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RESEARCH ARTICLE

Mulberry and Silk Production in Kenya

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Abstract

Mulberry is a plant that is grown for silkworm rearing. It is the exclusive food for the silkworm, which during its larval life is reared for silk production. Mulberry forms the basic food material for silkworms. Production of mulberry leaves on scientific lines is essential for organizing sericulture on sound economic lines. It is estimated that one metric ton of mulberry leaves is necessary for the rearing of silkworms emerging out of one case of eggs which will yield about 25kg to 30kg of cocoons of high quality. The findings show that mulberry plant can grow and thrive very well in Kenya because of very good climatic conditions that are favorable for mulberry plant. It is worth nothing however that mulberry tree can grow in a variety of climatic conditions. As a result of successful production of mulberry, silk production training is needed for skilled labour in mulberry growing and silk worm rearing in these high production areas of the country with similar climatic condition to the experimental area of Eldoret. Sericulture has the potential of poverty eradication and economic empowerment especially for women and youth in Kenya because it is a labour intensive venture. Silk production has the potential of serving as a supplement to the textile industry in Kenya due to the the dwindling cotton production. Despite the fact that the sericulture has been going on in Kenya for more than 45 years, there has been several challenges that has crippled the success of sericulture. The major bottleneck is the lack of domestic demand for the finished products due to unclear goals in quality and minimal product awareness, lack of well established government policies and lack of capacity and insufficient technical skills on mulberry and silkworm rearing. The study recommends that proper agronomical practices should be used to increase yield, intensive research is required on the available species of mulberry in Kenya. As a result of successful production of mulberry, training is needed for skilled labour in mulberry growing and silk worm rearing for high production.

INTRODUCTION

Historical evidence show that silk was discovered in China and from there it spread to other parts of the world. The earliest evidence is in the chronicles of Chou_King (2200 B. C), where silk featured prominently in public ceremonies as a symbol of homage for the emperor. First it was kept as secret within China due to jealousy but when commercial relations was established between China and Persia and later to other countries, export of raw silk extended up to southern Europe. First to learn the secret was Korea and then Japan. War was instrumental in the spread of the silk industry especially to Japan when Semiramus, a general in the army of empress Singu_kongo invaded and conquered Korea. The other factor for the spread of the industry was migration. During the latter part of 19th century, Japan gave a serious attention to the silk industry, introducing the use of processing machinery and improved techniques and carrying out intensive research in sericulture. In Indian silkworms were first domesticated in the foothills of the Himalayas. When the British came to India they established flourishing silk trade through the British East India Company. Sericulture spread over the century from China to other parts of the country and silk became a precious commodity highly sought after (Krishnaswami *et al.*, 1973; Veda *et al.*, 1997).

In Kenya, introduction of sericulture was a joint venture between experts of the Overseas Technical Co-operation Agency (OTCA) from Japan and the Ministry of Agriculture of Kenya in 1974. The first task was to establish a mulberry cultivation orchard at National Horticultural Research Centre (NHRC) in Thika. In order to establish this task, preliminary research to identify indigenous mulberry cultivars was undertaken. Some high yielding cultivars were imported from India and Japan in order to assess their performance in Kenyan climatic conditions.

In 1996, the International Centre of Insect Physiology and Ecology (ICIPE), an advanced research institute situated in Nairobi, opened a sericulture unit under its commercial insects programme. The unit is developing innovative sericulture technologies geared enhancing the productivity and economic returns of small-scale land users. The unit has laid emphasis on the conservation and utilization of wild silk moth rearing of the domesticated silkworm for raw silk production. The unit has successfully developed a new domestic silkworm hybrid, which flourishes in the African environment and produces high quality silk. The unit has also developed a full package of silk technology from mulberry cultivation to weaving.

1. Sericulture

Sericulture, or the raising of silkworms to produce silk, involves the incubation of the tiny eggs of the silkworm moth until they hatch and become worms. Basically laying of eggs by the moths is done on special kind of cards, which specifically act as a surface for hatching of the eggs. The process of transferring the newly hatched silkworms to rearing trays is called “brushing”. In order to obtain uniform hatching, eggs are kept in black boxes on the day prior to hatching. In this way, the early maturing embryos are prevented from maturing and the late maturing embryos are given time to develop and catch up with the early maturing ones. The next day they are exposed suddenly to diffused light so that the larvae hatch uniformly in response to phototropic stimulus (Rao, 1998).

After hatching, the worms are placed under a layer of gauze. For six weeks, the worms eat finely chopped mulberry leaves almost continuously. At the end of this period, they are ready to spin their cocoons, and branches of trees or shrubs are placed in their rearing houses. The worms climb these branches and make their cocoons in one continuous thread, taking about 8 - 14 days for the process. The amount of usable silk in each cocoon is small, and about 5,500 silkworms are required to produce 1 kg of raw silk.

After the complete cocoons have been gathered, the initial step in silk manufacture is to kill the insects inside them. Thus, the cocoons are first boiled or treated in ovens, killing the insects by heat. The silk fiber is obtained from the cocoons by a delicate process known as reeling.

The cocoons are first harvested. Timing is very important in that early harvesting will produce very delicate cocoon, which can easily rapture when disturbed. On the other hand, late harvesting might lead to the emergence of the moth thus destroying the cocoon as well as the filament. After harvesting the cocoons are selected according to colour, size, fibre diameter, and even uniformity of the cocoon. All these determine cocoon quality where by the bigger and the more uniform the cocoon the better. Also the thinner the fibre, the better.

The properties of silk produced by a given cocoon (from the outer to the inner) varies as shown in Table 1.

The cocoons are then heated in boiling water to dissolve the gummy substance that holds the cocoon filament in place. After this heating, the filaments from four to eight cocoons are joined and twisted and are then combined with a number of other similarly twisted filaments to make a thread that is wound on a reel. When each cocoon is unwound, it is replaced with another cocoon. The resulting thread, called raw silk, usually consists of 48 individual silk fibres. The thread is continuous and, unlike the threads spun from other natural fibres, such as cotton and wool, is made up of extremely long fibres.

The overall efficiency in sericulture is linked to the best management of the conversion of leaf to cocoon. Leaf to cocoon ratio indicates the amount of leaf required to produce 1 kg of cocoon. The ratio 20 is recommended, although, 16 and 18 are also accepted. Sericulture is quite different from other types of farming activities in that it has a chain of interrelated and interdependent stages. It involves three distinct phases of activity namely: mulberry cultivation, silkworm rearing and silk reeling.

2. Silkworm Seed Production

The most important step in silkworm rearing is the production of silkworm eggs required for rearing. The silkworm eggs or seeds required for commercial rearing should be of high quality and free from diseases.

3.1 Reproductive Seeds

Reproductive eggs or seeds are those intended for producing the seed cocoons, which are required in large numbers for producing commercial hybrid eggs or industrial seeds. These pure lines are difficult to rear and so special care must be taken and ideal rearing conditions provided.

3.2 Industrial Seeds

Industrial seeds are generally specific hybrids between two or more pure lines or race of silkworms and are reared by the Seri culturists for producing cocoons on a commercial scale for reeling purposes. There are four kinds of natural silk, which are commercially known and produced. Mulberry is the most important and contributes as much as 95% of world production, therefore, the term 'silk' generally refers to the silk of the mulberry silkworm. The other 3 kinds of silk apart from mulberry silk are:

- Eri silk _ is produced by eri silkworms, which are reared on castor oil plant leaves to produce white or brick red silk called eri silk.
- Tasar silk - is produced by tasar silkworms, which are reared on oak leaves and allied species to produce green silk thread called tasar silk.
- Muga silk - is produced by muga silkworm, which are reared on som (machilus bombycina), to produce an unusual lustrous golden - yellow silk thread, which is very attractive and strong. These are only found in the state of Assam.

These are non-mulberry silks.
The insect producing mulberry silk belongs to a domesticated variety of silkworm referred to as the mulberry silkworms. The silkworm is reared under human care because;

a) Its grasping power is weak, so it can hardly climb a tree, twig or a leaf of a tree; it is shaken off by even gentle breeze.
b) It has no crawling power. When there is no food in its neighbourhood, it will not be able to crawl and may starve to death. Silkworm can only move a few centimeters around itself however hungry.
c) It has a weak sense of smell such that mulberry one meter away will be too far.

With all these weaknesses, it becomes a necessity that food (mulberry leaves), has to be brought close to the silkworm. They belong to the species bomyx mori. The mulberry silkworm may be further identified as:
They belong to the species bomyx mori. The mulberry silkworm may be further identified as:

- ✓ Univoltine, bivoltine and multivoltine, depending on the number of generations produced in a year under natural conditions.
- ✓ Trimoulters, tetramoulters, and pentamoulters depending on the number of moults during larval growth, or
- ✓ As Japanese, Chinese, European or Indian origin, based on geographical distribution.

4 Mulberry Tree

4.1 Characteristics

As said earlier, mulberry tree leaves is the exclusive food for silkworm, where the leaf of white mulberry, *morus Alba* is used. Production of mulberry leaves on scientific lines is essential for organizing sericulture on sound economic lines. It is estimated that one metric ton of mulberry leaves is necessary for the rearing of silkworms emerging out of one case of eggs which will yield about 25kg to 30kg of cocoons of high quality.

This plant has been cultivated in china for centuries and has been successfully adapted in other regions. It is a woody flowering deco plant, belonging to the latex bearing woody plants, among the fig and marijuana plant. The tree normally spread in the in the tropics and bears small clusters of seeds red, black, or white, termed mulberries according to the colour of the fruits. Black mulberry bears large dark purple fruit, which looks like a long, slender blackberry. The red mulberry produces red very soft fruits while the white mulberry is the one used for silk rearing. Mulberries make up the family *moraceae* and order *urticales*. The representative genus is *morus*. The red mulberry is classified as *morus rubra*, the Texas mulberry as *morus microphylla*, and the white mulberry as *morus alba*

4.2 Mulberry tree propegation

Mulberry trees are cheap and easy to propagate. They are very easy to transplant and the tree grows rapidly. They are perennial and their pest immunity is comparatively more dependable than a tree that has just come from the forest, Baig (1996).

4.3 Uses of Mulberry

Mulberry trees have a wide variety of uses. It is mainly used in silkworm rearing as their major food. The fruits are used as pigs' food. Left over mulberry leaves are used as cattle feed, not used as substitute for other forms of fodder, but even to increase milk production. The leaves can also be used as a vitamin supplement in the in the diets of poultry and can improve egg production.

Mulberry bark can be made into paper pulp and used in the paper making industry. The bark can also be used as a treatment for worms or as a purgative. The frits can be cooked into squashes, jams, jellies, and pickles. Mulberry roots are used in dyeing, tanning, and colouring processes. The berries can also be used for ornamental purposes. Mulberry wood is resilient, shock resistant and tough. Therefore, they can be crafted into hockey sticks and racquets for tennis, badminton and squash. The sticks are used on fences, or woven into baskets and silkworm rearing trays.

4.4 Mulberry Agronomy in Kenya.

According to Kariaga (1992) due to favourable climatic conditions in Kenya, mulberry is mostly cultivated under rain fed conditions. A number of mulberry cultivars (local and imported) have been under study since 1979.

This has medium heart-shaped and smooth light green leaves. It roots easily and it is fairly drought resistant. It is suitable for both silkworm rearing and berry production.

In sericulture development project, the morus Alba ex-Thika variety is the one used for silkworm rearing.

Cultivars imported from Japan are two, namely wasemindori ex- Japan and ichinose ex – Japan. The only cultivars imported from a tropical country is morus alba var kanva ex – India. A number of mulberry cultivars (local and imported) have been under study since 1979. In Kenya, there are four locally adapted varieties, which are:

- Morus Alba Ex-Embu: this is characterized by short internodes, reddish bark, small size and high drought-resistance.
- Morus Alba Ex-Thika: this has large light green leaves, long internodes whitish bark and it is fairly drought-resistance.
- Morus Alba Ex-Limuru: it has small finger-shaped deeply serrated le3aves.it has very thin short internodes. It is a heavy berry producer. It is not recommended for silkworm rearing and is only recommended for berry production.
- Morus Alba Ex-Ithanga. This has medium heart-shaped and smooth light green leaves. It roots easily and it is fairly drought resistant. It is suitable for both silkworm rearing and berry production.

In sericulture development project, the morus Alba ex-Thika variety is the one used for silkworm rearing.

4.4.1 Conditions for Mulberry Growing

4.4.1.1 Land Scape

Mulberry grows well in flat fertile land, however if the slope is below 15%, it can be established in rows along the contour, where as in steeper slopes (15% - 30%), the terrace system is adopted preferably on a single row. Very steep land has higher soil erosion rate, which imply that the nutrients are lacking. Furthermore, plant anchorage is also weak.

4.4.1.2 Altitude

An elevation up to 700m above mean sea level is considered suitable for growth of mulberry. High altitude, where frost is likely to occur is unsuitable for mulberry growth.

4.4.1.3 Soils

4.4.1.3.1 Importance of soils to plants

Root systems usually comprise of no more than a quarter of the seed plant, but the roots are so finely divided that frequently they occupy a mass of greater than the volume of atmosphere occupied by the shoot. The result is tremendous amount of surface contact between soil and plant, which shows the plant's dependant upon the soil for anchorage, water and nutrients. Soil types affects plants in many aspects like:

- Ability of seeds to germinate
- Size and erectness of the plant
- Vigour of the vegetative organs
- Woodiness of the stem.
- Depth of root systems.
- Amount of pubescence.
- Susceptibly to drought, pest, diseases,
- Rate of growth, yield,

Sufficient growth of mulberry is subject to not only full growth of roots but also to the conditions required for growth, i.e. condition and composition of the soil in connection with absorption of water and fertilizer. Quality of soil of mulberry field does not only dominate growth and yield of mulberry but also quality of leaf, rearing conditions of silkworm and thus yield of cocoon and also its quality. Mulberry requires deep, friable, well drained aerated rich soil of good water holding capacity, and should be at least 50cm deep. Under soils, the following factors are considered:

- Soil fertility
- Depth and nature of profile
- Soil texture
- Soil pH
- Temperature of soil
- Soil moisture

4.4.1.3.2 Soil fertility

Soil fertility is defined as the ability of soil to provide physical conditions favourable for root growth, and to supply enough water and nutrients to enable the crop to produce the most out of the environmental features of a site. Soil fertility is the most important factor in determining the yield as well as the quality of leaves produced. The major factors entailed in soil fertility are:

- Organic content
- Soil reaction and
- Availability of major and micronutrients.

4.4.1.3.3 Depth and nature of profile

Very shallow soils are unproductive since they provide little root room for crop anchorage and extraction of nutrients and water and they are usually waterlogged or hold too little moisture. Soil depth good for mulberry growth should be at least 50cm deep. This is because mulberry is a perennial crop and can root up to 4.5m –6.0m where there is profound dry season.

4.4.1.3.4 Soil texture

Soil texture is defined as the coarseness or fineness of the soil particles. Soil texture is classified on the basis if equivalent spherical diameter. This is a system adopted by International Society of Soil Science, and texture classification is as shown in Table 2:

Mulberry requires clayey loam sandy soils for proper growth. Mulberry requires an average of 50mm of water once in 10 days in the case of loamy soils and same amount in 15 days in case of clay soils. To produce high yields, soils need to be well structured and accept water and rainfall without crusting, eroding or stupping. It should also hold moisture at reasonable levels.

4.4.1.3.5 pH of soil

Effect of pH on the plant is generally determined by the plant's root morphology. Acidity and alkalinity of the soil should be in an acceptable range. Slightly acidic soils of pH 6.2 – 6.8 are ideal for good growth of mulberry. Highly alkaline soils can be rectified by application of gypsum or sulphur and too acidic soils by applying lime. Table 3 below shows a ready reckoner for reclamation of acidic or alkaline soils. The quantity is given in tonnes per hectare.

4.4.1.3.6 Soil temperature

Growth of plants is greatly affected by soil temperature. When soils are moist, temperature is usually the dominant factor in determining the rate of germination and growth. This is because this temperature influences the root growth as well as the rate at which they take up nutrients and water, which further influences development and leaf expansion and consequently mulberry leaves yield. Recommended temperature for mulberry tree growth is 230C to 300C. Rate of water uptake is directly proportion to water uptake. Very high temperatures will kill the plant as well as very low temperatures. Soil temperature is normally affected by the organic matter present in the soil – they increase specific heat (due to microbial reactions) thus increase the soil temperature. It is also worth nothing that dark soils absorb more heat than light coloured soils, thus the dark soils have higher temperatures.

4.4.1.3.7 Soil moisture content.

The moisture content is a very important factor in determining the growth of plants. The maximum amount of capillary or hygroscopic water a particular soil can hold are determined chiefly by the kind and sizes of soil particles as well as the organic matter.

Therefore mulberry grows well on well-drained soils with an average of 50mm of water once in 10 days in the case of loamy soils and same amount in 15 days in case of clayey soils. Generally finer soils can hold more water than course soils. Soil moisture content most suitable for full growth of mulberry is 50 – 60% (in weight) of the maximum water – holding capacity of the soil.

Table 4, shows water content of major soils used for mulberry cultivation. Mulberry is largely influenced by the condition of moisture distribution in the soil, partly because mulberry needs more water for its growth than the water content in its own.

4.4.1.4 Water Factor

Water is a major factor for the proper growth of any plant. Though fairly resistant to drought, mulberry tree requires adequate amount of water for its growth and yield.

4.4.1.4.1 Importance of water to plants

In the physiology of plants, water is of paramount importance in many ways. As the closest approximation of a universal solvent, it dissolves all minerals contained in the soil. It is a medium by which solutes enter the plant and move about through the tissues. By permitting solution and ionisation within the plant it greatly enhances the chemical reactivity of both simple and elaborated compounds. It is a raw material in photosynthesis. It is essential for the maintenance of turgidity without which cells cannot function actively, and indeed it is necessary for the mere passive existence of the protoplasm.

4.4.1.5 Atmospheric moisture

This is the invisible water – vapour content in the air. It is usually expressed as % relative humidity. Temperature is a more important factor in determining relative humidity. Warm air can hold more water than cold air. For proper mulberry tree growth, the relative humidity 70% - 75%.

4.4.1.6 Effect on intensity of solar radiation

Solar radiation is the propagation of solar energy through space. It implies the transmission of heat, light, and other rays from the sun to the earth's surface. Water in the atmosphere intercepts this energy before it reaches the surface of the plant. Strong sunlight causes excessive transpiration on the plant and might, in severe cases cause wilting and improper growth of mulberry tree. On the other hand, inadequacy of sunlight and heat under shade causes improper photosynthesis.

4.4.1.7 Rainfall

Rainfall if the main source of soil moisture for plants. Although all soil moisture is derived from precipitation, not all precipitation is equally effective in increasing soil moisture. The slower and more gentle the showers, the higher the percentage of water that soaks in the soil in relation to that lost as run off. The greater the quantity of water that falling during any one rainy period, the more it sinks below reach of surface desiccation. Efficiency of precipitation as a source of soil moisture for plants is best measured by direct studies of the degree of penetration and duration of moisture in the soil. Mulberry tree requires average rainfall of over 800 mm per annum.

4.4.1.8 Temperature Factor

There is relatively little biologic activity below 0oC or above 50oC. Mulberry grows at temperatures between 23oC and 30oC. Optimum temperature for germination of mulberry seed is 330C – 370C at maximum and 120C – 130C at minimum.

4.4.1.9 Fertilizer for Mulberry

Components of manure required for mulberry cultivation are the same as those required for plants in general, however amount to be supplied is considerably different. Mulberry is a woody plant, and unlike annual herbaceous plants, it absorbs and utilizes fertilizer in a different way and also unlike other woody plants, such as fruit trees it is cultivate for harvest of leaves. Though for the purpose of harvesting leaves, unlike tea trees, in mulberry culture, most of the part above the earth is cut off for harvest.

Chopudhury and Giridhar (1996) states that yield of mulberry leaves is strongly influenced by amount of nitrogenous fertilizer. No nitrogenous fertilizer for mulberry means no manure at all. Meanwhile the yield is reduced by about 10% if there is no phosphoric acid fertilizer. Potassium fertilizers scarcely influence the yield. This might differ a bit according to soils. It is very important to calculate the exact amount if fertilizer for mulberry field. Proper quantity of fertilizer would be different according to the target of mulberry yield, soil character, climate, training method, type of fertilizer etc. theoretically speaking, the amount of component to be supplied as fertilizer is the amount of components taken away as harvest from the field, added with the amount of components required for growth of roots minus the amount of natural supply. Ratio of components to be absorbed by mulberry is different according to each component of fertilizer, and the amount of component to be supplied as fertilizer must be calculated from the absorption rate of the manure component. The above is expressed by the following formula.

$$\textit{Amount of fertilizer} = (CH + CG - CN) * 100 / R$$

$$\textit{Absorption rate of manure or fertilizer components} = (CH_f - CH_{F0}) / CS$$

Where,

- CH – amount of components in harvest
- CG – amount of components required for growth
- CN – amount of components naturally supplied
- R – absorption rate of manure components
- CS – amount of components of manure supplied
- CH_F – amount of components in harvest with fertilization
- CH_{F0} – amount of components in harvest without fertilization

The ultimate object of mulberry cultivation is to increase the yield of mulberry leaf as the food for silkworm at the same time maintaining the good quality of leaf. It is necessary to apply fertilizer separately to mulberry for young silkworm food leaves. The quality of mulberry for young silkworm is closely related to the health of the silkworm, and the quality of mulberry for old age worms largely influences the quality of cocoon.

5 Silk

Silk is the solidified viscous liquid excreted from special glands or orifices by a number of insects and spiders. The only significant source of silk for textile usage is the silkworm larva, known as the silk moth from the two glands on either side of their body. Silk is available for textile use both as continuous filament yarn and staple yarn. The filament range from 300 – 1200 meters in length. It is a polymer in which the principal amino acid constituents are, glycine, serine, alanine, and tyrosine.

5.1 Chemical Structure

Silk is composed of long chains of amino acids, mostly, glycine, and alanine are the main components, joined by peptide links with hydrogen bonding between parallel chains.

5.2 Composition of Raw Silk

Besides sericin and fibroin, raw silk contains small quantities of mineral matter, traces of fat, colouring matter and water in the compositions shown in Table 6.

5.3 Physical Properties

Silk is strong with a tensile strength of 0.34 N/Tex – 0.390.34 N/Tex and an elongation at break of 20 % -30%. It has a good natural crease resistance due to its good resilience and it recovers readily from deformation.

Silk is a highly hygroscopic fibre with moisture regain of 10% - 15%. It is a poor conductor of heat and electricity. It characterized with lightweight, warmth and good drapability.

It is a smooth translucent fibber with a triangular cross section. Continuous filament silk has a high lustre that contributes to its aura of luxury.

5.4 Chemical Properties

Silk is readily soluble in cold concentrated mineral acids. Nitric acid even in the most dilute form causes yellow discoloration. Cold concentrated solutions of caustic alkalis appear to have no effect when in contact with silk for a short time. Concentrated solutions of zinc chloride dissolve silk. Sodium chloride ha no effect when exposed for a shorter time.

5.5 Fibre Identification

Silk has very high lustre. It can be microscopically identified by observing the cross section. It has a triangular cross section. Silk is the only protein fibre that has no scales. Further identification is by dissolving silk in 59.5% - 70% sulphuric acid. This solution dissolves it. See appendix H for the appearance of different silks.

6 Data Collection, Results and Analysis.

6.1 Data Collection

The growth of mulberry was propagated in an experimental situation at Moi University farm. Observation was carried out and the stages of sprouting and it development and elongation was measured. Table 7 shows the growth.

6.2 Results

Table 1. Silk quality according position in cocoon

Description	Near outer	Middle	Near inner
Diameter of fibres (microns)	32	28	36
Elasticity (%)	13.3	24.3	24.7

Breaking load (g)	6.25	10.2	9.0

Table 2: Classification of soil according to texture

S/No.	Classification	Diameter (mm)
1	Course sand	2.0 – 0.2
2	Fine sand	0.2 – 0.02
3	Silt	0.02 – 0.002
4	Clay	Less than 0.002

Table 3: Dosage for reclamation of acidity or alkalinity of soil

S/No.	PH range	Limestone (tonnes per hectare	Gypsum (tonnes per hectare
1	3.5	12.5	-
2	4.5	8.75	-
3	5.5	5.0	-
4	7.4 – 7.8	-	2.0
5	7.9 – 8.4	-	5.0
6	8.5 – 9.0	-	9.0
7	9.1 and above	-	14.0

Table 5: Water content of soil

S/No.	Soil	Sandy loam	Loam	Clay
1	By weight%	48	56	61
2	By volume%	70	75	80

Table 6: Composition of raw silk

S/No.	Component	Amount (%)
1	Sericin	15 – 25
2	Fibroin	62.5 – 67
3	Water	10 – 11
4	Salts	1 – 1.5

Table 7: Growth of Mulberry propagated by cuttings

Cutting number	Days after planting												
1	14	S	20	S	23	S	26	S	29	S	32	S	35
2		1	√	2	√	3	√	D	√	D	√	D	√
3		1	√	2	√	3	√	D	√	D	√	D	√
4					√	1	√	2	√	3	√	D	√
5		1	√	2	√	3	√	D	√	D	√	D	√
6	√	2	√	3	√	D	√	D	√	D	√	D	√
7					√	1	√	2	√	3	√	D	√
8							√	1	√	2	√	3	√
9					√	1	√	2	√	3	√	D	√
10					√	1	√	2	√	3	√	D	√
11							√	1	√	2	√	3	√
12			√	1	√	2	√	3	√	D	√	D	√
13							√	1	√	2	√	3	√

Where:

- S – stage of sprout
- D – development and elongation

Figure 1: The growth of mulberry was measured as it shoots and length in centimeters represented against time

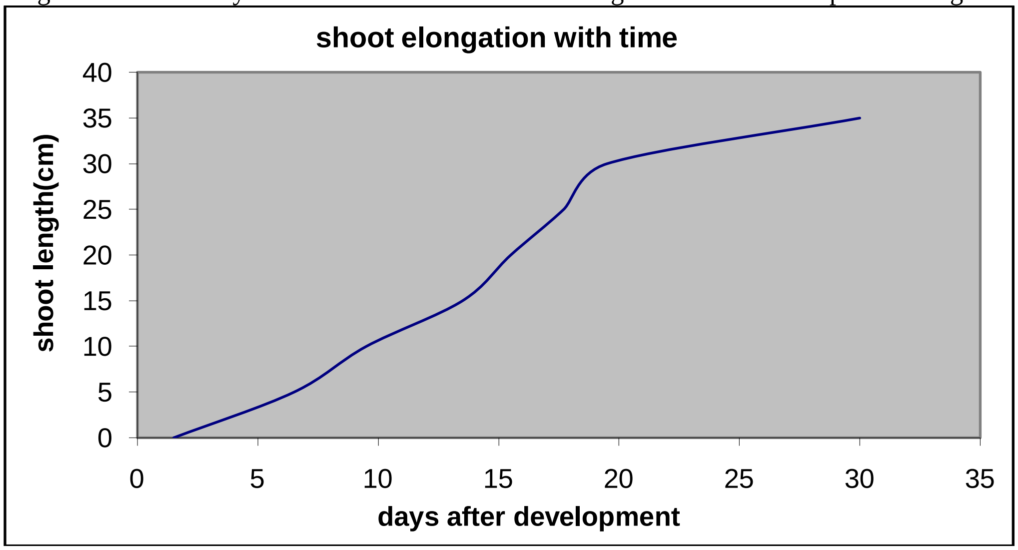

Figure 1: Graph of shoot elongation with time

6.2.1 Mulberry Tree Growth

Growth of a plant or an organ is ultimately the net result of the growth of the cells, which the plants meristematic regions are composed. There are three phases of plant growth namely; cell formation, the cell enlargement and the cell maturation. All the cells of plants are derived ultimately from the apical meristems and before maturation each cell must undergo the three phases.

Growth is confined to certain regions or growing points, which consist of meristematic cell, which are capable of cell division and giving rise to new cells. Such important cells are found at the stems and roots and are thus referred to as the apical meristems. Their activity results in primary growth i.e. the formation of the primary structure of the plant. They are responsible for all the increase in the length of the plant axis at both the stem and the roots ends for the production of stem and root appendages like root hairs, leaves and flowering part. In some cases, growth also occurs by the activity of intercalary meristems, which occur at the base of the internodes, node or at the leaf base.

The formation of new cell wall is soon followed by their enlargement. The young cell absorbs water and nutrients and as a result turgor pressure is set up and the extensible cell wall stretches. The stretching of the cell wall is made permanent by the addition of new cell wall material to the original wall, which consequently becomes thicker and still capable of further extension. In the apical meristems the maximum enlargement of the cell takes place on the side of the free apex and hence the stem and the root elongates.

The last phase of growth is the development and maturation stage. It involves the progressive transformation of the simple uniform cells with general functions into complex and diverse types, each with specialized function e.g. leaf develops from simple primary to complex mature organ. The cell wall begins to thicken on account of deposition of cellulose without stretching. It then undergoes differentiation (chemical transformation, deposition of lignin and suberin, and other complex transformations). Once differentiated the cells remain unchanged so long as they exist. During the maturation phase, assimilation of carbohydrates is very active and the assimilation of proteins is almost insignificant.

6.2.2 Stages of growth of mulberry tree

For the project, mulberry was propagated by cuttings. Each cutting had at least 3 buds. On planting only one bud was left exposed. The buds had 7 – 8 scales along their circumference and contain leaves inside.

The first stage of growth was the sprouting of the buds. The first buds sprout occurred after 14 days and the rest followed. The earliest time for sprouting was found to be 14 days. A total of 13 out of 18 buds sprouted

successfully. Sprouting of the buds was in three stages. The first stage was the period when the tip of the leaf appeared at the scale. The second stage was the period when a few leaves grew out of the scale and clustered together, and the third stage was the period when leaf blades appeared outside the scale and the petiole could be seen. All these occurred in a minimum of 21 days.
These sprouting stages maybe called development stage, the assimilation stage and the nutrition storing stage. The development is the initial stage and was when the branches and leaves are fostered using the stored nutrition. In the assimilation stage, the branches and leaves are fully fostered and absorbed nutrients are used to the maximum. In the last stage, the development is reduced with elongating growth checked, and nutrition assimilated in the in the leaves is transferred to the branches and roots and stored.

7 Conclusion and Recommendation

It is evident in this research that mulberry plant can grow very well in Kenyan because of the favourable climatic conditions and good environment. Kenya has the least requirements of mulberry agronomy, which are soil and rainfall. Proper fertilization or rooting chemicals were used to enable the plant to grow successfully.

It is worth noting however that mulberry tree can grow in a variety of climatic conditions. Its growth is not restricted to specific type of climate as long as there is plenty of rain. What will vary will be the yield.

It is therefore recommended that:

- ✓ The cultivation of mulberry plants is possible in Eldoret in preparation of rearing silkworms. Moi University which formed the bulk of experimental area could create suitable a research centre for sericulture.
- ✓ Proper agronomical practices should be used to increase yield as well as the quality of leaves. Pruning and thinning should be practiced appropriately. These highly increase yield of leaves.
- ✓ Further research is required on the available species of mulberry in Kenya.
- ✓ As a result of successful production of mulberry, silk production is possible
- ✓ Training is needed for skilled labour in mulberry growing and silk worm rearing in these high production areas of the country with similar climate to the experimental area of Eldoret.

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