Screening of some promising temperate Mulberry (*Morus* spp.) cultivars on the basis of their rooting behaviour using different media and growing conditions

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Javid Ahmed Najar
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Thesis
Submitted to
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in partial fulfillment of requirement for the award of the degree of

Master of Science in Sericulture

2005

DEDICATED TO

MY BELOVED

PARENTS

Sher-e-Kashmir
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Certificate – I

This is to certify that the thesis entitled. "**Screening of some promising temperate Mulberry (*Morus* spp.) cultivars on the basis of their rooting behaviour using different media and growing conditions"** submitted in partial fulfillment of the requirements for the award of the degree of **Master of Science in Sericulture,** to the **Faculty of Post-graduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir** is a record of bonafide research work carried out by **Mr. Javid Ahmed Najar (Regd. No. 2001-S-9-M)** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

It is further certified that information received during the course of investigation has duly been acknowledged.

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We, the members of the Advisory Committee of **Mr. Javid Ahmed Najar (Regd. No. 2001-S-9-M),** a candidate for the degree of **Master of Science in Sericulture** have gone through the manuscript of the thesis entitled, "**Screening of some promising temperate Mulberry (*Morus* spp.) cultivars on the basis of their rooting behaviour using different media and growing conditions"** and recommend that it may be submitted by the student in partial fulfillment of the requirements for the award of the degree.

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This is to certify that the thesis entitled "**Screening of some promising temperate Mulberry (*Morus* spp.) cultivars on the basis of their rooting behaviour using different media and growing conditions"** submitted by **Mr. Javid Ahmed Najar (Regd. No. 2001-S-9-M)** to the **Faculty of Post –graduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir** in partial fulfillment of the requirements for the award of the degree of **Master of Science in Sericulture** was examined and approved by the Advisory Committee and External Examiner on ....

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ABSTRACT

An investigation on the rooting behaviour of some temperate mulberry (*Morus* spp.) cultivars using different position of shoot, media and growing conditions was undertaken in the Division of Sericulture, Mirgund during 2002. The experiment was conducted to study the rooting behaviour of six mulberry cultivars viz; Limoncina, Kokuso-20, Kairyoroso, Francee, KNG and Chinese White (check). The study revealed that basal cuttings grown in sand media significantly improved rooting under polyhouse compared to middle and apical. Highest rooting of 93.33% was recorded from basal cutting of Limoncina under polyhouse condition, which excelled in most of the root and shoot characters. The rooting was 83.33, 80 and 73.33 per cent in Chinese white, Francee and Kokuso-20 cultivars respectively. Further, sand and soil media under polyhouse proved better than soil alone in improving rooting, while sand media performed better in improving root characters viz; average number of primary roots (8.03), length of the primary root (21.74 cm) and biomass underground (1.45 g). Sand and soil growing media also significantly improved shoot characters viz; average number of leaves (23.13), height of sapling (33.00 cm) and biomass upperground (30.76 g). Among the tested cultivars Limoncina and Francee were found superior over other varieties in most of the root and shoot characters in both the experiments.

Key words: Cuttings, Media ,Mulberry, Rooting and Shoot position

Signature of Student   Signature of Major Advisor
Dated________________

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Chapter-1

INTRODUCTION

Sericulture is an agro-industry comprising cultivation of mulberry (*Morus* spp.), rearing of silkworms (*Bombyx mori*. L.) and reeling of silk. Sericulture plays a vital role in the improvement of rural economy due to its employment generating potential, higher profitability and relatively shorter gestation period than other crops. In tropical areas of India where sericulture is being practised throughout the year with four to six total crops, one hectare of mulberry garden generates remunerative employment to 12-13 persons throughout the year (Jolly, 1987). In the State of Jammu and Kashmir silkworm rearing is being carried commercially during spring season only, however, there is considerable scope for its commercial rearing during summer and early autumn also. Currently the domestic demand for silk, all varieties put together, is nearly 24,500 MT, of which only around 64 per cent (15,742 MT) is produced in the country and the rest is being imported mainly from China (Anonymous, 2005a). Due to changing global silk scenario and demand for quality bivoltine silk at international market, efforts are already on in tropical areas of India to popularize production of quality bio-voltine silk (Datta, 2001). Jammu and Kashmir State is also ideally suited for promoting the production of quality bivoltine silk in the country in view of its favourable agro-climatic conditions. The state has potential of producing 200 MT of bivoltine silk, which has international market and can meet the quality demands of power loom sector and the export-oriented units. There are about twenty five thousand families associated with sericulture industry in the state contributing to the production of 521 MT of cocoons (Anonymous, 2005b).

Profitability of sericulture is interlinked with the productivity of mulberry plants in an unit area over a specific period of time. In sericulture, about 60 per cent cost of production is towards mulberry crop (Misra, 2000). About one metric ton of mulberry leaf is required to produce 25-30 kg of cocoons from one ounce of silkworm seed (Rangaswami *et al.,* 1976). Sericulture has wider scope for female labour employment in general and more particularly, better opportunities for family female labour (Lakshmanan *et al.,* 1999). Tanki *et al.* (2000) in an extensive survey on the share of total work done by men and women in sericulture, covering three sericulture zones of Kashmir viz; South zone (Anantnag and Pulwama), North zone (Baramulla and Kupwara) and Central zone (Srinagar and Budgam) revealed that in South zone 62.91 per cent of share of work is contributed by women and only 37.09 per cent by men, in North zone 64.04 per cent by women and 35.96 per cent only by men, while as in Central zone 56.41 per cent, share is contributed by women in comparison to 43.59 per cent by men.

Kashmir valley having an area of about 1600-2000 miles^2 and ranging in altitude between 5200-6000 ft. above msl (Dhar and Ahsan, 1989), about 5.19 lakh mulberry saplings are grown in tree form every year along roadsides, river bunds and farm boundaries (Anonymous, 2000a). Besides tree plantation, about 0.033 lakh hectares of land is under mulberry cultivation in the state (Anonymous, 1996).

In Kashmir province, the mulberry genotypes which have, over the years, become popular are of Japanese and Italian origin. Mulberry cultivars of Japanese origin have been found good in terms of leaf yield and quality under rainfed conditions of Kashmir (Iyenger and Sumbly, 1976a; Ganayee and Baksh, 1997). In addition, a number of indigenous varieties occur in wild as well as in cultivated form throughout the valley (Munshi *et al.,* 1991).

In Kashmir, mulberry is mainly propagated through root grafts which takes in all, four years to raise plants in the field (Baksh *et al.,* 2000). Some mulberry cultivars popular in Kashmir region do not produce saplings when propagated through stem cuttings (Iyenger and Sumbly, 1976b; Bindroo *et al.,* 1988). The rate of success in root grafting in Kashmir for propagation of some mulberry cultivars of temperate origin is 20-30% only (Baksh and Khan, 2001). Several studies have been conducted in tropical region to find out the rooting potential of different mulberry cultivars (Jolly and Dandin, 1986; Mala *et al.,* 1992 and Sushelamma *et al.,* 1990). Some studies have also been conducted in Kashmir valley to study the rooting potential of existing cultivars (Bindroo *et al.,* 1983; Das *et al.,* 1987; Peer, 2002 and Munshi *et al.,* 2003).

Keeping in view above facts, it is felt exigent that mulberry cultivars existing in Kashmir region be assessed for their rooting potential for propagation through stem cuttings to replace the age old traditional method of propagation through root grafting, which is highly technical, laborious, time consuming and uneconomical rendering sericulture an unfruitful job. For the economical management of sericulture in Kashmir, propagation of mulberry through stem cuttings is gaining importance. As such an investigation was carried out in this direction at Division of Sericulture, Mirgund with the following objectives:

1. To screen out suitable temperate mulberry cultivars on the basis of their rooting behaviour.
2. To study the influence of different media on rooting behaviour of some temperate mulberry cultivars.
3. To locate the suitable portion of the shoot for successful propagation through stem cuttings.

Chapter-2

REVIEW OF LITERATURE

Propagation, a method of perpetuation of crop plants from one generation to the next is perhaps the first step in dawn of agriculture by a prehistoric man. It has been reported that most fundamental consideration in vegetatively cultivated crops is the root initiation and rooting ability (Hartmann, and Kester, 1978). Root is the main organ which is in contact with the soil for absorbing nutrients and water. The development of root system in spread, depth and density controls the utilization of soil resources for plant nutrient supply. Studies on root are extremely important for characterizing different plant genotypes and their general growth pattern to various edaphic and agroclimatic conditions as well as their efficiencies in nutrient and water uptake (Bhat and Hittalmani, 1992). Rooting and sprouting together have a very important role in initial establishment of the mulberry farm. Tropical varieties are reported to be good in rooting, which is an added advantage in sericulture (Dandin and Jolly, 1986). Mala and Basavaiah (1991) reported that efficiency of rooting mainly contributes to the success of any vegetatively propagated crop. Various works have been conducted to find out rooting potential of different mulberry genotypes both in tropical and temperate regions of India (Shanmugavelu, 1975, Mukherjee and Sharma, 1971, Mukherjee and Sikdar 1974 and 1977, Mala *et al.,* 1992, Susheelama *et al.*, 1990 and 1992 and Sujathama and Dandin, 1998). Baksh *et al.*, (2000) while assessing the performance of ten mulberry genotypes under temperate climatic conditions of Kashmir, reported least rooting ability (5.56%) in Goshoerami.

Fotedar *et al.,* (1990) while assessing the rooting ability of Chinese- white and five other Japanese mulberry genotypes under polythene cover, obtained satisfactory results in case of Chinese-white. Similar results were obtained by Baksh *et al.* (2000) in case of Chinese-white which recorded (60.77%) rooting.

Chinese white though a good rooter was found susceptible to fungal diseases compared to Japanese genotypes which are moderately tolerant to such diseases (Munshi *et al.,* 1991 and Baksh *et al.,* 1995a). Satpathy *et al.,* (1995) observed significant variation in survival of 90 and 240 days old cuttings of S_1 and S_{1635} mulberry varieties. Goel *et al.,* (1998) observed wide range of variability in rooting parameters in 150 mulberry varieties (120 indigenous and 30 exotic) and accordingly grouped them as poor (< 50% survival), medium (50-70% survival) and good (>70% survival) rooters. Sujathama and Dandin (1998) in their study on various propagation parameters observed significant differences in respect of rooting among the cuttings of 23 elite mulberry genotypes under Rayalseema region of Andhara Pradesh. Tikadar *et al.,* (1997) recorded rooting percentage of 24.00-80.00 % in ringed cuttings compared to unringed cuttings (4.00-32.00%) in Japanese mulberry variety, Kosen (*Morus latifolia* Poir). Masilamani *et al.,* (2000) observed wide range of variability for various growth parameters in mulberry (*Morus alba* L.) var. Indica when propagated through cuttings. Root induction can be achieved successfully by using requisite quantity of root hormones. The efficiency of the chemical used varies from species to species and from variety to variety. The chemicals generally used are Indole acetic acid, Indole-butyric acid, Naphthalene acetic acid, Gibberallic acid and Seradix-B for different durations and at different concentrations.

Mukherjee and Sharma (1971) while studying the effect of some growth regulators on the rooting of a Japanese variety Kosen, observed optimum rooting and growth under the influence of IAA at 500 mg ml^{-1}. Isa *et al.,* (1993) in an experimental trial on rooting response of *Terminalia arjuna* Bedd. cuttings using different concentrations of three auxins viz; IAA, IBA and NAA recorded maximum rooting response at 1000 ppm concentration in all the three auxins. Baksh *et al.,* (1998) while studying rooting ability of hardwood stem cuttings of three exotic mulberry genotypes observed cent per cent rooting in ACC-68, 95% in ACC-69 and 83% in ACC-65. Tikader *et al.,* (1996) while studying the rooting behaviour of mulberry cuttings at ploidy level, obtained rooting percentage of

71.81 in diploids, 66.07 in triploids and 59.17 in tetraploids. In a mulberry trial conducted on the use of IBA, NAA and 2,4-D to promote rooting of shoot cuttings of mulberry (*Morus alba*) var. S-36, it was reported by Chandersheker *et al.,* (1997) that best treatments were 25 ppm and 50 ppm IBA with 66.3 and 61 per cent survival, respectively compared to untreated cuttings with 23.3 per cent .

Sharma *et al.,* (1994) observed better rooting in cuttings collected in spring than those collected in autumn, also ringed cuttings treated with IAA rooted better than untreated. Baksh *et al.,* (1998) while studying rooting ability of three exotic genotypes ACC-65 (*Morus multicaulis*), ACC-68 (English black) and ACC-69 (Okinowa) recorded survival of 83, 100 and 95 per cent, respectively. Root formation was effectively induced in difficult-to-root mulberry varieties by the use of auxins (Biswas and Sengupta, 1993).

In different experimental trials on the induction of rooting in Japanese varieties, Kosen and Goshoerami, by the use of growth regulators, “Poebder”, was found more effective in improving rooting (Rao and Khan, 1963). Honda (1970) while making comprehensive studies on propagation of mulberry through stem cuttings revealed that NAA and IBA have maximum influence on root induction, followed by IAA.

Mukherjee and Sharma (1971) reported best rooting in Japanese variety Kosen by using different growth regulators. Mulberry variety Rokokoyaso recorded 75% survival when propagated through stem cuttings using seradix-B (Anonymous, 1976).

Studies on propagation of mulberry through stem cuttings under temperate climatic conditions using different growth regulators viz; Gibberalic acid, Indole butyric acid and Naphthalene acetic acid, revealed that Gibberalic acid recorded highest rooting percentage in the cuttings of Goshoerami and Rokokoyaso mulberry varieties (Anonymous, 1978).

Kamili and Shah (1996) in their study revealed that success in rooting of mulberry cuttings under influence of growth regulators varies from species to species and from variety to variety. They further reported that IAA proved better in inducing rooting in Goshoerami variety of mulberry which is the most popular variety of Kashmir. Different experimental trials on the induction of rooting in hardwood cuttings of some temperate mulberry cultivars by the use of growth regulators, revealed that 100 μg ml^{-1} IBA considerably improved rooting in Rokokuyaso, KNG, Ichinose, Goshoerami and Kokuso-27. The study further revealed that IAA at 50 μg ml^{-1} proved effective in Chinese white and NAA was found least effective (Fotedar, 1989 and Fotedar *et al.,* 1990),

While studying the propagation of mulberry under sub-tropical conditions Bindroo *et al.*, (1996) stated that the varietal specificity in terms of regenerative capacity, growth and root induction potential plays a vital role in the propagation of mulberry through stem cuttings.

2.1 Suitable portion of shoot for successful rooting

There is a definite relationship between the maturity of the tissue of a cutting and readiness with which it forms the root. The nutrition factor of the stock plant exerts a strong influence on the development of roots and shoots from cuttings. In order to locate the suitable portion of shoot to be used for propagation through cuttings Kasivishwanathan and Iyenger (1967) in their experiment observed gradual reduction in the mean weight of cuttings from basal end to apical end. They further observed that cuttings obtained from the basal portion of shoot were superior to the cuttings obtained from the top portion of the shoot.

Honda (1972) observed positive correlation between weight of cuttings and weight of newly developed roots. He further observed that there is gradual decrease of rooting ability from basal part to the upper part of a branch. Basu and Gosh (1974) while studying the effect of nitrogen nutrition of the stock plant of *Justicia gendarursa* L. on rooting observed that cuttings with low nitrogen levels produced more number of roots, however, rooting improved considerably when cuttings were treated with Naphthalene acetic acid. Jawanda *et al.,* (1980) in a study aimed to find out the number of active buds required for successful rooting of almond (*Prunus amygdalus* Batsh) cuttings, revealed that cuttings obtained from basal portion of shoot with 3-4 active buds gave higher rooting than cuttings obtained from middle portion of shoot.

Both root and shoot characters of the rooted cuttings differ according to the parts of the shoot from which cuttings are made. Cuttings obtained from basal portion of the shoot exhibited better root and shoot characters.

Nanda and Kochar (1985) attributed the rooting potential of young cuttings to the high nutritional levels and high content of rooting co-factors and growth promoters in them. Besides edapho-climatic conditions, success in vegetative propagation of plants through stem cuttings, type of wood play an important role in rooting and subsequent survival of the cuttings (Hartmann and Kester, 1986). Mala and Basavaiah (1991) in an investigation on the rooting behaviour of cuttings revealed that high carbohydrate content of the cuttings improved rooting and with the increase in carbohydrate content rooting capacity also increases. Rodriguez and Gonzalez (1995) in a comprehensive study on the rooting behaviour of different portions of shoot taken from mulberry cultivar cristiana, observed considerable variation in rooting and subsequent survival of cuttings. Percentage survival was highest in middle portion with 92.5 followed by distal with 83% and basal with 79 per cent. They further reported that percentage survival after transplantation was relatively high in rooted basal cuttings with 76.3 and low in rooted middle and distal cuttings with 25.5 and 12.0 per cent, respectively. Very low nitrogen levels of the cuttings lead to reduced vigor, whereas high levels of nitrogen leads to excessive vigor, either extreme is not good for rooting (Arteca, 1997).

Munshi *et al.*, (2003) while studying the rooting behaviour of difficult to root mulberry cultivars of Kashmir succeeded in inducing rooting in difficult to root Goshoerami cultivar by 59 per cent.

Aleksandrove (1988) in an investigation on the rooting process in ripe mulberry cuttings (*Morus* spp.) cv. kinriu taken from basal, middle and top of one year old overwintered shoots recorded variation in their rooting ability, when cuttings were treated with 0 or 150 ppm. IBA rooted at 30^{o}C.

2.2 Effect of media on rooting of cuttings

The success in stem multiplication of different crops depends upon factors such as condition of mother plant, parts of the tree from where the cuttings are made, time of operation, rainfall, range of temperature, care while planting and after care. Besides these factors, rooting media also play an important role in successful rooting of cuttings.

Honda (1970) succeeded in inducing rooting in semi-softwood and hardwood cuttings of mulberry by hormonal treatments followed by maintaining optimum temperature and moisture level in soil. Nakagawa and Naot (1983) obtained 80-100% sprouting and root initiation in hardwood cuttings of Ichinose variety planted in volcanic ash soils and more than 80% in red-yellow soils. Bindroo *et al.*, (1983) in their study on propagation of mulberry under temperate climatic conditions using cuttings of Goshoerami variety after fifteen hormonal treatments and growing them in beds previously prepared by using soil, sand and farm yard manure in the ratio of 5:2:1 revealed significant differences in rooting amongst the different treatments. Baghel and Saraswat (1988) in an investigation conducted with the objective to evaluate the performance of different rooting media on rooting and growth of hardwood and semi-hardwood cuttings of pomegranate (*Punica granatum* L.) used eight types of rooting media i.e. soil (alone), soil + FYM, soil + sand, soil + saw dust, soil + FYM + sand, soil + FYM + saw dust, soil + FYM + sand + saw dust and river silt. The investigation revealed that river silt was the best media for maximum rooting than other media, while soil + FYM proved superior for most of the shoot and root characters.

Mala and Basavaiah (1991) while studying the effect of media on rooting of hardwood cuttings of mulberry variety S-36 reported that FYM + sand + soil in the ratio of 1:1:1 gave survival of 73 per cent, followed by FYM : sand + soil in the ratio of 1:2:1 with 70 per cent and FYM : sand : soil in the ratio of 1:6:1 with 69 per cent survival.

Rooting media must provide sufficient moisture, oxygen and source of nutrients until a root system is established. The rooting media makes an effect on the percentage of cuttings rooted and on the type of roots formed.

The most effective medium to propagate Som (*Persea bombycina* king ex. Hook. f. Kosterm) food plant of muga silkworm under intermittent mist condition was reported to be soil + sand + FYM in the ratio of 1:1:1. (Yadav and Goswami 1993). Raja Ram and Samson (1995) while studying the effect of age of mother plant on rooting behaviour found that rooting percentage decreased with the age of cuttings, when planted in nursery beds prepared by mixing sand + soil in the ratio 1:2. Highest rooting of 71.85 per cent was recorded in cuttings from two year plants and lowest of 1.48 per cent from twenty year old plants.

Jhon *et al.,* (2000) in an investigation on the effect of two rooting media sand and sand + soil on the rhizogenesis of semi hardwood cuttings of *Rosa hybrida* cv "Forever" recorded rooting percentage of 72.53 in sand and 66.29 in sand + soil. It was further revealed that survival percentage was higher i.e. 72.36 from cuttings raised in sand media over sand + soil. Khan and Sidhu (2002) using different hormones in their study on rooting performance of stem cuttings of shisham (*Dalbergia sisso* Roxb.) planted in polythene bags containing soil, sand and FYM (1:1:1) observed significant variation in rooting due to different treatments. In an investigation carried out by Chakraborti and Mukerjee (1980) it was observed that ringed cuttings gave higher survival rate than un-ringed cuttings.

Chapter-3

MATERIALS AND METHODS

The present investigation on screening of some promising temperate mulberry (*Morus* spp.) cultivars on the basis of their rooting behaviour using different media and growing conditions, was carried out at the experimental farm of Division of Sericulture, Mirgund during 2002. The mulberry cultivars used for investigation were:

a) Limoncina	(*M. alba* Linn.)
b) Kokuso-20	(*M. alba* Linn.)
c) Kairyoroso	(*M. multicaulis*)
d) Francee	(*M. bombycis* Koidz*)*
e) K.N.G	(*M. alba* Linn.)
f) Chinese-white	(*M. alba* Linn.)

3.1 Geographical features

The Division of Sericulture Mirgund is located at 34^o 17′ N latitude and 74^o 17′ longitude, at an elevation of 1585 meter above msl and is situated at a distance of 18 km from Srinagar. The Division is spread over 20 hectares, where field based research work is being carried out related to all the sericulture activities.

3.2 Climate

The climate is temperate cum-Mediterranean and of continental type characterized with marked seasonality. Winter is severe extending from middle of December to mid March, when whole of valley remains covered with snow and temperature often goes below freezing point.

The meteorological data during the year of experimentation are given in Appendix-V.

3.3 Experiment-I

Influence of variety, position of cutting and growing conditions on rooting behaviour.

3.3.1 Experimental details

i) Design	:	C.R.D (Factorial)
ii) Replication	:	03
iii) No. of cuttings/replications	:	10
iv) Treatments	:	03

a) Varieties : 06

i) Limoncina (V_1)

ii) Kokuso-20 (V_2)

iii) Kairyoroso (V_3)

iv) Francee (V_4)

v) K.N.G (V_5)

vi) Chinese-white-check (V_6 as check)

b) Growing conditions : 02

i) Natural (GC_1)

ii) Polyhouse (GC_2)

c) Position of cuttings : 03

i) Basal (L_1) > 1.5 – 2.0 cm diameter

ii) Middle (L_2) 1 – 1.5 cm diameter

iii) Apical (L_3) < 1 cm diameter

d) Treatment combinations : 36

3.3.2 Collection and preparation of cuttings

One year old vigorously growing shoots bearing healthy intact buds were pruned before bud sprouting from six test mulberry varieties maintained in the germplasm bank of the Division. Cuttings of 15 cm length with at least three viable buds were prepared from each of the basal, middle and apical portions of shoots. The cuttings were prepared by giving slant cut on both sides without damaging the bark and splitting the wood. The cuttings prepared were wrapped in moist jute bags to avoid dessication and used as per requirement.

3.3.3 Site and rooting media

The experiment was conducted both under natural and polyhouse conditions at the experimental farm of the Division. Washed coarse sand, free from gravel and soil particles was filled in polybags perforated at the bottom.

3.3.4 Planting and cultural operations

The cuttings prepared were planted in polybags in a slightly slanting position containing the rooting media at a distance of 2.5 cm each from cutting to cutting and row to row, keeping at least one active bud exposed. Rooting media was kept moist by spraying water. One set of cuttings in polybags was kept under natural conditions and another set in polyhouse. The cuttings were maintained by watering as and when required. In polyhouse favourable humidity was maintained by sprinkling water with the help of a spray pump in the form of mist. This was done to avoid drying of cuttings. When cuttings rooted, the polyethylene cover was gradually lifted to about one week time to avoid sudden exposure of the cuttings to drying.

3.4 Experiment-II

Influence of variety, media and growing conditions on rooting behaviour

3.4.1 Experimental details

i) Design	:	C.R.D (Factorial)
ii) Replications	:	03
iii) No. of cuttings/replications	:	10
iv) Treatments	:	03
a) Varieties	**:**	**06**

i) Limoncina (V_1)

ii) Kokuso-20 (V_2)

iii) Kairyoroso (V_3)

iv) Francee (V_4)

v) K.N.G (V_5)

vi) Chinese white (V_6 as check)

b) Growing conditions : 02

i) Natural (GC_1)

ii) Polyhouse (GC_2)

c) Rooting media : 03

i) Sand : (M_1)

ii) Soil : (M_2)

iii) Sand + soil : (M_3)

d) Treatment combinations : 36

3.4.2 Collection and preparation of cuttings

The procedure adopted for collection and preparation of cuttings was same as discussed in 3.3.2 except that cuttings from only basal portion of vigorously growing shoots were taken and planted in polybags.

3.4.3 Site and rooting media

The site of the experiment was same as already discussed at 3.3.3 . Cuttings of 15 cm length were planted in polybags containing three types of rooting media- one set containing sand, second soil and third sand + soil in equal proportion.

3.4.4 Planting and culture operations

The planting of cuttings and cultural operations were carried out in same way as discussed at 3.3.4.

3.5 Bio-metric observations recorded

The following bio-metric observations were recorded after three months of planting the cuttings as suggested by Dandin and Jolly (1986).

3.5.1 Rooting percentage

Ninety days after planting, the rooted cuttings were uprooted gently from the polybags and washed in clean water without damaging the root system. The data on the rooting percentage was calculated on the basis of total number of cuttings planted in each treatment and the number of the survivals.

3.5.2 Average number of primary roots

The number of roots arising from the base of the nodes in both experiments were recorded and then average calculated.

3.5.3 Average length of primary root

The average length of the roots of cuttings was measured from base to the tip and average length of primary root (cm) calculated. The procedure was adopted in both experiments.

3.5.4 Height of sapling

The height of sapling in both experiments was measured from the point of root formation to the tip of sapling and average height (cm) calculated.

3.5.5 Number of leaves

Average number of leaves of the sapling was recorded by counting the leaves arising from each node and average calculated.

3.5.6 Weight of leaves

Average weight of leaves was recorded by gently clipping the leaves from the shoot along with petiole without peeling the bark and weighed on the electronic balance for calculating the average weight (g).

3.5.7 Inter-nodal distance

The inter-nodal distance in both the experiments was measured and average length (cm) worked out.

3.5.8 Upper ground bio-mass

Saplings were cut at the point of root formation and weighed on the electronic balance and average weight (g) calculated.

3.5.9 Underground bio-mass

The underground bio-mass (root weight) was recorded by cutting the root portion from the sapling and weighing it on the electronic balance and average bio-mass (g) calculated.

3.6 Statistical analysis

Data obtained on all the parameters was statistically analysed as per procedure described by Cochron and Cox (1957) and Panse and Sukhatme (1985).

The data generated on number and length of primary roots, height of sapling, number of leaves, weight of leaves, inter-nodal distance, bio-mass under-ground and bio-mass upper-ground was subjected to square root $\sqrt{x+0.5}$ transformation and percentage data to angular transformation for analysis of variance. The treatment comparisons were made at 5 per cent level of significance. The analysis of data was done using INDOSTAT Software Package, Hyderabad based on Snedecor and Cochron (1967).

Chapter-4

EXPERIMENTAL FINDINGS

The chapter deals with findings of the study supported by data, tables and graphics. The appendices of various characters are duly appended.

EXPERIMENT- I

4.1 Influence of variety, position of cutting and growing conditions on rooting behaviour (Fig 1 – 9)

4.1.1 Percentage of rooting

The data (table 1) showed marked variations on the rooting percentage of mulberry cultivars due to various treatment effects.

Chinese-white serving as check, recorded significantly highest rooting percentage of 51.66 over other tested cultivars. Amongst the other tested varieties Francee recorded maximum rooting percentage of 48.33 which was closely followed by Limoncina with 46.66 and Kokuso-20 with 43.68, being significantly at par amongst themselves with regard to rooting percentage.

It is also evident from the data that polyhouse growing conditions recorded significantly higher rooting percentage of i.e. 46.10 of cuttings over natural conditions i.e. 30.36. (Plate No. 2 and 3).

As regards the effect of shoot position, it is found that mean rooting percentage for the basal cutting was significantly higher i.e. 57.77 over both middle cuttings with 44.16 and apical cuttings with 12.77. (Plate No. 4).

Table 1: Effect of growing condition and shoot position on rooting (%) of different mulberry genotypes

	Natural condition (GC-1)			Polyhouse condition (GC-II)			
Varieties	**Basal cuttings (BC)**	**Middle cuttings (MC)**	**Apical cutting (AC)**	**Basal cuttings (BC)**	**Middle cuttings (MC)**	**Apical cutting (AC)**	**Varietal mean**
Limoncina	50.00 (45.00)	36.66 (37.14)	10.00 (18.43)	93.33 (72.98)	73.33 (59.21)	16.66 (23.85)	46.66 (42.77)^{ab}
Kokuso-20	53.33 (47.21)	43.33 (41.15)	16.66 (23.36)	73.33 (60.00)	56.66 (48.84)	20.00 (26.07)	43.88 (41.10)^{b}
Kairyoroso	30.00 (33.00)	20.00 (26.07)	10.00 (18.43)	66.66 (55.07)	33.33 (35.21)	16.66 (23.85)	29.44 (31.94)^{c}
Francee	60.00 (50.85)	43.33 (41.15)	13.33 (21.14)	80.00 (63.93)	73.33 (59.21)	20.00 (26.07)	48.33 (43.72)^{ab}
K.N.G	20.00 (26.07)	10.00 (18.43)	0.00 (4.05)	33.33 (35.21)	13.33 (21.14)	0.00 (4.05)	18.77 (19.25)^{d}
*Chinese-white	70.00 (57.78)	56.66 (48.84)	10.00 (18.43)	83.33 (66.04)	70.00 (57.70)	20.00 (26.07)	51.66 (45.99)^{a}

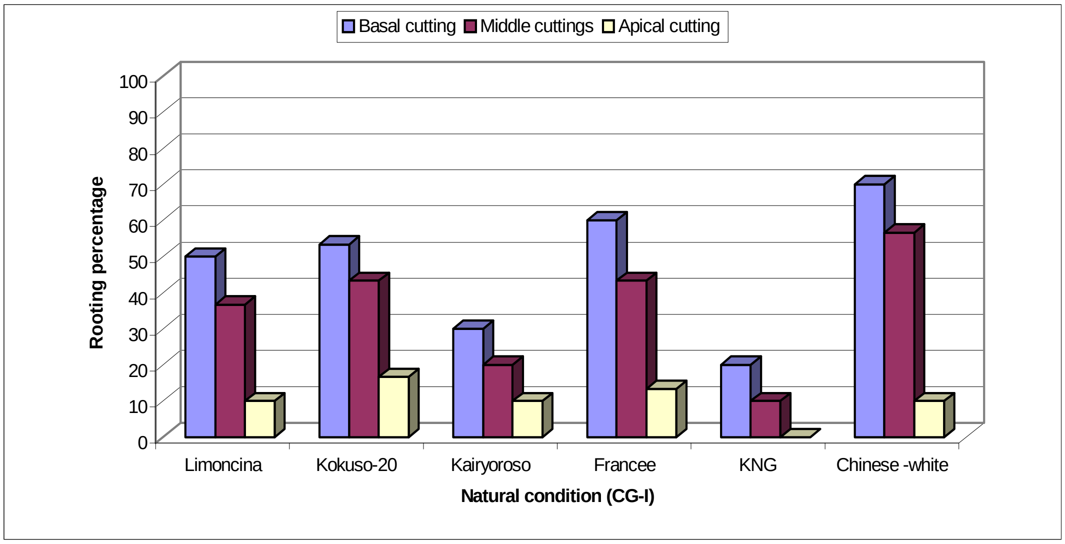
Mean for Basal cutting (BC) = 57.77 (49.97)^{a} Mean for Middle cutting (MC) = 44.16 (41.17)^{b} Mean for Apical cutting (AC) = 12.77 (19.25)^{c}

Mean for GC-I = 30.36 (31.75)^{b} Mean for GC – II = 46.10 (42.02)^{a}

		C.D (p=0.05)	**SEm±**			**C.D (p=0.05)**	**SEm±**
Variety (V)	=	4.75	2.37	V x GC	=	6.73	3.38
Growing conditions (GC)	=	2.74	1.34	V x L	=	8.24	4.14
Shoot position (L)	=	3.36	1.64	GC x L	=	4.76	2.39
				V x GC x L	=	N.S	

*Check

Note: Values in parentheses are angular transformation values: means followed by similar letter(s) are statistically identical



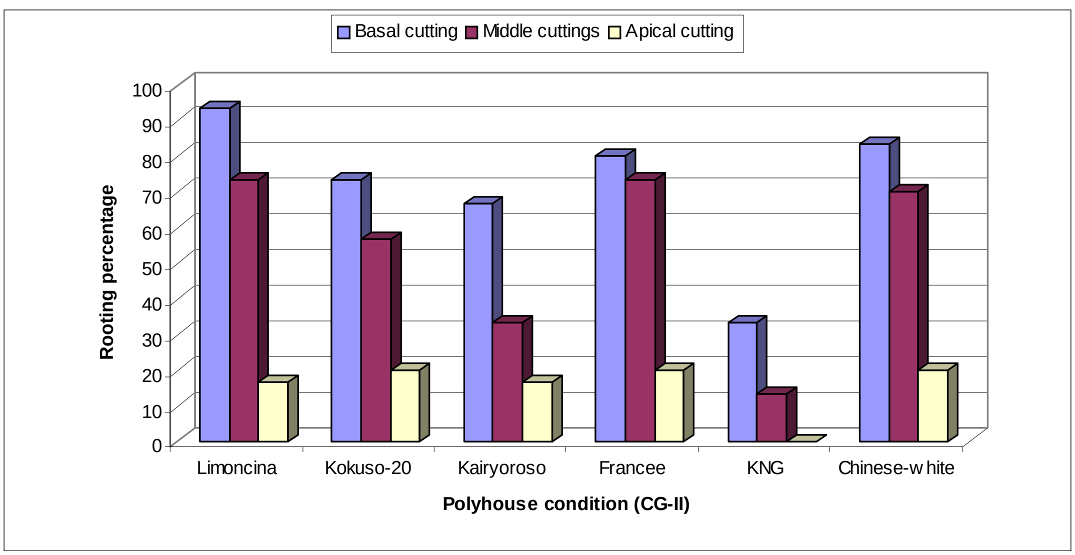


Fig 1: Effect of growing condition and shoot position on rooting (%) of different mulberry genotypes

Plate No.1: View of rooted sapling raised in polyhouse

Plate No.2: Mulberry cuttings grown under cultural conditions

Plate No. 3: Mulberry cuttings grown under polyhouse conditions

Apical cuttings

Basal cuttings

Middle cuttings

Plate No. 4: Influence of position of shoot on survival and biomass

Table 1.1: Interaction effect for rooting (%) between variety x position of shoot

Treatment	Basal	Middle	Apical
Limoncina	73.48	55.53	13.00
	(59.00)	(48.18)	(21.14)
Kokuso-20	64.80	50.00	17.54
	(53.61)	(45.00)	(24.76)
Kairyoroso	48.32	25.98	13.00
	(44.04)	(30.64)	(21.14)
Francee	70.98	59.00	16.04
	(57.40)	(50.19)	(23.61)
K.N.G	16.04	11.48	0.00
	(23.61)	(19.80)	(4.06)
Chinese-white	78.27	64.13	14.64
	(62.21)	(53.21)	2(2.50)
SE m±		4.14	
CD (p=0.05)		8.24	

Data presented in the table 1.1 showed a significant interaction effect for rooting percentage between variety x position of shoot. Significantly highest rooting of 78.27 per cent was recorded with interaction Chinese-white x basal cutting being statistically at par with interaction Limoncina x basal cutting with 73.48 per cent and Francee x basal cutting with 70.98 per cent.

Table 1.2: Interaction effect for rooting (%) between variety and growing condition

Treatment	Natural condition	Polyhouse condition
Limoncina	30.50	62.13
	(33.52)	(52.02)
Kokuso-20	36.30	49.97
	(37.23)	(44.98)
Kairyoroso	18.99	37.98
	(25.83)	(38.04)
Francee	37.41	58.21
	(37.71)	(49.73)
K.N.G	6.30	8.64
	(14.54)	(17.10)
Chinese-white	44.23	59.20
	(41.69)	(50.30)
SE m±	3.38	
CD (p=0.05)	6.73	

The data (table 1.2) revealed significant interaction effect for rooting percentage between variety x growing conditions. Significantly highest rooting, i.e. 62.13 per cent was recorded with interaction Limoncina x Polyhouse followed by Chinese-white x Polyhouse with 59.20 per cent and Francee x Polyhouse with 58.21 per cent. Significantly lowest rooting in 6.30 per cent was recorded with interaction KNG x Natural condition.

Table 1.3: Interaction effect for rooting (%) between position of shoot x growing condition

Treatment	Natural condition	Polyhouse condition
Basal	45.65 (42.50)	71.04 (57.44)
Middle	33.68 (35.47)	53.30 (46.89)
Apical	8.86 (17.31)	13.72 (21.74)
SE m±	2.39	
CD (p=0.05)	4.76	

Significant interaction effect was observed for rooting percentage between position of shoot x growing condition. Significantly highest rooting of 71.04 per cent was recorded with interaction basal cutting x polyhouse. Significantly lowest rooting was recorded with interaction apical cutting x natural conditions with 8.86 per cent.

4.1.2 Number of primary roots

From the perusal of the data (table 2) it is evident that Chinese-white, serving as check produced higher number of roots i.e. 6.93 over other varieties. However, amongst other tested varieties Francee proved to be significantly superior in the production of maximum number of primary roots i.e.6.73 closely followed by Limoncina with 6.04, Kokuso-20 with 5.88 and Kairyoroso with 5.69.

The data also revealed that cuttings grown under ployhouse showed significant increase in the number of primary roots being 7.14 compared to the cuttings grown under natural conditions with 4.64.

Table 2: Effect of growing condition and shoot position on number of primary roots of different mulberry genotypes

Varieties	Natural condition (GC-1) Basal cuttings (BC)	Natural condition (GC-1) Middle cuttings (MC)	Natural condition (GC-1) Apical cutting (AC)	Polyhouse condition (GC-II) Basal cuttings (BC)	Polyhouse condition (GC-II) Middle cuttings (MC)	Polyhouse condition (GC-II) Apical cutting (AC)	Varietal mean
Limoncina	7.33	4.77	2.92	10.44	6.82	4.02	6.04
	(2.70)	(2.30)	(1.84)	(3.29)	(2.70)	(2.12)	(2.56)^{a}
Kokuso-20	6.55	4.16	3.11	10.35	7.26	3.84	5.88
	(2.65)	(2.16)	(1.90)	(3.29)	(2.79)	(2.08)	(2.52)^{a}
Kairyoroso	5.88	4.35	3.25	9.55	7.05	4.10	5.69
	(2.52)	(2.22)	(1.91)	(3.16)	(2.74)	(2.13)	(2.49)^{a}
Francee	6.33	5.45	4.38	9.35	8.72	6.15	6.73
	(2.61)	(2.43)	(2.42)	(3.12)	(3.03)	(2.57)	(2.70)^{a}
K.N.G	4.33	3.10	0.00	8.23	7.97	0.00	4.05
	(2.18)	(2.05)	(0.71)	(2.96)	(2.91)	(0.71)	(2.13)^{b}
*Chinese-white	7.55	5.10	4.35	10.55	7.75	6.28	6.93
	(2.83)	(2.37)	(2.20)	(3.32)	(2.88)	(2.60)	(2.72)^{a}

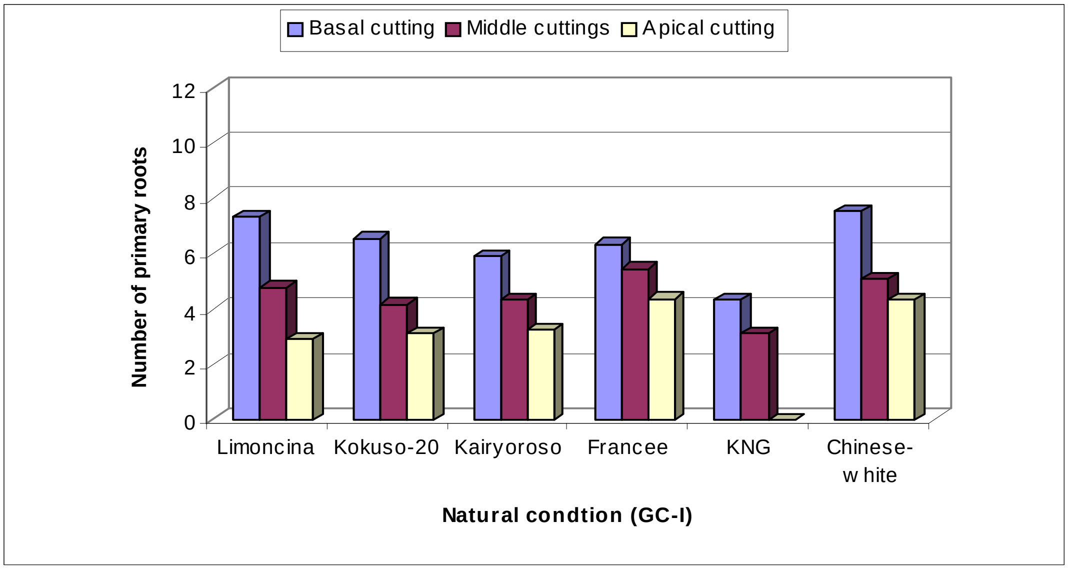
Mean for Basal cutting (BC) = 8.03 (2.92)^{a} Mean for Middle cutting (MC) = 6.10 (2.57)^{b} Mean for Apical cutting (AC) = 3.53 (2.01)^{c}

Mean for GC-I = 4.64 (2.26)^{b} Mean for GC – II = 7.14 (2.76)^{a}

		C.D (p=0.05)	SEm±			C.D (p=0.05)	SEm±
Variety (V)	=	0.25	0.11	V x GC	=	N.S	
Growing conditions (GC)	=	1.15	0.06	V x L	=	0.43	0.20
Shoot position (L)	=	0.18	0.08	GC x L	=	N.S	
				V x GC x L	=	N.S	

*Check

Note: Values in parentheses are $\sqrt{x+0.5}$ (sq root) transformation values: means followed by similar letter(s) are statistically identical



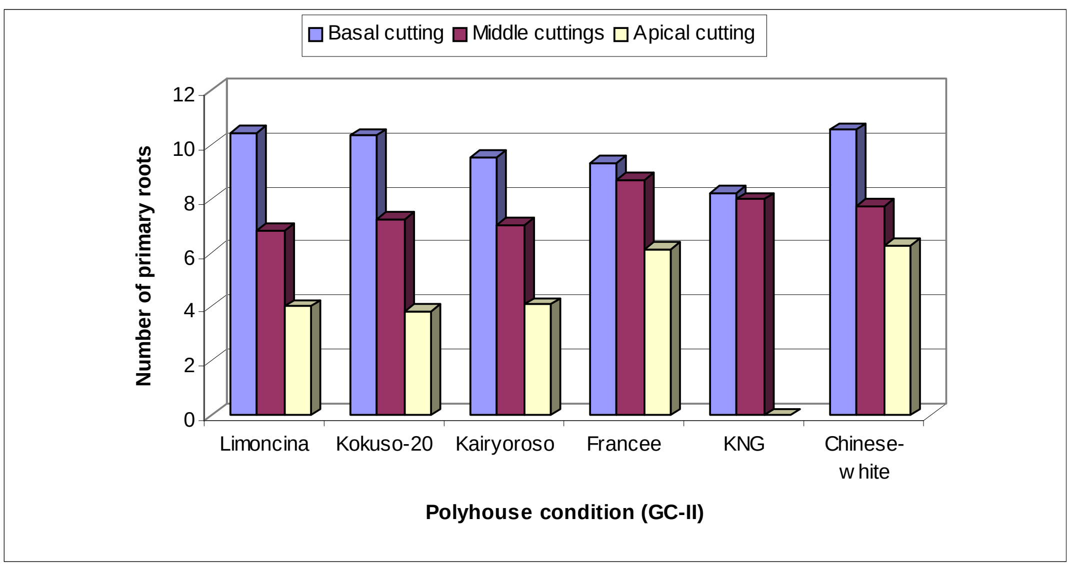


Fig 2: Effect of growing condition and shoot position on number of primary roots of different mulberry genotypes

The data also indicated that basal cuttings produced significantly higher number of primary roots i.e.8.03 over both middle with 6.10 and apical cuttings with 3.53.

Table 2.1: Interaction effect for average number of primary roots between variety x shoot position

Treatment	Basal	Middle	Apical
Limoncina	8.80 (3.05)	7.06 (2.75)	3.82 (2.08)
Kokuso-20	8.50 (3.00)	4.74 (2.29)	3.34 (1.96)
Kairyoroso	7.56 (2.84)	5.60 (2.47)	3.62 (2.03)
Francee	7.91 (2.90)	6.95 (2.73)	5.70 (2.49)
K.N.G	6.10 (2.57)	4.03 (2.13)	0.00 (0.71)
Chinese-white	8.98 (3.08)	6.10 (2.57)	4.38 (2.21)
SE m±		0.20	
CD (p=0.05)		0.43	

The data in (table 2.1) indicates a significant interaction effect between variety x shoot position for average number of primary roots. The highest values of 8.98 was recorded with interaction between Chinese-white and basal cutting being statistically at par with the treatment combination Limoncina x basal cutting with 8.80.

4.1.3 Length of the primary root

The data on the length of primary root as influenced by different treatments revealed significant variation (table 3). Francee recorded maximum length of primary root i.e. 20.20 cm. being significantly at par with Chinese-white. Limoncina and Kokuso-20 having 20.15, 20.05 and 19.95 cm, respectively. KNG recorded minimum of 13.15 cm root length.

As regards the effect of growing conditions, the cuttings under ployhouse recorded higher length of primary root with 20.26 cm compared to natural conditions with 16.48 cm. The data further, showed that basal cuttings produced

Table 3: Effect of growing condition and shoot position on length of primary roots (cm) of different mulberry genotypes

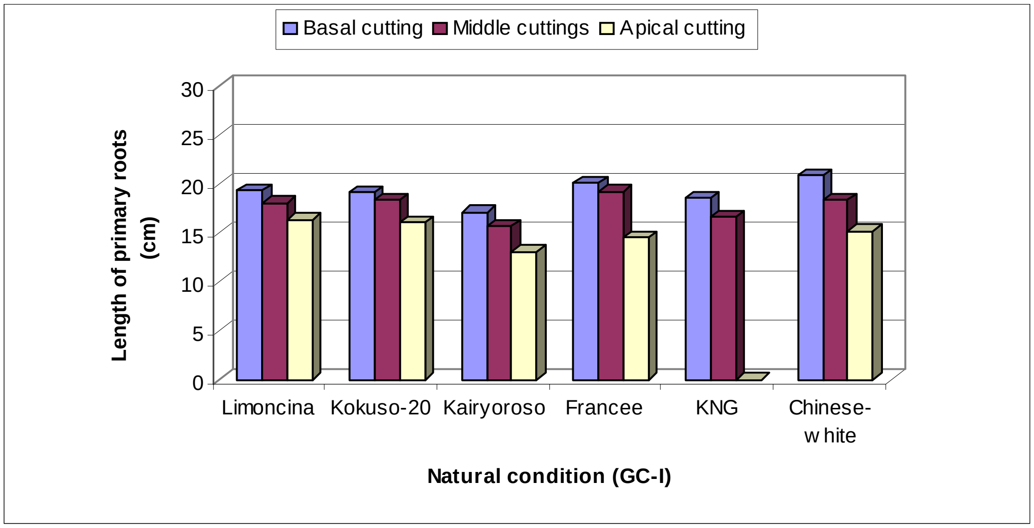
Varieties	Natural condition (GC-1) Basal cuttings (BC)	Middle cuttings (MC)	Apical cutting (AC)	Polyhouse condition (GC-II) Basal cuttings (BC)	Middle cuttings (MC)	Apical cutting (AC)	Varietal mean
Limoncina	19.34 (4.45)	18.10 (4.32)	16.35 (4.10)	24.77 (5.02)	22.17 (4.76)	19.57 (4.47)	20.05 (4.53)[a]
Kokuso-20	19.15 (4.43)	18.35 (4.34)	16.10 (4.07)	25.37 (5.08)	22.18 (4.76)	18.55 (4.36)	19.95 (4.52)[a]
Kairyoroso	17.10 (4.19)	15.65 (4.01)	13.10 (3.68)	21.15 (4.65)	18.30 (4.33)	16.45 (4.11)	16.95 (4.17)[b]
Francee	20.15 (4.53)	19.25 (4.44)	14.53 (3.87)	25.35 (5.08)	23.30 (4.87)	17.30 (4.82)	20.20 (4.54)[a]
K.N.G	18.52 (4.36)	16.65 (4.14)	0.00 (0.71)	23.10 (4.85)	20.65 (4.59)	0.00 (0.71)	13.15 (3.69)[c]
*Chinese-white	20.92 (4.62)	18.35 (4.34)	15.20 ((3.94)	25.97 (5.14)	23.30 (4.87)	17.20 (4.20)	20.15 (4.54)[a]

Mean for Basal cutting (BC) = 21.74 (2.71)[a]   Mean for Middle cutting (MC) = 19.68 (4.48)[b]   Mean for Apical cutting (AC) = 13.68 (3.76)[c]

Mean for GC-I = 16.48 (4.12)[b]   Mean for GC – II = 20.26 (4.55)[a]

		C.D (p=0.05)	SEm±			C.D (p=0.05)	SEm±
Variety (V)	=	0.09	0.04	V x GC	=	N.S	
Growing conditions (GC)	=	0.06	0.03	V x L	=	0.16	0.07
Shoot position (L)	=	0.07	0.03	GC x L	=	N.S	
*Check:				V x GC x L	=	N.S	

Note: Values in parentheses are $\sqrt{x+0.5}$ (sq root)transformation values: means followed by similar letter(s) are statistically Identical



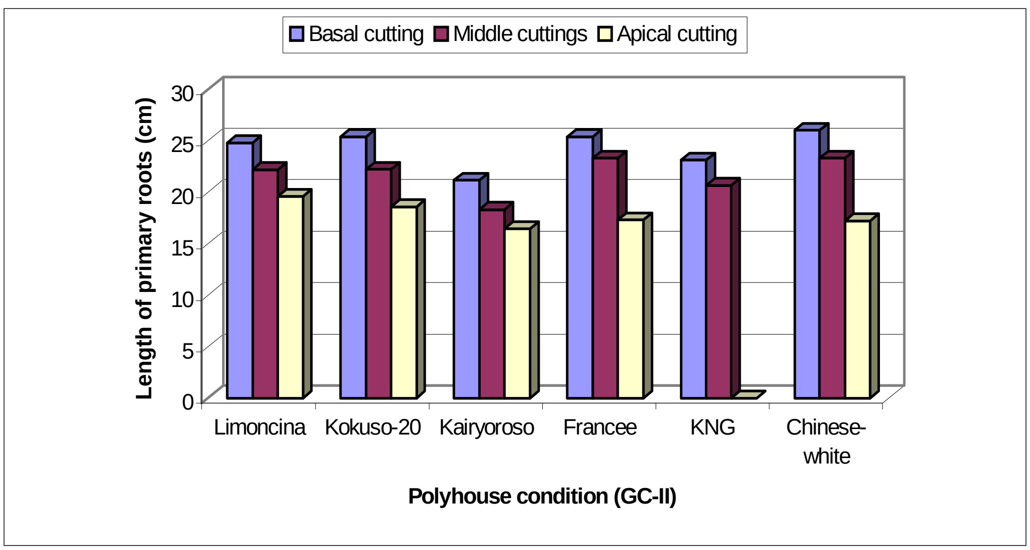


Fig 3: Effect of growing condition and shoot position on length of primary roots of different mulberry genotypes

significantly higher primary root length i.e.21.74 cm compared to middle cuttings with 19.68 cm and apical cuttings with 13.68 cm.

Table 3.1: Interaction effect for average length of primary root (cm) between variety and shoot position

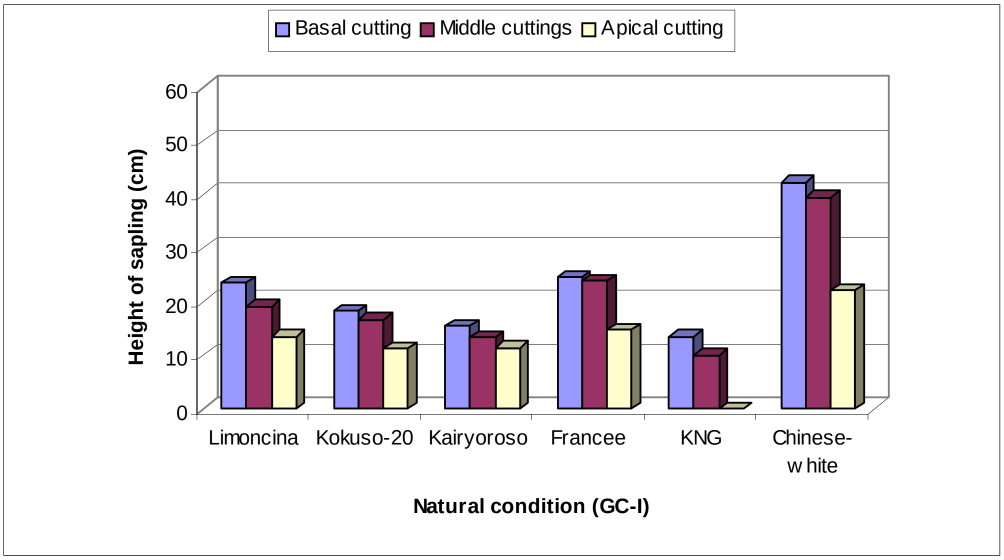
Treatment	Basal cutting	Middle cutting	Apical cutting
Limoncina	21.96 (4.74)	20.11 (4.24)	18.00 (4.30)
Kokuso-20	22.15 (4.76)	20.20 (4.56)	17.22 (4.21)
Kairyoroso	19.03 (4.42)	16.88 (4.17)	16.22 (4.09)
Francee	22.63 (4.81)	21.21 (4.66)	15.90 (4.05)
K.N.G	20.75 (4.61)	18.59 (4.37)	0.00 (0.71)
Chinese-white	23.31 (4.88)	20.75 (4.61)	16.14 (4.08)
SE m±		0.07	
CD (p=0.05)		0.16	

The data presented in table reveals significant interaction effect between variety x shoot position for average length of primary root. It can be observed that significantly highest average length of primary root i.e. 23.31 cm was obtained with the treatment combination Chinese-white x Basal cutting which was statistically at par with the treatment combination Francee x Basal cutting with 22.63 cm.

4.1.4 Height of sapling

Data (table 4) revealed significant variations in the height of sapling due to various treatment effects.

Significant variations in respect of height of sapling were recorded in different varieties. Chinese-white, obtained significantly maximum sapling height of 40.80 cm over other varieties. Amongst the other varieties Francee recorded the highest sapling height of 23.05 cm being significantly at par with Limoncina



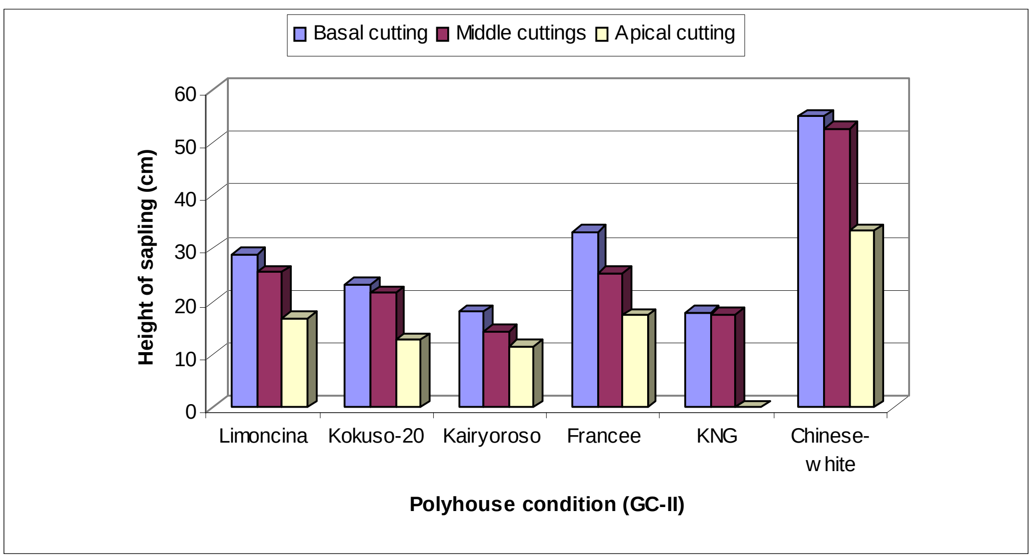


Fig 4: Effect of growing condition and shoot position on height of sampling (cm) of different mulberry genotypes

Table 4 :Effect of growing condition and shoot position on height of sapling (cm) of different mulberry genotypes

Varieties	Natural condition (GC-1) Basal cuttings (BC)	Natural condition (GC-1) Middle cuttings (MC)	Natural condition (GC-1) Apical cutting (AC)	Polyhouse condition (GC-II) Basal cuttings (BC)	Polyhouse condition (GC-II) Middle cuttings (MC)	Polyhouse condition (GC-II) Apical cutting (AC)	Varietal mean
Limoncina	23.44 (4.90)	19.10 (4.32)	13.62 (3.75)	28.92 (5.42)	25.54 (5.10)	16.87 (4.17)	21.24 (4.66)^{bc}
Kokuso-20	18.36 (4.34)	16.65 (4.14)	11.32 (3.43)	23.31 (4.88)	21.75 (4.71)	12.88 (3.65)	17.37 (4.22)^{cd}
Kairyoroso	15.57 (4.00)	13.45 (3.73)	11.50 (3.46)	18.04 (4.30)	14.34 (3.85)	11.58 (3.47)	14.08 (3.81)^{d}
Francee	24.59 (5.00)	23.86 (4.93)	14.68 (3.39)	33.13 (5.79)	25.44 (5.06)	17.37 (4.42)	23.05 (4.85)^{b}
K.N.G	13.57 (3.75)	9.98 (3.23)	0.00 (0.71)	17.87 (4.27)	17.55 (4.24)	0.00 (0.71)	9.82 (3.21)^{a}
*Chinese-white	42.32 (6.54)	39.47 (6.32)	22.07 (4.76)	54.93 (7.45)	52.63 (7.29)	33.39 (5.82)	40.80 (6.42)^{a}

Mean for Basal cutting (BC) = 26.17 (5.16)^{a} Mean for Middle cutting (MC) = 23.31 (4.49)^{b} Mean for Apical cutting (AC)= 13.78 (3.77)^{c}

Mean for GC-I = 19.65 (4.48)^{b} Mean for GC – II = 23.64 (4.90)^{a}

		C.D (p=0.05)	**SEm±**			**C.D (p=0.05)**	**SEm±**
Variety (V)	=	0.45	0.21	V x GC	=	N.S	
Growing conditions (GC)	=	2.26	0.12	V x L	=	0.78	0.36
Shoot position (L)	=	0.31	0.14	GC x L	=	N.S	
*Check				V x GC x L	=	N.S	

Note: Values in parentheses are $\sqrt{x+0.5}$ (sq.root) transformation values: means followed by similar letter(s) are statistically identical having 21.24 cm but significantly superior to other varieties. The lowest height of sapling was observed in KNG with 9.82 cm.

Perusal of the data further revealed that the growing conditions significantly influenced the sapling height. The cuttings planted in polyhouse significantly increased the mean height of sapling to 23.64 cm in comparison to 19.65 cm under natural conditions.

As regards the effect of shoot position, it was found that maximum height of sapling i.e. 26.17 cm was recorded in basal position as compared to middle position with 23.31 cm and apical with 13.78 cm.

Table 4.1:Interaction effect for height of sapling (cm) between variety and shoot position

Treatment	Basal cutting	Middle cutting	Apical cutting
Limoncina	26.12 (5.16)	21.59 (4.70)	15.02 (3.94)
Kokuso-20	20.38 (4.57)	19.03 (4.42)	12.03 (3.54)
Kairyoroso	16.72 (4.15)	13.63 (3.76)	11.54 (3.47)
Francee	28.66 (5.40)	25.51 (5.10)	15.74 (4.03)
K.N.G	21.30 (4.67)	15.50 (4.00)	0.00 (0.71)
Chinese-white	48.36 (6.99)	45.74 (6.80)	27.06 (5.25)
SE m±		0.36	
CD (p=0.05)		0.78	

It was observed that the interaction effect for height of sapling was significant between variety x shoot position. Significantly maximum height of sapling i.e. 48.36 cm was recorded with the treatment combination Chinese-white x Basal cutting, however it was significantly at par with treatment combination Chinese-white x Middle cutting with 45.74 cm.

4.1.5 Number of leaves

The data on number of leaves as influenced by growing conditions and shoot position in the test cultivars is presented in table 5

Table 5: Effect of growing condition and shoot position on number of leaves of different mulberry genotypes

	Natural condition (GC-1)			Polyhouse condition (GC-II)			
Varieties	**Basal cuttings (BC)**	**Middle cuttings (MC)**	**Apical cutting (AC)**	**Basal cuttings (BC)**	**Middle cuttings (MC)**	**Apical cutting (AC)**	**Varietal mean**
Limoncina	14.83 (3.91)	13.81 (3.69)	12.22 (3.55)	20.48 (4.58)	20.26 (4.51)	13.88 (3.79)	15.91 (4.00)^{a}
Kokuso-20	11.82 (3.50)	9.10 (3.09)	8.99 (3.08)	15.23 (3.95)	15.33 (3.97)	11.55 (3.46)	12.00 (3.51)^{xd}
Kairyoroso	10.67 (3.31)	9.84 (3.20)	9.00 (3.07)	12.94 (3.66)	11.03 (3.36)	9.84 (3.20)	10.55 (3.30)^{d}
Francee	11.63 (3.48)	11.26 (3.42)	10.48 (3.30)	17.06 (4.19)	16.47 (4.11)	15.33 (3.98)	13.70 (3.77)^{ab}
K.N.G	12.08 (3.52)	11.61 (3.48)	0.00 (0.71)	16.50 (4.11)	11.07 (3.40)	0.00 (0.71)	8.54 (2.95)^{c}
*Chinese White	12.00 (3.53)	10.78 (3.36)	7.86 (2.89)	17.93 (4.30)	16.46 (4.11)	12.77 (3.64)	12.96 (3.66)^{bc}

Mean for Basal cutting (BC) = 14.43 (3.83)^{a} Mean for Middle cutting (MC) = 12.75 (3.64)^{b} Mean for Apical cutting (AC) = 8.67 (3.02)^{c}

Mean for GC-I = 10.28 (3.28)^{b} Mean for GC – II = 13.61 (3.72)^{a}

		C.D (p=0.05)	**SEm±**			**C.D (p=0.05)**	**SEm±**
Variety (V)	=	0.24	0.11	V x GC	=	N.S	
Growing conditions (GC)	=	0.14	0.06	V x L	=	0.42	0.20
Shoot position (L)	=	0.14	0.07	GC x L	=	N.S	
*Check				V x GC x L	=	N.S	

Note: Values in parentheses are $\sqrt{x+0.5}$ (sq root) transformation values: means followed by similar letter(s) are statistically Identical

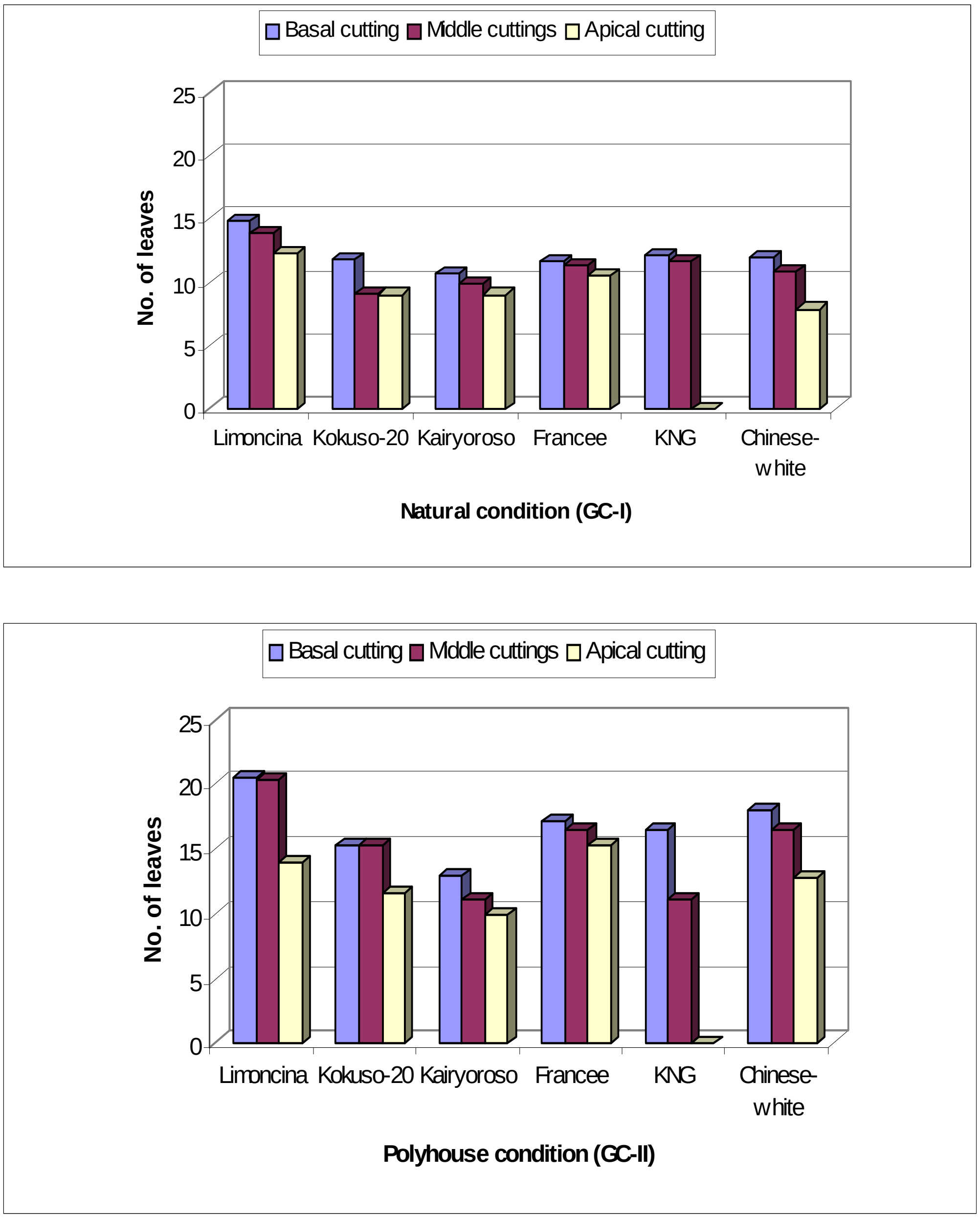


Fig 5: Effect of growing condition and shoot position on number of leaves of different mulberry genotypes

Significant variation in the number of leaves were observed in different varieties. Limoncina recorded significantly maximum number of leaves, i.e. 15.91 followed by Francee with 13.70, Chinese-white with 12.96, Kokuso-20 with 12.00. Limoncina and Francee were statistically at par among themselves in respect of average number of leaves. Minimum number of leaves i.e. 8.54 was recorded in KNG.

The data also revealed that growing conditions significantly affected the number of leaves. Maximum number of leaves i.e.13.61 were observed in cuttings planted in polyhouse.

It is also evident from the data that shoot positions significantly affected number of leaves per cutting. Significantly maximum number of leaves i.e. 14.43 were observed in basal position of shoot and mean minimum number of leaves i.e 8.67 in apical position of shoot.

Table 5.1:Interaction effect for number of leaves between variety and shoot position

Treatment	Basal cutting	Middle cutting	Apical cutting
Limoncina	17.30	16.40	12.97
	(4.22)	(4.11)	(3.67)
Kokuso-20	13.41	12.03	5.11
	(3.73)	(3.54)	(3.27)
Kairyoroso	11.68	10.25	9.35
	(3.49)	(3.28)	(3.14)
Francee	14.16	11.69	8.74
	(3.83)	(3.49)	(3.04)
K.N.G	14.09	11.33	0.00
	(3.82)	(3.44)	(0.71)
Chinese-white	14.78	13.41	10.06
	(3.91)	(3.73)	(3.25)
SE m±	0.20		
CD (p=0.05)	0.42		

The interaction effect of number of leaves between variety x shoot position was found significant. Significantly highest number of leaves i.e 17.30 was recorded with treatment combination Limoncina x Basal cutting, which was statistically at par with Chinese-white x Basal cutting and Francee x Basal cutting.

Table 6: Effect of growing condition and shoot position on weight of leaves (g) of different mulberry genotypes

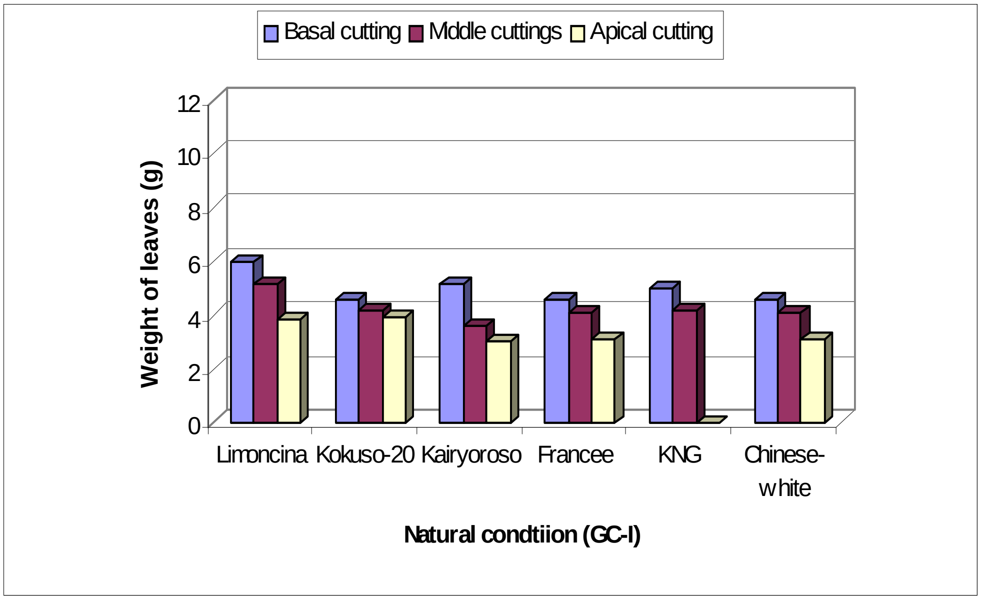
Varieties	Natural condition (GC-1)			Polyhouse condition (GC-II)			
	Basal cuttings (BC)	Middle cuttings (MC)	Apical cutting (AC)	Basal cuttings (BC)	Middle cuttings (MC)	Apical cutting (AC)	Varietal mean
Limoncina	5.95	5.16	3.83	10.03	6.35	4.35	5.94
	(2.53)	(2.37)	(2.05)	(3.24)	(2.61)	(2.19)	(2.51)^{a}
Kokuso-20	4.60	4.15	3.95	6.85	6.05	5.06	5.21
	(2.25)	(2.15)	(2.10)	(2.71)	(2.55)	(2.48)	(2.37)^{b}
Kairyoroso	5.17	3.62	3.05	6.25	4.95	3.45	4.41
	(2.38)	(2.02)	(1.88)	(2.59)	(2.33)	(1.98)	(2.20)^{c}
Francee	4.59	4.05	3.10	8.01	7.85	5.40	5.50
	(2.24)	(2.13)	(1.90)	(2.91)	(2.89)	(2.42)	(2.44)^{ab}
K.N.G	4.95	4.15	0.00	8.33	7.20	0.00	4.10
	(2.33)	(2.15)	(0.71)	(2.98)	(2.77)	(0.71)	(2.12)^{c}
*Chinese- white	4.55	4.05	3.10	7.70	7.05	4.45	5.15
	(2.24)	(2.13)	(1.89)	(2.86)	(2.74)	(2.22)	(2.35)^{b}

Mean for Basal cutting (BC) = 6.19 (2.56)^{a} Mean for Middle cutting (MC) = 5.33 (2.39)^{b} Mean for Apical cutting (AC)= 3.62 (2.00)^{c}

Mean for GC-I = 4.06 (2.12)^{b} Mean for GC – II = 6.04 (2.54)^{a}

		C.D (p=0.05)	SEm±			C.D (p=0.05)	SEm±
Variety (V)	=	0.10	0.04	V x GC	=	0.14	0.06
Growing conditions (GC)	=	0.06	0.03	V x L	=	0.18	0.09
Shoot position (L)	=	0.07	0.03	L x GC	=	0.11	0.05
*Check				V x GC x L	=	N.S	

Note: Values in parentheses are $\sqrt{x+0.5}$ (sq root) transformation values: means followed by similar letter(s) are statistically identical



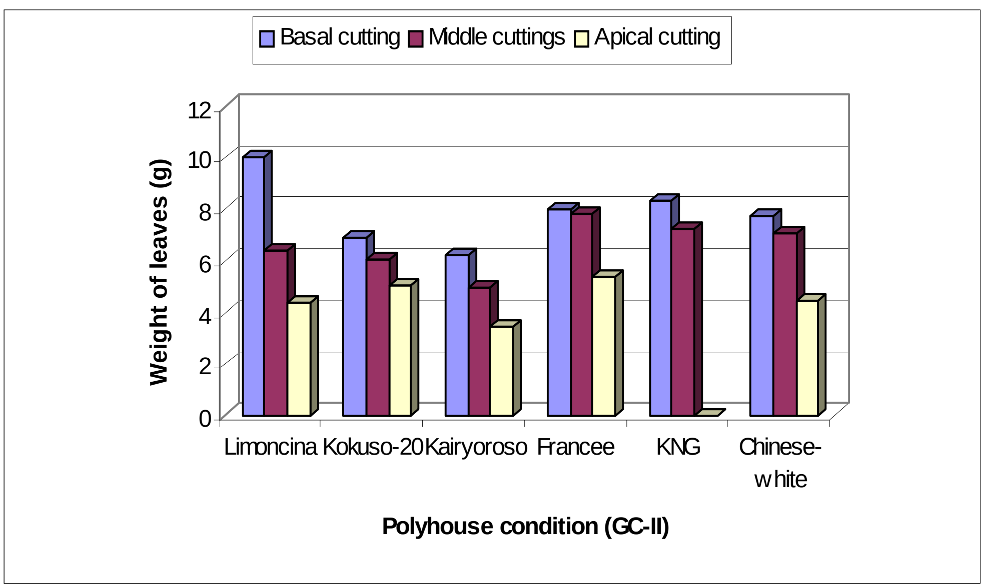


Fig 6: Effect of growing condition and shoot position on weight of leaves of different mulberry genotypes

4.1.6 Weight of leaves

The data pertaining to weight of leaves as affected by growing conditions and shoot position in the varieties is presented in table 6.

There was significant variation in weight of leaves of different varieties. Limoncina recorded maximum weight of leaves i.e.5.94 g which was at par with Francee with 5.57 g but significantly higher over other cultivars. The lowest weight of leaves i.e.4.10 g were observed in KNG.

The data also revealed that cuttings planted in polyhouse recorded significantly higher weight of leaves i.e. 6.04 g over natural condition with 4.06 g.

Perusal of the data also indicated that weight of leaves was significantly affected by shoot position. Cuttings from basal position of shoot recorded maximum weight of 6.19 g which was significantly higher over those from middle with 5.33 and apical with 3.62 g, respectively.

Table 6.1:Interaction effect for weight of leaves (g) between variety and growing condition

Treatment	Natural condition	Polyhouse condition
Limoncina	4.88 (2.32)	6.90 (2.72)
Kokuso-20	4.20 (2.17)	5.75 (2.50)
Kairyoroso	4.20 (2.17)	4.48 (2.23)
Francee	3.91 (2.10)	7.00 (2.74)
K.N.G	2.50 (1.73)	0.82 (1.15)
Chinese-white	3.87 (2.09)	6.31 (2.61)
SE m±	0.06	
CD (p=0.05)	0.14	

The data presented in the table showed a significant interaction effect between variety x growing condition for weight of leaves. Significantly maximum weight of leaves i.e.7.00g was recorded with the treatment combination Francee x

Polyhouse. However, it was statistically at par with the treatment combination Limoncina x Polyhouse and Chinese-white x Polyhouse condition.

Table 6.2:Interaction effect for weight of leaves between variety x position of shoot

Treatment	Basal cutting	Middle cutting	Apical cutting
Limoncina	8.09 (2.93)	5.76 (2.50)	4.00 (2.12)
Kokuso-20	5.66 (2.48)	5.07 (2.36)	4.80 (2.30)
Kairyoroso	4.74 (2.29)	4.34 (2.20)	3.91 (2.10)
Francee	6.15 (2.58)	5.75 (2.50)	4.17 (2.16)
K.N.G	6.52 (2.65)	5.60 (2.47)	0.00 (0.71)
Chinese-white	6.06 (2.56)	5.40 (2.43)	3.54 (2.01)
SE m±		0.09	
CD (p=0.05)		0.18	

The interaction data for weight of leaves clearly indicated that Limoncina x Basal cutting far excelled in recording significantly highest weight of leaves i.e.8.09 g while KNG x Apical cutting recorded the lowest weight of leaves i.e. 0.00 g. However, apical cuttings of the said variety could not root.

Table 6.3:Interaction effect for weight of leaves (g) between shoot position and growing condition

Treatment	Natural condition	Polyhouse condition
Basal	4.70 (2.28)	7.73 (2.67)
Middle	4.03 (2.13)	6.58 (2.66)
Apical	3.03 (1.88)	3.50 (2.00)
SE m±	0.05	
CD (p=0.05)	0.11	

It was found that under polyhouse condition the basal cutting recorded significantly highest weight of leaves i.e.7.73 g while the lowest weight of leaves i.e.3.03 g was recorded under natural conditions for apical cuttings.

Table 7: Effect of growing condition and shoot position on internodal distance (cm) of different mulberry genotypes

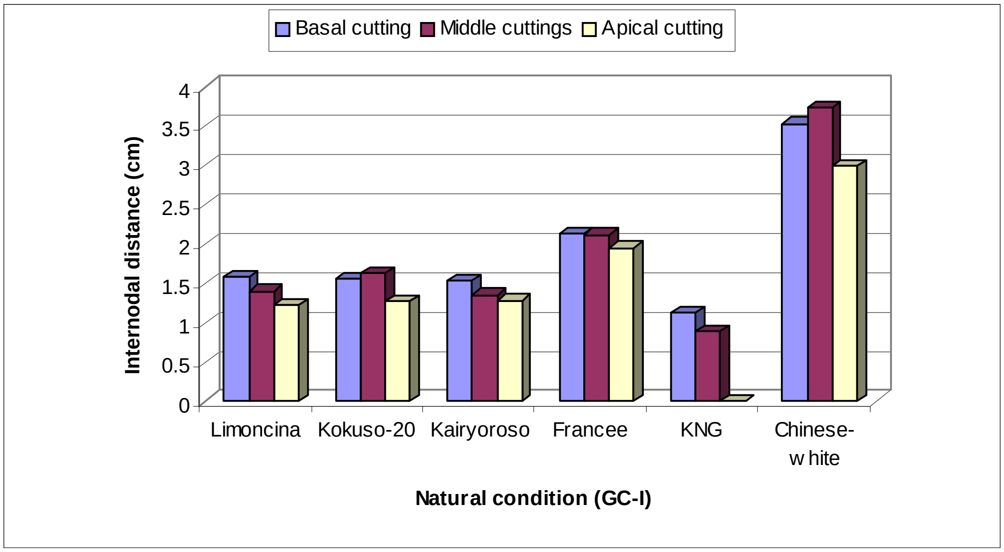
Varieties	Natural condition (GC-1) Basal cuttings (BC)	Middle cuttings (MC)	Apical cutting (AC)	Polyhouse condition (GC-II) Basal cuttings (BC)	Middle cuttings (MC)	Apical cutting (AC)	Varietal mean
Limoncina	1.58	1.40	1.23	1.45	1.25	1.32	1.35
	(1.44)	(1.38)	(1.31)	(1.39)	(1.32)	(1.31)	(1.36)^{c}
Kokuso-20	1.56	1.63	1.27	1.48	1.42	1.11	1.41
	(1.43)	(1.46)	(1.33)	(1.40)	(1.39)	(1.28)	(1.39)^{c}
Kairyoroso	1.53	1.36	1.28	1.39	1.35	1.19	1.35
	(1.42)	(1.37)	(1.33)	(1.38)	(1.36)	(1.30)	(1.36)^{c}
Francee	2.13	2.12	1.75	1.94	2.07	1.50	1.95
	(1.62)	(1.61)	(1.56)	(1.56)	(1.60)	(1.41)	(1.56)^{b}
K.N.G	1.13	0.89	0.00	1.08	1.58	0.00	0.78
	(1.28)	(1.18)	(0.71)	(1.26)	(1.44)	(0.71)	(1.13)^{a}
*Chinese-white	3.53	3.73	2.99	3.06	2.99	2.60	3.14
	(2.00)	(2.05)	(1.87)	(1.88)	(1.87)	(1.76)	(1.90)^{a}

Mean for Basal cutting (BC) = 1.82 (1.52)^{c} Mean for Middle cutting (MC) = 1.77 (1.50)^{a} Mean for Apical cutting (AC)= 1.36 (1.32)^{b}

Mean for GC-I = 1.73 (1.47)^{a} Mean for GC – II = 1.59 (1.42)^{b}

		C.D (p=0.05)	SEm±			C.D (p=0.05)	SEm±
Variety (V)	=	0.05	0.02	V x GC	=	0.07	0.03
Growing conditions (GC)	=	0.03	0.01	V x L	=	0.09	0.04
Shoot position (L)	=	0.09	0.02	L x GC	=	N.S	
*Check				V x L x GC	=	NS	

Note: Values in parentheses are $\sqrt{x+0.5}$ (sq root) transformation values: means followed by similar letter(s) are statistically Identical



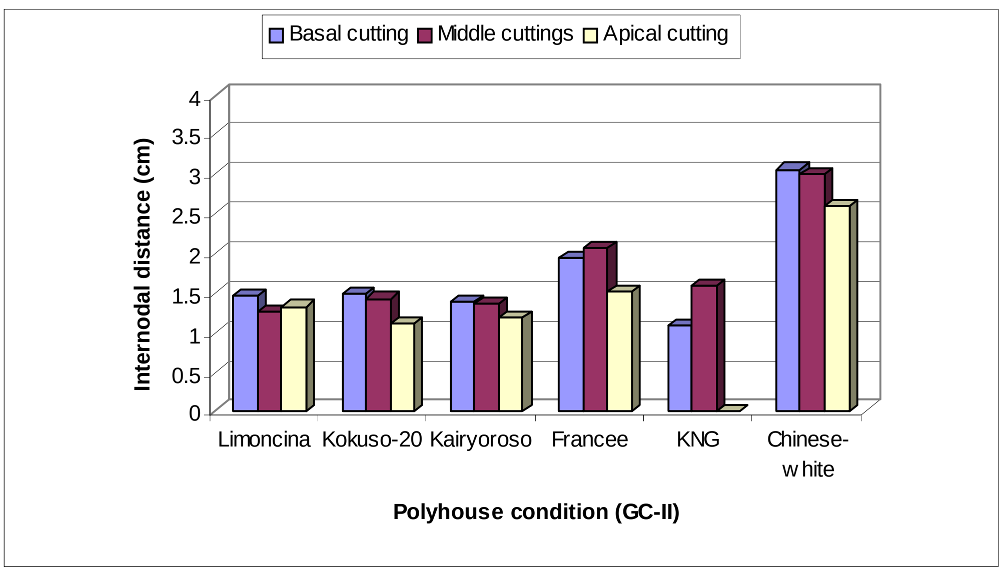


Fig 7: Effect of growing condition and shoot position on internodal distance of different mulberry genotypes

4.1.7 Inter-nodal distance

Data on inter-nodal distance of cuttings as influenced by growing conditions and position of shoot in the test cultivars is presented in (table 7).

Data revealed that all the varieties showed significant differences in the internodal distance. Chinese-white (check) recorded maximum i.e.3.14 cm internodal distance significantly higher over other varieties, being followed by Francee. The lowest inter-nodal distance i.e. 0.78 cm was recorded in KNG.

The data also revealed that growing of cuttings under natural conditions recorded inter-nodal distance of 1.73 cm compared to polyhouse which recorded inter-nodal distance of 1.59 cm.

A reference to the data in Table 7 further revealed that basal, middle and apical cuttings did not influence much on the inter-nodal distance. The lowest value for inter-nodal distance i.e.1.36 cm was recorded by apical cuttings and the highest i.e.1.82 cm by basal cuttings.

Table 7.1:Interaction effect for internodal distance (cm) between variety x position of shoot

Treatment	Basal cutting	Middle cutting	Apical cutting
Limoncina	1.51 (1.42)	1.32 (1.35)	1.21 (1.31)
Kokuso-20	1.49 (1.41)	1.60 (1.45)	1.19 (1.30)
Kairyoroso	1.46 (1.40)	1.35 (1.36)	1.24 (1.32)
Francee	2.03 (1.59)	2.09 (1.61)	1.49 (1.41)
K.N.G	1.11 (1.27)	1.43 (1.39)	0.00 (0.71)
Chinese-white	3.26 (1.94)	3.34 (1.96)	2.77 (1.81)
SE m±		0.04	
CD (p=0.05)		0.09	

The interaction effect of internodal distance between variety and shoot position was observed as significant. The maximum internodal distance i.e.3.34

cm was recorded with Chinese-white x Middle cutting which was at par with the internodal distance recorded by the interaction Chinese-white x Basal cutting with 3.36 cm.

Table 7.2:Interaction effect for internodal distance between variety and growing condition

Treatment	Natural condition	Polyhouse condition
Limoncina	1.38 (1.37)	1.34 (1.37)
Kokuso-20	1.51 (1.42)	1.35 (1.36)
Kairyoroso	1.31 (1.37)	1.30 (1.34)
Francee	2.06 (1.60)	1.81 (1.52)
K.N.G	0.91 (1.19)	0.62 (1.06)
Chinese-white	3.39 (1.97)	2.85 (1.83)
SE m±	0.07	
CD (p=0.05)	0.03	

From the perusal of the data presented in table 7.2 it was found that internodal distance was highest for Chinese-white i.e.3.39 cm grown under natural condition while it was lowest in KNG with 0.62 cm grown under polyhouse condition. The variety Francee proved to be second highest with regard to internodal distance under natural condition i.e. 2.06 cm. It was further observed that the internodal distance remained higher with all the varieties grown under natural conditions compared to polyhouse.

4.1.8 Biomass (upperground)

There was significant variation in upper ground biomass production in different cultivars. Limoncina, statistically at par with Francee, recorded significantly highest upper ground biomass i.e.19.30 g over other varieties. Francee recorded 17.35 g followed by Chinese-white with 16.85 g and Kokuso-20 with 15.45 g upper ground biomass. The minimum upper ground biomass of 11.40 g was recorded in KNG.

Table 8: Effect of growing condition and shoot position on biomass upperground (g) of different mulberry genotypes

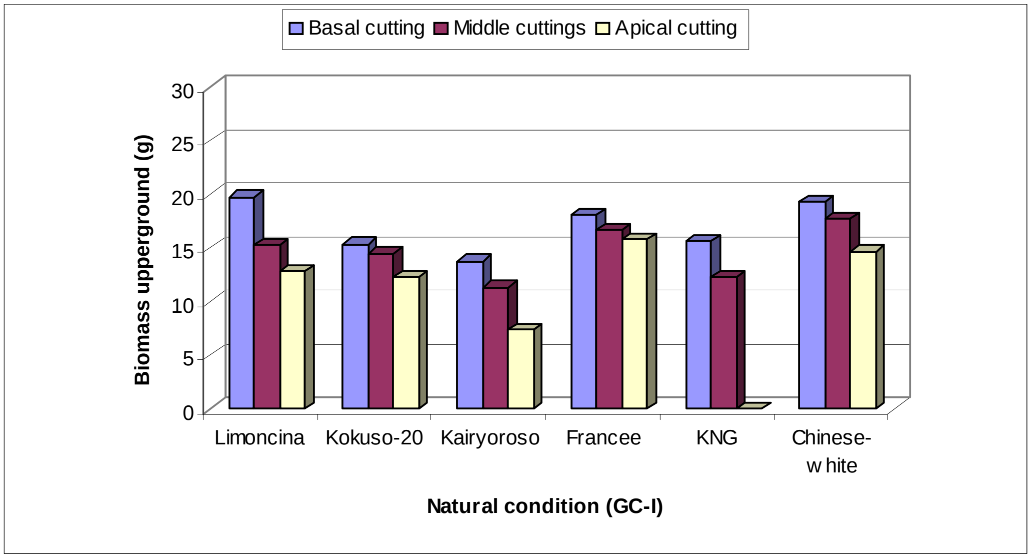
Varieties	Natural condition (GC-1)			Polyhouse condition (GC-II)			
	Basal cuttings (BC)	**Middle cuttings (MC)**	**Apical cutting (AC)**	**Basal cuttings (BC)**	**Middle cuttings (MC)**	**Apical cutting (AC)**	**Varietal mean**
Limoncina	19.75 (4.49)	15.25 (3.96)	12.85 (3.65)	26.70 (5.21)	23.45 (4.89)	15.37 (3.98)	19.90 (4.51)^{a}
Kokuso-20	15.37 (3.98)	14.44 (3.86)	12.28 (3.57)	19.64 (4.48)	17.85 (4.28)	13.65 (3.76)	15.53 (3.99)^{b}
Kairyoroso	13.76 (3.77)	11.30 (3.43)	7.35 (2.80)	16.62 (4.13)	12.21 (4.13)	9.20 (3.11)	11.74 (3.47)^{c}
Francee	18.11 (4.31)	16.79 (4.14)	15.76 (4.03)	23.11 (4.85)	22.76 (4.82)	18.31 (4.33)	19.13 (4.43)^{a}
K.N.G	15.61 (3.95)	12.25 (3.57)	0.00 (0.71)	21.20 (4.65)	19.35 (4.45)	0.00 (0.71)	11.40 (3.44)^{c}
*Chinese-white	19.26 (4.47)	17.74 (4.27)	14.65 (3.89)	26.55 (5.20)	19.87 (4.51)	16.80 (4.16)	19.14 (4.43)^{a}

Mean for Basal cutting (BC) = 19.49 (4.46)^{a} Mean for Middle cutting (MC) = 16.23 (4.07)^{b} Mean for Apical cutting (AC) = 10.15 (3.26)^{c}

Mean for GC-I = 13.34 (3.72)^{b} Mean for GC – II = 17.24 (4.21)^{a}

		C.D (p=0.05)	**SEm±**			**C.D (p=0.05)**	**SEm±**
Variety (V)	=	0.08	0.04	V x GC	=	0.11	0.05
Growing conditions (GC)	=	0.05	0.02	V x L	=	0.14	0.07
Shoot position (L)	=	0.06	0.03	GC x L	=	0.08	0.04
*Check				V x GC x L	=	N.S	

Note: Values in parentheses are $\sqrt{x+0.5}$ (sq root) transformation values: means followed by similar letter(s) are statistically Identical



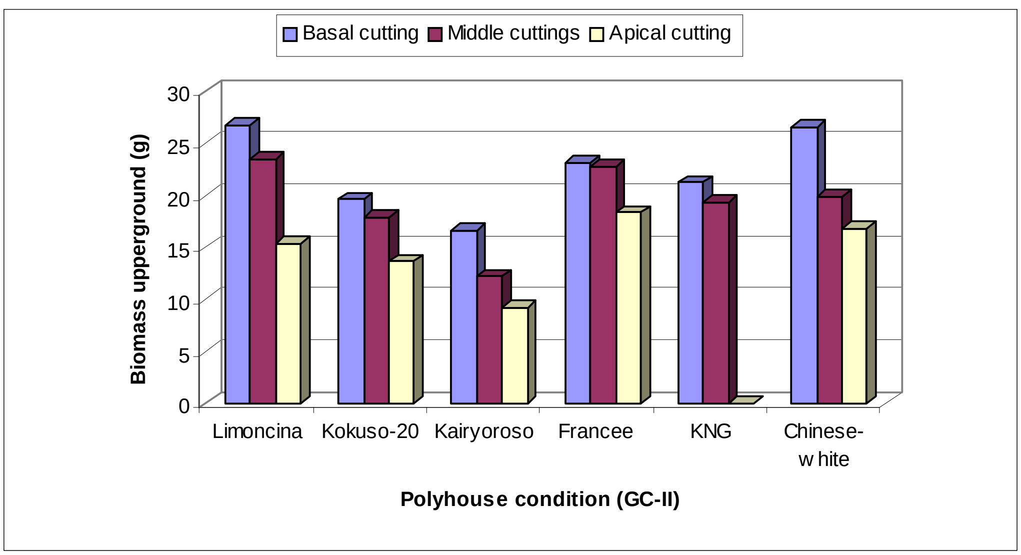


Fig 8: Effect of growing condition and shoot position on upper ground bio-mass (g) of different mulberry genotypes

The data further revealed that cuttings grown in polyhouse condition recorded significantly higher upper ground biomass i.e.17.24 g compared to natural conditions with 13.34 g.

From the perusal of data it was also noticed that shoot position affected upper ground biomass production significantly. Basal cuttings recorded maximum upper ground biomass of 19.49 g as against 16.23 g and 10.15 g upper ground biomass in middle and apical respectively.

Table 8.1:Interaction effect between variety x growing condition on upperground biomass (g)

Treatment	Natural	Polyhouse
Limoncina	15.82 (4.04)	21.59 (4.70)
Kokuso-20	14.01 (3.81)	16.97 (4.18)
Kairyoroso	10.58 (3.33)	12.46 (3.60)
Francee	11.54 (3.47)	15.02 (3.94)
K.N.G	7.00 (2.74)	10.19 (3.27)
Chinese-white	14.63 (3.89)	18.24 (4.33)
SE(m)±	0.05	
CD (0.05)	0.11	

It is evident from the table that significantly highest upper ground biomass of 21.59 g was recorded with the treatment combination Limoncina x Polyhouse condition.

Table 8.2:Interaction effect for upper-ground biomass between variety x position of shoot

Treatment	Basal cutting	Middle cutting	Apical cutting
Limoncina	23.00	19.62	14.00
	(4.85)	(4.43)	(3.81)
Kokuso-20	17.39	16.14	12.97
	(4.23)	(4.08)	(3.67)
Kairyoroso	15.19	11.76	8.27
	(3.96)	(3.50)	(2.96)
Francee	19.67	14.40	1.80
	(4.49)	(3.86)	(2.29)
K.N.G	13.00	13.59	0.00
	(4.30)	(4.01)	(0.71)
Chinese-white	22.82	16.31	11.13
	(4.83)	(4.10)	(3.41)
SE m±		0.07	
CD (p=0.05)		0.14	

The data presented in the table 8.2 indicated significant interaction effect between variety x shoot position. Significantly maximum upper-ground bio-mass of 23.00 g was recorded with the interaction Limoncina x Basal cutting being significantly at par with treatment combination Chinese-white x Basal cutting.

Table 8.3: Interaction effect for upper-ground bio-mass between shoot position and growing condition

Treatment	Natural condition	Polyhouse condition
Basal	16.63	22.16
	(4.14)	(4.76)
Middle	13.95	18.24
	(3.80)	(4.33)
Apical	8.14	9.74
	(2.94)	(3.20)
SE m±	0.04	
CD (p=0.05)	0.08	

Significantly highest upper-ground biomass of 22.16 g was recorded with basal cuttings grown under polyhouse conditions while significantly lowest upper-ground biomass of 8.14 g was recorded with apical cuttings grown under natural condition (Table 8.3).

Table 9: Effect of growing condition and shoot position on biomass underground (g) of different mulberry genotypes

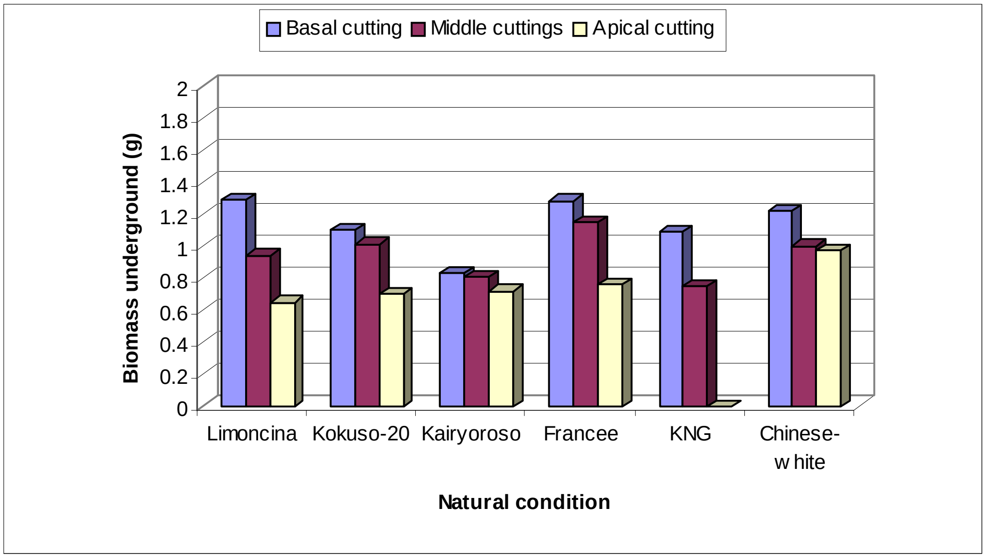
Varieties	Natural condition (GC-1) Basal cuttings (BC)	Natural condition (GC-1) Middle cuttings (MC)	Natural condition (GC-1) Apical cutting (AC)	Polyhouse condition (GC-II) Basal cuttings (BC)	Polyhouse condition (GC-II) Middle cuttings (MC)	Polyhouse condition (GC-II) Apical cutting (AC)	Varietal mean
Limoncina	1.29 (1.33)	0.94 (1.19)	0.65 (1.06)	1.87 (1.53)	1.86 (1.53)	0.97 (1.21)	1.26 (1.32)[a]
Kokuso-20	1.10 (1.26)	1.01 (1.24)	0.70 (1.09)	1.75 (1.55)	1.37 (1.35)	0.91 (1.10)	1.14 (1.28)[a]
Kairyoroso	0.83 (1.15)	0.81 (1.14)	0.72 (1.09)	1.45 (1.39)	1.10 (1.26)	0.86 (1.16)	0.96 (1.20)[b]
Francee	1.28 (1.33)	1.15 (1.29)	0.76 (1.12)	1.85 (1.53)	1.42 (1.34)	1.06 (1.24)	1.27 (1.33)[a]
K.N.G	1.09 (1.25)	0.75 (1.03)	0.00 (0.71)	1.84 (1.52)	1.16 (1.26)	0.00 (0.71)	0.80 (1.14)[c]
*Chinese-white	1.22 (1.31)	1.00 (1.22)	0.97 (1.21)	1.85 (1.53)	1.24 (1.31)	0.91 (1.19)	1.16 (1.28)[a]

Mean for Basal cutting (BC) = 1.45 (1.39)[a]   Mean for Middle cutting (MC) = 1.15 (1.28)[b]   Mean for Apical cutting (AC)= 0.70 (1.09)[a]

Mean for GC-I = 0.89 (1.17)[b]   Mean for GC – II = 1.30 (1.34)[a]

		C.D (p=0.05)	**SEm±**			**C.D (p=0.05)**	**SEm±**
Variety (V)	=	0.05	0.02	V x GC	=	N.S	
Growing conditions (GC)	=	0.03	0.01	V x L	=	0.09	0.04
Shoot position (L)	=	0.04	0.02	L x GC	=	0.05	0.02
*Check				V x GC x L	=	N.S	

Note: Values in parentheses are $\sqrt{x+0.5}$ (sq root) transformation values: means followed by similar letter(s) are statistically Identical



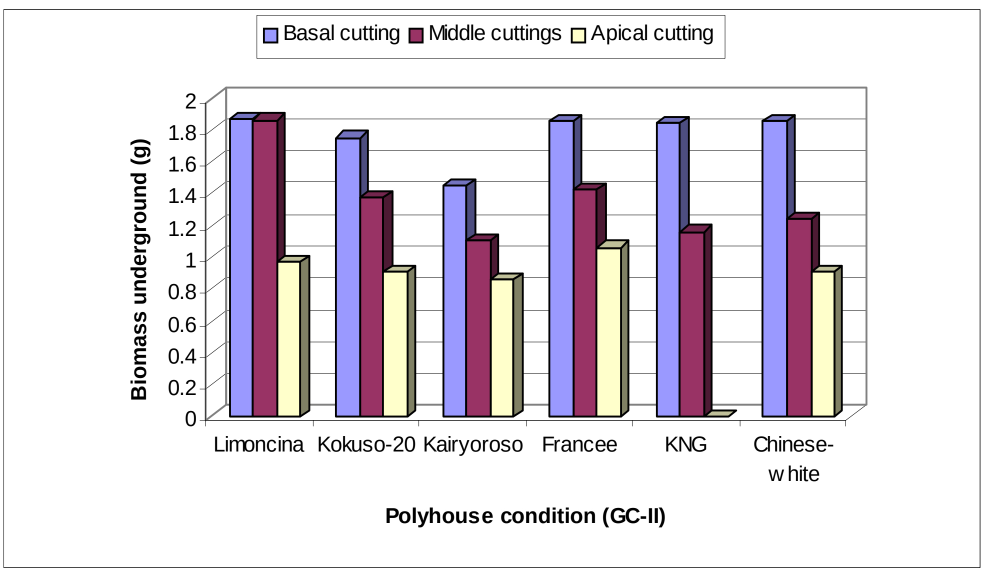


Fig 9: Effect of growing condition and shoot position on underground bio-mass (g) of different mulberry genotypes

4.1.9 Biomass (underground)

The data (table 9) indicated variations in underground biomass of the mulberry genotypes due to various treatment effects. No doubt Francee produced significantly higher underground biomass of 1.27 g but it was significantly at par with Limoncina with 1.26 g, Kokuso-20 with 1.14 and Chinese-white with 1.16g.

Regarding effect of growing conditions the cuttings grown under polyhouse produced significantly more underground biomass i.e.1.30 g compared to natural conditions with 0.89 g.

The data also revealed that basal cuttings produced significantly more underground biomass i.e.1.45 g compared to middle cuttings with 0.93 g and apical cuttings (o.91 g) and both middle and apical cuttings were statistically at par in the production of underground biomass.

Table 9.1:Interaction effect for under ground biomass between variety and shoot position

Treatment	Basal cutting	Middle cutting	Apical cutting
Limoncina	1.54 (1.43)*	1.19 (1.30)	0.94 (1.20)
Kokuso-20	1.46 (1.40)	0.78 (1.13)	1.64 (1.29)
Kairyoroso	1.11 (1.27)	0.78 (1.13)	0.94 (1.20)
Francee	1.49 (1.41)	0.80 (1.14)	1.19 (1.30)
K.N.G	1.43 (1.39)	0.80 (1.14)	0.00 (0.71)
Chinese-white	1.57 (1.44)	0.99 (1.22)	1.21 (1.31)
SE(m)±		0.04	
CD (0.05)		0.09	

The data reveals significant interaction effect between variety x shoot position for underground biomass. Maximum underground biomass of 1.57 g was recorded with the treatment combination of Chinese-white x Basal cutting followed closely by the treatment combination Limoncina x Basal cutting, Francee x Basal cutting and Kokuso-20 x Basal cutting.

Table 9.2:Interaction effect for underground bio-mass between shoot position and growing condition

Treatment	Natural condition	Polyhouse condition
Basal	1.14 (1.28)	1.79 (1.51)
Middle	0.91 (1.19)	1.19 (1.30)
Apical	0.59 (1.04)	0.90 (1.18)
SE m±	0.02	
CD (p=0.05)	0.05	

The interaction effect between shoot position x growing conditions revealed that significantly highest underground bio-mass of 1.79 g was recorded under polyhouse condition and significantly lowest underground of 0.59 g was recorded with apical cutting grown under natural condition.

EXPERIMENT-II

4.2 Influence of variety, media and growing conditions on the rooting behaviour (Fig 10 – 18).

4.2.1 Rooting percentage

The data (table 10) revealed significant variations in the rooting percentage of mulberry cuttings as affected by different treatments.

It was observed that Chinese white recorded significantly higher rooting percentage compared to other cultivars. Amongst five tested genotypes Francee recorded significantly higher rooting percentage of 54.44 over other cultivars though being at par with Limoncina with 53.33 per cent (Plate No. 10).

Regarding effect of growing conditions it is clear from the data that polyhouse condition was significantly superior to natural condition in increasing the rooting percentage of the cuttings (Plate No. 7 and 8).

Table 10: Effect of growing condition and media on rooting (%) of different mulberry genotypes

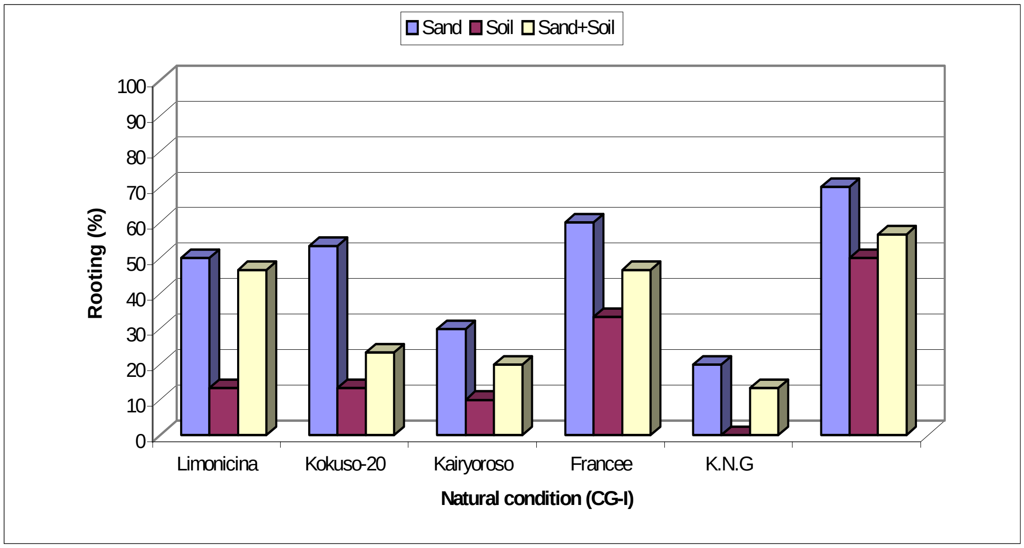
	Natural condition (GC-1)			Polyhouse condition (GC-II)			
Varieties	**Sand (M_1)**	**Soil (M_2)**	**Sand + Soil (M_3)**	**Sand (M_1)**	**Soil (M_2)**	**Sand + Soil (M_3)**	**Varietal mean**
Limoncina	50.00	13.33	46.66	93.33	33.33	83.33	53.33
	(45.00)	(21.14)	(41.15)	(72.98)	(35.21)	(66.64)	(46.85)^{b}
Kokuso-20	53.33	13.33	23.33	73.33	20.00	40.00	37.22
	(47.21)	(21.14)	(28.28)	(60.00)	(26.07)	(30.85)	(36.92)^{c}
Kairyoroso	30.00	10.00	20.00	66.66	16.66	30.00	28.88
	(33.00)	(18.43)	(26.07)	(55.07)	(23.85)	(33.00)	(31.57)^{d}
Francee	60.00	33.33	46.66	80.00	43.33	63.33	54.44
	(50.85)	(35.21)	(43.07)	(63.93)	(41.15)	(53.06)	(47.88)^{b}
K.N.G	20.00	0.00	13.33	33.33	0.00	30.00	16.11
	(26.07)	(4.05)	(21.14)	(35.21)	(4.05)	(33.00)	(15.81)^{c}
*Chinese-white	70.00	50.00	56.66	83.33	60.00	73.33	65.55
	(57.78)	(45.00)	(48.93)	(66.64)	(50.85)	(59.21)	(54.73)^{a}

Mean for Sand (M_1) = 57.77 (49.97)^{a} Mean for Soil (M_2) = 24.44 (27.10)^{c} Mean for Sand + Soil (M_3) = 43.88 (39.82)^{b}

Mean for Natural condition (GC-I) = 34.44 (36.66)^{b} Mean for Polyhoue condition (GC – II) = 50.73 (44.26)^{a}

		C.D (p=0.05)	**SEm±**			**C.D (p=0.05)**	**SEm±**
Variety (V)	=	5.18	2.56	V x M	=	8.10	4.5
Media (M	=	3.66	1.79	V x GC	=	7.33	3.69
Growing condition (GC)	=	2.99	1.46	M x GC	=	N.S	
*Check				V x M x GC	=	N.S	

Note: Values in parentheses are$\sqrt{x+0.5}$ angular transformation values: means followed by similar letter(s) are statistically Identical



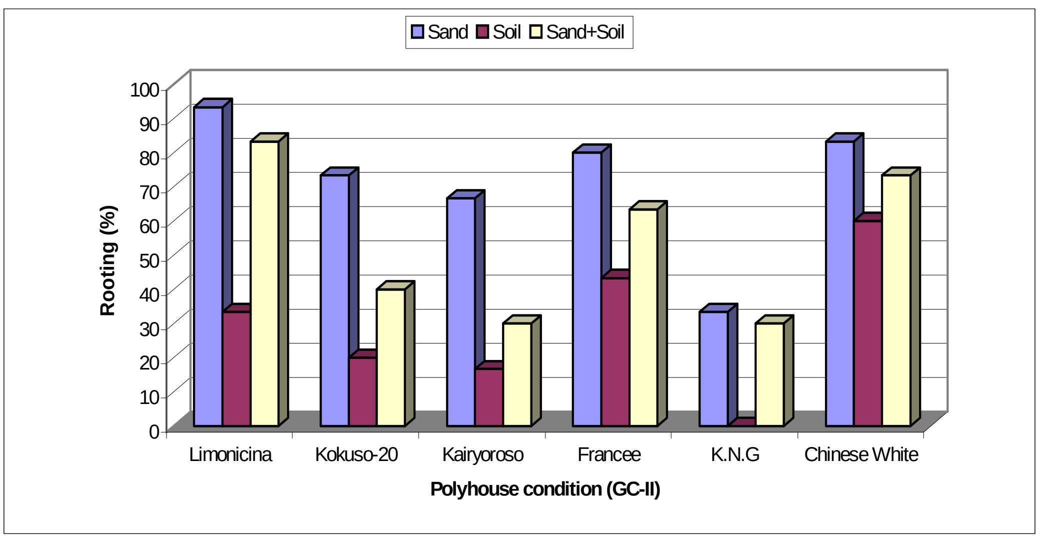


Fig 10: Effect of growing condition and media on rooting (%) of different mulberry genotypes

Plate No.5: Uprooted sapling grown in natural conditions

Plate No. 6: Uprooted cuttings grown in polyhouse conditions

Plate No. 7: Influence of media on survival and biomass (Upperground)
Ist set of polybag = Sand
2nd set of polybag = Soil
3rd set of polybag = Sand + Soil

Plate No.8: Influence of media on survival of cuttings/biomass (upperground)

Ist set of polybags = Sand

2^{nd} set of polybags = Sand + Soil

3^{rd} set of polybags = Soil

Plate No. 9: Influence of media on rooting behaviour

M_1 = Sand

M_2 = Soil

M_3 = Sand + Soil

Francee

Chinese-white

Kokuso-20

Plate No. 10: Rooted cuttings of different cultivars

Table 10.1: Interaction effect for rooting (%) between variety and media

Treatment	Sand	Soil	Sand + Soil
Limoncina	73.48	20.18	65.29
	(59.00)	(26.69)	(53.90)
Kokuso-20	64.80	16.04	30.60
	(53.61)	(23.61)	(33.58)
Kairyoroso	48.32	13.02	24.30
	(44.04)	(21.15)	(29.53)
Francee	70.98	38.22	55.40
	(57.40)	(38.19)	(48.10)
K.N.G	16.04	0.00	11.48
	(23.61)	(4.06)	(19.80)
Chinese-white	78.27	55.09	65.57
	(62.21)	(47.92)	(54.07)
SE(m)±		4.5	
CD (p=0.05)		8.10	

The interaction effect for rooting between variety x media was observed as significant. Significantly maximum rooting of 78.27 per cent was recorded with the interaction Chinese-white x Sand medium being statistically at par with interaction Limoncina x Sand medium with 73.48 per cent and Francee x Sand medium with 70.98 per cent.

Table 10.2: Interaction effect for rooting (%) between variety x growing conditions

Treatment	Natural (GCI)	Polyhouse (GC-II)
Limoncina	34.17	71.82
	(35.77)	(57.94)
Kokuso-20	28.41	44.15
	(32.21)	(41.64)
Kairyoroso	18.98	36.74
	(25.83)	(37.31)
Francee	46.59	63.30
	(43.04)	(52.71)
K.N.G	6.30	8.65
	(14.54)	(17.10)
Chinese-white	59.68	73.32
	(50.58)	(58.90)
SE m±	3.69	
CD (p=0.05)	7.33	

Table 11: Effect of growing condition and media on number of primary roots of different mulberry genotypes

Varieties	Natural condition (GC-1)			Polyhouse condition (GC-II)			Varietal mean
	Sand (M_1)	**Soil (M_2)**	**Sand + Soil (M_3)**	**Sand (M_1)**	**Soil (M_2)**	**Sand + Soil (M_3)**	
Limoncina	7.33 (2.79)	3.66 (2.03)	5.24 (2.39)	10.44 (2.29)	5.35 (2.43)	7.35 (2.79)	6.56 (2.65)^{a}
Kokuso-20	6.55 (2.65)	3.33 (1.95)	5.15 (2.37)	10.35 (3.29)	5.15 (2.37)	8.17 (4.06)	6.45 (2.63)^{a}
Kairyoroso	5.88 (2.52)	2.33 (1.67)	4.32 (2.33)	9.55 (3.16)	4.01 (2.11)	7.45 (2.81)	5.59 (2.43)^{a}
Francee	6.33 (2.61)	4.55 (2.24)	5.45 (2.43)	9.35 (3.12)	6.25 (2.59)	7.37 (2.88)	6.55 (2.65)^{a}
K.N.G	4.33 (2.18)	0.00 (0.70)	3.00 (1.85)	8.23 (2.96)	0.00 (0.70)	5.20 (2.88)	3.46 (1.93)^{c}
*Chinese-white	7.55 (2.83)	4.50 (2.19)	5.40 (2.42)	10.55 (3.32)	5.10 (2.36)	6.50 (2.64)	6.60 (2.66)^{a}

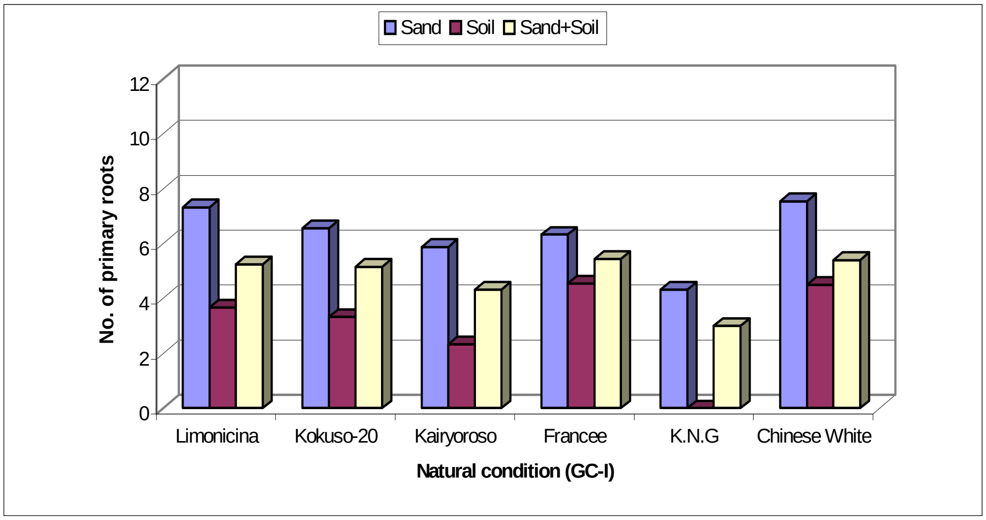
Mean for Sand (M_1) = 8.03 (2.92)^{a} Mean for Soil (M_2) = 3.68 (2.02)^{c} Mean for Sand + Soil (M_3) = 5.88 (2.53)^{b}

Mean for Natural condition (GC-I) = 4.71 (2.26)^{b} Mean for Polyhoue condition (GC – II) = 7.02 (2.73)^{a}

		C.D (p=0.05)	**SEm±**			**C.D (p=0.05)**	**SEm±**
Variety (V)	=	0.23	0.11	V x M	=	0.40	0.19
Media (M	=	0.16	0.07	V x GC	=	N.S	
Growing condition (GC)	=	0.13	0.06	M x GC	=	N.S	
				V x M x GC	=	N.S	

*Check

Note: Values in parentheses are $\sqrt{x+0.5}$ (sq root) transformation values: means followed by similar letter(s) are statistically identical



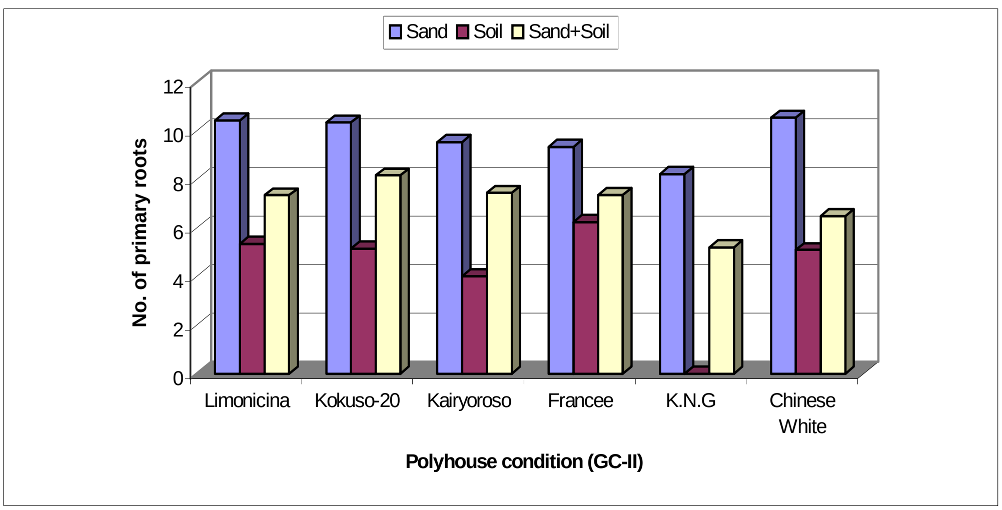


Fig 11: Effect of growing condition and media on number of primary roots of different mulberry genotypes

Perusal of the data (table 10.2) revealed significant interaction effect between variety x growing conditions in respect of rooting percentage. Maximum rooting of 73.32 per cent was recorded with the interaction Chinese-white x Polyhouse being statistically at par with interaction Limoncina x Polyhouse which recorded rooting of 71.82 per cent. Significantly lower rooting of 6.30 per cent was recorded with interaction KNG x Natural conditions.

4.2.2 Number of primary roots

From the perusal of the data (Table 11) it was observed that Chinese-white recorded highest number of primary root i.e. 6.60 while lowest number of 3.46 was recorded for KNG. However, number of primary roots in Limoncina with 6.56, Francee with 6.55, Kokuso-20 with 6.45 and Kairyoroso with 5.59 were statistically at par with those in Chinese-white.

It is evident that number of primary roots obtained in sand i.e. 8.03 were significantly higher over those obtained in sand + soil with 5.88 and soil alone with 3.68 (Plate No. 9).

Table 11.1: Interaction effect for number of primary roots between variety and media

Treatment	Sand	Soil	Sand + Soil
Limoncina	8.80 (3.05)	4.47 (2.23)	6.20 (2.59)
Kokuso-20	9.80 (3.21)	4.16 (2.16)	8.32 (2.97)
Kairyoroso	7.56 (2.84)	3.07 (1.89)	6.15 (2.58)
Francee	7.85 (2.89)	5.35 (2.42)	6.41 (2.63)
K.N.G	6.10 (2.57)	8.00 (0.71)	3.99 (2.12)
Chinese-white	8.98 (3.08)	4.69 (2.28)	2.12 (2.53)
SE(m)±		0.19	
CD (0.05)		0.40	

Table 12: Effect of growing condition and media on length of the primary roots (cm) of different mulberry genotypes

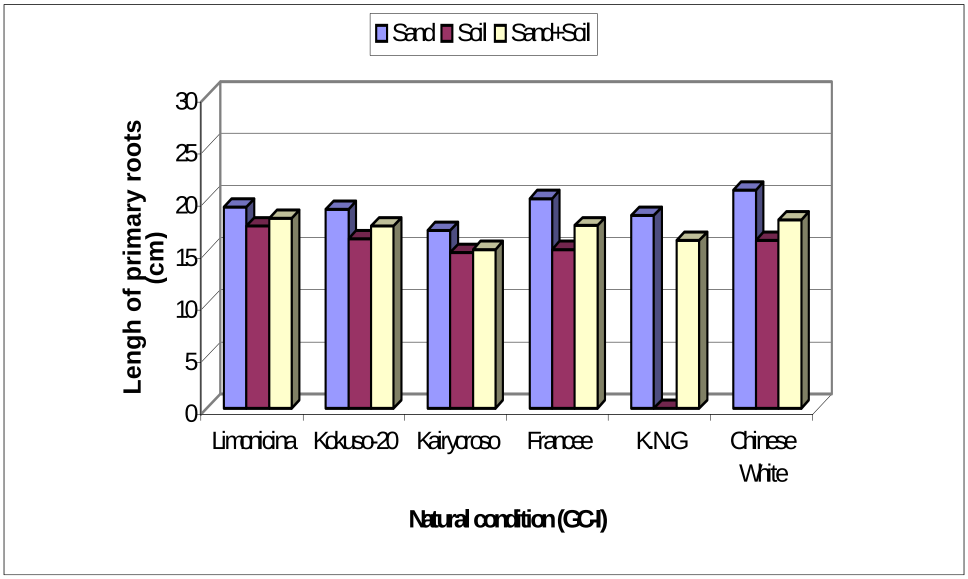
Varieties	Natural condition (GC-1)			Polyhouse condition (GC-II)			Varietal mean
	Sand (M_1)	Soil (M_2)	Sand + Soil (M_3)	Sand (M_1)	Soil (M_2)	Sand + Soil (M_3)	
Limoncina	19.34 (4.45)	17.53 (4.24)	18.23 (4.32)	24.77 (5.02)	18.34 (4.33)	20.77 (4.61)	19.83 (4.49)^{a}
Kokuso-20	19.15 (4.43)	16.29 (4.09)	17.54 (4.24)	25.37 (5.08)	18.08 (4.30)	22.25 (4.76)	19.78 (4.48)^{a}
Kairyoroso	17.10 (4.19)	14.94 (4.10)	15.23 (4.12)	21.15 (4.65)	17.66 (4.26)	18.74 (4.37)	17.47 (4.24)^{a}
Francee	20.15 (4.53)	15.29 (3.97)	17.55 (4.24)	25.35 (5.08)	17.90 (4.28)	22.87 (4.83)	19.86 (4.51)^{a}
K.N.G	18.52 (4.36)	0.00 (0.70)	16.11 (4.07)	23.10 (4.85)	0.00 (0.70)	20.00 (4.51)	12.95 (3.60)^{b}
*Chinese-white	20.92 (4.62)	16.12 (4.05)	18.10 (4.20)	25.97 (5.14)	18.4 (4.35)	20.32 (4.54)	19.98 (4.52)^{a}

Mean for Sand (M_1) = 21.74 (4.71)^{a} Mean for Soil (M_2) = 14.22 (3.81)^{c} Mean for Sand + Soil (M_3) = 18.97 (4.40)^{b}

Mean for Natural condition (GC-I) = 16.56 (4.11)^{b} Mean for Polyhoue condition (GC – II) = 20.06 (4.53)^{a}

		C.D (p=0.05)	SEm±			C.D (p=0.05)	SEm±
Variety (V)	=	0.13	0.06	V x M	=	0.23	0.11
Media (M	=	0.09	0.04	V x GC	=	N.S	
Growing condition (GC)	=	0.07	0.03	M x GC	=	N.S	
*Check				V x M x GC	=	N.S	

Note: Values in parentheses are $\sqrt{x+0.5}$ (sq root) transformation values: means followed by similar letter(s) are statistically identical



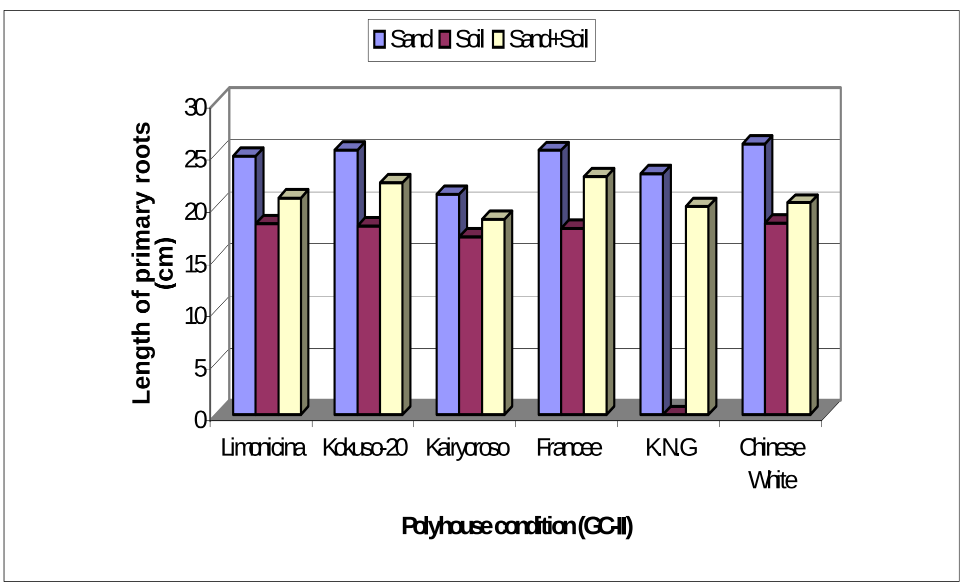


Fig 12: Effect of growing condition and media on length of primary roots of different mulberry genotypes

The data (Table 11.1) displayed a significant interaction effect for average number of primary roots between variety x media. Significantly maximum number of primary roots i.e. 9.80 were recorded with the treatment combination Kokuso-20 x Sand and were statistically at par with number of primary roots recorded with Chinese-white x Sand, Limoncina x Sand, Francee x Sand and Kairyoroso x Sand.

4.2.3 Length of the primary root

The data (table 12) showed significant variations in the length of primary roots due to different treatment effects.

The check variety (Chinese-white) recorded the highest length of primary root i.e.19.98 cm but on comparison with tested varieties it was at par with Francee (19.86 cm), Limoncina with 19.83 cm and Kokuso-20 with 19.78 cm. The minimum length of primary root was observed in KNG with 12.95 cm.

The polyhouse condition encouraged significantly longer primary roots i.e.20.06 cm over natural condition with 16.56 cm. The growing media significantly influenced the length of primary roots. The primary roots produced in sand media had significantly more length i.e.21.74 cm over those obtained in sand + soil with 18.97 cm and soil with 14.22 cm.

Table 12.1: Interaction effect for length of primary root (cm) between variety and media

Treatment	Sand	Soil	Sand + Soil
Limoncina	21.96 (4.74)	17.90 (4.29)	19.49 (4.47)
Kokuso-20	22.15 (4.76)	16.80 (4.20)	19.84 (4.51)
Kairyoroso	19.03 (4.42)	16.98 (4.18)	17.56 (4.25)
Francee	22.63 (4.81)	16.47 (4.12)	20.11 (4.54)
K.N.G	20.75 (4.61)	0.00 (0.71)	17.90 (4.29)
Chinese-white	23.31 (4.88)	17.14 (4.20)	18.60 (4.37)
SE m±	0.11		
CD (p=0.05)	0.23		

Table 13: Effect of growing condition and media on height (cm) of sapling of different mulberry genotypes

Varieties	Natural condition (GC-1)			Polyhouse condition (GC-II)			
	Sand (M_1)	Soil (M_2)	Sand + Soil (M_3)	Sand (M_1)	Soil (M_2)	Sand + Soil (M_3)	Varietal mean
Limoncina	23.44	26.80	31.31	28.92	33.81	37.71	30.33
	(4.90)	(5.22)	(5.64)	(5.42)	(5.85)	(5.19)	(5.55)^{b}
Kokuso-20	18.36	22.36	26.21	23.31	26.72	30.63	24.59
	(4.34)	(4.77)	(2.16)	(4.79)	(5.21)	(5.57)	(4.97)^{c}
Kairyoroso	15.57	19.89	23.58	18.04	23.22	20.95	20.20
	(4.00)	(4.48)	(4.82)	(4.30)	(4.86)	(5.20)	(4.57)^{d}
Francee	24.59	28.67	32.52	33.13	36.90	40.05	32.64
	(5.00)	(5.39)	(5.73)	(5.79)	(6.90)	(6.34)	(5.75)^{b}
K.N.G	13.57	0.00	22.36	17.87	0.00	25.28	13.18
	(3.75)	(0.71)	(4.77)	(4.27)	(0.70)	(5.06)	(3.69)^{c}
*Chinese-white	42.32	45.35	48.51	54.93	54.48	56.13	50.39
	(6.54)	(6.76)	(6.94)	(7.44)	(7.40)	(7.56)	(7.14)^{a}

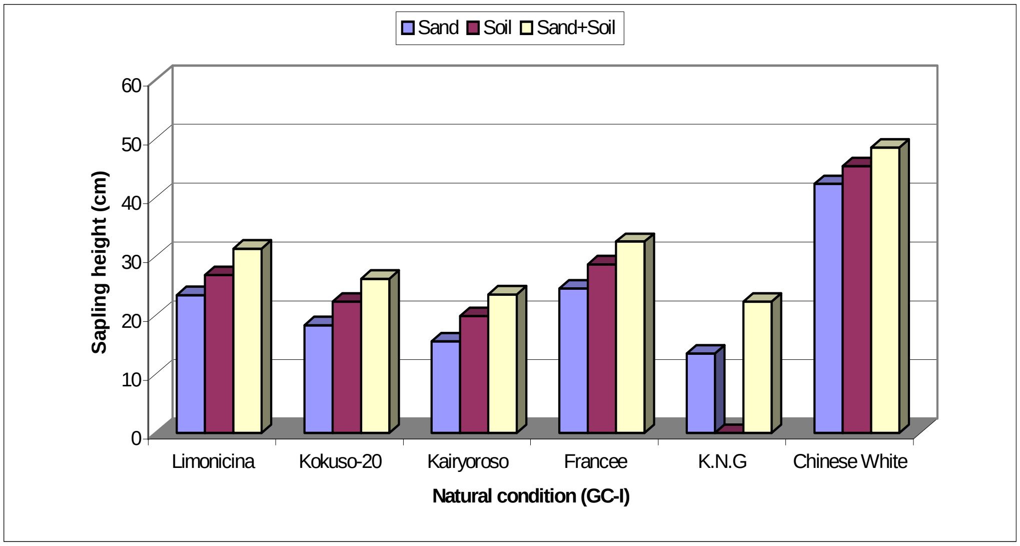
Mean for Sand (M_1) = 26.17 (5.17)^{b} Mean for Soil (M_2) = 26.51 (5.20)^{b} Mean for Sand + Soil (M_3) = 33.00 (5.74)^{a}

Mean for Natural condition (GC-I) = 25.85 (5.13)^{a} Mean for Polyhoue condition (GC – II) = 31.26 (5.63)^{a}

		C.D (p=0.05)	SEm±			C.D (p=0.05)	SEm±
Variety (V)	=	0.25	0.11	V x M	=	0.43	0.21
Media (M	=	0.18	0.08	V x GC	=	N.S	
Growing condition (GC)	=	0.14	0.06	M x GC	=	N.S	
				V x M x GC	=	N.S	

*Check

Note: Values in parentheses are $\sqrt{x+0.5}$ (sq root) transformation values: means followed by similar letter(s) are statistically Identical



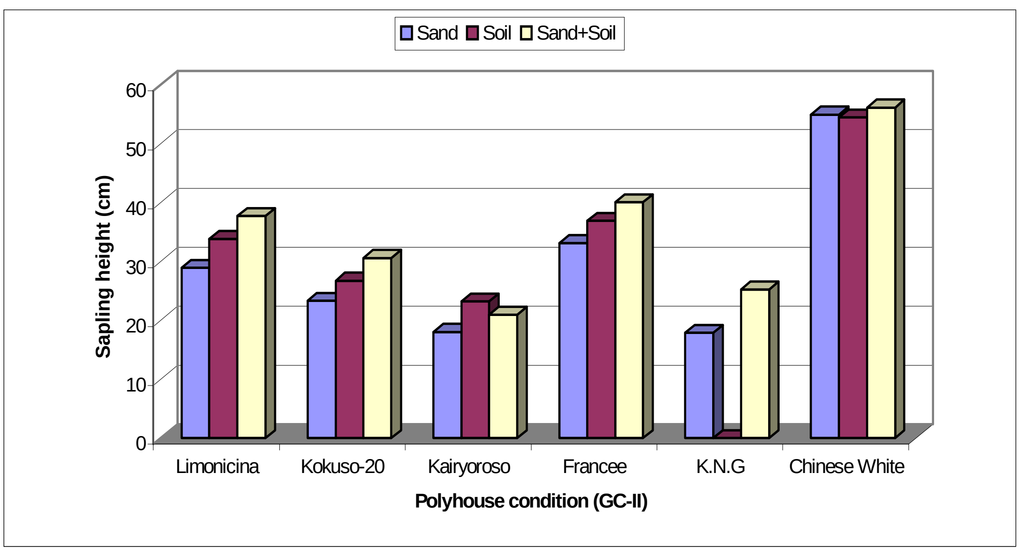


Fig 13: Effect of growing condition and media on height of sapling (cm) of different mulberry genotypes

The data presented in the table 12.1 revealed that significantly maximum length of primary root i.e. 23.31 cm, was recorded with the treatment combination Chinese-white x Sand which was statistically at par with Francee x Sand, Kokuso-20 x Sand and Limoncina x Sand.

4.2.4 Height of sapling

The data presented in table 13 showed significant variations on the sapling height of mulberry genotypes as a result of different treatments.

Chinese-white (check) cultivar recorded significantly higher sapling height i.e. 50.39 cm over other cultivars. However, amongst the other five test cultivars Francee and Limoncina recorded significantly higher sapling height of 32.64 cm and 30.33 cm, over other genotypes, respectively.

As regards the effect of growing conditions under polyhouse significantly taller sapling with 31.26 cm were produced compared to saplings grown under natural conditions with 25.85 cm (Plate No. 6).

The data further indicated that out of the three media sand + soil recorded significantly higher sapling height of 33.00 cm compared to other growing media, Soil medium recorded 26.51 cm and sand medium 26.17 cm taller saplings.

Table 13.1:Interaction effect for height of sapling (cm) between variety and media

Treatment	Sand	Soil	Sand + Soil
Limoncina	26.21 (5.16)	30.19 (5.54)	34.31 (5.90)
Kokuso-20	20.29 (4.56)	24.50 (5.00)	28.60 (5.38)
Kairyoroso	16.63 (4.14)	21.21 (4.66)	24.60 (5.01)
Francee	28.66 (5.40)	32.44 (5.74)	35.98 (6.04)
K.N.G	15.50 (4.00)	0.00 (0.71)	23.70 (4.92)

…contd..

Table 14: Effect of growing condition and media on number of leaves of different mulberry genotypes

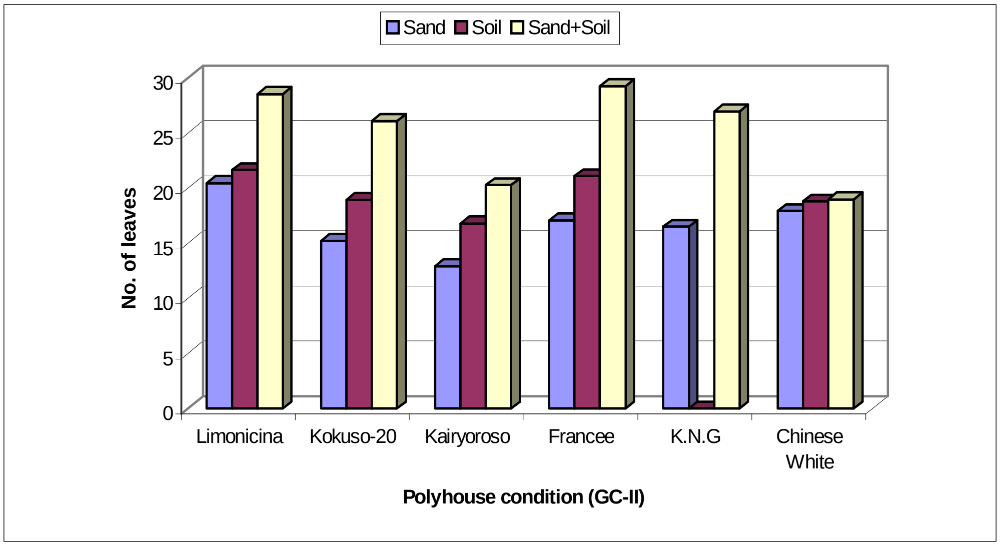
Varieties	Natural condition (GC-1) Sand (M_1)	Soil (M_2)	Sand + Soil (M_3)	Polyhouse condition (GC-II) Sand (M_1)	Soil (M_2)	Sand + Soil (M_3)	Varietal mean
Limoncina	14.83	15.43	21.85	20.48	21.64	28.55	20.46
	(3.91)	(4.00)	(4.73)	(4.58)	(4.70)	(5.69)	(4.57)[a]
Kokuso-20	11.82	15.22	21.51	15.23	18.95	26.09	18.13
	(3.50)	(3.95)	(4.69)	(3.95)	(4.40)	(5.14)	(4.30)[bc]
Kairyoroso	10.67	13.61	17.18	12.94	16.80	20.27	15.24
	(3.31)	(3.75)	(4.18)	(3.66)	(4.14)	(4.55)	(3.94)[d]
Francee	11.63	14.67	20.56	17.06	21.09	29.28	19.04
	(3.48)	(3.89)	(4.58)	(4.19)	(0.70)	(5.44)	(4.40)[a]
K.N.G	12.08	0.00	22.53	16.50	0.00	26.98	13.01
	(3.52)	(0.70)	(4.79)	(4.11)	(0.70)	(5.21)	(3.67)[e]
*Chinese-white	12.00	14.85	16.88	17.93	18.80	19.00	16.60
	(3.53)	(3.91)	(4.16)	(4.30)	(4.38)	(4.41)	(4.11)[cd]

Mean for Sand (M_1) = 14.43 (3.83)[b]   Mean for Soil (M_2) = 14.82 (3.91)[b]   Mean for Sand + Soil (M_3) = 23.13 (4.83)[a]

Mean for Natural condition (GC-I) = 15.22 (3.95)[b]   Mean for Polyhoue condition (GC – II) = 19.69 (4.46)[a]

		C.D (p=0.05)	SEm±			C.D (p=0.05)	SEm±
Variety (V)	=	0.19	0.08	V x M	=	0.37	0.17
Media (M	=	0.14	0.07	V x GC	=	N.S	
Growing condition (GC)	=	0.11	0.05	M x GC	=	N.S	
*Check				V x M x GC	=	N.S	

Note: Values in parentheses are $\sqrt{x+0.5}$ (sq root) transformation values: means followed by similar letter(s) are statistically identical



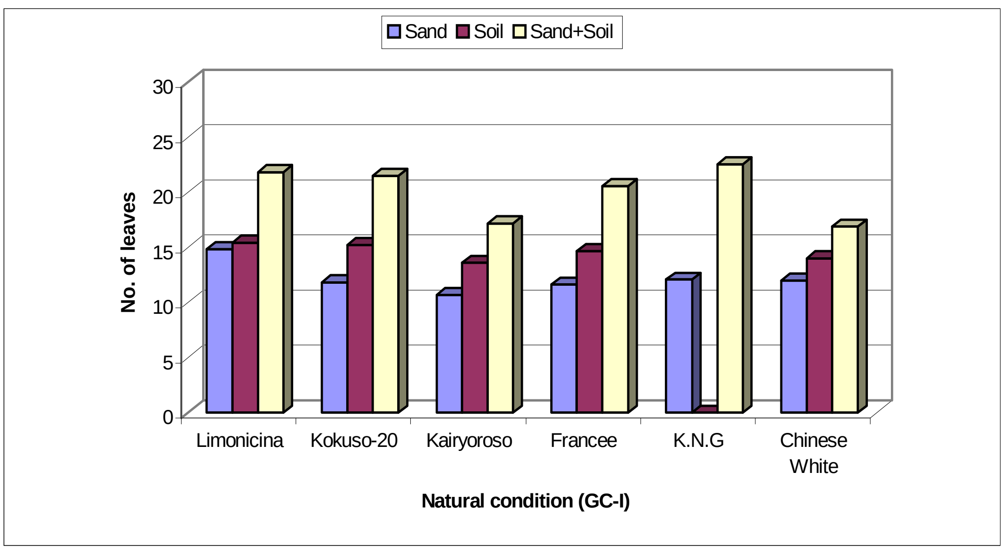


Fig 14: Effect of growing condition and media on number of leaves of different mulberry genotypes

Chinese-white	44.92	47.66	49.62
	(6.74)	(6.94)	(7.08)
SE m±		0.21	
CD (p=0.05)		0.43	

The data depicted in the (Table 13.1) showed significantly highest height of sapling i.e.49.62 cm with treatment combination Chinese-white x Sand + soil.

4.2.5 Number of leaves

Number of leaves were markedly influenced by different treatments (table 14). The number of leaves were highest i.e. 20.46 in Limoncina followed by Francee with 19.60 and Kairyoroso with 15.24. The minimum number of leaves were recorded in KNG with 13.01. Limoncina and Francee were statistically at par among themselves but significantly superior to other varieties in respect of number of leaves.

A reference to the data (Table 14) further revealed that the cuttings grown under polyhouse produced significantly more number of leaves i.e 19.69 compared to their growing under natural conditions being 15.22.

As regards the effect of growing media, the cuttings grown in sand + soil produced significantly highest number of leaves i.e. 23.13 compared to their growing in soil with 14.82 or sand with 14.43. On percentage basis, cuttings grown in sand + soil recorded an increase of 60.29 and 56.07 percent leaves over those grown in sand and soil media, respectively.

Table 14.1: Interaction effect for number of leaves between variety and media

Treatment	Sand	Soil	Sand + Soil
Limoncina	17.47	21.77	28.44
	(4.24)	(4.72)	(5.38)
Kokuso-20	13.41	16.97	23.70
	(3.73)	(4.18)	(4.92)
Kairyoroso	11.68	15.10	18.60
	(3.49)	(3.95)	(4.37)
Francee	14.16	17.73	24.70
	(3.83)	(4.27)	(5.02)
K.N.G	14.09	0.00	24.50
	(3.82)	(0.71)	(5.00)

…..contd

Table 15: Effect of growing condition and media on weight of leaves (g) of different mulberry genotypes

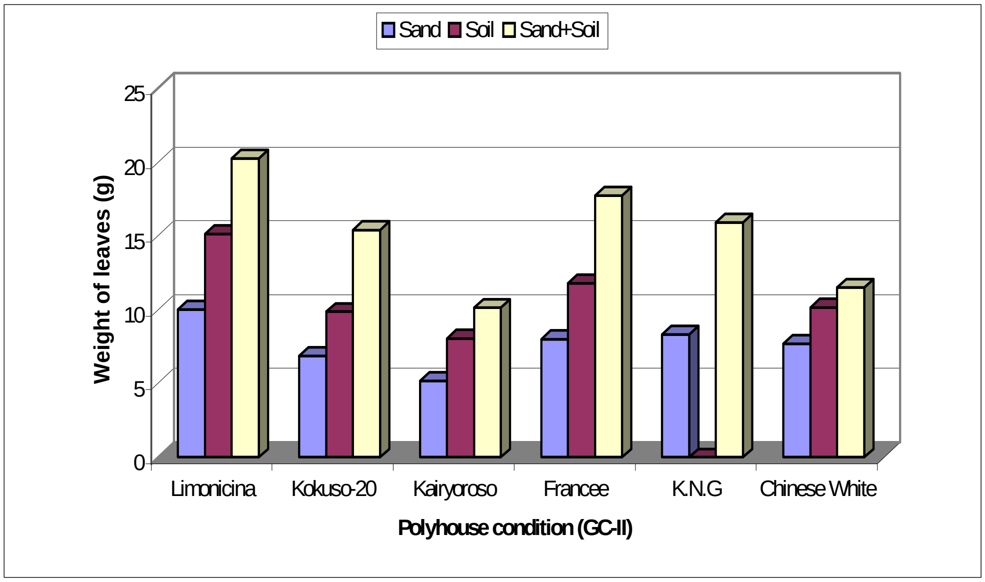
Varieties	Natural condition (GC-1)			Polyhouse condition (GC-II)			Varietal mean
	Sand (M_1)	Soil (M_2)	Sand + Soil (M_3)	Sand (M_1)	Soil (M_2)	Sand + Soil (M_3)	
Limoncina	5.95	10.88	14.67	10.03	15.12	20.25	12.81
	(2.53)	(3.36)	(3.89)	(3.24)	(3.95)	(4.55)	(3.60)^{a}
Kokuso-20	4.60	6.84	10.32	6.85	9.85	15.39	8.97
	(2.25)	(2.13)	(2.88)	(2.71)	(2.21)	(3.90)	(3.05)^{c}
Kairyoroso	3.62	5.71	7.90	5.17	8.06	10.13	6.76
	(2.02)	(2.48)	(2.89)	(2.38)	(2.92)	(3.28)	(2.66)^{e}
Francee	4.59	7.04	10.30	8.01	11.81	17.71	9.91
	(2.24)	(2.74)	(3.28)	(2.91)	(3.50)	(4.26)	(3.20)^{b}
K.N.G	4.59	0.00	11.49	8.33	0.00	15.91	6.72
	(2.33)	(0.70)	(3.46)	(2.98)	(0.70)	(4.00)	(2.56)^{e}
*Chinese-white	4.55	6.68	7.93	7.70	10.15	11.50	8.08
	(2.24)	(2.67)	(2.90)	(2.86)	(3.26)	(3.46)	(2.90)^{d}

Mean for Sand (M_1) = 6.19 (2.56)^{c} Mean for Soil (M_2) = 7.67 (2.85)^{b} Mean for Sand + Soil (M_3) = 12.79 (3.62)^{a}

Mean for Natural condition (GC-I) = 7.11 (2.73)^{b} Mean for Polyhoue condition (GC – II) = 10.66 (3.23)^{a}

		C.D (p=0.05)	SEm±			C.D (p=0.05)	SEm±
Variety (V)	=	0.12	0.05	V x M	=	N.S	
Media (M	=	0.09	0.04	V x GC	=	0.14	0.06
Growing condition (GC)	=	0.07	0.03	M x GC	=	N.S	
*Check				V x M x GC	=	N.S	

Note: Values in parentheses are $\sqrt{x+0.5}$ (sq root) transformation values: means followed by similar letter(s) are statistically identical



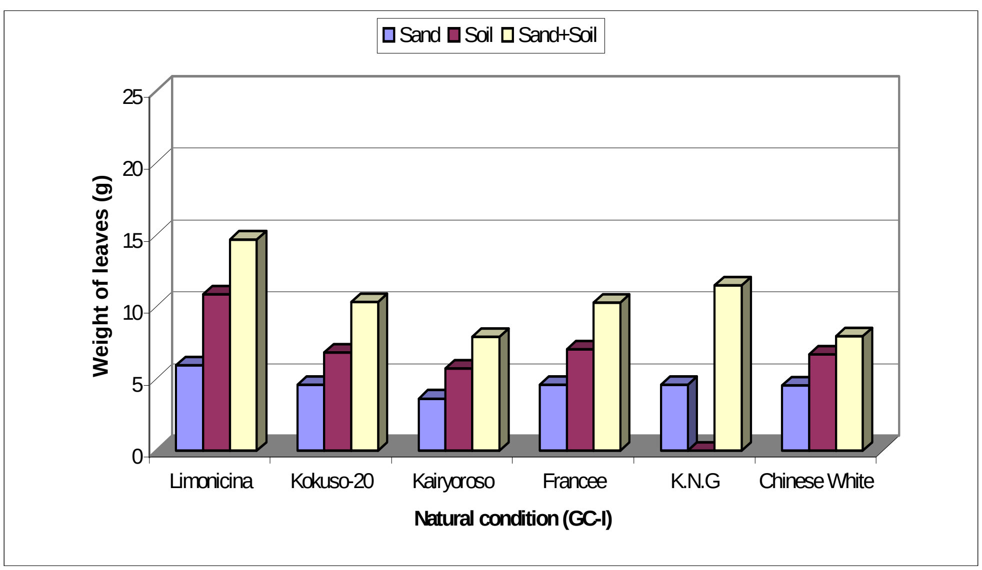


Fig 15: Effect of growing condition and media on weight of leaves (g) of different mulberry genotypes

Chinese-white	14.78 (3.91)	16.72 (4.15)	17.90 (4.29)
SE m±	0.17		
CD (p=0.05)	0.37		

The data (Table 14.1) revealed significantly interaction effect for number of leaves between variety x media and height number of leaves i.e. 28.44 with the treatment combination Limoncina x Sand + Soil, being statistically at par with treatment combination, Francee x Sand + Soil with 24.70.

4.2.6 Weight of leaves

The data (table 15) indicated a marked influence of different treatments on the weight of leaves. While comparing the weight of leaves in different genotypes it was found that barring KNG and Kairyoroso varieties, the check variety revealed significantly lowest weight of leaves i.e. 8.08 g.

Amongst the test genotypes, significantly highest weight of leaves i.e. 12.81 g was recorded in Limoncina followed by Francee with 9.91 g and Chinese-whit with 8.08 g, while the lowest weight of leaves i.e 6.72 g was recorded in K.N.G variety.

Perusal of the data (table 15) further revealed that cuttings grown under polyhouse produced significantly higher weight of leaves i.e. 10.66 g compared to those grown under natural condition with 7.11 g.

Regarding the effect of different media it was observed from the data that leaf weight of the cuttings grown in sand + soil medium was 12.79 g, being significantly higher over the leaf weight recorded in soil with 7.67 g and sand with 6.19 g.

Table 15.1:Interaction effect between variety x growing condition on weight of leaves (g)

Treatment	Natural (GCI)	Polyhouse (GC-II)
Limoncina	10.19 (3.27)	15.10 (3.95)
Kokuso-20	6.00 (2.55)	10.39 (3.30)
Kairyoroso	5.60 (2.47)	7.67 (2.86)

Contd…

Table 16: Effect of growing condition and media on internodal distance (cm) of different mulberry genotypes

Varieties	Natural condition (GC-1)			Polyhouse condition (GC-II)			
	Sand (M_1)	**Soil (M_2)**	**Sand + Soil (M_3)**	**Sand (M_1)**	**Soil (M_2)**	**Sand + Soil (M_3)**	**Varietal mean**
Limoncina	1.58	1.44	1.24	1.45	1.35	1.18	1.38
	(1.44)	(1.40)	(1.31)	(1.40)	(1.36)	(1.30)	(1.37)[e]
Kokuso-20	1.56	1.48	1.22	1.48	1.41	1.18	1.38
	(1.43)	(1.41)	(1.31)	(1.41)	(1.39)	(1.30)	(1.37)[c]
Kairyoroso	1.53	1.45	1.32	1.39	1.26	1.32	1.38
	(1.42)	(1.40)	(1.37)	(1.38)	(1.32)	(1.34)	(1.37)[c]
Francee	2.13	1.95	1.58	1.94	1.75	1.38	1.78
	(1.62)	(1.57)	(1.44)	(1.57)	(1.50)	(1.37)	(1.51)[b]
K.N.G	1.13	0.00	0.99	1.08	0.00	0.97	0.69
	(1.28)	(0.71)	(1.20)	(1.26)	(0.71)	(1.21)	(1.10)[d]
*Chinese White	3.53	3.06	2.85	3.06	2.90	2.91	3.05
	(2.00)	(1.89)	(1.82)	(1.89)	(1.84)	(1.84)	(1.88)[a]

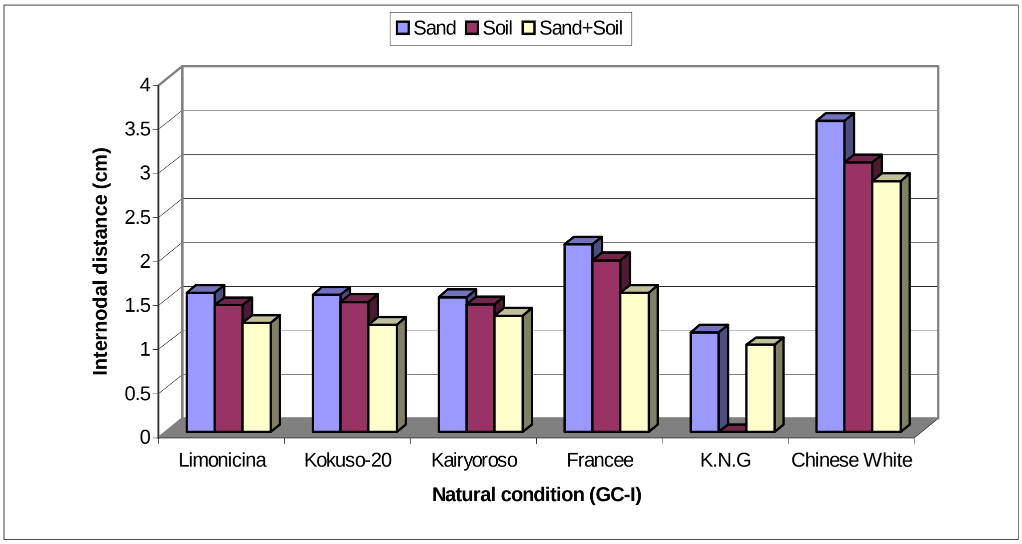
Mean for Sand (M_1) = 1.82 (1.52)[a] Mean for Soil (M_2) = 1.50 (1.40)[b] Mean for Sand + Soil (M_3) = 1.52 (1.42)[b]

Mean for Natural condition (GC-I) = 1.67 (1.44)[a] Mean for Polyhoue condition (GC – II) = 1.54 (1.41)[b]

		C.D (p=0.05)	**SEm±**			**C.D (p=0.05)**	**SEm±**
Variety (V)	=	0.04	0.02	V x M	=	0.08	0.04
Media (M	=	0.03	0.02	V x GC	=	N.S	
Growing condition (GC)	=	0.02	0.01	M x GC	=	N.S	
				V x M x GC	=	N.S	

*Check

Note: Values in parentheses are $\sqrt{x+0.5}$ (sq root) transformation values: means followed by similar letter(s) are statistically identical



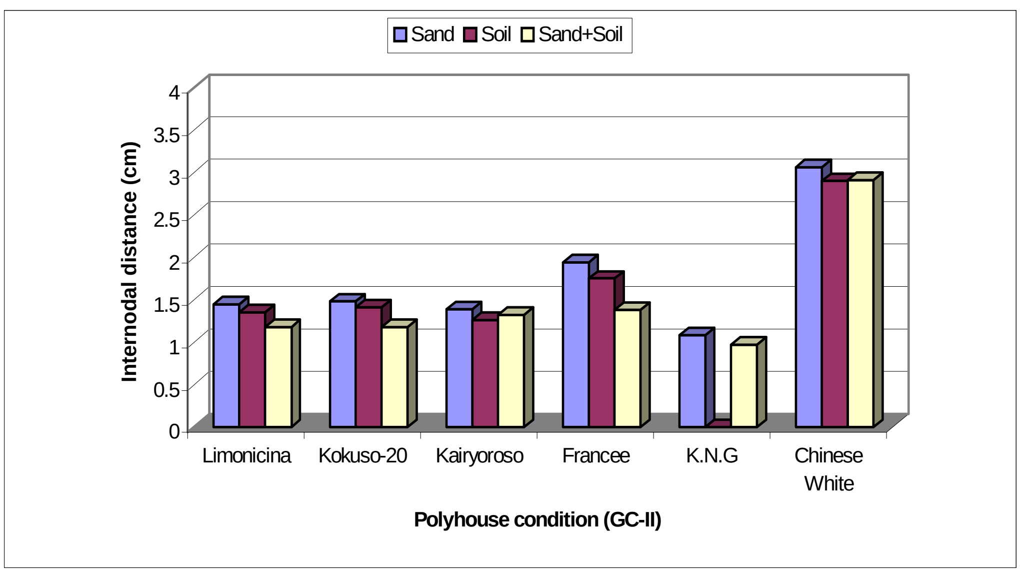


Fig 16: Effect of growing condition and media on internodal distance of different mulberry genotypes

Francee	7.11 (2.76)	12.17 (3.56)
K.N.G	4.20 (2.17)	6.05 (2.56)
Chinese-white	6.31 (2.61)	9.74 (3.20)
SE m±	0.06	
CD (p=0.05)	0.14	

Significantly maximum weight of leaves 15.10 g (Table 15.1) was recorded by the treatment combination Limoncina x polynouse. However, it was statistically at par with treatment combination Francee x Polyhouse and Chinese-white x Polyhouse.

4.2.7 Inter-nodal distance

The inter-nodal distance of mulberry cuttings showed marked variations under different treatments (table 16).

No doubt, significantly higher inter nodal distance of 3.05 cm was recorded in Chinese white cultivar (check) but amongst other five test cultivars the highest value of inter-nodal distance of 1.78 cm was observed in Francee while the lowest inter-nodal distance of 0.69 cm was found in KNG.. However the internodal distance in test cultivars varied from 0.69 to 1.78 cm.

The data also revealed that cuttings grown in polyhouse produced internodal distance of 1.54 cm compared to 1.69 cm under natural conditions.

Regarding the effect of growing media on the inter-nodal distance, it is evident that mean inter-nodal distance was maximum i.e.1.82 cm in the cuttings grown in sand and minimum of 1.50 cm in cuttings grown in soil medium.

Table 16.1: Interaction effect for internodal distance between variety and media

Treatment	Sand	Soil	Sand + Soil
Limoncina	1.52 (1.42)	1.40 (1.38)	1.27 (1.33)
Kokuso-20	1.48 (1.41)	1.43 (1.39)	1.19 (1.30)
Kairyoroso	1.46 (1.40)	1.35 (1.36)	1.35 (1.36)
Francee	2.02 (1.59)	1.84 (1.53)	1.46 (1.40)

Contd..

Table 17 :Effect of growing condition and media on biomass upperground (g) of different mulberry genotypes

Varieties	Natural condition (GC-1)			Polyhouse condition (GC-II)			Varietal mean
	Sand (M_1)	Soil (M_2)	Sand + Soil (M_3)	Sand (M_1)	Soil (M_2)	Sand + Soil (M_3)	
Limoncina	19.75	24.85	33.12	26.70	32.60	41.47	29.74
	(4.49)	(5.03)	(5.79)	(5.21)	(5.75)	(6.47)	$(5.46)^{a}$
Kokuso-20	15.37	19.75	27.81	19.64	24.40	33.52	23.41
	(3.98)	(4.49)	(5.32)	(4.48)	(4.98)	(5.88)	$(4.85)^{b}$
Kairyoroso	13.76	17.52	22.07	16.62	21.55	25.94	19.57
	(3.77)	(4.24)	(4.75)	(4.13)	(4.69)	(5.14)	$(4.45)^{c}$
Francee	18.11	22.93	32.23	23.11	32.18	43.33	28.65
	(4.31)	(4.84)	(5.72)	(4.86)	(5.71)	(6.62)	$(5.40)^{a}$
K.N.G	15.61	0.00	29.24	21.20	0.00	34.75	16.72
	(3.95)	(0.70)	(5.45)	(4.65)	(0.70)	(5.93)	$(4.10)^{d}$
*Chinese-white	19.26	28.78	31.92	26.55	30.75	34.70	28.66
	(4.47)	(5.41)	(5.70)	(5.20)	(5.59)	(5.93)	$(5.40)^{a}$

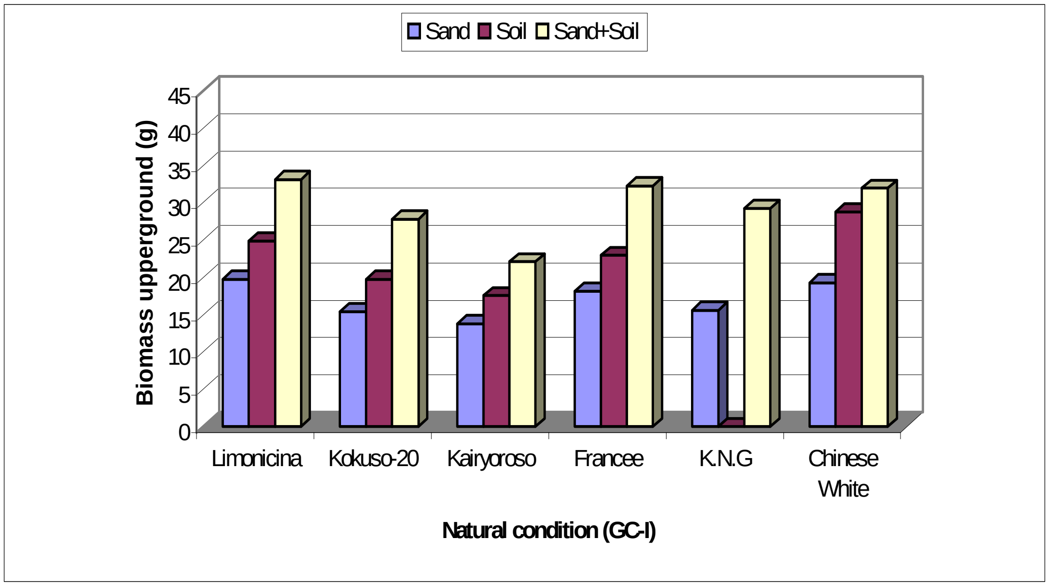
Mean for Sand (M_1) = 19.49 $(4.44)^{c}$ Mean for Soil (M_2) = 20.00 $(5.42)^{b}$ Mean for Sand + Soil (M_3) = 30.76 $(5.57)^{a}$

Mean for Natural condition (GC-I) = 20.73 $(4.47)^{b}$ Mean for Polyhoue condition (GC – II) = 26.11 $(5.14)^{a}$

		C.D (p=0.05)	SEm±			C.D (p=0.05)	SEm±
Variety (V)	=	0.07	0.03	V x M	=	0.13	0.06
Media (M	=	0.05	0.02	V x GC	=	0.11	0.05
Growing condition (GC)	=	0.04	0.02	M x GC	=	0.08	0.04
				V x M x GC	=	N.S	

*Check

Note: Values in parentheses are $\sqrt{x+0.5}$ (sq root) transformation values: means followed by similar letter(s) are statistically identical



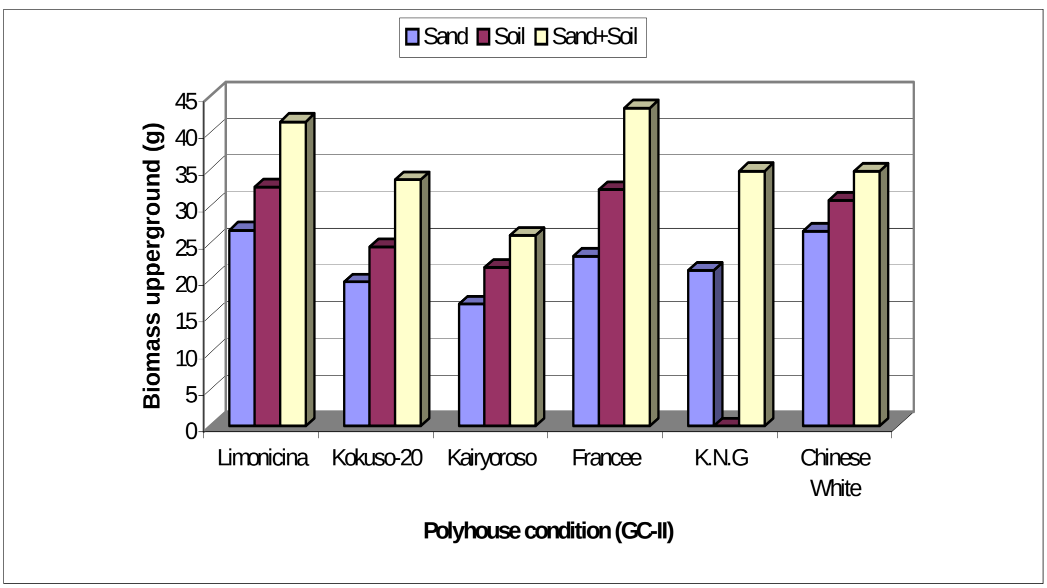


Fig 17: Effect of growing condition and media on bio-mass upper-ground (g) of different mulberry genotypes

K.N.G	1.11 (1.27)	0.00 (0.71)	0.96 (1.21)
Chinese-white	3.26 (1.94)	2.95 (1.86)	2.74 (1.80)
SE m±		0.04	
CD (p=0.05)		0.08	

The data depicted in table 16.1 showed that internodal distance was significantly highest (3.26 cm) with interaction Chinese-white (check) x Sand medium while it was significantly lowest with KNG x Soil medium of (0.00 cm). However, amongst the tested varieties Francee x Sand medium recorded significantly highest internodal distance of 2.02 cm.

4.2.8 Biomass (Upperground)

Comparing upper ground biomass production of tested varieties, the data (table 17) revealed that Limoncina produced the highest biomass of 29.74 g followed by Francee with 29.00 g, Chinese white with 25.36 g, Kokuso-20 with 23.41 g, Kairyoroso with 19.57 g and KNG with 16.72 g. However, Limoncina and Francee were statistically at par among themselves in respect of upper ground biomass.

The data further indicated that biomass production under polyhouse condition with 26.11 g being significantly higher compared to natural condition with 20.73 g. As regards the effect of different growing media on the upper ground biomass production, it was observed that biomass production in sand + soil medium with 30.76 g being significantly higher than produced in soil with 20.00 g and sand with 19.49 g.

Table 17.1: Interaction effect for upper ground biomass (g) between variety and media

Treatment	Sand	Soil	Sand + Soil
Limoncina	23.11 (4.86)	28.55 (5.39)	37.19 (6.14)
Kokuso-20	17.39 (4.23)	21.96 (4.74)	30.63 (5.58)
Kairyoroso	15.18 (3.95)	19.48 (4.47)	24.00 (4.95)

Contd..

Francee	19.57	23.70	33.00
	(4.48)	(4.92)	(5.79)
K.N.G	18.07	0.00	31.87
	(4.31)	(0.71)	(5.69)
Chinese-white	22.92	25.71	27.37
	(4.84)	(5.12)	(5.28)
SE m±		0.06	
CD (p=0.05)		0.13	

Significantly maximum biomass upper ground 37.19 g was recorded with the treatment combination Limoncina x Sand + Soil (table 17.1).

Table 17.2:Interaction effect between variety x growing condition on upperground biomass (g)

Treatment	Natural (GCI)	Polyhouse (GC-II)
Limoncina	25.61	33.26
	(5.11)	(5.81)
Kokuso-20	20.67	25.51
	(4.60)	(5.10)
Kairyoroso	17.64	21.21
	(4.26)	(4.66)
Francee	21.21	29.53
	(4.66)	(5.48)
K.N.G	10.92	13.71
	(3.38)	(3.77)
Chinese-white	23.41	27.38
	(4.89)	(5.28)
SE m±	0.05	
CD (p=0.05)	0.11	

The interaction effect between variety and growing condition revealed that Limoncina grown under polyhouse significantly improved upperground biomass over other varieties by recording 33.26 g which was followed by Francee with 29.53 g, Chinese-white with 27.38 g. The lowest upper-ground biomass of 13.71 g under polyhouse was recorded by KNG and the same variety recorded lowest upperground biomass of 10.92 g under natural conditions.

Table 17.3: Interaction effect between upper-ground bio-mass between Media x growing conditions

Treatment	Natural condition	Polyhouse condition
Sand	16.63 (4.14)	22.16 (4.76)
Soil	15.42 (3.99)	19.49 (4.47)
Sand + Soil	27.70 (5.31)	33.38 (5.82)
SE m±	0.04	
CD (p=0.05)	0.08	

The results (Table 17.3) indicated that Sand + Soil medium under polyhouse condition recorded significantly highest upper-ground biomass of 33.38 g over other media and recorded 25 per cent increase over growing under natural condition. Significantly lower upperground biomass of 15.42 g was recorded with interaction soil medium under natural conditions which was 26.3 per cent lower over growing under polyhouse conditions.

4.2.9 Biomass (Underground)

The underground biomass production was highest i.e 1.27 g in Chinese-white (Table 18). But amongst the other cultivars Limoncina was at par with Francee and Kokuso-20 producing significantly more underground biomass of 1.17, 1.16 and 1.14 g, respectively.

The biomass underground under polyhouse condition was 1.27 g being significantly higher over that under natural condition with 0.88 g.

As regards the effect of growing medium on the underground biomass production it was found that sand media recorded significantly highest underground biomass of 1.45 g compared to those grown in sand + soil with 1.09 g and soil medium with 0.70 g.

Table 18: Effect of growing condition and media on biomass underground (g) of different mulberry genotypes

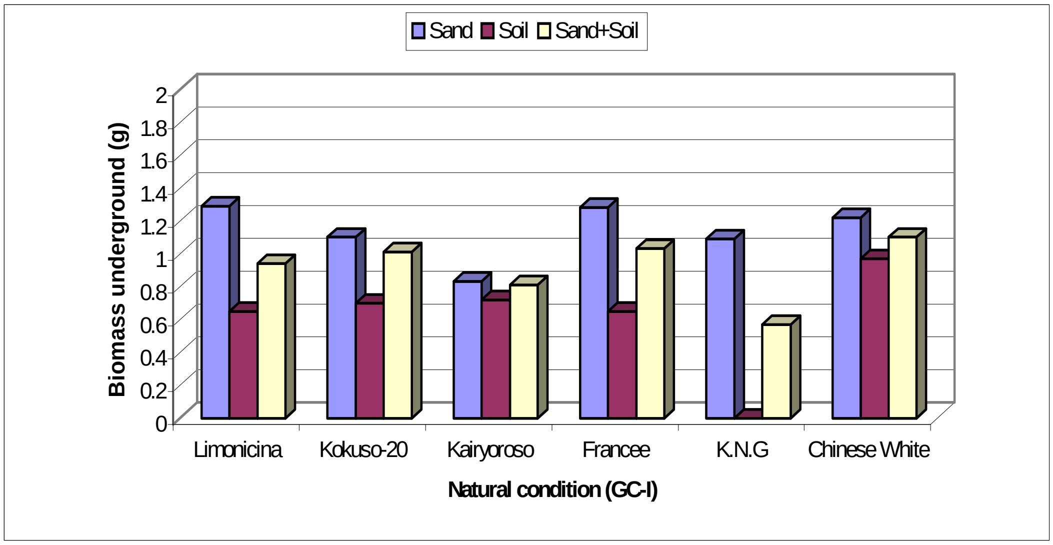
	Natural condition (GC-1)			Polyhouse condition (GC-II)			
Varieties	**Sand (M_1)**	**Soil (M_2)**	**Sand + Soil (M_3)**	**Sand (M_1)**	**Soil (M_2)**	**Sand + Soil (M_3)**	**Varietal mean**
Limoncina	1.29	0.65	0.94	1.87	0.97	1.35	1.17
	(1.33)	(1.07)	(1.19)	(1.53)	(1.21)	(1.35)	(1.28)[a]
Kokuso-20	1.10	0.70	1.01	1.75	0.91	1.37	1.14
	(1.26)	(1.08)	(1.22)	(1.55)	(1.18)	(1.36)	(1.28)[a]
Kairyoroso	0.83	0.72	0.81	1.45	0.86	1.10	0.96
	(1.15)	(1.10)	(1.14)	(1.39)	(1.16)	(1.26)	(1.20)[b]
Francee	1.28	0.65	1.03	1.85	0.95	1.31	1.16
	(1.33)	(1.07)	(1.26)	(1.53)	(1.20)	(1.35)	(1.28)[a]
K.N.G	1.09	0.00	0.57	1.84	0.0	1.16	0.77
	(1.25)	(0.70)	(1.03)	(1.52)	(0.70)	(1.28)	(1.08)[c]
*Chinese-white	1.22	0.97	1.10	1.85	1.02	1.35	1.27
	(131)	(1.21)	(1.26)	(1.53)	(1.23)	(1.36)	(1.32)[a]

Mean for Sand (M_1) = 1.45 (1.39)[a] Mean for Soil (M_2) = 0.70 (1.08)[c] Mean for Sand + Soil (M_3) = 1.09 (1.25)[b]

Mean for Natural condition (GC-I) = 0.88 (1.16)[b] Mean for Polyhoue condition (GC – II) = 1.27 (1.31)[a]

		C.D (p=0.05)	**SEm±**			**C.D (p=0.05)**	**SEm±**
Variety (V)	=	0.05	0.02	V x M	=	0.09	0.04
Media (M	=	0.04	0.02	V x GC	=	N.S	
Growing condition (GC)	=	0.03	0.01	M x GC	=	N.S	
*Check				V x M x GC	=	N.S	

Note: Values in parentheses are $\sqrt{x+0.5}$ (sq root) transformation values: means followed by similar letter(s) are statistically identical



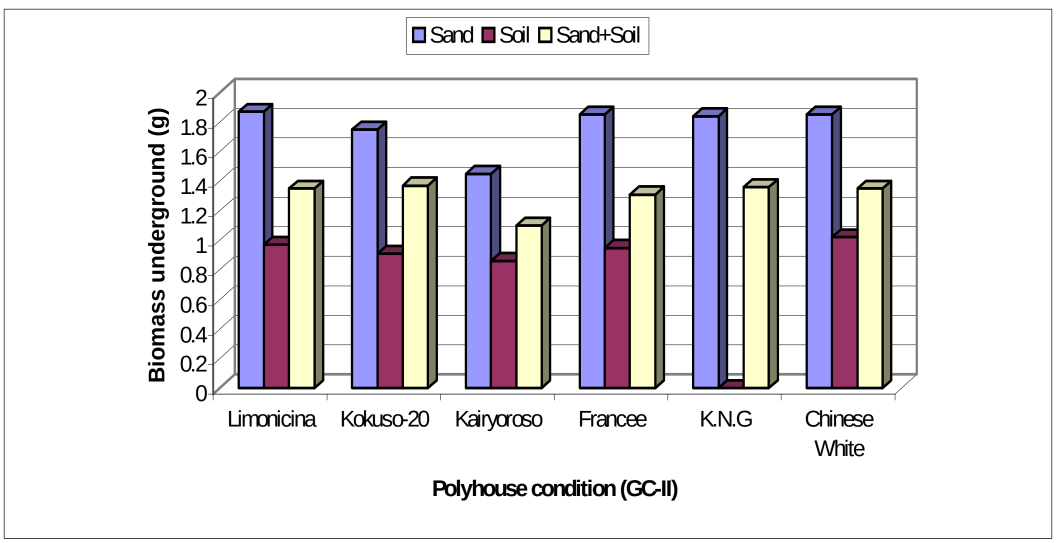


Fig 18: Effect of growing condition and media on biomass underground (g) of different mulberry genotypes

Table 18.1: Interaction effect for underground biomass (g) between variety and media

Treatment	Sand	Soil	Sand + Soil
Limoncina	1.54 (1.43)	1.13 (1.28)	1.48 (1.41)
Kokuso-20	1.48 (1.41)	0.79 (1.14)	1.16 (1.29)
Kairyoroso	1.11 (1.27)	0.77 (1.13)	0.94 (1.20)
Francee	1.49 (1.41)	0.79 (1.14)	1.21 (1.31)
K.N.G	1.43 (1.39)	0.00 (0.71)	0.84 (1.16)
Chinese-white	1.57 (1.44)	0.99 (1.22)	1.21 (1.31)
SE m±		0.04	
CD (p=0.05)		0.09	

From the perusal of data it is found that the interaction effect for underground biomass was significant between variety x media and the maximum underground biomass of 1.57 g was recorded with the treatment combination Chinese-white x Sand followed by 1.54 g for Limoncina x Sand, 1.49 g for Francee x Sand and 1.48 g for Kokuso-20 x Sand.

Chapter-5

DISCUSSION

The traditional method adopted for propagation of mulberry stock in the Kashmir region has been through root grafting. It takes around four years to develop a mulberry sapling by grafting method. In the first year, seed is sown in the seed beds and young seedlings are transplanted next year to develop the root stocks. In the third year, the stock-scion union is established and the saplings are raised. The process often ends with a low success. However, mulberry plants can be raised by cutting method with relative ease in the Kashmir valley. In view of short comings of grafting, an attempt to screen some of the existing mulberry cultivars for propagation through stem cuttings without any artificial treatment was made during present investigation.

5.1 Experiment-I

Influence of variety, position of cutting and growing conditions on rooting behaviour.

5.1.1 Rooting

During the present investigation it was found that rooting percentage increased significantly to 51.66 in Chinese-white being statistically at par with Francee, Limoncina and Kokuso-20. This could be attributed to the genetic make up of the variety. Stem or branch portion are generally very good material for rooting purpose, because they usually have undifferentiated tissues which may permit initiation of root primordia, and have buds already formed. There might be better availability of carbohydrates and nitrogen compounds in cuttings of Chinese-white, Francee, Limoncina and Kokuso-20. These findings are in conformity with findings of Susheelama *et al.*, (1992) who reported variable rooting percentage among the mulberry genotypes. The polyhouse condition recorded significantly higher rooting percentage 46.10 over natural conditions. The better maintenance of temperature and relative humidity could have contributed to the better rooting under controlled conditions (Hartmann *et al.,* 1997). These results find support from the findings of Anonymous (1985), Anonymous (2000b) and Munshi *et al.,* (2003) which reported higher percentage of rooting under polyhouse.

Amongst the three shoot positions the basal cuttings recorded significantly higher rooting percentage than middle and apical ones. Better performance of basal cuttings might be due to their more food material reserve status. It is known fact that because of more maturity and thickness, basal cuttings contain higher amount of carbohydrates and nitrogen compounds than middle and apical. These results are in close conformity with the findings of Honda (1972) ,Rodriguez and Gonzalez (1995) and Peer (2002) who reported highest percentage of rooting in basal cuttings of mulberry.

5.1.2 Average number of primary roots

During the present investigation it was found that there was no significant difference in the number of primary roots amongst the varieties barring K.N.G which could be attributed to the inherent constitution of the cultivars. These findings are supported by findings of Susheelama *et al.* (1990) who reported similar response of different mulberry varieties. The polyhouse growing condition was significantly superior to natural conditions in recording more number of roots. Alizhonov (1983) reported similar findings while propagating mulberry cuttings under plastic cover. Amongst the three shoot positions, the basal cuttings recorded significantly higher rooting percentage which could be due to the fact that the basal portion of the cuttings contain higher carbohydrate content thereby forcing more number of roots from the cuttings (Sadhu, 1999 and Shanmugavelu, 1975). These findings are also in close agreement with the results of Murakami (1980) who reported that amount of roots of the cuttings differed according to the parts of the shoots from which cuttings were made, also lower portion of the plants were found more suitable in producing large amount of roots than younger ones.

5.1.3 Length of primary roots

There were non-significant differences with respect to length of primary roots amongst the varieties, except K.N.G which could be due to the inherent constitution of the varieties. Basal cuttings recorded maximum length of primary root as compared to middle and apical. Similar results were obtained by Shanmagavelu (1975) in MR-2.

Cuttings rooted in polyhouse recorded significantly maximum length of primary roots as compared to cuttings rooted in natural condition. Maximum length of primary root under polyhouse might be due to accelerated metabolic activity because higher temperature and relative humidity in polyhouse which resulted in more rapid growth of roots (Hartmann *et al.,* 1997).

5.1.4 Height of sapling

All the varieties exhibited significant difference in respect of height of sapling over KNG. Apart from Chinese-white serving as check, Francee recorded the highest sapling height, while KNG recorded lowest sapling height. The variation in the sapling height of the varieties could be attributed to the genetic constitution of the cuttings. Polyhouse conditions significantly increased the sapling height over natural conditions. The effect of favourable temperature and relative humidity available in polyhouse encouraged more root development as a result of which more absorption of nutrients and moisture could have favoured better growth of saplings. Similar findings were also reported by Singh *et al.,* (1999). The present investigation also revealed that maximum height of sapling was recorded in basal cuttings as compared to middle and apical cuttings. This maximum height of sapling recorded with basal cuttings could be due to better root system which in turn absorbed more nutrients along with moisture. These results corroborate with the findings of Kasivishwanathan and Iyenger (1967) in local mulberry variety and Peer (2002) in Chinese-white, Rokokuyaso and Goshoerami..

5.1.5 Number of leaves

Significant differences in number of leaves were observed during the study. Maximum number of leaves i.e. 5.91, was recorded by Limoncina followed by Chinese-white, Kokuso-20 and Francee. However, K.N.G recorded minimum number of leaves. The production of maximum number of leaves in Limoncina could be attributed to the shorter inter-nodal distance in the variety. The cuttings planted in polyhouse showed maximum number of leaves compared to natural conditions. This could be attributed to the fact that favourable temperature and relative humidity available in polyhouse resulted into active growth of the saplings in terms of height; thereby increasing the number of leaves.

Amongst the portions of the shoot tested, basal portion of shoot recorded maximum number of leaves as compared to middle and apical portions of shoots. The increase in number of leaves could be attributed to the fact that the inter-nodal distance was shorter in basal cuttings in comparison to middle and apical cuttings. Similar results were also reported by Kasivishvanathan and Iyenger (1967) in local mulberry cultivars.

5.1.6 Weight of leaves

Significant variation was observed in weight of leaves. Limoncina recorded significantly maximum weight of leaves followed by Francee, Kokuso-20 and Chinese-white. Better rooting characteristics in Limoncina provided better nutrition to the cultivars that might have resulted in more leaf weight in the variety. Further better penetration of sun light may have also contributed to more photosynthates resulting in more weight of leaves (Baghel *et al.*, 1993). The cuttings rooted in polyhouse recorded maximum weight of leaves compared to natural conditions. Better sapling height, minimum inter-nodal distance and more number of leaves obtained in polyhouse condition has contributed to the more weight of leaves. It was also found that cuttings from basal portions of shoot recorded significantly maximum weight of leaves compared to middle and apical cuttings. The more of weight of leaves in basal cuttings could be attributed to fact that basal cuttings accumulate more photosynthetic metabolites and nutrients in the leaves.

5.1.7 Internodal distance

Test varieties showed significant differences in respect of inter-nodal distance with KNG recording minimum inter-nodal distance followed by Limoncina, Kairyoroso, Kokuso-20 and Francee. Chinese-white recorded maximum inter-nodal distance. The cuttings planted in polyhouse condition registered minimum inter-nodal distance in comparison to natural conditions. It was also found that cuttings from basal portion of shoot recorded minimum inter-nodal distance closely followed by middle cuttings.

5.1.8 Biomass (upperground)

Significant variation in test varieties was observed in respect of upper-ground biomass. Maximum upper-ground biomass was recorded by Limoncina followed by Francee, Chinese-white and Kokuso-20 in the decreasing order. Minimum bio-mass was recorded in KNG. The significant increase in the biomass, exhibited by Limoncina, could be due to maximum number and weight of leaves recorded by the said cultivar. There was significant increase in upper-ground bio-mass under polyhouse condition over natural condition. This could be attributed to the increased sapling height, shorter inter-nodal distance, more number and weight of leaves exhibited under controlled conditions. It was also found that cuttings rooted from basal portions of the shoot recorded significantly higher bio-mass compared to those rooted from middle and apical portions of shoot. The more accumulation of photosynthates at basal portion of shoot might have contributed to the increased upperground biomass of the cuttings. The results get support from Murakami (1980) who also reported maximum biomass in the saplings raised from the lower portions of shoots.

5.1.9 Biomass (underground)

Francee and Limoncina cultivars produced significantly more under-ground bio-mass compared to other cultivars. Among other factors responsible, the length and diameter of the root would have contributed to the more underground biomass of the cultivars. The superiority of polyhouse condition over natural condition as observed in the findings may be due to better maintenance of temperature and relative humidity to the cultivars under the condition. Further, superiority of saplings from basal cuttings with regard to underground biomass resulted from more rooting percent and more number and length of roots. Similar results were observed by Murakami (1980) in local mulberry variety and Peer (2000) in Chinese-white, Rokokuyaso and Goshoerami varieties of mulberry.

5.2 Experiment-II

Influence of variety, growing conditions and media on rooting behaviour.

5.2.1 Rooting

During the present investigation there was significant variation for rooting percentage in the cultivars and Chinese-white far excelled in this context. The highest percentage of survival in case of Chinese-white is probably due to its exotic origin and has been maintained under tropical conditions and higher survival rate might be due to its exotic origin (Goel, *et al.* 1998). Chinese-white recording highest percentage of rooting also gets support from the findings of Baksh *et al.,* (1995 b) who recorded more than 50% rooting in the said cultivar. The growing conditions significantly varied with regard to rooting percent and polyhouse growing marked superiority over natural conditions as a matter of fact the congenial growth factors like temperature, humidity and moisture were available to the cultivars under such controlled conditions resulting in more percentage of roots over natural condition. Similar findings have been reported earlier by Das *et al.,* (1987) who got encouraging results while studying the rooting behaviour of tropical cultivars both under natural and polyhouse conditions. These results also find support from the findings of Alizhonov (1983) and Shanmugavelu (1975). It was also found that sand medium recorded higher rooting percentage over other growing media. The most probable reasons for maximum percentage of success and survival of cuttings in sand medium may be due to excellent drainage, absence of spores of roting disease causal agents and more friability with more aeration, resulting in better availability of moisture in the rooting zone and better penetration and proliferation of roots. These results also find support from the findings of John *et al.,* (2000).

5.2.2 Number of primary roots

Genotypes vary greatly in their genetic make-up and thus show variations in their rooting behaviour, rooting characteristics viz; root length, rooting depth. In this investigation the genotype Chinese-white recorded more number of primary roots over other genotypes. These results are in conformity with those of Gupta (1980) and Fotedar *et al.* (1990). The growing media plays an important role in altering the rooting characteristics of a variety. The proliferation of primary roots is more in loose soil compared to compact soil. In the present investigation the number of primary roots were significantly higher in sand compared with soil or sand + soil media. This could be attributed to the easy penetration of roots in sand medium. Similar findings were also reported by Paul and John (1992) in the rooted cuttings of ornamentals.

Maintenance of optimum temperature and relative humidity has a favourable effect on the growth and yield of the plants. Under the polyhouse condition the requisite temperature, moisture content is favourably maintained for the plant. The present investigation revealed that polyhouse growing condition was superior in increasing the number of primary roots of mulberry cuttings over natural growing conditions. These results could be attributed to the favourable soil temperature and better moisture availability to the cuttings under these conditions. These results corroborate with the findings of Alizhonov (1983).

5.2.3 Length of primary root

The present investigation revealed highest length of primary roots in Chinese-white closely followed by test cultivar Limoncina and Francee. This could be attributed to the genetic make up of the variety. Earlier Satpathy *et al.* (1995) have also reported similar findings. The significant increase in the root length of the cuttings grown in sand over soil and sand + soil media was observed during the investigation. The reason for longest root in sand medium could be that the root initiation may have started earlier in the cuttings in sand medium which might have resulted in longer roots in these cuttings. It was also found that cuttings grown under natural condition did not strike longer roots compared to those grown under polyhouse condition. The favourable soil temperature and optimum moisture level available to the growing roots might have increased their length under polyhouse conditions. This could probably be attributed to the fact that better aeration to the roots in sand prevented any rotting leading to more penetration in the medium.

5.2.4 Height of sapling

Significant variations amongst the test varieties were observed with respect to sapling height. The maximum height of 32.64 cm recorded by Francee could be attributed to more food reserve material available in the variety as well genetic make up. Similar findings have also been made earlier by Tikader *et al.* (1996). The cuttings raised under polyhouse condition recorded significantly higher sapling height over those grown under natural condition. Earlier Peer (2002) also reported significant increase in the sapling height of cuttings under polyhouse. The increase in the sapling height under polyhouse condition could be attributed to the effect of favourable temperature and relative humidity to the cuttings which encouraged better increase in their height. The growing media marked significant variations in the sapling height of the cuttings and sand + soil medium recorded the maximum sapling height of 33 cm. Earlier Baghel and Saraswat (1988) recorded maximum shoot length of 32.27 cm of pomegranate cuttings planted in soil + FYM medium which was closely followed by sand + soil medium with 24.66 cm. The increase in the sapling height under sand + soil media could be attributed to better retention of water in the said medium, hence the better availability of nutrients to the growing saplings.

5.2.5 Number of leaves

Number of leaves showed a significant variation with different varieties. Limoncina recorded maximum number of leaves followed by Francee and Kokuso-20. Maximum number of leaves in Limoncina was because of the shorter inter-nodal distance in the said cultivar. However K.N.G recorded the lowest internodal distance but number of leaves was less because of the death of buds, which could be due to its poor root development. Further K.N.G had a lowest sapling height as well. Earlier Baghel and Saraswat (1988) also observed only 49.69% success in semi hardwood cuttings of pomegranate which had about 91% sprouting leading finally to the decrease in the number of leaves. It was also found that cuttings grown under polyhouse condition produced more leaves compared to natural conditions. This could be attributed to the favourable effects of the temperature and relative humidity available to the cuttings under the conditions.

The sand + soil medium produced significantly more leaves in the cuttings compared to sand and soil media. This could be attributed to the better supply of nutrients to the cuttings grown in sand + soil medium due to better retention of moisture resulting in emergence of leaves from most of the buds. These findings are supported by the observation of Yadav and Goswami (1993) who reported that most effective media to propagate *Persea bombycina* is sand + soil + FYM (1:1:1), if number of newly originated leaves per shoot are under consideration.

5.2.6 Weight of leaves

A significant difference was recorded in respect of weight of leaves in different genotypes, being maximum in Limoncina followed by Francee and Kokuso-20. The increase in weight of leaves might be due to higher accumulation of photosynthates due to better nutrition and better photosynthesis. Earlier Peer, (2002) has also recorded similar findings. Chakarvorty and Borgohain (2000) also recorded similar findings when they observed significantly higher weight in JRH variety of mulberry. It was also found that cuttings grown under polyhoue condition produced significantly more leaf weight compared to natural condition. This could be attributed to better nutrition to the cuttings under controlled conditions resulting in more leaves. It was also observed that growing medium of sand + soil recorded significantly higher leaf weight compared to both sand and soil media. The better retention of moisture in sand + soil medium and thereby better nutrient supply to the growing cuttings might have contributed to the increase in the leaf weight.

5.2.7 Inter-nodal distance

Inter-nodal distance is a genetic character in the genotypes and is almost unaffected by the treatments. In the present investigation although Chinese-white cultivar recorded the highest internodal distance followed by Francee. However, the lowest inter-nodal distance was recorded in KNG. The variation in genetic make up of varieties might have contributed to the variation in the inter-nodal distance of different cultivars. It was also found that under polyhouse condition the inter-nodal distance was lower compared to natural conditions. However this variation in the inter-nodal distance under the two growing conditions is almost negligible. Similar results have also been observed by Peer, (2002).

Growing media exerted very little influence on the internodal distance of cuttings, however sand medium recorded higher values for internodal distance over other media. As a matter of fact, the inter-nodal distance is a genetic character with the cultivar and better environment to the cultivars in sand + soil medium might have contributed to retain their inter-nodal character.

5.2.8 Biomass (upperground)

The biomass production depends largely upon growth characters and yield contributing characters of the genotypes. In the present study it was found that Limoncina produced significantly maximum upper-ground biomass. This could be attributed to the better sapling height, number of leaves and leaf weight. Limoncina produced maximum number of leaves, recorded maximum leaf weight and also longer sapling height. All these factors helped to increase the biomass of the cultivar.

The investigation also indicated higher biomass production of the cuttings grown under polyhouse conditions in comparison to the natural conditions. This could be attributed to the overall affect of sapling height, number of leaves and weight of leaves which were found significantly higher in the cuttings grown under polyhouse because of higher average temperature and relative humidity.

The findings also revealed higher bio-mass production in the cuttings in sand + soil medium over those grown in soil and sand media. Better performance of cuttings for shoot characteristics could be due to their more food reserve status. Baghel and Saraswat (1988) also reported better performance and more dry matter percentage in the pomegranate cuttings in soil + FYM medium.

5.2.9 Biomass (underground)

In the present investigation the Chinese-white genotype far excelled in producing more under-ground biomass. However it was closely followed by the tested varieties viz; Limoncina, Francee and Kokuso-20. The increased under-ground biomass production observed in the genotypes could be attributed to the more primary roots and better length of the primary roots. It was also found that cuttings grown under polyhouse condition recorded higher under-ground biomass compared to natural conditions. The more bio-mass production in the polyhouse might be due to availability of favourable temperature and relative humidity necessary for root initiation and their development (Hartman *et al.* 1997). These results are in close conformity with the results of Anonymous (2000c) which reported higher rooting percentage under polyhouse.

Present study further revealed more under-ground biomass production of the grown cuttings in sand medium compared to soil and sand + soil media. The probable reasons for this increase in bio-mass underground could be attributed to higher rooting percentage, higher root length and more root production in sand due to better root in sand medium penetration and root proliferation leading to higher biomass production.

Chapter-6

SUMMARY AND CONCLUSION

The investigation entitled "Screening of some promising temperate mulberry (*Morus* spp.) cultivars on the basis of their rooting behaviour using different media and growing conditions' was undertaken in the experimental Farm of the Division of Sericulture, Mirgund during 2002-03. The important findings made during the study are summarized as follows:

6.1 Effect of growing condition and shoot position

Amongst different cultivars Chinese-white serving as check, being at par with Limoncina and Francee, recorded significantly highest rooting percentage. Basal cuttings proved significantly superior to both middle and apical cuttings in producing more rooting percent and amongst growing conditions polyhouse for excelled over natural condition with regard to rooting percentage.

With regard to length of primary roots the varieties Chinese-white, Francee, Limoncina and Kokuso-20 were significantly at par among themselves but produced significantly higher length of primary roots over other varieties. The basal cutting recorded significantly higher primary roots over middle and apical cuttings. Growing under polyhouse proved better over natural condition in significantly increasing the length of primary roots. Further, the interaction effect between variety and shoot position was found to be significant.

With regard to underground biomas Francee produced significantly more underground biomass over other cultivars. Basal cutting proved significantly better over both middle and apical cuttings. Polyhouse condition was more favourable over natural conditions. The interaction effect between variety and shoot position was found significant.

Chinese White cultivar recorded significantly tallest saplings from the basal cuttings under polyhouse conditions. Similar results were also observed in case of internodal distance. As regards the number of leaves Limoncina, at par with Francee, produced significantly higher number of leaves from the basal cuttings grown under polyhouse. Similar results were also observed with regard to weight of leaves and upperground biomass.

6.2 Effect of growing condition and media

Chinese-white (check) cultivars proved significantly superior to other cultivars in rooting percentage though being statistically at par with Limoncina and Francee in this respect. Amongst different growing conditions the rooting percentage was significantly higher under polyhouse over natural condition. Sand medium encouraged significantly higher percentage of roots over both soil and sand + soil media.

All the cultivars were significantly superior to KNG with regard to the number of primary roots. Chinese-white recorded significantly highest number of primary roots. Polyhouse condition proved significantly superior to natural condition in the number of primary roots. Amongst these different media sand proved significantly better with regard to the number of primary roots. The interaction between variety and media was observed to be significant for this character. Similar findings were also made for the length of primary roots, however, in addition to KNG, Kairyoroso cultivar proved significantly inferior to others.

Chinese-white (check), statistically at par with Limoncina and Francee, recorded significantly more underground biomass over other cultivars. Polyhouse condition provided significantly more underground biomass over natural condition and sand medium proved significantly better over both soil and sand + soil media in this respect. Besides, the interaction effect between variety x media was found significant.

Sapling height was significantly highest with Chinese White (check). Amongst growing conditions, polyhouse significantly increased sapling height over natural conditions, while sand + soil medium provided significantly taller sapling over both sand and soil media. Further the interaction effect between variety and media was found significant with regard to sapling height.

All the varieties showed marked variation in inter-nodal distance. Limoncina cultivars produced significantly highest number of leaves. Amongst growing conditions polyhouse favoured significantly higher number of leaves over natural condition. Sand + soil medium was better over sand and soil media in producing significantly higher number of leaves. The interaction effect between variety and media was also found to be significant. Similar findings were also made with regard to the weight of leaves, however only the interaction between variety x growing condition was found significant.

With regard to the upperground biomass Limoncina though at par with Francee and Chinese-white recorded significantly more upperground biomass. Growing of cultivars under polyhouse in sand + soil medium gave significantly higher upperground biomass over natural condition and other media, respectively. The interaction effect between variety x media was found significant.

CONCLUSION

The investigation made it clear that the mulberry cultivars viz; Chinese-white, Limoncina and Francee exhibited better rooting characters when grown under polyhouse conditions. Besides sand medium proved superior to both sand + soil medium with regard to the rooting characteristics of the cultivars. However, for shooting characteristics sand + soil medium proved better over both soil and sand media. Again, the shooting characters of the cultivars were encouraging in basal cuttings over middle and apical cutting.

LITERATURE CITED

*Aleksandrove, A. 1988. Investigation on the rooting process in ripe mulberry cutting taken from various parts of over-wintered shoots. *Rasteniev Ani Nauki.* **25** (9) :86-93 [c.f. Plant Growth Regulator Abstracts, 1989, **15** (5) :827].

*Alizhonov, A. 1983. Mulberry propagation by softwood cuttings under plastic covers. *Shelk* **5** :5-6 (Ru). [c.f. Bibliography on mulberry 1900-1984, 1:483].

Anonymous, 1976. Comparative performance of different varieties of mulberry under rainfed conditions. *Annual Report* Central Silkworm Seed Station, Pampore, India. pp 42-43.

Anonymous, 1978. Vegetative propagation studies of mulberry. *Annual report.* Regional Sericulture Research Pampore, India. pp. 24-25.

Anonymous, 1985. Propagation of mulberry through cuttings in Kashmir. *Annual Report* Central Sericulture Research and Training Institute Pampore, India. pp. 59-76.

Anonymous, 1996. National Sericulture project, *Review Mission,* Dec. 6-13, p. 38.

Anonymous, 2000a. *Digest of Statistics,* Directorate of Economics and Statistics, Planning and Development Department Govt. of Jammu and Kashmir, Srinagar. p. 159.

Anonymous, 2000b. Influence of polyhouse on rooting behaviour of mulberry varieties. *Annual Report. Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Division of Sericulture*, Mirgund. pp. 47-49.

Anonymous, 2005a. Preparation of Technology Mission for India silk (TMIS) Document Centre Silk Board Ministry of Technology Govt. of India pp.3-4.

Anonymous, 2005b. Progress Report. Directorate of Sericulture Development Department Srinagar pp. 1-8.

Arteca, R.N. 1997. Rooting. In: Plant growth substances Principles and Applications. Pub. CBS Publishers and Distributors, New Delhi. pp. 127-143.

Baghel, B.S., Kirar, D.S., Nema, B.K. and Pandey, S.K. 1993. Effect of mechanical treatments and growth regulators on rooting and growth of seedless lemon (*Citrus lemon* Burm.) cuttings. *Indian Journal of Horticulture* **50** (3) : 219-233.

Baghel, B.S. and Saraswat, R.K. 1988. Effect of different rooting media on rooting and growth of hardwood semi-hardwood cuttings of pomegranate (*Punica granatum* L.), *Indian Journal of Horticulture* **46** (1) : 459-462.

Baksh, S. and Khan, M.A. 2001. New grafting techniques for quick raising of poor tooting mulberry varieties under temperate climatic conditions of Kashmir. Central Sericulture Research and Training Institute, Pampore, Publication. pp. 1-6.

Baksh, S., Mir, M.R. and Darzi, G.M. 1998. Testing of rooting ability of hardwood stem cuttings under natural field conditions. *Annual Report*, Central Sericulture Research and Training Institute, Pampore, India, pp. 20-21.

Baksh, S., Mir, M.R., Darzi, G.M. and Khan, M.A. 2000. Performance of hardwood stem cuttings of mulberry genotypes under temperate climatic conditions of Kashmir. *Indian Journal of Sericulture.* **39** (1):30-32.

Baksh, S., Singh, Y., Koul, S. and Mukherjee, P. 1995b. Comparative evaluation of mulberry genotypes for vegetative propagation through stem cuttings under sub-tropical conditions of Jammu and Kashmir State. Abstr., *Current Technology Seminar on Mulberry and Silkwom, Breeding and Genetics, Molecular Biology and Agronomy,* 20-22nd September, Central Sericulture Research and Training Institute, Pampore, India, pp. 14-19.

Baksh, S., Trag, A.R. and Khan, M.A. 1995a. Improvement of mulberry for sub-tropical and temperate regions of Jammu and Kashmir In. *Current Technology Seminar on Mulberry* and *Silkworm Breeding and Genetics, Molecular Biology and Agronomy,* Central Sericulture Research and Training Institute, Mysore, 20-22nd September, 1995. p 32.

Basu, R.N. and Gosh, S.K. 1974. Effect of nitrogen nutrition of stock plants of *Justicia gendarursa* L. on the rooting of cuttings. *Journal of Horticultural Science.* **49** : 245-254.

Bhat, G.G. and Hittalamani Shailaja. 1992. Colonel differences in mulberry (*Morus* spp.) for root growth parameters *Indian Journal of Sericulture* 31 **(1) :5-8.**

Bindroo, B.B., Fotedar, R.K. and Anil Dhar. 1996. Propagation of mulberry under sub-tropical conditions. *Indian Silk* , **34** (9): 11-15.

Bindroo, B.B., Tiku, A.K. and Javid, G.N. 1983. Studies on the propagation of mulberry under temperate climatic conditions part-I propagation through hardwood cuttings. *In National Seminar on Silk Research and Development, Bangalore,* India. p. 108.

Bindroo, B.B., Tiku, A.K. and Pandit, R.K. 1988. Response of Japanese mulberry varieties propagated through cuttings under Kashmir eco-climatic conditions, *Geobios,* New Report. **7** : 36-39.

Biswas, S. and Sengupta, K. 1993. Effect of hormones on the mulberry. A review *Sericologia* **33** (3) : 461-478.

Chakraborty, S. and Mukherjee, S.K. 1980. Effect of ringing, growth promoters and sucrose either singly or in combination on rooting of poor rooting mulberry variety (var. Kosen) *In: Proceedings of Sericulture Symposium and Seminar,* TNAU, Coimbatore pp. 73-77.

Chakravorty, R. and Borgohain, P.N. 2000. Identification of an improved mulberry variety suitable for North Eastern part of India. *Indian Journal of Sericulture* **39** (1) : 74-75.

Chandersheker, D.S., Radakrishnan, S., Sikdar, A.K., Datta, R.K. and Shetty, H.S. 1997. Effect of growth regulators on the propagation of S-36 mulberry cuttings. *Indian Forester.* **122** (6) : 525-527.

Cochran, W.G. and Cox, G.M. 1957, *Statistical Methods.* 2nd Edition. John Wiley and Sons, Inc. New York pp. 95-105.

Dandin, S.B. and Jolly, M.S. 1986. Mulberry descriptor *Sericologia* **26** (4) :465-475.

Das, B.C., Bindroo, B.B., Ticku, A.K. and Pandit, R.K. 1987. Propagating mulberry through cuttings. *Indian Silk* **26** (1) :12-13.

Datta, R.K. 2001. A break through in tropical bivoltine sericulture. *Indian Silk* **39** (9) :19-23.

Dhar, A. and Ahsan, M.M. 1989. Mulberry species and their distribution in North Western India. *In*: *Proceedings of genetic resources on mulberry and utilization,* A.K. Sengupta and S.B. Dandin (Eds.) Central Sericulture Research and Training Institute, Mysore, India pp. 112-113.

Fotedar, R.K. 1989. Use of hormones in mulberry propagation. *Indian Silk.* **28** (5) :17-18.

Fotedar, R.K., Ahsan, M.M. and Dhar, A. 1990. Screening of mulberry varieties for rooting and induction of rooting by the use of growth regulators. *Sericologia* **30** (3) : 347-361.

Ganayee, M.S. and Baksh, S. 1997. Evaluation of mulberry genotypes under rainfed conditions. *Annual Report* Central Sericultural Research and Training Institute, Pampore, India. pp. 30-39.

Goel, A.K., Ravindaran, S., Anand Rao, A., Girish Naik, V., Tikader, A., Mukerjee, P. and Sekar, S. 1998. Variability in rooting parameters at juvenile stage in mulberry (*Morus* spp.) germplasm. *Indian Journal of Sericulture* **37** (2) : 109-112.

Gupta, B.K. 1980. Propagation of mulberry cuttings. *Annual Report,* Central Silkworm Seed Station, Pampore, India pp. 26-27.

Hartmann, H.T. and Kester, D.E. 1978. *Plant Propagation Principles and Practices,* Prentice Hall of India, New Delhi.

Hartmann, H.T. and Kester, D.E. 1986. *Plant Propagation- Principles and Practices.* Prentice Hall of India Pvt. Ltd., New Delhi.

Hartmann, H.T., Kester, D.E., Davis Jr, F.T. and Geneve, R.L. 1997. *Plant Propagation-Principles and Practices,* 6^{th} *edition.* (Indian Reprint), Prentice Hall of India Pvt. Ltd, New Delhi.

Honda, T. 1970. Studies on the propagation of mulberry trees by cuttings. *Bull. Seric. Expt. Stn.* **24** (1) : 133-236.

Honda, T. 1972. Technical problems on mulberry cuttings in Japan. *Japan Agricultural Research Quarterly* **6** (4) : 235-239.

Isa, Md., Srivastava, D.P., Goel, A.K. and Thangavelu, K. 1993. Vegetative propagation of Termanalia arjuna Bedd. through auxin treated stem cuttings. *Indian Journal of Sericulture* **32** (1) : 115-116.

Iyenger, M.N.S. and Sumbly, S.N. 1976a. Comparative performance of different varieties of mulberry under rainfed conditions. *Annual Report,* Central Silkworm Seed Station, Pampore, India pp. 42-43.

Iyenger, M.N.S. and Sumbly, S.N. 1976b. Studies on propagation of mulberry by cuttings under Kashmir climate. *Annual Report,* Central Silkworm Seed Station, Pampore, India pp. 43-44.

Jawanda, J.S., Josen, J.S. and Singh, S.N. 1980. Studies on the rooting of Almond (*Prunus amygdalus* Batsch) cuttings. *Indian Journal of Horticulture* **37** (2) : 146-150.

Jhon, A.Q., Ganai, Z.A. and Neelofer Lolapori. 2000. Effect of Indole butyric acid, node number and rooting media on the rhizogenesis of semi hardwood cuttings of *Rosa hybrida. Applied Biological Research* **2** : 139-144.

Jolly, M.S. 1987. Sericulture and its economics. *In*: Appropriate Sericulture Techniques. Jolly, M.S. (Ed.) ICTRETS, Central Sericulture Research and Training Institute, Mysore pp. 1-16.

Jolly, M.S. and Dandin, S.B. 1986. Collection, conservation, and evaluation of mulberry (*Morus* spp.) germplasm, Central Sericulture Research and Training Institute, Mysore, India p. 18.

Kamili, A.N. and Shah, A.M. 1996. Effect of some growth regulators and vitamins on the rooting of two exotic mulberry cutting. *Oriental Science* **1**(2) :99-104.

Kasivishwanathan, K. and Iyenger, M.N. Sitarama. 1967. Nursery investigations on the effect of number of buds and methods of planting, manuring, position of buds, duration and methods of storage on the final stand on growth of mulberry. *Indian Journal of Sericulture* **1** (2) :99-107.

Khan, P.A. and Sidhu, D.S. 2002. Effect of growth regulators on rooting performance of stem cuttings of Shisham (*Dalbergia sissoo* Roxb.) *SKUAST Journal of Research* **4** :88-92.

Lakshmanan, S., Malikarjuna, B., Gopinath Rao, R., Jayaram, H. and Geeta Devi, R.G. 1999. An empirical investigation on labour productivity in mulberry sericulture. *Indian Journal of Sericulture* **38** (1) : 48-52.

Mala, V.R. and Basavaiah. 1991. Improvement of rooting ability in selection variety. *Indian Silk* **30** (8) : 56-58.

Mala, V.R., Dandin, S.B. and Ramesh, S.R. 1992. *Morus multicaulis*, a potential exotic introduction for mulberry improvement performance in India. *Sericologia* **32** (1) : 85-90.

Masilamani, S., Reddy, A.R., Sarkar, A. and Jayaswal, K.P. 2000. Selection of quantitative traits in mulberry (*Morus* spp.) for root growth parameters. *The Madras Agricultural Journal* **87** (10-12) : 689-690.

Misra, S.S. 2000. Races of silkworm and cultivation of their food plants with special reference to mulberry. *In*: Sericulture in India, vol (2), Aggrawal, H. and Seth, M.K. (Eds.) Bishen Singh, Mahindra pal Singh Publication, Dehradun, India. pp. 305-318.

Mukherjee, S.K. and Sharma, D.N. 1971. Effect of some growth regulators on the rooting of mulberry cuttings. *Indian Journal of Sericulture* **10** (1) : 23-27.

Mukherjee, S.K. and Sikdar, A.K. 1974. Effect of ringing and application of growth regulators and vitamins on the propagation of mulberry cuttings. *Indian Journal of Sericulture.* **13** (1) :1-10.

Mukherjee, S.K. and Sikdar, A.K. 1977. Effect of auxins, vitamins and their combination on the rooting of mulberry cuttings. *Indian Journal of Sericulture* **16** (1) :1-9.

Munshi, N.A., Baqual, F.A., Malik, G.N., Qayoom, S., Azad, A.R. and Sheikh, N.D. 2003. Studies on the rooting behaviour of some temperate mulberry cultivars. *SKUAST Journal of Research* **5** : 125-128.

Munshi, N.A. Tanki, T.N., Zargar, M.A. and Lone, A.H. 1991. Screening of some mulberry varieties against *Phloeospora* leaf spot disease of mulberry under Kashmir conditions. *Sericologia* **31** (4) : 719-723.

Murakami, T. 1980. Studies on the hardwood cuttings of mulberry plant part –I cutting slip from various parts of shoot and quantity of new roots and shoots. *Journal of Sericulture Science Japan* **49** (2) : 159-166.

Nakagawa, I. and Naot, T. 1983. The relationship between moisture tension of volcanic ash soils, red-yellow soils and production of young cuttage of mulberry tree. *Japanese Journal of Sericulture* **54** (4) : 290-95.

Nanda, K.K. and Kochar, V.K. 1985. Vegetative propagation of plants. Kalyani Publishers, New Delhi, pp. 1-234.

Panse, V.G. and Sukhatme, P.V. 1985. *Statistical Methods for Agricultural Workers. Fourth Edition.* Indian Council of Agricultural Research, New Delhi 381 pp.

Paul, T.M. and John, A.Q. 1992. Influence of node number and IBA treatments on rooting of *Hydranger macrophylla* (thumb) cuttings. *Advances in Plant Sciences*, **5** : 619-622.

Peer, K.A. 2002. Studies on propagation of some cultivars of mulberry (*Morus* spp.) through stem cuttings under Kashmir climatic conditions. *M.Sc. Thesis, Sheri-e-Kashmir University of Agricultural Sciences and Technology of Kashmi* pp. 1-135.

Raja Ram and Samson, M.V. 1995. Rooting behaviour in cuttings of som (*Machillus bombycina* King). *Indian Journal of Sericulture* **34** (1) :54-56.

Rangaswami, G., Narashimhanna, M.N., Kasiviswanathan, K., Sastry, C.R. and Jolly, M.S. 1976. Sericulture Mannual –I, Mulberry Cultivation F.A.O. *Agricultural Services Bulletin* 15/1.1.

Rao, L.S.P. and Khan, A.A. 1963. Vegetative propagation of Japanese mulberry varieties by use of growth regulators, *Indian Journal of Sericulture*. **1** (3) :7-23.

*Rodriguez Navaroo, J. and Gonzalez Marin, F. 1995. Mulberry propagation and varieties. *Vida rural* **2** (24) : 64-67. [c.f. Plant growth regulator abstract **23** : (2) : 880].

Sadhu, M.K. 1999. *Plant propagation.* Newage International Private Limited, Publishers, New Delhi. p. 287.

Satpathy, B., Purohit, K.M., Ghosh, J.K. and Gosh, P.L. 1995. Propagation of mulberry (*Morus alba* L.) through young shoots in West Bengal. *Indian Journal of Sericulture* **34** (1) : 42-45.

Shanmugavelu, K.G. 1975. Introduction of rooting of mulberry (*Morus alba* L.) in cutting with the aid of plant growth regulators under intermittent mist. *Indian Journal of Sericulture* **14** (1) : 22-26.

*Sharma, V.P., Gaur, J.P. and Rais, S. 1994. Effect of Indole acetic acid on rooting behaviour of promising mulberry varieties in Doon valley, India. *Indian Journal of Forestry*. **17** (2): 262-266 [c.f. Plant growth regulator abstract **22** (2) : 911].

Singh, D., Kalu Ram., Pandit, R.K. and Koul, A. 1999. Optimum season for propagation of mulberry cuttings. *Life Science Reporter* **1** (2) : 50-53.

Snedecor, G.W. and Cochran, W.G. 1967. Statistical methods, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, (VI Edn.) 593 pp.

Sujathama, P. and Dandin, S.B. 1998. Evaluation of mulberry (*Morus* spp.) genotypes for propagation parameters. *Indian Journal of Sericulture* **37** (2) : 133-136.

Susheelama, B.N., Jolly, M.S., Girdhar, K. and Sengupta, K. 1990. Evaluation of germplasm genotypes for drought resistance in mulberry. *Sericologia* **30** (3) : 327-41.

Susheelama, B.N., Kumar, J.S., Sikdar, A.K., Dandin, S.B., Jolly, M.S. and Sengupta, K. 1992. Exploitation of promising mulberry genotypes for yield potentiality. *Sericologia* **32** (2) : 295-300.

Tanki, N., Tasneem., Raja, T.A., Munshi, N.A. and Khan, M.A. 2000. Role of women in sericulture: A case study of Kashmir. *SKUAST Journal of Research.* **2** :70-74.

Tikader, A., Vijayan, K., Dutta, R.N., Roy, B.N. and Pavan Kumar, T. 1997. Effect of ringing on the propagation of mulberry cuttings. *Sericologia* **37** (2) : 245-247.

Tikader, A., Vijayan, K., Roy, B.N. and Pavan Kumar, T. 1996. Studies on the propagation efficiency of mulberry (*Morus* spp.) at ploidy level. *Sericologia* **36** (2) 345-349.

Yadav, G.S. and Goswami, B.C. 1993. Why do some cuttings fail to root. *Indian Silk* **38** (1) : 37-44.

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*original not seen

APPENDEX-I

Analysis of variance for Experiment-I

Source of variation	d.f	MEAN SUM OF SQUARES				
		Rooting percentage	**Number of primary roots**	**Length of primary roots**	**Height of sapling**	**Number of leaves**
Variety	5	2342.0**	0.5585**	4.8027**	21.5910**	3.5709**
Position of shoot	2	8838.6**	4.3602**	13.7569**	26.4222**	9.5439**
Growing conditions	1	2847.0**	3.9257**	4.7695**	4.3448**	5.5226**
Variety x position of shoot	10	140.7**	0.3261**	3.6125**	2.7674**	2.0764**
Variety x Growing condition	5	129.0**	0.1504	0.0130	0.6007	0.2254
Position of shoot x Growing condition	2	257.8	0.2933	0.1490	0.2421	0.1454
Variety x Position of shoot x Growing condition	10	35.1	0.0638	0.0176	0.1590	0.0879
Error	72	51.3	0.1440	0.0218	0.4601	0.1357

APPENDEX-II

Analysis of variance for Experiment-I

Source of variation	d.f	MEAN SUM OF SQUARES			
		Weight of leaves	**Internodal distance**	**Biomass upperground**	**Biomass underground**
Variety	5	0.75073**	1.32750**	4.8128**	0.15084**
Position of shoot	2	3.79935**	0.40126**	18.2162**	0.74045**
Growing conditions	1	4.56990**	0.05684**	5.8679**	0.67907**
Variety x Portion of shoot	10	0.98224**	0.08085**	2.6176**	0.07848**
Variety x Growing condition	5	0.17239**	0.02479	0.0840**	0.00775**
Position of shoot x Growing condition	2	0.55532**	0.00317	0.3447**	0.03923
Variety x Position of shoot x Growing condition	10	0.02534	0.01069	0.0634	0.02358
Error	72	0.02534	0.005	0.0147	0.007

APPENDEX-III

Analysis of variance for Experiment-II

Source of variation	d.f	MEAN SUM OF SQUARES				
		Rooting percentage	**Number of primary roots**	**Length of primary roots**	**Height of sapling**	**Number of leaves**
Variety	5	3546.57**	2.2596**	4.7943**	28.0719**	5.1934**
Media	2	4728.84**	8.6188**	11.2929**	7.3694**	14.2780**
Growing conditions	1	3036.19**	6.7947**	3.8055**	5.6337**	6.997**
Variety x Media	10	135.20	0.5426**	3.8411**	5.1628**	4.5962**
Variety x Growing condition	5	186.45**	0.2102	0.0308	0.1126	0.1258
Media x Growing condition	2	186.56**	0.2771	0.3004	0.1599	0.0380
Variety x Media x Growing condition	10	19.38	0.1434	0.0126	0.1234	0.0404
Error	72	60.99	0.1200	0.04	0.14	0.08

APPENDEX-IV

Analysis of variance for Experiment-II

Source of variation	**d.f**	**MEAN SUM OF SQUARES**			
		Weight of leaves	**Internodal distance**	**Biomass upperground**	**Biomass underground**
Variety	5	3.2430**	1.25254**	7.9504**	0.13558**
Media	2	12.1341**	0.17792**	18.7270**	0.89146**
Growing conditions	1	9.7576**	0.04210**	7.7612**	0.61596**
Variety x Media	10	2.1475	0.10297**	6.1389**	0.05904**
Variety x Growing condition	5	0.1402	0.00264	0.1513**	0.00364
Meida x Growing condition	2	0.0096	0.00177	0.0437	0.05687
Variety x Meida x Growing condition	10	0.0744	0.00081	0.0686	0.00467
Error	72	0.03	0.003	0.0131	0.00635

Appendix-V

Weekly meteorological data from March 2002 to June 2003

Standard week	Maximum Temperature (^oC)	Minimum temperature (^oC)	Relative humidity (%)	Total rainfall (mm)
9 March	11.7	1.7	68	2.0
10	11.4	1.2	66	46.6
11	19.1	2.3	52	0.0
12	16.5	6.3	69	59.4
13	18.4	4.8	61	2.8
14	15.5	6.6	73	31.3
15	23.1	6.1	56	0.0
16	29.9	7.5	59	0.0
17	16.0	7.7	79	40.2
18	22.6	8.0	66	3.4
19	26.5	9.2	67	3.1
20	26.4	10.0	69	17.2
21	29.1	8.9	53	0.0
22	27.6	11.8	59	19.4
23	29.7	12.4	58	5.0
24	28.3	13.9	68	38.9
25	28.4	13.4	68	20.1
26	28.9	16.1	74	18.0
27	31.4	15.3	70	0.0
28	31.3	14.2	68	0.0
29	31.1	17.1	69	3.5
30	29.5	14.9	71	13.2
31	30.9	15.5	75	0.0
32	31.5	18.6	77	1.5
33	26.6	15.3	79	31.5
34	30.1	17.3	75	21.7
35	28.0	16.2	81	23.9
36	24.7	11.2	50	13.6
37	25.2	11.7	74	11.1
38	25.8	9.8	76	4.0
39	24.4	7.7	71	0.0
40	26.4	6.6	77	0.0
41	23.6	7.9	76	20.0
42	21.8	5.9	79	2.8
43	21.1	2.3	74	0.0
44	21.2	1.2	71	0.0

Contd..

45	20.0	2.8	72	0.0
46	18.5	0.6	67	0.0
47	17.3	-1.3	65	0.0
48	15.9	-2.9	65	0.0
49	11.9	-3.1	69	0.0
50	10.4	0.8	68	0.0
51	6.8	0.8	90	8.2
52	9.2	-1.3	78	1.6
1 Jan	12.0	-4.7	70	0.0
2	11.1	-6.0	67	0.0
3	10.5	-2.8	64	0.0
4	10.5	-1.3	60	7.2
5	7.7	-0.7	83	31.9
6	9.7	-0.6	75	56.6
7	8.2	0.7	82	106.0
8	7.6	1.4	75	127.4
9	9.0	-0.2	72	16.0
10	12.2	3.0	74	7.0
11	17.3	4.8	69	0.0
12	16.6	6.0	74	22.7
13	18.2	4.8	68	20.4
14	23.3	8.0	70	6.2
15	18.4	7.0	79	53.9
16	21.2	8.8	72	47.8
17	18.6	6.8	69	45.2
18	21.8	6.0	61	6.4
19	25.5	7.2	54	0.0
20	20.8	10.0	76	32.8
21	26.0	9.4	64	1.0

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Certificate

This is to certify that all corrections and modifications suggested by the external examiner in the thesis script of **Mr. Javid Ahmed Najar (Regd. No.2001-S-9-M)** entitled "**Screening of some promising temperate Mulberry (*Morus* spp.) cultivars on the basis of their rooting behaviour using different media and growing conditions"** have been taken care of before final binding of the same.

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