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ESTABLISHMENT OF SEED ORCHARDS IN THE PUNJAB



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FINAL TECHNICAL REPORT

Project Title : Establishment of Seed Orchards
in the Punjab.

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ESTABLISHMENT OF SEED ORCHARDS
IN THE PUNJAB.

SUMMARY.

Seed Orchards of commercially important tree species have been established in the Punjab. For establishing seed orchards/progeny tests four hundred and sixteen candidate plus trees of various species were marked in different parts of the Punjab. Quality seed collected from the marked plus trees was sown in bed/potted nurseries at Punjab Forestry Research Institute for raising planting stock for establishing seed orchards/progeny tests. Seed Orchards over 26 acres were raised at two locations. The area under seed orchards in Bhagat reservoir is 19.5 acres and in Chakku Rakh Plantation 6.5 acres. To improve the quality of wood, stem form, resistance to disease etc. vegetative propagation or clonal propagation offers the advantage of greater genetic uniformity and immediate availability of superior clones for establishing clonal seed orchards. Keeping in view the importance of vegetative propagation, several experiments were conducted to study the vegetative propagation behaviour of Eucalyptus camaldulensis, Dalbergia sissoo, Acacia nilotica, Tamarix aphylla and Morus alba etc. through root shoot cuttings, stem or branch cuttings and root cuttings with application of different concentrations of chemicals and hormones and without application of any chemical and hormones.

INTRODUCTION:-

Selection, preservation and multiplication of superior germplasm is a pre-requisite of a successful tree improvement programme. There is an acute shortage of wood in our country. The situation is further aggravated owing to the fact that trees growing already in our forests or plantations are defective, malformed and inferior. Moreover seed is collected from these inferior trees and nurseries are raised for further stock, resulting in forest or plantations which are almost deprived of superior trees. This practice needs rectification, emphasis is required on selecting superior trees and stands for seed collection. Multiplication of these superior germplasm is quite useful in lifting quality of the growing stock upto the level desired.

To meet the ultimate purpose i.e. procurement of quality seed, Punjab Forestry Research Institute, Faisalabad started a project "Establishment of Seed Orchards in the Punjab", with the collaboration of Pakistan Agricultural Research Council. The project period was from January, 1985 to June, 1989.

The subject i.e. genetic improvement of forest stands, is some what new in Pakistan. Already some efforts had been made in this direction especially in marking of plus trees of Shishan, Kail, Chir etc. but that was not enough. This project aimed at carrying out research relating to genetical and silvicultural aspects of all the important tree species of the Punjab. The project was located in various

PLUS TREE SELECTION.

For establishment of seed orchards/progeny tests first step was selection of plus trees. The work of plus tree marking was started during 1985 with the commencement of the project. The criteria adopted for selection of plus trees was vigorous growth, desirable wood quality, disease resistance and quality seed production, etc. On the basis of above criteria candidate plus trees of various species were marked during the project period in different forest divisions. The location is given as under:

1. Eucalyptus camaldulensis:

Criteria for selection was based on outstanding straightness of bole, natural good branch shedding, occlusion of knots, resistance to diseases, adaptation to locality, adaptation to the marginal sites, fast growth, seed producing capacity.

The detail of plus trees selected is as follow:-

<u>Forest Division.</u>	<u>Location.</u>	<u>Tree Nos.</u>
Bahawalpur	Chak Katora Plantation Cpt.No.11.	1 to 14
"	" " " " " 37.	1 to 54
"	" " " " " 28.	1 to 23
Kasur	Changa Manga Plantation Cpt.No.28.	1 to 2
"	" " " " " 20.	1 to 2
Multan	Pirawala Plantation Cpt.No.136.	1 to 7
"	" " " " " 84.	1 to 13
Faisalabad	Faisalabad Samundri Road Block.	1 to 4
	Total:-	<u>119</u>

P/5.

2. Dalbergia sissoo: Characteristics taken into account for selection were:-

Straightness of bole, stem quality, disease resistance, bark thickness, fast growth, branching habit, seed production & higher seed weight. The location of selecte trees is as follow:-

<u>Forest Division.</u>	<u>Location.</u>	<u>Tree Nos.</u>
Faisalabad	Rajana Distributory near Bhagat Reservoir.	1 to 27
"	Bhagat Plantation Cpt.No.2,3,5,14	1 to 7
Bahawalpur	Lal Suhanra Plantation Cpt.No.91, 92.	1 to 4
"	Chak Katora plantation.	1 to 2
Multan	Pirawala Plantation compound area	1
Gujrat	Daphar Plantation Cpt.No.16	1
Multan	Pirawala Plantation Cpt.No.125 A	1 to 6
Total:-		<u>48</u>

3. Salmalia malabarica:

The charactristics for selection were:-

Straightness of bole, natural good branch shedding, occultation of knots, disease resistance, fast growth, good seed producing capability, etc.

The trees marked are:-

<u>Forest Division.</u>	<u>Location.</u>	<u>Tree Nos.</u>
Kasur	Changa Manga Plantation Cpt.No.28.	1 to 15
Bahawalpur	Chak Katora Plantation Cpt.No.11.	1 to 12
Chichawatni	Chichawatni Plantation Cpt.No.138/ W & 226/W	1 to 3 & 1 to 4
Multan	Khanewal Mianchannu Railway track near Mian Channu.	1 to 29
Total:-		<u>63</u>

P/6.

4. Pinus roxburghii: The factors taken into account for selection were:-

Height and diameter growth, straightness and taper of the stem, clearance of the stem from branches, degree of self pruning, branch thickness, length and angle of insertion of branches, crown shape, resin yield etc.

The location of the trees marked is:-

<u>Forest Division.</u>	<u>Location.</u>	<u>Tree Nos.</u>
Rawalpindi South	Block Kultia Murree Hills (Panjar)Cpt.No.58.	1 to 10
"	Block Kaloian Chakla Murree Hills (Panjar)Cpt.No.24.	1 to 14
Murree Hills	Block Surba Cpt.No.70(V)	1 to 19
"	Block Ghoragali Cpt.No.57 (II) & 58.	1 to 4
"	Block Tret Cpt.No.86(II)	1 to 17
Total:-		64

5. Melia azedarach: Straightness of bole, stem quality, natural good branch shedding, fast growth, crown shape, seed producing capability etc. were factors taken into account for selection.

Trees marked are:-

<u>Forest Division.</u>	<u>Location.</u>	<u>Tree Nos.</u>
Bahawalpur	Bahawalpur Plantation Cpt.No.12.	1 to 16
Total:-		16

6. Acacia nilotica: Characters taken into account for selection were:-

Frost resistance, fast growth, straightness of bole upto 1/3 height of the bole; crown shape etc., their location is:-

P/7.

<u>Forest Division.</u>	<u>Location.</u>	<u>Tree Nos.</u>
Rahim Yar Khan	Abassia Plantation Cpt.No.3.	1 to 4
"	" " " "477.	1 to 8
Bahawalpur	Chak Katora Plantation Cpt.No.23.	1 to 16
Chichawatni	Harapa city road and Vehari Luddon road.	1 to 6
Sahiwal	Sahiwal-Arifwala Road.	1 to 6
Total:-		40

7. Eucalyptus citriodora:

Outstanding straightness, natural good branch shedding, occultation of knots, disease resistance, stem quality were the main factors taken into account for selection.

The location of the trees marked is:-

<u>Forest Division.</u>	<u>Location.</u>	<u>Tree Nos.</u>
Bahawalpur	Chak Katora Plantation Cpt.No.11.	1 to 7
Kasur	Changa Manga Cpt.No.56	1 to 2
Total:-		9

8. Pinus wallichiana:

High growth rate, good stem form, crown shape, angle, thickness and length of branches, wind firmness etc. were considered at the time of selection of plus trees.

The location of the trees is:-

<u>Forest Division.</u>	<u>Location.</u>	<u>Tree Nos.</u>
Murree Hills	Patriata Forest Cpt.No.26	1 to 4
"	Cpt.No.36	1 to 11
Total:-		15

9. Morus alba: The factors taken into account were:-

Straightness of bole, disease resistance, fast growth, etc.

The location is as follows:-

<u>Forest Division.</u>	<u>Location.</u>	<u>Tree Nos.</u>
Kasur	Changa Manga Plantation Cpt.No.51	1 to 31
		Total:- 31

10. Prosopis juliflora:
(Mesquite)

The factors taken into account were:-

Straightness of bole, high growth rate, disease resistance, etc.

The location of the trees marked is as under:-

<u>Forest Divison.</u>	<u>Location.</u>	<u>Tree Nos.</u>
Chichawatni	Vehari Luddon road	1 to 5
"	Burewala-Vehari road	1 to 2
		Total:- 7

11. Syzigium cumini:

Outstanding straightness upto 1/3 height of stem, fast growth and adaptability to varying types of soils were taken into account for selection of plus trees.

The location of plus trees marked is as under:-

<u>Forest Division.</u>	<u>Location.</u>	<u>Tree Nos.</u>
Kasur	Changa Manga Plantation Cpt.No.56	1 to 2
		Total:- 2

12. Albizzia procera:

The basis for selection were bole straightness upto 1/3 height of bole, disease resistance and crown shape etc.

The location of plus trees is:-

<u>Forest Division.</u>	<u>Location.</u>	<u>Tree Nos.</u>
Kasur	Changa Manga Plantation(Arboratum) Cpt.No.56	1 to 2
		Total:- 2

SEED COLLECTION:

Second step in establishing seed orchards/progeny tests was collection of quality seed from marked candidate plus trees because seed collection from plus trees is very essential for tree breeding & tree improvement works.

In actual field practice seed is collected from inferior & stunted trees which ultimately results in wood land occupied by malformed, defective trees. To replace these undesirable individuals by desirable ones focus should be on procuring & producing quality seed. To fulfil this objective seed from plus trees selected in different localities of Punjab was collected during the project period for raising seed orchards.

1. Eucalyptus camaldulensis.

Seed was collected during November, December and January during the years 1985, 1986, 1987, 1988 from the plus trees marked at Chak Katora, Bahawalpur Forest Division and along Faisalabad Samundri Road.

2. Acacia nilotica.

Seed was collected during the month of June, 1985, 1986, 1987, 1988 from the plus trees marked in Abassia plantation, Rahim Yar Khan Forest Division and Chak Katora, Bahawalpur Forest Division.

3. Dalbergia sissoo:

Seed was collected during January, 1987; from the plus trees marked along Rajana distributory, Distt: Toba Tek Singh.

4. Morus alba:

Seed was collected during the month of April, 1986, from the plus trees marked in Changa Manga Plantation, Kasur Forest Division.

5. Melia azedarach:

Seed was collected during January, 1986, from the plus trees marked in Bahawalpur plantation.

6. Salmalia malabarica:

Seed was collected during April, 1987, & 1988 from the plus trees marked along railway track near Mian Chann & Changa Manga plantation.

NURSERIES RAISED:

After the collection of seed, nurseries were raised for raising planting stock for establishing seed orchards. The detail of nurseries raised is as under:-

<u>Year.</u>	<u>No. of plants/ or area raised</u>	<u>Species.</u>
1984-85	31000 Nos.	<u>Eucalyptus camaldulensis</u> = 25000
		Miscellaneous species = 6000
1935-86	20000 Nos.	<u>Acacia nilotica</u> = 10000
		<u>Eucalyptus camaldulensis</u> = 10000
	0.125 acres.	<u>Melia azedarach</u>
	0.25 acres.	<u>Morus alba</u>
1986-87	5000 Nos.	<u>Eucalyptus camaldulensis</u>
	2000 Nos.	<u>Acacia nilotica</u>
	0.125 acres.	<u>Dalbergia sissoo</u>
	0.125 acres.	<u>Salmalia malabarica</u>

1987-88 0.125 acres.

Dalbergia sissoo

0.125 acres

Salmalia malabarica

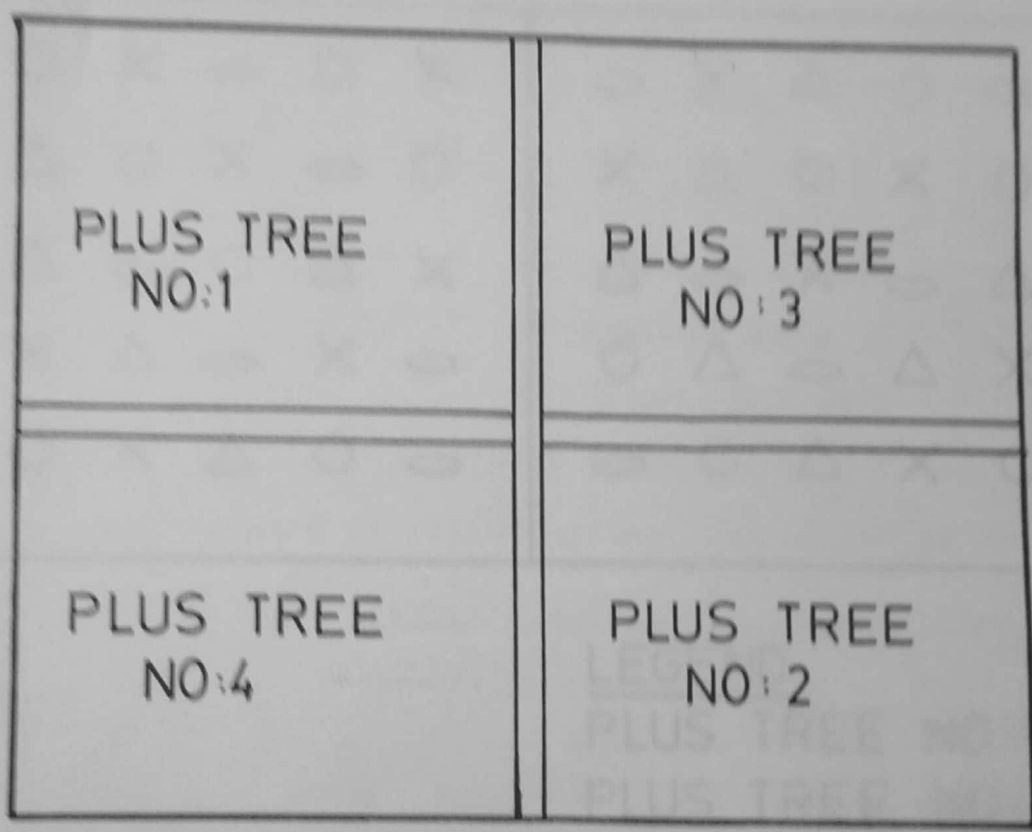
After meeting the requirements for establishing seed orchards, the good quality seed was also supplied to field staff of different Forest Divisions.

ESTABLISHMENT OF SEED ORCHARDS.

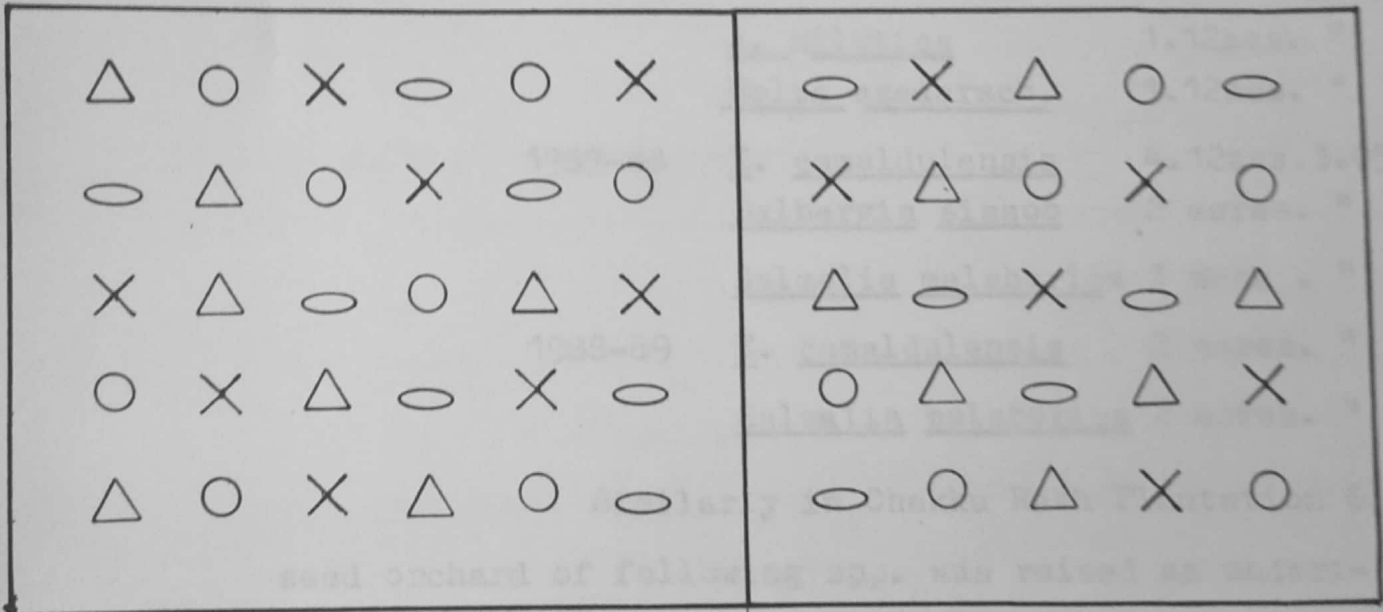
Sites for establishment of seed orchards were selected at Bhagat Reservoir Cpt.No.1 & 7 and Chakku Rakh Plantation Cpt No.6 keeping in view the chances of pollination by trees outside the orchard area. As complete isolation is practically impossible sites were so selected as to minimize the risk of pollination from local inferior pollen sources. Both the plantations are easily accessible and major tree species is shisham. Selected sites were prepared after mainfelling of the areas. All the existing stumps were removed and sites were Disc-ploughed followed by cultivation. Land was levelled with tractor and earth work done manually. Seed orchards were established using root-shoot cuttings/entire seedlings. Planting pattern adopted was (i) Pure rows of individual progenies (ii) Alternating progenies of plus trees in each row & column of the orchard. Complete randomization was done between all the available planting positions and the area was also divided into plots/blocks.

- Weeding of seed orchards is being done as and when required, to reduce the competition.
- Irrigation is done regularly as per requirement of plants.
- Seed orchard had been fenced to protect them from animals and men.

LAYOUT OF SEED ORCHARD USING
PROGENY OF SINGLE PLUS TREE IN
A PLOT.



LAYOUT OF SEED ORCHARD USING PROGENIES OF DIFFERENT PLUS TREES ALTERNATING AMONG THEMSELVES IN EACH ROW IN A PLOT.



LEGEND

- PLUS TREE NO:1 = Δ
- PLUS TREE NO:2 = ○
- PLUS TREE NO:3 = ◌
- PLUS TREE NO:4 = X

Seed orchard over 26 acres has been raised at two locations. The area under seed orchards in Bhagat reservoir is 19.5 acres and in Chakku Rakh Plantation 6.5 acres. At both the places progenies of following species planted during different financial years are:-

<u>Location.</u>	<u>Year.</u>	<u>Species.</u>	<u>Area.</u>	<u>Spacing.</u>
Bhagat Reservoir.	1985-86	<u>E. camaldulensis</u>	3 acres.	3.05 x 1.85 M
		<u>A. nilotica</u>	2 acres.	3.05 x 1.85 M
	1986-87	<u>E. camaldulensis</u>	1.12 acs.	3.05 x 1.85 M
				1.85 x 1.85 M
				3.05 x 3.05 M
		<u>A. nilotica</u>	1.12acs.	" "
		<u>Melia azedarach.</u>	1.12acs.	" "
	1987-88	<u>E. camaldulensis</u>	4.12acs.	3.05 x 1.85 M
		<u>Dalbergia sissoo</u>	2 acres.	" "
		<u>Salmalia malabarica</u>	1 acre.	" "
1988-89	<u>E. camaldulensis</u>	2 acres.	" "	
	<u>Salmalia malabarica</u>	2 acres.	" "	

Similarly in Chakku Rakh Plantation 6.5 acres seed orchard of following spp. was raised as under:-

<u>Year.</u>	<u>Species.</u>	<u>Area.</u>	<u>Spacing.</u>
1986-87	<u>E. camaldulensis</u>	4.17 acres.	3.05 x 1.85
	<u>A. nilotica</u>	1.17 acres.	" "
	<u>Morus alba</u>	1.17 acres.	" "

The detail of seed orchards raised at Bhagat Reservoir and Chakku Rakh Plantation is given as under:-

SEED ORCHARDS-I (BHAGAT RESERVOIR).

Bhagat reservoir plantation is about 90 Km from Faisalabad. The area of the plantation is 750 acres. Seed orchards have been established in compartment No.1 & 7, over an area of 19.5 acres. Five species are used for establishing seed orchard. The detail is as below:-

i. Acacia nilotica.

The species covers an area of 3.12 acres; from which 2.0 acres were raised during March, 1986 in Cpt.No.7 and 1.12 acres raised during April, 1987 in Cpt No.1. Seed was collected from plus trees marked in Abassia plantation of Rahim Yar Khan Forest Division.

For raising 2.0 acres seed orchard in Cpt.No.7 seed was collected from four plus trees i.e. (Nos.1,2,3,4) & the plants were raised in nursery & planted out after a year. The area was divided into 18 plots of size 17.5 x 17.5m each consisting of the progeny of a single plus tree. Spacing adopted was 2.0 M x 2.0 M providing an array of 9 x 9 = 81 plants per plot. The purpose of using such a close spacing was to protect kikar to some extent against frost damage at early stages. Secondly this spacing can enhance natural pruning and boles clear of knots will be obtained later on. Thinnings will also be carried out in the orchard at proper time.

In Cpt.No.1 seed orchard over an area of 1.12 acres was raised during April, 1987. Seed source & progenies used were the same as for establishing seed orchard in Cpt.No.7. Planting was done at three different spacings viz; 3.05m x 3.05m, 1.83m x 3.05m & 1.83m x 1.83m. The area was divided into 9 plots of 21.5m x 17.5m, each consisting of progenies of all the four plus trees alternating with each other in each row. Age of plants at the time of planting was 1½ year and the average height of 0.61m.



Best Orchard of *Apple miltaria*



Seed Orchard of Acacia nilotica
at
Bhagat- April, 1987.

The spacings adopted were replicated three times and the objective of using various spacings was to study their effect on form of trees as well as intensity of thinnings required for optimum production of quality seed.

ii. Eucalyptus camaldulensis.

In Cpt. No. 7 of Bhagat Reservoir seed orch of this species was raised over an area of 3.0 acres during March, 1986 and over two acres during April, 1986. In seed orchard raised during 1986, there are 34 plots. In 25 plots progeny of plus tree No.2, in 6 plots progeny of plus tree No.10, in one plot progeny of plus tree No.1 has been raised. All the plus trees mentioned above are marked in Chak Katora plantation of Bahawalpur Forest Division. In remaining one plot root-shoot cuttings of plus tree No.1 progeny (marked at Changa Manga) were planted. All the root-shoot cuttings sprouted, but when growth and survival data was recorded during Dec, 1987, 27 plants were missing out of 64 plants. So survival % age was 42.19. Plot size is 15m x 15m each and spacing adopted is 2m x 2m. Each plot consists of progeny of single plus tree making an array of 8 x 8 plants.

In 2 acres seed orchard raised during April, 1989, there are 4 plots and in each plot progeny of single plus tree No.1,2,3, & 4 was planted at the spacing of 3.05 x 1.85m. All the four plus trees mentioned above were marked along the Faisalabad-Samundri Road, in Faisalabad Forest Division.



Mirza Muhammad Ashraf, Director (F&E) PARC
visited seed orchard of Eucalyptus camaldulensis

at

Bhagat

Out of 5.24 acres of Eucalyptus camaldulensis seed orchard raised in Cpt.No.1, 1.12 acres were established during April, 1987, 1.12 acres during August, 1987 and remaining 3 acres during June, 1988. Progenies of five different plus trees i.e. No.2,10,18,26, & 42 were used for seed orchards raised during April, 1987 and August, 1987. All the above mentioned plus trees were marked in Chak Katora plantation of Bahawalpur Forest Division. For each 1.12 acres seed orchard, three different spacings viz; 3.05 x 3.05m, 1.85m x 3.05m and 1.85m x 1.85m were used. Area was divided into 9 plots having size of 21.5 x 17.5m and all the five progenies alternating in each row. Complete randomization of all the progenies between all the available planting positions was done. For 3 acres seed orchard established during June, 1988 progenies of five plus trees i.e. No.5,7,10,26 & 42 were used. Planting was done at a spacing of 3.05m x 1.85m using plot size 24.6m x 80m, consisting of progeny of single plus tree.

iii. Melia azedarach.

The seed orchard of this species covers an area of 1.12 acres in Cpt.No.1 at Bhagat Reservoir. It was planted during April, 1987 at the spacing of 3.05m x 3.05m, 3.05m x 1.85m & 1.85m x 1.85m, using progeny of nine different plus trees i.e. No.2,3,8,10,12,13,14 & 15 marked in Bahawalpur plantation of Bahawalpur Forest Division. The area was divided into 9 plots of size 21.5 x 17.5m and all the nine progenies of plus trees alternating in each row. Complete randomization of all the progenies between all the possible planting positions was done.

iv. Dalbergia sissoo.

This species covers an area of 2 acres in Cpt.No.1 of Bhagat Reservoir as seed orchard. It was planted during June, 1988 at the spacing of 3.05m x 1.85m. Progenies of three plus tree Nos. 3, 5 & 9 were used which are marked along Rajana distributry near Bhagat. The area was divided into 3 plots of size 80 x 24.6m and each plot consists of a single plus tree progeny which have been placed in plots at random.

v. Salmalia malabarica.

This species covers an area of 3 acres, from which one acre planted during June, 1988 in Cpt.No.1 and 2 acres raised during April, 1989 in Cpt.No.7. Seed was collected from plus tree Nos.15, 18, 23 & 24 marked along Railway track near Mian Channu for raising one acre seed orchard. Planting was done at the spacing of 3.05m x 1.85m. The area was divided into 4 plots of size 33.85m x 24.6m and progenies of all the four plus trees were planted at random pure in each plot.

For raising 2 acres seed orchard in Cpt.No.7, seed was collected from five plus trees i.e. 15, 18, 6, 3, & 8 marked in Changa Manga plantation. Planting was done at the spacing of 3.05m x 1.85m. The area was divided into five plots and progeny of single plus tree was allotted to each plot at random.

SEED ORCHARD-II (CHAKKU RAKH PLANTATION).

Site is situated about 77 Km from Faisalabad near Jaranwala. The area of Chakku Rakh plantation is 293 acres, out of this 6.5 acres were selected in Cpt. and an orchard comprising of three species was established.

Seed of E. camaldulensis, Kikar and mulberry collected from plus trees marked in Changa Manga, Abassia and Chak Katora plantations was first sown in the nursery and later on the seedlings/stumps obtained were used for raising seed orchard. Following species were raised:-

i. Eucalyptus camaldulensis.

This species covers an area of 4.17 acres, planted during June, 1987. Seed source was Chak Katora plantation of Bahawalpur Forest Division; and seed was collected from four plus trees i.e. No.10,13,26 & 42. Area was divided into 12 plots each having size 19.82m x 31.71m. Spacing adopted was 1.83m x 3.05m. Randomization was done between all the available planting positions. Average height of the plants at the time of planting was 1.07m and age of plants was 1½ to 2 years.

ii. Acacia nilotica.

Seed orchard of this species was established over an area of 1.17 acres & planting done during June, 1987. Progeny of four plus trees i.e. No.1,2,3,4 were used which were marked in Abassia plantation. Plants were planted in 3 plots of size 19.82 x 31.71m each at a spacing of 1.83m x 3.05m, each progeny of plus trees alternating in each row. Further planting positions within each plot were completely randomised. Average height of the plants at the time of planting was 0.76m and age at the time of planting was 1 to 1½ years.

iii. Morus alba.

Seed orchard over an area of 1.17 acres was raised during June, 1987. Progeny of six different plus trees i.e. Nos. 3,4,15,16,19 & 25 marked in Changa Manga plantation was used. Spacing adopted was 1.83m x 3.05m and size of plots was 19.82m x 31.71m each. All the progenies of plus trees alternate in each and each block is randomised independently regarding available

planting position. Stumps of one year old plants were used.

HERITABILITY STUDIES.

One of the main objectives of the Project "Establishment of Seed Orchards in the Punjab" was to study the heritability of commercial characters of various species for establishing final stage seed orchards. The heritability studies enable us to know how a particular trait is influenced by genetic factors and to what extent. It is important to note that heritability is not any fixed magnitude, but depends both on the population and on the environment.

* K. M. Siddiqui and M. Vida-Kovic, 1968, pointed out that environmental influences and management practices affect the safe and high genetic gain in even dominant phenotypes growing under different environmental conditions. Their dominance may be entirely due to better environmental conditions and management practices and not due to their genetic constitution. It is therefore necessary in the beginning of breeding work to raise progenies from a large number of parent trees and subsequently carryout intensive selection within and between the progenies. It means that our real starting material will be the progenies which have been raised under the same environmental conditions.

Keeping in view these factors, Punjab Forestry Research Institute, established seed orchards/progeny tests during the project period in well planned manner for the specific purpose of estimation of heritability under uniform environmental conditions and management practices.

Data regarding straightness, diameter and height growth of seed orchards/progeny tests at Bhagat reservoir recorded during June, 1988 was categorised into five classes i.e.very

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- * Vidakovic, M. and Siddiqui, K.M. (1968). Heritability of height and diameter growth in Shisham (Dalbergia sissoo Roxb) using one parent progeny test P.J.F. Vol-18, No.1: 75-94.

straight, straight, moderate, crooked and very crooked. Following were the provisional indications for different species. Final conclusions will be drawn after completion of Phase-II of the Project.

Eucalyptus camaldulensis.

Seed Orchard over an area of 1.12 acre raised in April, 1987 from seed collected from plus tree No.2, 10, 18, 26 and 42 was studied for straightness, dia. and height growth of trees. Following were provisional indications.

Total No. of plants examined		572
Very straight	18 No.	3%
Straight	31 No.	14%
Moderate	235 No.	41%
Crooked	175 No.	31%
Very crooked	63 No.	11%
Average height		6.51 meter
" Dia		2.19 Cm.

Similarly for Eucalyptus seed orchard over 1.12 acre raised during August, 1987, straightness of bole indication were as under:

Total No. of plants examined		532
Very straight	7 No.	1.32%
Straight	63 No.	11.84%
Moderate	183 No.	34.40%
Crooked	185 No.	34.8%



Seed Orchard of Eucalyptus canaldulensis

at

Bhagat- April, 1987.

Very crooked

94 No.

17.7%

Average height

6.25 M

Average Dia.

2.08 Cm.

For Eucalyptus seed orchard raised over /
3 acres during June, 1988 the straightness of bole results
are as under:

No. of plants examined		1199
Very straight	28 No.	2.33%
Straight	124 No.	10.34%
Moderate	601 No.	50.12%
Crooked	362 No.	30.19%
Very crooked	84 No.	7%
Average height of plants		2.95 M
Average dia. of plants.		2.02 Cm.

Acacia nilotica.

Seed orchard over an area of 1.12 acre raised
during April, 1987 from seed collected from plus trees No.
1,2,3 & 4 from Abassia plantation was studied for straightness
of bole, height and diameter.

Following were provisional indications.

Total No. of plants examined		496
Very straight	12 No.	2.50%
Straight	30 No.	6.04%
Moderate	75 No.	15.12%
Crooked	213 No.	42.49%
Very crooked	166 No.	33.40%

Average height of plants	4.9 M
Average dia. of plants	1.85 Cm.

Nelia aneiarach.

Seed orchard over an area of 1.12 acre raised in April, 1937 from plus trees No.5,12,8,14,10,13,15 and 12 from Changa Manga was studied for straightness of bole and provisional results are:

Total No. of plants examined		345
Very straight	4 Nos.	1.16%
Straight	22 Nos.	6.38%
Moderate	143 Nos.	41.45%
Crooked	108 Nos.	31.3%
Very crooked	68 Nos.	19.71%
Average height		3.11 M
Average diameter		1.37 Cm.

Dalbergia sissoo.

Bed nursery of Dalbergia sissoo (Shisham) over an area of 0.125 acres was raised in May, 1937 using seed from plus trees No.3,7 & 9 marked along Rajana Distributry, District T.T.Singh. Height and diameter of the plants was recorded.

Straightness was also studied and categorised into five classes i.e. very straight, ^{straight} moderate, crooked and very crooked. The observations were as under:-

Total No. of plants examined:		926
Very straight	117 Nos.	12.63%
Straight	374 Nos.	40.39%
Moderate	220 Nos.	23.74%
Crooked	187 Nos.	20.19%
Very crooked.	38 Nos.	4.10%

Recording of observations will continue to draw definite conclusions regarding the heritability of various characters of shisham.

Eucalyptus camaldulensis.

Seed orchard over an area of 3.0 acres raised in March, 1986 from seed collected from plus trees (No.2,10) from Chak Katora was studied for straightness, diameter and height of trees. Trees were categorized into five classes i.e. very straight, straight, moderate, crooked and very crooked. Following were provisional indications:

Total No. of plants examined.		1899
Very straight	242 Nos.	12.74%
Straight	380 "	20.01%
Moderate	530 "	27.91%
Crooked	530 "	27.91%
Very crooked	217 "	11.43%

Average height 5.86 M

Average diameter 4.40 Cm.

Acacia nilotica.

Seed orchard over an area of 2.0 acres raised in March, 1986 from seed collected from plus trees (No.1,2,3) from Abassia Plantation was studied to observe heritability of characters of this species. Straightness, height and dia was observed/measured and recorded. All the trees examined were classified into five classes on the basis of their straightness.

Following were provisional indications:-

Total No. of plants examined.		1097
Very straight	93 Nos.	8.48%
Straight	145 Nos.	13.22%
Moderate	165 Nos.	15.04%
Crooked	235 Nos.	21.42%
Very crooked	459 Nos.	41.84%

Average height	3.71 M.
Average diameter	4.24 Cm.

This high frequency of crookedness could be the result of frost damage and resprouting. Study will be continued to draw definite conclusions.

CLONAL PROPAGATION.

Plants can be propagated sexually or asexually. Improvement through sexual means involves several generations. Multiplication through seeds even when collected from elite trees/plus trees will continue to maintain heterozygous behaviour. Though with continuous breeding and selection, improvement is possible, the immediate genetic gains may not be much.

The improvement through asexual means i.e. vegetative propagation or clonal propagation offers the advantage of greater genetic uniformity and immediate availability of superior clones for large scale plantation works and establishing clonal seed orchards. Plants with desired characters as straightness of bole, resistance to diseases and pests, good branching, high seed yield, frost resistance, fast rate of growth and quality production can be multiplied at will and made available in the shortest possible time. For successful multiplication of clones, high degree of rooting in vegetative material like stem/branch cuttings, leafy cuttings or coppice shoot cuttings is desired.

The rooting success of stem/branch cuttings depend upon the age of the plant, the condition of cuttings, the time of collection, the rooting medium and special treatments. Some species are easy to propagate while many are difficult to

propagate vegetatively; some species can root without the application of hormones and the others by using the hormone. Most commonly used rooting hormones are indolacetic acid (I.A.A), indolbutyric acid (I.B.A), and naphthalene acetic acid (N.A.A), etc. The effect of these hormones varies with the kind of species and the environment in which the cuttings are kept. The hormones can be applied in powder form, soaking the cuttings in diluted solution or quickly dipping them in concentrated solution.

The experiments on clonal propagation of some species were carried out; the detail of which is given below:-

1. Shoot cutting experiments:

i. Shoot cuttings (20cm) of Dalbergia sissoo, Acacia nilotica, Morus alba, Eucalyptus camaldulensis and Tamarix aphylla, were made from vigorously growing shoots of one year old branches of plants, growing in Punjab Forestry Research Institute, Faisalabad in the month of April/May and July/August. Leaves from the cuttings were removed and cuttings were kept moist during carriage. Then bottom of each cutting was dipped in naphthalene acetic acid powder for few minutes. The cuttings were then planted in flat beds of loamy soil in such a way that there were five rows, each consisting of 90 cuttings of each species. The sixth row was control and had a total of 50 cuttings i.e. 10 cuttings for each species. The cuttings planted in control row were not treated with N.A.A. The irrigation was done as per requirement of cuttings. The experiment was kept under observations for one year. After one year observations were recorded on 31.5.1986 as under:-

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Table-1: Effect of some growth regulators on rooting behaviour of E.camaldulensis, A.nilotica, D.sissoo, M. alba and T.aphylla.

Species.	Treatment.	No.of cuttings treated.	No.of cutting rooted.	Rooting %
1. <u>E. camaldulensis</u>	N.A.A.	180	-	-
" "	Control	20	-	-
2. <u>A. nilotica</u>	N.A.A.	180	-	-
" "	Control	20	-	-
3. <u>D. sissoo</u>	N.A.A.	180	119	62.63 %
" "	Control	20	15	75 %
4. <u>M. alba</u>	N.A.A.	180	57	30 %
" "	Control	20	1	5 %
5. <u>T. aphylla</u>	N.A.A.	180	54	28.04 %
" "	Control	20	5	25 %

In A. nilotica and Eucalyptus camaldulensis roots were not produced in the cuttings regardless of whether these were treated with N.A.A. or not as shown in table-1.

In Dalbergia sissoo roots were produced in 119 cuttings treated with N.A.A. and 15 cuttings not treated. Similarly Morus alba and Tamarix aphylla 57 & 54 cuttings rooted out of 180 treated cuttings in each spp. From 20 cuttings not treated (control) rooting was only 1 & 5 in Morus alba and Tamarix aphylla respectively.

The results show that effect of hormone on branch cuttings in E. camaldulensis, A. nilotica, M. alba & T. aphylla are not encouraging where as D. sissoo gave somewhat promising results.

ii. Shoot cuttings 10-12 Cm long and 0.8-1.5 Cm in dia with 2 nodes were made from 5 year old desirable plants of 8 Eucalyptus species in the month of November, 1988 and were exposed to sun light for one hour, and then given dip treatment.

with strike (Rooting powder with Captan Fungicide) for 5 minutes in powder form, extra powder was removed by shaking off the cuttings before planting. Five cuttings of each species were planted in pots filled with soil, sand & manure (1; 1; 1) and watering was done well before & after planting.

Observations for rooting were recorded after 28 days as given in table-2.

Table-2. Rooting behaviour of Eucalyptus species by the application of strike.

Species.	No. of cuttings spp.	No. of cuttings planted for each rooted.	Rooting % as
1. <u>E. torelliana</u>	5	0	0
2. <u>E. dealbata</u>	5	0	0
3. <u>E. kitsoniana</u>	5	0	0
4. <u>E. tereticornis</u>	5	1	20%
5. <u>E. pruinosa</u>	5	0	0
6. <u>E. melano-phloia</u>	5	0	0
7. <u>E. camaldulensis</u>	5	0	0
8. <u>E. populnea</u>	5	0	0

The table-2 shows that the rooting occurred only in one cutting of E. tereticornis. The results are not encouraging. It needs further experimentation for arriving at any conclusion.

2. Branch cutting experiments:

i. Branch cuttings of Dalbergia sissoo plants (20 year old) were taken to study their rooting behaviour under various combinations of different growth hormones. Following hormones and their various combinations of different concentrations used were:-

- Hormones:
1. Naphthalene acetic acid (NAA)
 2. Benzyl amino-purine (BAP)
 3. Gibberellic acid (GA)

Combinations of different hormone concentrations.

i. NAA	1 mg/litre
BAP	"
GA	"
ii. NAA	1 mg/litre
BAP	0.8 "
GA	1 "
iii. NAA	0.8 mg/litre
BAP	1 mg/litre
GA	1 mg/litre
iv. NAA	0.8 mg/litre
BAP	0.8 "
GA	1 "
v. Control.	

Branch cuttings 15 Cm long & 0.5 Cm dia were made from one year old branches of 20 years old plus trees in the month of August, 1987. The cuttings were given 24 hour dip treatment with different concentrations of NAA, BAP&GA and planted in pots filled with pure sand. Pots were irrigated after every 3 days. In each of the treatments six **branch** cuttings were planted. They were up-rooted after 58 days to record sprouting & rooting data; the sprouting and rooting was observed only in one **branch** cutting in case of first combination of different hormones. (1 mg/litre per each) as given in table-3.

Table-1.

OBSERVATIONS RECORDED FOR ROOTING BEHAVIOUR OF SHISHAM.

Treatments.	Month of planting.	No. of cuttings planted.	No. of cuttings sprouted.	No. of cuttings rooted.	Percentage of cuttings.	
					<u>Sprouted.</u>	<u>Rooted.</u>
1. NAA 1mg/litre	August, 1987	6	4	1	66.67	16.67
BAE "	"	6	3	0	50	-
GA "	"	6	5	0	83.33	-
2. NAA 1mg/litre	"	6	1	0	16.67	-
BAE 0.2 "	"	6	0	0	0	-
GA 1mg/litre	"	6	0	0	0	-
3. NAA 0.2 mg/litre	"	6	0	0	0	-
BAE 1mg/litre	"	6	0	0	0	-
GA "	"	6	0	0	0	-
4. NAA 0.2 mg/litre	"	6	0	0	0	-
BAE 0.2 mg/litre	"	6	0	0	0	-
GA 1mg/litre	"	6	0	0	0	-
5. Control: (No hormone treatment)	"	6	0	0	0	-

The experiment was repeated with different combinations of the above growth hormones again. In branch cuttings treated with NAA, BAE, GA 1mg/litre & NAA & GA 1mg/litre & 2mg/litre concentration combination, the sprouting was 50% while rooting was observed in four branch cutting only.

ii: In an other experiment on Eucalyptus camaldulensis branch cuttings 10 Cm long and about pencil thickness with two buds & leaves were prepared from coppicing shoots during August, 1937. The experiment was conducted just like D. sissoo using different combinations of various concentration of the above hormones. The sprouting & rooting behaviour was studied after 58 days. Except for the control, sprouting was 10 percent in all the treatments but no rooting was observed in any of the branch cuttings used.

iii: In an other experiment branch cuttings of E. camaldulensis & D. sissoo 10-12 Cm long and 0.8-1.5 Cm in dia were made from 5 years old desirable plants in the month of March, 1939. The branch cuttings were exposed to sun light for one hour and then given dip treatment with different concentrations of $KMNO_4$, NAA and NAA+IBA (200 PPM & 100 PPM). The control branch cuttings were not given any treatment. Four branch cuttings treated with each treatment were planted in pot filled with mixture of soil, sand & farm yard manure (1:1:1). Pots were watered well before & after planting of cuttings. The experiment was replicated three times & observations regarding sprouting and rooting were recorded after three months as shown in table-4.

Table-4. Behaviour of branch cuttings taken from 5 year old plants.

Species.	Treatments	Concentration	No. of cuttings treated.	No. of cuttings gs sprouted.	No. of cuttings rooted.
<u>E. camaldulensis</u>	$KMNO_4$	200 PPM	12	0	0
	"	100 PPM	12	0	0
	NAA	200 PPM	12	0	0
	"	100 PPM	12	0	0
	NAA+IBA	200 PPM	12	0	0



Seed Orchard of Eucalyptus camaldulensis

at

Bhagat- June, 1988.

NAA+IBA	100 PPM	12	0	0
Control	-	12	0	0
<u>Dalbergia sissoo</u>				
KMNO ₄	200 PPM	12	7	0
"	100 PPM	12	11	0
NAA	200 PPM	12	10	0
"	100 PPM	12	9	0
NAA+IBA	200 PPM	12	5	4
"	100 PPM	12	8	1
Control	-	12	1	0

The data on behaviour of branch cuttings of E. camaldulensis shows that sprouting and rooting did not occur in any of the cuttings in any of the treatments. In case of D. sissoo sprouting occurred in varying degree in all the treatments but rooting occurred only in cuttings treated with NAA+IBA.

3. Root-shoot cutting experiment.

Eucalyptus camaldulensis & A. nilotica are raised in polythene bags in nurseries for about a year & then out planted in fields. This involves more expenditure than planting through root-shoot cutting. To study sprouting behaviour of root-shoot cutting-s of E. camaldulensis & A. nilotica, a bed nursery of these species was raised at Research nursery of Punjab Forestry Research Institute and root-shoot cuttings were made from half to one year old seedlings, during April/May, 1935. 100 stumps of Eucalyptus and 70 stumps of A. nilotica were planted in flat beds.

Survival data was recorded after one year as under:-

Species.	No. of stumps planted.	No. of stumps sprouted.	Survival % age.
1. <u>Eucalyptus camaliulensis</u>	100	100	100 %
2. <u>Acacia nilotica</u>	70	70	100 %

The data on behaviour of root-shoot cutting of both the species show that sprouting occurred in all the stump & all the stumps survived. The same experiment was repeated during July, 1988. Fifty root-shoot cutting-s of E. camaliulensi and A. nilotica were made from 6 to one year old plants raised in polythene tubes and were planted in flat beds just after rain & just after preparation of stumps. The survival data was recorded after two months & is given as under:-

Species.	No. of Root-shoot cuttings planted	No. of Root-shoot cuttings sprouted.	Survival % age.
1. <u>Eucalyptus camaldulensis</u>	50	18	36 %
2. <u>Acacia nilotica</u>	50	35	70 %

In an other experiment root-shoot cuttings of E. camaldulensis & A. nilotica (23 Cm long) were prepared from 6 month to one year old plants raised in polythene tubes at Punjab Forestry Research Institute nursery. The stumps for treatment T₁ were prepared just at the time of planting, for treatment T₂, T₃, T₄ the stumps were prepared one day, two days & three days respectively prior to planting. The control in this experiment was tubed nursery plants. Planting was done in flat beds and 50 stumps of each treatment were planted in a plot at a spacing of 1' x 1'. The experiment was replicated four times, planting was done during March, 1989 & survival data recorded after two months is given in table-5.

Table-5.

<u>Species.</u>	<u>Treatments.</u>	<u>No. of plants planted.</u>	<u>No. of plants. sprouted.</u>	<u>Survival % age.</u>
<u>E. camaldulensis</u>	T ₁	200	173	86.5
	T ₂	200	148	74
	T ₃	200	163	81.5
	T ₄	200	168	84
	To (Control)	200	199	99.5
<u>A. nilotica</u>	T ₁	200	45	22.5
	T ₂	200	63	32.5
	T ₃	200	78	39
	T ₄	200	67	35.5
	To (Control)	200	195	96.5

In all the three experiments root-shoot cuttings sprouted and survived regardless of whether these were made just at the time of planting or one day, two days & three days prior to planting. However the sprouting percentage was higher in cuttings made same day before planting in case of Eucalyptus as compared with other treatments. In case of A. nilotica, sprouting percentage was higher in cuttings made two days prior to planting.

4. Root cutting experiment.

Dalbergia sissoo root cuttings 5 Cm long and 0.5 Cm in dia were made from a 15 year old shisham tree in the month of August, 1987. One hundred root cuttings were planted in pots in two positions i.e. horizontal and vertical. Watering was done after 3 days interval & pots were put outside laboratory along its wall on northern aspect. Observations were recorded after 58 days. In case of horizontally planted root cuttings 24 rooted & sprouted out of 50, giving 48 % success while the average length of roots grown was 55 Cm & average number of twigs formed was 5.

In case of vertically planted cuttings 32 rooted & sprouted out of 50, giving 64 % success. However the average length of roots formed was 30 Cm & average No. of twigs formed was 4. Keeping in view the success of above trials 75 root cuttings of D. sissoo were planted in March, 1988 in pots vertically, out of them 42 root cuttings(56%) sprouted & rooted.

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- c. In a branch cutting experiment using NAA, BAP and GA rooting hormones in different concentrations and combinations, maximum sprouting of Dalbergia sissoo was 83.33% in NAA 0.8 mg/litre and BAP 1mg/litre combination. But no rooting was observed under this treatment. Under treatment of NAA, BAP & GA 1mg/litre combination sprouting & rooting was observed 66.67% & 16.67% respectively. In case of Eucalyptus camaldulensis in a similar experiment sprouting was 100% in all the treatments but no rooting was observed in any of the treatments. Dalbergia sissoo only has given encouraging result.
- d. In another branch cutting experiment with the application of $KMNO_4$, NAA & NAA + IBA rooting hormone in different concentrations, no sprouting and rooting was observed in Eucalyptus camaldulensis.
- e. In root-shoot cutting experiment on Eucalyptus camaldulensis and Acacia nilotica sprouting and survival was observed regardless of whether these were made just at the time of planting or one, two & three days prior to planting. However in case of Eucalyptus camaldulensis the sprouting and survival percentage was higher in cuttings made same day of planting as compared with other treatments. These experiments are still continuing.
- f. In root cutting experiment on Dalbergia sissoo high sprouting and rooting percentage was observed in vertically planted cuttings i.e. 64%. While the average length of roots formed (55 Cm) and average number of twigs formed (5 no.) was higher in horizontally planted root cuttings.

SALIENT ACHIEVEMENTS.

1. Four hundred and sixteen plus trees of different forest species marked in different localities of the Punjab served as primary source of seed for establishing seed orchards/progeny tests and these will be a permanent source of seed for future.
2. Seed orchards/progeny tests of important forest species i.e. Shisham, Simal, Kiker, Eucalyptus, Mulberry and Bakain raised over 26 acres will produce seed of superior quality to meet at least partial demand of field foresters and there will be gradual improvement of genepool in the forests.
3. Effect of Naphthalene acetic acid (NAA), strik Benzyl amino purine (BAP), Gibberelic acid (GA), Indol Butyric acid (IBA) and $KMNO_4$ rooting hormones were studied individually and in various combinations & concentrations on shoot cuttings of various species. Only Dalbergia sissoo gave encouraging results. This technique will help in multiplication of superior trees on large scale.
4. Eucalyptus camaldulensis & Acacia nilotica were raised in beds/polythene bags. After one year their root-shoot cuttings were prepared and planted in beds. Most of them developed into plants. Raising of these species in beds & their field planting through root-shoot cuttings will save a lot of expenditure as compared to planting of containerised plants.
5. Root-cuttings of Dalbergia sissoo have given encouraging results of rooting and if this technique is perfected then clonal propagation & multiplication of superior trees will become feasible on large scale.