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COLLECTION, CONSERVATION AND EVALUATION OF MULBERRY (MORUS SPP.) GERMPLASM

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CENTRAL SERICULTURAL RESEARCH AND TRAINING INSTITUTE
Central Silk Board — Government of India
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INTRODUCTION

Germplasm, the sum total of genetic variability available in the genus, is a basis for crop improvement programme. Collection, conservation and evaluation of the genepool is the first step in breeding crop plants for various traits. Mulberry, the sole food plant of silkworm (*Bombyx mori L.*) is cultivated in more than 50 countries of the world both in temperate and tropical climates. In India, the total area under mulberry is 2,14,800 ha and is spread in almost all states. To meet the requirements of diverse agroclimatic conditions under which mulberry is grown, location/region specific strains are a must to make the silk industry more viable and remunerative. To meet the above requirement, assemblage, catalogueing and evaluation of genepool is a must; and in the present publication the detailed procedure to be followed for collection, conservation and evaluation of the genepool is discussed. In addition, type of material available, places of its conservation, accessions conserved etc., are given to take stock of the entire material. Yield/growth parameters to be studied, method of evaluation of each trait, range of variability in all the important morphological as well as yield characters is also discussed. A model descriptor is designed to describe 'all type of materials' and also for its systematic characterization. Suitable procedures for quality analysis are also suggested. This document will serve as a handbook for a breeder not only for the germplasm resource studies but also for screening the population of 'different type' for evolving new varieties.

GERMPLASM AND CROP IMPROVEMENT

Variation is the basis for improvement. Collection, conservation and evaluation of the existing genepool is the foundation for all the crop improvement programmes. Exploitation of existing genetic variability by systematic exploration and collection of primitive land races, wild relatives, undomesticated forms and related weedy species are the need of the day, as they have been screened through the sieves of natural selection and withstood the vagaries of nature. Preservation of this natural wealth is more important as the very existence of these species is under threat. Cultivation of standard varieties and introduction of improved strains have resulted in rapid elimination of primitive land races having wider adaptability. Extensive farming and over grazing have destroyed the natural habitat of wild relatives and undomesticated forms. As a result of above factors, the genetic erosion is faster than ever before. General awareness and concern have developed among plant breeders all over the world. Many National and International Organisations have come forward to conserve the existing genetic wealth and prevent further loss of genotypes.

Germplasm is the never ending need of present day breeders, as the pressure on human needs are exhaustive and diverse. Problems of the day are more complex due to modernization and specific needs. To meet the demands of diverse nature, plant breeding programmes of present day require more broader genetic base than ever before. However, the germplasm should not be only a living museum of the sum total of the variability. Evaluated genepool should serve as a stock of required genotypes for a needy breeder, as a parent material for his breeding programme; to conduct a multilocation test for recommending location/region specific strains; to serve as a donor of a specific gene for stress and saline resistance; to serve as a best combiner parent for heterosis exploitation and as a good stock material for grafting with fairly good rooting capacity and resistance to soil borne pests.

For most of the agriculturally important crops work is being done to take stock of the whole genetic variability by systematic exploration, collection and cataloguing. International Board of Plant Genetic Resources (IBPGR) and National Board of Plant Genetic Resources (NBPGR) with a net work of regional organizations are working for this task. Work is in progress to evaluate and classify the genotypes for desirable traits and also to coordinate the supply of material for needy breeder. Methods have also been developed for both long term and short term preservation of the material in various forms. Mulberry, the sole food source of silkworm(*B.mori*) has not received due importance in this direction. Very little work has been done in serculturally advanced countries like Japan and China to conserve and evaluate the available genotypes mostly of temperate origin. (Ogure 1967, 1979; Katsumata 1972; Yokoyama and Matsushima 1982a, 1982b; Ono 1983; Shikata et al., 1984 and Nakajima, unpublished). However, for tropical and subtropical regions, where sericulture is fast spreading this work needs emphasis without further delay.

India is the third largest raw silk producer and leading sericulture country in the tropics; sericulture industry is expanding fast and now it has spread to almost all the states and union territories of the country. As a result, the need of the location specific varieties of mulberry is very much felt. In addition, both the developing and underdeveloped countries of tropical region which have taken up sericulture also depend on India for mulberry and silkworm strains. To meet the demand, large scale breeding programmes have to be started for evolution of high yielding mulberry strains with good quality leaf. As a prerequisite, collection, conservation and evaluation of the existing material has to be taken up on priority basis.

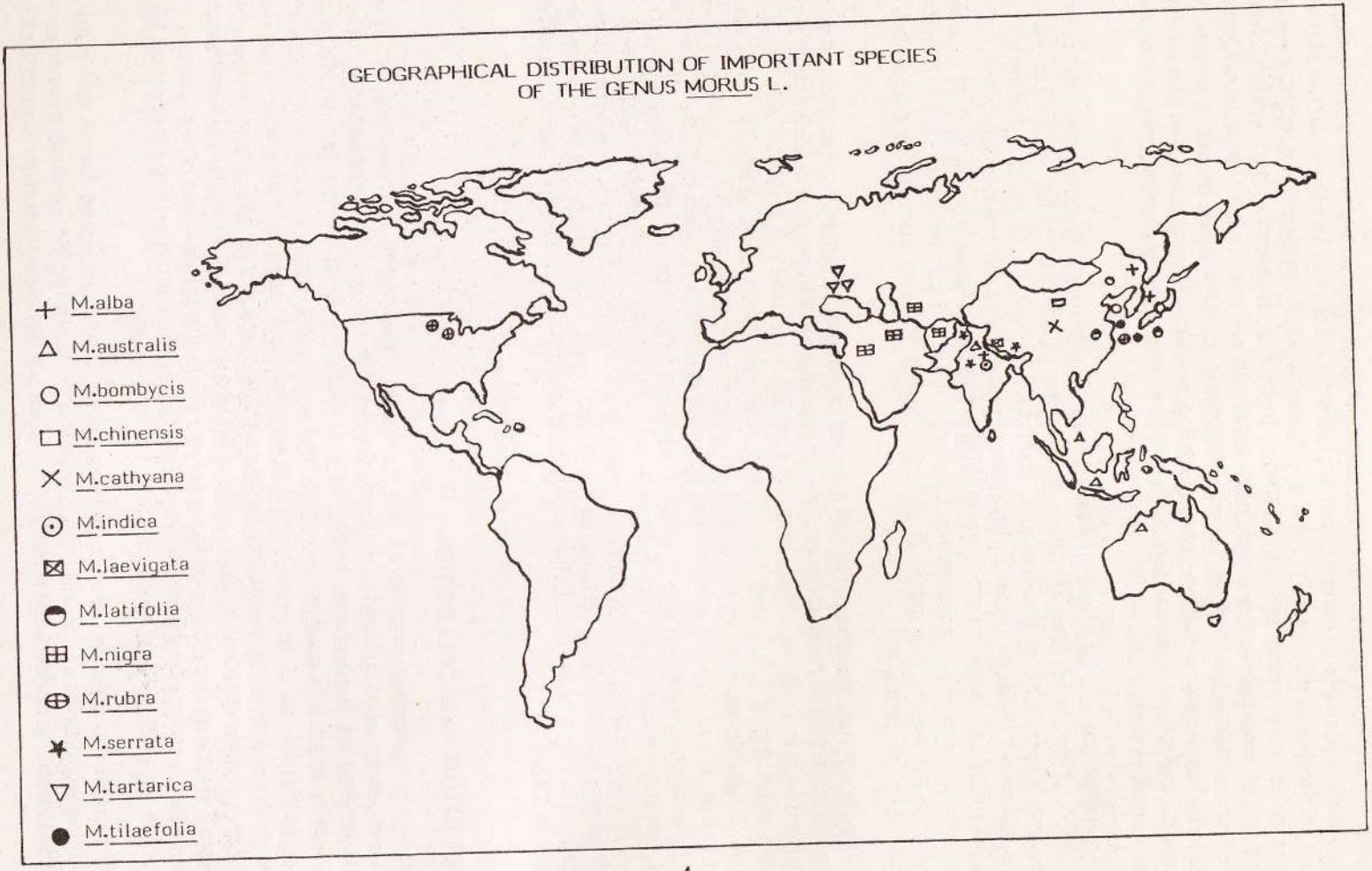
Knowledge on phytogeography and areas of cultivation is imperative for effective collection of material. Breeder must have a thorough knowledge about primary and secondary centres of origin/diversity; cultivated provinces of various countries; land races/improved varieties under cultivation in respective countries; mode of their origin, cultural practices followed etc. Information on natural variability, pattern of evolution, reproductive behaviour, crossability barriers, places of conservation, type of material conserved for respective crops is also important for any successful collection and conservation of genepool.

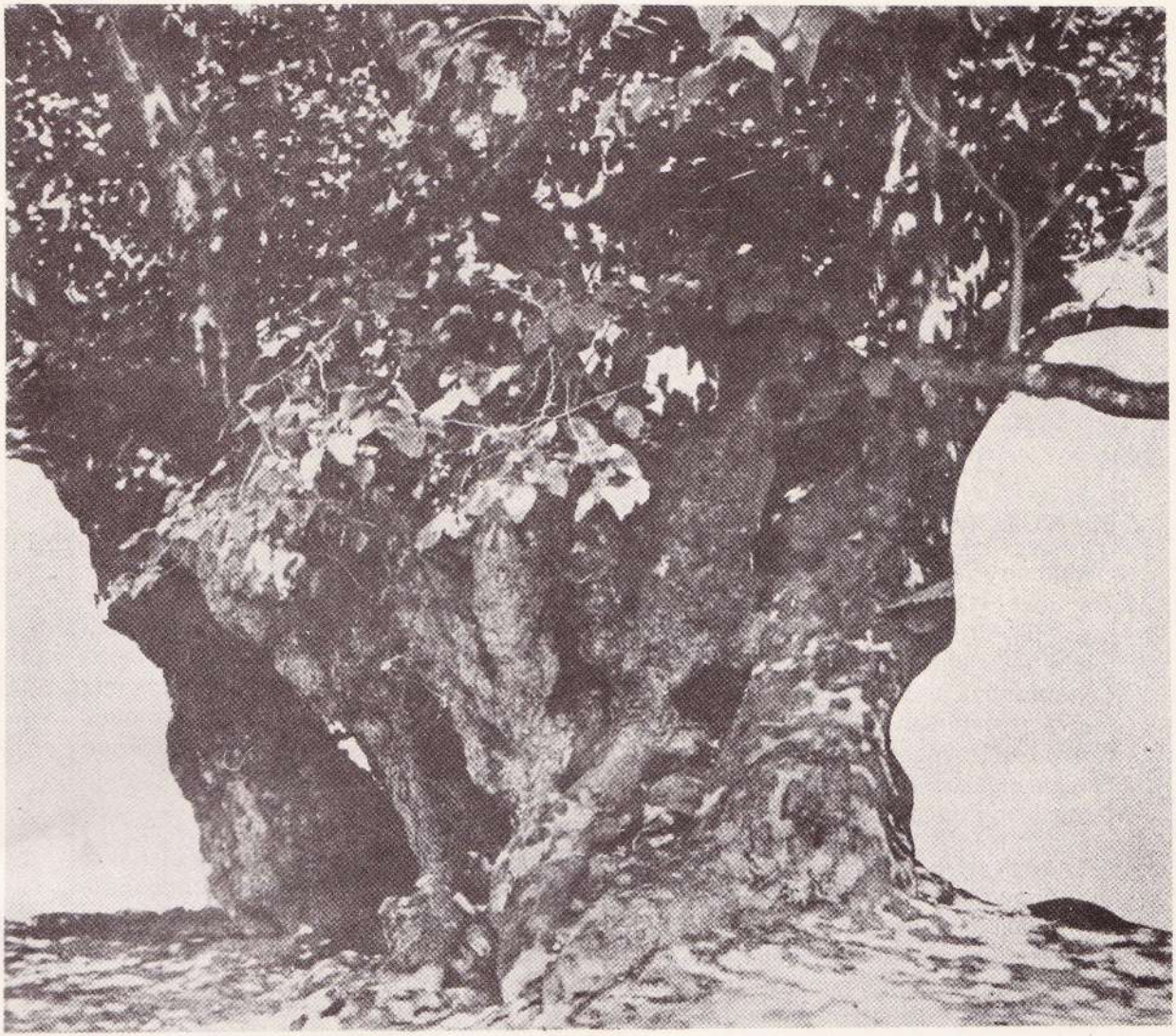
Mulberry, a heterozygous perennial species is a native of Indo-China and found widely distributed in both the hemispheres. The original home of the genus is a lower Himalayan belt of Indo-China region, where about 6 species are found occurring in wild condition upto an elevation of 7,000 feet. In addition, a few mulberry species are found in Japan, Russia, South Korea etc. The distribution of the important species of genus *Morus* is given in *Fig. 1* and species available in different countries is given in *Table 1.* Owing to cross fertilization, wider range of variation exists in natural populations; especially in the moist deciduous forests in foot hills of Himalaya, China, Japan and South-East Asian region. It is interesting to note that this region is the home of sericulture where it is being practiced since 2600 BC. In addition to these wild types, large number of strains are being maintained in these countries. Different kinds of germplasm and type of material available is given in *Table 2.*

EXPLORATION AND COLLECTION

Indigenous germplasm material is of utmost importance in breeding, as these genotypes are adapted to local conditions. Owing to the origin of the genus *Morus* in sub-Himalayan belt of Indo-china, many natural varieties exist in this region. Of eight sericulturally important species reported, four are found widely occuring in Himalayan region and distributed right from Jammu & Kashmir to Assam upto an elevation of 7000 feet above the sea level. *M. serrata, M. indica, M. laevigata* and *M. alba* are found as a part of natural vegetation in Khasia, Garo, hills of Meghalaya and Badrinath in Uttar Pradesh. The sacred mulberry tree belonging to *M. serrata* is the largest and oldest among the known mulberry trees of the world which has 6M girth and estimated to be more than 1200 years old is located in Uttar Pradesh (Rau 1967) [*Fig. 2*].

Apart from these species, several wild relatives, undomesticated forms and natural open pollinated hybrids are found throughout the northern region, representing an array of genetic variability. Systematic survey of this area will definitely result in huge collection


GEOGRAPHICAL DISTRIBUTION OF IMPORTANT SPECIES
OF THE GENUS MORUS L.
M.alba
M.australis
M.bombycis
M.chinensis
M.cathyana
M.indica
M.laevigata
M.latifolia
M.nigra
M.rubra
M.serrata
M.tartarica
M.tilaefolia



2. THE SACRED MULBERRY TREE AT JOSHIMATH (UP)

of the material. In addition, most of the older gardens of Uttar Pradesh and neighbouring states are planted with open pollinated hybrid seedlings from where large number of genotypes can be collected. At present, mulberry is being cultivated in about 2,14,838 ha of area covering almost all states and union territories of India. Statewise area under mulberry is given in *Table 4*. Various types of material is under cultivation in all these areas which again deserves survey for better collections of germplasm material.

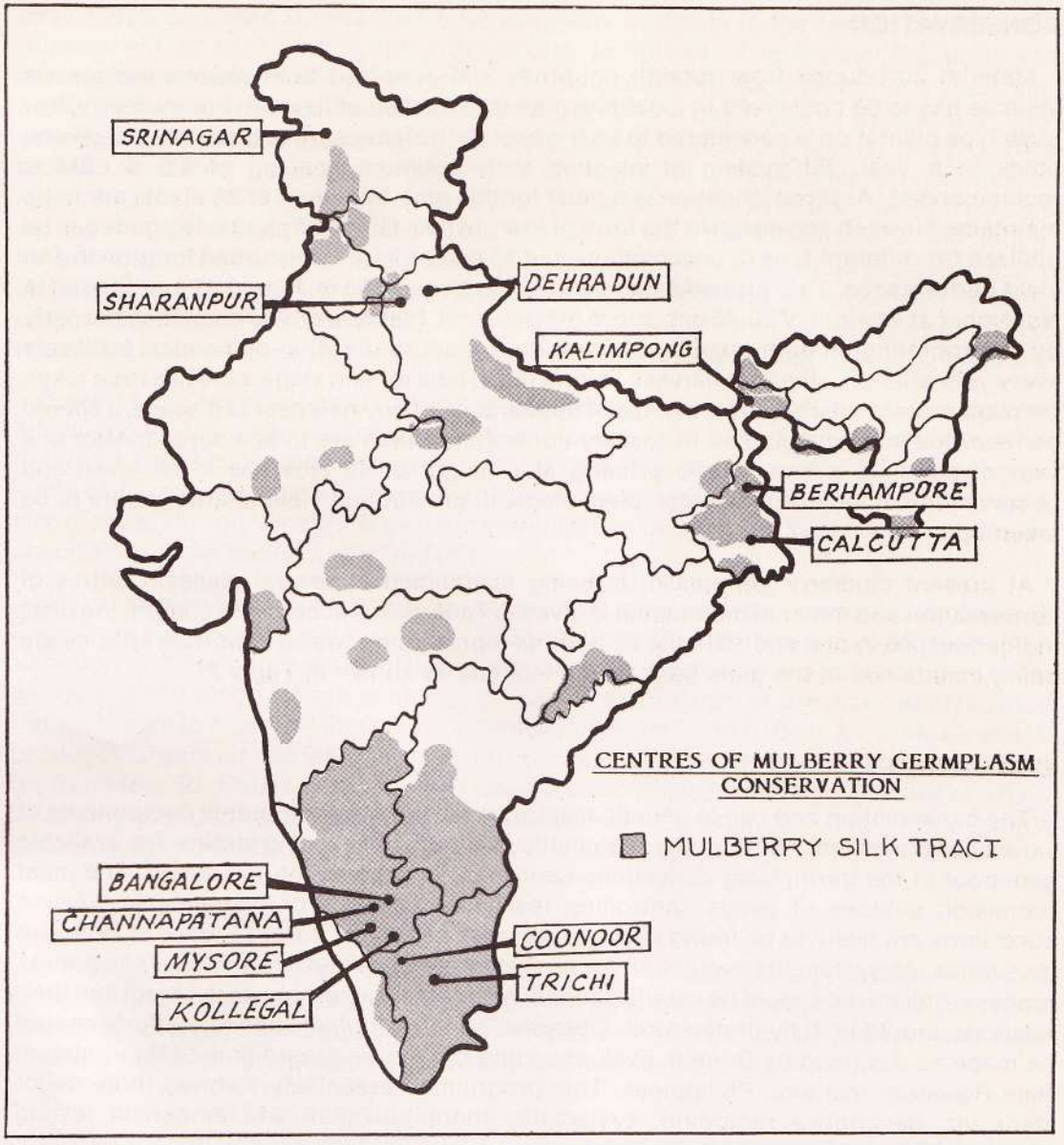
Since 1981 exploration work is taken up by comprehensive and systematic survey of different cultivated and forest areas. So far 5 explorations have been conducted and the states covered are Jammu & Kashmir, Assam, West Bengal; large amount of material was collected and brought to main station. In addition, strains maintained at Regional Sericultural Research Station, Pampore; State Department Farm, Meergund (Jammu & Kashmir); State Sericulture Farm, Sujanpur; Horticultural Garden, Saharanpur; Regional Sericultural Research Station, Majra (Uttar Pradesh); Central Sericultural Research and Training Institute, Berhampore; Regional Sericultural Research Station, Kalimpong; Indian Botanical Garden, Calcutta (West Bengal); Mahabaleshwar Hills (Maharashtra); State Sericulture Farms, Coonoor and Hosur (Tamil Nadu); Karnataka State Sericulture Development Institute, Thalaghattapura; Tippu Farm, Channapatha; State Sericulture Farms, Kolar; Mudigundum and Kunigal (Karnataka) were also procured. Statewise collection of material is given in *Table 5* and distribution of cultivated area of mulberry and places from where mulberry germplasm is collected are shown in *Fig. 3*.

PLANT INTRODUCTION

Mulberry varieties have been introduced to India from Japan as early as 1900 and since then there is a continuous flow of material from various temperate countries. Most of our previous introductions are unsuccessful because of the reason that they are all adapted to temperate climate. Varieties like KNG and Ichinose are the most popular among Japanese Sericulturists and occupty more than 70% of total mulberry area, but have completely failed under Indian conditions because of climatic barriers. However, some of the varieties like Goshoerami of Japan proved successful in Kashmir region where similar temperate climate exists. Hence, climatic parallel is the most important factor to be considered while introducing the material.

Enough care should be taken to observe quarantine formalities as the material is introduced in the form of cuttings and grafts where the chances of entry of pathogens is more unlike in the seed. Secondly, while preparing the material for supply, cuttings must be prepared from at least 8-10 months old healthy shoots free from pests. Length of the cuttings must be minimum of 20 cm with 3-4 healthy buds. Both the ends are to be waxed to avoid drying during transit and must be packed in well aerated packets. If the material is poor in rooting, root grafts are to be prepared on a good rooting stock free from nematodes and other root pathogens. Plants must be raised in pots and allowed to grow for a period of 3-4 months. Then the material has to be uprooted and nicely dressed before packing. It is always advisable to send the material through IBPGR/NBPGR or its regional stations after obtaining necessary phytosanitory certificate.

When the material is received from foreign source, soon after the receipt it has to be checked for pests and pathogens. Material has to be accessioned and planted in earthen


SRINAGAR
SHARANPUR
DEHRA DUN
KALIMPONG
BERHAMPORE
CALCUTTA
CENTRES OF MULBERRY GERMPLASM CONSERVATION
MULBERRY SILK TRACT
BANGALORE
CHANNAPATANA
MYSORE
KOLLEGAL
COONOOR
TRICHI

pots of convenient size instead of directly planting them in field. This prevents the spread of pests/pathogens if any to the field. In case the material is meagre, it is better to graft or bud them on an existing plant. After 4-5 months of growth, it will be ready to transplant. Number of Exotic strains in the Germplasm bank of CSR & TI, Mysore is given in *Table 3.*

CONSERVATION

Material introduced from foreign countries and collected from various indigenous sources has to be conserved in a definite plan for effective utilisation. For mulberry, low bush type plantation is considered to be the best as the leaves are to be harvested several times in a year. Pit system of planting with optimum spacing of 1.5 x 1.5M is recommended. Assured irrigation is a must for this plot. Minimum of 25 plants are to be maintained in each accession in the form of low bushes. Of the 25 plants, 15 plants can be ultilized for different type of observations and 10 can be kept undisturbed for growth and yield performance. Two prunings can be given in a year, one in June-July and second in November at a height of 30-45 cm. above ground level. Plants are to be nourished properly by incorporating enough quantity of Farm Yard Manure (FYM) and chemical fertilizers every year after pruning/leaf harvest. During the establishment stage, care has to be taken for plant protection measures. In case of appearance of any new pest or disease, it should be recorded immediately and necessary control measures are to be adopted. After one year of planting, a first middle pruning at a height of 45 cms has to be given and observations of all morphological, physiological, growth and yield characters are to be taken up.

At present mulberry germplasm is being maintained at several places. Centres of conservation and material maintained is given in *Table 6.* 259 accessions comprising of 92 indigenous, 66 exotic and 101 elite F1 hybrids representing twelve important species are being maintained in the gane bank of the institute as shown in *Table 7.*

EVALUATION

The conservation and use fo genetic resources are the two inseparable components of varietal improvement. Without the systematic evaluation of existing strains, the available genepool in the germplasm collections cannot be utilized to the full extent. The most promising sources of genes controlling resistance to pests or tolerance to adverse conditions are likely to be found in minor varieties or special purpose types or primitive land races. As systematic evaluation for all these traits is expensive and time consuming process, objectives should be clearly defined. Attributes concerning each object and their relations should be fully understood. Objective oriented multidisciplinary efforts should be made as designed by Genetic Evaluation and Utilisation programme of International Rice Research Institute, Philippines. This programme essentially involves three major steps viz. descriptive recording, systematic characterization and emperical testing (Chang 1976).

i. Descriptive recording:

Descriptive recording is an essential step which provides the gross morphological details of each accession enabling to catalogue and classify the material systematically. This also provides information on specific gene source for breeding programme. For the descriptive recording, an internationally accepted descriptor is a must and the same has been prepared based on the sum total variability available in the genus, covering the requirement of scientists working in various disciplines of mulberry. The proposed descriptor is based on the observations on 250 accessions for a period of 3 years and publications on similar subjects by other workers. The descriptor is divided into nine major groups of characters covering Phytogeography, Gross morphology, Reproductive biology, Anatomy, Cytology, Growth/Yield attributes, Quality parameters, response to physiological conditions and resistance to pests and diseases. 130 characters contributing directly or indirectly to yield and growth have been taken into consideration. Format presented is similar to the one designed and approved by Food and Agricultural Organisation (FAO) & International Board of Plant Genetic Resources (IBPGR) for other crops, enabling its world wide use. Specific characters of all the accessions were also taken into account for classifying the mulberry strains as a source of special genes.

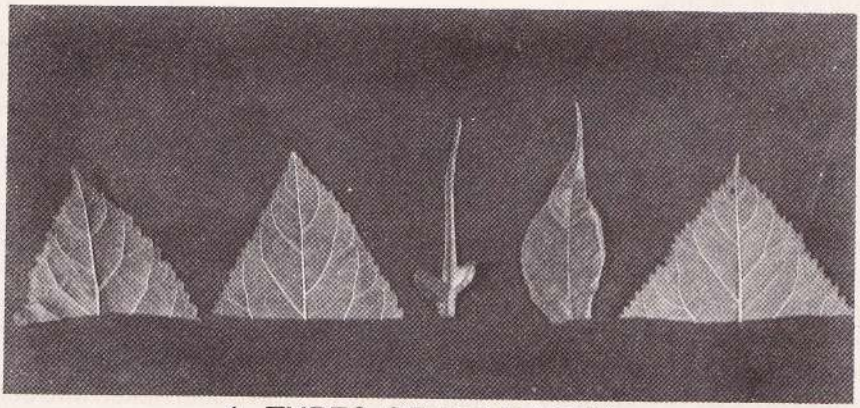
Some of the morphological characters considered for classification of *Morus* species are length of the style, nature of the stigma, shape, size and distribution of cystolith, nature of leaf lobation etc. (Koidzumi 1977, Hotta 1953 & Katsumata 1972). Variation in some of the morphological characters such as leaf apex, leaf base, serration of the margin, size of the male and female inflorescences which can be used for classification of various species has been studied. (*Fig. 4, 5, 6*).

Sexual composition for all the 259 accessions is studied and presented in *Table 8.* Femaleness is found to predominate (46.0%) followed by monoecious flowers (34.8%). Variation in the length and size of the male and female inflorescences is also studied in the genus and the length range is shown in *Figs. 7 & 8.* Length of the male inflorescence ranges from 2 to 6 cm and the female inflorescence from 1.5 to 10.0cm. *M. laevigata* which produces largest female inflorescence and longest fruit is a more popular strain cultivated for fruits (*Fig. 9*). Nature of the stigma is also studied for about 85 female strains of which 20 strains bear papillose stigma and 65 strains show hairy stigma. Pollen fertility in male strains ranges from 59.5 to 98.5%.

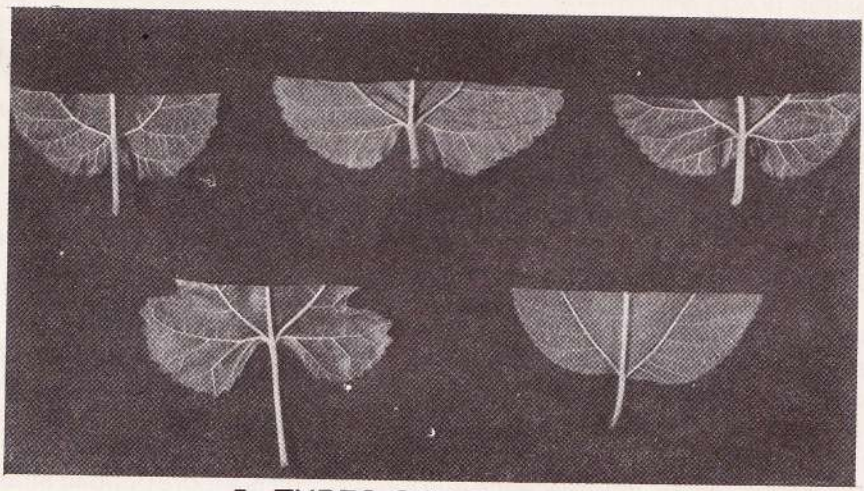
ii. Systematic Characterization:

In tropical conditions, the objectives of mulberry breeding are production of more foilage of good quality throughout the year, strains with high capacity of regeneration and amenable to vegetative propagation, genotypes with thick succulent leaves and high moisture content. Parameters contributing to the above objectives are:

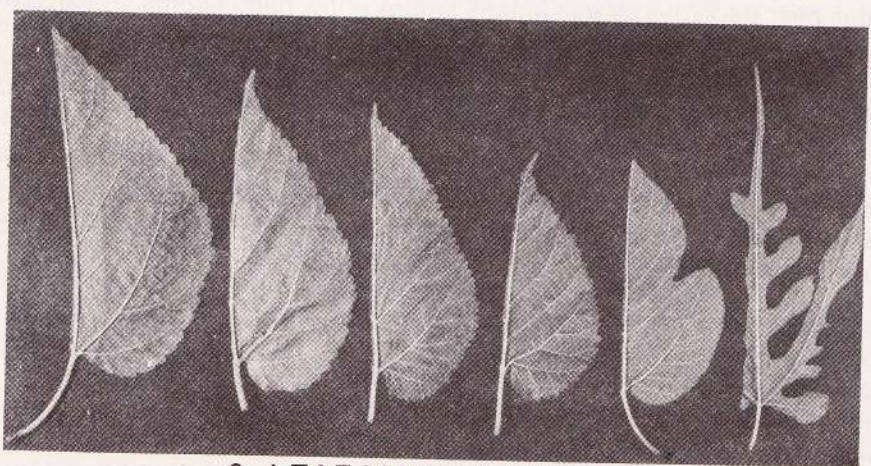
1. Fast growth and high regenerating capacity
2. Production of maximum number of primary and secondary branches with short internodes
3. Thick succulent unlobed leaves
4. Quick sprouting and high rooting capacity
5. Good responses to agronomical practices like repeated pruning, manuring etc.



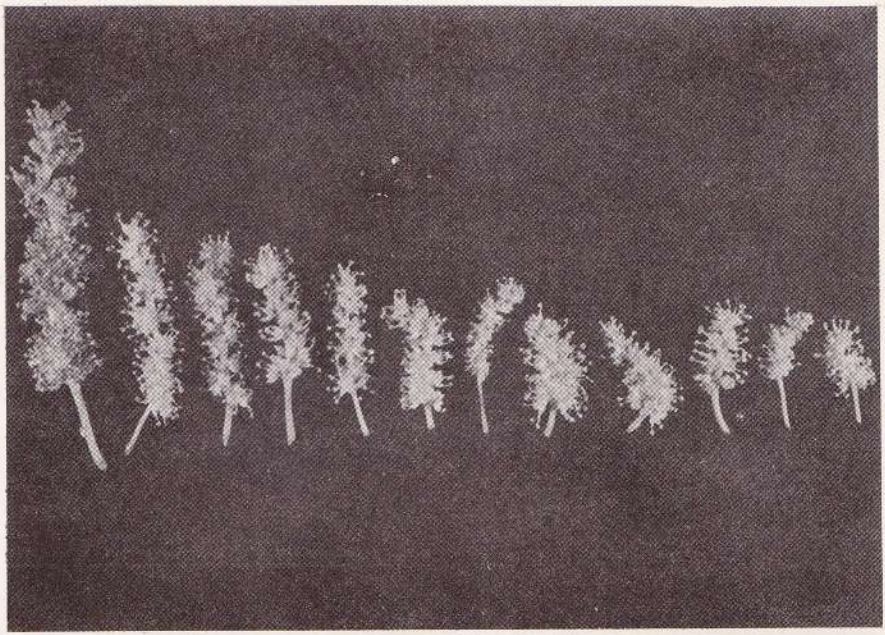
4. TYPES OF LEAF APEX



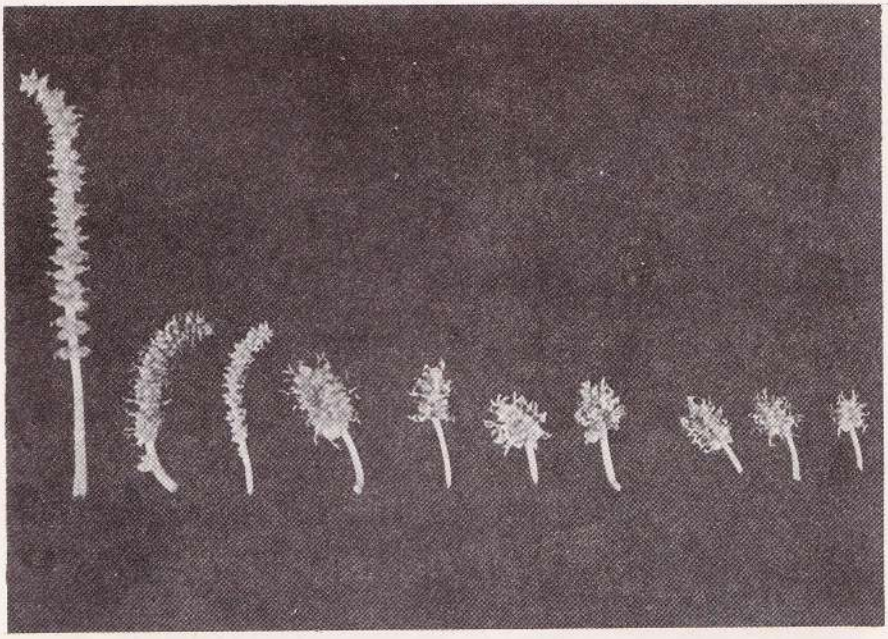
5. TYPES OF LEAF BASE



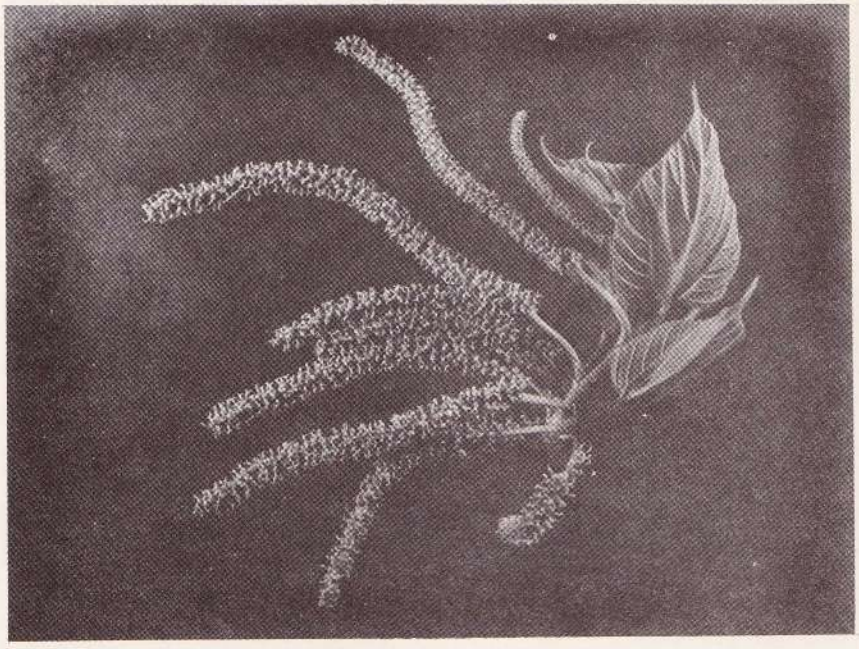
6. LEAF MARGIN TYPES



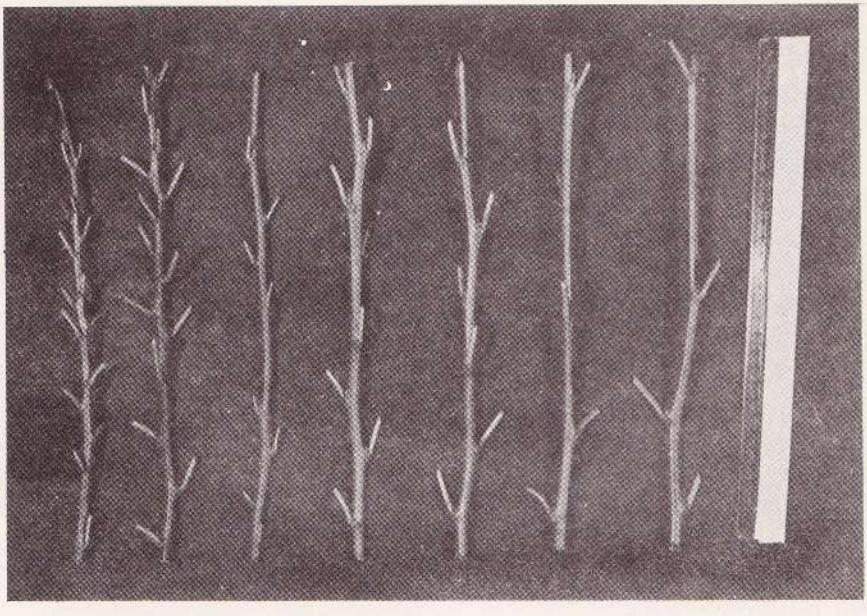
7. VARIATION IN LENGTH OF MALE INFLORESCENCE



8. VARIATION IN LENGTH OF FEMALE INFLORESCENCE



9. INFLORESCENCE OF M.LAE VIGATA



10. VARIATION IN INTERNODAL DISTANCE

6. High mositure content of leaves with better moisture retaining capacity
7. Better root initiation, growth and proliferation
8. Resistance to drought
9. Resistance to pests and diseases.

For better understanding of the extent of variability in each of the above characters and also to elucidate the relationship among them, a systematic preliminary characterization has been done for about 190 accessions. Studies were conducted for 4 years and optimum values for some of the characters were fixed (*Table 9*). This would facilitate easy screening of large population of diverse nature within a short period. For the evaluation of above characters individually, suitable methods have been evolved to minimise the error and seasonal influence. In most of the cases average of several observations were taken.

a. 1. Growth rate:

Growth rate over a definite period determines the total aerial biomass produced. As mulberry is pruned once in 60-70 days, new flush of buds must sprout quickly and grow fast to provide sizable amount of leaf to rear silkworms. Growth rate per 70 days would be ideal period for assessing the total shoot produced per plant.

Number and length of primary shoots and secondary branches was recorded for nine plants in each accession and average of 9 observations for three years covering the major seasons was taken into account. As a growth index, height of the tallest shoots was also recorded. The height of the plant varies from 335.4cm (Acc.141) to 100.30 cm (Goshoerami). List of 10 strains producing maximum length of shoot is given in *Table 11.* Girth of the stem has been considered to estimate the total shoot produced by the Plant. However, the method was not found accurate as compared to the direct measuring of shoot produced.

2. Internodal distance

Internodal distance is another important genotypic attribute which determines total foliage produced by each plant. Shorter the internodal distance, more are the number of leaves per plant. Usually in mulberry, leaves are arranged in an alternate fashion with a phyllotaxy of 1/2 to 3/5 rank. Occasionally, opposite leaf arrangement is noticed. Internodal distance is measured by taking the total length of the shoot and total number of buds and also by counting number of leaves per meter length. As this is a genetic character the seasonal variation is minimum.

Internodal distance ranges from 2.25 cm in Kairyonezumigaeshi to 7.38 cm in Miz x BC P4. The average internodal distance is 4.81 cm and more than 38 strains show less than the average internodal distance. The pattern of leaf arrangement and internodal distance of few strains is shown in *Fig. 10.* List of top 10 strains with respective internodal distances is given in *Table 10.*

b. Leaf:

Leaf, the major economic unit of the Sericulture Industry, is one of the important attributes and shows maximum variability both in morphology and its constitution. Lobation which will not follow regular pattern has become one of the puzzles for the

scientists. Some strains show seasonal variation in lobation pattern and pruning season has got tremendous impact on leaf lobation. Usually lobed leaf is found dominant over entire leaf and the same was confirmed in our breeding studies also. However, there are few exceptions to this. Different types of lobation observed in the existing material right from fully entire leaf to highly dissected leaf is shown in *Fig. 13*. Varieties like Kajali (Acc. 162) show highly dissected leaves with little of lamina. In varieties Kanva 2 and Kosen, irrespective of the season, climate and pruning time, leaf shape is maintained throughout. These characters are genetic and provide some information on inheritance pattern.

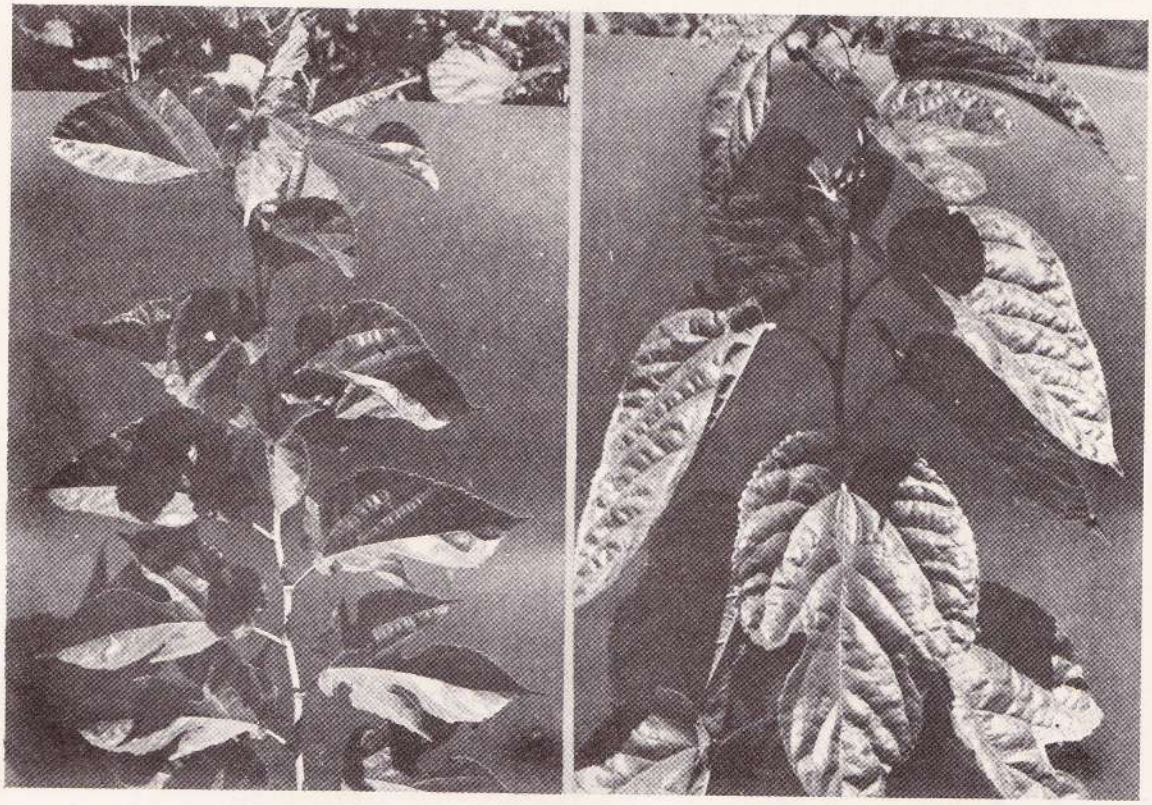
Of the 259 strains studied, 168 produce entire leaves, 39 produce dissected leaves and 52 produce heterophyllous leaves. Among the strains which show heterophyllous nature, the pattern varies greatly. In one and the same plant different permutation combinations are met with viz., few branches show lobed and few unlobed leaves. In the same branch lower leaves are lobed and upper are unlobed; upper lobed and lower unlobed leaves are also seen. In few other plants mixed type of leaves are produced in irregular fashion (*Fig. 11 & 12*).

Leaf petiole, which constitutes roughly about 10% of the total leaf weight is also considered as a parameter to assess the consumable portion of leaf, as the petioles are not consumed by the silkworms. Lengthwise there is no much variation among the strains. The more important aspect would be the weightwise ratio between lamina or leaf blade to petiole. This character was studied for all the accessions and ranges between 93.0:7.0 (Acc. 132) to 64.5:34.5 (Acc. 135). The average ratio is 79:21 and about 129 strains show more that the average value. The top 10 accessions showing the minimum values for this character are given in *Table 11*.

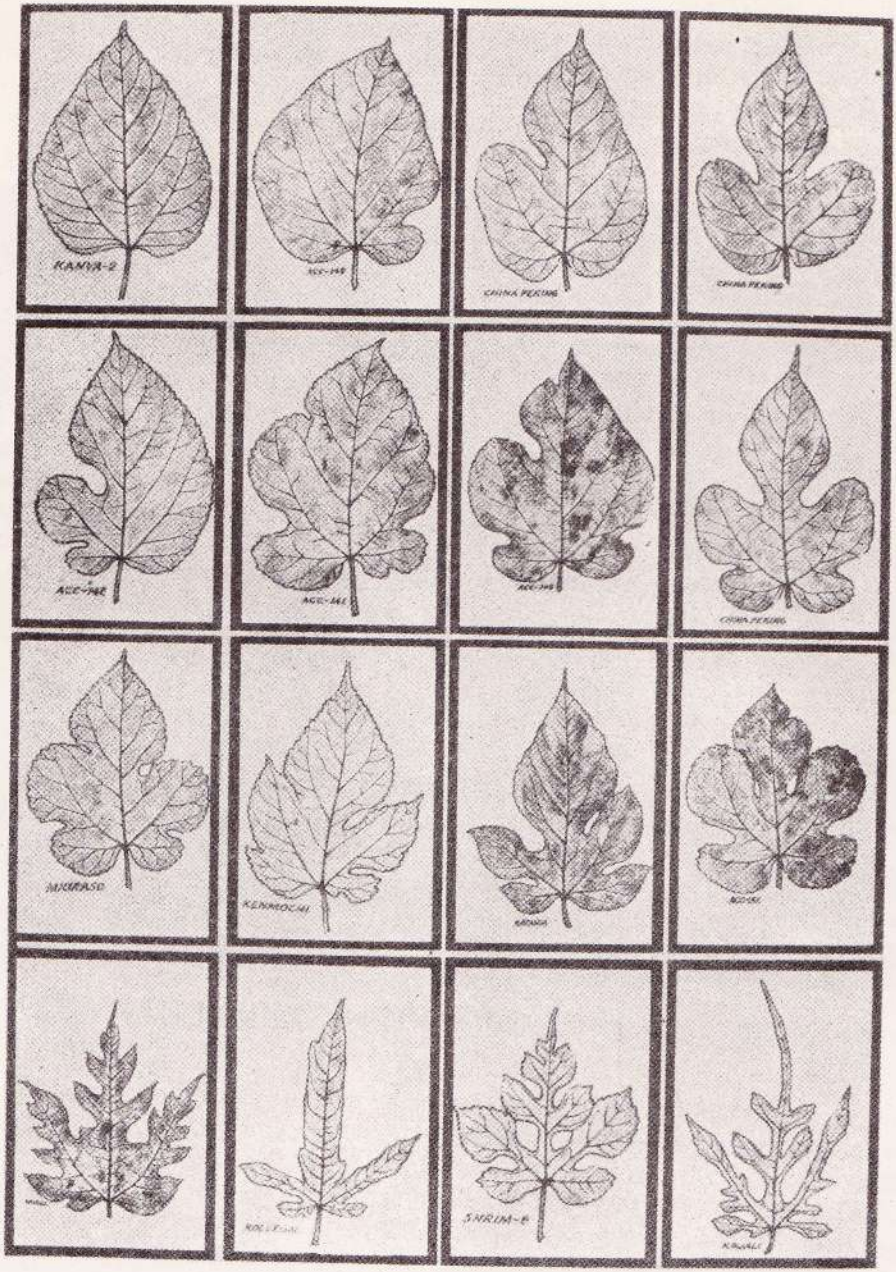
c. Leaf Size:

Leaf size in mulberry is a highly variable character and influenced greatly by the climatic and edaphic factors. Soil fertility and moisture content have a large bearing on this character. However, the variation fall in a definite range and each strain has shown relative plasticity in leaf area. Unlike other species where leaf area can be easily measured by a physical means, it is rather difficult in mulberry owing to its irregular shape, marginal serration and shape of leaf apex and base. However, earlier attempts by Kasiviswanathan and Iyengar (1966) by planimeter and by Shamachary and Jolly (unpublished) by grid system were found accurate; owing to time factor and labour they are not easily adoptable in the field where large samples are to be studied. As an alternative, area meter would be the best solution for this study.

Leaf area of all the strains was studied by area metre (LICOR 3100). Leaves produced per meter length of shoot was measured and in each of the observations 3 readings were taken (excluding petiole). The value ranges from 7093.75 sq.cm (Acc. 167) to 1225.73 sq.cm (Acc. 138) and the average of 93 strains studied is 4159.74 sq.cm. 38 accessions show more than a leaf area of 4159.74 sq.cm which is above the average. Varieties like Goshoerami, MR-2 and Dhar local produce large size leaves, contrary to the strains like Kalia Kutahi, Kajali and Acc. 119 which produce smallest leaves. Top 10 strains producing largest leaves are listed in *Table 11*.



11. & 12. POLYMORPHISM IN LEAF



13. LEAF LOBATION PATTERN

d. Weight of fresh leaves:

Leaf, an economic unit of mulberry crop is a direct component of yield. Economy of cocoon crop is very much dependent on the leaf yield per unit area. In majority of the fodder crops, leaf dimension is taken as an index to assess the total yield. In case of mulberry, often the leaves are highly lobed, having longer apex and deep basal notches; hence the total area determination is not possible in many strains. Secondly, of the total weight of leaf, 50-70 percent is moisture which determines the quality and cannot be measured by leaf area estimate. As an alternative and more precise method, weight of 100 leaves is taken as a unit to assess the leaf yield per plant. Though the character is highly influenced by various agronomical practices like spacing, irrigation, soil fertility etc. all the strains have shown their own genetic potential under similar set of conditions. Secondly, to avoid the error arising due to such influence, 2-3 observations covering different seasons for 3 years is taken and an average of the above is considered for final tabulation.

Leaves from top to bottom of randomly selected branches were taken in polythene cover and were sealed immediately. Weight was taken immediately along with the cover to account for moisture loss also. Weight of 100 fresh leaves ranges from 1400 gm in Goshoerami, to 98.00 gm in Acc. No. 117. The average is 430.52 gm for all the strains studied and 73 strains show more than average weight. Top 10 strains showing maximum leaf weight are given in *Table 11*.

e. Moisture content:

Moisture content of leaf determines the nutritive quality of the leaves and plays an important role in cocoon quality and quantity. 70 percent and more of moisture in leaf is considered optimum for silkworm rearing. Moisture content of the leaf is determined on the dry weight basis. 100 fresh leaves will be harvested and put in polythene cover and sealed. Fresh weight of the same is taken. Leaves are then dried in hot air oven at 60° C for 48-72 hours till the constant weight is obtained. To avoid charring of leaves, low temperature and long duration are preferred for drying. Moisture percentage is then calculated by substracting the dry weight from the fresh weight. The value thus obtained is divided by fresh weight and multiplied by 100.

Moisture content ranges from 45.8% (WBxKosen-P1) to 78.7% (Acc. 116). Average for all the 195 strains studied is 62.5% and more than 144 strains show above average value. Most of the Japanese strains have higher moisture content compared to indigenous ones, which is due to more thickness of leaf with high amount of palisade and spongy parenchyma tissue. On the contrary, most of the indigenous strains have comparatively thinner leaves with low moisture.

f. Moisture retaining ability:

Mositure retention capacity is also an important consideration. As the leaves are stored at least for 8-10 hours after harvest to last feeding, leaves should retain their moisture content to the maximum without withering. Slow withering is one of the main points to be considered for selection as indicated by Kasiviswanathan et al., (1973). In addition, retention of moisture by detached leaf indicates the drought resistance/tolerance nature

of the strain and this criterion can be made use of in screening strains for stress environment.

Moisture retention ability was studied by keeping leaves in open condition under room temperature and weight was taken at an hourly interval till 12 hours from the time of harvest. Moisture lost during 3,6,9,12 hours after harvest was calculated and moisture retained at 12 hours was then converted into the final percentage. In all the 195 strains studied moisture retention after 12 hours varied from 76.8 to 41.26%. Hybrid Miz. x Catt. P_3 showed highest moisture retention after 12 hours of storage and hybrid WB x Kos P_1 showed the least. There is a positive correlation between initial moisture content and moisture retention ability. This particular character depends upon the number and nature of stomata and their distribution per unit area in the leaf.

g. Rooting:

Rooting behaviour of a variety is purely a genetic character and plays a prominant role in the cultivation of vegetatively propagated crops. One of the most fundamental consideration in vegetatively cultivated crops is the rooting ability and root initiation (Hartman & Kester 1959). Mulberry is chiefly propagated through cuttings and rooting behaviour is an important criterion to be possessed by an evolved variety. This method of propagation has been of advantage for easy perpetuation of desirable parental character without deterioration, producing uniform crop stand and early yield of foliage over a seedling population. Survivality of 80% and above is taken as an optimum for selecting the strains. 100 cuttings from 6-8 months old shoots should be taken. Length of the cuttings must be 20-23 cm with 3-4 healthy buds and about 10-12 mm in thickness. Cuttings should be planted in nursery beds at a distance of 10 cm from cutting to cutting and 20 cm from row to row. Rooting ability has to be calculated based on the survival rate after 90 days of planting; observations have to be made right from 30th day onwards, at an interval of 5 days, to observe the quickness and rate of root initiation. Though rooting is a genetic feature as already stated, has a strong influence of soil moisture and temperature. Root initiation is slow and poor under less moisture and cool climate. Hence, studies should cover minimum of six observations for all seasons.

Rooting behaviour was studied in all the 195 accessions for 3-4 seasons and average of all the observations were considered. Rooting ability ranges from 100% (Acc.117) to 2.44% (Local x Kos.P_3). Average rooting was around 50%; more than 30 strains showed 80% and above rooting. Most of the temperate varieties were found very poor in rooting and hence rendering difficulty in vegetative propagation. On the contrary, high percentage of rooting was observed in majority of indigenous accessions. Similarly, in most of the indigenous strains root initiation is quick compared to exotic. Top ten strains showing maximum rooting are given in *Table 11.*

h. Sprouting:

Sprouting is the inherent capacity of the strains to unfold the buds and produce new flush of shoots. Capacity and quickness of sprouting determine the subsequent growth and yield in fodder crops and mulberry is not an exception to this. In addition, sprouting ability determines the success of establishment of new garden. In case of irrigated mulberry garden where shoot harvest system is followed, the number and quickness of

bud sprouting determines the number of primary and secondary branches and in turn the leaf yield. Whereas in rainfed garden, the individual leaf plucking is practiced and here total number of sprouted buds on each branch after leaf harvest determines the lead yield of subsequent crops. Though sprouting is a genetic feature of the strain, soil moisture and temperature have a profound influence. Maximum sprouting can be experienced in summer with optimum moisture in the soil. In winter, the breaking of buds is slow due to low temperture, hence the yield of the subsequent crop is less.

Sprouting as such has to be studied in two specific ways. The first one is sprouting percentage of cuttings after planting in field which plays a vital role in establishement of new gardens. Early sprouting leads to better establishment and early crop. Cuttings of 6-8 months age with 3-4 healthy buds planted in nursery beds is used for this study. First observation is made on 10th day of planting followed by 15th and 20th day. 20th day after planting is taken as optimum time to assess the sprouting rate; 80% and above is considered as optimum for selection of strains. As sprouting after 20th day leads to ununformity in crop stand, slow sprouting strains are not suitable.

To get an overall picture of sprouting , studies were conducted 6 times, covering all seasons for two years. Among the 195 strains studied, the earliest sprouting was observed 8-10 days after planting in strains like S41, Acc.119, Local and it was continued upto 30-40 days in few exotic strains especially of temperate origin. Percentage of sprouting ranges from 1.36(K2xBC-P_6) to 99.2% (Kalia kutahi). Average sprouting is around 49.6 percent and a total of 16 strains show more than 90 percent sprouting. Top ten strains showing higher sprouting are given in *Table 11.*

The second aspect of sprouting relates to breaking open of buds after leaf harvest or pruning of plants. As subsequent leaf yield depends on the quickness and number of buds sprouted; this character has been studied in considerable detail.

Range of variability in all the characters and representing accessions is given in *Table 10.* After assessing varieties for the above mentioned general attributes, strains can also be assessed for their drought resistance, pest or disease resistance and for other special characters. The characters associated with drought are leaf thickness, presence of cuticle, size and number of stomata, thickness of the palisade parenchyma and presence of bundle sheath around the vascular bundles. Suitable methods to assess these characters at both laboratory and field level are already available and same methods can be applied here also. In addition, the rate of root growth, root proliferation and moisture retained after detachment of leaves can also be studied as important critaria for drought tolerance/resistance. The amount of root produced after 90 days of planting and its ratio to shoot can be taken as an index for screening different strains [*Table 11*].

YIELD TRIALS:

After the assessment of all the individual characters contributing to growth and yield, the strains faring better with respect to all characters can be taken for yield testing. Yield of the leaf in mulberry can be tested in a multitiered system comprising of 3 trials, viz., progeny row yield trial, primary yield trial and final yield trial. The recommended practices

of cultivation which are being practiced by the farmers should be adopted with respect to spacing, fertilizer doses, pruning and leaf harvest etc. This will avoid the fluctuation in the experimental data and also the error due to the different cultivation practices. The presently recommended three tier system is more suitable for the perennial crops like mulberry, where vegetative propagation through cuttings is commonly practiced. While doing initial test, material can also be multiplied for the subsequent tests.

In progeny row yield trial, superior lines can be tested by planting the vegetative progeny in individual lines keeping mother plant in a guard row. Locally adapted popular variety has to be planted along with these lines as a check. At the time of every annual pruning, the material can be multiplied in nursery. Minimum time of 4 years is considered optimum for assessing the yield. Depending upon the total number of lines involved in the test and their superiority over the local control 20 to 30 percent of the top strains can be selected for the primary yield trial. For this trial, Randomised Block Design (RBD) is most suitable as the number of strains involved is high. A minimum of 500 to 800 plants must be available for yield assessment from all replications. Annually a minimum of five leaf harvests have to be obtained at an interval of 70 days followed by normally recommended cultural practices. This trial should run for a minimum of 4 years to get better yield performance of all the strains over seasons. Similar to the previous trial, material has to be multiplied after every pruning.This nursery multiplication also facilitates repeated checking of rooting and sprouting behaviour of selected strains as this is one of the most important considerations for vegetatively propagated crops.

Final yield trial could be started after fourth year of the planting of primary yield trial. Minimum population of 1000 plants must be available for yield assessment in this trial. Randomised Block Design is most suitable design which can accommodate 8 to 10 strains with 3 to 4 replications. In this trial also, it is necessary to maintain spacing, planting etc., as per the recommendations Minimum 5 harvests with two bottom prunings must be given annually. Fertilisers and farm yard manure should be applied as per the recommended doses. Simultaneously, rearing studies must also be conducted to assess the nutritive quality and palatability of the strains.

QUALITY EVALUATION:

Quality of the mulberry varieties can be tested both by bio-assay and chemical analysis. Feeding trials could be conducted in two ways viz., moulting test and full rearing test. In the moulting test, only 70% of the total feed required to the known number of larvae should be fed and their moulting performance should be observed. Observations on number of worms going for normal moulting, number of worms delayed to undergo moult and number of worms which come out of the moult within the specific period must be observed. In this study, inspite of under feeding, healthyness or otherwise of the worms reflects on the nutritive quality of the leaves which can be taken as an index. This method is more suitable where large number of strains are to be tested at a time and can be utilized for preliminary screening for nutritive quality. In the second method, full rearing has to be conducted by keeping a quantum of the feed and number of larvae constant. The growth rate and the general healthyness should be observed till fifth age and finally the leaf cocoon ratio can be calculated based on cocoon harvest. Studies on ERR, Shell ratio,

Shell percentage, filament length etc., should also be made to correlate the silk quantity to the nutritional quality of the leaf.

As a check and for comparison, chemical analysis of the leaf for the moisture, total sugars, reducing sugars, carbohydrates and minerals are to be made. Detailed qualitative and quantitative analysis of specific contents like amino acids, isozymes etc. can also be made. The results obtained thus can be correlated with that of the feeding trial results. This will also help in knowing the phylogenetic relationship of the strains.

MULTILOCATION TRIAL:

Varieties found superior both in yield and quality can be further tested for their suitability to different agroclimatic conditions for recommending region/location specific strains. This is more relevant because of the fact that sericulture is now being practiced in almost all the states and union territories of India with diverse agro-climatic conditions. While conducting the multilocational trial, the most important aspect is classifying the regions into different agrozones based on edaphic and climatic conditions. Identification of the locality to conduct these trials must be based on available infrastructural facilities. While fixing the strain for each locality, information available on primary screening based on individual character analysis should be viewed in relation to the conditions under which the strain is being tested. These trials must be conducted for a minimum period of 5 years along with simultaneous rearing studies. The superior ones could be recommended later to the respective regions. To achieve this goal an All India Co-ordinated Project is recommended.

MULBERRY DESCRIPTOR

I. PHYTOGEOGRAPHICAL INFORMATION:

1. Botanical name
2. Common/Varietal name
3. Origin : Indigenous/Exotic (Country/State/Province)
4. Wild or cultivated
5. If cultivated
   a. Mode of origin : Introduction/Selection/Hybrid/Mutant/Polypoli
   b. Areas of cultivation : Temperate/Tropical/Subtropical

II. MORPHOLOGICAL CHARACTERS (Vegetative)

1. Habit : Tree/Bush
2. Branching nature : Errect/Spreading/Drooping
3. Colour of the stem
4. Lenticels
   a. Presence : Present/Absent
   b. Distribution : Dense/Medium/Sparse
5. Colour of the young shoot : Green/Purple/Dark purple
6. Leaf
   a. Internodal distance : Top (1st — 7th leaf)
      Middle (8th — 15th leaf)
      Base (below 15th leaf)
   b. Phyllotaxy : Alternate/Opposite/Whorled
   c. Rank : 1/2, 2/3, 2/5, 3/5
   d. Nature : Uniform/Heterophyllus
   e. Stipules
      i. Presence : Present/Absent
      ii. Nature : Simple/Folaceous
      iii. Duration : Deciduous/Caducous.
   f. Petiole length (cm)
   g. Lamina
      i. Lobation : Lobed/Entire
         if lobed : Regular/Irregular
      ii. Shape
      iii. Base
      iv. Apex
      v. Margin
      vi. Surface
      vii. Texture
      viii. Hairiness
      ix Venation
      x. Average leaf size : Length/Breadth (cm)/Area (sq.cm)
      xi. Thickness (μ)

III. REPRODUCTIVE STRUCTURES

1. Sexuality : Male/Female/Monoecious/Bisexual/Mixed
2. Flowering nature : Regular/Occasional
3. Frequency : Heavy/Shy
4. Inflorescence
   a. Length (cm)
   b. Diameter (cm)
   c. Flower arrangement : Loose/Thick
5. Male flowers
   a. No. of stamens
   b. Nature : Exerted/Included
6. Pollen grains
   a. Size
   b. Openings
   c. Fertility (%)
   d. Viability (%)
7. Female flower
   a. Style length (mm)
   b. Stigma
      i. Length (mm)
      ii. Colour
      iii. Nature : Bifid errect/Bifid divericate/Bifid spreading
8. Fruit
   i. Size: Length & diameter (cm)
   ii. Colour
   iii. Taste (ripe fruit) : Sweet/Salty/Sour
9. Seed
   a. 100 seed weight (mg)
   b. Germination (%)
   c. Viability (duration)

IV. ANATOMICAL FEATURES

1. Idioblasts
   a. Presence : Present/Absent
   b. Frequency (No./sq.cm)
   c. Size (width)
   d. Shape
   e. Projection length (μ)
2. Stomata
   a. Distribution : Abaxial/Adaxial
   b. Type
   c. Position : Sunken/Surface
   d. Frequency (per unit area)
   e. Size (μ) : Length/Breadth
   f. Guard cell size (μ) : Length/Breadth
   g. Stomata chlorophast (No.)

3. No. of Palisade layers
4. Ratio of palisade/spongy layer by thickness
5. Thickness of cuticle (μ)
6. Special features, if any

V. CYTOLOGICAL DETAILS

1. Somatic
   a. 2n chromosome No.
   b. Ploidy level
   c. Karyotype formula
   d. Total chromatin length
   e. No. of sat-chromosomes
   f. No. of large chromosome pairs
2. Meiotic
   a. Meiotic behaviour — Regular/Irregular
   b. Chromosome configuration
   c. Meiotic abnormalities
   d. Tetrad type
3. Special features, if any

VI. PROPAGATION

1. Sprouting
   a. Quality : Fast/Medium/Slow
   b. Percentage on 20th day
2. Rooting
   a. Nature : Fast/Medium/Slow
   b. Percentage (on 60th day)
3. Root proliferation rate (on 90th day)
   a. Weight of dry roots
   b. Length of longest root
   c. Dry shoot/root ratio (by weight)
4. Suitability as stock : Good/Medium/Poor
5. Cuttings standards for propagation
   a. Optimum age of shoot
   b. Optimum length of cutting : Buds Length
   c. Optimum girth of cutting

VII. GROWTH AND YIELD ATTRIBUTES

A. Quantitative

1. Growth
   a. Nature : Slow/Medium/Fast

b. Rate/90 days (cm)
   i. No. of primary branches (cm)
   ii. Length of primary branches (cm)
   iii. No. of secondary branches
   iv. Length of secondary branches (cm)
   v. Total shoot length (cm)
   vi. Leaf No./meter
   vii. Wt. of 100 fresh leaves (gm)
c. Lamina/Petiole ratio
   i. By length
   ii. By weight
d. Leaf-shoot ratio by wt.
e. Total leaf yield/plant/harvest
f. Annual yield/plant
g. Calculated yield/ha

B. Qualitative

1. Moisture %
   i. Top Middle Base
   (1-7) (8-15) (below 15)
   ii. Average
2. Mositure retention capacity
   average at 12th hour of harvest
3. Chemical contents
   i. Non reducing sugars
   ii. Reducing sugars (%)
   iii. Total sugars (%)
   iv. Crude protein (%)
   v. Mineral (%)
   vi. Fibre (%)
4. Palatability
5. Moulting test (70% feed upto 2nd moult)
6. Leaf cocoon ratio (by feeding trial)

VIII. RESPONSE TO DIFFERENT PHYSIOLOGICAL CONDITIONS

1. Resistance to drought : Resistant/Tolerant/Susceptible
2. Resistance to salinity : Resistant/Tolerant/Susceptible
3. Response to winter : Good/Medium/Poor
4. Response to repeated pruning : Good/Medium/Poor

IX. RESISTANCE TO DISEASES AND PESTS

1. Diseases:
   a. Fungal leaf spot
   Cercospora moricola : Resistant/Tolerant/Susceptible
   b. Powdery mildew
   Phyllactinia corylea : Resistant/Tolerant/Susceptible

c. Leaf rust.
Cerotelium fici Resistant/Tolerant/Susceptible

d. White root rot
Rosellinia necatrix Resistant/Tolerant/Susceptible

e. Violet root rot
Helicobasidium mompa Resistant/Tolerant/Susceptible

f. Bacterial leaf spot
Pseudomonas mori Resistant/Tolerant/Susceptible

g. Any other disease
(Not covered above)

2. Pests:

a. Hairy caterpillar
Diacrisia obliqua Resistant/Tolerant/Susceptible

b. Jassids **Empoasca flavescens** Resistant/Tolerant/Susceptible

c. Mealy bugs
Maconellicoccus hirsutus Resistant/Tolerant/Susceptible

d. Red scale **Aonidella aurantii** Resistant/Tolerant/Susceptible

e. Thrips (5 species) Resistant/Tolerant/Susceptible

f. Mites
Tetranychus spp. Resistant/Tolerant/Susceptible

g. Root knot nematode
Meloidogyne incognita Resistant/Tolerant/Susceptible

h. Any other pests (Not covered above)

LIST OF MULBERRY STRAINS MAINTAINED AT CSR & TI, MYSORE AND OTHER PLACES IN INDIA

INDIGENOUS MULBERRY STRAINS MAINTAINED AT CSR&TI., MYSORE

Sl. No.	Acc. No.	Name
1.	103	Kalia Kutahi
2.	105	Assamabola
3.	106	—
4.	109	Sujanpur-1
5.	110	Jatinuni
6.	111	MR-2
7.	112	—
8.	113	—
9.	114	—
10.	115	—
11.	117	—
12.	118	—
13.	119	I-19
14.	120	—
15.	121	—
16.	130	Sujanpur-5
17.	138	—
18.	139	Ber. S 1
19.	140	Ber. c763
20.	141	Ber. c776
22.	142	Ber. S799
22.	144	Local male
23.	145	Kanva-2
24.	146	Local female
25.	150	MR-1
26.	153	—
27.	154	—
28.	155	—
29.	156	S-30
30.	157	S-36
31.	158	S-41
32.	159	S-54
33.	161	Cuckpilla
34.	162	Bilidevalaya
35.	163	Dhar local (Unlobed)
36.	166	Birds Foot
37.	170	OPH-3

38.	172	Batatul
39.	175	Chattatul
40.	184	Serpentina
41.	185	Jagtul
42.	187	Nadigam
43.	188	Chattatul Zangir
44.	193	Lazward
45.	194	Jodhpur
46.	195	Almora local
47.	196	Local lobed
48.	197	Punjab local
49.	198	Himachal local
50.	199	LF-2
51.	200	FGDTR-9
52.	201	TR-8
53.	202	TR-10
54.	203	LF-1
55.	206	Brentul
56.	207	S-31
57.	208	S-146
58.	209	S-523
59.	210	S-642
60.	211	S-741
61.	212	S-796
62.	213	S-1096
63.	214	RFS-135
64.	215	S-1301
65.	216	S-1531
66.	217	BC2 59
67.	218	TR-4
68.	219	**M.laevigata**
69.	221	Berhampore
70.	222	BSI Var-1
71.	223	BSI Var-2
72.	224	Matigara Black
73.	225	Meergund-2
74.	226	Meergund-6
75.	227	Ms-2
76.	228	Ms-5
77.	229	Ms-7
78.	230	Ms-9
79.	232	Rabis Sarnal
80.	237	OPH-1
81.	240	RFS-175

82.	241	Chinarpati
83.	242	Roznitul
84.	243	Dhar local (Lobed)
85.	244	Kajali
86.	251	Meergund-1
87.	252	Meergund-5
88.	253	Ms-1
89.	254	Ms-3
90.	255	Ms-6
91.	256	Ms-8
92.	258	Chattatul Meergund
93.	259	Kollegal
94.	260	Ficus 2X
95.	261	Surat Var.

MATERIALS MAINTAINED AT OTHER CENTRES

96.	T1
97.	S-8
98.	S-1708
99.	S-1635
100.	S-1608
101.	C-1690
102.	C-1726
103.	C-1730
104.	C-1729
105.	C-1733
106.	C-1614
107.	KPG-I
108.	KPG-II
109.	C-53
110.	C-147
111.	Berhampore-B
112.	Teesta Valley
113.	CSRS-2
114.	Dudhia
115.	S-1537
116.	C-775
117.	Berhampore-A
118.	Berhanpore-4
119.	Berhampore-6
120.	Berhampore-20

121.	Berhampore-39
122.	CSRS-I
123.	**M.indica** 'X'
124.	Assam Jatti
125.	Lloyos
126.	Nan nayapatti
127.	Kolitha-3
128.	Kolitha-7
129.	Kolitha-8
130.	Kolitha-9
131.	Mirganj
132.	Dudhia-red
133.	Bishnupur-4
134.	Bishnupur-9
135.	Tollyganj
136.	Bush malda-B
137.	Matigara white
138.	Kurseong
139.	Sultanpur
140.	Black Cherry
141.	Takada
142.	KPG-III
143.	White Badana
144.	Kabli-I
145.	Monla-I
146.	**M.indica** (H.P.)
147.	Muki
148.	Zangbad
149.	Shatut
150.	T-20
151.	CTI
152.	Berhampore (non dehiscen
153.	Thalaghattapura.
154.	Dehradun
155.	Berhampore
156.	Delhi Wild
157.	Mother graft
158.	Acc.3
159.	Acc. 6
160.	Acc. 30
161.	Acc. 71
162.	Acc. 72
163.	Acc. 73
164.	Acc. 74
165.	Acc. 75

	Acc. 76
166.	Acc. 77
167.	Acc. 78
168.	Acc. 79
169.	Acc. 81
170.	Acc. 82
171.	Acc. 83
172.	Acc. 84
173.	Acc. 85
174.	Acc. 87
175.	Acc. 90
176.	

EXOTIC MULBERRY STRAINS MAINTAINED AT CSR&TI., MYSORE

Sl.	Acc. No.	Name	Origin
1.	101	Kosen	Japan
2.	102	KNG	Japan
3.	104	China White	China
4.	107	—	—
5.	108	—	Japan
6.	116	—	—
7.	122	Mizusawa	Japan
8.	123	—	—
9.	124	Kokuso-13	Japan
10.	125	Fernodias	Paraguay
11.	126	Tsukasaguwa	Japan
12.	127	Goshoerami	Japan
13.	128	—	Japan
14.	129	Cattaeneo	Italy
15.	131	Moulai	Burma
16.	132	English Black	France
17.	133	Sanish-5	Russia
18.	134	—	—
19.	135	—	—
20.	136	Roso	Japan
21.	137	Kenmochi	Japan
22.	143	Kokuso-21	Japan
23.	147	China Peking	China
24.	148	—	—
25.	149	Ichihei	Japan
26.	151	—	—
27.	152	—	—
28.	160	Ichinose	Japan
29.	164	Limoncina	Japan
30.	165	—	—
31.	167	—	Japan
32.	168	Katania	Japan
33.	169	Shinichinose	Japan
34.	171	Rokokuyoso	Japan
35.	173	Kairyo Roso	Japan
36.	174	Senmatsu	Japan
37.	176	Italian Sarnal	Italy
38.	177	Ensatakasuke	Japan
39.	178	Shrim-2	Bangla Desh
40.	179	Shrim-5	Bangla Desh
41.	180	Shrim-8	Bangla Desh
42.	181	Shimanochi	Japan
43.	182	Kokuso-20	Japan

Sl. No.	Acc.	Name	Origin
44.	183	Kokuso-27	Japan
45.	186	Paraguay	Paraguay
46.	189	Calabresa	Paraguay
47.	190	Atsubamidori	Japan
48.	191	Miuraso	Paraguay
49.	192	French	France
50.	204	White Mulberry	Japan
51.	205	Kasuga	Japan
52.	220	**M.australis**	Australia
53.	231	Tomeiso	Japan
54.	233	**M.australis**	Indonesia
55.	234	**M.cathyana**	Indonesia
56.	235	**M.multicaulis**	Indonesia
57.	236	**M.nigra**	Indonesia
58.	238	Seizuro	Japan
59.	239	Burma-8	Burma
60.	245	Okinawa	Japan
61.	246	PKS (1-12)	Pakistan
62.	247	PKS (1-11)	Pakistan
63.	248	PKS (1-9)	Pakistan
64.	249	PKS (1-4)	Pakistan
65.	250	PKS (1-2)	Pakistan
66.	257	Togowase	Japan

MATERIALS MAINTAINED AT OTHER CENTRES

Sl. No.	Origin	Name
67.	Lisbon	Portugal
68.	Canton China	China
69.	Bogura-1	Bangla Desh
70.	Bogura-4	Bangla Desh
71.	Aoroso	Japan
72.	Ilokuso	Japan
73.	Sosuke	Japan
74.	Moratiana	—
75.	Sukakuchi	Japan
76.	Tusim Kawa	Japan
77.	Kurimato	Japan
78.	Akagi	Japan
79.	Asiyoke	Japan
80.	Kanmasori	Japan
81.	China Black A	China

82.	China Black B	China
83.	China Black C	China
84.	Phillipine	Phillipine
85.	**M.chouseIrange**	France
86.	**M.rubra**	Italy
87.	Rosodilumbadium	Italy
88.	Rosteli	Italy
89.	Shid seguwa	Japan
90.	Kabul	Afghanistan
91.	Ankara	Turkey
92.	Italian mulberry	Italy
93.	Egypt Kairo	Egypt
94.	Hungarian	Hungary
95.	Fukushima Aha	Japan
96.	Rangoon (**M. alba**)	Burma
97.	**M.rotundiloba**	Burma
98.	Cyprus	Greece
99.	Kairyo akita	Japan
100.	Oshima	Japan
101.	Rohachi	Japan
102.	Artificial	Japan
103.	Wasemidori	Japan
104.	Sterile	Japan
105.	Madrid spain	Spain
106.	Atucanidia	Spain
107.	Moretiseringe	France
108.	Takawase	Japan
109.	Obawase	Japan
110.	Zest	Exotic
111.	Italian	Italy
112.	Japan-I	Japan
113.	Japan-II	Japan
114.	Sulaweri-I	Sulaweri
115.	Sulaweri-II	Sulaweri
116.	Kanzan	Japan
117.	Kairyoichinose	Japan
118.	Hazzaz	Lebanon
119.	PKS — 1-14	Pakistan
120.	Acc-54	Egypt
121.	Acc-55	Egypt
122.	Acc-56	Egypt
123.	Acc-57	Egypt
124.	Acc-58	Egypt
125.	Acc-59	Egypt

126.	Bendola	Egypt
127.	Acc-61	Egypt
128.	Acc-62	Egypt
129.	Acc-63	Egypt
130.	Acc-64	Zimbabwe
131.	Acc-65	Egypt
132.	Acc-66	Egypt
133.	Acc-88	Srilanka
134.	Acc-100	Srilanka
135.	Acc-101	Srilanka
136.	Acc-102	Srilanka
137.	Acc-103	Srilanka
138.	Acc-104	Srilanka
139.	Acc-105	Srilanka

Table 1
GEOGRAPHICAL DISTRIBUTION OF IMPORTANT SPECIES OF THE GENUS **MORUS**

Name of the species	Distribution
M. alba L.	North Eastern China, Korea
M. australis poir. (**M. acidosa** Griffith)	Australia, India, Indonesia, Philippines, South China
M. bombycis Koidz.	China, Japan, Korea, Southern Sakhalin
M. Chinensis L.	China
M. cathyana Hemsl.	Central China
M. indica L.	India
M. laevigata Wall.	India (Himalaya), West China
M. latifolia Poir. (**M. multicaulis** Rafin.)	China, Japan, South Korea
M. nigra L.	Caucaseous, Persia, West Asia
M. rubra L.	North America
M. serrata Roxb.	India (Himalaya)
M. tartarica L.	Russia
M. tilaefolia Makino	Japan, Korea

Table 2
SOURCES AND TYPES OF GERMPLASM MATERIAL AVAILABLE

Type of Source	Centres of diversity (Indochina region)	Centres of cultivation (leading sericultural countries)	Research Institute & breeding centres
Type of material	Primitive cultivars Natural hybrids Wild relatives Weedy forms Related genera	Commercial cultivars Obsolete varieties Minor varieties Special purpose types	Pure lines Elite hybrid varieties Open pollinated hybrids Breeding lines Breeding stocks Mutants Polyploids Intergeneric and Interspecific hybrids Cytoplasmic sources Composites and synthetics

Table 3

COUNTRYWISE COLLECTIONS OF MULBERRY STRAINS AT CENTRAL SEICULTURAL RESEARCH AND TRAINING INSTITUTE, MYSORE

Name of the country	No. of accessions
Australia	1
Bangladesh	3
Burma	2
China	2
France	2
India	92
Indonesia	4
Italy	2
Japan	31
Pakistan	5
Paraguay	4
USSR	1
Unknown	9
Total	158

Table 4

STATEWISE AREA UNDER MULBERRY CULTIVATION (in ha.)

Sl. No.	Name of the State	Area in ha.	Percentage
1.	Andhra Pradesh	40891	19.10
2.	Assam	900	0.42
3.	Arunachal Pradesh	27	—
4.	Bihar	261	0.12
5.	Jammu & Kashmir	632	0.29
6.	Karnataka	126567	59.10
7.	Maharashtra	474	0.22
8.	Manipur	1000	0.46
9.	Madhya Pradesh	360	0.15
10.	Mizoram	117	0.05
11.	Meghalaya	500	0.23
12.	Nagaland	20	—
13.	Orissa	275	0.13
14.	Punjab	64	—
15.	Tamilnadu	27151	12.68
16.	Tripura	480	0.22
17.	Uttar Pradesh	2586	1.07
18.	West Bengal	12407	5.80
19.	Others	126	0.06
	Total	214838	100.00

Table 5

STATEWISE COLLECTIONS OF INDIGENOUS STRAINS OF MULBERRY AT CSRTI MYSORE

Name of the State	No. of accessions
Assam	1
Himachal Pradesh	1
Jammu & Kashmir	18
Karnataka	17
Madhya Pradesh	2
Punjab	3
Rajasthan	3
Tamilnadu	2
Uttar Pradesh	20
West Bengal	14
Unknown source	11
Total	92

Table 6

CENTRES AT WHICH MULBERRY GERMPLASM IS BEING MAINTAINED IN INDIA

Sl. No.	Place	Type of material			
		Indigenous	Exotic	Other	Total
1.	CSRTI, Mysore (CSB)	92	66	101	259
2.	CSRTI, Berhampore (CSB)	52	69	—	121
3.	RSRS, Kalimpong (CSB)	31	12	—	43
4.	RSRS, Majra (CSB)	39	—	—	39
5.	RSRS, Pampore (CSB)	11	21	13	46
6.	RSRS, Coonoor (CSB)	19	6	8	25
7.	Mysore University	3	5	—	8
8.	BSI, Calcutta	3	1	—	4
9.	Horticultural garden Saharanpur (U.P)	3	—	—	3
10.	KSSDI, Bangalore	43	55	7	105
11.	Sher-e-Kashmir University of Agricultural Sciences, Srinagar	30	23	—	53
12.	Bharathidarshan University, Tiruchirapalli	5	4	—	9
13.	Tamilnadu Sericulture Department Coonoor	19	4	—	23

Table 7

SPECESIWISE COMPOSITION OF MULBERRY STRAINS MAINTAINED AT CENTRAL SERICULTURAL RESEARCH AND TRAINING INSTITUTE, MYSORE.

Species	No. of accessions
M. alba	18
M. australis (M. acidosa)	1
M. bombycis	5
M. cathyana	1
M. chinensis	2
M. indica	21
M. laevigata	4
M. latifolia (M. multicaulis)	24
M. lhou	2
M. nigra	2
M. serrata	4
M. tilaefolia	1
Unidentified	73
Total	158

Table 8

SEXUAL COMPOSITION OF MULBERRY STRAINS

	No. of strains	Percentage
I. DIOECIOUS		
i. Exclusively female	58	46.0
ii. Exclusively male	13	10.3
II. MONOECIOUS		
ii. Predominately male (sub androecious)	15	11.9
ii. Predominately female	3	2.3
iii. Male and female in equal proportion	26	20.6
III. BISEXUAL TYPES (Occasional)	6	4.7
IV. NON-FLOWERING TYPE	5	3.9
Total	126	100.00

Table 9
YIELD PARAMETERS AND OPTIMUM VALUES

Sl. No.		Optimum values
1.	Leaf lobation	Unlobed
2.	Height of the plant (cm)	250.00
3.	Internodal distance (cm)	4.00
4.	Fresh weight of 100 leaves (g)	450.00
5.	Sprouting (percentage)	90.00
6.	Rooting (percentage)	80.00
7.	Root proliferation by length (cm)	50.00
8.	Moisture (percentage)	73.00
9.	Moisture retaining capacity (percentage) after 12 hours	68.00

Table 10
RANGE OF VARIABILITY OF DIFFERENT CHARACTERS AND REPRESENTING ACCESSIONS

Name of the Character	Maximum value	Minimum value	Average value	Total No. of accessions showing more than average
Plant height (cm)	355.40 (141)	100.30 (Goshoerami)	227.85	37
Internodal distance (cm)	7.38 (Miz x BCP)	2.25 (102)	4.81	38
Weight of 100 leaves (gm)	1400 (Goshoerami)	98.0 (117)	430.52	73
Leaf petiole ratio by weight	92.98:7.02 (132)	64.5:35.5 (135)	78.74:21.26	129
Sprouting percentage	99.2 (103)	1.36 (K2xBCP6)	49.6	110
Rooting percentage	100.0 (117)	2.44 (Local x Kosen) P3	50.0	85
Moisture percentage	78.7 (116)	45.8 (WBx Kosen P1)	62.25	144
Mositure retaining capacity Goshoerami	76.80 (Miz. x Cat. P3)	41.26	59.03	137
Leaf area/meter	7093.75 (167)	WB x Kosen P1 1225.73 (138)	4159.74	38

Table 11

THE VALUES OF DIFFERENT PARAMETERS IN TOP 10 STRAINS OF MULBERRY AT CENTRAL SERICULTURAL RESEARCH AND TRAINING INSTITUTE, MYSORE

Plant height (cm)	355.40 (141)	301.40 (158)	295.50 (140)	284.70 (121)	283.30 (157)	280.60 (155)	276.40 (214)	274.20 (139)	274.0 (239)	271.20 (113)
Internodal distance	2.25 (102)	2.5 (133)	2.94 (156)	3.00 (AB x KO-KUSO-13)	3.07 (119)	3.14 (237)	3.20 (106)	3.20 (158)	3.21 (144)	3.23 (120)
Weight of 100 leaves (gm)	1400 (Goshoe-rami)	693 (Suj. x Phil. R5P2)	676 (151)	673 (Miz. x BCP9)	665 (Suj. x Phil. P2)	655 (Miz. x catt. P7)	645 (Miz. x catt.P10)	640 (Miz . x BC 96	635 (K2 x Kosen) P3	614 (140)
Leaf petiole ratio (by weight)	92.98:7.02 (138)	92.30:7.67 (131)	92.10:7.90 (151)	91.99:8.01 (110)	91.85:8.15 (120)	91.82:8.18 (144)	91.70:8.30 (122)	91.68:8.32 (156)	91.62:8.38 (108)	91.60:8.4 (139)
Sprouting (%)	99.2 (103)	96.6 (104)	95.6 (105)	95.0 (109)	95.0 (144)	95.0 (158)	95.0 (112)	93.44 (ABxPhil P9)	92.90 (Miz.xBCP12)	92.00 (ABxPhil.P6)
Rooting (%)	100.00 (117)	98.0 (115)	95.90 (Miz x BC P9)	95.4 (132)	94.2 (214)	95.5 (121)	92.0 (103)	90.2 (143)	90.0 (144)	90.0 (130)
Moisture (%)	78.00 (116)	75.60 (Miz.xCat.P3)	75.5 (ABxPhil P8)	75.4 (114)	75.4 (Miz.xCatP10)	75.0 (152)	75.00 (Suj.xPhil R4P6)	74.70 (K2xBC R5P6)	74.70 (Suj.xPhil. R5P6)	74.50 (Suj.xPhil. R5P4)
Moisture retaining Capacity (%)	76.80 (Miz.xcat.P3)	73.63 (214)	72.50 (Miz.xcat.P7)	70.94 (240)	70.80 (Suj.xPhil R4P1)	70.70 (Suj.xPhil R5P6)	70.50 (Suj.xPhil. R5P5)	70.50 (Suj.xPhil. R4P4)	70.40 (K2 x Kosen. P4)	70.00 (151)
Leaf area/meter (cm^2)	7093.75 (167)	7023.95 (159)	6876.65 (181)	6836.09 (157)	6736.78 (158)	6517.86 (122)	6357.18 (133)	5851.48 (101)	5835.55 (125)	5777.64 (156)

Note: Accessions are represented an parenthesis

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