varieties, is nearly 25,000 MTs, of which only around 18,475 MTs (2006-07) is getting produced in the country and the rest being imported mainly from China. Indian domestic silk market has over the years been basically driven by multivoltine mulberry silk. Due to inferior quality of the silk produced, India could not meet the international quality standard. Though, R&D efforts have been made to improve the quality of multivoltine silk, even the best of multivoltine silk produced could not match the bivoltine silk in quality. Therefore, it is essential to enlarge the production base and improve current productivity levels of bivoltine silk to meet the international standards and quality demands of the power loom sector. Steps need to be taken to ensure that export oriented units having automatic state of the art weaving machinery (Gangopadhyay, 2008).

India is the largest consumer of the silk in the world. Around 85 per cent of the silk produced is consumed within the country. In addition, India has developed an international market for Indian silk goods. India has a niche market for the handloom silk having its own weaves textures and design. India also exports world quality silk produced out of imported bivoltine silk in sophisticated weaving machines. Silk has a miniscule percentage of the global textile fiber market- less than 0.2%. But this figure can be a gross under-estimation, since the actual trading value of silk and silk products is much more. The unit price for raw silk is roughly twenty times that of raw cotton. The annual turnover of the China National Silk Import and Export Corporation alone is US$ 2–2.5 billion (ITC Silk review, 2001). India earned foreign exchange revenue of Rs 1530.02 crore through export of silk goods in 2000-01. Continuous dependence on foreign silk is detrimental to the sericulture industry of the country. Hence, India needs to produce bulk quantities of uniform grade silk to meet the requirements of power loom and mill sectors. Production of bivoltine cocoon in large scale and reeling out the quality silk using modem filatures equipped with multi-end reeling machines are essential to meet the demand for quality silk (Datta, 1994).

Sericulture has attained a significant growth in the past five decades in India after independence. The mulberry area increased steadily from 83 thousand hectares in
1960-61 to 3418 thousand hectares in 1993-94, but there was decline in the mulberry area in the ensuring years and so reduced to 1,79,065 hectares during 2005-06. The raw silk yarn production was stagnant and was hovering around two thousand tones in sixties and seventies. But silk production increased considerably in the eighties and reached 11.49 thousand tones in 1990-91. The growth rate of raw silk production reduced in the later part of the last decade due to the reduction in mulberry area, but still there was an improvement in the total raw silk production due to increased productivity and so the silk production increased from 15742 tonnes in 2003-04 to 17305 tonnes in 2005-06. To meet the domestic demand of raw silk, India imports silk from China, Uzbekistan, Vietnam and other countries. The total volume of imports during 2010-11 was 5870 tonnes valued at Rs 9384.4 million as can be observed. Apart from raw silk, India also imports natural silk yarn and silk fabrics. India imported natural silk yarn worth Rs 1473.7 million and Rs 6201.6 million of fabrics during 2010-11 (Vigneshwara Varmudy, 2011).

Sericulture finds a place among the most competitive agro-based enterprises and many corporate bodies are showing interest to step into this sector. India has to play a suitable strategy not only to increase its silk production but also to improve silk quality standards, to be competitive in the world silk market. India is regularly exporting its silk to many countries in the world against stiff competition from other silk producing countries, mainly from China. Now global trade scenario is fast changing and the countries are liberalizing exports and import policies. From 2005, WTO regulated International trade under the guiding principle of GATT which imposes stiff competition among countries to make their produce more acceptable to the people by its quality and low price, which will mean that India should produce more quality silk at a low price.

The export of silk goods steadily increased from a modest level of Rs.17 million in 1960-61 to a whopping Rs. 3194.20 crores during 2005-06. *The export of Rs. 2998.22 crores has been achieved during April to February during the period of year 2006 – 07. The import of raw silk during the period April to February of the year 2006 – 07 decreased by 35.6% (i.e. 2733 MT) as compared to the corresponding period of the year 2005 – 06, Rs. 3338.35 crores during 2006-07. The import of raw silk during the
period April to February of the year 2006 – 07 increased by 4.5 crore, Rs. 2727.87 crores during 2007-08. The import of raw silk during the period April to February of the year 2006 – 07 decreased by 18.3 crore, Rs. 3178.19 crores during 2008-09. The import of raw silk during the period April to February of the year 2008 – 09 increased by 16.5 crore, Rs. 2892.44 crores during 2009-10. The import of raw silk during the period April to February of the year 2009 – 10 decreased by 9 crore, Rs. 2723.86 crores during 2010-11. The import of raw silk during the period April to February of the year 2010-11 decreased by 5.8 crore (Source: Directorate General of Commercial Intelligence & Statistics, Kolkata).

The demand for superior quality silk is increasing in India for domestic consumption as well as for value addition for exports. As the sufficient quantity of quality silk is not produced within the country, India has to depend on the foreign countries for bivoltine silk. The import price of raw silk has been always cheaper than the domestic raw silk, as the cost of production of Indian silk is high due to low productivity, small-scale production by the farmers and reellers, adoption of old and traditional technologies and manipulations by intermediaries in the trade of raw silk. The sericulture industry may be adversely affected after the implementation of new region free trade. India has no alternative except to prepare itself to effectively adopt high yielding mulberry varieties and silkworm races and new technologies to enhance the quality and reduce the production costs by increasing the productivity to face the challenges successfully (Department of Sericulture, Karnataka, 2001).

**Types of silks in India:**

India is a home to a vast variety of silk secreting fauna which also includes an amazing diversity of silk moths. This has enabled India to achieve the unique distinction of being a producer of all the five commercially traded varieties of natural silks namely, Mulberry, Tropical Tasar, Oak Tasar, Eri and Muga. Silk obtained from sources other than mulberry are generally termed as non-mulberry or Vanya silks. The bulk of the commercial silk produced in the world is mulberry silk that comes from the domesticated silkworm, *Bombyx mori* L. which feeds solely on the leaves of the mulberry (*Morus sp.*) plant. Tasar silk is copperish in colour, coarse in nature and is mainly used for furnishing and interiors and secreted by the Tropical Tasar silkworm,
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*Antheraea mylitta* which thrives on Asan and Arjun (*Terminalia sp.*). Rearing is done on naturally growing trees in the forests and is the main stay for many tribal communities in the states of Jharkhand, Chattisgarh, Orissa, Maharashtra, West Bengal and Andhra Pradesh. Oak Tasar is a finer variety of Tasar produced by the temperate Tasar silkworm, *Antheraea proylei* which feeds on natural oak plants (*Quercus sp.*) and is found in abundance in the sub-Himalayan belt. Eri silk is a silk spun from open-ended cocoons and secreted by the domesticated silkworm, *Samia cynthia ricini* that feeds mainly on castor leaves. Muga silk is golden yellow in colour and an exclusive produce of India, primarily the state of Assam where it is the preferred attire during festivities. Muga silk is secreted by *Antheraea assama* that feeds on aromatic leaves of naturally growing Som (*Persia bombycina*) and Sualu (*Litsea polyantha*) plants. Variety-wise share of raw silk production during the year 2007-08 has been depicted. (Source: *Indian Silk* 47(5), 2008).

**Potential, strengths and challenges of sericulture industry in India:**

Research and Development achievements like development of indigenous mulberry varieties with highest leaf yields in the world, new bivoltine silkworm hybrids eminently suited to the tropical regions of the country, farmer-friendly technologies, cost-effective new package of practices for cultivation of food plants, rearing and reeling coupled with huge natural and man-made resources and trained manpower clearly indicates the future prospects of sericulture industry to emerge as a promising indicator of economic development for the upliftment of the socially deprived communities and the downtrodden. The strengths, weakness, opportunities and challenges (SWOT analysis) of Indian silk industry have been given.

Among 34 mega biodiversity countries in the world, India is home to many species of insects with a diverse silk moth fauna. In addition to the diverse silkworm races, there are vast genetic resources of mulberry, tasar, muga and eri host plants spread over diverse geographical locations. This offers a great opportunity for economic utilization of the natural flora and fauna. However, due to deforestation and destruction of habitats, there is a challenge to bring about development without disturbing the ecological balance.
Women contribute to a little less than 50% of the country’s population and most of them are largely rural based, deriving their livelihood through agriculture and other land based activities, either as family members or wage earners. As a cottage industry, sericulture provides ample work for women in the rural areas particularly in silkworm rearing and reeling, while men, largely work in the field and in weaving. The involvement of women in different activities of sericulture is about 53% and their contribution in the on-farm activities understandably is lower than that in post-cocoon activities.

Sericulture being a farm-based enterprise is highly suited for both large and small land holdings, with low capital investment. The very nature of this industry with its rural based on-farm and off-farm activities and enormous employment generation potential has attracted the attention of many planners and policy makers to recognize the industry as one of the most appropriate avenues for socio-economic development of a largely agrarian economy like ours. Generally, silk goods are purchased by the urban rich and middle-class consumers and it is estimated that around 57% of the final value of silk fabrics flows back to the primary producers in rural areas. Sericulture can also play a very vital role in alleviating rural poverty due to its high work participation rate and thereby can check migration from rural to urban areas.

The percentage of population below the poverty line ranges from 47.15% in Orissa to 12.72% in Kerala. In major silk producing states it is about 30% on an average. Raw silk production is the most appropriate tool to provide gainful employment to these poorer sections of the society, as net incomes range from Rs. 12,000 to 70,000 per annum depending upon the variety of the silk to be produced and the unit area (under host plants). It is estimated that sericulture can generate employment @ 11 man-days per kg of mulberry raw silk production (in on-farm and off-farm activities) throughout the year.

Sericulture as a remunerative crop can suit all categories of farmers from small/marginal farmers with meager resources to a large farmers. With short gestation periods, the returns are quick. The net returns in case of mulberry sericulture (when a farmer has one acre of mulberry plantation using family labor), is estimated at about Rs.
48,000 per annum. Mulberry is highly amenable to inter-cropping. Economics of mulberry with inter cropping of vegetable for 3,700 sq. meters.

Survey of Sericulture in Maharashtra and Marathwada Region:

India comprises of twenty eight states and seven union territories. Maharashtra state is situated in the western part of India constituted by thirty five districts. Geographically, Maharashtra can be divided into five main regions: Viddarbha, Marathwada, North Maharashtra, Western Maharashtra, and Konkan regions. Climatic conditions of Maharashtra are semi-dry. The temperature ranges from 10°C to 47°C and annual rainfall from 700 to 1,000 mm. seven agro-climatic zones extend from Western Ghats (Sahyadri Mountain range) to the Deccan plateau on the East. Introduction of sericulture was tried out in Maharashtra way back in the year 1959 by Maharashtra Khadi and Village Industries Board, and later by a separate Directorate, established by Maharashtra Government. However, these initial attempts to introduce sericulture were not successful and the industry did not expand to any significant extent in the state.

Maharashtra, a state without a tradition of silk production, has a large gap between demand and supply of raw silk and more than 4,000 (Anon., 2008.) silk weavers in Yeola, Paithan, and Mohadi areas source their raw silk from neighboring states, amounting to a total value of ‘imports’ of Rs. 2,500 to 3,000 million (USD 50 to 60 million) per year. This demand for raw silk could become a source of rural employment within Maharashtra. The main constraints to sericulture in Maharashtra state were: lack of mulberry tree varieties adapted to local agro-climatic conditions, lack of suitable silkworm races, and lack of knowledge and skills among the farmers. Moreover management practices were poor, leading to diseases and low productivity (30kg/ 100DFL) (Anon., 2006a). In 2005 there were 3,000 families maintaining 4,200 acres of mulberry plantations spread over 1,004 villages of 20 districts (Anon., 2008) in Maharashtra. In 2008, the number of families adopting sericulture had increased to 8,000 with over 10,000 acres of mulberry plantations, however with low productivity (30kg/ 100DFL) (Anon., 2008). Among the mulberry silk producing states in India, Maharashtra occupies the seventh position.

Maharashtra is India’s third largest state in terms of area of about 308,000 square kilometers and the second largest state in terms of population. As per 2001 census
(Anon., 2006b), the population of Maharashtra state is approximately 96,752,000 resulting in a population density of 322.5 people per km. Over 64% of the population is employed in agriculture or agriculture-related activities (Anon., 2006a). The area under irrigation is 33,500 km$^2$ about 11% (Anon., 2006a). Rice, Jawar (sorghum), Bajara (millet), wheat, oranges, grapes, bananas, mangoes and pulses are the important food crops. Cash crops include groundnut, cotton, sugarcane, turmeric and tobacco.

The share of Maharashtra in sericulture is very negligible. Hence, there is a scope to do for sericulture in Maharashtra and need to boost sericultural activities in the state. Maharashtra is considered as a non-traditional state of sericulture. Sericulture did not gain importance in Maharashtra due to alternate cash crops such as sugarcane, cotton, grapes etc. However due to international demand to sericultural products, Maharashtra Government is taking keen interest in this business. Maharashtra has carved out a district place in the world of textile by virtue of its exquisite “Paithani” weaving known for extra ordinary craftsmanship; occupy a place of honor in the world of fabrics (Jadhav, 1999). Plantation increased from 1354 (1988-89) 6682 acre (Anonymous, 2007). Whereas consumption of Sericulture in Maharashtra is practiced in 1441 villages of 22 districts, (Kalantri and Jadhav, 2006), consumption of dils increased form 2.17 lakhs (1988-89) to 18.40 lakhs in 2007. Cocoon production increased from 34.62 MTs (1988-89) to 766 MTs in 2007, (Kalantri, et al., 2007). Whereas consumption of Sericulture in Maharashtra is practiced in 1441 villages of 22 districts, (Kalantri and Jadhav, 2006), consumption of dils increased form 2.17 lakhs (1988-89) to 18.40 lakhs in 2007. Cocoon production increased from 34.62 MTs (1988-89) to 766 MTs in 2007, (Kalantri, et al., 2007). But it 200 MTs in 2008-09 and 218 MTs in 2009-10 (Vigneshwara Varmudy, 2011). A separate Directorate of sericulture at Nagpur has now been established in September 1997 to boost sericulture in Maharashtra.

Marathwada region includes eight districts namely Aurangabad, Jalna, Parbhani, Nanded, Beed, Hingoli, Osmanabad and Latur. The major activity carried out in the region is agriculture and common food crops are Bajara, Jawar, Wheat, Rice along with the pulses such as Mung, Toor and cash crops as cotton, sugar cane, oil seeds (Sun flower, Ground nut, Kardai etc). The cash crops are cultivated where the facility of irrigation is available only. Though region is having average rain fall but also
experiences the shortage of water for drinking during summer in most of districts. Because of this the dependence of farmers for the agricultural activities can be attributed for average rain falls in the area. The area does not experience sufficient rain falls to cater the need of drinking water and irrigation. The temperature of the region is also high and during summer it reaches to the level of 42-45°C in many districts as such the region is warm.

Marathwada region has great potential for sericulture; its environment is good for this industry. Secondly it adjoins Karnataka the pioneer sericulture state in India and having well facilities for transport. It has been proved that mulberry silkworm rearing is technically feasible and economically viable in Marathwada region. The availability of irrigation water in the command area of Jayakwadi, Sidheshwar, Yeldari and Manjara projects has further brightened the prospects of sericulture in Marathwada. Area under mulberry cultivation in Marathwada is 1112.30 acres with cocoon production of 105287.800 kg and average cocoon production of 30 kg / 100 dfl’s and 87 kg cocoon/acre (Anonymous, 2001).

In Aurangabad district during the year 2001-2002, there was increasing trend in sericulture industry. Total 90 villages with 277 farmers were carried out sericulture practice in this district. A total of 319 acres of mulberry plantation with produced cocoon production of 36655 kg. By rearing 1, 01, 922 dfl’s of cross breed variety (multiply bivoltine). But average cocoon production was very low (Hiware, et al., 2004). Whereas, Japan produced 60 kg cocoon per 100 dfl’s. The overall production in Marathwada may increase by 50 %. Aurangabad district in 7 talukas about 32 villages have sericulture activities with mulberry acreage of about 91.50 acres covering 67 farmers during 2009-10. 40% of the mulberry area is available in four villages namely Pokhari, Dongergaon, Pathari and Kasanpur. The remaining 60% is scattered 28 villages where area ranges 1.00 to 4.00 acres. The V1 variety in district accounts about 94 % and remains 6% for S 1635 and S 36 (Annual Report, 2010).

The climatic conditions such as average rain fall and high temperature in the region, the sericulture is a seasonal activity and carried out from August to February in a year (Annual Report, 2007). The dependence of farmers on rain for agricultural activity which can provide a gainful occupation during the limited season in the year. For
growth of this activity the government of India has established regional as well as
district sericulture boards and offices in almost all states of India (Annual report, 2007-
2008). The offices provide technical guidance as well as financial support to the
farmers. Besides this quality seeds/ eggs are also marketed by these offices where the
eggs are available with nominal prices. Establishment of arrangements for purchase of
the cocoon crop at attractive rates is also made by this office at district places. To
promote this activity, government has also formulated schemes for financial assistance
for activity and subdivided assistance to the farmers willing to set up sericulture industry
for cocoon production. The help is also extended for cultivation of highly productive
mulberry fields and also eggs of high yielding races of silk worm for rearing.

The present thesis entitled “Studies on Rearing Performance of *Bombyx mori* L.
and the Pests Associated with Mulberry Garden.” is presented on following lines and the
work is carried out at Aurangabad region during 2009-11.

2. The plant parasitic nematodes associated with mulberry garden.
3. Taxonomic study of plant parasitic nematodes associated with mulberry garden
   and their fluctuations.
4. Study of insects and molluscan pests associated with mulberry garden.

Although in Maharashtra, not much extensive work has been done on the rearing
performance of *Bombyx mori* L. by using various minerals, chemicals, phytococosteroids,
drugs, botanicals and artificial diet also. But use of plant extracts study shows
tremendous impact on silkworm growth and cocoon quality also. In Aurangabad region
is not developed with the sericulture organization because lack of research on this field,
due which we consider this point in mind do the same thing. Generally laboratory
condition work shows better results but sometimes on field such trials fails, so ignore
this fact the total work of rearing as well as reeling is carried out on farmer fields. Plant
extracts under study shows positive impact on biological parameters of *Bombyx mori* L.
The pests i.e. plant nematode; insect and other pest study play important role in this
region for loss of mulberry leaves by deteriorating quality and quantity of leaf. This
study also helps farmers in Aurangabad to know the diversity of plant nematode; insect
and other pest on mulberry plant with different season and know their impact on the
mulberry garden.
1. Introduction

Sericulture is a biotechnological, labour intensive and rural welfare agro-based industry. It is the process and activity of silk production through cultivation of mulberry, rearing of silkworm and reeling cocoons. India also earns huge amount of hard currency through export of silk products. Therefore, sericulture has a place in planning for rural development in India (Bhaskar et al., 2008). The *Bombyx mori* L. is a beneficial monophagous insect which has been reared to obtain the valuable commodity “silk”, feeding only on mulberry leaves. As silk industry plays an important role in our rural economy, the research on silk worm and mulberry crop enhancement has achieved a prime importance in socio-economic development of farmers (Hiware and Bhalerao, 2008). Vast information is already available on the effects of nutrients fortification in silkworm *Bombyx mori* L. in this context, it is better to select a botanicals for use their extracts formulation can be effectively used as nutrient fortification supplement for rearing of silkworm; so that important cocoon character of silkworm including cocoon yield in the preparation of such formulations.

Mulberry (*Morus* species) leaf is the solo food and source of nutrition for the silkworm, *Bombyx mori* L. due to the presence of morin (Tribhuwan, et al., 1989). Nutritional study on silkworm is an essential prerequisite for its proper commercial exploitation. Nutrition of silkworm is sole factor which almost individually augment quality and quantity of silk (Laskar and Datta, 2000). There are numerous reports on increasing the cocoon or silk yield by the nutrient supplementation, but studies to increase the resistance in silkworm are limited. Supplementation of antibiotics and some botanicals to mulberry leaves were attempted by a few workers to increase the survival in silkworms previous reports indicated that Choromycetin treatment increased resistance to disease (Murthy and Sreenivasaya, 1953). Mulberry leaf supplemented with spirulina as a feed to *Bombyx mori* L. (Lepidoptera: Bombycidae) orally found to be effective in enhancing the larval and cocoon characters (Venkataramana, 2003).

Mulberry (*Morus sp*) is the only food plant and it plays an important role in the growth and development of silkworm and subsequently the production and productivity of silk. Leaf quality and quantity influence the growth and development
of silkworms as well as cocoon production and quality of raw silk produced. It is true that, nearly 70 per cent of silk protein produced by mulberry silkworm is derived from protein of mulberry leaves. Thus silkworm should feed with good quality mulberry leaves in optimum quality for successful cocoon production (Bhaskar et al., 2008, Narayanan et al., 1967). The supplementation or fortification of mulberry leaves is recent technique in sericulture research (Sitarama lyangar, 1973 and Murgan et al., 1998).

Nutrition plays a vital role in sericulture by improving the commercial characters of silkworms. Silkworm is a monophagous, deriving almost all the constituents required for its growth from the mulberry leaf. Feeding of nutritionally enriched leaves provided better growth and development of silkworms as well as gain in economic characters of cocoons (Krishnaswami et al., 1971). Effects of diets with different nutrients such as proteins, amino acids, carbohydrates, hormones, vitamins and minerals on the better production of cocoon crops have been reported earlier by Narasimhamurthy and Govindappa (1988), Bose and Majumdar (1989), Islam and Khan (1993), Reddy et al. (1994), Khan and Saha (1997a,b), Faruki (1998), Nirwani et al. (1998) and Nakamura (2000). The dietary nutritional management influences directly the quality and quantity of silk production (Shyamaia and Bhat, 1968; Hugar et al., 1977; Benchmark and Jolly, 1986; Tayade et al., 1988 and Murgan et al., 1998).

Studies on nutritional ecology of an insect are very important for its commercial exploitation (Scriber and Slasky, 1981). A need for such studies is for the estimation of rate of ingestion, digestibility and conversion efficiency of food, so also growth rate of the animal etc, (Englemann, 1966). The principles of the major insect nutritional requirements for growth and reproduction have been established since 1940’s through the studies on representative of the major insect group (Dadd, 1973; Davis, 1968; House, 1965; House, 1974; Nation, 2001; Simpson and Raubenheimer, 1995; Slansky and Srieber, 1985, Genc H. Phaon., 2002). Phytophagous insects generally require almost the equal amount of proteins, amino acids and carbohydrates such as Orthoptera, Coleoptera, and Lepidoptera.

Sometimes, nonessential amino acids motivate growth, because of the optimization of the nutrient balance and the good organization of the biochemical
pathways concerned in the synthesis of the nonessential amino acids. For example, alanine and glycine or serine is necessary for optimal growth in *Bombyx mori* (Nation, 2001). Some amino acids are important in morphogenesis. It has been shown that tyrosine is crucial for cuticular sclerotization and tryptophan for the synthesis of visual screening pigments. Some other amino acids are known to be neurotransmitters such as γ-aminobutyric acid and glutamate. Proline is essential for development and as energy sources for *Culex spp.* and several Diptera species. Aspartic acid and glutamic acid are important for *Phormia sp.* and *Bombyx mori* L. (Chapman, 1998).

The nutrition, particularly as it relates to the physiology of digestion, is the most fundamental and important challenges in the sericulture. Effective culture cannot occur unless a species can be grown quickly and economically. The *Bombyx mori* L (silkworm) is phytophagous lepidopteron insect that is monophagous feeder on *Morus alba* L (mulberry leaves). According to Kellner, 1887 the silkworm digests albumin, fat and carbohydrate except cellulose. Mulberry leaves of high yielding varieties cultivated under poor soil nutrient management with low nutritive value, when fed to larvae of highly productive silkworm breeds, it will lead to inferior quality cocoon production. So, there is a need for enrichment of leaf by supplementing the required nutrient in the silkworm food.

A wide range of chemicals including vitamins, minerals, amino acids, soyatose protein, hormones and plant extract have been used as supplements for enrichment of mulberry leaf to improve cocoon characters including reproductive potential of silkworm. Except a few, most of the investigations are laboratory finding on silkworm recording the influence of nutrient supplements on cocoon character of economic importance. So, there is scope for conducting studies on the efficacies of vitamins, minerals, amino acids, soyatose protein, hormones and plant extracts for the improvement of seed cocoon crop with respect to pupation rate, fecundity and egg recovery.

The silkworm, *Bombyx mori* L. is a holometabolus insect that passes through four distinct stages in its life cycle. The silkworm feeds only in the larval stage, which extends for a period of about 25-26 days. The larval stage is important for the fact that the silk produced at the end of this stage is dependent on the quality and quantity of

Silk, mulberry leaves play a very important role in the larval life of silkworm, Bombyx mori L. Benachim and Jolly (1986) are also of the same opinion that the quality of mulberry leaves influences the growth of the silkworms that help in the production of good cocoon crops. The leaves with low nutritive value, when fed to the silkworm will lead to the production of inferior quality cocoons. The imported physiological factor in silkworm growth, silk productivity is nutrition.

Importance of the research on effect of different fortification agents in silkworm nutrition can be judged from the principle of cooperating supplements (House, 1996), which states that the substitution sources of nutrients cooperating with the commonly recognized food stuff of the species, essential to fulfill the nutritional requirements in many insects. Supplementary nutrients are chemicals which, when added to normal food makes it more useful (Bajpeyi et al., 1991). In recent years, several attempts have been made to fortify the leaves with different beneficial nutrients and combination of nutrients (Rajegowda, 2002) to enhance the quality of cocoon crop.

Nutritional aspects are an important consideration for the survival of the silkworm, ultimately, deciding success of cocoon crops. Even as it has adapted to the nutritional status of its natural fed, the mulberry leaf for its growth and development, the silkworm, Bombyx mori L. encounters various constraints like attack from pathogen in the environment and accumulation of toxic phytochemicals from feed itself. Supplementation of some important nutrient/factors is one valuable strategy to increase the disease tolerance for better survival of the silkworm (Chandarakala et al., 2007). The nutrition background of the larvae influences greatly on the resulting pupa, adults and silk production. The leaves of superior quality enhance the chances of good cocoon crop. The dietary nutritional management influences directly on quality and quantity of silk production in Bombyx mori L. (Muragan, et al., 1998).

The integrated nutrient management in sericulture needs to address nutritional requirements of silkworm, Bombyx mori L. at different larval instars. For sustainable sericulture it is imperative to find a remedy for leaf quality at the cost of leaf yields. It is no secret that leaf with low nutritive value from high yielding mulberry variety when fed to larvae of highly productive silkworm breeds will lead to production of
inferior quality cocoon. Also, the farmers have secondary preference to soil nutrient management in mulberry garden. Under these circumstances there is an option for enrichment that except a few field trials most of the researches on this subject have been carried out in laboratory. The leaf with low nutrient value when fed to silkworms will lead to inferior quality cocoon production. Keeping this in view, many scientists have made attempts to enrich mulberry leaf by supplementing it with compounds such as vitamins, proteins, amino acids, carbohydrates, hormones, plant extracts and other chemicals so as to improve the quality and quantity of cocoon crop. These supplements when added to the mulberry enrich nutrition value of diet making it more useful from the nutritional point of view (Bhargava et al., 2008).

The first attempt was made to use homeopathic drugs by Hiware (2006) and Hiware (2005a, b) also shows that silkworm Bombyx mori L. larvae were fed on mulberry leaves treated with the homeopathic drug, Nux vomica mother tincture, Chelidonium mother tincture and Phytolacca berry mother tincture shows better results on biological characters of silkworm Bombyx mori L.

Proteins and especially free amino acids play important roles in insect development. Presence of high levels of amino acids in insects indicates that besides their role in protein synthesis, they have additional functions related to neural transmission, detoxification, synthesis of phospholipids, energy production and morphogenetic processes (Chen, 1985). Rodwell (1993) reported that amino acids and their derivatives participate in intracellular functions as diverse as nerve transmission, regulation of cell growth and the biosynthesis of various compounds in silkworm.

The requirements of amino acids in silkworm were confirmed by a number of experiments (Inokuchi and Ito, 1972; Bose and Majumdar, 1989; Quader et al., 1994; Khan and Saha, 1995). It has been determined that 10 amino acids viz., arginine, histidine, isoleusine, leusine, glysine, methionine, phenylalanine, threonine, tryptophan and valine are essential for silkworm nutrition (Arai and Ito, 1964; Inokuchi et al., 1967; Ito, 1967; Akter and Arghar, 1972). Bose et al. (1989) stated that amino acids are one of the most important constituents in silkworms that require 18 amino acids for their adequate nutrition. It is thus obvious that the study of larval growth is an important aspect of research for the insects that are economically
important. Successful cocoon crops in sericulture depend mostly on a healthy larval growth.

Recently, much research has been done on the diet supplementation of mulberry leaves fed to silkworms. These supplementations include vitamins such as ascorbic acid, thiamin, niacin, folic acid and multi-vitamins (Etebari 2002; Nirwani and Kaliwal 1996, 1998; Saha and Khan 1996; Etebari et al., 2004). Although some of the compounds have shown significant results, enrichment has not always caused the improvement of biological characteristics of the silkworm. In different studies, increase of supplement compound or increase of the period of its use show negative effects that could be due to hypervitaminosis. Etebari et al., (2004) reported the yield decrease, when ascorbic acid concentration is enhanced in silkworm diet. Saha and Khan (1996) reported the same effects from multi-vitamins. When silkworm larvae were treated with different concentrations of nicotinamide, high mortality was observed, although this vitamin is essential for *Bombyx mori* L. (Etebari 2002). Dosage of this vitamin is very determinative for normal growth of Mediterranean fruit fly. Chang and Li (2004) reported that nutritional interactions exist between vitamin B₃ and other groups of vitamin B.

Sericulture is a remunerative agro enterprise providing livelihood to millions of people in India. In order to meet our growing demand, the production and productivity of silk has to be improved. Among various technologies to improve the cocoon productivity, application of juvenile hormone (JH) on silkworm is practiced in several silk producing countries. They tend to keep the Fifth instar silkworm young for a specified period by extending the larval period and increase the silk secretion. It postpones the spinning stage by few hours. Altosid, R394, Manta and ZR512 are some of the commercial synthetic JH analogues used in countries like Japan and China. Synthetic JH analogues are hitherto not available for use by sericulturists in India. Moreover, the import of the chemical is cost prohibitive. Hence there is a need for identification of cost effective JH formulation for improving silk productivity.

It is established in insects that larval moulting is induced by the co-ordination of juvenile hormone, secreted by the corpora allata with the moultng hormone, secreted by the prothoracic glands and metamorphosis is induced by the moultng
hormone. The crystalline material of the moulting hormone secreted by the
prothoracic gland was first isolated from *Bombyx mori* L. pupae and was named
ecdysone (Butenandt *et al.*, 1954). Many plants contain a variety of chemicals with
moulting hormone activity in insects. The ready isolation from plants in contrast to the
extremely poor yield from insects and other sources makes it possible to produce large
amounts of active substances for biological testing. Over 100 ecdysteroids have been
structurally identified from a wide range of plant species (Lafont and Horn., 1989).

Considering the great bio-diversity of Indian flora, phytochemical research is
anticipated to provide potent radio modifiers and anticancer agents as well as
formulations for eco-friendly agriculture and sericulture. To this end, a new
polysaccharide obtained from the Indian medicinal plant, *Tinospora cordifolia* has
been found to possess impressive immunomodulatory (Indian Patent 183805) and
radio protective properties. The tissue culture technique has been evoked for its
optimized generation. A cheap moulting phytohormone (MH) preparation that
provides better quality of silk in a short time has been developed from an indigenous
natural source. The MH formulation was prepared by a continuous extraction
technique using an indigenous plant that is widely growing in the costal region of
India. Application of the formulation at a very low concentration (20 ppm) assists in
faster and uniform spinning of the silkworms leading to better silk productivity with
minimum loss of silk. The MH technology has been developed up to a scale of 5 kg of
the plant. The product is given to Central Sericulture Research and Training Institute,
Mysore for free distribution to silk farmers (Chattopadhyay, 2010).

The substances which are regulating the growth and yield in plants are called
plant growth regulators. It has been suggested that the plant growth regulators such as
gibberellins, auxins, cytokinines, abscissic acid and ethylene participate decisively in
complex bioprocesses. Administration of plant growth regulators are reported to
influence upon the developmental process of insects (Carlisle *et al.*, 1963). Panitz,
(1967) has found a specific effect of gibberlic acid GA3 upon the activity of the
genome exposed by puffs in the polytene chromosomes of larvae of midge,
*Acricotopus indicus*. Supp-lementation of GA3 increased larval duration, larval
weight, decreased fecundity and hatching in the bollworm, *Heliothis virescenc*

(Guerra, 1970), increased larval and pupal periods, emergence percentage and decreased pupal weight longevity, fecundity and hatching in Spodopter littoralis (Salama and Sharaby, 1972); absorption of plant materials in phytophygous insects influences development and physiology increased fecundity and viable eggs in the grass hopper, Aulocara eliotti (Neumam, 1982). It has been reported that the treatment with chloremphenicol increases the larval weight and shell ratio in the silkworm, B. mori (Krishnaswami, 1978). Feeding of mulberry leaves sprayed with GA₃ to IV instar larvae was reported to increase the larval weight and cocoon weight in the silkworm, Bombyx mori L. (Kamada and Ito 1984), Pai et al., (1986) have reported that topical application with Paraminobenzoic acid causes a significant reduction in hatchability of eggs of NB18 race of the silkworm, Bombyx mori L.

Magadum and Hooli (1989, 1991a, b) have reported that topical application with IAA, IBA, GA₃ and IPA in different larval stadium of pure Mysore multivoltine breed of the silkworm, B. mori, resulted in a significant increase in the larval weight, silk gland weight, cocoon weight and its shell weight in bivoltine silkworm, Bombyx mori L. (Hugar and Kaliwal, 1997). Goudar and Kaliwal (2001a,b) have reported that plant growth regulators 2, 4-dichloro-phenoxy acetic acid (2, 4-D) and naphthoxy-acetic acid (NOA) enhance the economic traits like larval weight, silk gland weight, cocoon weight, filament length and denier in the silkworm, Bombyx mori L.

Probiotics are the live microbial food supplements beneficially affecting the host by improving the microbial balance (Fuller, 1991 and Austin et al., 1995). Several researchers have reported about beneficial role played by use of probiotics in Humans (Chan et al., 1985; Brigidi et al., 2000 and 2001), aquaculture (Douillet and Langdon, 1994 and Gildberg et al., 1997) and insects (Dillon and Dillon, 2004). Therefore, products containing probiotic bacteria are gaining popularity, increasing the importance of their accurate speciation (Yeung et al., 2002). Similarly, in mulberry silkworm (Bombyx mori L.) presences of different types of bacteria in the gut have been reported (Roy et al., 2000 and Kodama, 2001). Most of the species belonging to Genus Streptococcus are found to be pathogenic to Bombyx mori L. larvae while bacteria from Genus Pediococcus, Leuconostoc and Lactobacillus didn’t produce any infected silkworm. The precise mechanism of beneficial effect on host or interaction
among the different bacterial strains present as micro-flora is not known (Steinhaus, 1949 and Kodama, 2001). Different species of lactic acid bacteria have been extensively studied (Bruno et al., 1993; Bernet Camard et al., 1997; Gibson et al. 1998; Kodama, 2001) and found to be beneficial as probiotics (Fuller, 1991; Bernet Camard, 1997; Sakamoto et al; 2001). Therefore it was planned to study the effect of a lactic acid bacteria namely *Lactobacillus plantarum* a known probiotics on economic parameters of *Bombyx mori* L.

Recently plant extracts particularly weeds are being used extensively in sericulture to increase the silk cocoon and egg yield of *Bombyx mori* L. Rajashekhargouda (1991). As the weeds are easily available and help to bring down the cost of production. It is seen that, there are very scanty attempts made by using the plants product fortification for improving the status of sericulture industry. An attempt made by Hiware and Bhalerao (2008) find out the effect of extract prepared from four medicinal plants viz. *Phyllanthus niruri, Tephrosia purpurea, Phyllanthus emblica,* and *Phyllanthus amarus* on the biological parameters of silkworm *Bombyx mori* L. In recent years many attempts have been made to fortify mulberry leaf with nutrients of botanical extracts so as to improve the leaf quality and feeding efficiency of silkworm which in turn will help to increase the cocoon production and silk quality (Bajpeyi, 1991; Das et al., 1993; Shivakumar et al., 1996; Kim et al., 1997; Patil et al., 1997a,b; Krishnaprasad et al., 2001; Hipparagi et al; 2003; Jeyapaul et al., 2003; Sabitha et al., 2003; Sujatha and Purushothamrao, 2003; Sujatha et al., 2003a,b; Venkataramana et al., 2003). Treatment of mulberry leaf with botanicals can increase the silkworm productivity leading to economic gain. The dietary nutritional management influences directly the quality and quantity of silk production in *Bombyx mori* L. (Benchamin and Jolly, 1986; Murugan et al., 1998).

Rajesh (2011) done a current experiment on mulberry leaves were supplemented with goose berry extract to study its effect on growth and silk production of silkworm. He shows that the mature larval weight did not differ significantly among the treatments. Gain in larval weight was significantly higher in control (without water), other treatments on par with each other. Pupal weight was significantly higher in the 20% solution treatment, other treatments being on par with

Goose berry (*Phyllanthus emblica L.*) is one of the richest sources of ascorbic acid. Barthakur and Arnold (1991) estimated that the berry contain 5889 ppm ascorbic acid. Apart from this the berry contain sugars, various minerals, amino acids and vitamins etc all of which play important role in the nutrition of silkworm and silk production (Shyamaia and Bhat, 1965; Subburathinam and Sulochana Chetty, 1990; Ito, 1960 and Ito, 1961).

Chandramohan (2011) also reported in Department of Sericulture, Tamil Nadu Agricultural University, Coimbatore has screened several plant products and short listed fewer plants possessing JH activity, (Phytojuvenoid) against silkworms. Extraction procedures were standardized and a novel botanical formulation was developed. Comparing the growth of silkworm to different phases of moon, the new formulation has been named ‘ILAMATHI’ (young moon) as it keeps the larvae young. The botanical formulation was found to increase the larval duration, cocoon weight and there by yield of 25.16 percent and also an increase in cocoon and over control.

*D. lablab* is a leguminous plant, found in India, is a seasonal dicotyledonous legume. It is commonly called as Indian bean. For the fulfillment of need of dietary proteins, the population of the subtropics, being predominantly vegetarian, looks to legumes like *D. lablab* as it is having more protein content. It is also called as poor man bean as it is cheap when compared with other beans. Extracts of *D. lablab* seeds were found to be mitogenic properties (Aurich et al., 1971). Although the effects of nitrogen, vitamin and salts supplementation on the growth of silkworm have been investigated by many researchers, the effect of mulberry leaves enriched with *D. lablab* was not investigated. So, the present study was aimed to find out the effective dose of *D. lablab* application to mulberry leaves on pupa weight, silk length and silk weight. By using the effective dose, further analysis of the activities of the digestive enzymes were done in the midgut of fourth day of fourth instar larvae of silkworm and an ultimate aim to find out whether the change in activities of the enzymes have impact on the growth and silk production of silkworm by Saravanan Manjula et al., (2010).

Kim et al., (1997) reported the effects of methanol extract of *Achyranthes japonica* on the development stages of silkworm, *Bombyx mori* L. Administration of

Methanolic extract of this plant at 6 hours before the appearance of early mature larvae enhanced remarkably the pupation ratio and cocoon quality besides shortening mounting duration. Murugan et al., (1999) shows aqueous of botanicals such as Tridax procumbens, Lantana camera, Clerodendron sp. and Croton sparsiflours stimulated the growth and development of mulberry silkworm, Bombyx mori L. (PM × NB4D2). Krishnaprasad et al., (2001) reported that mulberry leaf supplemented with potato leaf extract once during 3rd and 4th instar and twice during 5th instar recorded superior larval weight, lower larval mortality and larval duration higher cocoon weight, shell weight and shell ratio.

Hipparagi et al., (2003) showed the effects of filed spray of Lantana camara, Tridex procumbens and Parthenium hysterophorus extract at 30 and 40 % concentration during rainy, winter and summer seasons on silkworm growth and development. The results indicated that Parthenium (30 % aqueous) produced more fecundity while Lantana (30 %) and Tridex (40 %) results more cocoon yield. The effects of botanical extracts were found to be superior during rainy season than winter and summer seasons on silkworm growth and development. The supplementation of Spirulina (100 ppm) with mulberry feed to silkworm larvae (NB4D2 race) during 5th instar significantly enhanced the pupation rate, cocoon weight, shell weight and shell ratio as compared to control.

Sujatha and Purushothamrao (2003a) studied the effect of Eucalyptus globules leaf extract (0.1, 1.0, 2.0 and 5.0%) when fed to silkworm along with mulberry leaf. The total rearing period was reduced in all the concentration of E. globules. The economical character such as cocoon weight, shell weight, shell ratio and filament length showed improvement in 15 concentration of Eucalyptus leaf extract. Sujatha et al., (2003b) reported the effects of leaf of Azadirachta indica and Vitex negundo when supplemented to mulberry feeding of silkworm. There was significant improvement in shell ratio and filament length at 2.0% concentration of Vitex leaf extracts. But cocoon weight decreased in comparison to control.

Sabitha et al., (2003) reported that phytoecdysteroid treated silkworm during 5th instar completed spinning in 14 to15 hours as compared to control (32 to 38 hours). There was no adverse effect of phytoecdysteroid on cocoon characters. Jeypaul et al.,
(2003) reported that food assimilation rate, conversion efficiencies were significantly higher in silkworm fed on mulberry leaf supplemented with *Coffea Arabica* leaf extract at 1:25 concentration. The treatment recorded significantly higher cocoon weight, pupal weight and shell weight.

Padmalatha *et al.*, (2005) also study the effect of four ferns such as *Nephrolepis auriculata*, *Christrelia parasitica*, *Decranopteris linearis* and *Pityurogramma calomelanes* on the quantitative traits and energetic as of *B. mori* L. The impact of ferns to increase in the larval weight was noticed among fern extracts treated batches. The mean of the observations of three concentrations of each fern showed improvement in larval for *N. auriculata*, *C. parasitica*, *D. linearis* and *P. calomelanes*, respectively over control (0.493 g / animal). Significant differences in economic parameters of silkworm existed in relation to plant extracts. *N. auriculata* extracts at 0.1 0.2 and 0.4 per cent concentrations recorded higher cocoon weight, shell weight, pupal weight, and shell percentage.

Dietary nutritional management influences silk production in *Bombyx mori* L. In a study, the growth enhancing principles from indigenous botanicals, which have potential medicinal value and growth promoting effect were screened. The silk worm, *Bombyx mori* L. is a monophagous insect feeding on mulberry leaves. Adequate feed is required to rear silkworm and treatment with botanicals to the mulberry can increase production. *Leucas aspera* plant is a medically important and easily available plant. In view of these facts, the growth promoting effect of *L. aspera* on feeding, growth and bio-chemical changes of *Bombyx mori* L. were done (Senthil Nathan and Sangeetha, 2002).

The effects of potent substances showing positive results from laboratory finding need filed trials before developing a suitable nutrient as feed supplement for silkworm, *Bombyx mori* L. most of the work is conducted in laboratory without confirming the results in a large scale field trials at sericultural farms and or farmers field. An earnest effort is the need of hour to systematically test the efficacy of such Botanicals/ plant extracts keeping in mind the cost effectiveness of any future product to be developed as supplement for silkworm with an objective of improvement of cocoon characters of both parental breeds and hybrids.
Hence, attempt is made to find out the effect of extract prepared from two medicinal plants viz. *Ziziphus jujuba* L. and *Ficus racemosa* L. on the biological parameters of silkworm *Bombyx mori* L. As it is cheap, easy and effective methodology can be utilized by farmer to earn more in the same efforts.
2. Materials and Methods

The present investigations were undertaken during 2009-2011 seasonally/ in all seasons to study of PM X CSR2 hybrid race of silkworm *Bombyx mori* L. by feeding them with fortified mulberry leaves with certain plant extracts.

2.1 Location:

The studies were carried out at farmer mulberry field at Dongergaon village, Phulambri tehsil, Aurangabad (Maharashtra), India. Aurangabad is situated on 19° 52' North Latitude and 75° 18' East Longitude. The mean annual rainfall is about 750-850 mm. The mean daily maximum temperature varies from 30 °C in December to 45 °C in May. The minimum temperature varies from 11 °C in winter and 25-27 °C in summer. The mean relative humidity ranges from 30-90 %, as it is observed during study period 2009-11.

2.2 Materials used:

2.2.1 Seed Stock

Fresh disease free eggs of *Bombyx mori* L. (Race: PM ×CSR2) were obtained from the State Sericulture Department, Aurangabad District; Maharashtra, India. The experiment on fortification studies and biological characteristics of silkworm *Bombyx mori* L. were conducted with (Race: PM ×CSR2) hybrid.

2.2.2 Rearing Equipments

Following equipments were used for rearing the silkworms,

i) Rearing tray.

ii) Rearing stand.

iii) Chopping board, Soft wooded board.

iv) Chopping knife.

v) Chop sticks (used for giving space for young age)

vi) Feathers (used to brush newly hatched worms).

vii) Cleaning nets.

viii) Mountages (plastic).

ix) Paraffin paper, polythene sheet and foam pads to maintain humidity in rearing beds.

x) Formalin/Formaldehyde (0.2 - 0.4 %).

xi) ‘Vijetha’- bed disinfectant.

xii) 0.5% Slaked lime.

xiii) Muslin cloth – used for dusting ‘Vijetha’.

xiv) Humidifier.

xv) Polymeter (used to record temperature and humidity) (Plate No. 1).

xvi) Electric heater and other miner equipment necessary in rearing.

xvii) Reeling apparatus (Plate No. 4).

2.3 Rearing Method:

The rearing of silkworm was conducted as per the technology suggested by Krishnaswami, (1978) and Hiware, (2001). The rearing of silkworm hybrids was undertaken with the use of well grown mulberry plantation of different mulberry varieties.

The rearing house (Plate No. 1) and all the rearing appliances were disinfected with Formalin solution (2-4 %) to make them free from pathogens before rearing. Paper sheet of disease free layings (dfls) of silkworm hybrids were obtained from State Sericulture Department, Aurangabad District; Maharashtra, India and were incubated at of $25 \pm 1^\circ C$ and $75 \pm 5$ % relative humidity. The egg sheets were spread out in a single layer in rearing trays and covered with paraffin paper. Wet foam rubber pads were kept all around the egg sheets to ensure the required humidity for incubation. The trays containing egg sheets were stored in cool place in rearing house.

On attaining the blue egg stage, the egg sheets were placed into a cardboard box and covered by black piece of cloth and left undisturbed for uniform growth of embryo, after which the egg were exposed to bright light for one hour for uniform hatching immediately after hatching fresh tender mulberry leaves cut into size 0.5 to 1.0 sq. cm were sprinkled on worms. When all the larvae crawled over the sprinkled leaves. The leaves along with the worms were gently brushed on the polythene sheets spread in the rearing trays.

Soon after brushing rearing bed was made with more chopped leaves and covered with polythene sheet. Clean wet foam pads were placed around the rearing bed to ensure required humidity. The rearing room temperature was maintained at about $27^\circ C \pm 1$. The trays were piled up one above other in the form of box to
maintain temperature to conserve leaf moisture and to ensure vigorous larval growth. Tender mulberry leaves with more moisture content were fed for feeding the worms in the initial stages of rearing. The worms were fed four times a day with chopped leaves for feeding first instar larvae highly nutritious top two full blown leaves as mulberry immediately below the growing bud were plucked and fed fresh. Care was taken to distribute the worms uniformly and to maintain the space in the rearing bed. Every day morning before feeding the beds were spread to dry the leaves and to enable the larvae to crawl on the surface of fresh leaves. This helped in maintaining hygiene and microclimate of bed. When the worms started setting for first moult the polythene sheet cover and wet foam pads were removed. Feeding was reduced during the period. During moulting the rearing bed was kept dry and undisturbed. The worms required about 24 hrs to come out of first moult. When the worms were ready for resumption of feeding the bed disinfectant Vijetha was taken in a thin cloth and dusted all over the worms as per the schedule mentioned by Kawakami, et al., (2003) per 100 dfls. Feeding was resumed 30 minutes later.

Clean nylon bed nets of required mesh size were spread on the bed and chopped tender mulberry leaves spread on it. In short time all the larvae crawled on the leaves over the net and were lifted along with net. After removing the bed waste, the worms were placed back in the trays. The wet foam pads were placed in position and the trays were covered with polythene sheet. The feeding was continued four times a day. The rearing beds were cleaned daily in morning expanding the size of bed corresponding to growth of larvae. When larvae settled for 2nd moult again foam pads and polythene covers were removed to unnecessary moisture in the tray. When worms completely settled for moult, feeding was stopped. In about 24 hrs time all the larvae came out of 2nd moult. The bed disinfected with ‘Vijetha’, the larvae were fed with tender mulberry leaves and beds were cleaned as described earlier. As per requirement space was provided in 3rd instar the polythene sheet was spread and the wet foam pads were not used due to less requirements of relative humidity i.e. below 80 %. The leaves with medium maturity were feed. The rearing beds were cleaned daily in morning from third instar onwards. In the third instar larvae were fed for 3 to 3.5 days after which they settled for moult. Following the regular procedure, the feeding was
resumed and required spacing was provided after 24 hours. The fourth instar took 4 to 4.5 days followed by 4th moult (about 30 hrs). The duration of 5th instar was normally 6 to 7 days and the larvae started to spin cocoons by the end of this stage. On the 4th day of 5th instar the bed was disinfected with ‘Vijetha’ once more. During 5th instar larvae were fed with fully matured mulberry leaves and for the last two days coarse leaves were used for feeding at the end of 5th instar plate larvae release wet faecal matter, shrink in size, body becomes translucent and start crawling in the bed with raised head. These are indications that larvae were ready for spinning the cocoon. They were individually picked up and transferred to mountages for spinning the cocoon. When about 70-80 % worms were mounted, the remaining worms were mounted at once. The Larvae were left undisturbed till 6th day of spinning after which cocoons were harvested.

2.4. Method of recording observations:

The observations on economic parameters such as mature larval weight, cocoon weight, pupal weight, shell weight, shell percentage, filament length and denier were determined. Growth parameters were measured on dry weight basis (Waldbauer, 1968). Observations were recorded on following parameters on ten randomly selected larvae / cocoons of silkworm hybrid (Race: PM ×CSR2).

2.4.1 Larval weight (g)

Mean larval weight was recorded in grams for ten randomly selected five day old 5th instar larvae from each replication and hybrid. Larval weight was taken by using an electronic balance (Plate No. 4).

2.4.2 Total Mortality (g)

Record of dead larval number from selected 5th instar larvae up to spinning stage from each replication and hybrid.

2.4.3 Single cocoon weight (g)

The cocoon weight (g) was calculated as average weight of ten cocoons taken at random each replication. Ten randomly selected cocoons were taken and weighed using an Electronic balance. The weight was expressed in grams.

2.4.4 Single cocoon shell weight (g)

The shell weight (g) calculated as average weight as 10 shells taken at random from each replication. The shell weight of the cocoon, after removing the floss and pupa was weighed using an Electronic balance.

Cocoon shell weight = \( \frac{\text{Weight of shell (g)}}{\text{Total number of shell}} \)

2.4.5 Shell ratio percentage (%)

The cocoon shell ratio was determined by dividing the cocoon shell weight by cocoon weight. The Shell ratio was calculated using the following formula and expressed in percentage.

Cocoon shell ratio (%) = \( \frac{\text{Weight of cocoon shell (g)}}{\text{Weight of cocoon (g)}} \times 100 \)

2.4.6 Pupal weight (g)

Mean pupal weight was recorded in grams for ten randomly selected pupae from cocoon of each replication and hybrid. After removing the floss, the cocoons were cut open and the pupae were taken out without causing any damage to them. Then the pupae were weighed using an electronic balance.

2.4.7 Filament length (m)

The length of filament reeled from single cocoon is measured in meter ten cocoon were collected randomly from each replication and reeled individually. An average of ten cocoons is recorded. Cocoons from each replication were stifled in boiling water and threads from individual cocoons were reeled using an epprouvette and observed for their silk characters such as silk filament length.

2.4.8 Filament weight (g)

The weight of filament was measured in gram which reeled from individual cocoon. Cocoons from each replication were stifled in boiling water and threads from
individual cocoons were reeled using an epprouvette and observed for their silk characters such as filament weight.

2.4.9 Denier

This denotes the thickness of the filament. Nine thousand meters of silk filament weighing 1 gm is considered as 1 denier. The reeled silk was dried and weight was taken for calculation. Denier is the unit, used to denote the thickness of silk filament. It is the weight of 9,000m length of silk expressed in gms. The value of denier varies from 1.7 to 2.8. It is calculated by using the formula.

\[
\text{Denier} = \frac{\text{Weight of raw silk reeled (g)}}{\text{Weight of raw silk reeled (m)}} \times 9000
\]

Filament denier is used to estimate the number of cocoons required to reel the silk of a specific denier. Filament denier is measured using an epprouvette and a denier scale.

2.4.10 No. of Breakages

The total number of breakages during reeling of silk thread of ten cocoons is recorded.

2.5 Fortification studies and biological characterization of Silkworm using certain plant extracts on economic traits of silkworm.

2.5.1 Experimental details

i) Design : Completely Randomized Design (CRD)

ii) Number of Replication : 2

iii) Mulberry variety feed : V1

iv) Number of treatments : 6

\[
\begin{align*}
T1 &= \text{Ziziphus jujuba (1:2)} \\
T2 &= \text{Ziziphus jujuba (1:4)} \\
T3 &= \text{Ziziphus jujuba (1:8)} \\
T4 &= \text{Ficus racemosa (1:2)} \\
T5 &= \text{Ficus racemosa (1:4)} \\
T6 &= \text{Ficus racemosa (1:8)}
\end{align*}
\]
The disease free laying of (Race: PM × CSR2) was used for the evaluation of fortification studies and biological characteristic of silkworm. The experiments were conducted by taking randomly fresh 4th moult parsed 5th instar larvae (Plate No. 1) in five groups each containing 50 larvae with two replicas. For fortification of the fresh parts of plant, *Ficus racemosa* (Leaves of plant) and *Ficus racemosa* (Leaves of plant) were procured from Dr. Babasaheb Ambedkar Marathwada university campus, Aurangabad and were used to prepare the test solution.

The test solution were prepared by crushing 25gm of plant material in glass pestle and mortar and extracted with 100ml distilled water. The extract was filtered through muslin cloth and filtrates were used as stock solution. The stock solution was used to further dilution of 1:2, 1:4 and 1:8 ratio of each extract in distilled water (Plate No. 2). The quantity of feed given to the each groups was 40 g of matured mulberry chopped leaves for each feed and four feeding per day were provided. One group was kept as control and given feeding with non treated mulberry leaves but the experimental groups was given first feed sprinkled, mixed with the 5 ml of test solution till the larvae went on spinning (Plate No. 2) during rearing, the worms were grouped in two batches with 50 larvae each. All test is individual were maintained in the farmers field at 27 ± 4 °C and 60 ± 15 % relative humidity. All the rearing operations were carried out according to Krishnaswami et al., (1978) and Hiware, C. J (2001).

2.5.2 Observations recorded and Statistical analysis

The evaluation of fortification was based on the economic parameters such as Larval weight, Total mortality of larvae, Cocoon weight, Pupal weight, Shell ratio %, Average filament length, Average weight of filament, Average denier of filament and No. of breakages was investigated during the period of experimentation and the values were compared in between experimental and control groups by showing percent change over control. For fortification study the significant difference between control and experimental groups were observed by t - test.

\[
\text{Percentage change over control} = \left( \frac{\text{Treated value} - \text{Control value}}{\text{Control value}} \right) \times 100
\]
3. Results

Experimental studies were undertaken to evaluate the performance of PM X CSR2 hybrid race using *Ziziphus jujuba* L. and *Ficus racemosa* L. plant extracts on economic traits of silkworm *Bombyx mori* L. the results obtained are presented in this chapter.

3.1. Fortification studies and biological characteristic of silkworm *Bombyx mori* L. using certain plant extracts.

3.1.1. Larval weight (g)

The data on larval weight among silkworm hybrid PM X CSR2 presented in table 1 – 12 and graphically depicted in Fig 1 – 12.

3.1.1 (a) In Rainy season

During 2009 – 10

The results on the effect of plant extracts on larval weight of silkworm are presented in table 1, 2 and 7, 8 as well as graphically depicted in fig 1, 2 and 7, 8.

The results were very interesting in all the treated cases. In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the larval weight was seen increased by T3 (57.89 %), T2 (53.92 %) and T1 (44.79 %) during rainy season 2009. During rainy season 2010 shows that larval weight was also increased by T3 (16.93 %), T1 (11.35 %) and T2 (3.65 %) respectively when compared with the percent change over control group.

In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the larval weight was seen increased by T4 (56.66 %), T5 (40.54 %) and T6 (26.59 %) during rainy season 2009. During rainy season 2010 shows that larval weight was also increased by T5 (19.79 %), T4 (8.40 %) and T6 (7.18 %) respectively when compared with the percent change over control group.

From this it is clear that during rainy season 2009 -10 shows increased larval weight for all treated groups of both plant extracts as compared with percent change over control group. But overall performance of T3 and T5 both shows better result as compare with other treated groups and control group for larval weight parameter during study period.
3.1.1 (b) In Winter season

During 2009 – 10

The results on the effect of plant extracts on larval weight of silkworm are presented in table 3, 4 and 9, 10 as well as graphically depicted in fig 3, 4 and 9, 10.

In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the larval weight was seen increased by T3 (22.06 %), T1 (13.65 %) and T2 (10.75 %) during winter season 2009. During winter season 2010 shows that larval weight was also increased by T3 (33.74 %), T2 (15.23 %) and T1 (13.97 %) respectively when compared with the percent change over control group.

In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the larval weight was seen increased by T6 (22.51 %), T5 (12.95 %) and T4 (12.55 %) during rainy season 2009. During winter season 2010 shows that larval weight was also increased by T6 (33.24 %), T5 (27.45 %) and T4 (20.53 %) respectively when compared with the percent change over control group.

From this it is clear that during winter season 2009 - 10 shows increased larval weight for all treated groups of both plant extracts as compared with control group. But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for larval weight parameter during study period.

3.1.1 (c) In Summer season

During 2010 – 11

The results on the effect of plant extracts on larval weight of silkworm are presented in table 5, 6 and 11, 12 as well as graphically depicted in fig 5, 6 and 11, 12.

The results were very interesting in all the treated groups. In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the larval weight was seen increased by T3 (48.94 %), T2 (41.40 %) and T1 (27.094 %) during summer season 2010. During summer season 2011 shows that larval weight was also increased by T3 (15.55 %), T2 (12.60 %) and T1 (2.43 %) respectively when compared with percent change over the control group.

In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the larval weight was seen increased by T6 (38.069 %), T5 (37.089 %) and T4 (27.19 %) during summer season 2010. During summer season 2011
shows that larval weight was also increased by T6 (23.17 %), T5 (17.697 %) and T4 (10.085 %) respectively when compared with the percent change over control group.

From this it is clear that during summer season 2010 -11 shows increased larval weight for all treated groups of both plant extracts as compared with control group. But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for larval weight parameter during study period.

3.1.2 Total mortality
The data on total mortality number during fortification after fourth moult passed larvae up to spinning stage were note down during study period which is presented in table 1 – 12 and graphically depicted in Fig 1 – 12.

3.1.2 (a) In Rainy Season
During 2009 – 10

The mortality has also shown negative trend during the rearing it was -100 % for all treatments *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) during rainy season 2009 – 2010. The *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts shows that variation in mortality trends i.e.T4 (50%), T5 (100%) and T6 (-100 %) during rainy season 2009, but rainy season 2010 shows negative trend during the rearing it was -100 % for all treatments when compared with percent change over control group.

3.1.2 (b) In Winter Season
During 2009 – 10

The mortality has also shown negative trend during the rearing it was -100 % for all treatments *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) during winter season 2009 – 2010. The *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts shows that negative trend during the rearing it was -100 % for all treatments when compared with percent change over control group during winter season 2009 – 2010.

3.1.2 (c) In Summer Season
During 2010 – 11

The mortality has also shown negative trend during the rearing it was -100 % for all treatments *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) during summer season 2010 – 2011. The *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts shows that negative trend
during the rearing it was -100 % for all treatments when compared with percent change over control group during summer season 2010 – 2011.

It indicates that both plant extracts treatments had no mortality to remarkable extent. So that it is clear those treatments have no larvicidal activity with various concentrations and it requires further detail study.

3.1.3 Cocoon weight (g)
The data on cocoon weight among silkworm hybrid PM X CSR2 presented in Table 1 – 12 and graphically depicted in Fig 1 – 12.

3.1.3 (a) In Rainy Season
During 2009 – 10

Cocoon shell weight along with cocoon weight and cocoon shell ratio is considered to be the most important economic characters in silkworm. The results on the effect of plant extracts on cocoon weight of silkworm are presented in table 1, 2 and 7, 8 as well as graphically depicted in fig 1, 2 and 7, 8.

The results were very interesting in all the treated cases. In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the cocoon weight was seen increased by T1 (33.58 %), T3 (30.33 %) and T2 (15.80 %) during rainy season 2009. During rainy season 2010 shows that cocoon weight was also increased by T3 (23.52 %), T1 (22.28 %) and T2 (7.60 %) respectively when compared with the percent change over control group.

In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the cocoon weight was seen increased by T6 (42.88 %), T4 (32.83 %) and T5 (24.43 %) during rainy season 2009. During rainy season 2010 shows that cocoon weight was also increased by T6 (35.40 %), T5 (26.24 %) and T4 (21.43 %) respectively when compared with the percent change over control group.

From this it is clear that during rainy season 2009 -10 shows increased cocoon weight for all treated groups of both plant extracts as compared with percent change over control group. But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for cocoon weight parameter during study period.
3.1.3 (b) In Winter season

During 2009 – 10

The results on the effect of plant extracts on cocoon weight of silkworm are presented in table 3, 4 and 9, 10 as well as graphically depicted in fig 3, 4 and 9, 10.

In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the cocoon weight was seen increased by T1 (18.30 %), T3 (5.25 %) and T2 (4.18 %) during winter season 2009. During winter season 2010 shows that cocoon weight was also increased by T3 (31.62 %), T2 (30.10 %) and T1 (19.77 %) respectively when compared with the percent change over control group.

In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the cocoon weight was seen increased by T5 (3.94 %), T4 (3.77 %) and T6 (1.149 %) during winter season 2009. During winter season 2010 shows that cocoon weight was also increased by T6 (45.63 %), T5 (27.22 %) and T4 (22.25 %) respectively when compared with the percent change over control group.

From this it is clear that during winter season 2009 - 10 shows increased cocoon weight for all treated groups of both plant extracts as compared with control group. But overall performance of T3 and T5 both shows better result as compare with other treated groups and control group for cocoon weight parameter during study period.

3.1.3 (c) In Summer season

During 2010 – 11

The results on the effect of plant extracts on cocoon weight of silkworm are presented in table 5, 6 and 11, 12 as well as graphically depicted in fig 5, 6 and 11, 12.

The results were very interesting in all the treated groups. In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the cocoon weight was seen increased by T3 (8.57 %), T2 (0 %) and T1 (-0.46 %) during summer season 2010. During summer season 2011 shows that cocoon weight was also increased by T1 (20.99 %), T2 (16.81 %) and T3 (14.67 %) respectively when compared with percent change over the control group.

In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the cocoon weight was seen increased by T6 (38.069 %), T5
Rearing performance of *Bombyx mori* L. using certain plant extracts.

(37.089 %) and T4 (27.19 %) during summer season 2010. During summer season 2011 shows that cocoon weight was also increased by T6 (23.17 %), T5 (17.697 %) and T4 (10.085 %) respectively when compared with the percent change over control group.

From this it is clear that during summer season 2010 -11 shows increased cocoon weight for all treated groups of both plant extracts as compared with control group. But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for cocoon weight parameter during study period.

### 3.1.4 Pupal weight (g)

The data on Pupal weight among silkworm hybrid PM X CSR2 presented in Table 1 – 12 and graphically depicted in Fig 1 – 12.

**3.1.4 (a) In Rainy Season**

**During 2009 – 10**

The results on the effect of plant extracts on pupal weight of silkworm are presented in table 1, 2 and 7, 8 as well as graphically depicted in fig 1, 2 and 7, 8.

The results were very interesting in all the treated cases. In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the pupal weight was seen increased by T1 (32.51 %), T3 (26.52 %) and T2 (15.07 %) during rainy season 2009. During rainy season 2010 shows that pupal weight was also increased by T1 (20.49 %), T3 (18.65 %), and T2 (4.24 %) respectively when compared with the percent change over control group.

In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the pupal weight was seen increased by T6 (41.41 %), T4 (32.15 %) and T5 (24.06 %) during rainy season 2009. During rainy season 2010 shows that pupal weight was also increased by T6 (29.17 %), T5 (23.82 %) and T4 (14.77 %) respectively when compared with the percent change over control group.

From this it is clear that during rainy season 2009 -10 shows increased pupal weight for all treated groups of both plant extracts as compared with percent change over control group. But overall performance of T1 and T6 both shows better result as
compare with other treated groups and control group for pupal weight parameter during study period.

3.1.4 (b) In Winter season

During 2009 – 10

The results on the effect of plant extracts on pupal weight of silkworm are presented in table 3, 4 and 9, 10 as well as graphically depicted in fig 3, 4 and 9, 10.

In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it was observed that the pupal weight was seen increased by T1 (14.51 %), T3 (-1.05 %) and T2 (-1.33 %) during winter season 2009. During winter season 2010 shows that pupal weight was also increased by T3 (15.82 %), T2 (12.54 %) and T1 (8.80 %) respectively when compared with the percent change over control group.

In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it was observed that the pupal weight was seen decreased by T5 (-0.477 %), T4 (-0.764 %) and T6 (-2.101 %) during winter season 2009. During winter season 2010 shows that pupal weight was also increased by T6 (26.59 %), T5 (12.82 %) and T4 (10.39 %) respectively when compared with the percent change over control group.

From this it is clear that during winter season 2009 show decreased pupal weight for both plant extracts and winter season 2010 shows increased pupal weight for all treated groups of both plant extracts as compared with control group. But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for pupal weight parameter during study period.

3.1.4 (c) In Summer season

During 2010 – 11

The results on the effect of plant extracts on pupal weight of silkworm are presented in table 5, 6 and 11, 12 as well as graphically depicted in fig 5, 6 and 11, 12.

The results were very interesting in all the treated groups. In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it was observed that the pupal weight was seen decreased by T1 (-0.895 %), T3 (-2.127 %) and T2 (-7.39 %) during summer season 2010. During summer season 2011 shows that pupal weight was also increased by T1 (20.98 %), T2 (16.19 %) and T3 (12.63 %) respectively when compared with percent change over the control group.
In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the pupal weight was seen decreased by T6 (3.023 %), T5 (-2.687 %) and T4 (-6.047 %) during summer season 2010. During summer season 2011 shows that pupal weight was also increased by T4 (29.32 %), T5 (15.90 %) and T6 (13.86 %) respectively when compared with the percent change over control group.

From this it is clear that during summer season 2010 show decreased pupal weight for both plant extracts and summer season 2011 shows increased pupal weight for all treated groups of both plant extracts as compared with control group. But overall performance of T1 and T4 both shows better result as compare with other treated groups and control group for pupal weight parameter during study period.

### 3.1.5 Shell weight (g)

Cocoon shell weight along with cocoon weight and cocoon shell ratio is considered to be the most important economic characters in silkworm. The data on shell weight among silkworm hybrid PM X CSR2 presented in Table 1 – 12 and graphically depicted in Fig 1 – 12.

#### 3.1.5 (a) In Rainy Season

**During 2009 – 10**

The results on the effect of plant extracts on shell weight of silkworm are presented in table 1, 2 and 7, 8 as well as graphically depicted in fig 1, 2 and 7, 8.

The results were very interesting in all the treated cases. In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the shell weight was seen increased by T3 (49.32 %), T1 (39.82 %), and T2 (19.45 %) during rainy season 2009. During rainy season 2010 shows that shell weight was also increased by T3 (49.75 %), T1 (31.70 %), and T2 (25.56 %) respectively when compared with the percent change over control group.

In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the shell weight was seen increased by T6 (50.22 %), T4 (34.39 %) and T5 (26.24 %) during rainy season 2009. During rainy season 2010 shows that shell weight was also increased by T6 (68.29 %), T4 (56.09 %) and T5 (40.97 %) respectively when compared with the percent change over control group.
From this it is clear that during rainy season 2009-10 shows increased shell weight for all treated groups of both plant extracts as compared with percent change over control group. But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for shell weight parameter during study period.

3.1.5 (b) In Winter season

During 2009 – 10

The results on the effect of plant extracts on shell weight of silkworm are presented in table 3, 4 and 9, 10 as well as graphically depicted in fig 3, 4 and 9, 10.

In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the shell weight was seen increased by T1 (44.70 %), T3 (42.35 %) and T2 (39.41 %) during winter season 2009. During winter season 2010 shows that shell weight was also increased by T2 (135 %), T3 (126.11 %) and T1 (85.55 %) respectively when compared with the percent change over control group.

In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the shell weight was seen increased by T4 (32.35 %), T6 (21.76 %) and T5 (17.64 %) during winter season 2009. During winter season 2010 shows that shell weight was also increased by T6 (159.44 %), T5 (107.7 %) and T4 (93.33 %) respectively when compared with the percent change over control group.

From this it is clear that during winter season 2009-10 shows increased shell weight for all treated groups of both plant extracts as compared with control group. But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for shell weight parameter during study period.

3.1.5 (c) In Summer season

During 2010 – 11

The results on the effect of plant extracts on shell weight of silkworm are presented in table 5, 6 and 11, 12 as well as graphically depicted in fig 5, 6 and 11, 12.

The results were very interesting in all the treated groups. In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the shell weight was seen increased by T2 (29.16 %), T1 (11.45 %) and T3 (-6.25 %) during summer season 2010. During summer season 2011 shows that shell weight
was also increased by T3 (24.69 %), T1 (23.49 %) and T2 (19.87 %) respectively when compared with percent change over the control group.

In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the shell weight was seen increased by T6 (33.85 %), T4 (20.31 %) and T5 (5.729 %) during summer season 2010. During summer season 2011 shows that shell weight was also increased by T4 (30.12 %), T6 (16.86 %) and T5 (16.26 %) respectively when compared with the percent change over control group.

From this it is clear that during summer season 2010 -11 shows increased shell weight for all treated groups of both plant extracts as compared with control group. But overall performance of T1 and T6 both shows better result as compare with other treated groups and control group for shell weight parameter during study period.

### 3.1.6 Shell ratio (%)

Cocoon shell ratio is considered as one of the most important characters because it decides even the price of cocoon in the market. The data on shell ratio (%) among silkworm hybrid PM X CSR2 presented in Table 1 – 12 and graphically depicted in Fig 1 – 12.

#### 3.1.6 (a) In Rainy Season

During 2009 – 10

The results on the effect of plant extracts on shell ratio of silkworm are presented in table 1, 2 and 7, 8 as well as graphically depicted in fig 1, 2 and 7, 8.

The results were very interesting in all the treated cases. In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the shell ratio was seen increased by T3 (15.29 %), T1 (5.059 %), and T2 (2.92 %) during rainy season 2009. During rainy season 2010 shows that shell ratio was also increased by T3 (21.12 %), T2 (15.31 %) and T1 (6.81 %) respectively when compared with the percent change over control group.

In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the shell ratio was seen increased by T6 (5.29 %), T5 (1.37 %) and T4 (1.13 %) during rainy season 2009. During rainy season 2010 shows that shell ratio was also increased by T4 (25.93 %), T6 (22.81 %) and T5 (11 %) respectively when compared with the percent change over control group.
From this it is clear that during rainy season 2009-10 shows increased shell ratio for all treated groups of both plant extracts as compared with percent change over control group. But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for shell ratio parameter during study period.

3.1.6 (b) In Winter season

During 2009 – 10

The results on the effect of plant extracts on shell ratio of silkworm are presented in table 3, 4 and 9, 10 as well as graphically depicted in fig 3, 4 and 9, 10.

In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the shell ratio was seen increased by T3 (36.35 %), T2 (32.92 %) and T1 (23.13 %) during winter season 2009. During winter season 2010 shows that shell ratio was also increased by T2 (77.15 %), T3 (72.71 %) and T1 (51.50 %) respectively when compared with the percent change over control group.

In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the shell ratio was seen increased by T4 (26.22 %), T5 (25.16 %) and T6 (20.34 %) during winter season 2009. During winter season 2010 shows that shell ratio was also increased by T6 (74.42 %), T5 (64.32 %) and T4 (55.047 %) respectively when compared with the percent change over control group.

From this it is clear that during winter season 2009-10 shows increased shell ratio for all treated groups of both plant extracts as compared with control group. But overall performance of T3 and T5 both shows better result as compare with other treated groups and control group for shell ratio parameter during study period.

3.1.6 (c) In Summer season

During 2010 – 11

The results on the effect of plant extracts on shell ratio of silkworm are presented in table 5, 6 and 11, 12 as well as graphically depicted in fig 5, 6 and 11, 12.

The results were very interesting in all the treated groups. In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the shell ratio was seen increased by T3 (50.11 %), T2 (35.91 %) and T1 (11.57 %) during summer season 2010. During summer season 2011 shows that shell ratio was also
increased by T3 (9.61 %), T2 (2.83 %) and T2 (2.005 %) respectively when compared with percent change over the control group.

In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the shell ratio was seen increased by T4 (23.31 %), T6 (21.09 %) and T5 (8.894 %) during summer season 2010. During summer season 2011 shows that shell ratio was also increased by T6 (2.182 %), T4 (1.179 %) and T5 (0.766 %) respectively when compared with the percent change over control group.

From this it is clear that during summer season 2010 -11 shows increased shell ratio for all treated groups of both plant extracts as compared with control group. But overall performance of T3 and T4 both shows better result as compare with other treated groups and control group for shell ratio parameter during study period.

### 3.1.7 Filament length (m)

The data on Filament length (m) among silkworm hybrid PM X CSR2 presented in Table 1 – 12 and graphically depicted in Fig 1 – 12.

#### 3.1.7 (a) In Rainy Season

**During 2009 – 10**

The results on the effect of plant extracts on Filament length of silkworm are presented in table 1, 2 and 7, 8 as well as graphically depicted in fig 1, 2 and 7, 8.

The results were very interesting in all the treated cases. In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the Filament length was seen increased by T3 (44.22 %), T1 (42.76 %), and T2 (39.89 %) during rainy season 2009. During rainy season 2010 shows that Filament length was also increased by T3 (25.38 %), T2 (25.16 %) and T1 (16.46 %) respectively when compared with the percent change over control group.

In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the Filament length was seen increased by T6 (50.98 %), T4 (47.07 %) and T5 (41.11 %) during rainy season 2009. During rainy season 2010 shows that Filament length was also increased by T6 (29.16 %), T5 (18.29 %) and T4 (8.77 %) respectively when compared with the percent change over control group.

From this it is clear that during rainy season 2009 -10 shows increased Filament length for all treated groups of both plant extracts as compared with percent
change over control group. But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for Filament length parameter during study period.

3.1.7 (b) In Winter season

During 2009 – 10

The results on the effect of plant extracts on Filament length of silkworm are presented in table 3, 4 and 9, 10 as well as graphically depicted in fig 3, 4 and 9, 10.

In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the Filament length was seen increased by T3 (16.56 %), T1 (14.96 %) and T2(10.16 %) during winter season 2009. During winter season 2010 shows that Filament length was also increased by T3 (28.65 %), T2 (17.20 %) and T1 (7.627 %) respectively when compared with the percent change over control group.

In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the Filament length was seen increased by T6 (16.52 %), T4 (11.14 %) and T5 (9.897 %) during winter season 2009. During winter season 2010 shows that Filament length was also increased by T6 (31.26 %), T5 (20.75 %) and T4 (13.50 %) respectively when compared with the percent change over control group.

From this it is clear that during winter season 2009 - 10 shows increased Filament length for all treated groups of both plant extracts as compared with control group. But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for Filament length parameter during study period.

3.1.7 (c) In Summer season

During 2010 – 11

The results on the effect of plant extracts on Filament length of silkworm are presented in table 5, 6 and 11, 12 as well as graphically depicted in fig 5, 6 and 11, 12.

The results were very interesting in all the treated groups. In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the Filament length was seen increased by T3 (11.64 %), T2 (5.99 %) and T1 (5.33 %) during summer season 2010. During summer season 2011 shows that Filament length
was also increased by T3 (45.39 %), T2 (24.52 %) and T1 (18.95 %) respectively when compared with percent change over the control group.

In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the Filament length was seen increased by T6 (19.62 %), T5 (17.35 %) and T4 (11.54 %) during summer season 2010. During summer season 2011 shows that Filament length was also increased by T6 (35.013 %), T4 (31.77 %) and T5 (28.64 %) respectively when compared with the percent change over control group.

From this it is clear that during summer season 2010 -11 shows increased Filament length for all treated groups of both plant extracts as compared with control group. But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for Filament length parameter during study period.

### 3.1.8 Filament weight (g)

The data on Filament weight (g) among silkworm hybrid PM X CSR2 presented in Table 1 – 12 and graphically depicted in Fig 1 – 12.

#### 3.1.8 (a) In Rainy Season

**During 2009 – 10**

The results on the effect of plant extracts on Filament weight of silkworm are presented in table 1, 2 and 7, 8 as well as graphically depicted in fig 1, 2 and 7, 8.

The results were very interesting in all the treated cases. In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the Filament weight was seen increased by T3 (61.65 %), T2 (54.88 %), and T1 (47.37 %) during rainy season 2009. During rainy season 2010 shows that Filament weight was also increased by T3 (30.065 %), T2 (23.53 %) and T1 (18.95 %) respectively when compared with the percent change over control group.

In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the Filament weight was seen increased by T6 (75.19 %), T4 (66.16 %) and T5 (63.90 %) during rainy season 2009. During rainy season 2010 shows that Filament weight was also increased by T6 (35.94 %), T5 (19.60 %) and T4 (11.76 %) respectively when compared with the percent change over control group.
From this it is clear that during rainy season 2009-10 shows increased Filament weight for all treated groups of both plant extracts as compared with percent change over control group. But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for Filament weight parameter during study period.

3.1.8 (b) In Winter season

During 2009 – 10

The results on the effect of plant extracts on Filament weight of silkworm are presented in table 3, 4 and 9, 10 as well as graphically depicted in fig 3, 4 and 9, 10.

In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the Filament weight was seen increased by T3 (26.61 %), T1 (16.93 %) and T2 (12.90 %) during winter season 2009. During winter season 2010 shows that Filament weight was also increased by T3 (55.94 %), T2 (27.27 %) and T1 (11.88 %) respectively when compared with the percent change over control group.

In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the Filament weight was seen increased by T6 (28.22 %), T4 (18.55 %) and T5 (16.93 %) during winter season 2009. During winter season 2010 shows that Filament weight was also increased by T6 (58.04 %), T5 (55.24 %) and T4 (32.86 %) respectively when compared with the percent change over control group.

From this it is clear that during winter season 2009 - 10 shows increased Filament weight for all treated groups of both plant extracts as compared with control group. But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for Filament weight parameter during study period.

3.1.8 (c) In Summer season

During 2010 – 11

The results on the effect of plant extracts on Filament weight of silkworm are presented in table 5, 6 and 11, 12 as well as graphically depicted in fig 5, 6 and 11, 12.

The results were very interesting in all the treated groups. In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the Filament weight was seen increased by T3 (18.24 %), T2 (12.40 %) and T1 (10.94 %)
during summer season 2010. During summer season 2011 shows that Filament weight was also increased by T3 (75.92 %), T2 (28.70 %) and T1 (20.37 %) respectively when compared with percent change over the control group.

In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the Filament weight was seen increased by T6 (24.81 %), T4 (24.087 %) and T5 (18.98 %) during summer season 2010. During summer season 2011 shows that Filament weight was also increased by T6 (51.85 %), T5 (51.85 %) and T4 (43.51 %) respectively when compared with the percent change over control group.

From this it is clear that during summer season 2010 -11 shows increased Filament weight for all treated groups of both plant extracts as compared with control group. But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for Filament weight parameter during study period.

### 3.1.9 Denier

The data on Denier among silkworm hybrid PM X CSR2 presented in Table 1 – 12 and graphically depicted in Fig 1 – 12.

#### 3.1.9 (a) In Rainy Season

**During 2009 – 10**

The results on the effect of plant extracts on Denier of silk filament are presented in table 1, 2 and 7, 8 as well as graphically depicted in fig 1, 2 and 7, 8.

The results were very interesting in all the treated cases. In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the Denier was seen increased by T3 (12.94 %), T2 (12.34 %), and T1 (3.87 %) during rainy season 2009. During rainy season 2010 shows that Denier was also increased by T3 (3.649 %), T1 (2.212 %) and T2 (-0.89 %) respectively when compared with the percent change over control group.

In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the Denier was seen increased by T5 (19.59 %), T6 (18.45 %) and T4 (13.74 %) during rainy season 2009. During rainy season 2010 shows that Denier
was also increased by T6 (7.104 %), T4 (2.834 %) and T5 (1.358 %) respectively when compared with the percent change over control group.

From this it is clear that during rainy season 2009 -10 shows increased Denier for all treated groups of both plant extracts as compared with percent change over control group. But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for Denier parameter during study period.

3.1.9 (b) In Winter season

During 2009 – 10

The results on the effect of plant extracts on Denier of silk filament are presented in table 3, 4 and 9, 10 as well as graphically depicted in fig 3, 4 and 9, 10.

In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the Denier was seen increased by T3 (15.35 %), T2 (8.72 %) and T1(7.72 %) during winter season 2009. During winter season 2010 shows that Denier was also increased by T3 (24.019 %), T2 (11 %) and T1 (6.124 %) respectively when compared with the percent change over control group.

In the group treatment with *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the Denier was seen increased by T6 (17.35 %), T4 (13.49 %) and T5 (13.10 %) during winter season 2009. During winter season 2010 shows that Denier was also increased by T5 (30.98 %), T6 (23.78 %) and T4 (13.21 %) respectively when compared with the percent change over control group.

From this it is clear that during winter season 2009 - 10 shows increased Denier for all treated groups of both plant extracts as compared with control group. But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for Denier parameter during study period.

3.1.9 (c) In Summer season

During 2010 – 11

The results on the effect of plant extracts on Denier of silk filament are presented in table 5, 6 and 11, 12 as well as graphically depicted in fig 5, 6 and 11, 12.

The results were very interesting in all the treated groups. In the group treatment with *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the
Denier was seen increased by T3 (8.937 %), T2 (8.808 %) and T1 (8.074 %) during summer season 2010. During summer season 2011 shows that Denier was also increased by T3 (21.42 %), T1 (2.807 %) and T2 (1.041 %) respectively when compared with percent change over the control group.

In the group treatment with Ficus racemosa L. (1:2, 1:4 and 1:8) extracts, it were observed that the Denier was seen increased by T4 (14.72 %), T6 (8.16 %) and T5 (4.31 %) during summer season 2010. During summer season 2011 shows that Denier was also increased by T5 (18.34 %), T6 (12.86 %) and T4 (9.646 %) respectively when compared with the percent change over control group.

From this it is clear that during summer season 2010 -11 shows increased Denier for all treated groups of both plant extracts as compared with control group. But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for Denier parameter during study period.

3.1.10 Number of Breakages

The data on Number of Breakages during reeling of silk filament were note down during study period which is presented in table 1 – 12 and graphically depicted in Fig 1 – 12.

3.1.10 (a) In Rainy Season

During 2009 – 10

The Number of Breakages has also shown negative trend during the reeling of silk filament it was -100 % for all treatments Ziziphus jujuba L. (1:2, 1:4 and 1:8) during rainy season 2009 – 2010. The Ficus racemosa L. (1:2, 1:4 and 1:8) extracts also shows negative trend during the reeling of silk filament it was -100 % for all treatments during rainy season 2009 – 2010 when compared with percent change over control group.

3.1.10 (b) In Winter Season

During 2009 – 10

The Number of Breakages has also shown negative trend during the reeling of silk filament it was -100 % for all treatments Ziziphus jujuba L. (1:2, 1:4 and 1:8) during winter season 2009 – 2010. The Ficus racemosa L. (1:2, 1:4 and 1:8) extracts also shows negative trend during the reeling of silk filament it was -100 % for all
treatments during winter season 2009 – 2010 when compared with percent change over control group.

3.1.10 (c) In Summer Season

During 2010 – 11

The Number of Breakages has also shown negative trend during the reeling of silk filament it was -100 % for all treatments *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) during summer season 2010 – 2011. The *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts also shows negative trend during the reeling of silk filament it was -100 % for all treatments during summer season 2010 – 2011 when compared with percent change over control group.

It indicates that both plant extracts treatments had no breakages of silk filament, So that it is clear those treatments have well for silk thread activity with various concentrations.

From this study it is indicated that the plant extracts exhibits the presence of certain growth stimulant and can be used to increase the silk yield in commercial silkworm rearing. The *Ziziphus jujuba* (L.) leaf extract of 1:8 concentration daily feeding recorded higher the all the biological parameters of silkworm *Bombyx mori* L. from all the treatments it is shows better results, so therefore one feeding may be recommended to the sericulturists to promote the economic characters like Cocoon weight, Pupal weight, Shell weight, Shell ratio, Filament length, Filament weight and Denier.
4. Discussion

The perusal of literature shows that, very scanty information is available on fortification of plant extracts selected for study under Aurangabad condition. Hence the results obtained are discussed in the light of available literature on the various treatments and biological characters of Boomyx mori L.

4.1. Fortification studies and biological characteristic of silkworm Boomyx mori L. using certain plant extracts.

4.1.1. Larval weight (g)

During 2009-2011

The mean larval body weight in 5th instar showed an increase in Ziziphus jujuba L. (T1, T2 and T3) as well as Ficus racemosa L. (T4, T5 and T6). In treated groups Ziziphus jujuba L. (T3) and Ficus racemosa L. (T6) showed highly increased larval weight for all season when compared with the control. The treatment with extract of Ziziphus jujuba L. (T3) has 57.89 and 16.93 % and Ficus racemosa L. (T6) has 56.66 and 19.79 % larval weight was recorded as compared to the control. Ziziphus jujuba L. (T1 and T2) as well as Ficus racemosa L. (T4 and T5) also recorded higher values for these parameters next to Ziziphus jujuba L. (T3) and Ficus racemosa L. (T6).

The present findings are in conformity with the findings of Ananda Kumar et al., (2011) evaluated the parameters so far studied indicated significant variations among the treatments; these variations may be due to the effect of feed supplement on the metabolic activity in the silkworm larvae. The parameters increase in T1 batch, indicated that the quantity and time of application in a day may affect the larval growth and finally reflects on cocoon production. It shows that, even one treatment /day is enough to bring considerable improvement in nutritional efficiency, cocoon production and silk productivity. Therefore from the present investigation it is very clear that, the feed supplement ‘SERIFEED’ which has the involvement of beneficial fortifying nutrients gave a vaccination for silkworm larvae for better growth and development for the increased cocoon production.

The mean body weight of 5th instar larvae was significantly increased in T1 treatment, where as in other treatments there was a marginal increase when compared
with the control. The increase of body weight in T1 treatment may be due to the fortification of leaf with the feed supplement ‘SERIFEED’. This implies that some of the essential nutrients in the feed supplement are responsible for the larval growth and perhaps the effective utility by the larvae.

Also, these research findings are in conformity with results of Amala et al., (2011) evaluate that when the inoculated worms were treated with the probionts Bifidobacterium bifidum and yeast at different concentrations. Bifidobacterium bifidum showed significant enhancement in larval weight. The weight was maximum in IV Instar larvae fed with yeast at 6% dilution treated mulberry leaves (52.46±0.87mg). In control worm the body weight was only (39.14 ±2.45mg/animal/day). In the V instars stage the larval weight was (84.54±0.37mg) when fed with yeast at 4% dilution and (88.67±0.67mg) when fed with yeast at 6% dilution. Whereas the larval weight for the control was (75.34±1.90 mg dry wt/animal/day).

The present report of increased larval weight is in accordance with the earlier ones i.e. Bhaskar et al., (2008) also shows that the silkworm fed with mulberry leaves and sprayed with different plant extracts showed significant differences in crop I and crop II, respectively with respect to mature larval weight and silk productivity. However, the maximum of 28.63 and 30.13 g /10 of mature larval weight and 4.040 cg/day silk productivity were recorded when larvae were administered with Psoralea coryleifolia leaves followed by P. nirurii (27.87 and 28.40 g /10 and 3.732 Cg/ day) when compare to absolute control (21.91 and 26.96 g/10; and 2.731 Cg/day). Their interaction effect was also found significant with respect to mature larval weight and silk productivity.

Further it is also confirmed by Murgesh (2002) spraying of T. procumbens, T. terrestris and P. hysterophorus resulted in maximum fifth instar larval weight (33.75, 33.74 and 33.56 g/10 larvae) compared to control. Further Shubha (2005) observed better larval weight and survival rate when mulberry leaves were fortified with Psoralea coryleifolia and P. nirurii compare to without fortification. Higher silk productivity was encountered in Psoralea coryleifolia followed by P. nirurii in both the crops. These results are also agreement with findings of Patil (1991) according to
whom; an increased larval weight can be realized when mulberry leaves were extra foliated with *T. procumbens* and *P. coryleifolia* and fed to the silkworm, *Bombyx mori* L.

Similar results were observed by Hiware and Bhalerao (2008) which is shows that the group treated with *P. niruri* whole plant extract, it was seen larval weight increased by 17.27% when compared with the control group. In the group treated with the *T. purpurea* root extract similar trend was observed; the larval weight was increased by 7.692 % and also same finding of the increased larval weight is in accordance with the earlier by Mahesha *et al.*, (1999).

Mariba *et al.*, (2008) shows that the aqueous botanical extracts were prepared at concentration of 10, 20, and 40 per cent and sprayed on mulberry leaves prior to feeding it to silkworms. Among these plants used administration of 40 per cent of P3 to the larva of PM X CSR2 hybrid registered significant improvement (at 5% significant ) in larval weight (4.50g); SCW (1.95g); SSW (0.37g), while the carrier and normal control batches recorded lower larval weight (4.45 and 4.01g). The feasibility of usage of botanicals and its impact on improvement of economic traits of silkworm, *B. mori* L.

Mururai *et al.*, (2008) also same results using different plant extracts viz., *Cucumis sativus*, *Emblica officinalis*, *Citrus lemon L.*, *Ocimum sanctum L.*, *cumcura longa L.*, *Allium sativum L.*, *Cicer arietinum* at two different concentration Viz., 2 and 6 per cent. The results indicated that, among the tried plant extracts when, silkworm (PM X CSR2) reared on mulberry leaves sprayed with *Cucumis sativus* plant extracts exhibited significant difference with respect to economic traits and disease incidence. However, larval weight (2.94 g) were significantly maximum in *cucumis sativus* at 6 per cent concentration beside reducing the larval duration (6.89 days) compared with others treatments. The results clearly indicated that the fortification of mulberry leaf with plant extracts (*cucumis sativus*) had significantly increased the economic parameters of the silkworm *B. mori* L.

Murugesh *et al.*, (2008) evaluated that the botanicals treated *Tridax procumbens* (9.17 %) and *Parthenium hysterophorus* (10.11%) were found to be topical application of *T. Procumbens* and *Tribulus terrestris* on silkworm larva
significantly enhanced the larval weight (33.75g and 33.74g/10) compared with control (30.25g/10).

Salimnath et al., (2007) shows that the improvement in the cocoon quality and yield is to achieve an increase in the larval weight by enriching the nutritional value of silkworm feed by supplementing it with additional nutrients. It is reported that silkworm reared on the leaves supplemented with soybean flour recorded significantly higher larval and cocoon traits. In this regard, oral supplementation of soyflour with mulberry leaves has proved a success in increasing the cocoons quality and yield.

Pratheesh Kumar et al., (2007) shows exactly opposite results by used ethanol extract of 20 botanicals in 3 concentrations i.e., 2.5%, 5% and 10% were evaluated that there is not much impact on larval weight for their efficacy to improve reproductive performance of mulberry silkworm (Bombyx mori L.) through feeding botanical enriched mulberry leaves during 2nd day of 4th age as well as 1st and 3rd day of 5th age larvae. Five botanicals viz., Asparagus recetnosus, Achyranthes aspera, Tribulus terrestris, Withania somnifera, Parthenium histerophorus ranked first were further evaluated at 8% 5% and 3% concentrations to confirm their effectiveness and standardize effective concentration. Among the rearing parameters, mature larval weight is not significantly influenced by the treatments.

The present findings are in conformity with the findings of Vanitha., et al., (2006) having shows same results for Silkworm (PM X CSR2) fed on mulberry leaves dusted with cereal and legume combination viz., 80% activated horsegram regular flour + 20% regular ragi flour produced significantly higher mature larval weight to supplementation exclusively during fifth instar. The performance of the silkworm hybrid was superior with fortification as against unsupplemented control.

Also, these research findings are in conformity with results of Gayathri et al., (2006) shows that the water extracts of plant such as Tinospora cordifolia Wild, Coleus armaticus Benth, Bacopa monnieri L., Centella asiatica L., Eclipta prostrata L., Acorus calamus L., Withania somnifera Dunal, Sauropus androgynus Merr, Phyllanthus niruri L. and Terminalia chebula Retz., stimulated the growth of mulberry silkworm. However, the best plant extracts found were E. prostrata, Bacopa
monnieri, Centella asiatica and Tinospora cordifolia at two per cent concentration which enhanced the larval weight and silk productivity.

The present report of increased larval weight is in accordance with the earlier ones i.e. Eswaran et al., (2006) shows the effects of two food stuffs, tapioca flour and green leaves of Amaranthus viridis, used as fortification agents to enrich the nutritional quality of mulberry leaves for the silkworm B. mori were investigated. The fortification agents were prepared by dissolving 1 g tapioca flour and 1 ml aqueous crude extract of A. viridis leaves in 100 ml of water separately. These were separately smeared on mulberry leaves which were fed to the experimental larvae. The control worms were fed with unsmeared leaves. The tapioca flour (1%) had a better growth stimulatory effect on the feeding parameters of silkworm than the control and the A. viridis leaves.

Similar results were observed by Jyothi et al., (2006) evaluate an experiment was conducted during the 1999 summer (March-April) and kharif (August-September) and 2000 winter (January-February) seasons in Bangalore, Karnataka, India, to study the effect of foliar applied Daman Penshibao (a multifunctional organic plant tonic) on irrigated mulberry at 10, 25 and 40 days after bottom pruning. The effects of Daman Penshibao on B. mori rearing performance were also studied. Daman Penshibao was applied at 0.5, 1.0, 2.0 and 3.0 ml/10 liters water. Daman Penshibao at 3.0 ml/10 liters water showed the highest meant mature larval weight (34.66 g).

Also, these research findings are in conformity with results of Narayanswamy et al., (2006) shows that the mean body weight of 5th instar larvae showed an increase in T1 treatment, whereas in other treatments, there was no significant increase when compared with the control. This implies that some of the essential nutrients in the feed supplement ‘Serifeed’ are responsible for the larval growth. In silkworm, the quality of food consumption has direct relevance on weight of larva. Also, these research findings are in conformity with results of Nirwani et al. (1996 a, b).

Singh et al., (2005) shows that the silkworm larvae were fed on mulberry leaves treated with a probiotic bacterium namely Lactobacillus plantarum during different instars and its effect on larval body weight, mature body weight. Approximately all the treatment with L. plantarum a probiotics was significantly

superior to that of control. L. plantarum treated groups recorded significantly higher values for larval body weight at all the instars namely 1st, 2nd, 3rd, 4th and 5th instar respectively as compared to control. The study indicated that the probiotic bacteria exhibit inducement of certain growth factors leading to increase in silk yields.

The results on effect of probiotic bacteria L. plantarum on economical parameters of silkworm on the larval of treatment groups had significantly higher larval weight as compared to control group. Also overall analysis of interaction between different treatment groups and control group showed significant higher values for larval weight and L. plantarum treated mulberry leaves fed to larvae at 1st, 2nd, 3rd, 4th and 5th instars recorded maximum larval weights 2.90, 2.86, 2.90, 2.86 and 2.93 gm respectively as compare to control group.

The higher value of larval weights and cocoon parameters indicated the greater suitability /acceptability of probiotic L. planterum along with food plants. The amount of food consumed by a larva influences its growth rate, development, final body weight and Probability of survival (Slansky and Scriber, 1985). Sukumar (1983) has reported enhancing effect on silk yield using mulberry phylloplane yeast Sporobolomyces roseus.

Singh (1997) also shows that statistically no significance was observed with respect to mature larva weights in treatment and control groups which may due to common timing of picking the ripe larvae in treated and control groups.

Padmalatha et al., (2005) also shows the effect of four ferns such as Nephrolepis auriculata, Christrella parasitica, Decranopteris linearis and Pityurogramma calomelanes on the quantitative traits and energetic as of B. mori. The impact of ferns to increase in the larval weight was noticed among fern extracts treated batches. The mean of the observations of three concentrations of each fern showed improvement in larval weight i.e., 0.528, 0.521, 0.503 and 0.532 g for N. auriculata, C. parasitica, D. linearis and P. calomelanes, respectively over control (0.493 g / animal). D. linearis and P. calomelanes treatments indicated slight improvement in food consumption as compared to the other two ferns treatment (N. auriculata and C. parasitica). Larval weight improved significantly by the application of fern extracts. The study concludes that the mulberry leaves supplemented with extracts of ferns.
enhance the economic parameter of silkworm *Bombyx mori* L. which is accordance with our findings.

The present report of increased larval weight is in accordance with the earlier ones i.e. Anju Dube *et al* (2005) was conducted to study the effect of two narcotic plant extracts (2 % aq.) viz. *Palavers rhoeas* L and *Cannabis sativa* L. along with two other extracts viz. *Nicotina plumbaginifolia* and *Rosa dama scamena* on biological and economic parameters of full grown worms of *Bombyx mori* L. (race: NB4D2 X SH6). The worms fed with narcotic plant extracts initially showed better feeding and weight gain over control. Rose water (*Rose damascena*) however showed better results over control in terms of larval weight gain (1.33 v/s 1.16 mg).

The results of Narayanaswamy *et al*., (2006) also correlate with a investigation was carried out to know the influence of enriched mulberry leaf with Kokhiko silcare feed supplement and its effect on rearing performance of silkworm hybrid (CSR2 x CSR4). The enrichment of mulberry leaf with Kokhiko silcare feed supplement @ 1000g /100 dfls recorded significantly higher mature larval weight.

Similar results were reported by Jeypaul *et al*., (2003) which shows that food assimilation rate, conversion efficiencies were significantly higher in silkworm fed on mulberry leaf supplemented with *Coffea Arabica* leaf extract at 1:25 concentration. The treatment recorded significantly higher larval weight. Plant extracts known to increase economical characters the silkworm like larval, cocoon and shell weights (Murugan *et al*., 1998) which results were similar with our findings.

Senthil Nathan *et al*., (2002) also shows that Feeding experiments revealed that the increased food consumption, relative growth rate and nutrition efficiency measures lead to good cocoon formation. Also, a strong relation was found to exist between growth of *Bombyx mori* L. (silk worm) and silk production after treatment of *Leucas aspera*. *Leucas aspera* showed growth promoting effects by stimulating biochemical process.

Prasad *et al*., (2000) were conducted a study in which *Morus* leaves were dipped in extract from solanaceous crops (potato, tomato, aubergine, chilli and tobaco), which were collected at seedling, active growth and flowering stages. Extract concentration were 1:1, 1:2 and 1:4 w/v. treated Morus leaves were fed to fifth instar
latter of *B. mori* L. supplementation of mulberry leaves with potato leaf extract collected at growth stage, potato leaf extract at 1:4 concentration and in border cropping control treatment resulted in the highest mature larval weight (2.48, 2.66 and 2.50 g). This indicates that potato leaf extract collected at growth stage and at 1:4 concentration significantly improved the economic parameters of silkworm.

Sashidaran Nair *et al.*, (2000) also shows that a juvenile hormone mimicking compound NL-24 (formyl longifolene oxime citronellyl ether), an oxime ether of carbohydrate derived from longifolene of Indian turpentine oil extracted from the plant, *Pinus longifolia* Roxb, was administrated to silkworm, *Bombyx mori* L. For improving KA × NB4D2, the larval weight was enhanced by a maximum of 7.06% when treated at 48 h with 5 ppm of the compound. This was followed by an increase of 6.19% when treated at 24 h with the same concentration.

Murugan *et al.*, (1999) shows aqueous of botanicals such as *Tridax procumbens*, *Lantana camera*, *Clerodendron* sp. and *Croton sparsiflours* stimulated the growth and development of mulberry silkworm, *Bombyx mori* L. (PM × NB4D2). Krishnaprasad *et al.*, (2001) reported that mulberry leaf supplemented with potato leaf extract once during 3rd and 4th instar and twice during 5th instar recorded superior larval weight.

An increase in larval weight on administration of JH compounds was reported earlier (Nihmura *et al.*, 1972; Akai *et al.*, 1985; Trivedy *et al.*, 1993, 1997). In almost all these cases, the increase in larval weight was accompanied by a prolongation in larval period. But in the present study, the increase in larval weight was not associated with a corresponding increase in the larval feeding period. The studies undertaken by Patil *et al.*, (1997a, b) on the eri-silkworm, raised on mulberry leaves, enriched with 1, 5, 10, 15 and 20% solution of leaf extract of *Parthenium hysterophorus*, the leaf extract, stimulated the silkworm larvae not only to consume/ utilize more food, but also to grow up into a bigger size and produce bigger cocoons, with significant improved economic traits.
4.1.2. Total Mortality

During 2009-2011

The results were indicates that both plant extracts treatments had no mortality to remarkable extent. So that it is clear those treatments have no larvicidal activity with various concentrations.

The present findings are in conformity with the findings of Krishnaprasad et al., (2001) reported that mulberry leaf supplemented with potato leaf extract once during 3rd and 4th instar and twice during 5th instar recorded lower larval mortality.

Similar results were observed by Subha et al., (2008) shows in the experiment was conducted to know the effect of medicinal plant extracts on larval and pupal mortality of Bombyx mori L. the results revealed that, the botanical extract Psoralea coryleifolia fed larvae registered lower larval and pupal mortality (3.00 and 3.08 %) compare to other medicinal botanical extracts. Further, the fifth instar larvae of (PM X CSR2) fed with Phyllanthus niruri (5.00 and 4.21%), Tribulus terrestris (7.00 and 5.39%), Withania somnifera (12.00 and 5.73 %) and Adathoda vasicda (13 and 11.63%), registered decreased level of mortality and found significant superior to control (24.00 and 18.41%). Also, these research findings are in conformity with results of the application of formulation of botanicals with soya flour as base reduced mortality in silkworm when Caesalpinia criria, Acacia suma and Psoralea coryfolia sources were utilized (Sivaprakasam, 1999).

Anju Dube et al., (2005) reported opposite results from our findings in which the effect of two narcotic plant extracts (2 % aq.) viz. Palavers rhoeas L and Cannabis sativa L. along with two other extracts viz. Nicotina plumbaginifolia and Rosa damascena on biological and economic parameters of full grown worms of Bombyx mori L. (race: NB4D2 X SH6). The worms fed with narcotic plant extracts initially showed better feeding and weight gain over control which later culminated into poor ingestion and mortality (≥ 93%). None of the worms survived in the treatment with Nicotina plumbaginifolia and Cannabis sativa, in Palavers rhoeas terminal larval mortality was 93.33% as compared to control (3.33 %). This condition may be attributed to the chronic toxicity.
Rajesh (2011) observed that the larvae fed on higher concentrations had longer larval duration, took more time for pupation and showed pupal deformities and high post cocoon mortality. Some larvae remained inside the cocoon without undergoing pupation. Lower concentrations did not affect pupation. These observations call for further investigations in the same line using lower concentrations of the emblica fruit extract as a food additive to silkworms, to prolong larval duration and to improve silk yield.

The adverse effect was observed by Hiware and Bhalerao, (2008) in which the group treated with \textit{P. niruri} whole plant extract, it was seen that the mortality showed positive trend i.e. during rearing and spinning it was 75 and 80\% respectively. In the group treated with the \textit{T. purposes} root extract similar trend was observed; the larval weight was increased by 7.692 \% with mortality value during rearing and spinning were 76.92 and 92.85 \% respectively indicating that both the extracts had increased mortality to remarkable extend.

Jyothi \textit{et al.}, (2006) evaluate an adverse effect in experiment during the 1999 summer (March-April) and kharif (August-September) and 2000 winter (January-February) seasons in Bangalore, Karnataka, India, to study the effect of foliar applied \textit{Daman Penshibao} (a multifunctional organic plant tonic) on irrigated mulberry at 10, 25 and 40 days after bottom pruning. The effects of \textit{Daman Penshibao} on \textit{Bombyx mori} L. rearing performance were also studied. Daman Penshibao was applied at 0.5, 1.0, 2.0 and 3.0 ml/10 liters water. Data were recorded for larval mortality; While 2.0 ml \textit{Daman Penshibao}/10 liters water gave the highest mean larval mortality (8.45\%).

Lee \textit{et al.}, (1989) observed a repellent effect of extracts from wild weed species viz., \textit{Pulsatilla koreana}, \textit{Sophora flavescens} and \textit{Persicaria conspicua} on \textit{Bombyx mori} late age worms as well as Datta and Gupta (2002) have reported complete mortality of silkworm larvae within 5 days of feeding mulberry leaves dipped in alcoholic tulsi extract at the lowest concentration of 10\%, while in other concentration (50 and 100 \%) all larvae died at an early stage. \textit{Putranjiva roburghii} and \textit{Jatropa curcas} (concentration 8\%) tested by Sharma (2005) proved to be highly detrimental for growth and development of \textit{V}th instar worms of \textit{Bombyx mori} L. showing a negative growth rate. \textit{J. curcas} 8\% cause 100\% mortality in the worms and
no cocoon could be obtained. All of these findings show adverse effect on silkworm as compare to our findings.

Murugesh and Bhaskar (2008) observed similar findings for the botanicals treated *Tridax procumbens* (9.17 %) and *Parthenium hysterophorus* (10.11%) were found to be statically superior in bringing down the larval mortality compared with control (12.10%). Similar results were observed by Narayanaswamy *et al.*, (2005) carried out to know the influence of enriched mulberry leaf with Kokhiko silcare feed supplement and its effect on rearing performance of silkworm hybrid (CSR2 x CSR4). The enrichment of mulberry leaf with Kokhiko silcare feed supplement @ 1000g /100 dfls recorded lower larval mortality.

### 4.1.3 Cocoon weight (g)

**During 2009-2011**

From results it is clear that during 2009 -11 shows increased cocoon weight for all treated groups of both plants extract as compared with control group. *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the cocoon weight was seen increased by T1 (33.58 %), T3 (30.33 %) and T2 (15.80 %) and *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the cocoon weight was seen increased by T6 (42.88 %), T4 (32.83 %) and T5 (24.43 %). But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for cocoon weight parameter during study period.

The present report of increased cocoon weight is in accordance with the earlier ones in which Chandramohan (2011) shows that ‘ILAMATHI’ botanical formulation was found to increase cocoon weight and there by yield of 25.16 %.

The present findings are in conformity with the findings of Venkatesh Kumar *et al.*, (2009) has analysed of Variance which has indicated high significant differences (at p = 0.01) between the treatment values in respect of single cocoon weight. The treatment with 300ppm concentration spirulina has very significantly increased the single cocoon weight when compared with control. Therefore, the 300ppm concentration has shown high impacts on the cocoon characters. Secondly, the differences between 300 ppm concentration and other two concentrations namely 100 and 200 ppm are also significant.

Similar results were observed by Pratheesh Kumar et al., (2007) used ethanol extract of 20 botanicals in 3 concentrations i.e., 2.5%, 5% and 10% were evaluate that the botanicals which influence the single cocoon weight by using five botanicals viz., Asparagus recetnosus, Achyranthes aspera, Tribulus terrestris, Withania somnifera, Parthenium histerophorus ranked first were further evaluated at 8% 5% and 3% concentrations.

Also, these research findings are in conformity with results of Abida Nasreen et al., (1999) to evaluate Silkworm (Bombyx mori L.) larvae are commonly raised on leaves of mulberry (Morus alba). They can be reared successfully on leaves of peepal (Ficus religiosa), when fed after third instar. From this clear that the larvae not only can consume and utilize the new food aptly but can also produce healthy cocoons.

Kim et al., (1997) reported the effects of methanol extract of Achyranthes japonica on the development stages of silkworm, Bombyx mori L., Administration of methanolic extract of this plant at 6 hours before the appearance of early mature larvae enhanced remarkably the cocoon quality.

Murugan et al., (1999) also shows aqueous of botanicals such as Tridax procumbens, Lantana camera, Clerodendron sp. and Croton sparsiflours stimulated the growth and development of cocoon parameters of Bombyx mori L. (PM × NB4D2).

Krishnaprasad et al., (2001) reported that mulberry leaf supplemented with potato leaf extract once during 3rd and 4th instar and twice during 5th instar recorded higher cocoon weight and Hipparagi et al., (2003) also showed the effects of filed spray of Lantana camara, Tridex procumbens and Parthenium hysterophorus extract at 30 and 40 % concentration during rainy, winter and summer seasons on silkworm growth and development. From this results Lantana (30 %) and Tridex (40 %) have more cocoon yield. The effects of botanical extracts were found to be superior during rainy season than winter and summer seasons on silkworm growth and development. The supplementation of Spirulina (100 ppm) with mulberry feed to silkworm larvae (NB4D2 race) during 5th instar significantly enhanced the cocoon weight as compared to control.
Sujatha et al., (2003a, b) studied the effect of *Eucalyptus globules* leaf extract (0.1, 1.0, 2.0 and 5.0%) when fed to silkworm along with mulberry leaf which improve the economical character of cocoon weight in 15 concentration of *Eucalyptus* leaf extract.

Jeypaul et al., (2003) reported that the silkworm fed on mulberry leaf supplemented with *Coffea arabica* leaf extract at 1:25 concentration recorded significantly higher cocoon weight. Results showed significant for *Coffea arabica* leaf extracts at 1: 100, 1:50 and 1:25 concentration which recorded maximum cocoon weight (1.671, 1.646, and 1.699 g) and leaves of *Alternanthera sessilis, Eichhornia crassipes* at 1:100 and 1:50 concentration recorded higher cocoon weight than control.

Senthil Nathan et al., (2002) also shows the treatment of *Leucas aspera* showed growth promoting effects to the cocoon parameter by stimulating biochemical process.

Sashindran Nair et al., (2003) shows that the influence of bakuchiol a JH analogue from Bemchi (*Psoralea corylifolia*) on the silk yield of silkworm, *Bombyx mori* L. of hybrids, KA x NB4D2 (bivoltine x bivoltine) and PM x NB4D2 (multivoltine x bivoltine). The compound was administered topically to 5th instars at 24, 48, 72 and 96 h as a single dose. Three concentration viz., 0.625, 1.25 and 2.5 ppm were tested. The result showed that 1.25 ppm of bakuchiol was the most favorable treatment for improvement of commercial traits of Cocoon weight have increased significantly due to this treatment.

Prasad et al., (2000) were conducted a study in which *Morus* leaves were dipped in extract from solanaceous crops (potato, tomato, aubergine, chilli and tobacco), make extract concentrations were 1:1, 1:2 and 1:4 w/v. Supplementation of mulberry leaves with potato leaf extract collected at growth stage, potato leaf extract at 1:4 concentration and in border cropping control treatment resulted in the highest cocoon weight (1.69, 1.68 and 1.57 g). This indicates that potato leaf extract collected at growth stage and at 1:4 concentration significantly improved the economic parameters of silkworm.

Kanitsara et al., (2007) was evaluate the effects of ethanolic extracts of phytoestrogen - rich plant, white Kwao-Krua (*Peuraria mirifica*) on cocoon character.
of Thai Multivoltine Silkworm, *Bombyx mori* L. In addition, the crude extracts were administered topically on mulberry at 3 concentrations, 1%, 5%, and 10% w/v on the 48-hour old fifth instar silkworm. However, the cocoon weights at 1% w/v treatment increased.

Jyothi *et al.*, (2006) evaluate an experiment during the summer (March-April) and kharif (August-September) and winter (January-February) seasons in Bangalore, Karnataka, India, to study the effect of foliar applied *Daman Penshibao* (a multifunctional organic plant tonic) on irrigated mulberry at 10, 25 and 40 days after bottom pruning. The effects of Daman Penshibao on *Bombyx mori* L. rearing performance at 0.5, 1.0, 2.0 and 3.0 ml/10 liters water. Daman Penshibao at 3.0 ml/10 liters water showed the highest cocoon yield (156.43 g).

Padmalatha *et al.*, (2005) also shows the effect of four ferns such as *Nephrolepis auriculata*, *Christrella parasitica*, *Decranopteris linearis* and *Pityurogramma calomelanes* on the quantitative traits and energetic as of *Bombyx mori* L. The extract of *N. auriculata* at 0.1 0.2 and 0.4 per cent concentrations recorded higher cocoon weight (1.89, 1.78, 1.77 g). *C. parasitica*, *D linearis* and *P. calomelanes* at different concentrations recorded higher cocoon weight than control. This shows that the mulberry leaves supplemented with extracts of ferns enhance the economic parameter of silkworm *Bombyx mori* L.

The results are in conformity with the earlier report of Murugan *et al.* (1999) who reported an increase in cocoon weight for some plant extracts tested the overall energy budgets of the *Bombyx mori* L. The aqueous extracts of botanicals such as *Tridax procubens*, *Lantana camera*, *Clerodendron sp.* and *Croton sparsiflorus* stimulated the growth and development of mulberry silkworm, *Bombyx mori* L. (*PMxNB4D2*). Plant extract had greatly influence the feeding and efficiency measures of silk worm larvae and also increase the weight of the cocoon.

Sashidaran Nair *et al.*, (2000) show the Cocoon weight was improved substantially by the administration of the JH compound. The maximum improvement in KA x NB4D2 was obtained in the case of 5ppm JH at 48h (15.79%) followed by 5ppm at 24 h (7.97%). In PM x NB4D2, an increase of 12.78% with 2 ppm NL-24 at 48 h and 10.44% with 10 ppm at 24 h could be recorded. Generally, the silkworm was
far more receptive at 24 and 48 h respect of enhancement in the cocoon characters compared to that of 72 and 96 h.

Rajegowda, (2002) observed higher cocoon and shell weight in ‘SERIPRO’ supplemented leaves fed batches. The average shell ratio in treatment T1 showed a marginal increase when compared with the control.

Murugan, (1994) also shows that the effective rate of cocooning percentage show a significant increase in T1 batch when compared with the control. This variation could be due to the presence of vitamins and antibiotics in the feed supplement. The average cocoon weights in treated and control batches from T1 to T5. The cocoon and shell weights considerably increased in treated batches when compared with the control. Among the treatments T1 showed a significant increase in cocoon weight and shell weight, where as in other treatments there was a marginal increase when compared with the control.

Bajepyi et al., (1991) were also shows that the parameters under study were indicated significant variations among the treatments; these variations may be due to the effect of feed supplement on the metabolic activity in the silkworm larvae. The parameters increase in T1 batch, indicated that the quantity and time of application in a day may affect the larval growth and finally reflects on cocoon production. It shows that, even one treatment /day is enough to bring considerable improvement in nutritional efficiency, cocoon production and silk productivity. Therefore from the present investigation it is very clear that, the feed supplement ‘SERIFEED’ which has the involvement of beneficial fortifying nutrients gave a vaccination for silkworm larvae for better growth and development for the increased cocoon production.

Singh et al., (2005) shows that the silkworm larvae were fed on mulberry leaves treated with a probiotic bacteria namely *Lactobacillus plantarum* during different instars and its effect on cocoon weight was studied. Approximately all the treatment with *L. plantarum* a probiotics was significantly superior to that of control. *L. plantarum* treated groups recorded significantly higher values for cocoon weight at all the instars namely 1st, 2nd, 3rd, 4th and 5th instar respectively as compared to control. From the results on effect of Probiotics bacteria *L. plantarum* on economical parameters of silkworm showed that the cocoon weight as compared to control group.
Also overall analysis of interaction between different treatment groups and control group showed significant higher values for cocoon weight. *L. plantarum* treated mulberry leaves fed to larvae at 1st, 2nd, 3rd, 4th and 5th instar recorded maximum cocoon weight (1.09, 1.27, 1.30, 1.29, 1.22 and 1.33gm) as compare to control group.

Amala *et al.*, (2011) evaluate that when the inoculated worms were treated with the probionts Bifidobacterium bifidum and yeast at different concentrations. *Bifidobacterium bifidum* showed significant enhancement in cocoon weight.

Mariba *et al.*, (2008) also shows that the aqueous botanical extracts were prepared at concentration of 10, 20, and 40 per cent and sprayed on mulberry leaves prior to feeding it to silkworms. Among these plants used administration of 40 per cent of P3 to the larva of PM X CSR2 hybrid registered significant improvement (at 5% significant cocoon weight (1.95g).

This is in agreement with the work done by Mururai *et al.*, (2008) in which different plant extracts viz., *Cucumis sativus*, *Embilca officinalis*, *Citrus lemon* L., *Ocimum sanctum* L., *cumcura longa* L., *Allium sativum* L., *Cicer arietinum* at two different concentration Viz., 2 and 6 per cent. The results indicated that, among the tried plant extracts when, silkworm (PM X CSR2) reared on mulberry leaves sprayed with *Cucumis sativus* plant extracts exhibited cocoon weight (1.79g) was significantly maximum in *cucumis sativus* at compared with others treatments.

Murugesh *et al.*, (2008) were studied the botanicals treated *Tridax procumbens* (9.17 %) and *Parthenium hysterophorus* (10.11%) were found to be statically superior in bringing down cocoon weight (17.24 and 17.20g/10) compared with control (15.08g/10).

Vanitha *et al.*, (2006) also shows that Silkworm (PM X CSR2) fed on mulberry leaves dusted with cereal and legume combination viz., 80% activated horsegram regular flour + 20% regular ragi flour produced significantly cocoon weight when supplement was provided from fourth instar till spinning as compared to supplementation exclusively during fifth instar.

Dunal, *Sauropus androgynus* Merr, *Phyllanthus niruri* L. and *Termatania chebula* Retz., for stimulation of the growth of mulberry silkworm. However, the best plant extracts found were *E. prostrata*, *Bacopa monnieri*, *Centella asiatica* and *Tinospora cordifolia* at two per cent concentration which enhanced the economic characters of cocoon weight and silk productivity.

Anju Dube *et al.*, (2005) were conduct an experiment on the study effect of two narcotic plant extracts (2 % aq.) viz. *Palavers rhoeas* L and *Cannabis sativa* L. along with two other extracts viz. *Nicotina plumbaginifolia* and *Rosa damascena* on biological and economic parameters of full grown worms of *Bombyx mori* L. (race : NB4D2 X SH6). Rose water (*Rose damascena*) however showed better results over control in terms of Single cocoon weight (1.44 v/s 1.04 gms).

Also, these research findings are in conformity with results Narayanswamy *et al.*, (2006) shows that the cocoon weight considerably increased in treated batches when compared with the control. Among the treatments, T1 showed a significant (P≥ 0.01) increase in cocoon weight, where as in other treatments, there was a marginal increase when compared with control.

The results are conformity with that of Rajegowda (2002) who observed higher cocoon and shell weight in ‘seripo’ supplemented leaves fed batches. Silk productivity also increased significantly (P≥ 0.01) in the above batches when compared with the other treatment and the control. Similar results were observed by Nagesh and Devaiah (1996) who observed increased silk productivity in supplementation of ‘sericare’.

Salimnath *et al.*, (2007) which also shows one way of improving the cocoon quality and yield is to achieve an increase in the larval weight by enriching the nutritional value of silkworm feed by supplementing it with additional nutrients. It is reported that silkworm reared on the leaves supplemented with soybean flour recorded significantly higher larval and cocoon traits. In this regard, oral supplementation of soyflour with mulberry leaves has proved a success in increasing the cocoons quality and yield.
4.1.4 Pupal weight (g)

During 2009 – 11

From results it is clear that during 2009 - 11 show decreased pupal weight for both plant extracts and summer season 2011 shows increased pupal weight for all treated groups of both plant extracts as compared with control group. *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the pupal weight was seen increased by T1 (32.51 %), T3 (26.52 %) and T2 (15.07 %) and *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the pupal weight was seen increased by T6 (41.41 %), T4 (32.15 %) and T5 (24.06 %). But overall performance of T1 and T4 both shows better result as compare with other treated groups and control group for pupal weight parameter during study period.

The present report of increased pupal weight is in accordance with the earlier ones Saravanan *et al.*, (2010) evaluate that the effects of various concentrations of *D. lablab* supplementation with mulberry on the pupal weight. There is a significant raise in the pupa weight of the larvae fed with *D. lablab* supplemented mulberry when compared with control groups. There is a significant increase in the 7.5% and 10% dose of *D. lablab* with respect to pupal weight. So, 7.5% was fixed as the effective dose. This is agreement with the work done by Hiware (2006) regarding the increased pupal weight when silkworm treated with homeopathic drug *Nux vomica*.

The present findings are in conformity with the findings of Venkatesh Kumar *et al.*, (2009) has analysis of Variance has indicated high significant differences (at p = 0.01) between the treatment values in respect of pupal weight. The treatment with 300ppm concentration *spirulina* has very significantly increased the pupal weight when compared with control.

Pratheesh Kumar *et al.*, (2007) also used ethanol extract of 20 botanicals in 3 concentrations i.e., 2.5%, 5% and 10% were evaluated for their efficacy to improve reproductive performance of mulberry silkworm (*Bombyx mori* L.) through feeding botanical enriched mulberry leaves during 2nd day of 4th age as well as 1st and 3rd day of 5th age larvae. The preliminary screening was done by ranking the botanicals based on influence in most important reproductive contributing parameters such as pupation rate.

Similar results were observed by Kim et al., (1997) reported the effects of methanol extract of Achyranthes japonica on the development stages of silkworm, Bombyx mori L. Administration of methanolic extract of this plant at 6 hours before the appearance of early mature larvae enhanced remarkably the pupation ratio.

Hipparagi et al., (2003) showed the effects of filed spray of Lantana camara, Tridex procumbens and Parthenium hysterophorus extract at 30 and 40 % concentration during rainy, winter and summer seasons on silkworm growth and development. The supplementation of Spirulina (100 ppm) with mulberry feed to silkworm larvae (NB4D2 race) during 5th instar significantly enhanced the pupation rate as compared to control.

Jeypaul et al., (2003) reported that food assimilation rate, conversion efficiencies were significantly higher in silkworm fed on mulberry leaf supplemented with Coffea arabica leaf extract at 1:25 concentration. Coffea Arabica leaf extracts at 1: 100, 1:50 and 1:25 concentration recorded maximum pupal weight (1.328, 1.359, 1.403 g). Leaves of Alternanthera sessilis, Eichhornia crassipes at 1:100 and 1:50 concentration recorded higher pupal weight than control. The above plant extracts at 1:25 concentration recorded lower pupal weight than control.

Also, these research findings are in conformity with results of Prasad et al., (2000) were conducted a study in which Morus leaves were dipped in extract from solanaceous crops (potato, tomato, aubergine, chilli and tobaco), which were collected at seedling, active growth and flowering stages. Extract concentration were 1:1, 1:2 and 1:4 w/v. treated Morus leaves were fed to fifth instar larvae of Bombyx mori L. supplementation of mulberry leaves with potato leaf extract collected at growth stage, potato leaf extract at 1:4 concentration and in border cropping control treatment resulted in the highest pupal weight (1.42, 1.42 and 1.33 g).

Similar results were reported by Kanitsara et al., (2007) was evaluate the effects of ethanolic extracts of phytoestrogen - rich plant, white Kwao-Krua (Peuraria mirifica) on toxicity, larval maturation and cocoon character of Thai Multivotine Silkworm, Bombyx mori L. In addition, the crude extracts were administered topically on mulberry at 3 concentrations, 1%, 5%, and 10% w/v on the 48 hr old fifth instar silkworm. The results showed decreased pupae at 5% and 10% w/v.
Padmalatha et al., (2005) also shows the effect of four ferns such as *Nephrolepis auriculata*, *Christrella parasitica*, *Decranopteris linearis* and *Pityurogramma calomelanes* on the quantitative traits and energetic as of *B. mori*. Significant differences in economic parameters of silkworm existed in relation to plant extracts. *N. auriculata* extracts at 0.1 0.2 and 0.4 per cent concentrations recorded higher pupal weight (1.54, 1.46, 1.47 g) than control.

Singh et al., (2005) shows that the silkworm larvae were fed on mulberry leaves treated with probiotic bacteria namely *Lactobacillus plantarum* during different instars and its effect on pupal weight. *L. plantarum* treated groups recorded significantly higher pupal weight values for at all the instars namely 1st, 2nd, 3rd, 4th and 5th instar respectively as compared to control. The results on effect of probiotic bacteria *L. plantarum* on economical parameters of silkworm showed that the larvae of treatment groups had significantly higher pupal weight as compared to control group. Also overall analysis of interaction between different treatment groups and control group showed significant higher values pupal weight. *L. plantarum* treated mulberry leaves fed to larvae at 1st, 2nd, 3rd, 4th and 5th instar recorded maximum pupal weight (1.07,1.10,1.08 and 1.02gm) as compare to control group.

This is in agreement with the work done by Amala et al., (2011) shows that the mean weight of the pupal was maximum (12.23±0.66) in 6% of *Bifidobacterium bifidum* treatment. It was followed by 4% treatment of *B. bifidum* (11.4 ±0.45). The pupal weight of the control was only (9.98 ±0.01). In yeast treatment worms the pupal weight was maximum (11.32 ±0.44) in 6% concentration.

Mururai et al., (2008) conducted an experiment using different plant extracts viz., *Cucumis sativus*, *Emblica officinalis*, *Citrus lemon L.*, *Ocimum sanctum L.*, *cumcwa longa L.*, *Allium sativum L.*, *Cicer arietinum* at two different concentration Viz., 2 and 6 per cent. The results indicated that, among the tried plant extracts when, silkworm (PM X CSR2) reared on mulberry leaves sprayed with *Cucumis sativus* plant extracts exhibited significant difference with respect to economic traits. However, pupal weight (1.48g) was significantly maximum in *cucumis sativus* at 6 per cent concentration.
Vanitha et al., (2006) work shows that the Silkworm (PM X CSR2) fed on mulberry leaves dusted with cereal and legume combination viz., 80% activated horsegram regular flour + 20% regular ragi flour produced significantly higher pupal weight when supplement was provided from fourth instar till spinning as compared to supplementation exclusively during fifth instar.

4.1.5 Shell weight (g)

During 2009 – 11

From this it is clear that during 2009 -11 shows increased shell weight for all treated groups of both plant extracts as compared with percent change over control group. *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the shell weight was seen increased by T3 (49.32 %), T1 (39.82 %), and T2 (19.45 %) and *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the shell weight was seen increased by T6 (50.22 %), T4 (34.39 %) and T5 (26.24 %). But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for shell weight parameter during study period.

The present report of increased shell weight is in accordance with the earlier ones Saravanan Manjula et al., (2010) evaluate the effects of various concentrations of *D. lablab* supplementation with mulberry on the silk weight. There is a significant raise in the silk weight of the larvae fed with *D. lablab* supplemented mulberry when compared with control groups. This is in agreement with the work done by Hiware (2006) regarding the increased silk weight when silkworm treated with homeopathic drug *Nux vomica*.

This is in agreement with the work done by Venkatesh Kumar et al., (2009) has analysed of Variance which has indicated high significant differences (at p = 0.01) between the treatment values in respect of single shell weight. The treatment with 300ppm concentration spirulina has very significantly increased single shell weight when compared with control.

The present findings are in conformity with the findings of Krishnaprasad et al., (2001) reported that mulberry leaf supplemented with potato leaf extract once during 3rd and 4th instar and twice during 5th instar recorded superior shell weight.

Hipparagi et al., (2003) also showed the effects of filed spray of Lantana camara, Tridex procumbens and Parthenium hysterophorus extract at 30 and 40 % concentration during rainy, winter and summer seasons on silkworm growth and development. The results indicated that Parthenium (30 % aqueous) produced more fecundity while Lantana (30 %) and Tridex (40 %) results more cocoon yield. The effects of botanical extracts were found to be superior during rainy season than winter and summer seasons on silkworm growth and development. The supplementation of Spirulina (100 ppm) with mulberry feed to silkworm larvae (NB4D2 race) during 5th instar significantly enhanced the shell weight as compared to control.

These values are in concurrence with that Sujatha et al., (2003) studied the effect of Eucalyptus globules leaf extract (0.1, 1.0, 2.0 and 5.0%) when fed to silkworm along with mulberry leaf. The economical character such as shell weight showed improvement in 15 concentration of Eucalyptus leaf extract.

Jeypaul et al., (2003) also reported that food assimilation rate, conversion efficiencies were significantly higher in silkworm fed on mulberry leaf supplemented with Coffea Arabica leaf extract at 1:25 concentration. The treatment recorded significantly higher shell weight. The studies indicated that the plant extracts exhibit the presence of certain growth stimulant and can be used to increase the silk yield in commercial silkworm rearing. The results showed significant difference among Plant extracts at different concentrations. Coffea Arabica leaf extracts at 1: 100, 1:50 and 1:25 concentration recorded maximum shell weight (0.289, 0.287, 0.279 g). Leaves of Alternanthera sessilis, Eichhornia crassipes at 1:100 and 1:50 concentration recorded higher shell weight than control. The above plant extracts at 1:25 concentration recorded lower shell weight than control.

Also, these research findings are in conformity with results of Sashindran Nair et al., (2003) shows that the influence of bakuchiol a JH analogue from Bemchi (Psoralea corylifolia) on the silk yield of silkworm, Bombyx mori L. The result showed that 1.25 ppm of bakuchiol applied to 48 h old 5th instars was the most favourable treatment for improvement of commercial traits. Cocoon shell weight has increased significantly due to this treatment.
Similar results were reported by Prasad et al., (2000) were conducted a study in which Morus leaves were dipped in extract from solanaceous crops (potato, tomato, aubergine, chilli and tobacco), which were collected at seedling, active growth and flowering stages. Extract concentration were 1:1, 1:2 and 1:4 w/v. treated Morus leaves were fed to fifth instar larvae of Bombyx mori L. supplementation of mulberry leaves with potato leaf extract collected at growth stage, potato leaf extract at 1:4 concentration and in border cropping control treatment resulted in the highest shell weight (0.27, 0.26 and 1.33 g).

Kanitsara Chawna et al., (2007) was evaluate the effects of ethanolic extracts of phytoestrogen - rich plant, white Kwao-Krua (Peuraria mirifica) cocoon character of Thai Multivoltine Silkworm, Bombyx mori L. In addition, the crude extracts were administered topically on mulberry at 3 concentrations, 1%, 5%, and 10% w/v on the 48 -hour old fifth instar silkworm. The results showed shell cocoon weights at 1% w/v treatment increased.

Padmalatha et al., (2005) also shows the effect of four ferns such as Nephrolepis auriculata, Christrella parasitica, Decranopteris linearis and Pityurogramma calomelanes on the quantitative traits and energetic as of B. mori. N. auriculata extracts at 0.1 0.2 and 0.4 per cent concentrations recorded higher shell weight (0.35, 0.32, 0.30 g). C. parasitica, D linearis and P. calomelanes at different concentrations recorded higher shell weight than control.

Further it is also confirmed by Sashidaran Nair et al., (2000) shows that the cocoon shell weight was improved substantially by the administration of the JH compound. The improvement pattern was also similar. The maximum improvement in KA x NB4D2 was obtained in the case of 5 ppm JH at 48 h (15.79%) followed by 5 ppm at 24 h (7.97%).

This is in agreement with the work done by Murugan et al., (1994) has also shows the effective rate of cocooning percentage show a significant increase in T1 batch when compared with the control. This variation could be due to the presence of vitamins and antibiotics in the feed supplement. The average shell weights in treated and control batches from T1 to T5. The cocoon and shell weights considerably increased in treated batches when compared with the control. Among the treatments
T1 showed a significant increase in cocoon weight and shell weight, where as in other treatments there was a marginal increase when compared with the control.

The results are in conformity with Rajegowda (2002) who observed higher shell weight in ‘SERIPRO’ supplemented leaves fed batches. The average shell weight in treatment T1 showed a marginal increase when compared with the control.

Singh et al., (2005) also shows that the silkworm larvae were fed on mulberry leaves treated with a probiotic bacteria namely *Lactobacillus plantarum* during different instars and its effect on shell weight were studied. Approximately all the treatment with *L. plantarum* a probiotics was significantly superior to that of control. *L. plantarum* treated groups recorded significantly higher values for shell weight at all the instars namely 1st, 2nd, 3rd, 4th and 5th instar respectively as compared to control.

These values are in concurrence with that the results on effect of probiotic bacteria *L. plantarum* on economical parameters of silkworm Also overall analysis of interaction between different treatment groups and control group showed significant higher values for shell weight. *L. plantarum* treated mulberry leaves fed to larvae at 1st, 2nd, 3rd,4th and 5th instar recorded maximum shell weight (0.20, 0.20, 0.21, 0.20,and 0.21 gm) as compare to control group.

Amala et al., (2011) evaluate that when the inoculated worms were treated with the probionts Bifidobacterium bifidum and yeast at different concentrations. *Bifidobacterium bifidum* showed significant enhancement in shell weight.

Mariba Shetty et al., (2008) also shows that the aqueous botanical extracts were prepared at concentration of 10, 20, and 40 per cent and sprayed on mulberry leaves prior to feeding it to silkworms. Among these plants used administration of 40 per cent of P3 to the larva of PM X CSR2 hybrid registered significant improvement (at 5% significant) in shell weight (0.320 and 0.338 g).

Similar results were reported by Mururai et al., (2008) has shows that the study was conducted by using different plant extracts viz., *Cucumis sativus, Emblica officinalis, Citrus lemon L., Ocimum sanctum L., cumcura longa L., Allium sativum L., Cicer arietinum* at two different concentration Viz., 2 and 6 per cent. The results indicated that, among the tried plant extracts when, silkworm (PM X CSR2) reared on mulberry leaves sprayed with *Cucumis sativus* plant extracts exhibited significant
difference with respect to economic traits. However, Shell weight (0.312g) was significantly maximum in *cucumis sativus* at 6 per cent concentration.

Murugesh *et al.*, (2008) also reported that the botanicals treated *Tridax procumbens* (9.17 %) and *Parthenium hysterophorus* (10.11%) were found to be topical application on silkworm larva significantly enhanced the Shell weight (3.18 and 3.17 g/10) compared with control (30.25g/10, 15.08g/10, 2.46g/10 and 16.31% respectively).

Vanitha *et al.*, (2006) observed better about Silkworm (PM X CSR2) fed on mulberry leaves dusted with cereal and legume combination viz., 80% activated horsegram regular flour + 20% regular ragi flour produced significantly higher shell weight when supplement was provided from fourth instar till spinning as compared to supplementation exclusively during fifth instar.

Also, these research findings are in conformity with results of Gayathri *et al.*, (2006) show that the water extracts of plant such as *Tinospora cordifolia* Willd, *Coleus armaticus* Benth, *Bacopa monnieri* L., *Centella asiatica* L., *Eclipta prostrata* L., *Acorus calamus* L., *Withania somnifera* Dunal, *Sauropus androgynus* Merr, *Phyllanthus niruri* L. and *Terminalia chebula* Retz., stimulated the growth of mulberry silkworm. However, the best plant extracts found were *E. prostrata, Bacopa monnieri, Centella asiatica* and *Tinospora cordifolia* at two per cent concentration which enhanced the economic characters such as shell weight.

Anju Dube *et al.*, (2005) also shows that the effect of two narcotic plant extracts (2 % aq.) viz. *Palavers rhoeas* L and *Cannabis sativa* L. along with two other extracts viz. *Nicotina plumbaginifolia* and *Rosa damascena* on biological and economic parameters of full grown worms of *Bombyx mori* L. (race : NB4D2 X SH6). Rose water (*Rosa damascena*) however showed better results over control in terms of single shell weight (0.32 v/s 0.2 gms).

Narayanswamy *et al.*, (2006) also show that the shell weight considerably increased in treated batches when compared with the control. Among the treatments, T1 showed a significant (P ≥ 0.01) increase in shell weight, where as in other treatments, there was a marginal increase when compared with control.
The results are conformity with that of Rajegowda (2002) who observed higher shell weight in ‘seripo’ supplemented leaves fed batches. Shell weight showed significant increase (P≥ 0.01 and P≥ 0.05) in T1 batches when compared with control and among other treatments.

Further it is also confirmed by Hiware and Bhalerao, (2008) were shows that the treatment of \textit{T. purpurea} had very deleterious effect on all the parameters under study except shell weight had positive % change over control with values 7.692. There is positive change observed in shell weight, silk ratio % it was in accordance with others Sakay \textit{et al.}, (1993) and Verma and Atwal (1963).

The present findings are in conformity with the findings of Sridevi \textit{et al.}, (2004 a, b) found that the treatment with extract of \textit{W. somnifera} at 0.1 percent concentration recorded the maximum shell weight (0.446g) compared to the control. \textit{Terminilia arjuna, Tinospora cordifolia} and \textit{Leptadenia reticulata} also recorded higher values for these parameters next to \textit{W. somnifera}. The treatments with the extracts of \textit{Tagetes erecta} and \textit{Adhatoda vasica} recorded the minimum shell weight and also a laboratory experiment conducted on the influence of medicinal plant extracts on hell weight. Administration of 0.1 % of \textit{Withania somnifera} registered 0.41g of shell weight. However, \textit{Terminilia arjuna, Tinospora cordifolia} and \textit{leptadenia reticulata} recorded 0.38g, 0.39g and 0.34g of shell weight. The concentration of botanicals of 0.1 % revealed higher shell weight than 0.5%. The control lots recorded lower shell weight 0.33g.

This is in agreement with the work done by Narayanaswamy \textit{et al.}, (2005) show the enrichment of mulberry leaf with Kokhiko silcare feed supplement @ 1000g /100 dfls recorded significantly higher shell weights.

Ranganatha \textit{et al.}, (1999) shows that the plant extracts were administrated topically to fifth instar worms at 48 hours at three different concentration viz., 500 ppm, 800 ppm and 1000 ppm. \textit{Thuja orientalis} at 800 ppm registered maximum shell weight followed by \textit{Psoralea corylefolia} (800 ppm).
4.1.6 Shell ratio (%)

During 2009 – 11

From results it is clear that during 2009 -11 shows increased shell ratio for all treated groups of both plant extracts as compared with percent change over control group. *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the shell ratio was seen increased by T2 (77.15 %), T3 (72.71 %) and T1 (51.50 %) and *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the shell ratio was seen increased by T6 (74.42 %), T5 (64.32 %) and T4 (55.047 %). But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for shell ratio parameter during study period.

The present report of increased shell ratio is in accordance with the earlier ones Krishnaprasad *et al.*, (2001) which is reported that mulberry leaf supplemented with potato leaf extract once during 3rd and 4th instar and twice during 5th instar recorded superior shell ratio.

Sujatha *et al.*, (2003a) also shows similar findings to study the effect of *Eucalyptus globules* leaf extract (0.1, 1.0, 2.0 and 5.0%) when fed to silkworm along with mulberry leaf. The economical character such as shell ratio showed improvement in 15 concentration of *Eucalyptus* leaf extract.

Sujatha *et al.*, (2003b) reported the effects of leaf of *Azadirachta indica* and *Vitex negundo* when supplemented to mulberry feeding of silkworm. There was significant improvement in shell ratio at 2.0% concentration of *Vitex* leaf extracts.

Similar results were observed by Jeypaul *et al.*, (2003) reported that food assimilation rate, conversion efficiencies were significantly higher in silkworm fed on mulberry leaf supplemented with *Coffea Arabica* leaf extract at 1:25 concentration. *Coffea Arabica* leaf extracts at 1: 100, 1:50 and 1:25 concentration recorded maximum shell ratio (17.44, 17.87 and 17.42 %). Leaves of *Alternanthera sessilis*, *Eichhornia crassipes* at 1:100 and 1:50 concentration recorded higher cocoon shell ratio than control.

Similar results were reported by Prasad *et al.*, (2000) were conducted a study in which *Morus* leaves were dipped in extract from solanaceous crops (potato, tomato, aubergine, chilli and tobacco). Extract concentration were 1:1, 1:2 and 1:4 w/v. treated
Morus leaves were fed to fifth instar larvae of *B. mori* L. supplementation of mulberry leaves with potato leaf extract collected at growth stage, potato leaf extract at 1:4 concentration and in border cropping control treatment resulted in the highest shell percentage (15.98, 15.48 and 15.29, respectively). This indicates that potato leaf extract collected at growth stage and at 1:4 concentration significantly improved the economic parameters of silkworm.

Padmalatha *et al.*, (2005) also shows the effect of four ferns such as *Nephrolepis auriculata*, *Christrella parasitica*, *Decranopteris linearis* and *Pityurogramma calomelanes* on the quantitative traits and energetic as of *B. mori*. Significant differences in economic parameters of silkworm existed in relation to plant extracts. *N. auriculata* extracts at 0.1, 0.2 and 0.4 per cent concentrations recorded higher shell percentage (18.52, 17.98 and 16.95%). *C. parasitica*, *D. linearis* and *P. calomelanes* at different concentrations recorded higher shell percentage than control.

This is in agreement with the work done by Sashidaran Nair *et al.*, (2000) also shows that the maximum improvement in shell ratio of KA x NB4D2 was obtained in the case of 5 ppm JH at 48 h (15.79%) followed by 5 ppm at 24 h (7.97%). In PM x NB4D2, an increase of 12.78% with 2 ppm NL-24 at 48 h and 10.44% with 10 ppm at 24 h could be recorded.

The results are in conformity with Rajegowda (2002) who observed higher shell ratio in ‘SERIPRO’ supplemented leaves fed batches. The average shell ratio in treatment T1 showed a marginal increase when compared with the control. These values are in concurrence with the work of Subbu Rathinum and Krishna (1998) who have sprayed mineral (Iron 2.5kg/ha) that favorably influenced higher shell percentage.

Singh *et al.*, (2005) shows that the silkworm larvae were fed on mulberry leaves treated with a probiotic bacteria namely *Lactobacillus plantarum* during different instars and its effect on shell ratio was studied. Results showed that the larvae of treatment groups had significantly shell ratio as compared to control group. Also overall analysis of interaction between different treatment groups and control group showed significant higher values for shell ratio. *L. plantarum* treated mulberry leaves
fed to larvae at 1st, 2nd, 3rd, 4th and 5th instar recorded maximum shell ratio (15.98, 15.33, 16.21, 16.32 and 15.65%) respectively as compare to control group.

Amala et al., (2011) also evaluate that when the inoculated worms were treated with the probionts Bifidobacterium bifidum and yeast at different concentrations. Bifidobacterium bifidum showed significant enhancement in shell ratio. The shell ratio is an important commercial characteristic of B. mori. When compared to control, the shell ratio had increased 2.75%, 8.88% and 11.87% in 2%, 4%, and 6% treatment of B. bifidum respectively. The shell ratio had increased to 4.81%, 10.12% and 13.8% in 2%, 4% and 6% treatment of yeast respectively.

Similar results were observed by Maribab et al., (2008) shows that the aqueous botanical extracts were prepared at concentration of 10, 20, and 40 per cent and sprayed on mulberry leaves prior to feeding it to silkworms. Among these plants used administration of 40 per cent of P3 to the larva of PM X CSR2 hybrid registered significant improvement (at 5% significant ) in Shell ratio (19.38%), while the carrier and normal control batches recorded lower Shell ratio (18.45 and 18.49 %).

Further it is also confirmed by Mururai et al., (2008) fount that the study using different plant extracts viz., Cucumis sativus, Emblica officinalis, Citrus lemon L., Ocimum sanctum L., cumcuro longa L., Allium sativum L., Cicer arietinum at two different concentration Viz., 2 and 6 per cent. The results indicated that, among the tried plant extracts when, silkworm (PM X CSR2) reared on mulberry leaves sprayed with Cucumis sativus plant extracts exhibited significant difference with respect to economic traits. However, shell ratio (17.70%) was significantly maximum in Cucumis sativus at 6 per cent concentration beside reducing the larval duration (6.89 days) compared with others treatments.

Similar results were observed by Murugesh (2008) which is use an topical application of T. Procumbens and Tribulus terrestris on silkworm larva significantly enhanced the shell ratio (18.44%), compared with control (16.31%).

Vanitha et al., (2006) also shows that the silkworm (PM X CSR2) fed on mulberry leaves dusted with cereal and legume combination viz., 80% activated horsegram regular flour + 20% regular ragi flour produced significantly higher shell
ratio when supplement was provided from fourth instar till spinning as compared to supplementation exclusively during fifth instar.

Also, these research findings are in conformity with results of Gayathri et al., (2006) were shows that the water extracts of plant such as *Tinospora cordifolia* Willd, *Coleus armaticus* Benth, *Bacopa monnieri* L., *Centella asiatica* L., *Eclipta prostrata* L., *Acorus calamus* L., *Withania somnifera* Dunal, *Sauropus androgynus* Merr, *Phyllanthus niruri* L. and *Termitalia chebula* Retz., stimulated the growth of mulberry silkworm. However, the best plant extracts found were *E. prostrata, Bacopa monnieri, Centella asiatica* and *Tinospora cordifolia* at two per cent concentration which enhanced the economic characters i.e. shell ratio.

Anju Dube (2005) attempt an experiment was shows that the effect of two narcotic plant extracts (2 % aq.) viz. *Palavers rhoeas* L and *Cannabis sativa* L. along with two other extracts viz. *Nicotina plumbaginifolia* and *Rosa damascena* on biological and economic parameters of full grown worms of *Bombyx mori* L. (race : NB4D2 X SH6). The worms fed with narcotic plant extracts initially showed better shell ratio (23.85 v/s 20.08 %) over control.

The present findings are in conformity with the findings of Hiware and Bhalerao, (2008) were shows that the treatment of *T. purpurea* had very deleterious effect on all the parameters under study except silk ratio % only and had positive % change over control with values 7.692, 1.587, 6.85 respectively. There is positive change observed in silk ratio %.

This is in agreement with the work done by Sridevi et al (2004 a, b) found that the effect of extracts (at 0.1 and 0.5 %) of medicinal plants (*Tagetes erecta, Withania somnifera, Tinospora cordifolia, Leptadenia reticulata, Terminalia arjuna* and *Adhatoda vasica*) on mulberry leaves fed to silkworm resulted in the improvement of shell ratio of (PM x CSR2). The treatment with extract of *W. somnifera* at 0.1 percent concentration recorded the maximum shell ratio (21.40) compared to the control. The treatments with the extracts of *Tagetes erecta* and *Adhatoda vasica* recorded the minimum shell ratio and a laboratory experiment conducted on the influence of medicinal plant extracts on shell percentage. Administration of 0.1 % of *Withania somnifera* 20.20% of shell percentage. However, *Terminalia arjuna, Tinospora*
cordifolia and leptadenia reticulata recorded 19.57%, 20.15% and 18.56% of shell percentage. The concentration of botanicals of 0.1 % revealed higher shell percentage than 0.5%. The control lots recorded lower shell percentage of 19.07and 15.81 % which were lower.

The present findings are in conformity with the findings of Narayanaswamy et al., (2005) was carried out to know the influence of enriched mulberry leaf with Kokhiko silcare feed supplement and its effect on rearing performance of silkworm hybrid (CSR2 x CSR4). The enrichment of mulberry leaf with Kokhiko silcare feed supplement @ 1000g /100 dfls recorded significantly higher shell ratio.

Ranganatha et al., (1999) were also similar results for topical application of solvent extract of certain botanicals viz. Thuja orientalis, Ocimum gratissimum, Lantana camera and Psoralea coryleifolia hybrid silkworm PM x NB4D2. The plant extracts were administrated topically to fifth instar worms at 48 hours at three different concentration viz., 500 ppm, 800 ppm and 1000 ppm. Thuja orientalis at 800 ppm registered maximum shell ratio followed by Psoralea coryleifolia (800 ppm).

Pratheesh Kumar et al., (2007) also used ethanol extract of 20 botanicals in 3 concentrations i.e., 2.5%, 5% and 10% were evaluated for their efficacy to improve reproductive performance of mulberry silkworm (Bombyx mori L.) through feeding botanical enriched mulberry leaves during 2nd day of 4th age as well as 1st and 3rd day of 5th age larvae. Five botanicals viz., Asparagus recetnosus, Achyranthes aspera, Tribulus terrestris, Withania somnifera, Parthenium histerophorus ranked first were further evaluated at 8% 5% and 3% concentrations to confirm their effectiveness and standardize effective concentration. Among the rearing parameter shell ratio were not significantly influenced by the treatments. This is an adverse result compared with our findings.

Amala et al., (2011) shows impact of supplementation of Amway protein on the economic character of silkworm, Bombyx mori L. the results shows that mulberry leaves treated with Amway protein (10 %) was very effective when compared to control. Mulberry leaves treated with Amway protein (10 %) fed larvae recorded a maximum shell ratio (18.25 % Vs 16.75%).
4.1.7 Filament length (m)

During 2009 – 11

From results it is clear that during 2009-11 shows increased Filament length for all treated groups of both plant extracts as compared with percent change over control group. *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the Filament length was seen increased by T3 (44.22%), T1 (42.76%), and T2 (39.89%) and *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the Filament length was seen increased by T6 (50.98%), T4 (47.07%) and T5 (41.11%). But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for Filament length parameter during study period.

This is in agreement with the work done by Saravanan Manjula *et al.*, (2010) which evaluate the effects of various concentrations of *D. lablab* supplementation with mulberry on the silk length. There is a significant raise in the silk length of the larvae fed with *D. lablab* supplemented mulberry when compared with control groups. This may be due to the increased protein content of the mulberry supplemented with *D. lablab*. There is a significant increase in the all parameters while there is no significance between the 7.5% and 10% dose of *D. lablab* with respect to silk filament length.

The present report of increased filament length is in accordance with the earlier ones Venkatesh Kumar *et al.*, (2009) has been analyzed an Variance which indicated high significant differences (at p = 0.01) between the treatment values in respect of silk filament length. The treatment with 300 ppm concentration spirulina has very significantly increased the silk filament length when compared with control. The differences between 100 and 200 ppm concentrations are not found to be significant except for filament length.

Similar results were observed by Sujatha (2003a) studied the effect of *Eucalyptus globules* leaf extract (0.1, 1.0, 2.0 and 5.0%) when fed to silkworm along with mulberry leaf. The economical character such as filament length showed improvement in 15 concentration of *Eucalyptus* leaf extract.

Sujatha *et al.*, (2003b) reported the effects of leaf of *Azadirachta indica* and *Vitex negundo* when supplemented to mulberry feeding of silkworm. There was
significant improvement in filament length at 2.0% concentration of *Vitex* leaf extracts.

Sashindran Nair *et al.*, (2003) shows that the influence of bakuchiol a JH analogue from Bemchi (*Psoralea corylifolia*) on the silk yield of silkworm, *Bombyx mori* L. was studied involving two popular commercial hybrids, KA x NB4D2 (bivoltine x bivoltine) and PM x NB4D2 (multivoltine x bivoltine). The compound was administered topically to 5th instars at 24, 48, 72 and 96 h as a single dose. Three-concentration *viz.*, 0.625, 1.25 and 2.5 ppm were tested. Economic characters of the larvae and the resultant cocoon traits were measured. The result showed that 1.25 ppm of bakuchiol applied to 48 h old 5th instars was the most favourable treatment for improvement of commercial traits. Filament length has increased significantly due to this treatment.

Prasad *et al.*, (2000) were conducted a study in which *Morus* leaves were dipped in extract from solanaceous crops (potato, tomato, aubergine, chilli and tobacco). Extract concentration were 1:1, 1:2 and 1:4 w/v. treated Morus leaves were fed to fifth instar larvae of *B. mori* L. supplementation of mulberry leaves with potato leaf extract collected at growth stage, potato leaf extract at 1:4 concentration and in border cropping control treatment resulted filament length was also maximum at 1:4 concentration of potato leaf extract (650.00 m) and in border cropping control recorded maximum length (610.00 m).

Also, these research findings are in conformity with results of Sashidaran Nair *et al.*, (2000) were studied that the increased cocoon shell weight is aptly reflected in the filament length in the present study. Increase in filament length almost corresponding to that in cocoon shell weight is visible in the other treatments also.

Amala *et al.*, (2011) evaluate that when the inoculated worms were treated with the probionts *Bifidobacterium bifidum* and yeast at different concentrations. *Bifidobacterium bifidum* showed significant enhancement in filament length. *Bifidobacterium bifidum* with a concentration of 6% was very effective. Mulberry leaves treated with *Bifidobacterium bifidum* (6%) fed larvae recorded a maximum filament length (956.33±47.18).The filament length was maximum, (956.33±47.18m) in B. bifidum 6% treated worms and it showed an increase of 24.3% when compared
to the control. Silkworm larvae treated with 4% dilution of B. bifidum showed a filament length (858±70.02m) and it was 11.57% more than the control. The filament length of worms treated with 4% and 6% of yeast are (848±64.62m) (884±82.48m) respectively. The percentage of increase was 10.27 and 14.95. This suggests that the supplements have an ability to increase the length of the filament.

This is in agreement with the work done by Mururai (2008) shows that using different plant extracts viz., Cucumis sativus, Emblica officinalis, Citrus lemon L., Ocimum sanctum L., cumcuma longa L., Allium sativum L., Cicer arietinum at two different concentration Viz., 2 and 6 per cent. The results indicated that, among the tried plant extracts when, silkworm (PM X CSR2) reared on mulberry leaves sprayed with Cucumis sativus plant extracts exhibited significant difference with respect to economic traits. However, filament length (983.86m) was significantly maximum in cumcuma sativus at 6 per cent concentration compared with others treatments.

Similar results were reported by Vanitha (2006) which is shows that the silkworm (PM X CSR2) fed on mulberry leaves dusted with cereal and legume combination viz., 80% activated horsegram regular flour + 20% regular ragi flour produced significantly higher filament length when supplement was provided from fourth instar till spinning as compared to supplementation exclusively during fifth instar. The performance of the silkworm hybrid was superior with fortification as against unsupplemented control

Narayanaswamy et al., (2006) shows that the average filament length in T1 batch showed a significant increase (P ≥ 0.01), when compared with the control and other treatments. However, in T2 and T6 treatments, increase in filament length was only marginal while in T4 treatment, there was marginal decrease in length of silk filament. This is an adverse result with our findings.

Further it is also confirmed by Sridevi (2004a, b) which conduct an experiment to investigate the effect of extracts (at 0.1 and 0.5 %) of medicinal plants (Tagetes erecta, Withania somnifera, Tinospora cordifolia, Leptadenia reticulata, Terminilia arjuna and Adhatoda vasica) on cocoon and reeling parameters of silkworm, Bombyx mori L. (PM x CSR2). The extract treated mulberry leaves fed to silkworm resulted in the improvement of silk filament length of (PM x CSR2). The treatment with extract
of *W. somnifera* at 0.1 percent concentration recorded the maximum silk filament length (1144.24) compared to the control. *Terminilia arjuna*, *Tinospora cordifolia* and *Leptadenia reticulata* also recorded higher values for these parameters next to *W. somnifera*. The treatments with the extracts of *Tagetes erecta* and *Adhatoda vasica* recorded the minimum silk filament.

This is in agreement with the work done by Narayanaswamy, (2005) were conduct an investigation was carried out to know the influence of enriched mulberry leaf with Kokhiko silcare feed supplement and its effect on rearing performance of silkworm hybrid (CSR2 x CSR4). The enrichment of mulberry leaf with Kokhiko silcare feed supplement @ 1000g /100 dfls recorded significantly higher single cocoon filament length.

Ranganatha *et al.*, (1999) also shows that the topical application of solvent extract of certain botanicals viz. *Thuja orientalis*, *Ocimum gratissimum*, *Lantana camera* and *Psoralea coryleifolia* on larval and cocoon parameters of *Bombyx mori* L. were studied using commercial hybrid silkworm PM x NB4D2. The plant extracts were administrated topically to fifth instar worms at 48 hours at three different concentration viz., 500 ppm, 800 ppm and 1000 ppm. *Thuja orientalis* at 800 ppm registered maximum filament length, followed by *Psoralea coryleifolia* (800 ppm).

Goudar *et al.*, (2001a) shows that the effect of topical application with 200, 400 and 600 µg / ml 2,4- dichlorophenoxyacetic acid (2,4- D) on the fifth larval stadium of the silkworm *Bombyx mori* L. was analyzed. The results of the filament length increased significantly in 200 µg / ml (2, 4- D) treated groups when compared with corresponding parameters of carrier controls. Similar results have been reported after the topical application with IAA to the bivoltine silkworm *Bombyx mori* (Hugar and Kaliwal, 1997).

This is in agreement with the work done by Kochi *et al.*, (2005) which is conduct a topical application with 100, 200 and 300 mg/ml phytohormone salicylic acid on commercial traits was analyses in bivoltine CSR2, CSR4 and CSR2XCSR4 crossbreed races of the silkworm, *Bombyx mori* L. The results of the study showed that the topical application with salicylic acid increased significantly in filament length with all the treated groups in CSR4, filament length in all the treated groups in CSR2.

There was also a significant increase in filament length with 200 ng/ml treated groups in crossbreed CSR2XCSR4 silkworm, *Bombyx mori* L.

Similar results have been reported after the topical application with IAA, 2, 4-D and NOA to bivoltine silkworm, *Bombyx mori* L. (Hugar and Kaliwal, 1997). These results also suggest that CSR4 showed good response to phytohormone salicylic acid as compared with those of crossbreed CSR2 and CSR2xCSR4 races of the silkworm, *B. mori*. Goudar and Kaliwal (2001a, b) have reported that plant growth regulators 2, 4-dichloro-phenoxy acetic acid (2, 4-D) and naphthoxy-acetic acid (NOA) enhance the economic traits like filament length in the silkworm, *Bombyx mori* L.

When JH or JH like compounds are administered to the insect larvae, they disrupt the normal developmental pattern leading to developmental deformity. But interestingly, the silkworm, *Bombyx mori* L. is known to have a stimulatory effect on the administration of exogenous JH analogues in minute quantities which lead to enhancement in commercial traits such as silk filament length (Akai *et al*., 1985; Mamatha *et al*., 2006; 2008, Sashindran Nair *et al*., 2010).

Amala *et al*., (2011) shows impact of supplementation of Amway protein on the economic character of silkworm, *Bombyx mori* L. the results shows that mulberry leaves treated with Amway protein (10 %) was very effective when compared to control. Mulberry leaves treated with Amway protein (10 %) fed larvae recorded a maximum filament length (888 Vs 769).

4.1.8 Filament weight (gm)

**During 2009 – 11**

From results it is clear that during 2009 -11 shows increased Filament weight for all treated groups of both plant extracts as compared with percent change over control group. *Ziziphus jujuba* L. (1:2, 1:4 and 1:8) extracts, it were observed that the Filament weight was seen increased by T3 (61.65 %), T2 (54.88 %), and T1 (47.37 %) and *Ficus racemosa* L. (1:2, 1:4 and 1:8) extracts, it were observed that the Filament weight was seen increased by T6 (75.19 %), T4 (66.16 %) and T5 (63.90 %). But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for Filament weight parameter during study period.
The present report of increased filament weight is in accordance with the earlier ones Saravanan Manjula et al., (2010) which evaluate the effects of various concentrations of *D. lablab* supplementation with mulberry on the silk filament weight of the larvae fed with *D. lablab* supplemented mulberry when compared with control groups. This may be due to the increased protein content of the mulberry supplemented with *D. lablab*. There is a significant increase in the all parameters while there is no significance between the 7.5% and 10% dose of *D. lablab* with respect to silk weight. So, 7.5% was fixed as the effective dose. This is in agreement with the work done by Hiware (2006) regarding the increased silk filament weight when silkworm treated with homeopathic drug *Nux vomica*.

Similar results were observed by Hiware and Bhalerao (2008) shows an increased or positive trend seen in the values of different parameters; weight of filament and denier in group treated with *P. niruri* in the experimental group when compared with the control group and values are 15.18 and – 9.17 indicating that the plant extract showed good effect on the filament of silk in which the length increased with the fine denier, it is essential to produce gradable silk like that Chinese silk i.e. with long and thin filament, these results are in accordance with others i.e. Kalpana et al., (2002).

Murugan et al. (1999) who reported an increase the aqueous extracts of botanicals such as *Tridax procubens, Lantana camera, Clerodendron sp.* and *Croton sparsiflorus* stimulated the growth and development of mulberry silkworm, *Bombix mori* L. (PMxNB4 D2). Plant extract had greatly influence the feeding and efficiency measures of silk worm larvae and also increase the weight of the cocoon and silk filament. Silk filament length and weight also increase after the treatment of plant extracts.

The present findings are in conformity with the findings of Mururai (2008). The study was conducted by using different plant extracts viz., *Cucumis sativus, Emblica officinalis, Citrus lemon L., Ocimum sanctum L., cumcura longa L., Allium sativum L., Cicer arietinum* at two different concentration Viz., 2 and 6 per cent. The results indicated that, among the tried plant extracts when, silkworm (PM X CSR2) reared on mulberry leaves sprayed with *Cucumis sativus* plant extracts exhibited

significant difference with respect to economic traits. However, filament weight (0.252g) was significantly maximum in *cucumis sativus* at 6 per cent concentration. The results clearly indicated that the fortification of mulberry leaf with plant extracts (*cucumis sativus*) had significantly increased the economic parameters of the silkworm *B. mori* L.

This is in agreement with the work done by Kochi *et al.*, (2005) which is conduct a topical application with 100, 200 and 300 mg/ml phytohormone salicylic acid on commercial traits was analysed in bivoltine CSR2, CSR4 and CSR2XCSR4 crossbreed races of the silkworm, *Bombyx mori* L. The results shows that the topical application with salicylic acid increased significantly in filament weight with all the treated groups in CSR4, filament weight with 300 mg/ml and denier with 200 and 300 ng/ml salicylic acid treated groups in CSR2 silkworm, *Bombyx mori* L. There was also a significant increase in filament weight and denier with 100 and 200 mg/ml treated groups in crossbreed CSR2XCSR4 silkworm, *Bombyx mori* L. Similar results have been reported after the topical application with IAA, 2, 4-D and NOA to bivoltine silkworm, *Bombyx mori* L. (Hugar and Kaliwal, 1997; Goudar and Kaliwal 2001a, b).

These results also suggest that CSR4 showed good response to phytohormone salicylic acid as compared with those of crossbreed CSR2 and CSR2xCSR4 races of the silkworm, *Bombyx mori* L.

Hiwari (2005a, b) also shows that silkworm *Bombyx mori* L. larvae were fed on mulberry leaves treated with the homeopathic drug, *Chelidonium* mother tincture. From the study it is clear that the supplementation with homeopathic drug, *Chelidonium* is very good effect on the length and size of filament and *Phytolacca berry* mother tincture find same results during study period.

Amala *et al.*, (2011) shows impact of supplementation of Amway protein on the economic character of silkworm, *Bombyx mori* L. the results shows that mulberry leaves treated with Amway protein (10 %) was very effective when compared to control. Mulberry leaves treated with Amway protein (10 %) fed larvae recorded a maximum filament weight (3.2 Vs 1.3).

Nguku *et al.*, (2007) shows that the fourth instar *Bombyx mori* L. silkworm larvae fed on mulberry leaves to which royal jelly had been added. The filament
obtained from cocoons produced by larvae fed on royal jelly was significantly longer than the filament obtained from the control group. Likewise, the mean filament weight obtained from control group was less compared with that of the royal jelly group. The differences were statistically different to that of the royal jelly group.

Goudar et al., (2001a, b) shows that the effect of topical application with 200, 400 and 600 µg/ml 2,4-dichlorophenoxyacetic acid (2,4-D) on the fifth larval stadium of the silkworm Bombyx mori L. was analysed. The results of the filament length and weight increased significantly in 200 µg/ml (2, 4-D) treated groups when compared with corresponding parameters of carrier controls. Similar results have been reported after the topical application with IAA to the bivoltine silkworm Bombyx mori L. (Hugar and Kaliwal, 1997).

Chamundeshwari et al., (1994) also study on the impact of zinc and nickel on the larval and cocoon characters of silkworm Bombyx mori L. The results of 20 ppm zinc as well as nickel shows increase in filament weight relative to control.

4.1.9 Denier

During 2009 – 11

From results it is clear that during rainy season 2009 - 11 shows increased Denier for all treated groups of both plant extracts as compared with percent change over control group. Ziziphus jujuba L. (1:2, 1:4 and 1:8) extracts, it were observed that the Denier was seen increased by T3 (15.35 %), T2 (8.72 %) and T1(7.72 %) and Ficus racemosa L. (1:2, 1:4 and 1:8) extracts, it were observed that the Denier was seen increased by T6 (17.35 %), T4 (13.49 %) and T5 (13.10 %). But overall performance of T3 and T6 both shows better result as compare with other treated groups and control group for Denier parameter during study period.

Similar results were observed by Hiware and Bhalerao (2008) shows an increased or positive trend seen in the values of different parameters; weight of filament and denier in group treated with P. niruri in the experimental group when compared with the control group and values are 15.18 and – 9.17 indicating that the plant extract showed good effect on the filament of silk in which the length increased with the fine denier, it is essential to produce gradable silk like that Chinese silk i.e.
with long and thin filament, these results are in accordance with others i.e. Kalpana et al., (2002).

The present report of increased denier is in accordance with the earlier ones Amala et al., (2011) evaluate that when the inoculated worms were treated with the probionts Bifidobacterium bifidum and yeast at different concentrations. Bifidobacterium bifidum showed significant enhancement in Denier. Bifidobacterium bifidum with a concentration of 6% was very effective. Mulberry leaves treated with Bifidobacterium bifidum (6%) fed larvae recorded a maximum Denier (13.3%) over the control. There was not much difference in the denier value of worms treated with 2% dilution of yeast. However 4% and 6% of yeast treatment showed an increase of 5.17% and 9.28% than the control. The worms treated with 2%, 4% and 6% dilution of B. bifidum treatment showed an increase of 4.08%, 7.21% and 13.3% than the control.

The present findings are in conformity with the findings of Sridevi, et al., (2004a,b) were conducted an experiment was conducted to investigate the effect of extracts (at 0.1 and 0.5 %) of medicinal plants (Tagetes erecta, Withania somnifera, Tinospora cordifolia, Leptadenia reticulata, Terminilia arjuna and Adhatoda vasica) on cocoon and reeling parameters of silkworm, Bombyx mori L. (PM x CSR2). The extract treated mulberry leaves fed to silkworm resulted in the improvement of denier, of (PM x CSR2). The treatment with extract of W. somnifera at 0.1 percent concentration recorded the minimum denier (2.21) compared to the control. The treatments with the extracts of Tagetes erecta and Adhatoda vasica recorded the maximum denier.

Sashidaran Nair et al., (2000, 2001) also shows that the influence of a Plant based juvenile hormone mimicking compound NL-24 (formyl longifolene oxime citronellyl ether), an oxime ether of carbohydrate derived from longifolene of Indian turpentine oil extracted from the plant, Pinus longifolia Roxb., was administrated to silkworm, Bombyx mori L. But at the same time, there was no substantial change in the denier. This is to be appreciated because, if the thicker cocoon shell is unwound to shorter filament of thicker denier, the industry may not accept it a widely known. The increased cocoon shell weight is understood to have converted to the end product, the

reelable silk filament in the present study. An enhancement of 14.45 and 12.79 % in filament length was observed in KA x NB4D2 and PM x NB4D2, respectively.

Further it is also confirmed by Kochi and Kaliwal (2005) was shows that the application with 100, 200 and 300 mg/ml phytohormone salicyclic acid on commercial traits was analysed in bivoltine CSR2, CSR4 and CSR2XCSR4 crossbreed races of the silkworm, Bombyx mori L. The results of the present study showed that the topical application with salicylic acid increased significantly in denier with all the treated groups in CSR4 and denier with 200 and 300 mg/ml salicylic acid treated groups in CSR2 silkworm, Bombyx mori L. There was also a significant increase in denier with 100 and 200 mg/ml treated groups in crossbreed CSR2XCSR4 silkworm, Bombyx mori L.

Similar results have been reported after the topical application with IAA, 2, 4-D and NOA to bivoltine silkworm, Bombyx mori L. (Hugar and Kaliwal, 1997). These results also suggest that CSR4 showed good response to phytohormone salicyclic acid as compared with those of crossbreed CSR2 and CSR2xCSR4 races of the silkworm, Bombyx mori L. Goudar and Kaliwal (2001a, b) have reported that plant growth regulators 2, 4-dichloro-phenoxy acetic acid (2, 4-D) and naphthoxy-acetic acid (NOA) enhance the economic traits like denier in the silkworm, Bombyx mori L.

Hiware (2006) shows that silkworm Bombyx mori L. larvae were fed on mulberry leaves treated with Nux vomica mother tincture. The impact on denier was investigated. The results were shows that negative trend with Nux vomica treatment values 1.229 %, 3.535% and 14.70% (P< 0.001), respectively.

Hiware (2005 a, b) also shows that silkworm Bombyx mori L. larvae were fed on mulberry leaves treated with the homeopathic drug, Chelidonium mother tincture. From the study it is clear that the supplementation with homeopathic drug, Chelidonium was used to produce gradable silk like Chinese silk with long, thin filament (thin denier) and Phytolacca berry mother tincture also shows better denier over control treatment.

Amala et al ., (2011) shows impact of supplementation of Amway protein on the economic character of silkworm, Bombyx mori L. the results shows that mulberry leaves treated with Amway protein (10 %) was very effective when compared to
control. Mulberry leaves treated with Amway protein (10 %) fed larvae recorded a maximum Denier (2.87 Vs 1.63).

Nguku et al., (2007) shows that the fourth instar Bombyx mori L. silkworm larvae fed on mulberry leaves to which royal jelly had been added. The filament obtained from cocoons produced by larvae fed on royal jelly was significantly longer than the filament obtained from the control group. However, the silk denier from the control group was not significantly different to that of the royal jelly group.

Rezina Laz et al., (2006) shows the effect of Methionine and tryptophan on some economic characters in the mulberry silkworm Bombyx mori L. the results shows that at four conc. Viz. 250, 500, 750 and 1000 ppm to evaluate the effects of these amino acid on the denier.

Goudar and Kaliwal (2001a,b) shows that the effect of topical application with 200, 400 and 600 µg/ ml 2,4- dichlorophenoxyacetic acid (2,4- D) on the fifth larval stadium of the silkworm Bombyx mori L. was analysed. The results of the denier increased significantly in 200 µg / ml (2, 4- D) treated groups when compared with corresponding parameters of carrier controls.

4.1.10 Number of Breakages
During 2009 – 11

The results indicates that both plant extracts treatments had no breakages of silk filament, So that it is clear those treatments have well for silk thread activity with various concentrations.

Hiwared (2006) shows that silkworm Bombyx mori L. larvae were fed on mulberry leaves treated with Nux vomica mother tincture. The impact on denier was investigated. The results were the number of breakages per filament during reeling in both the groups was only two and there was no significant different between treatments.

Hiwared (2005a) also shows that silkworm Bombyx mori L. larvae were fed on mulberry leaves treated with the homeopathic drug, Chelidonium mother tincture. From the study it is clear that the supplementation with homeopathic drug, Chelidonium is shows that the number of breakages during reeling is -50 % And Phytolacca berry mother tincture shows 50 %.
Hiware (2005b) also shows that silkworm *Bombyx mori* L. larvae were fed on mulberry leaves treated with the homeopathic drug, *Phytolacca berry* mother tincture. From the study it is clear that the supplementation with homeopathic drug, *Phytolacca berry* is shows that the number of breakages during reeling is 50%.

Nguku *et al.*, (2007) shows that the fourth instar *Bombyx mori* L. silkworm larvae fed on mulberry leaves to which royal jelly had been added. Significantly fewer reeling breaks were recorded in filament obtained from cocoons produced by royal jelly fed larvae compared to the breaks were recorded for the filament from the control group.