INFLUENCE OF DIFFERENT N SOURCES ON THE GROWTH, LEAF YIELD AND QUALITY OF MULBERRY (*Morus alba*)

BY

AMPPIAH ARNOLD SYLVESTER

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DECLARATION

1 hereby declare that, except for references to other researchers work which have been duly cited, this work is the result of my own original research and that this Thesis has neither in whole nor in parts been presented for any degree elsewhere.

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AMPPIAH ARNOLD SYLVESTER

(STUDENT)

DATE ……

……

PROF. JOHN OFOSU-ANIM

(SUPERVISOR)

DATE ……..……

……..

PROF. DANIEL OBENG-OFORI

(CO-SUPERVISOR)

DATE……..

ABSTRACT

The influence of inorganic N sources on growth, leaf yield and quality of mulberry (*Morus alba*) was studied under field conditions before (Experiment 1) and after (experiment 2) pruning. The treatments consisted of three mulberry varieties (Kanva-2, S-36 and Mysore local) and three N sources (urea, Sulphate of Ammonia and NPK) and a control. The experimental design used was a split plot design. Varieties formed the main plot and N sources the sub-plot factors. The N sources had significant influence on growth, leaf yield and quality of mulberry. Plant height, number of leaves per plant, number of branches, leaf yield (leaf fresh weight) and leaf quality (moisture and crude protein) were significantly increased by SoA in experiment 1. However, NPK significantly increased plant height, number of leaves per plant, stem diameter, leaf yield (leaf fresh weight) and leaf quality (leaf moisture, leaf crude protein, mineral content and leaf N) after pruning (experiment 2). Among the varieties, S-36 was superior with regards to leaf protein and leaf moisture in both experiments. Mysore local on the other hand was superior in terms of leaf mineral content and protein. The status of sericulture was determined by conducting a survey using questionnaire and group discussions. It was revealed that 5.9% of sericulture farmers had no formal education. Brong-Ahafo Region had the highest (88.2%) number of sericulture farmers. The low patronage and low cocoon production was due to lack of market, price discrimination, lack of market and lack of knowledge on the existence of cocoon market outside Ghana.

DEDICATION

I dedicate this work to God Almighty and my Dad, Mr. Amppiah Michael Edmund.

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Glory to God Almighty.

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LIST OF ABBREVIATIONS

B/A	Brong- Ahafo Region
CSIR	Centre for Scientific and Industrial Research
E/R	Eastern Region
J H S	Junior High School
M local	Mysore local
N	Nitrogen
N sources	Nitrogen sources
N/R	Northern Region
S H S/S S S	Senior High School/Senior Secondary School
SoA	Sulphate of Ammonia
SPDA	Sericulture Promotion and Development Association
W AP 2	Weeks after pruning
WAP 1	Weeks after planting

CHAPTER ONE

1.0 Introduction

Mulberry is a perennial woody plant which belongs to the family Moraceae and Genus Morus. The mulberry (*Morus* sp.) has about 100 known varieties and of these varieties only 10% are widely cultivated including *Morus alba* (Rajan *et al*. 2000). The mulberry tree is known as food for silkworm as well as an economic tree (Kasiviswanathan *et al*, 1988; Jayeola and Adeduntan, 2002). It is a hard crop that can be grown in uplands and non-irrigated areas as a rain fed crop. Depending on cultivation conditions, the tree can be grown as a bush, shrub or a tree (Rangaswami *et al*, 1976).

Mulberry is economically productive under rainfed conditions and is cultivated mainly for the sericulture industry, as the leaves are the only food of the silkworm, *Bombyx mori* (Rangaswami *et al*, 1976). It is estimated that 1tonne of mulberry leaves will produce approximately 25-30kg cocoons when fed to silkworms (Rangaswami *et al*, 1976).One hectare of fertile land yields about 15 - 40 tonnes of mulberry leaves per annum depending on the variety of mulberry, agronomic practices and climatic conditions.

To increase the quantity and quality of mulberry leaves for commercial sericulture in Ghana, there is the need for the application of appropriate fertilizers, irrigation systems, breeding of mulberry and selection of high yielding varieties and adoption of appropriate planting distances (Rangaswami *et al*, 1976).

Nitrogen application to plants improves the nutrition of plants and enhances plant growth. Nitrogen also enhances the resistance of plants to pests and diseases and improve yield of crops (Simpson and Simpson, 1990). Over application and injudicious use of nitrogen (N)

can result in plant lodging, vegetative growth at the expense of yield and vulnerability to pests and diseases (Imayavaramban *et al.,* 2004). It is therefore important that this essential nutrient is supplied to crops in desirable quantities and at the right time during the growth period. Nitrogen fertilizer is a major nutrient for mulberry production. Nitrogen management optimizes leaf yield and leaf quality, while it minimizes the potential for leaching of N beyond the crop rooting zone.

The factors which influence the quantity and quality of mulberry leaves include the rate of fertiliser application and its use by the plant (Krishnaswami *et al.*,1971), season (Yamanouchi *et al.*,2001), cropping density (Krishnaswami *et al.*,1971; Yamanouchi *et al.*,2001;Reddy *et al*. 2002; Baksh *et al*., 2000), and water use. The average temperature for maximum yield and optimum growth is 23 – 27^{o}C and rainfall of 600 - 2500 mm per year (Rangaswami *et al*, 1976).

All measures taken to maximise leaf yield simultaneously help to improve the quality of leaves which automatically lead to the production of quality cocoons (Rangaswami *et al*, 1976).Leaf yield and quality are significantly increased by adequate fertilisation (Wang *et al*., 2001).Mulberry varieties of higher leaf yields are therefore significant to sustainable profitability in sericulture (Das & Krishnaswami, 1965).The mulberry leaves are composed of the proteins, carbohydrates and minerals needed for growth and cocoon production.

The mulberry is not only food for the silkworm but also used in many ways. Besides feeding silkworm, mulberry leaves, shoots and branches can be used as feed for other animals such as poultry, goats, sheep and cattle, the fruit is used to prepare fruit juice,

jams and liquors. The fruits are also useful in the cosmetic and pharmaceutical industries (Ercisli and Orhan, 2007) and as human food, the wood for firewood or for arts and craft purposes and for their medicinal properties.

Sericulture thrives on the suitability of environmental factors, quality and high yielding mulberry varieties and on high yielding silkworm races. It is estimated that more than 60% of the production cost of cocoon is incurred by mulberry leaf production. Sericulture is an industry which involves the production of cocoon and raw silk. It is composed of activities such as breeding and maintenance of silkworm races, mulberry breeding and cultivation, silkworm egg production, silkworm rearing and mounting, cocoon drying, silk reeling, raw silk testing, to the production of silk products by manufacturing and weaving, as well as the silk thread and silk fabric (Ntaanu, 2007). Silk farming is an eco-friendly, agro-based venture with a great potential for environmental amelioration, employment and income generation, artisan's development, diversification of agriculture, and expansion of export earnings (Kioko *et al*., 2009; Ntaanu, 2007).Sericulture can be undertaken as rural micro-enterprise initiatives by resource-poor farming communities which depend on the forest. This will help to reduce the pressure on the natural forest and conserve biodiversity. Sericulture requires low investment for establishment. Small area of land and capital are needed for its start-up (FAO, 2001; Ntaanu, 2007). Farmers with low income and little area of land can undertake this venture to earn additional profit. Though some farmers engage in sericulture as a commercial enterprise, it is a subsidiary source of income for rural communities who are for most of their time engaged in other farming activities. This can be explored to increase the income of farmers in the rural communities in order to alleviate poverty in the larger society. Sericulture has three main

components and these are; Agriculture, Industry and Art. The agriculture component of sericulture involves the production of mulberry leaf for silkworm rearing and subsequent cocoon production. The industry (sericulture) depends on the availability of quality cocoon which also depend on the type of mulberry produced and the rearing techniques used. This means that the production of silk fabric depend strongly on agriculture.

In this study the current status of the sericulture industry in Ghana would be established and this would help in policy formulation and decision making about the sericulture industry in Ghana. It would also form the data base upon which investment in the industry would be based in order to attract investment into the industry and help government to use sericulture as a tool for alleviating poverty and also for conservation of forest and biodiversity. The selection of high yielding mulberry varieties would enable farmers to produce high quality and quantity of mulberry for high quality silk for both the local and global silk market. Awareness of the potential of silk farming in improving the livelihoods of rural communities would be created. This would in turn influence investment in the industry and also entice more rural folks and even urban dwellers to take up sericulture as a means of livelihood.

1.1 Problem statement

Mulberry has been growing in various parts of Ghana since 1994 (Ntaanu, 2012). Different varieties have been introduced into the country but the suitability of specific cultivars to the different ecological zones has not been studied and the influence of nitrogen on leaf yield and quality is also not established. In Ghana mulberry cultivation and cocoon production takes place in almost all the ten regions. The current number of

farmers engaged in sericulture need to be updated and also the size of land under mulberry cultivation is not known. The source of the silkworm eggs into the country is not established and also there is no reliable market for raw cocoon in the country.

The low level of productivity in the sericulture industry in Ghana can among others be attributed to these factors.

1.2 Objectives of the Study

The study sought to establish the current status of sericulture industry in Ghana and to determine the influence of different sources of inorganic fertilizer on growth, leaf quality and regeneration of mulberry varieties. Specifically the study sought to achieve the following objectives:

- Determine the number of farmers engaged in sericulture in Ghana.
- Establish the land area under mulberry cultivation in each region of Ghana
- Ascertain the constraints associated with Cocoon marketing/processing in Ghana
- Determine the sources of silkworm egg supply in Ghana
- Determine the influence of different sources of inorganic nitrogen on the growth, leaf quality and yield of mulberry varieties

CHAPTER TWO

LITERATURE REVIEW

2.0 The sericulture industry

Mulberry has been growing in Ghana since 1994 (Ntaanu, 2012) in various parts of the country. Different varieties have been introduced into the country but the suitability of specific cultivars to the different ecological zones has not been studied and the influence of nitrogen on leaf yield and quality is also not established. In Ghana mulberry cultivation and cocoon production takes place in almost all the ten regions. The current number of farmers engaged in sericulture is yet to be established and also the size of land under mulberry cultivation is not known. The source of the silkworm eggs into the country is not established and also there is no reliable market for raw cocoon in the country.

The low level of productivity in the sericulture industry in Ghana can among others be attributed to these factors.

2.1 Importance of sericulture

Sericulture is a profitable rural activity which has the capacity to yield income in a short period of time. It also requires minimal investment and has maximum employment potential and quick turnover for investment (Kasi, 2000, 2009a; 2009d). In India, sericulture is practised in about 69,000 villages (Central Silk Board, 2002; Geetha and Indira, 2011; Lakshmanan *et al*., 2011). Sericulture generates direct and indirect employment in various ways. First, mulberry cultivation creates employment on farms.

Secondly, cocoon production, which uses mulberry leaves as an input, creates large-scale employment for family members of the mulberry growers. There are even instances where non-mulberry growers take up cocoon production alone as a full-time occupation. They buy leaves from mulberry growers and then use them as raw material for cocoon production.

Further, the reeling activity is also done locally, either in the rural areas or in semi urban areas and the employment generated by this activity certainly helps to reduce rural unemployment.

Although sericulture has been considered as a secondary occupation in rural areas, recent technological advancements have pave way for the practice of sericulture on a commercial scale, yielding greater profits than most agricultural ventures and hence it can be assessed for its feasibility in developing countries such as Ghana (Dingle *et al*., 2005). Due to the fact that it has the highest employment capacity and because most people who depend and engage in agriculture are poor and live in the rural areas, increase in agricultural income is more effective in reducing poverty in any country (Christiaensen and Demery, 2007; World Bank, 2008b).

One sure way or strategy of achieving poverty reduction and sustainable forest conservation is through silk farming or sericulture. This industry has the capacity to engage the unemployed youth, increase the income of farmers and provide an alternative source of livelihood for rural communities and this will reduce or totally remove dependence of rural population on the ever depleting forest which in turn will conserve biodiversity. The artisan industry in Ghana can also be developed and well expanded through silk farming. This is because the silk yarn produced can serve as the raw material

for these small scale industries which will also create more employment. Kente and Smock weavers import cotton yarns because what is produced is not enough to feed the industry. Silk yarns when locally produced can substitute for cotton.

2.2 Global silk production

Silk is produced across the length and breadth of the globe with China and India being the leading producers (Table 2.1). The main silk-producing countries of the world include China, India, DPR Korea, Turkmenistan, Brazil, Uzbekistan, Thailand, Vietnam, Kyrgyzstan, Japan, Iran, Tajikistan, Romania and Indonesia (FAO, 2001).

Table 2.1: World Mulberry Raw silk production

Country	2005	2006	2007	2008	2009	% Share
China	87800	93100	78000	70980	84000	81.06
India	15445	16526	16245	15610	16322	15.75
Japan	150	150	105	95	90	0.09
Brazil	1285	1387	1220	1177	811	0.78
Korea Rep.	150	150	150	135	135	0.13
Uzbekistan	950	950	950	865	750	0.72
Thailand	1420	1080	760	1100	665	0.64
Vietnam	750	750	750	680	550	0.53
Others	1500	1000	500	350	304	0.29
Total	109450	115092	98680	90992	103627	100.00

Note: Unit in Metric tons**Source:** Silk industry in China; ISC web-site update as on January, 2010; SS: 11-05-2010

Some African countries such as Kenya, Egypt, Nigeria and Madagascar have also made significant contributions to the production of silk globally. World silk production has almost doubled in the last decade and continues to increase despite the production of synthetic fibres to replace silk for some uses (Dingle *et al*., 2005).

China and India are the two main producers of silk worldwide, together manufacturing more than 50% of the world production each year. China since the 1970's has drastically increased its silk production and has become the world's leading producer of silk. China was the first country to develop sericulture and it is also the leading producer of silk of all kinds. In the year 2003-2004, India produced 16,319 MT of raw silk out of which 14,617 MT is mulberry silk and India is the second largest producer of silk in the world next to China. Tasar, Eri and Muga silk contributes 284, 1316 and 102 MT respectively to the world total silk (Anon., 2003). Mulberry Silk is the most common type of silk and contributes to nearly 95% of world's silk production. It is produced from the cocoons of silkworms fed with mulberry leaves.

2.2.1 Global Imports and Exports of Silk and Silk Products

There has been a significant change in relation to silk market in the last decade. Silk is a raw material which is traded in the form of cocoons, raw silk, waste silk, silk noils (short, tangled fibres) and spun silk or yarn.

Silk products are relatively less expensive compared to other fabrics and also silk has a unique property which makes it stand out among other fabrics. Some of the properties of silk are;

- It can absorb moisture without feeling damp and its cool-in-summer, warm-in winter and this property is yet to be matched by other synthetics;
- Durability (ability to withstand wear and decay) as a result used for suture materials;
- Flame resistance, which makes it suitable for wall coverings and upholstery.

These and many others give silk a competitive advantage over other fabrics (Dingle, 2000). Silk is widely used for producing various silk fabrics such as dresses, kimonos, quilt covers and ties. By-products of cocoons such as inferior cocoon, un-reelable cocoon, pupal shirt, cocoon floss and waste filaments are utilized as raw materials in cosmetics, foodstuffs and in the electric industry. New developments in silk technology allow silk garments to be hand washed rather than dry-cleaned (Gongyin and Cui, 1996). World trade in silk is divided almost equally between raw silk, fabrics and finished goods (Dingle *et al*., 2005). India converts a high proportion of its raw silk into silk fabrics and exports about 20%. China produces over 81% of the world's raw silk and exports about 40% of the world's silk fabric. Imports of raw silk to Europe has reduced and attention is been moved to the importation of fabrics and finished garments. Italian and Belgian companies handle about 85% of the European silk trade (FAO, 2001).

Table 2.2: Shows the imports and exports of raw silk and by-products of silk globally

Country	Exports in 1999(Mt)	Imports in 1999(Mt)
Bangladesh		2200
China	12089	173
Germany	590	963
Hong Kong	1048	1059
India	17	2743
Italy	22	2695
Japan	3	2596
Korea(DPR)	1000	5
Korea(South)	11	2107
Kyrgyzstan	20	250
Paraguay	224	-
Singapore	157	120
Tajikistan	150	-
Thailand	8	75
Turkey	-	154
Turkmenistan	4100	-
Uzbekistan	240	-
Vietnam	60	90

The data provided on silk production and demand for silk globally indicates that there is an opportunity for developing countries like Ghana to enter into silk production. The environmental conditions are suitable for the cultivation of mulberry and rearing of silk worm nationwide. There is good market for cocoons and raw silk in Africa and the continent has not been able to meet its demand for silk and silk products. Some African countries which have established market for cocoons include: Kenya, Egypt, South Africa, Madagascar and Ghana.

Silk markets in Kenya include National Sericulture Station, Thika, International Centre for Insect Physiology and Entomology (ICIPE), Kakamega Forest Silk Market Centre, in Kakamega, Pendeza Weaving, in Kisumu, Spin Weave, in Nairobi, Gramwa, in Kiambu. Other cocoon markets across the length and breadth of Kenya are; Mwingi Silk Market Place, in Mwingi, Arabuko Sokoke Silk Market Place, in Malindi, Molo Weavers, in Elburgon, Rivatex, in Eldoret (Prospective large scale buyer), Kimahuri youth group in Nyeri county and Sarah Jane in Nairobi. This makes Kenya a better place in Africa to embark on commercial cocoon production as compared to the situation in Ghana.

2.3 Raw Silk Cocoon Production in Ghana

The production of cocoon in Ghana started with the establishment of the silk factory in Accra in 2004. The factory was established by the partnership between FAO, Ghana government and the government of India. The funding for the establishment was provided by FAO and Technical expertise was provided by the government of India. The major stakeholders are Ministry of Food and Agriculture (MoFA), Institute of Industry Research (IIR-CSIR) and Sericulture Promotion and Development Association (SPDA).

The major areas of raw cocoon production are; Brong-Ahafo Region and Eastern Region and Kpaliga in the Northern Region. The quantities of cocoon produced for the operation of the factory was insufficient and could not meet the production capacity of the factory (Amoah, 2012). The table below shows the annual cocoon production of Ghana.

Table 2. 3: Annual Cocoon Production of Ghana

Year	Quantity produced (kg)
2004	112.4
2005	65.5
2006	154.5
2007	134.2
2008	326.6
2009	146.5
2010	50
2011	50

Source: Amoah, J. (2012).

In spite of the great potential and environmental suitability of the country, the cocoons produced over the years are most of the times low quality with reference to reelability and the denier of the yarns. This can be attributed to the race of the silkworm reared, the quality of the mulberry leaf fed to the worms, the rearing technique used, climatic conditions and other factors.

Ghana has not been able to explore its great potentials for the production of silk as a result of the challenges that beset the silk industry. These challenges include:

- Unavailability of market for the cocoons and price discrimination;
- Long distance to market;

- Inadequate information on market trend;
- Lack of finance.

2.4 Description of mulberry plant

Mulberry (*Morus*, Moraceae) is a fast growing deciduous woody tree with alternate leaves, it has unisexual and bisexual flowers in the leaf axils, and fleshy fruits (sorosis). It is believed that mulberry first originated in the hills of Himalayas and later spread into Asia, Europe, Africa, and America (Sanchez, 2000a, b).

Currently, mulberry is grown in many parts of the world (Yokoyama 1962); and from sea level to altitudes as high as 4000 m (Tutin et al., 1996). Taxonomically, the genus, *Morus,* is divided into two sections, the *Dolichostylae* (long style) and the *Macromorus* (short style) and each section is further divided into two groups namely *Papillosae* and *Pubescentae* based on the nature of the stigmatic hairs. Further classification of mulberry is based on characters of leaf, inflorescence and sorosi (Koidzumi 1917 and Katsumata, 1972).

About 150 species and more of mulberry have been identified but most of them have been treated either as synonyms or as varieties rather than species, and some have also been transferred to allied genera (Sharma *et al.* 2000).

A few prominent species of *Morus*, which have wide acceptance among mulberry taxonomists and geneticists, are *M. alba, M. indica,M. serrata*, *M. laevigata, M. multicaulis*, *M. tartarica*, *M. nigra M. australia*, *M. cathyana*, *M. mierovra M. atropurpurea* , *M. mizuho, M. rubra, M. insgnis, M. mesozygia,* and *M. macroura*.

Mulberry has a deep-root system. The leaves are simple, alternate, stipulate, petiolate, entire or lobed. Number of lobes varies from 1 to 5. Plants are generally dioecious.

Inflorescence is catkin with pendent or drooping peduncle bearing unisexual flowers. The main pollinating agent in mulberry is wind. The fruit is a sorosis and the colour of the fruit is mainly violet black (Datta, 2007). The Chemical composition of mulberry leaf varies with variety, age of plant, nutrition and environmental conditions (Datta, 2007). However, the general chemical leaf composition is as follows:

Moisture 65 - 78 %
Protein 19 – 25 %
Minerals 10 – 15 %
Reducing sugars 1.2 – 1.9
Sugars 10 – 15 %

2.4.1 Description of some Mulberry Varieties

Kanva-2 variety/ M-5:

Belongs to *Morus indica* and it is a diploid. It is widely cultivated in the tropical areas of India. It was obtained by selections from natural population of Mysore Local variety. It has high rooting ability and wide adaptability and it is able to resist mulberry diseases. The leaves mature in a relatively short time with yields ranging between 30 - 35 MT/ha/year under irrigation condition (Datta, 2007).

Leaf composition

Leaf moisture content 70%,

Protein content 21% and

Sugar content 11.5%

S-36:

It was developed from Berhampore local and belongs to *Morus indica*. The leaves are heart shaped, thick, light green and shiny. It is tolerant to leaf spot and powdery mildew but susceptible to leaf rust and tukra infestation. Due to its high moisture content, it is more suitable for chawky rearing. It yields about 38-45 MT/ha/year under irrigation.

Leaf composition

Leaf moisture 76%

Protein content 22%

V-1:

Belongs to Morus indica. It was developed as a cross between S-30 and Berc.776. It has high rooting and sprouting ability and highly recommended for cultivation under irrigation. The leaves are broad, thick, dark green and oval in shape. The leaf yield under irrigation is about 55-70 MT/ha /year. It is resistant to leaf spot, leaf rust and tukra infestation (Datta, 2007).

Leaf composition

Leaf moisture 72.5-78.9%

Protein 24.6%

Total sugar 16.9%

2.4.2 Economic importance of mulberry

The economic importance of mulberry is primarily due to its leaves, which are being used for feeding the silkworm for silk production. Mulberry is also utilised as forage for livestock due its high protein and mineral content and palatability (Sanchez, 2000b). The fruits are used as antiphlogistic, a diuretic and as expectorant and also for fruit juice and

jams (Koyuncu, 2004; Ercisli, 2004). Mulberry is also consumed as a delicious vegetable (young leaves and stems). It is used in the pharmaceuticals due its medicinal properties and traditionally as mulberry leaf tea. The mulberry plant has medicinal value and it is used traditionally for healing asthma, bronchitis, cachexia, cold, constipation, cough, diarrhoea, dropsy, dyspepsia, edema, epilepsy, fever, headache, hyperglycemia, hypertension, insomnia, melancholy, menorrhagia, snakebite, sore throat, stomatitis, tumors, and wounds including other kinds of diseases (Datta, 2007).

The wood is used as firewood, building material, and in furniture making. It is also used for making stocks, spokes, poles, shafts of carriages and casts. The wood is suitable for making plywood, carving and making of toys and tea chests, tennis rackets, agricultural implements and cheap types of rifles and guns (Datta, 2007). The plant is used in landscaping (Tipton, 1994).

2.5 Cultivation of mulberry

Mulberry thrives well in deep, fertile, well drained soils with high organic matter content. It grows on sandy loam to black loam soil which has good water holding capacity with soil pH of 6.2-6.8. The average temperature for maximum yield and optimum growth is 23 – 27 ^{o}C and rainfall of 600 - 2500 mm per year (Rangaswami *et al*. 1976; Datta, 2007).

Planting materials and planting

Mulberry is planted using cuttings and seeds. The use of cuttings is the most common method of propagation. The cuttings can be planted directly in the field and can also be raised in the nursery and the saplings transplanted after 2-3 months. Cuttings are obtained from mature plants of 8-10 months at a length of 25-30cm with 4-6 healthy buds.

Establishment of mulberry farm starts at the beginning of the raining season. The planting distance adopted is 90cm x 90cm or 60cm x 60cm in single row or the double row system (Datta, 2007).

Pests and diseases

There are numerous pests and diseases of the mulberry plant. The pests are mostly insects and the major ones include;

1. Pink mealy bug (*Maconellicoccus hirsutus*) and papaya mealy bug (*Paracoccus marginatus*). The mealybugs feed by sucking sap of apical and tender shoots. Their feeding activity leads to the spread of diseases. The pink mealybug is known for the transmission of the Tukra disease of mulberry.
2. Thrips, *Pseudodendrothrips mori; Bathrips melenicornis; Megalurothrips distalis and Scirtothrips dorsalis*: Both adults and nymphs lacerate the leaf tissue and suck the oozing cell sap from young buds and leaves. The infested parts get hardened; leaves become brittle, malformed with reduced leaf area. In addition, sap extraction by the thrips results in necrosis and drying up of leaves. Due to thrips infestation, the epidermal cells get punctured, leaves and buds become rudimentary resulting in premature fall. During laceration, the thrips secrete saliva which coagulates with sap resulting in the formation of white streaks in early stage.
3. Mites **:** mites belonging to Tetranychidae and Eriophyidae are known to infest mulberry. This include; Bud mites, *Aceria morikcifes* (Eriophydae); *Tetranychus equitorius* (Tetranychidae); and *T. ludani* (Tetranychidae).Mites are found on the leaves, bud scales, nodes and apical shoots. Both nymphs and adults insert their stylets in to leaf tissue and suck the sap. The affected portion of the plant turns grayish white and

ultimately withers. The leaves infested by *T.ludani* show white speckles at the place of feeding. With increase in intensity of feeding, the speckles increase in number and gradually coalesce with one another, finally producing large patches. Infested plants remain stunted for a longer period without any sign of growth.

4. Bihar hairy caterpillar: *Spilosoma* (*Diacrisia*) *oblique.* The young caterpillars feed on the chlorophyll layer of the leaf exposing the veins which impart dried/dead appearance to the leaves (Skeletonization). The grown up larva feed on the entire leaf rendering the branches without leaves.
5. Other insect pests of mulberry are; leaf webber (*Diaphania pulverulentalis*), grasshoppers, leaf miners and termites.

Management of insect pests and Diseases of mulberry

Effective weed control, pruning infested parts, appropriate planting distance, appropriate use of recommended insecticides and biological control.

It is estimated that the incidence of pests can cause loss in mulberry leaf yield up to 34.24% and 4500 kg/ha/year (Sakthivel, 2012).

Diseases attack the foliage and stems and roots. Foliar diseases of mulberry reduce the yield and quality of leaf thereby affecting silkworm rearing and cocoon production. The yield loss due to foliar diseases is estimated to be around 15-18%, besides deteriorating the leaf quality. The diseases which infect the leaves include:

1. **Powdery mildew** : It is caused by *Phyllactinia corylea*

Symptoms: White powdery patches appear on the lower surface of leaf which increases gradually and covers the whole leaf surface. Affected leaves turn yellowish and drop prematurely. The disease becomes more severe around October-November.

Control measure: Foliar spray with the recommended fungicides and also the lower surface of the leaves should be thoroughly drenched.

2. **Leaf rust :** The causal organism is called *Peridiospora mori*

Symptoms: Several small pin head shaped brown postules appear on the lower surface of mature leaves. Reddish brown spot appear on the upper surface of the infected leaves. Severely infected leaves turn yellowish and margin of the leaves become dry.

Control measure: Foliar spray with recommended fungicide

3. **Leaf spot** : The causal organism is *Cercospora moricola*

Symptoms: circular light brown spots appear on both sides of the leaves. The adjacent spots unite together to form a larger spot. The necrotic tissues of such spots drop out and form the characteristic shot holes. Highly infected leaves defoliate prematurely.

Control measure: Avoid dense planting and also collect and burn unused infected leaves after pruning.

4. **Root knot disease**: The estimated yield loss due to the disease is 15-30%. The organism that causes the root knot disease is a nematode called *Meloidogyne incognita*. It is an endoparasite which inhabits mulberry roots. The symptoms of the disease can be grouped into two, namely;

Foliage symptoms: which is characterised by stunted growth, poor and delayed sprouting, reduced leaf size and yield, chlorosis and marginal necrosis of leaves, yellowing and wilting of leaves in spite of adequate soil moisture availability and death of plants in severe cases?

Root symptoms: formation of galls on roots, reduced and stubby root system, retarded root growth, necrotic lesions on the root surfaces and death of active rootlets.

Control: Plant resistant varieties, recommended nematicide can be used in infested soils or farms.

5. **Tukra disease**: it is caused by the pink mealybug, *Maconellicoccus hirsutus*. The nymph and adult mealybug feed by sucking the sap of young and apical shoot.

Symptoms: leaves become dark green and deformed, swelling and twisting of apices of internodes, leaf curl and crinkling of apical shoots, flattening and thickening of the affected part of shoot and presence of white mealybugs and crawlers at the base of leaves in the malformed regions of the shoot.

Control: plant resistant varieties of mulberry, clear farm off weeds, clipping and destruction of affected apical shoots, biological control of mealybugs with *Cryptolaemus montrouzeri* beetle and also apply recommended insecticide.

Yield: the leaf yield of mulberry depends on factors such as variety, cultivation practices and climatic conditions and plant density (Yamanouchi *et al.*, 2001). The yield of some varieties are; Kanva-2 - 30-35Mt/ha/year; S-36 - 35-38Mt/ha/year; V-1 - 70Mt/ha/year; K-2 – 10-12 MT/ha/year; S-13 – 14-15 MT/ha/year and S-34 – 14-15 MT/ha/year (Datta, 2007).

Harvesting and postharvest handling

Mulberry leaves will be ready for harvesting 6 months after planting. There are three methods of leaf harvesting. These are; individual leaf picking, branch cutting and whole shoot cutting. In individual leaf picking, individual leaves are picked together with leaf petiole whiles the other methods involve the cutting of branches and whole shoot. Young and succulent leaves should be harvested for chawky rearing and mature leaves for mature worms. The leaves should be harvested early in the morning or evening when

temperatures are cool. This is to reduce loss of moisture from fresh leaves. Moisture loss from leaves reduces the edibility and palatability of leaves for silkworms.

Leaf preservation after harvest is therefore important especially in situations where the rearing house is far from the mulberry farm. Fresh leaves should be stored in wet jute sacks or wooden baskets lined with moist jute sack or material. Leaves preserved under wet cloth and jute sacks should be kept wet all the time by sprinkling water on it repeatedly at intervals. Leaves preserved as such remain fresh with high moisture and protein content and are easily digestible to worms (Sakthivel, 2012).

2.6 Influence of inorganic nitrogen on plant growth, leaf yield and leaf quality

Nitrogen (N) is often one of the most limiting nutrients in crop production. Hence, the application of nitrogenous fertilizers results in increased biomass production and protein yield.

Nitrogen is an essential component of the cell membrane, chlorophyll molecule and many other compounds essential for plant growth processes.

It is an essential component of proteins, amides, amino acids, nucleic acids and nucleotides which are critical for building plant tissues, cell nuclei and protoplasm. Nitrogen stimulates vegetative growth and induces the deep green colour of leaves. Nitrogen enhances roots and shoots development and influences the uptake of other macronutrients and micro nutrients. It is known that Nitrogen fertilizer is an essential component of any system in which the primary objective is to maintain good yield (Law and Egharevba, 2009).

Increases in productivity of mulberry has been possible as a result of irrigation, fertilizer application particularly nitrogen and other agronomic practices. It is estimated that mulberry production constitutes 60 per cent of the total cost of sericulture. Much research evidence has shown that fertilizer application increases the crop yields but without fertilizer high yielding varieties cannot perform better than the local varieties (Munireddy, 2005**).** However, different varieties respond differently to nutrient application as a result of differences in their genetic composition and physiological processes (Chandra *et al*., 1992).

2.7 Influence of inorganic nitrogen on growth and leaf yield of mulberry

The use of fertilizer especially nitrogen fertilizers increases the growth and yield of crops. The application of nitrogen promotes leaf growth and expansion. Mulberry is a plant which responds well to the application of nitrogen fertilizers which result in higher leaf yield. This has been reported by many researchers.

Pain (1965) reported lower leaf yields in mulberry when fertilizers other than nitrogen fertilizers were used. This report highlights the importance of nitrogen fertilizers in mulberry cultivation. Majumder *et al.* (2003) investigated the influence of nitrogen on mulberry and reported that the application of 200, 250 and 300 kg N/ha/year to S-1 mulberry in spring season increased the leaf yield as compared to the control (150 kg N/ha/year). They also indicated that higher dosages of inorganic nitrogen are significant for leaf production in mulberry cultivation. Bose and Majumder (1998) conducted studies into the influence of nitrogen on mulberry and reported that the application of 400:120:120 kg NPK/ ha/year to M-5 mulberry variety increased the leaf yield and other vegetative parameters more than the control.

The application of inorganic nitrogen and organic fertilizers also significantly increases leaf yield in mulberry cultivation. This has been confirmed by studies of many researchers.

Sinha *et al*. (2001) in their work on mulberry found that S-1 mulberry variety produced significant leaf yield when150:50:50 kg NPK/ha/year was combined with 10 tonnes of FarmYard Manure and applied compared to the control.

Shankar *et al.* (2000) achieved higher yields when Farm Yard Manure at a rate of 20 tonnes/ha in a year was applied in combination with 280:120:120 kg NPK/ha/year as compared to the application of only Farm Yard Manure. This implies that the presence of inorganic N is important in optimizing crop yield. Also in the study of the effect of different spacing and nitrogen levels on different varieties of mulberry by Bongale *et al.* (2000), the S-36 variety produced significant leaf yield at 400kg N as compared to smaller levels of nitrogen. Regular irrigation, appropriate planting densities and judicious use of nitrogen result in higher leaf yield and leaf quality (nitrogen and protein). The study by Shivaprakash *et al., (*2000) revealed that at a spacing of 60cm × 60cm under irrigated condition, S-36 produced higher leaf yield and leaf quality (nitrogen) at 300:120:120 kg NPK/ha/year.

Singh *et al*. (2001) also conducted research on the response of mulberry varieties to different levels of NPK in different seasons and reported that at 250:120:110 kg NPK/ha/year, the M-5 variety produced maximum leaves per branch (24.7) in spring, 46.8 in autumn). They also observed an increase in plant height and leaf yield. In the same way, 100 kg N /ha/year nitrogen increased the leaf yield of mulberry as compared to 50 kg/ha/year nitrogen in split applications (Anon, 1971). Kasiviswanathan and

Iyengar (1970) also reported higher leaf yield in 200 kg N /ha/year than was found in 100 kg N per ha/year.

Several authors have reported that the application of NPK increases number of leaves and leaf area of plants (Bijimol and Singh, 2001; Broschat and Moore , 2001; Hend ,2002; Kumar *et al*. 2002 and Dar *et al*. 2002).

Improved varieties of crops especially mulberry require higher dosages of nitrogen fertilizers. Inadequate supply of this nutrient to improved varieties will hinder their ability to perform better than local varieties. Phukan *et al*. (2000) studied different improved varieties of mulberry and found out that cv. S-1635 was significant in terms of plant height and leaf yield in India. The application of higher dosage of nitrogen to improved mulberry varieties increased the leaf yield more than smaller dosages. Krishnaswami *et al.* (1971) realised significant improvement in economic characters including leaf yield of improved mulberry varieties when heavy dosage of Nitrogen (900 kg/ha) was applied as compared to local varieties given wider spacing and 100 kg/ha of nitrogen.

Karic *et al*. (2005) reported maximum number of leaves per plant at 200kg N/ha but no significant effect was noticed on the number of leaves at 100 kg N/ha which is similar to that obtained by Shahbazi (2005) who recorded maximum number of leaves per plant at 200kg N/ha when four nitrogen levels (0, 50, 100, 150 and 200 kg N/ha) was used. Bhaskar *et al.* (2003) also studied M-5 mulberry under irrigated condition with varied levels of N (200-280 kg/ha/year), P (80-140 kg /ha/ year) and K (80-140 kg/ha/year) and reported that application of 280:80:80 kg NPK/ha/year significantly improved number of leaves per plant, leaf area and moisture content and other growth parameters as compared

to control. Rajegowda *et al* (1999) reported increased in plant growth, leaf yield and leaf quality parameters (moisture and chlorophyll) when N and K_2SO_4 was applied at a rate of 400:180kg/ha/year in M-5 as compared to 300:120kg/ha/year (N and KCl).

Studies have shown that the application of 75-100 kg N/ha/year increased the growth and leaf yield of mulberry. It has been observed that response to nitrogen increased with increased soil moisture (Kasiviswanathan and Iyengar, 1965). Anon (1969) reported that it was necessary to apply nitrogen to mulberry every year under irrigated conditions as the residual effect of nitrogen was not significant. Significantly higher yields were recorded in split applications of 200kg N/ha/year than split application of 100kg N /ha/year (Kasivishanathan and Iyengar, 1970).

Paul and Qaiyyum (2009) also studied the effect of different levels of NPK fertilizers and irrigation on leaf yield and nutritive quality of mulberry leaf of three mulberry varieties. They found out that BM-1 had significant increase in plant height and leaf number per plant than the other varieties but number of branches and leaf yield were significantly higher in BM-3 than the rest. They also reported increased growth and higher leaf yield in fertilizer treated plants than the control.

Bongale *et al*. (2000) studied the effect of different plant densities and nitrogen levels on Viswa (DD), S-36 and M-5 mulberry (Morus indica L.) varieties under irrigated condition and reported the highest leaf yield and leaf N uptake in S-36 with the application of 400kg N/ha. They reported significant increase in leaf number, plant height, leaf N content and uptake and leaf yield with the application of 400kg N/ha

2.7.1 Influence of inorganic nitrogen on leaf quality of mulberry

Manchashetty (1979) observed that when nitrogen, phosphorus and potassium are applied at 0.5% as soil and foliar spray the leaf quality with reference to crude protein and mineral content of mulberry increased. Sarkar *et al. (*2000) reported high leaf quality in V-1 mulberry variety with the application of NPK in combination with Farm Yard Manure as compared to Mysore local, M-5, S-54 and S-36 under irrigation. According to Sengupta *et al*. (1972) the application of 600 and 900 kg N increased leaf yield of M-5 mulberry variety which also resulted in increased high leaf quality (high leaf protein, reducing sugar and total sugar content of leaves).

The application of different sources of inorganic nitrogen influences the leaf quality of mulberry differently. This has been confirmed by Subbarayappa *et al*. (1994) who reported that the application of ammonium sulphate increased leaf quality of mulberry as compared with the control (no fertilizer), ammonium nitrate and urea. Subbaswamy *etal*. (1999) also studied the influence of different sources of inorganic nitrogen fertilizers on leaf quality of mulberry and reported higher leaf yield and high leaf protein content in plants fertilised with ammonium sulphate as compared with plants fertilised with calcium ammonium nitrate and urea.

Ushioda (1954) reported that nitrogen has the highest influence on leaf quality, leaf protein content and moisture content of leaves when supplied through fertilizers. Ray *et al*. (1973) reported increased leaf yield and leaf quality in terms of protein and mineral content in M-5 mulberry variety with the application of NPK in combination with Farm Yard Manure.

Yokayama (1962); Kasivishwanathan and Iyengar (1965 and 1966) have reported that fertilization of mulberry with nitrogen increased the leaf yield and leaf quality. Many authors also agree that the application of nitrogen fertilizer result in increased protein content of crops and hence increased crop quality (Abu-Rayyan and Al-Hadidi, 2005; Balemi *et al.*, 2007; Shaheen *et al.*, 2010; Imtiaz *et al*., 1995). It has been observed by El Hassan (2010) that the application of different sources of nitrogen has different effects on the quality of leaves. He observed that the application of NPK and Ammonium sulphate significantly increased the crude protein of leaves except urea. His result agrees with the findings of Singh et al., (1992) and Koul (1997) who also reported increased leaf protein with the application of nitrogen. Paul and Qaiyyum (2009) reported that the leaf quality of BM-3 mulberry variety was higher than BM-1 and BM-2 varieties except for leaf moisture. They added that the application of NPK fertilizers significantly increased the leaf quality of mulberry more than the control. They observed that increasing NPK reduces the mineral content of mulberry leaf. Marzouk and Kassem (2011) reported the application of inorganic fertilizers reduces the protein and the carbohydrate content of crops. Also, Anon (1994a) reported that the application of 300:120:120 kg NPK/ha/year had no influence on the water use efficiency and the leaf quality of V-1 and S-36 mulberry varieties except the chlorophyll content of leaves. This implies that the application of inorganic fertilizers do not always improve the quality of mulberry leaves.

CHAPTER THREE

MATERIALS AND METHODS

3.1 The Survey

A survey was conducted in January and February, 2012 starting with identification of regions and districts in which sericulture is practiced in Ghana. This was done with the help of Mr. Ntaanu, the Founder and Technical Director of Sericulture Promotion and Development Association of Ghana (SPDA). After the preliminary observations the following communities were selected for in-depth study: Kpaliga, in the Tolon-Kumbungu District in the northern Region, Odumase and Kwatre in the Sunyani West District in the Brong – Ahafo Region, and Pukrom in the Akuapim South District of the Eastern Region. Sixteen (16) sericulture farmers were interviewed and out of the 16 farmers, five (5) were female and eleven (11) were male. The Sericulture Associations interviewed were Community Based Rural Project (Sericulture) at Kwatre and Kpaliga Tree Growers Association. There was only one farm at Pukrom and that was also visited. The issues discussed centered on the variety of mulberry cultivated, land area for mulberry cultivation, Race of silkworm reared, rearing technique used, source of silkworm egg supply and constraints associated with rearing and marketing of cocoons in Ghana.

The silk factory at CSIR compound was visited and informal interviews and discussions were held with staff of the factory to assess the status of the factory in terms of production level and constraints. The Asuansi Farm Institute was also visited to assess the progress of work by the Ministry of Food and Agriculture in multiplying some varieties of mulberry and also establishment of a sericulture training center. Informal discussions

were also held with staff to obtain information on sericulture. This approach was adopted to get an in-depth understanding of the issues discussed with farmer groups and other relevant stakeholders.

The Tolon-Kumbungu District lies between latitude 10-20^0 North and Longitude 10- 50^0 West, shares border with West Mamprusi District in the North, West Gonja District in the West and South and the East with Savelugu/Nanton District and the Tamale Municipal Assembly. The District covers an area of about 2,741 square kilometres (Ghana districts.com).

The Sunyani West District lies between latitude 7º 19´N and 7º 35´N and longitudes 2º 08´ W and 2º 31´ W. It shares boundaries with Wenchi Municipality to the North - East, Tain District to the North, Berekum and Dormaa East to the West, Sunyani Municipal to the South East and to the Eastern boundaries of the District are the Tano North and Ofinso North Districts. Sunyani West District has a total land area of 1658.7 square kilometers. The district enjoys two rainy seasons in the year and the abundance of rainfall offers the district a favourable climate for agricultural production (Ghana districts.com). The Akuapim-South District covers a land area of 403 square kilometres. The total arable land under cultivation is about 20,000 hectares. The district shares boundaries with Ga West Municipal and and Tema Metropolis to the south, Suhum-Kraboa-Coaltar, Akuapim North and West Akim Municipal to the North-West respectively. About 60% of the population is engaged in subsistence and commercial farming. The district enjoys bimodal rainfall which creates favourable climatic conditions for agricultural activities (mofa.gov.gh).

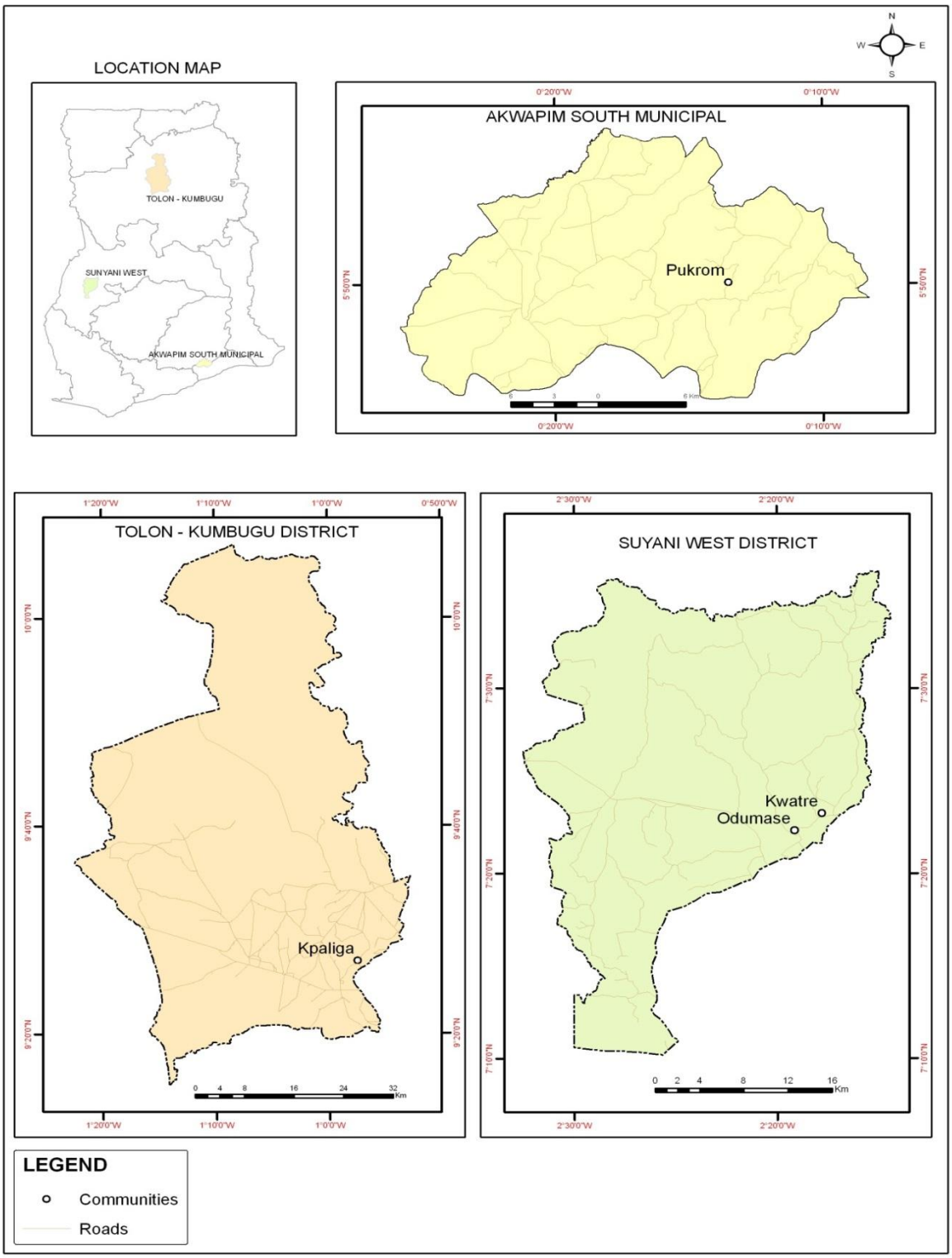

Figure 3.1: A Map of Ghana Showing Districts and Communities in which Sericulture is practiced in Ghana

Semi-structured questionnaires were administered and also interviews and group discussions were held with farmers and Sericulture Associations in the various communities. At Pukrom, in the Akuapim – South District, only one sericulture farmer was interviewed. This is because only one farmer was into sericulture at the time of visit. In Odumase and Kwatre, the farmers were thirty (30) and they have five rearing houses. The Kpaliga Tree Growers Association which happens to be the sericulture group was also interviewed. It was observed that the farmers have one farm land and a rearing house. They cultivate mulberry and also do rearing together.

3.2 Field Experiments

A field study was carried out from June, 2012 to February, 2013 to investigate the influence of three sources of fertilizer on the growth, leaf quality and regeneration of three varieties of mulberry under rain fed conditions at the University farm, Legon. The University farm is located in the coastal savannah zone of Ghana and situated at latitude $5^0$39'N and $0^0$11'W at an altitude of 97.24m above sea level. The soil of the experimental site belongs to the Adentan series and it is a savannah acrisol (FAO/UNESEO, 1999). The soil is dark-brown to reddish-brown sandy –clay loam and it is well drained and slightly sticky. The climatic data of the experimental area during the experiment is represented in table 3 below.

Table 3: Mean monthly temperature (oC), rainfall (mm) and relative humidity (%)

Month	Temperature (^{o}C)		Rainfall	Relative humidity (%)	
	Minimum	Maximum	(mm)	Minimum	Maximum
June	23.7	30.3	173.2	78	89
July	23.1	28.8	20.9	68	86
August	22.4	28.2	11.5	67	86
September	23.2	30.0	42.5	67	86
October	23.8	31.2	88.3	67	89
November	24.6	32.4	14.0	63	88
December	24.9	32.6	41.9	66	91
January	25.5	33.4	34.0	88	90
February	25.4	33.7	0.0	66	93

Source: Ghana Meteorological Agency, Mempehuasem, Legon, 2012.

Two field experiments were conducted in the farm.

3.2.1Experiment 1: Influence of nitrogen on the growth and leaf quality of three mulberry varieties

A field experiment was carried out to investigate the influence of different inorganic fertilizers on growth, leaf quality and regeneration of mulberry varieties from June to December, 2012.

3.3Soil Sampling and Analysis

Soil samples were collected from a depth of 0-45cm and mixed thoroughly to give a composite soil, air dried, powdered and sieved through a 2.0mm mesh sieve. This was done before planting. The soil sample was preserved in labeled polythene bag and later

analysed for various parameters such as pH, Cation Exchange Capacity, organic carbon and mineral composition such as N, P, K, Ca and Mg.

3.3.1 Soil pH

Twenty grams (20g) of the composite soil sample was weighed into a 50ml beaker. An amount of 20ml distilled water was then added to make the ratio (1:1). The soil suspension was then stirred for 30 minutes. The suspension was allowed to stand for an hour to allow the entire suspended particles to settle. A glass electrode pH meter was standardized with two aqueous solutions of pH 4 and 7. The pH of the prepared suspension was measured by carefully and gently placing the glass electrode into the supernatant and the pH read.

3.3.2 Determination of soil total nitrogen

Two (2) grams of air-dried soil sample was weighed into a 250mls Kjeldahl flask followed by addition of digestion accelerator, selenium catalyst and 5mls of concentrated sulphuric acid (H_2SO_4). The mixture was allowed to digest for at least two (2) hours until the digest became clear. It was allowed to cool and then transferred with distilled water into a 50 ml volumetric flask and made up to the volume. A 5 ml aliquot was pipetted from the digest into a distillation flask and 5 ml of 40% sodium Hydroxide (NaOH) was added with 100 ml distilled water. The sample was then distilled and collected in 5 ml of 2% boric acid to which about 2 drops of methylene blue indicator had been added. The distillate was then titrated against 0.01 N HCl (Bremner, 1965) from green to a reddish end point.

The amount of N (%) was calculated using the formula:

$$\% \text{ N} = \frac{\text{Molarity of HCl} \times \text{titre volume} \times 0.014 \times \text{vol.of extractant}}{\text{Weight of soil sample} \times \text{volume of aliquot}} \times 100$$

3.3.4 Soil Phosphorus (P)

Available phosphorus was determined from soil sample by Bray 1 method. The ultraviolet visible spectrophotometer was used to read the amount of P in the soil sample. Available phosphorus was determined by the formula below.

$$\text{P (g / Kg)} = \frac{(A - B) \times C}{a \times b}$$

Where,

A is the spectrophotometer reading in μgP

B is the blank reading

C is the total volume of extract

*a*is the volume of aliquot

b is the weight of soil sample

3.4 Determination of Exchangeable Bases in Soil

Ten (10) grams of soil was weighed into an extraction bottle and 100ml of 1N ammonium acetate solution (NH_4OAc) buffered at pH 7.0 was added. The bottle and its contents were placed on a mechanical shaker and shaken for an hour after which it was centrifuged for 20 minutes. The supernatant solution was then filtered through No.42 Whatman filter paper. The filtered solutions (aliquot) were used for the determination of Ca, Mg and K.

3.4.1 Soil available Potassium (K)

The flame photometer was used to determine the concentration of potassium in the aliquot. The amount of potassium present in the soil as shown in the formula below.

$$\text{K (Cmol/Kg)} = \frac{\text{R} \times \text{Vol.of extract} \times 100}{\text{Weight of soil (g)} \times 39.1}$$

Where,

R is the flame photometer reading (ppm)

39.1 is the atomic weight of K2

3.4.2 Soil available Calcium (Ca)

To a 10ml aliquot of the sample solution 10ml of 10% KOH and 1ml triethanolamine (TEA) were added. Three drops of 1M KCN solution and a few crystals of cal-red indicator were then added after which the mixture was titrated against 0.02N EDTA solution from red to blue end point. The titre value was used in the calculation of calcium as shown below.

$$\text{Ca (Cmol/Kg)} = \frac{\text{Titre value} \times \text{Normality of EDTA} \times \text{vol. of extract} \times 100}{\text{Aliquot} \times \text{Weight of soil(g)}}$$

3.4.3 Soil available Magnesium (Mg)

To a 10ml aliquot of the sample solution, 5ml of ammonium chloride – ammonium hydroxide buffer solution was added followed by 1ml of triethanolamine. Three drops of 1M KCN solution and a few drops of Eriochrome black T solution were then added after which the mixture was titrated with 0.02N EDTA solution from red to blue end point. This end point titre value determines the amount of calcium and magnesium in the

solution. The titre value of magnesium was then determined by subtracting the value obtained for calcium above. This titre value of magnesium was then used for the calculation of the concentration of magnesium (Mg) as shown below.

$$\text{Mg (Cmol/ Kg)} = \frac{\text{Titre value} \times \text{Normality of EDTA} \times \text{Vol. of extract} \times 100}{\text{Aliquot} \times \text{Weight of soil (g)}}$$

3.4.4 Soil Organic Carbon (SOC)

Organic carbon was determined by the wet combustion method of Walkley and Black (1934). This method involves the reduction of the $Cr_2O_7^{2-}$ ion by the organic matter and the unreduced $Cr_2O_7^{2-}$ measured by titration with ammonium sulphate. The quantity of organic matter oxidized is calculated from the amount of $Cr_2O_7^{2-}$ reduced. A 10ml of 1M potassium dichromate ($K_2Cr_2O_7$) solution and 20ml of concentrated sulphuric acid (H_2SO_4) were added to 0.5g of soil in a conical flask and digested for 2 hours. The K_2CrO_7 remaining in solution after the digestion was titrated against 0.2M ferrous ammonium sulphate using barium diphenylamine sulphonate as the indicator to a green end point. The titre values were used to calculate the % C from the formula below:

$$\% \text{ C} = \frac{0.3[10\text{-}(XN)]1.33}{W}$$

Where,

X = titre value of ferrous ammonium sulphate

N = normality of ferrous ammonium sulphate

W = weight of soil.

3.4.5 Cation Exchange Capacity (CEC)

Ten (10) gramme of soil sample was weighed into an extraction bottle and 100 mls of 1 M ammonium acetate solution added. The bottle with its content was shaken for 30 minutes on a mechanical shaker. The content was filtered through a No. 42 Whatman filter paper and the sample leached four times with 25 mls of methanol to wash off excess ammonium. Thereafter 25 mls of 1 M acidified potassium chloride was used to leach the soil four times. A 5 mL aliquot of the leachate was taken into a Markham distillation apparatus and 5 mls of 40% NaOH solution was added and distilled. The distillate was collected into 5 mls of 2% boric acid to which three drops of methyl red and methylene blue indicator were added. The distillate was back titrated against 0.01 M HCl to purplish end point. The cation exchange capacity in Cmolc/Kg soil was calculated from the number of moles of HCl consumed in the back titration.

3.5 Soil Physical Properties

3.5.1 Particle size analysis

The particle size distribution was determined by the modified Bouyoucous hydrometer method described by Day (1965). Soils from 0 – 15 cm, 15 – 30 cm and 30 – 45 cm depth were analysed for clay, sand and silt content. Forty grams (40 g) of the 2 mm sieved soil was weighed into a beaker and 60 ml of 6% H_2O_2 was added to oxidize the organic matter. The content was transferred into a dispersion cup and mixed with 100 ml of 5% Calgon solution (Sodium hexametaphosphate). The suspension was shaken and transferred into a settling cylinder and was made up to the 1000 ml mark with distilled water. The suspension was agitated vigorously with a plunger and the time noted

immediately shaking was stopped. The temperature of the suspension was recorded after equilibration. The hydrometer was placed into the suspension and the first and second readings noted after 5 minutes and 5 hours, respectively. The suspension was then poured directly onto a 47 µm sieve and the particles retained on the sieve washed thoroughly with water and dried in an oven at 105 °C for 24 hours. The dried samples were weighed to represent the sand fraction. The particle size distribution was then determined using the following formulae:

$$\text{i) Silt \% + Clay \%} = \frac{\text{5 minutes hydrometer reading}}{\text{weight of soil}} \times 100 \ldots\ldots\ldots\ldots (1)$$

$$\text{ii) Clay \%} = \frac{\text{5 hour hydrometer reading}}{\text{weight of soil}} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$\text{iii) Silt \%} = (\text{i}) - (\text{ii}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$\text{iv) Sand \%} = \frac{\text{oven dry mass (g) of particles retained on the 47 µm sieve}}{\text{weight of soil}} \times 100$$

3.5.2 Experimental materials

The mulberry cuttings for planting were obtained from already established farms which were five (5) years old or more. The cuttings with 4-5 buds and 30-45cm long were used. The Mysore local and S-36 varieties were obtained from Pukrom near Nsawam in the Akuapim South District and the Kanva-2 variety was obtained from Kwatre near Sunyani in the Sunyani West District.

The inorganic nitrogen fertilizers were obtained from Agricultural materials shop at Madina-Accra. The fertilizers consisted of Urea, Sulphate of ammonia and NPK (15:15:15).

3.5.3 Experimental treatments and field layout

A factorial experiment involving three inorganic nitrogen sources and three mulberry varieties and a control was conducted in a split-plot design with three replicates. There were three replications with each replication having twelve (12) plots. The land area for the experiment was 747.96m^2 (54.2m × 13.8m). The blocks were 1.5m apart and the plots were spaced 1.0m. Each block was divided into three main plots and each main plot was split into four sub-plots making 12 plots per replication. The size per plot was 3.6m × 3.6m (12.96m^2) with plant spacing of 0.9m × 0.9m. The treatments tested were as follows:

Main plots – Varieties

V1, (Kanva-2)

V 2, (S-36)

V 3, (Mysore Local)

Sub-plots – Nitrogen sources

Control (N0)

Urea: 100 kg N/ ha (N1)

Sulphate of ammonia: 250kg N/ha (N2)

NPK (15:15:15): 300kg N/ha (N3).

3.6 Cultivation Practices

The cuttings were obtained from existing farms which were five and more years old. The length of the cuttings were 30-45cm with about 4-5 buds. A spacing of 0.9m × 0.9m was adopted. Each plot had twenty five (25) plants per plot. The planting was done in June, 2012 which was the mid of the major rainy season in coastal Ghana. Weeds were controlled by hoeing as and when necessary. The incidence of pests such as termites was controlled using Hercules insecticide. This was applied at a rate of 50mls per 15Litres of water into the planting holes before planting. The incidence of mealybugs in the dry season was controlled using Cydim super (cypermethrin and dimethoate) at a rate of 35mls in 15L of water.

Supplementary water was applied using watering cans during periods of low soil moisture.

3.6.1 Fertilizer application

Three different sources of inorganic nitrogen (fertilizer) were applied in the form of urea, sulphate of ammonia and NPK 15:15:15. The fertilizer was applied at 8 and ten (10) weeks after planting in two equal splits using the ring method. The fertilizer was applied at rate of 100kg N/ha, 250kg N/ha and 300kg N/ha in the form of urea, Sulphate of ammonia and NPK (15:15:15).

3.7 Data Collection

Different growth parameters such as plant height, number of leaves per plant, stem diameter, number of branches per plant and leaf area were recorded. Other parameters taken included fresh and dry weight of leaves, fresh and dry weight of stems. The

moisture and protein content of leaves at harvest was determined and the N, P, K, Ca and Mg content of the leaves and stems were determined. The growth parameters were taken at two weeks interval after first fertilizer application and fresh and dry weight of leaves were taken at 24 weeks of growth at the end of the first experiment.

The height of plant in centimetres was measured from the base of the plant to the base of the fully opened leaves. The height of five randomly selected plants was measured using the meter rule and tape measure and the average values were recorded.

The number of leaves per plant of five randomly selected plants per treatment was counted and the average values recorded.

The diameter of five record plants per treatment was measured at 15cm from the base and recorded in millimetres (mm) and the average calculated and recorded. The diameter of new shoots was also recorded using venier calipers.

The number of branches per plant was recorded from each record plant in a plot and the mean number of branches calculated as follows

$$\text{Number of branches per plant} = \frac{\text{total number of branches}}{\text{Number of plants}}$$

3.7.1 Dry matter yield

Two plants from each plot at random were selected. The plants were cut at 30cm above ground. The shoot was separated into leaves and stems and the fresh weight recorded. The samples were chopped into pieces and oven dried at $70\ ^{0}$C for 72 hours to constant weight. The dry weight of leaves and stems were recorded and calculated in gram per plant. The weights were then computed in kilogram per plant.

3.8 Experiment 2: Regeneration of Mulberry Plants

The experiment two investigated the influence of different sources of inorganic nitrogen on the growth and leaf quality of regenerated mulberry after bottom pruning. The six (6) months old plants were bottom pruned at a height of 30cm above ground with a sharp cutlass in December, 2012. The plants were allowed to regrow from January – February, 2013 which was in the middle of the dry season in coastal Ghana.

Three different inorganic fertilizers were applied in two equal dose to the pruned mulberry plants at a rate of 100kg N/ha, 250kg N/ha and 300kg N/ha in the form of urea, Sulphate of ammonia and NPK (15:15:15).

The data collected on growth parameters were number of sprouts per plant, number of leaves, plant height, stem diameter and leaf area at two weeks interval after fertilizer application. Other parameters measured were fresh and dry weight of leaves and fresh and dry weight of stems. The moisture and protein content of leaves at harvest was determined and the N, P, K, Ca and Mg content of the leaves and stems were determined. Nutrients uptake by the crop was also determined by multiplying the dry weight of the plant parts by the nutrients concentration of the respective plant parts.

3.9 Plant Analysis

The parameters measured for leaf quality are moisture content (%), % crude protein, minerals and total sugars. The nutrient composition of the leaves and stems were also determined. The nutrients determined were; Nitrogen (%), phosphorus (%), potassium (%), magnesium (%) and calcium (%) at the end of each experiment. For the determination of N, P, K, Ca and Mg, the plant samples (leaves and stems) were

grounded into powder using a Willy type cutting mill, DIK-2900 (Daiki Rika Kogyo Co. Ltd., Tokyo, Japan) and passed through a 0.5mm sieve.

3.9.1 Moisture content (%)

Leaves were harvested from each treatment and preserved in polythene bags of which the fresh weight was taken. The leaves were oven dried at 70^0C for 48hrs and the dry weight recorded. The moisture content of the fresh leaves was computed as

$$\% \text{ moisture} = \frac{\text{fresh leaf weight (g)} - \text{dry leaf weight (g)}}{\text{dry leaf weight (g)}} \times 100$$

3.9.2 Digestion of plant sample

0.1g of milled, oven-dried plant sample was weighed into a khedjal flask. Fifty (50) ml of concentrated sulphuric acid (H_2SO_4) was added and the sample digested till it became clear on addition of drops of hydrogen peroxide H_2O_2 . The solution was then allowed to cool. The mixture was filtered into a 100mls volumetric flask and topped with distilled water to the mark.

The determination of N, P, K, Ca and Mg was done by measuring specific volumes of the aliquot.

3.9.3 Total Nitrogen

The total nitrogen was estimated by Khedjal method (Jackson, 1973).

Percent nitrogen was calculated as shown below:

$$\% \text{ N} = \frac{\text{Molarity of HCl} \times \text{titre volume} \times 0.014 \times \text{vol. of extractant}}{\text{Weight of plant sample (g)} \times \text{volume of aliquot}} \times 100$$

Where, 0.014 = milliequivalent of nitrogen

3.9.4 Plant total Phosphorus (P)

The P content in the extract was read using the ultraviolet visible spectrophotometer at a wavelength of 719 and calculated as below;

$$\text{Total P (\%)} = \frac{\text{meter reading x extraction volume x100}}{\text{weight of sample x aliquot x 1000000}}$$

3.9.5 Plant Potassium (K)

The K was determined using the flame photometer. The K was then calculated using the formula:

$$\text{K (\%) in the sample} = \frac{(a - b) \text{ x V x f x 100}}{1000 \text{ x w x 1000}}$$

Where a = concentration of potassium in the digest; b = concentration of flask of the blank digest; w = the weight of sample; v = volume of the digest solution and f = dilution factor

3.9.6 Calcium and Magnesium

Ca and Mg in the extract were determined using the Atomic Absorption Spectrometer (AAS). The concentration of calcium and magnesium in the plant sample expressed in percentage was calculated as follows:

$$\%\text{Ca and Mg} = \frac{\text{meter reading} \times \text{extract volume} \times 100}{\text{weight of sample} \times 1000000}$$

3.9.7 Leaf crude protein

The crude protein was calculated from the %N in leaf using the formula

(%) Crude protein = % N (leaf) × 6.25.

3.10 Statistical Analysis

Data obtained were subjected to analysis of variance (ANOVA) using Genstat (version 9.0) and descriptive statistics. Means were separated using L.S.D at p= 0.05. Graphs were drawn using Microsoft Excel 2010.

CHAPTER FOUR

RESULTS

4.0 Status of Sericulture in Ghana

4.1 Demographic Characteristics of Sericulture Farmers

About 62.5% of the sericulture farmers were within the age group of 40-49 years old (Table 4.1).

Table 4.1: Age of respondents in a sericulture farmer survey

Age of respondent	Frequency	Percentage (%)
30-39	1	6.25
40-49	10	62.5
50-59	2	12.5
60-69	1	6.25
70-79	2	12.5

About 52.9% and 23.5% of the sericulture farmers were Junior High School and Senior High School graduates, respectively (Fig. 4.1). Only 5.9% of the farmers had no formal education.

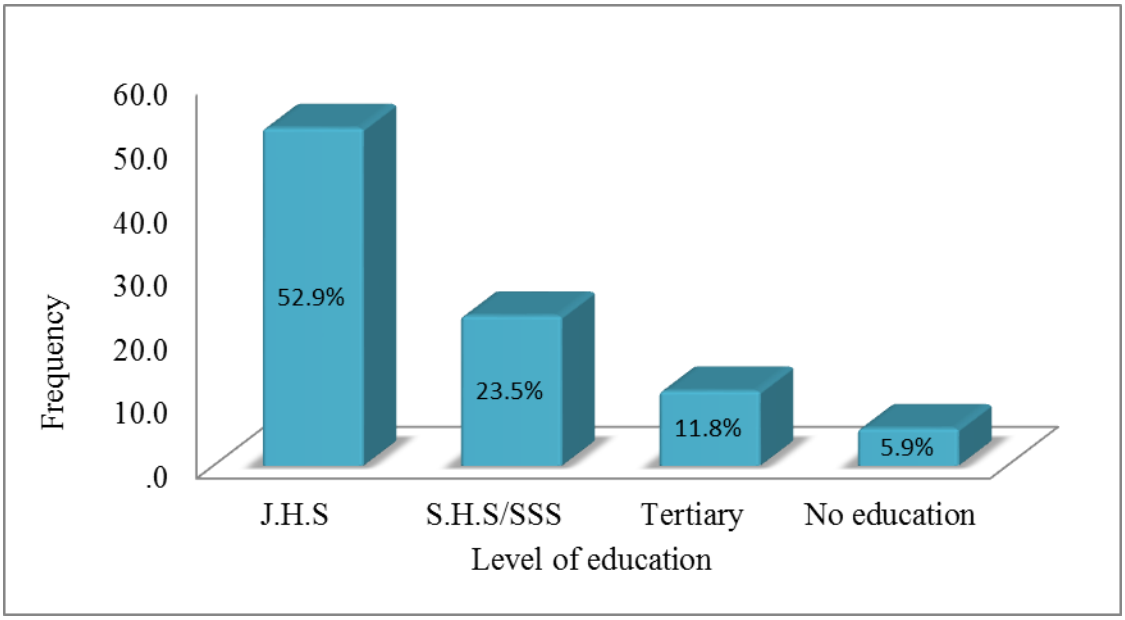

Figure 4.1: Level of Education of Respondents in a sericulture farmer survey

Figure 4.2 shows the household size of the sericulture farmers. The household size of 1-5 persons per family and 6-10 persons per family were 44% each.

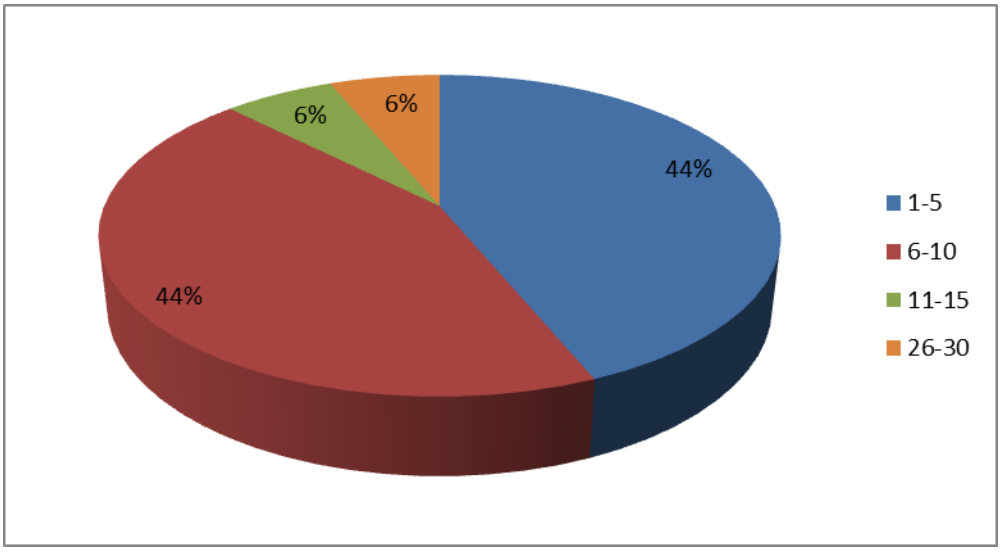

Figure 4.2: Household Size of Respondents

It was observed that sericulture was practiced in the Eastern, Western, Ashanti, Central, Volta, Brong-Ahafo and Northern Regions. However, in the process of identification, it was revealed that most farmers have abandoned mulberry cultivation. On the distribution of sericulture farmers, the results showed that 88.2%, 5.9% and 5.9% of them were found in Brong-Ahafo, Eastern and Northern Regions, respectively.

The total farm land for the respondents in all the regions is 132.6 hectares of which 56 hectares are used for mulberry cultivation. Table 4.2 shows the land distribution of the respondents in the regions and the land area cultivated to mulberry.

Table 4. 2: Total land area and area cultivated to mulberry

Region	Total farm land (ha)	Land area cultivated to mulberry (ha)
B/A	119.8	43.2
E/R	12	12
N/R	0.8	0.8

About 21% of the total land available to sericulture farmers in Ghana was used for mulberry cultivation.

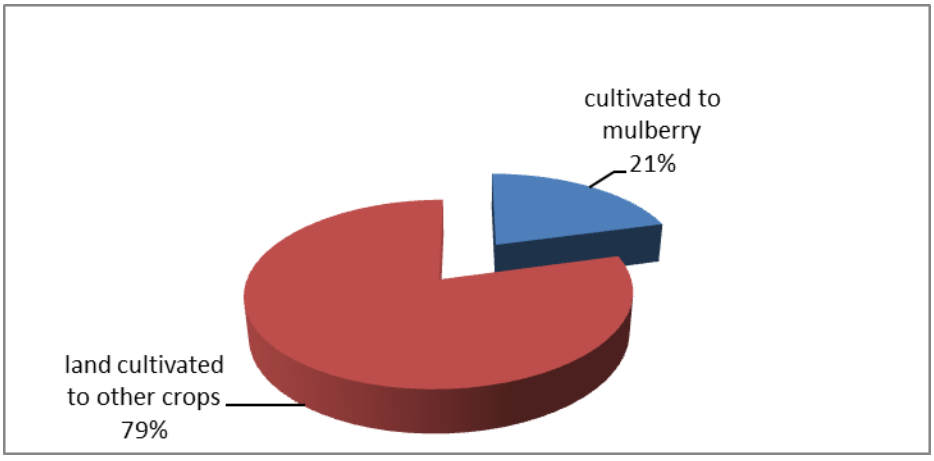

Figure 4.3: Total land area cultivated to mulberry and other crops in Ghana

4.2 Production and Marketing of Mulberry Grown in Ghana

The common mulberry varieties grown in Ghana are Kanva-2, S-36 and Mysore local. About 83.3% of the farmers grew Kanva-2, 5.6% grew Mysore local whiles 11.1% grew S-36 and Mysore local (Table 4.3). The Kanva-2 is widely grown in the Brong-Ahafo Region.

Table 4.3: Varieties of mulberry grown in Ghana

Region	Mulberry variety cultivated	Frequency	Percentage (%)
B/A	Kanva-2	15	83.3
E/R	S-36, Mysore local	2	11.1
N/R	Mysore local	1	5.6

Out of the seventeen (17) respondents who cultivated mulberry, 8 said the variety they grew was the one available to them and 5 said it was high yielding. Three said it was the only variety they knew whiles 1 person said it was well adapted to the local climate. Figure 4.5 represents the frequencies and reasons why farmers grew particular mulberry varieties.

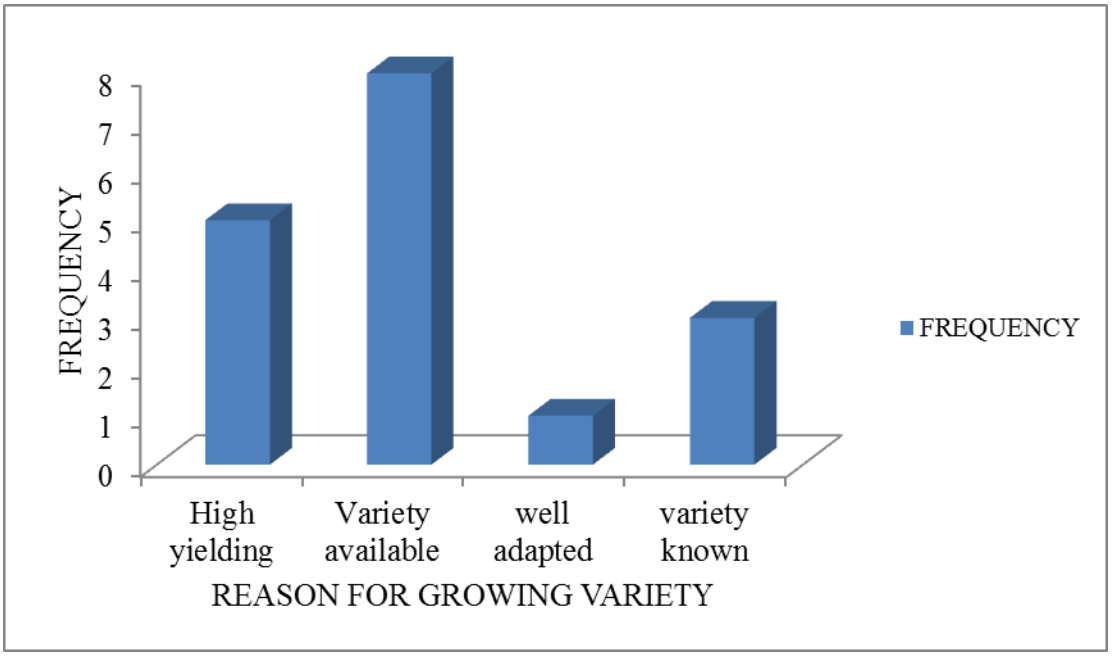

Figure 4.4: Reasons why farmers grow particular mulberry varieties

Figure 4.5 below shows that lack of markets for cocoon, price discrimination and fluctuation, Lack of knowledge of farmers on the existence of market outside Ghana for cocoons and lack of reeling centres accounted for 59%, 22%, 15% and 4% of the constraints.

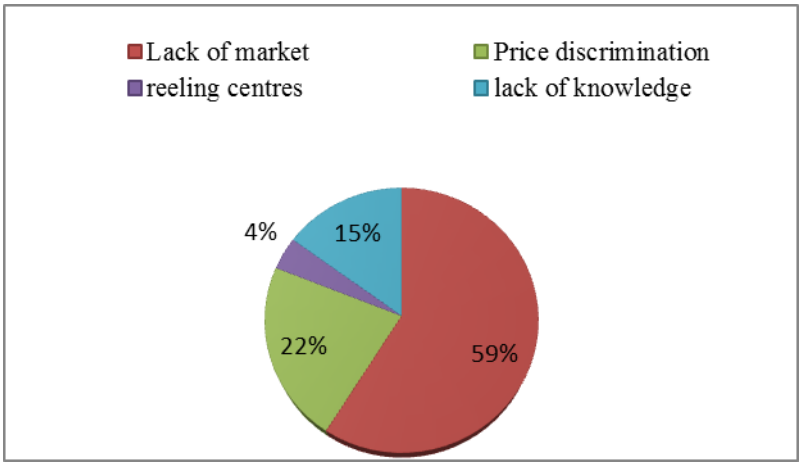

Figure 4. 5: Challenges in marketing of Cocoons

4.3 Rearing of Silkworm egg in Ghana

Silkworm egg imported into the country was from India, Sericulture Promotion and Development Association (SPDA) Ghana, Kenya and Belgium in the percentages of 38%, 33%, 24% and 5% respectively.

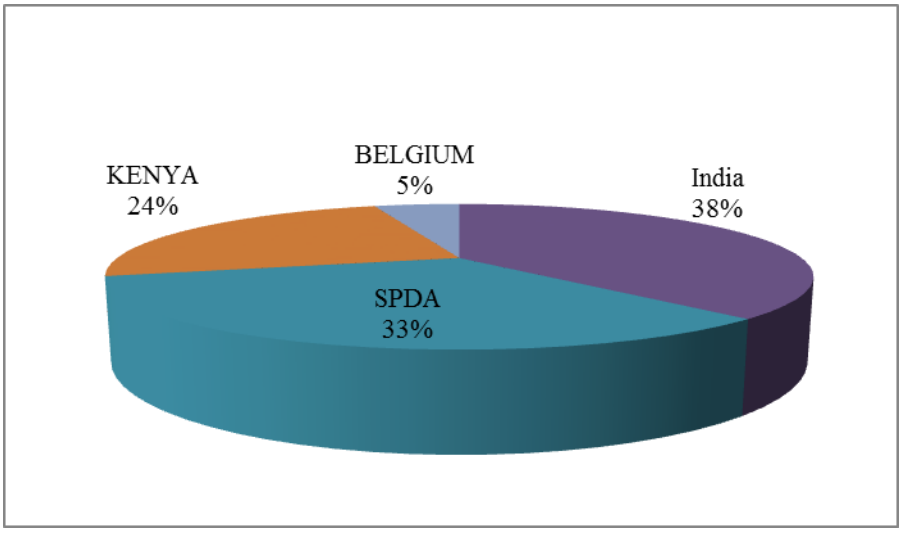

Figure 4.6: Sources of Silkworm egg supply to Ghana

The race of silkworm reared in Ghana is the Bivoltine. 29.4% reared the bivoltine because it was the race available, 23.53% reared the race because it spins good quality cocoons, 11.76% reared bivoltine because it was commercially viable. Also, 5.88% of the sericulture farmers in Ghana reared the bivoltine because it was recommended to them by SPDA because it was adapted to the climatic conditions of the country (Figure 4.7).

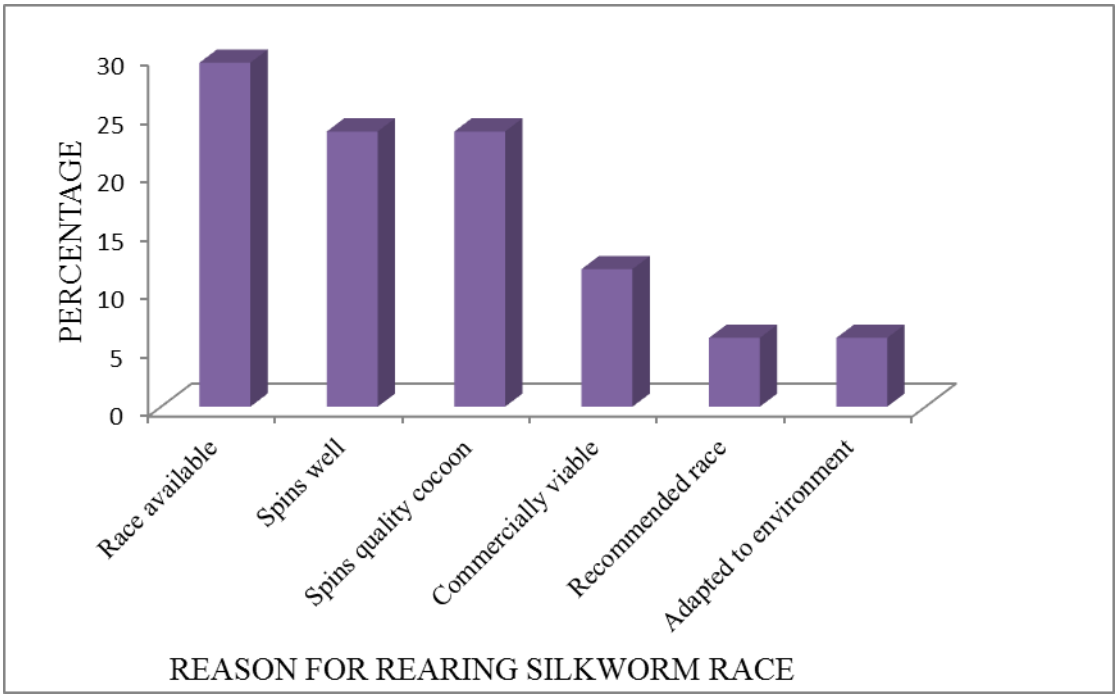

Figure 4.7: Reasons for rearing Bivoltine Silkworm race

4.4 Sericulture Training Programmes

It was observed that 71% of the farmers did not attend training programme in sericulture whiles 29% of the farmers attended training programmes in sericulture.

4.5 Sources of Finance and Profitability of Mulberry

Only 17.6% of the sericulture farmers interviewed had access to credit. In general, majority of the farmers indicated that the sericulture business was profitable (Table 4.4).

Table 4. 4: Profitability of Sericulture

Item	Frequency	Percentage
Not profitable	1	5.9
Profitable	12	70.6
Very profitable	1	5.9
Not very profitable	3	17.6

4.6 Field Experiment 1:

4.6.1 Soil physical and chemical properties

The result of the initial soil analysis showed that the soil used for the cultivation was acidic, had low organic matter content and was low in nutrients especially nitrogen (N) and K (Table 4.5). The soil was sandy (59.7%) which meant that water retention was low and nutrient leaching was high.

Table 4. 5: Soil Physical and chemical properties

% Sand	% Silt	% Clay	pH(1:1 H_2O)	OC	N	P	K	Na	Ca	Mg	CEC
59.7	16.04	24.2	4.51	0.46	0.085	13.94	0.544	1.202	3.22	2.5	34.731

Plant height

The influence of inorganic N sources on plant height of mulberry is shown in Figs 4.8a-d. Plant height was significantly increased ($p< 0.05$) by urea followed by SoA. NPK recorded lower heights than the other sources. S-36 and Mysore local produced significantly ($P< 0.05$) taller plants compared to Kanva-2 in the urea and SoA treated

plots (Figs. 4.8a & b). However, Mysore local was significantly shorter than S-36 and Kanva-2 in the NPK treated plants (Fig. 4.8c). Plants were significantly taller in Kanva-2 by Mysore local in the control. On the other hand, S-36 recorded significantly lower heights in the control plots compared to the other varieties (Fig. 4.8d).

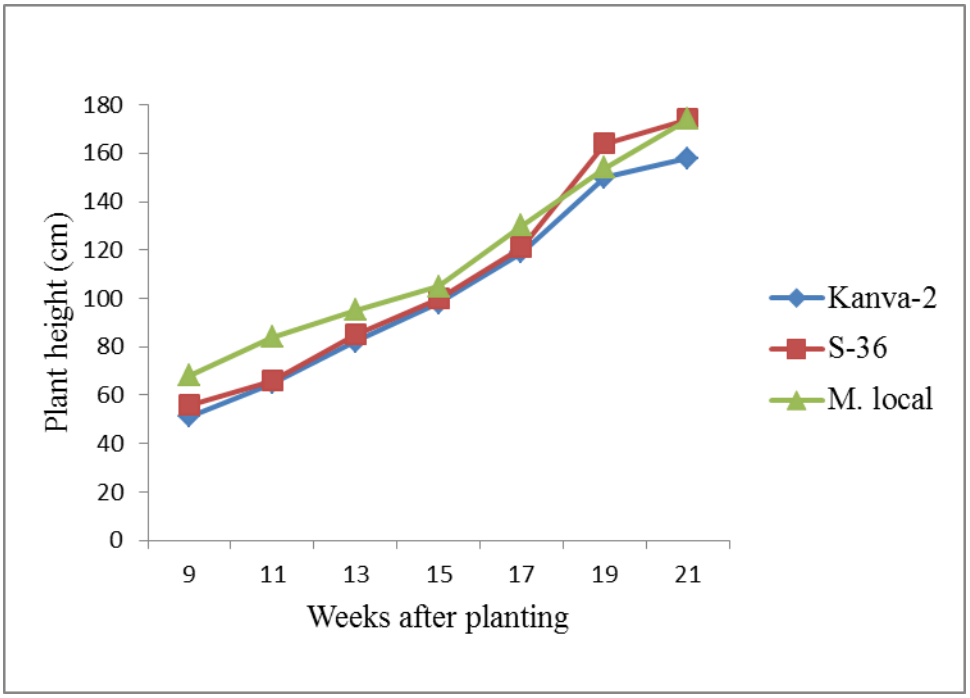

Figure 4. 8a: Influence of Urea on plant height (cm)

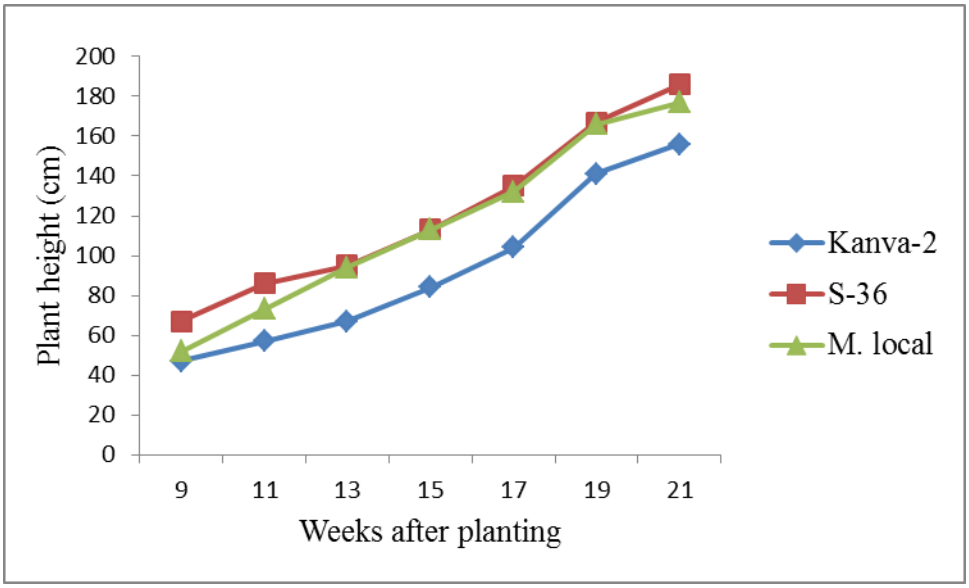

Figure 4.8b: **Influence of SoA on plant height (cm)**

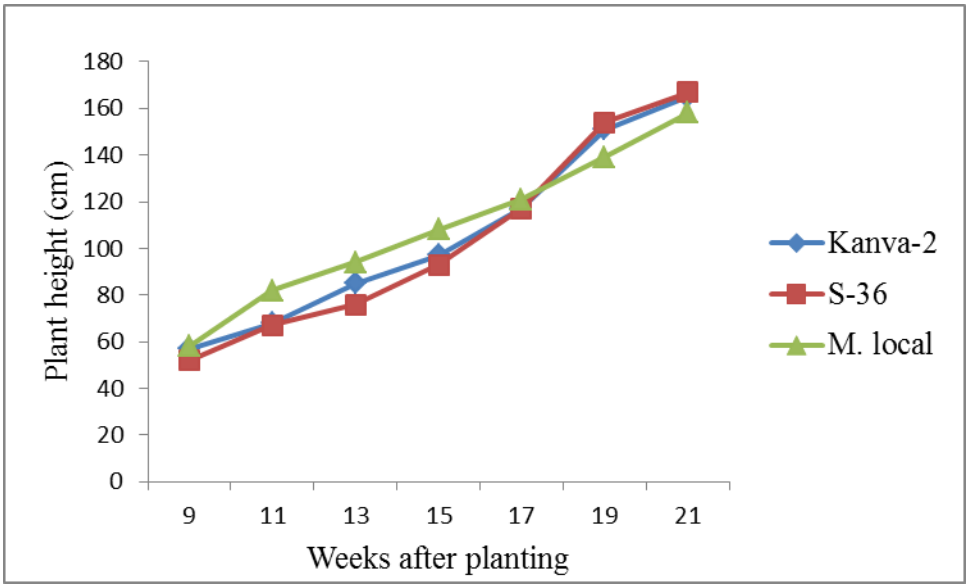

Figure 4.8c: **Influence of NPK on plant height (cm)**

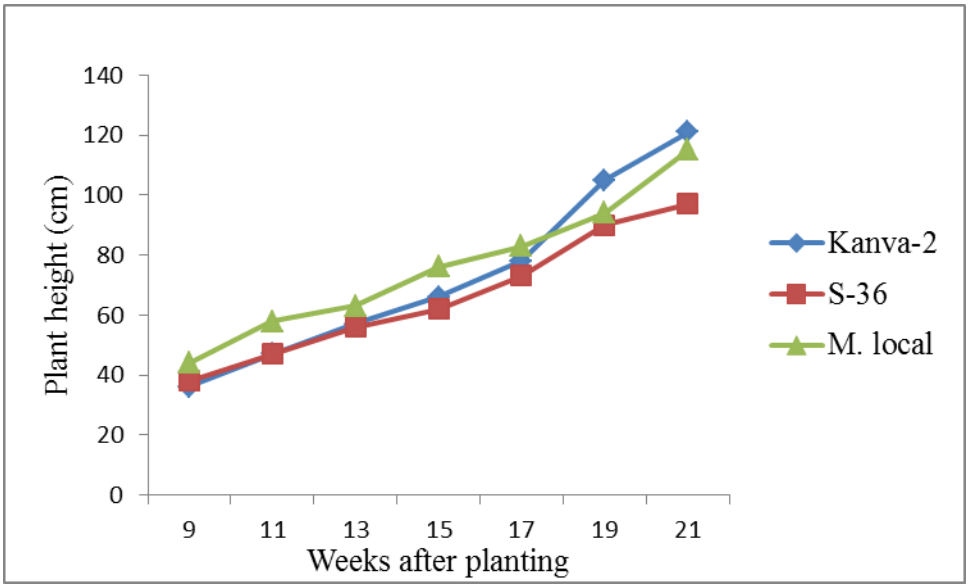

Figure 4.8d: **The height of control plants (cm)**

Number of leaves per plant

Significant increase (P< 0.05) in number of leaves was observed among the nitrogen sources. Nitrogen significantly increased the number of leaves in Mysore local more than S-36. The lowest number of leaves was produced by Kanva-2 in the N treated plots (Figures 4.9a-c). However, more leaves were produced by Kanva-2 in the control plots compared to the other varieties. On the average, application of urea resulted in the production of more leaves than SoA and NPK. NPK treated mulberry produced the lowest number of leaves among the N sources.

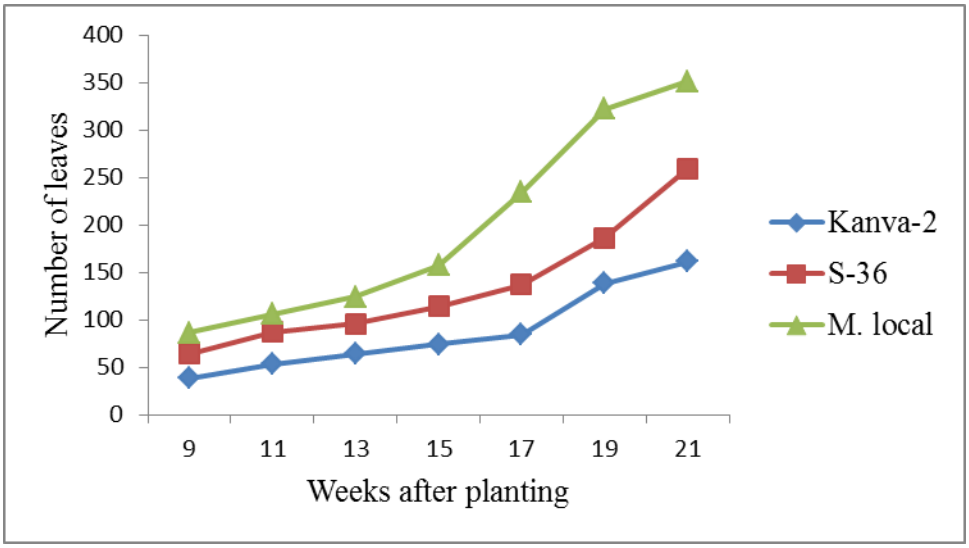

Figure 4.9 a: Influence of Urea on number of leaves (cm)

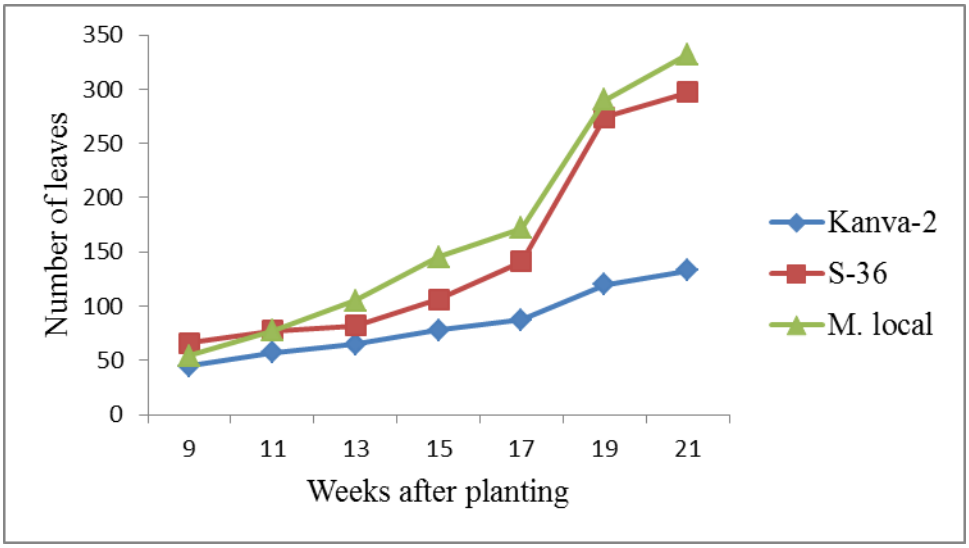

Figure 4.9 b: Influence of SoA on number of leaves

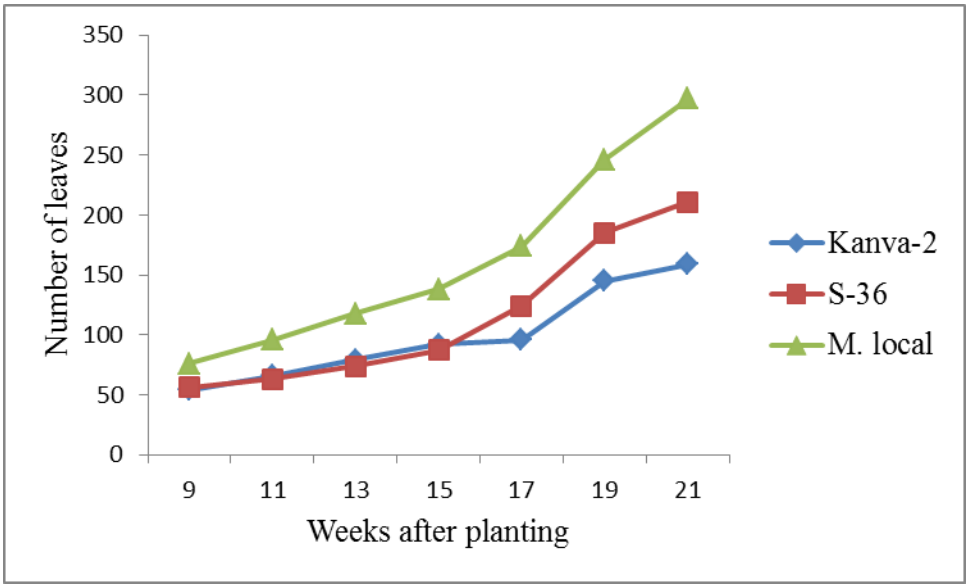

Figure 4.9 c: Influence of NPK on number of leaves

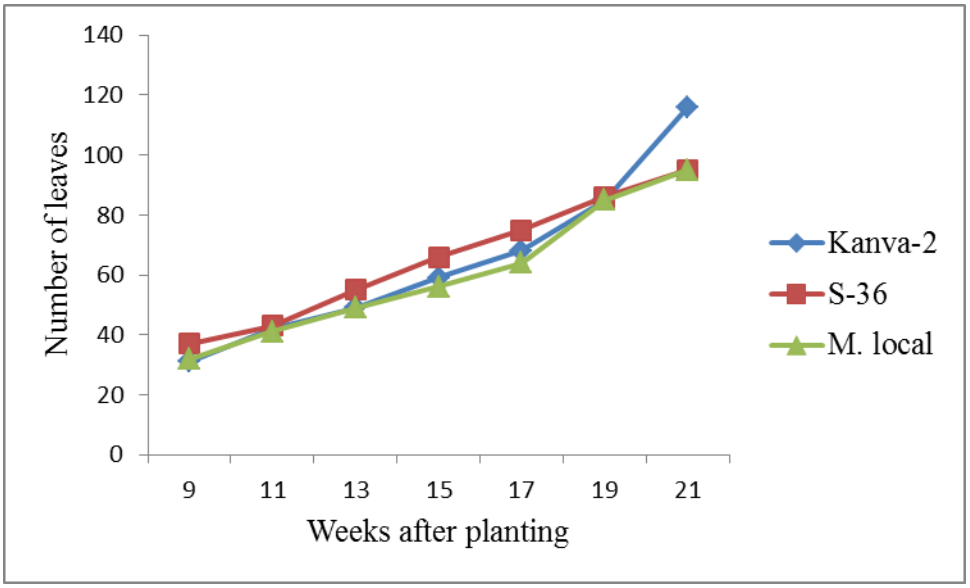

Figure 4.9 d: Number of leaves per plant in the control

Stem diameter

Figures 4.10a-d shows the stem diameter of mulberry as affected by the N sources. No significant difference was observed among the N sources with reference to stem diameter. However, SoA treated plants had the largest stem diameter. Among the mulberry varieties, Mysore local was observed to have the highest stem diameter in urea, NPK and control plots. S-36 had the highest stem diameter in SoA treated plants. No significant interaction was recorded.

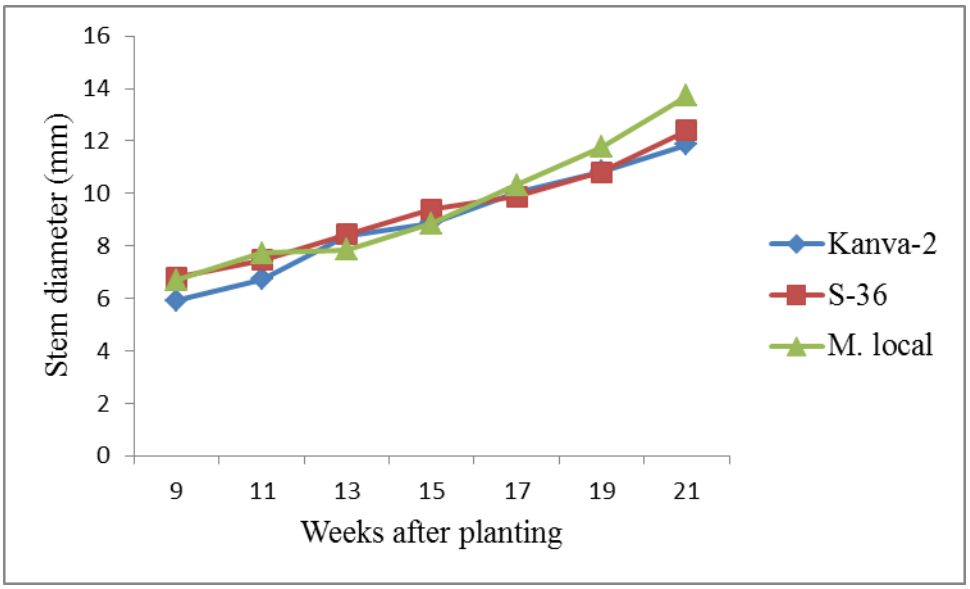

Figure 4.10 a: Influence of Urea on stem diameter

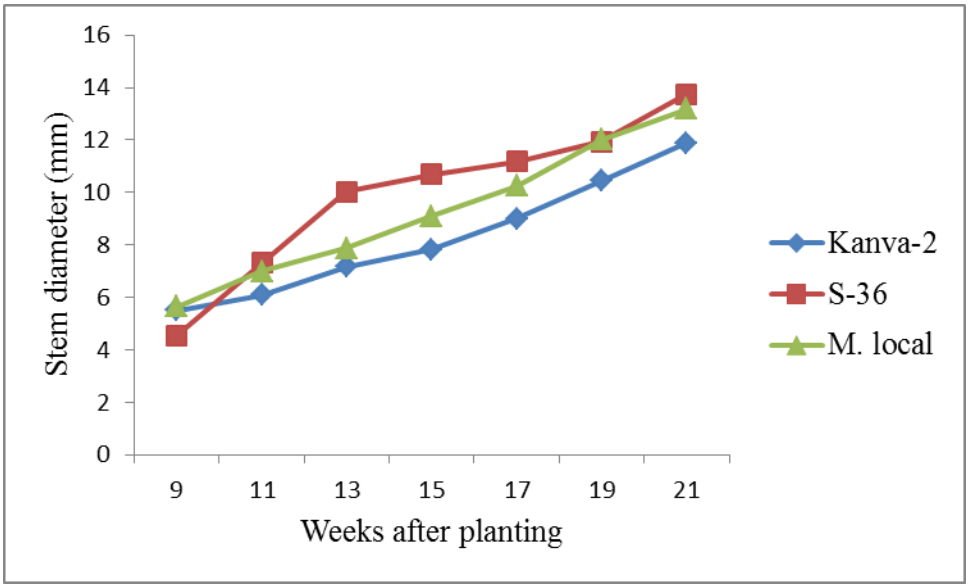

Figure 4.10 b: Influence of SoA on stem diameter

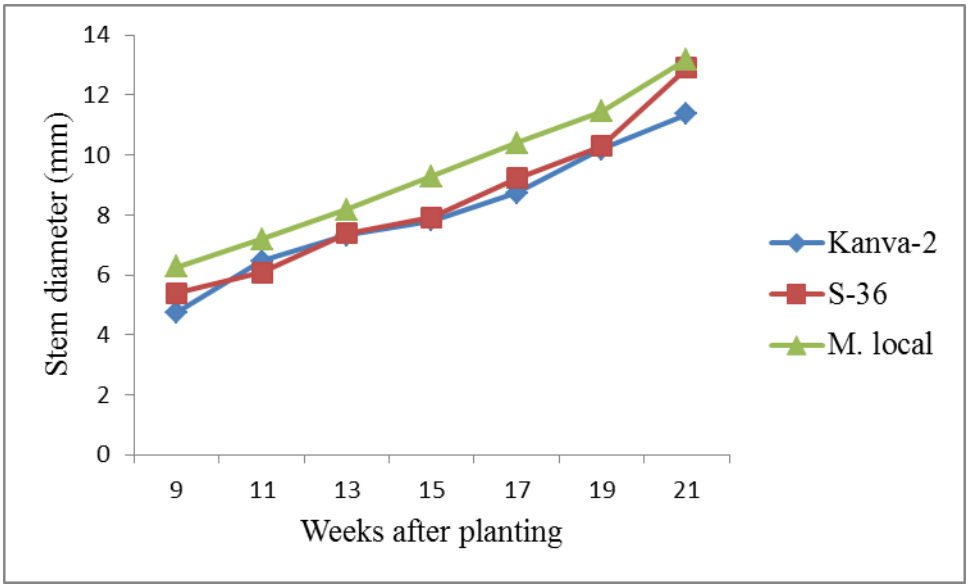

Figure 4.10 c: Influence of NPK on stem diameter

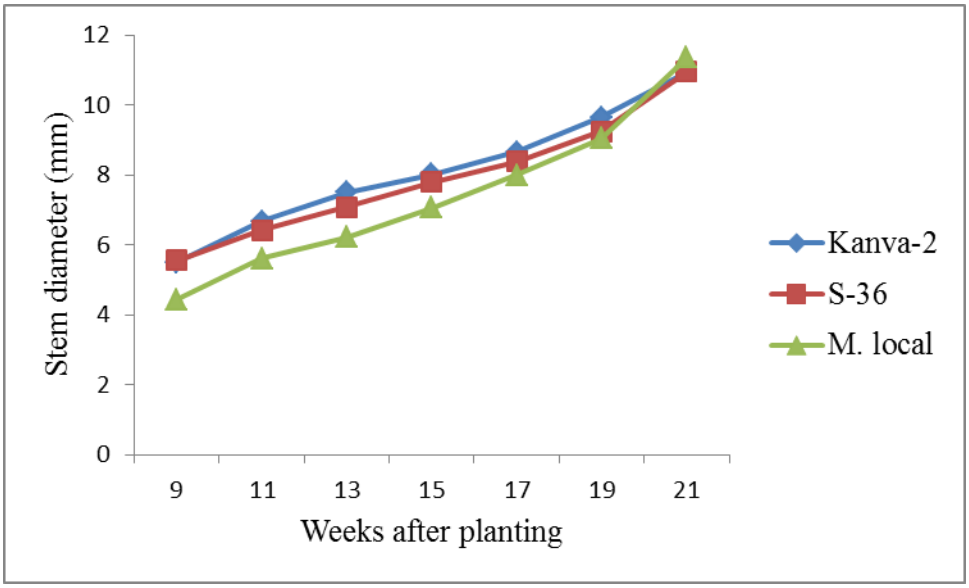

Figure 4.10 d: Stem diameter of control mulberry plants

Number of branches per plant

Table 4.6 shows the influence of inorganic N on the number of branches per plant at 21 WAP 1. No significant ($P< 0.05$) difference was recorded among the varieties, N sources and the interactions. However, the maximum number of branches (7.0) was produced by plants that were fertilized with NPK compared to the control (6.0). Similarly, no significant difference occurred among the varieties in the number of branches noticed. However, the highest number of branches (9.0) was produced by Mysore local. S-36 and Kanva-2 produced similar number of branches (Table 4.6).

Table 4.6: Influence of inorganic N on number of branches per plant at 21 WAP 1

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	5.0	5.0	4.0	6.0	**5.0**
S-36	5.0	4.0	6.0	6.0	**5.0**
Mysore local	9.0	9.0	9.0	10.0	**9.0**
Mean	**6.0**	**6.0**	**6.0**	**7.0**	

LSD (0.05): V= NS; V= NS; V x N= NS.

Leaf fresh weight (g)

Leaf fresh weight was significantly (P< 0.05) increased with the application of N. In table 4.7 significant differences exists between leaf fresh weight of plants that received SoA and urea. Urea, SoA and NPK increased leaf fresh weight by 6.4%, 8.3% and 8.1%, respectively more than the control. Similarly, S-36 produced higher leaf fresh weight than Kanva-2 and Mysore local. Also, no significant interaction was recorded between the varieties and the N sources.

Table 4.7: Influence of inorganic N on leaf fresh weight at 21 WAP 1

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	125.6	178.4	192.2	183.1	**169.8**
S-36	135.8	169.1	198.1	188.7	**172.9**
Mysore local	128.8	171.1	167.1	183.1	**162.5**
Mean	**130.1**	**172.9**	**185.8**	**185.0**	

Lsd (0.05): V= 11.9; N= 10.8; V x N= 18.2.

Leaf dry weight (g)

The production and partitioning of dry matter to plant parts was significantly (P< 0.05) influenced by the application of different sources of inorganic nitrogen. The highest leaf dry weight (69.4g) was obtained in NPK treated plots and the lowest dry weight (49.4g) was produced in control plots (Table 4.8). There was no varietal difference in terms of leaf dry weight, however, the highest leaf dry weight (66.2g) was produced by Mysore local. Significant interaction was noticed.

Table 4.8: Influence of inorganic nitrogen and mulberry variety on mulberry leaf dry weight (g/plant)

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	47.7	69.5	66.6	64.0	**61.9**
S-36	49.5	58.3	53.3	73.4	**58.6**
Mysore local	50.9	68.5	74.3	70.8	**66.2**
Mean	49.4	65.4	64.8	69.4	

LSD (0.05): V= NS; N= 4.526; V x N= 9.897

Leaf fresh yield (kg/ha)

Significant (P< 0.05) increase in fresh leaf yield was observed due to the application of the different N sources. SoA and NPK application resulted in higher leaf yield. However, SoA and NPK did not produce significant increase. Although varietal effect was non-significant, S-36 produced significantly (P< 0.05) higher yield (2135kg/ha) compared to Kanva-2 (2097kg/ha) and Mysore local (2007kg/ha) (Table 4.9). Also, the application of SoA to S-36 produced higher leaf fresh yield compared to other N sources. N treated plants performed better than the control.

Table 4.9: Nitrogen influence on fresh leaf yield (kg/ha) of mulberry

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	1550	2203	2373	2261	**2097**
S-36	1677	2088	2446	2330	**2135**
Mysore local	1677	2112	2063	2260	**2007**
Mean	**1606**	**2135**	**2294**	**2284**	

Lsd (0.05): V= 146.6; N= 132.7; V x N= 225.2.

Leaf dry yield (kg/ha)

Inorganic N produced significant increase (P< 0.05) in dry leaf yield at 21 WAP 1 (Table 4.10). NPK had the highest dry leaf yield and this was followed by urea. SoA and urea did not produce any significant effect. The N treated plants had higher leaf yield than the control. No significant varietal influence was observed. However, Mysore local recorded the highest (817.3kg/ha) leaf dry yield (Table 4.10). There was significant interaction among between nitrogen and mulberry varieties.

Table 4.10: Influence of Nitrogen on dry leaf yield (kg/ha) of mulberry

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	589.3	858.5	823.1	790.6	**765.3**
S-36	611.3	720.4	658.9	906.4	**724.2**
Mysore local	629.2	846.5	918.3	875.1	**817.3**
Mean	**610.0**	**808.5**	**800.1**	**857.4**	

LSD (0.05): V= 111.3; N= 55.88; V x N= 122.19.

Stem fresh weight (g)

Table 4.11 shows that stem fresh weight was significantly (P< 0.05) influenced by N sources at 21 WAP 1 more than the control. The effect urea was significantly different from NPK. No Significant variety and interaction was recorded at 21 WAP 1. However, the highest stem fresh weight (186.4g) was produced by S-36.

Table 4. 11: Influence of inorganic N on stem fresh weight of mulberry

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	98.9	173.8	169.7	160.4	**150.7**
S-36	119.8	217.7	186.0	222.3	**186.4**
Mysore local	103.0	232.1	230.6	159.4	**181.3**
Mean	**107.2**	**207.9**	**195.4**	**180.7**	

Lsd (0.05): V= 37.5; N= 27.08; V x N= 49.3.

Stem dry weight (g)

Significant (P< 0.05) impact of N sources on stem dry weight was observed. Urea recorded the highest (83.7g/plant) stem dry weight. Table 4.12 shows no significant difference between stem dry weight of plants fertilized with urea and SoA and also between SoA and NPK. The N treated plants had greater stem dry weights than the control. No significant variety and nitrogen source interaction was observed. However, Mysore local produced significantly (P< 0.05) higher dry weight (82.9g/plant) than Kanva-2 (61.1g/plant) and S-36 (71.3g/plant).

Table 4. 12: Influence of N sources on stem dry weight (g) of mulberry

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	44.1	70.5	66.1	63.9	**61.1**
S-36	59.4	78.1	67.7	80.0	**71.3**
Mysore local	62.2	102.6	103.5	63.0	**82.9**
Mean	**55.2**	**83.7**	**79.1**	**69.0**	

LSD (0.05): V= 28.4; N= 12.9; V x N= 30.1.

Total Shoot Yield (kg/ha)

Total shoot yield which comprising of leaves and stems was significantly influenced by the N sources. The N sources significantly (P< 0.05) increased the total shoot yield of the varieties more than the control (Table 4.13). NPK treated plots recorded the lowest shoot yield (1713kg/ha) among the N sources. Mysore local had significantly larger shoot yield (1993kg/ha) than Kanva-2 and S-36. Significant interaction was observed between nitrogen source and varieties of mulberry.

Table 4.13: Influence of inorganic N sources on total shoot yield at 21 WAP 1

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	1190	1717	1875	1580	**1590**
S-36	1243	1725	1495	1893	**1589**
Mysore local	1397	2312	2599	1665	**1993**
Mean	**1277**	**1918**	**1990**	**1713**	

LSD (0.05): V= 172.6; N= 164.7; V x N= 276.0.

Fresh stem yield (kg/ha)

Table 4.14 shows significant increase in fresh stem yield due to application of N sources. Urea treated plants recorded the highest stem yield (2566kg/ha) followed by SoA (2413kg/ha) treated plants. The application of urea and SoA to Mysore local produced higher fresh stem yield than the application of NPK to Mysore local. Control plots recorded the lowest yield.

Table 4.14: Influence of N sources on fresh stem yield (kg/ha) of mulberry varieties

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	1221	2146	2096	1981	**1861**
S-36	1479	2688	2296	2744	**2302**
Mysore local	1272	2865	2847	1968	**2238**
Mean	**1324**	**2566**	**2413**	**2231**	

Lsd (0.05): V= 463.2; N= 334.4; V x N= 609.1

Dry stem yield (kg/ha)

There was significant (P< 0.05) increase in dry stem yield with the application of inorganic N (Table 4.15). SoA produced the highest yield followed by Urea. There was a significant difference between SoA and NPK in dry stem productivity. The lowest yield was observed in control plots. Influence of variety was non-significant. However, Mysore local yielded better than Kanva-2 and S-36. Significant interaction was observed between varieties and nitrogen sources.

Table 4.15: Influence of N sources on stem dry yield (kg/ha) of mulberry

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	524	858	865	789	**759**
S-36	631	876	836	987	**833**
Mysore local	768	1267	1454	778	**1067**
Mean	**641**	**1001**	**1052**	**851**	

Lsd (0.05): V= 306.7; N= 168.0; V x N= 348.6

4.6.2 Leaf quality parameters

Leaf moisture (%)

The leaf moisture content was significantly (P< 0.05) increased due to application of Nitrogen. The highest moisture content of fresh leaves was obtained with the application of SoA (85.5%) followed by NPK (85%) and urea (72.9%). Varieties effect on leaf moisture content was non-significant. However, S-36 recorded the highest (73%) leaf moisture content.

Table 4.16: Influence of N source and Variety on fresh leaf moisture (%)

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	25.6	78.4	92.2	83.1	**69.8**
S-36	35.8	69.2	98.1	88.7	**73.0**
Mysore local	28.8	71.1	67.1	83.1	**62.5**
Mean	**30.1**	**72.9**	**85.8**	**85.0**	

LSD (0.05): V= 11.9; N= 10.8; V x N= 18.2

Crude Protein (%)

Application of Nitrogen from different sources significantly (P< 0.05) increased the crude protein of mulberry leaf. SoA and NPK greatly improved the protein content (36.58% and 35.43%) of mulberry leaves (Table 4.17) more than urea. No significant (P< 0.05) difference was obtained among the varieties. However, S-36 recorded the highest leaf protein (34.87%). The application of SoA to S-36 produced the highest leaf moisture (39.0%) content.

Table 4.17: Leaf Crude protein (%) of fresh leaf

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	31.3	32.4	35.0	33.8	**33.1**
S-36	32.5	32.9	39.0	35.3	**34.9**
Mysore local	32.6	33.2	35.7	37.1	**34.7**
Mean	**32.1**	**32.8**	**36.6**	**35.4**	

LSD (0.05): V= 1.5; N= 0.8; V x N= 1.7

Leaf mineral content (%)

The mean leaf mineral content of N treated plots was significantly higher (P< 0.05) than the control plots. The highest mineral content (6.602%) was achieved due to NPK application. There was significant interaction between varieties and N sources (Table 4.18). The highest (7.328%) interaction effect was produced by NPK and Mysore local interaction. The highest mineral (6.669%) composition was measured in Mysore local.

Table 4.18: Influence of inorganic N on leaf mineral (%) composition

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	6.225	5.895	6.561	5.815	**6.124**
S-36	5.852	6.899	6.943	6.662	**6.589**
Mysore local	6.535	6.951	5.861	7.328	**6.669**
Mean	**6.204**	**6.582**	**6.455**	**6.602**	

LSD (0.05): V= 0.0860; N= 0.1435; V x N= 0.2229.

Nitrogen uptake into leaf

Uptake of N into leaf was significantly (P< 0.05) enhanced by the application of N sources. The uptake of N into leaf increased with the application NPK followed by urea (Table 4.19). Nitrogen uptake as a result of application of SoA and urea were not significantly different from each other. There was no significant varietal effect but interaction between variety and nitrogen source was significant. Mysore local recorded the highest N uptake when NPK was applied. This was the same for S-36.

Table 4.19: Influence of N sources on N uptake into leaf

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	245.2	352.1	339.3	344.1	**320.2**
S-36	251.9	301.9	301.0	438.6	**323.3**
Mysore local	294.3	437.0	399.2	492.5	**405.7**
Mean	**263.8**	**363.7**	**346.5**	**425.1**	

LSD (0.05): V= 70.0; N= 28.9; V x N= 72.5.

4.7 Field Experiment 2:

4.7.1 Influence of inorganic nitrogen on regeneration, growth and leaf quality of mulberry varieties after pruning

Number of sprouts per plant

The number of sprouts after pruning was significantly ($P < 0.05$) influenced by the application of inorganic N sources. There was significant difference among the varieties with reference to the number of sprouts after pruning (Figure 4.11). S-36 had the highest number of sprouts followed by Kanva-2. The number of sprouts in Mysore local decreased at week 6 after pruning.

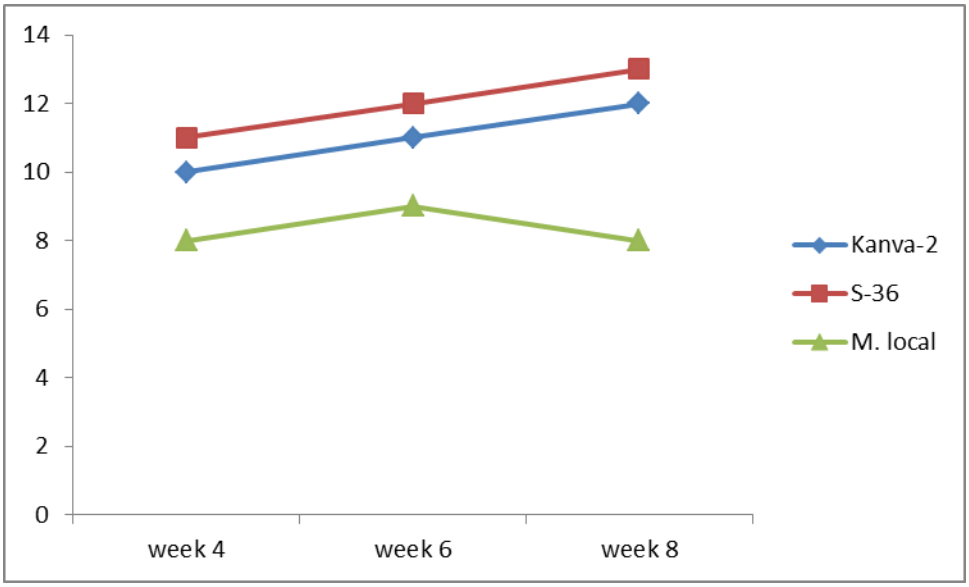

Figure 4.11: Influence of inorganic N on number of sprouts per plant after pruning

Plant height (cm)

Plant height of mulberry as influenced by N sources is indicated in (Figures 4.12a-d). Significant influence of inorganic N sources was observed. Mysore local had the highest

plant height. S-36 had the highest plant height in the control. Among the N sources, NPK had taller plants as compared to the other N sources.

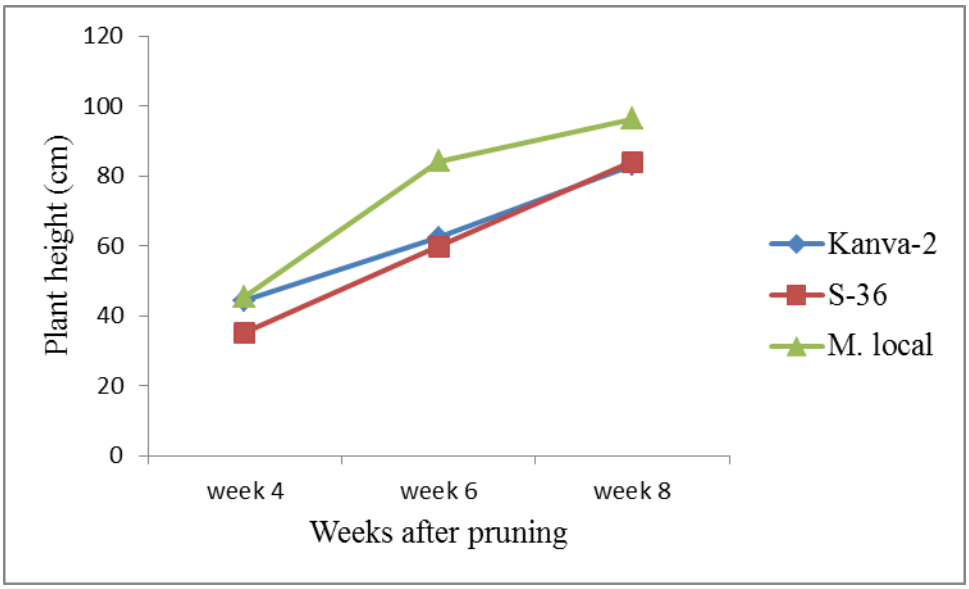

Figure 4.12 a: Influence of Urea on plant height after pruning

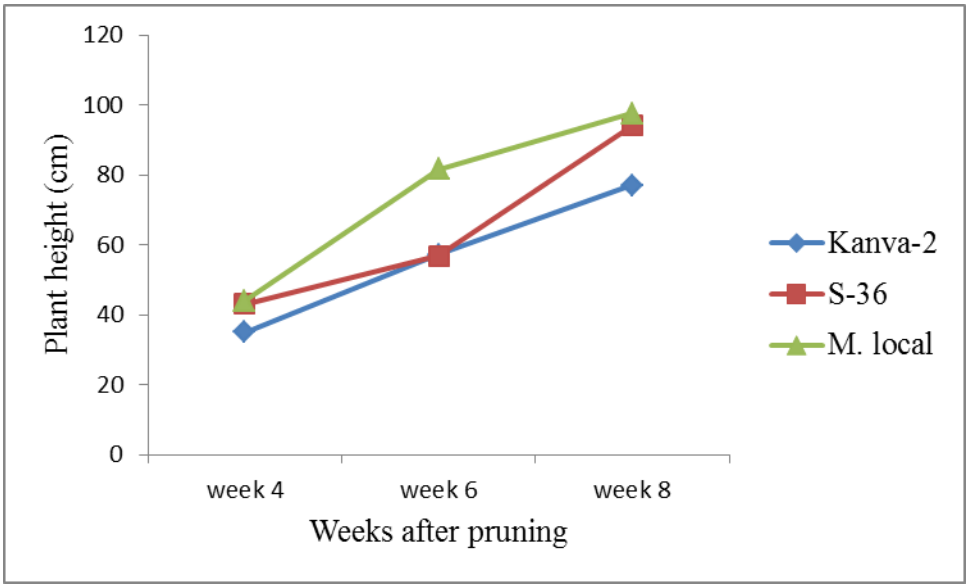

Figure 4.12 b: Influence of SoA on plant height after pruning

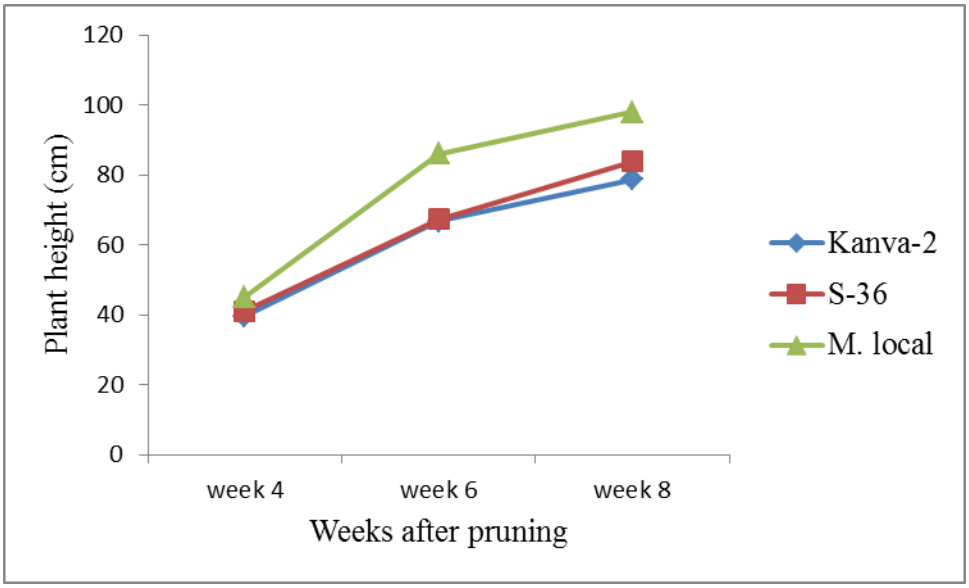

Figure 4.12 c: Influence of NPK on plant height after pruning

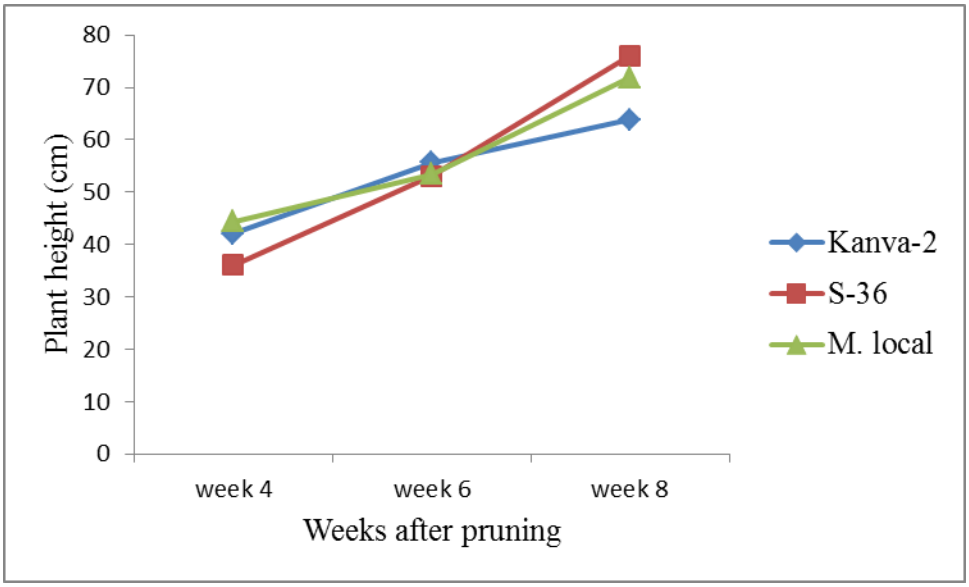

Figure 4.12 d: Height of control plants after pruning

Number of leaves

The number of leaves increased significantly ($P< 0.05$) at application of inorganic N. The number of leaves of Mysore local was significantly more than any of the varieties in the treated plots. However, S-36 had more leaves in the control than Mysore local. The increase in number of leaves was in the order of NPK > Urea > SoA. The control plots had the lowest number of leaves in all the varieties.

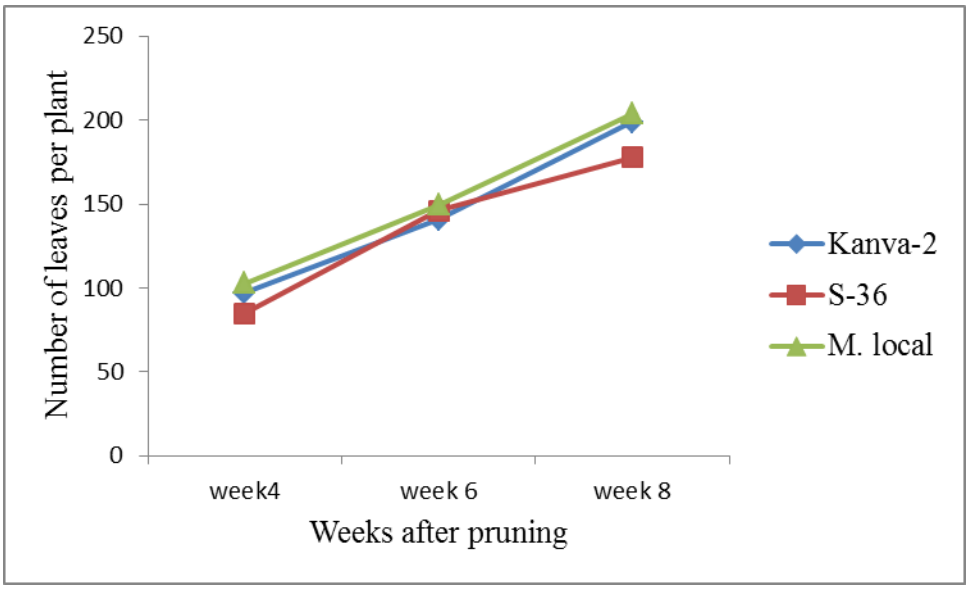

Figure 4.13 a: Influence of Urea on number of leaves per plant after pruning

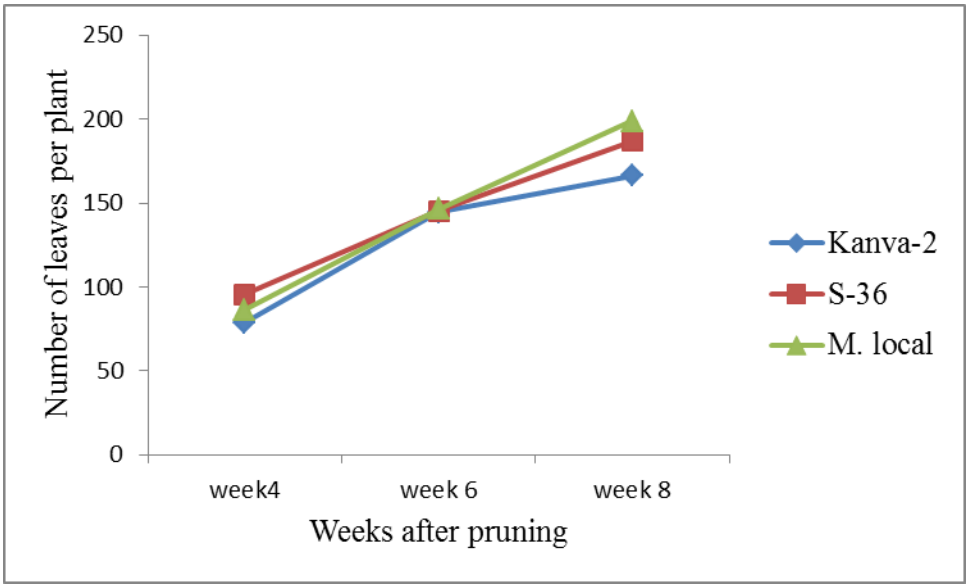

Figure 4.13 b: Influence of SoA on number of leaves per plant after pruning

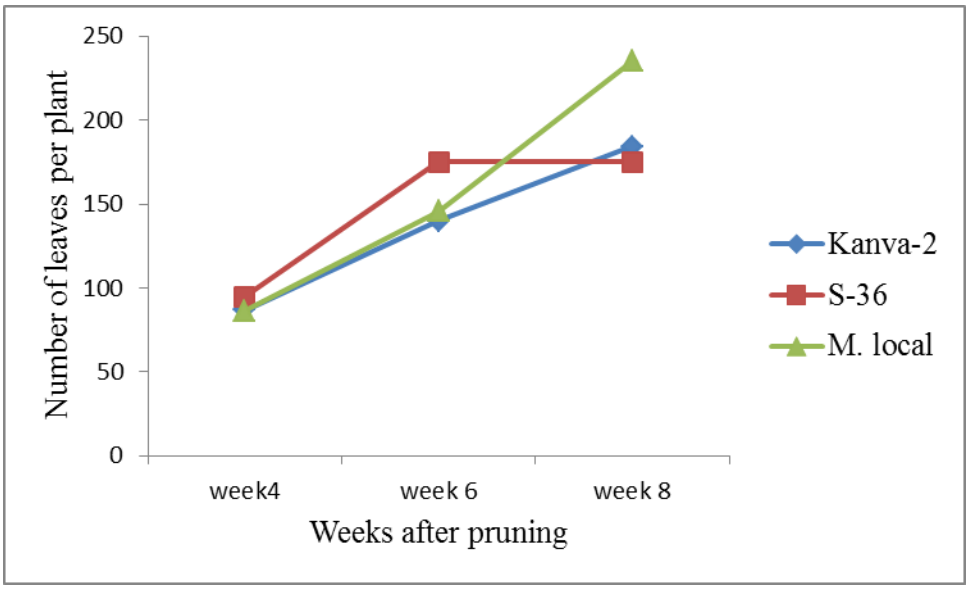

Figure 4.13 c: Influence of NPK on number of leaves per plant in experiment 2

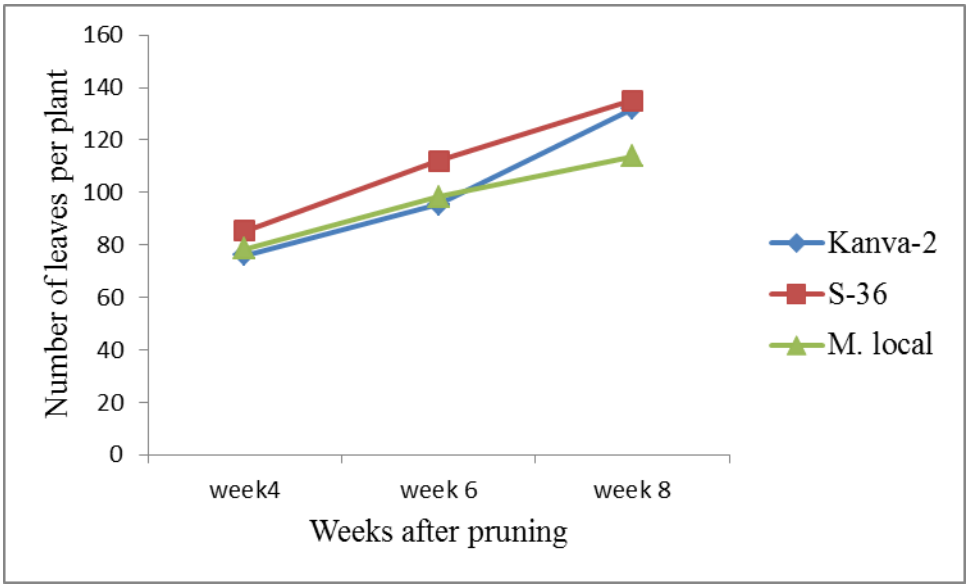

Figure 4.13 d: Number of leaves per plant in the control treatment

Stem diameter

The stem diameter per plant was significantly influenced by the application of inorganic N sources (Figures 4.14a-d). The application of urea and NPK increased the stem diameter of Mysore local more than the other varieties. SoA on the other hand, increased the stem diameter of S-36 more than Kanva-2 and Mysore local. The control favoured Kanva-2 in terms of diameter growth. The influence of NPK and SoA on stem diameter was non-significant.

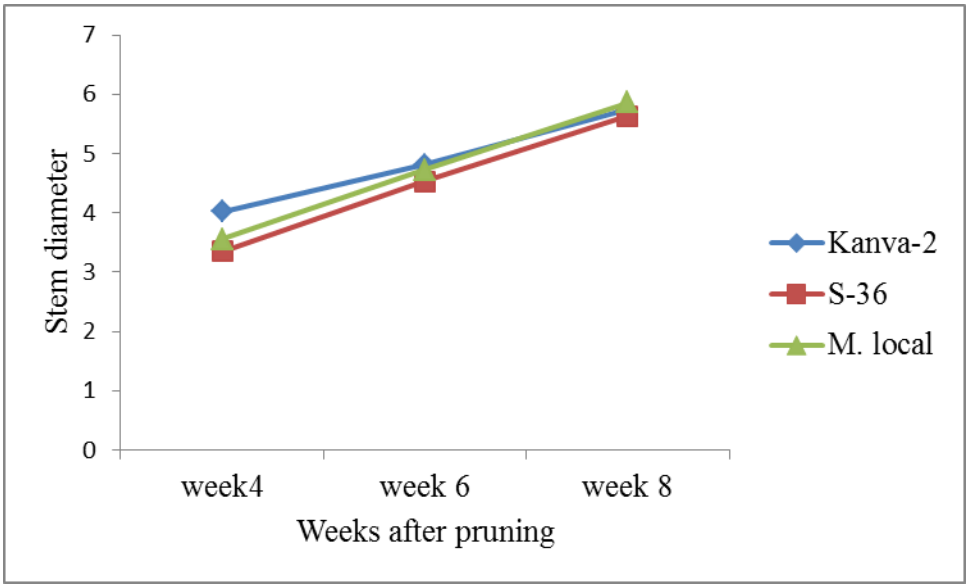

Figure 4.14 a: Influence of Urea on stem diameter after pruning

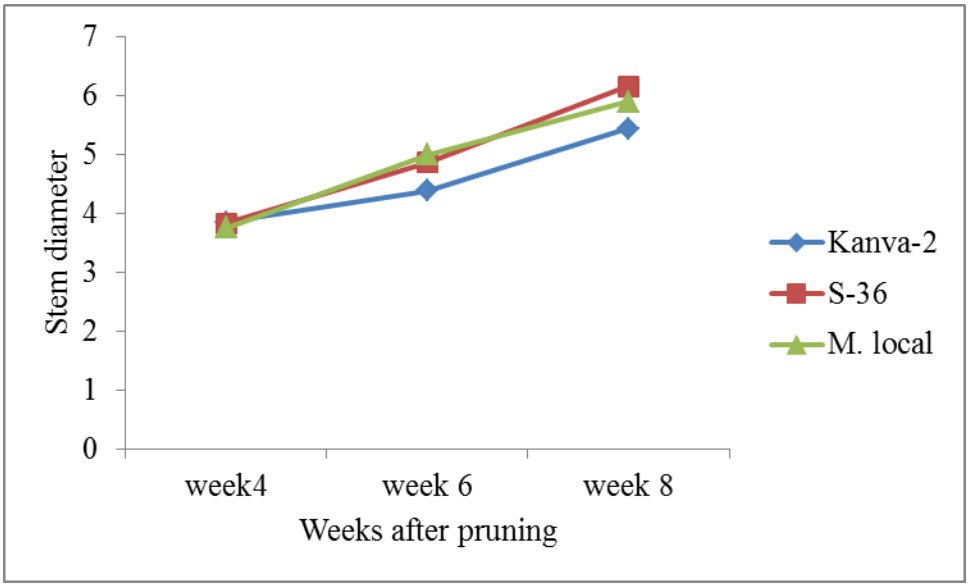

Figure 4.14 b: Influence of SoA on stem diameter after pruning

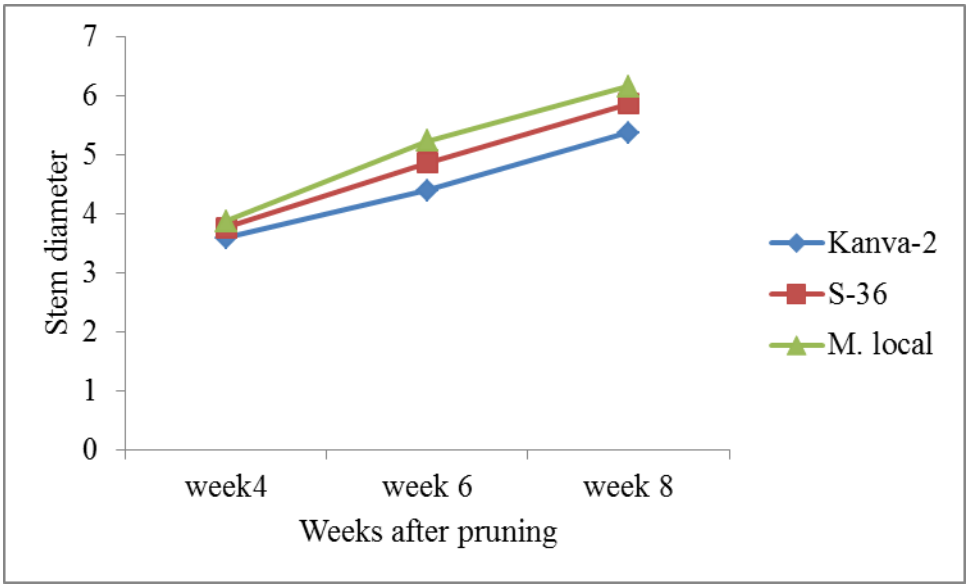

Figure 4.14 c: Influence of NPK on stem diameter after pruning

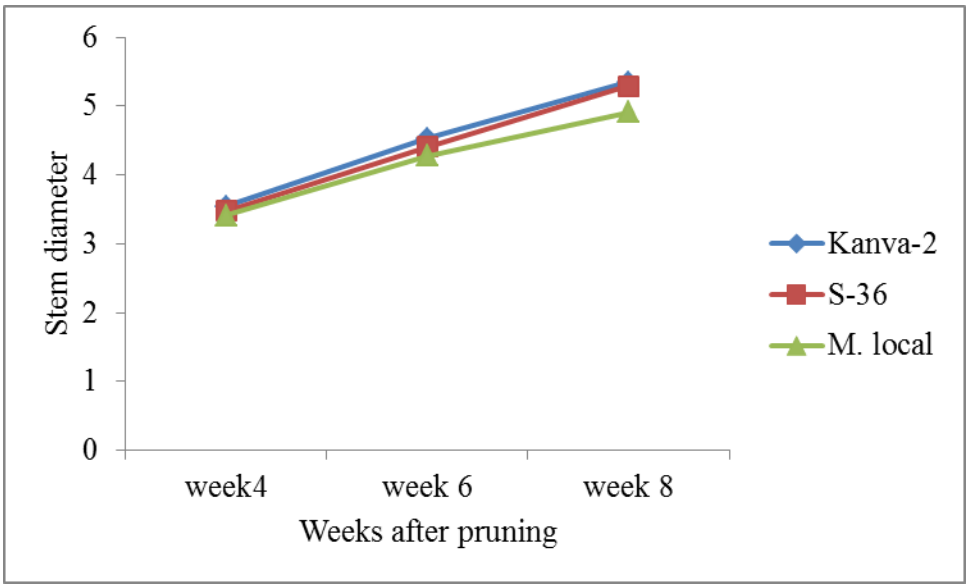

Figure 4.14 d: Influence of Control on stem diameter after pruning

Leaf fresh weight (g)

N sources had significant (P< 0.05) effect on fresh leaf weight. The highest leaf fresh weight (457.1 g/plant) was produced in NPK treated plots followed by Urea (401.1g/plant) and SoA (335.3g/plant). The control produced the lowest leaf fresh weight. Significant difference was observed among the N sources (Table 4.20). There was no varietal effect on leaf fresh weight. However, S-36 recorded higher leaf yield than Kanva-2 and Mysore local. There was significant interaction between variety and nitrogen source.

Table 4.20: Influence of nitrogen on leaf fresh weight (g) at 8 weeks after pruning

Variety	**Nitrogen source**				**Mean**
	Control	Urea	SoA	NPK	
Kanva-2	219.8	361.4	353.5	394.3	**332.2**
S-36	269.3	468.1	355.2	484.7	**394.3**
Mysore local	229.2	373.8	297.4	492.2	**348.1**
Mean	**219.0**	**401.1**	**335.3**	**457.1**	

LSD (0.05): V= 50.2; N= 36.7; V x N = 66.5.

Leaf dry weight (g/plant)

Leaf dry weight was significantly (P< 0.05) influenced by inorganic N sources. Differences among N sources were significant (Table 4.21). Urea treated plants produced significantly higher leaf dry weight (123.2g/plant) than NPK (108.4g/plant) and SoA (106.0g/plant). No significant difference was observed between plants that were fertilized

with SoA and NPK. Also, no significant varietal influence was observed. However, S-36 produced higher leaf weight than Kanva-2 and Mysore (Table 4.21). There was no significant interaction between the varieties and N sources.

Table 4.21: Influence of nitrogen source on leaf dry weight (g) of mulberry at 8 weeks after pruning

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	67.3	99.8	95.5	98.4	**90.3**
S-36	76.9	144.3	135.9	138.0	**123.8**
Mysore local	69.1	125.4	86.5	88.8	**92.5**
Mean	**71.1**	**123.2**	**106.0**	**108.4**	

LSD (0.05): V= 31.0; N= 17.1; V x N = 35.4.

Fresh leaf weight (kg/ha)

There was significant (P< 0.05) impact of N sources on fresh leaf yield of mulberry varieties. There was also significant difference among N sources with respect to leaf fresh weight (Table 4.22). The highest fresh leaf weight (2821kg/ha) was obtained in NPK treated plants and the least(1478kg/ha) in the control plants. No significant varietal influence was recorded. However, S-36 performed better than Kanva-2 and Mysore local. Significant interaction was observed among varieties and nitrogen sources.

Table 4.22: Influence of N sources on leaf fresh weight (kg/ha)

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	1357	2231	2182	2434	**2051**
S-36	1663	2890	2192	2992	**2434**
Mysore local	1415	2307	1836	3039	**2149**
Mean	**1478**	**2476**	**2070**	**2821**	

LSD (0.05): V= 310.0; N= 226.4; V x N= 410.6

Dry leaf weight (kg/ha)

The leaf dry weight of mulberry was significantly (P< 0.05) influenced by N sources applied. Urea application significantly increased leaf dry weight of mulberry varieties more than SoA and NPK. NPK and urea treated plots were non-significant. Variety had no significant impact on leaf dry weight. However, S-36 yielded (764kg/ha) more than Kanva-2 (557kg/ha) and Mysore local (571kg/ha). Similarly, interaction effect was non-significant but the highest interaction effect (891kg/ha) was between S-36 and urea (Table 4.23).

Table 4.2314: Effect of N sources on leaf dry yield of mulberry

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	416	616	590	607	**557**
S-36	474	891	839	852	**764**
Mysore local	427	774	534	548	**571**
Mean	**439**	**760**	**654**	**669**	

Lsd (0.05): V= 191.4; N= 105.8; V x N= 218.4.

Stem fresh weight (g/plant)

The stem fresh weight of mulberry varieties after pruning was significantly (P< 0.05) influenced by the application of inorganic sources of N. Table 4.31 shows significant differences among the N sources. Stem fresh weight as a result of NPK and urea application were significantly different from each other. However, NPK and urea increased stem fresh weight by 18.3% and 11.8%, respectively more than the control (Table 4.24). Mysore local had higher stem fresh weight (284g/plant) than Kanva-2 (204g/plant) and S-36 (264g/plant). Mysore local and S-36 were not significantly different from each other.

Table 4.25: Influence of inorganic N on stem fresh weight (g) at 8 weeks after pruning

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	131	233	222	230	**204**
S-36	175	261	263	357	**264**
Mysore local	158	324	226	428	**284**
Mean	**154**	**273**	**237**	**338**	

LSD (0.05): V= 61.5; N= 72.6; V x N= 116.9.

Stem dry weight (g/plant)

Table 4.26 indicates N sources significantly (P< 0.05) influenced the stem dry weight of mulberry. Significant difference was observed between the application of NPK and SoA. The highest stem dry weight (121.5g/plant) was recorded at the application of NPK followed by urea (101.8g/plant). Table 4.32 shows Mysore local had significantly (P< 0.05) higher stem dry weight followed by S-36. However, no significant difference was observed between Mysore local and S-36.

Table 4.26: Influence of inorganic N on stem dry weight

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	47.5	85.0	78.1	79.3	**72.4**
S-36	62.0	103.0	88.9	127.8	**95.4**
Mysore local	64.0	117.3	88.8	157.3	**106.9**
Mean	**57.8**	**101.8**	**85.3**	**121.5**	

LSD (0.05): V = 15.3; N= 24.9; V x N= 38.7.

Stem fresh weight (kg/ha)

N sources significantly (P< 0.05) impacted stem fresh weight of mulberry varieties. Table 4.33 indicates significant difference among varieties and N sources. The highest stem fresh yield (2089kg/ha) was obtained in NPK treated plots and the lowest (953kg/ha) in the control plots (Table 4.27). Stem fresh yield was highest (1754kh/ha) in Mysore local than the other varieties. Stem fresh weight of S-36 and Mysore local were not significantly different from each other.

Table 4.27: Influence of N sources on stem fresh weight (kg/ha) at 8 weeks after pruning

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	807	1439	1371	1421	**1259**
S-36	1078	1608	1621	2201	**1627**
Mysore local	974	2002	1396	2644	**1754**
Mean	**953**	**1683**	**1463**	**2089**	

LSD (P0.05): V= 379.5; N= 448.0; V x N= 721.6

Stem dry weight (kg/ha)

The difference in stem dry weight of mulberry was significantly different (P< 0.05) among N sources. The lowest stem dry weight (357kg/ha) was produced in control plots. NPK and urea increased stem dry yield more than SoA. NPK and urea were not significantly different from each other. In the same way, Mysore local yielded significantly better than Kanva-2 and S-36. However, S-36 and Mysore local had no significant difference (Table 4.28).

Table 4.28: Influence of N sources on stem dry weight of mulberry varieties (kg/ha) at 8 weeks after pruning

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	292	525	482	490	**447**
S-36	383	636	549	789	**589**
Mysore local	395	724	548	971	**660**
Mean	**357**	**628**	**526**	**750**	

LSD (0.05): V= 94.2; N= 153.6; V x N= 238.9.

Total shoot yield (kg/ha)

The total shoot yield (leaves and stems) was significantly (P< 0.05) influenced by N sources. The N treated plants had significantly higher shoot yield than the control. Urea and NPK treated plots were not significantly different from each other. No significant difference was observed between S-36 and Mysore local. However, Kanva-2 had significantly lower shoot yield (1004kg/ha) across N sources compared to S-36 (1353kg/ha) and Mysore local (1231kg/ha) (Table 4.29).

Table 4.29: Influence of N sources on total shoot yield (kg/ha) after pruning

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	708	1141	1072	1097	**1004**
S-36	857	1526	1387	1641	**1353**
Mysore local	822	1499	1083	1519	**1231**
Mean	**796**	**1389**	**1181**	**1419**	

LSD (P< 0.05): V= 197.9; N= 213.8; V x N= 349.4.

4.7.2 Leaf quality parameters

Leaf moisture content (%)

Table 4.30 shows the mean values for moisture content of fresh leaves. There was significant (P< 0.05) influence of inorganic N sources on leaf moisture content. The highest leaf moisture (76.2%) was obtained in NPK treated plots and the least (69.33%) obtained from urea treated plots. However, no significant difference in leaf moisture content existed between urea and SoA. Influence of variety on moisture content of leaves was not significant. However, Kanva-2 recorded the highest moisture content (72.4%). The application of NPK to Mysore local produced the highest (81.95%) leaf moisture content.

Table 4.30: Influence of N sources on leaf moisture content of mulberry varieties

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	69.4	72.4	73.0	75.1	**72.4**
S-36	71.0	69.2	61.8	71.5	**68.4**
Mysore local	68.8	66.4	71.0	82.0	**72.0**
Mean	**69.7**	**69.3**	**68.5**	**76.2**	

LSD (0.05): V= 3.6; N= 4.4; V x N = 7.0

Crude protein (%)

The protein content of the leaves was positively influenced by the application of inorganic N. Application of urea recorded significantly (P< 0.05) higher (34.6%) protein content than NPK (28.1%) and SoA (27.2%). No significant difference was observed between Urea and SoA. No significant varietal effect was observed. However, S-36 had the highest protein (26.8%) followed by Mysore local (26.3) (Tale 4.31).

Table 4.31: Influence of N on leaf protein content (%)

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	14.6	35.1	26.3	27.7	**25.9**
S-36	16.3	34.4	27.1	29.2	**26.8**
Mysore local	15.2	34.4	28.3	27.4	**26.3**
Mean	**15.4**	**34.6**	**27.2**	**28.1**	

LSD (0.05): V= 3.5; N= 2.3; V x N= 4.4.

Leaf mineral content (%)

Significant (P< 0.05) influence of inorganic N sources on the mineral content of mulberry leaf was observed. The highest mineral content (9.2%) was recorded by the application of urea followed by NPK and the lowest was recorded in the control. No significant difference was observed between urea and NPK (Table 4.32). Mysore local recorded the highest mineral content and the lowest by Kanva-2. No significant difference existed between S-36 and Mysore local.

Table 4.32: Influence of inorganic N sources on mineral composition of mulberry leaf

Variety	Nitrogen source				Mean
	Control	Urea	SoA	NPK	
Kanva-2	5.7	8.6	8.2	8.7	**7.8**
S-36	5.8	9.6	8.6	9.1	**8.3**
Mysore local	6.1	9.4	8.9	9.7	**8.5**
Mean	**5.9**	**9.2**	**8.5**	**9.2**	

LSD (0.05): V= 0.3376; N= 0.3485; V x N= NS

Nitrogen uptake into leaf (g/plant)

N sources significantly (P< 0.05) influenced the uptake of N into the leaf. There was significant increase in the uptake of N into the leaf in the N treated plots compared to the control. Urea, SoA and NPK increased the uptake of N into leaf by 27.9%, 16% and 17.3% folds, respectively compared to the control. There was no significant difference between SoA and NPK in N uptake. S-36 had higher leaf N than Kanva-2 and Mysore

local. There was no significant difference between Mysore local and Kanva-2 (Table 4.33).

Table 4.33: Influence of N sources on leaf N after pruning

Variety	**Nitrogen source**				**Mean**
	Control	Urea	SoA	NPK	
Kanva-2	157	560	407	431	**389**
S-36	202	783	589	644	**555**
Mysore local	166	691	391	386	**408**
Mean	**175**	**678**	**463**	**487**	

LSD (0.05): V= 88.5; N= 87.4; V x N= 145.3.

CHAPTER FIVE

DISCUSSION

5.0 The Status of Sericulture in Ghana

5.1 Demographic Characteristics of Sericulture Farmers

The results indicate that economically active labour force is engaged in sericulture. More males are engaged in silk farming in Ghana than females. Olaleye (2000) reported that there are more males into rural agriculture than females in Nigeria. It was also observed that the majority of sericulture farmers are educated and this directly linked with technology adoption and productivity. The educated farmers are likely to be more productive as compared than uneducated farmers. Sericulture is a venture which requires specialized skills and this may be attributed to the high level of education among the farmers.

The study revealed that the household size of sericulture farmers in Ghana is large. The large family sizes serve as sources of family labour, since large households will pay less for labour and reduce the cost of production thereby increasing the income of farmers.

The Brong-Ahafo Region has the highest number of sericulture farmers. This may be attributed to the favourable climatic and environmental factors for the growth of mulberry and rearing of the silkworm. The climatic and environmental factors prevailing in the Northern Region may not be conducive for the production of cocoons throughout the year. Hence, the fewer number of silk farmers in that Region.

The challenges which beset the sericulture industry may have contributed to the low cocoon production and low patronage of the industry by farmers. It may be the same reason why farmers cultivate other crops other than mulberry and also why farmers use it

as subsidiary instead of full time occupation. Savithri *et al*. (2013) has reported similar challenges in India.

The results show that most of the silkworm eggs were imported from India indicating the keen interest of India in promoting sericulture in Ghana. Kenya has similar climatic and environmental conditions as Ghana. Due to these factors, worms from Kenya would be better adapted to the Ghanaian conditions than those from other countries.

5.2 Influence of Inorganic N on Growth Parameters of Mulberry Varieties

The results of the study revealed that inorganic N sources enhanced the growth, leaf yield and quality of mulberry. Growth parameters such as plant height stem girth, number of leaves and dry matter production increased with the application of N than the control. The results obtained in this study agree with the report that nitrogen is essential for plant growth (Chiroma *et al.*, 2006; Adamtey *et al*., 2009). Results of experiment 1 indicated high growth with the application of SoA whiles in experiment 2, plants responded to NPK more than the other fertilizers. The difference in response to the N sources by mulberry varieties may be due to genetic variability and physiological processes among the varieties (Chandra *et al*., 1992). Also, it may be attributed to residual effect by the compound fertilizer (NPK). The results also showed that nitrogen application increased nutrients uptake leading to enhanced carbohydrate synthesis thereby resulting in increased cell division and enlargement with resultant increase in plant height and stem diameter (Prabhu *et al*., 2003). Application of nitrogen also promotes plant growth by increasing the number and length of internodes which results in increased plant height and stem girth. The increased number of leaves could be attributed to enhanced cell division and growth as well as availability of nutrients for leaf initiation. Bongale *et al*.

(2000) and Shahbazi (2005) had also reported that N application increased the number of leaves in mulberry.

5.3 Leaf Yield of Mulberry

Increased leaf yield may be due to increased number of leaves and leaf area which may be due to the application of inorganic nitrogen. The application of inorganic N led to the release and enhanced uptake of nitrogen and other plant nutrients which resulted in leaf initiation, cell division and leaf expansion, increased light interception, increased photosynthesis and dry matter production and partitioning into leaves (Bose and Majumder, 1998)). The results obtained in this study showed high leaf yield in S-36 at the application of SoA (250kg N/ha) and NPK (300kg N/ha). This confirms earlier report that application of 200, 250 and 300kg N/ha significantly increased leaf yield more than control in mulberry (Majumder *et al*., 2003). Shivaprakash *et al*. (2000) and Ghosh *et al*. (1997) reported higher leaf yield in S-36 at the application of 300kg N/ha/year but at a spacing of 60cm x 60cm. Islam *et al*. (1982) also reported significant increase in leaf yield of mulberry as a result of N application compared to the control. Bose and Majumder (1998) also investigated the influence of nitrogen on mulberry and reported that the application of fertilizer nitrogen increased the leaf yield and other vegetative parameters more than the control.

5.4 Leaf Quality of Mulberry

The present study showed increase leaf quality of mulberry following the application of N. The results revealed high leaf moisture and crude protein in S-36 and high mineral

content and crude protein in Mysore local. The increase in leaf moisture, leaf crude protein, leaf mineral content (N, P, K, Ca and Mg) and leaf N by SoA and NPK may be due to the presence of more than one nutrient in the compound fertilizers. The current results corroborate the report of Subbaswamy *et al*. (1999) who studied the influence of different sources of inorganic nitrogen fertilizers on leaf quality of mulberry and reported higher leaf yield and high leaf protein content in plants fertilized with ammonium sulphate compared with plants fertilized with calcium ammonium nitrate and urea. Also, Manchashetty (1979) observed that application of nitrogen, phosphorus and potassium (NPK) to mulberry increased leaf quality with reference to crude protein and mineral content of the leaves. The application of NPK and other compound fertilizers enhances the uptake of nutrients by plants and the presence of minerals other than N increases plants access to minerals. This increases the mineral nutrition of plants, hence high quality crops. Subbarayappa *et al*. (1994) also reported that the application of ammonium sulphate increased leaf quality of mulberry compared with the control (no fertilizer), ammonium nitrate and urea.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.0 Conclusion

It can be concluded that the numerous challenges that beset the industry is a contributing factor to the low patronage of sericulture and production of cocoon in Ghana.

From the study, it can be concluded that the application NPK and SoA increased growth, leaf yield and quality of mulberry than urea and control (no fertilizer application) before pruning. However, in the regrowth, urea application resulted in the highest moisture and protein content of leaves compared to the application of NPK and SoA.

Among the varieties, S-36 gave the highest leaf yield and quality (moisture and protein content of leaves).High protein content and fast growth was observed in Mysore local.

These results have important agronomic and nutritional implications for sericulture in Ghana. The combined application of SoA and NPK would results the production of quality mulberry leaves for sericulture. It can be concluded from the results that S-36 and Mysore local are more productive in the coastal savannah zone than Kanva-2.

6.1 Recommendations

Based on the results obtained, the following recommendations are made:

- From the study, S-36 is recommended for chawky rearing due to its high moisture and high protein content.
- Due to its high mineral and protein content, Mysore local is recommended for late instar rearing of silkworm.

- The government and non-governmental agencies in the field of agriculture should embark on awareness campaign to promote sericulture production in Ghana
- The government should support the establishment of reeling centres to add value to cocoons produced
- Training programmes should be organized for farmers to equip farmers with the necessary skills for quality cocoon production
- Further studies should be conducted in different ecological zones to determine the suitability of the different varieties to the different ecological zones of Ghana.
- Further research should be carried out using organic and inorganic fertilizers to assess the response of the different mulberry varieties to integrated fertilizer management

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APPENDICES

Appendix 1: Interview Schedule

UNIVERSITY OF GHANA

COLLEGE OF AGRICULTURE AND CONSUMER SCIENCES

CROP SCIENCE DEPARTMENT

STATUS OF SERICULTURE IN GHANA

The impact of the sericulture industry has not been fully realised. Therefore the need to assess its current status in Ghana and the way forward for the industry. I would be very grateful if you could provide information on the current status of Sericulture in Ghana for my graduate studies at the Department of Crop Science, University of Ghana. You are assured that the information given would be treated as ***strictly confidential*** and that no reference would be made to you in presenting the results.

Thank you.

Demographic Information

Region ……. District …….....

Town/Village/community …… Date of Interview …….....

Name of enumerator ……..

Name and telephone number of the farmer…….

Socio-economic characteristics

Please tick [√] where appropriate.

1. Age of respondent:……..years.
2. Gender of respondent: 1. Male [ ] 2. Female [ ]
3. Marital status:
   1. Single. 2. Married. 3. Divorced. 4. Separated

4. Are you the head of household? 1. Yes 2. No

5. Religion of respondent:
   1. Christian 2. Muslim. 3. Traditional religion 4. Other, specify, …

6. Native of community? 1. Yes 2. No
   If no, indicate where you come from …….

7. For how long have you been resident here?.....……. Years

8. Level of education of farmer
   1. No schooling. 3. JSS. 5. SSS 7. O /A Level 9. Tertiary
   2. Primary 4. MSLC. 6. Voc/Tech 8. Training college 10. Informal

9. Household size of the respondent. …….

Cultivation and sources of mulberry varieties and silkworm races in Ghana

10. Ownership of land: (1) Personal property (2) Family property (3) Lease (4) Others, if others, specify: .....

11. What is the total acreage of all your farmlands?.....

12. What is the size of your mulberry farm/total land area cultivated to mulberry??
    .....

13. Apart from mulberry, what other crops do you cultivate?
    .....

14. What variety(s) of mulberry do you cultivate?.....

15. Why do you grow this variety(s)?.....

    .....

16. Where do you normally get your planting materials?.....

17. How many cuttings do you plant per plot?.....

18. Indicate the planting distance ……..

19. How long have you been into sericulture?.....

20. What are some of the major constraints/challenges to mulberry production in this area?

.....

.....

.....

.....

21. On the average, what is the quantity of mulberry you produce in a year?.....

22. Do you have the wild mulberry variety in this area? (1) Yes (2) No

23. Apart from mulberry, is there any other plant that can be fed to silkworm?
(1). Yes (2). No

If yes, mention the plant or any two of such plants.....

24. What race(s) of silkworm do you rear?.....

25. Why do you rear this race(s) of the silkworm?.....

.....

26. Where do you get the silkworm eggs?.....

27. Do you have the wild silkworm race in this area? (1). Yes (2). No

28. Have you noticed people who harvest cocoon from the wild in this area? (1). Yes
(2). No

29. What rearing techniques do you use in producing the silkworms?

.....

30. On the average, what is the total quantity of silkworms you produce in a year?.....

31. What are some of the major constraints/challenges to silkworm production in this area?

.....

.....

.....

32. Do you attend training programmes on sericulture? (1). Yes (2). No

33. If yes, how often do you attend such training programmes? (1). Very often (2). Often (3). Not very often

34. Which organization(s) offers such training programmes?.....

.....

35. Do you pay for the trainings programmes? (1). Yes (2). No

Marketing of cocoons in Ghana

36. On the average, what is the quantity of cocoon you produce per season?.....

37. Do you have access to ready markets for the produce? (1). Yes (2). No

38. How are your cocoons marketed?.....

.....

39. How much do you sell 1kg of cocoon?.....

40. How do you determine the price of the cocoon?.....

.....

41. In which form do you normally sell the cocoon?.....

42. What are some of the major challenges/constraints associated with the marketing of the cocoons?

.....

.....

.....

.

Profitability of sericulture in Ghana

43. How would you rate the sericulture industry in Ghana in terms of profitability? (1). Not profitable (2). Profitable (3). Not very profitable (4). Very profitable

44. Would you encourage other farmers to take up this venture? (1). Yes (2). No

45. What other work do you do apart from sericulture?.....

46. Do you cultivate mulberry in the dry season? (1). Yes (2). No

47. Do you use irrigation on your mulberry farm? (1). Yes (2). No

48. If yes, what type of irrigation facility do you use? (1). Sprinkler (2). Water pump (3) Drip/irrigation pipes (4). Use of bucket

49. What is the source of your irrigation water? (1). Well (2). Dam/stream (3). Pond (4). Others, please specify……

50. Do you always have access to labour for production? (1). Yes (2). No

51. If yes, what type of labour: (1). Family labour (2). Hired labour (3) Cooperative (4). Both family and hired (5). Others, please specify.....

52. In one season, how many labourers do you employ?.....

53. Do you usually have access to credit facilities for production? (1). Yes (2). No

54. If yes, what are your main sources of credit: (1). Banks (2).Money lenders (3). Family and friends (4) Others, please specify.....

55. Do you use fertilizer in your mulberry farm? (1). Yes (2). No

56. If yes, what type of fertilizer do you use? (1). Organic fertilizer (2). Inorganic fertilizer

57. What type organic or inorganic fertilizer do you apply in your farm?

……

58. What quantity of the fertilizer do you use?

.....

59. Kindly outline some of the key things that you would like the government and/or other organizations to do about the sericulture industry in Ghana?

.....

.....

……

Appendix 2: Analysis of Variance (ANOVA) for experiment 1

ANOVA for leaf fresh weight (g/plant)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replication	2	100.9	50.4	0.46	
Variety	2	686.5	343.2	3.13	0.152
Residual	4	439.2	109.8	0.93	
Nitrogen source	3	18598.8	6199.6	52.63	<.001
Variety x Nitrogen source	6	1308.4	218.1	1.85	0.145
Residual	18	2120.1	117.8		
Total	35	23253.8			

ANOVA for Leaf dry weight (g/plant)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
replication	2	81.89	40.94	0.65	
variety	2	342.43	171.21	2.71	0.181
Residual	4	253.13	63.28	3.03	
Nitrogen source	3	2103.48	701.16	33.57	<.001
Variety x Nitrogen source	6	723.21	120.54	5.77	0.002
Residual	18	375.96	20.89		
Total	35	3880.11			

ANOVA for fresh leaf yield (kg/ha)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replication	2	15372.	7686.	0.46	
Variety	2	104633.	52317.	3.13	0.152
Residual	4	66944.	16736.	0.93	
Nitrogen source	3	2834896.	944965.	52.63	<.001
Variety x Nitrogen source	6	199429.	33238.	1.85	0.145
Residual	18	323160.	17953.		
Total	35	3544435.			

ANOVA for leaf dry yield (kg/ha)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replication	2	12482.	6241.	0.65	
Variety	2	52194.	26097.	2.71	0.181
Residual	4	38583.	9646.	3.03	
Nitrogen source	3	320621.	106874.	33.57	<.001
Variety x Nitrogen source	6	110235.	18372.	5.77	0.002
Residual	18	57305.	3184.		
Total	35	591421.			

ANOVA for leaf moisture (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replication	2	100.9	50.4	0.46	
Variety	2	686.5	343.2	3.13	0.152
Residual	4	439.2	109.8	0.93	
Nitrogen source	3	18598.8	6199.6	52.63	<.001
Variety x Nitrogen source	6	1308.4	218.1	1.85	0.145
Residual	18	2120.1	117.8		
Total	35	23253.8			

ANOVA for leaf crude protein (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replication	2	2.0835	1.0418	0.56	
Variety	2	21.5238	10.7619	5.82	0.065
Residual	4	7.4024	1.8506	2.83	
Nitrogen source	3	123.3340	41.1113	62.97	<.001
Variety x Nitrogen source	6	25.6085	4.2681	6.54	<.001
Residual	18	11.7508	0.6528		
Total	35	191.7031			

Appendix 3: Analysis of Variance (ANOVA) for experiment 2

ANOVA for leaf fresh weight (g/plant)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replication	2	185.	93.	0.05	
Variety	2	24969.	12485.	6.36	0.057
Residual	4	7852.	1963.	1.43	
Nitrogen source	3	236186.	78729.	57.42	<.001
Variety x Nitrogen source	6	23962.	3994.	2.91	0.036
Residual	18	24680.	1371.		
Total	35	317835.			

ANOVA for dry leaf weight (g/plant)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replication	2	590.3	295.2	0.39	
Variety	2	8418.9	4209.5	5.63	0.069
Residual	4	2991.9	748.0	2.50	
Nitrogen source	3	13128.2	4376.1	14.62	<.001
Variety x Nitrogen source	6	2948.6	491.4	1.64	0.193
Residual	18	5387.8	299.3		
Total	35	33465.7			

ANOVA for leaf fresh yield (kg/ha)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replication	2	7050.	3525.	0.05	
Variety	2	951484.	475742.	6.36	0.057
Residual	4	299190.	74797.	1.43	
Nitrogen source	3	9000098.	3000033.	57.42	<.001
Variety x Nitrogen source	6	913101.	152184.	2.91	0.036
Residual	18	940465.	52248.		
Total	35	12111387.			

ANOVA for dry leaf yield (kg/ha)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replication	2	22494.	11247.	0.39	
Variety	2	320811.	160405.	5.63	0.069
Residual	4	114010.	28503.	2.50	
Nitrogen source	3	500262.	166754.	14.62	<.001
Variety x Nitrogen source	6	112358.	18726.	1.64	0.193
Residual	18	205308.	11406.		
Total	35	1275243.			

ANOVA for leaf moisture (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replication	2	25.93	12.96	1.29	
Variety	2	121.10	60.55	6.03	0.062
Residual	4	40.15	10.04	0.51	
Nitrogen source	3	334.95	111.65	5.73	0.006
Variety x Nitrogen source	6	322.10	53.68	2.75	0.045
Residual	18	351.01	19.50		
Total	35	1195.25			

ANOVA for leaf crude protein (%)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replication	2	23.280	11.640	1.19	
Variety	2	4.594	2.297	0.23	0.801
Residual	4	39.226	9.806	1.81	
Nitrogen source	3	1737.597	579.199	106.75	<.001
Variety x Nitrogen	6	12.706	2.118	0.39	0.876
Residual	18	97.663	5.426		
Total	35	1915.065			