STUDY OF GENETIC IMPROVEMENT TECHNIQUES OF *TERMINALIA CHEBULA* RETZ. - AN IMPORTANT MULTIPURPOSE MEDICINAL TREE SPECIES OF INDIA

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Introduction

Terminalia chebula Retz. is one of the very important indigenous multipurpose tree species that occurs in mixed deciduous forests of India. The fruit is valued for preparation of dye used at present in dyeing leather and handloom clothes. In the past, before coaltar based dyes replaced vegetable dyes, powerloom clothes were also dyed with 'chebulic myrabolam'. Its fruit, called 'harar' in Hindi, has been traditionally used in Indian system of medicine - Ayurveda. It is also routinely used as household remedy throughout the sub-continent for treating stomach colic of suckling infants and as a laxative for the old. A quantum jump in scale of cultivation of this medicinal tree in sheltered valleys and farm forestry situations in the Shiwaliks is a distinct possibility that needs to be commercially exploited. Being one of the six 'rasayanas' of Ayurveda, fruit pulp of *Terminalia chebula* is used in many of the standard preparations such as 'trifala' and 'chayvanprash' that is used as food supplement during winter.

In some States of India such as Jammu & Kashmir and Assam; and some countries from Gulf, Arabia, Afghanistan and Pakistan; whole fruit jam is used as a food supplement. Large-sized fruits are a connoisseur's delight and command a premium price of minimum three times that of wild variety. They are used in making 'murabba' (pickle in Persian), therefore, called as 'murabbi' variety and are three to five times as large as 'wild' variety called 'kachri'. Natural regeneration of this species is a problem in certain parts of the country. One such region is in hills of Haryana, Punjab and Himachal Pradesh as the nuts that contain seeds are enclosed in horny endocarp and germinate poorly. The raw fruits are collected and sold for pickle making. Leftover fruits are rolled over hot sand for drying to prolong shelf life of stored produce; this process kills the seed. Old trees become hollow. They are unable to carry the weight of large non-hollow branches and consequently shed them. Over a period these die and new recruitment is almost absent. In addition, selective extraction of 'murabbi' variety is causing dysgenic impact on the base population as superior germplasm is getting drained. Studies were under taken

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to solve the basic problem of restoring natural regeneration if possible or effect artificial regeneration with emphasis on providing genetically superior seedlings for raising plantations (Troup, 1950; Anon., 1960).

Also, search for alternative indigenous tree species for farm forestry to substitute *Eucalyptus tereticornis* and *Populus deltoides* has been a pressing problem particularly for hilly terrain. This multipurpose tree species has potential to emerge as an important Non-Wood Forest Produce (NWFP), in agricultural situations practicing wheat-paddy/maize rotations as it is winter deciduous. It blends profitably into existing agronomic practices. Many examples of successful farm forestry practices are available in Shiwalik hills that required to be replicated in other areas that can support this tree species.

Entomophilous open pollination is the usual mechanism of mating in most of the species belonging to genus *Terminalia* including *T. chebula* (Srivastava, 1993). Heritable variations have accumulated and most of the resultant individuals are heterozygous. Rare fortuitous circumstances result in chance combination of elite individuals that are eagerly sought out (Zobel, 1984). Such elite tree germplasm requires to be conserved and further propagated, for greater benefit of all concerned. Through sexual method of reproduction such elite genome breaks down owing to segregation. True- to- type individuals can be produced through cloning either by micro-propagation (cell of tissue culture) or macro-propagation (rooting explants). Micro-propagation of fruit bearing plants is usually not done as propagation process related imperfections (some clonal mutations?) are likely to foul resultant plants. Response to macro-propagation methods of mature explants of genus *Terminalia* except *Terminalia arjuna*, so far as studies have found, is difficult to obstinate for root induction (Ramprasad *et al.*, 1992). Approach grafting of elite plants was done at Coimbatore, Tamil Nadu (Srivastava, 1993).

The present work relates to operationalizing a concept called 'rapid and continuous tree improvement programme' acronymed as 'TREIMP'. It has been initiated to transfer genetic gains to actual practice in existing field conditions so that benefits flow to the user in the shortest possible time in available degrees on 'as is where is basis' yet striving for excellence in the long run. The work enumerated as under was carried out in a nursery situated at Panchkula District (Haryana) longitude 77°34" and latitude 30° 45"; mist chambers situated at Seonti of Kurukshetra District and forest and farm forestry locations of three provenances cited in Table 1.

Material and Methods

(i) *Survey of base population*

Terminalia chebula Retz. (Harar) is reported to be indigenous to Shiwalik hills (Parker, 1956; Kanjilal, 1927). Trees are found in wide sheltered valleys often planted along field boundaries. Unconfirmed reports say that Mr. Hamilton (ex-Inspector General of Forests) introduced Harar trees in one of the three areas of now Haryana State. viz., Mandhna, as a trial to extend plantation of an important and hardy tree species of the hills. Base population occurring in three provenances (pollen transfer barrier exists among three discrete populations

Table 1

Provenances of T. chebula within Haryana State

Provenance	Geographic location		Size of base Population	No. of candidate plus trees selected
	N. Latitude	E. Longitude		
Brahampura-Philorhi	30° 25"	77° 10"	16	3
Salyo - Hathia	30° 41"	77° 10"	2350	7+1*
Mandhna	30° 35"	77° 05"	180	3
Total			2546	13**

* Control ** Sampling intensity 5/1000

because of separation caused by successive hill ranges and physical distance) of Haryana State viz., Brahampura, Sahalyo and Mandhna, were surveyed during three successive fruiting seasons. Information was also gathered by informal interviews with old traders and owners of trees from hills, who used to carry Harar fruits to Rawalpindi and other cities (now in Pakistan) for sale before 1947. Their descendents, who follow the traditional occupation and sell fruits at Khari Baoli (Delhi), Hoshiarpur and Amritsar (Punjab), were employed as guides in locating Candidate Plus Trees (CPTs) and also qualifying determining traits of the fruit that are sought in the market.

Those healthy trees that bear exceptionally large fruits in greater quantity were selected as CPTs. So far, the total number of CPTs selected are 13 our of 2,456 trees surveyed. CPTs were arranged in decreasing order of magnitude based on weighted criterion method on average index score as used by Institute of Forest Genetics and Tree Breeding, Coimbatore. Selection intensity was 1 out of 200 trees i.e. 0.5%. Fruit is the most important determining trait, heritability of fruit characters is to be established beyond any doubt as that forms the fundamental basis of genetic improvement work that is being done. Fortunately, true to type bearing of fruits from successfully grafted buds/scions from donor elite trees situated hundreds of kilometres away establishes heritability and mitigates/ eliminates role of site factors (environment). Replication of elite trees done through horticultural means done in three sites viz., Bangalore, Jachh and Panchkula on budded or grafted plants produce identical fruits. There is also corroborative field evidence that fruit character is a heritable trait from two provenances where F1 progeny were raised. Fruit borne by F1 progeny and parent collected at random are similar though not identical in volume and weight when F1 trees in question are located on altered sites. Corroborative evidence of other edible fruits similarly reproduced further reinforces above observation.

Though alternate high and low bearing as in mangoes is not known, but some sort of cycle exists; it cannot be denied as there are unexplained low and no fruit bearing episodes during some years. Such episodes affect individual trees instead of

the entire population. Trees growing in shade of other trees usually do not produce fruits or bear fruits only on those branches on sunnier side.

(ii) ***Studies on Germination (prevent dysgenic drainage of germplasm)***

In North India, flowering of *Terminalia chebula* commences from first week of May; two flowering flushes have been observed, first beginning from May and second from August and ripening of fruits lasts till April. Fruits were allowed to fully ripen on some trees and collected during April and sown in three replications of 30 fruits each in nature simulated condition after weathering under leaf litter of mother trees and exposed to the elements of nature between April to end of September. Observations were recorded once a month in the first three months between April to June (summer) and thereafter once a week till end of September (monsoon rains). Germination commences during third week of July and continues up to the end of August, within the same seed lot there are variations in size of resultant seedlings.

Traditional practice of seed pretreatment was to bury mature fruits collected during spring season in a pit of fully rotted farm yard manure for three weeks. That resulted in complete break down of pulp of fruit by microbial action and stones so released were sown directly into soil. In some nurseries of Himachal Pradesh fruits are pretreated by enclosing in containers such as two polythene bags, one drawn over the other, or mouth tied to encourage fungal digestion of pulp thus releasing the stone. This process is known as "bhong" (Troup, 1950). It is reportedly beneficial for ready germination of fruits that are fully ripe. Three such replications were made with 30 nuts each and sown in three different places. Observations were timed similar to above treatment (Anon., 1960).

Ripe fruits were de-pulped after soaking in water and nuts were cracked after 48 hour duration cycles of soaking and drying for a month. Cracked nuts were reconstituted as they were and sown in vermiculite. Set up was subject to hourly mist under open to sky conditions. Observations were recorded every week (Thakur *et al.*, 1996); Negi and Todaria, 1997; Sidhu, 1992; Todaria and Negi, 1995).

Picking of raw fruits for pickling regularly commences after Dasehra festival of mid-October and lasts up to the end of November. Known weights of raw fruits were bought from farmers owning candidate plus trees that were identified in three provenances (Table 1) where base population exists. Fruits were dried in shade by repeated turning to prevent fungal infection (to reduce adverse effects of raw collection). In this treatment raw fruits were sown identical to first treatment discussed above, only difference was early collection of fruits by about five months. In the second treatment fruits were subject to fungal digestion of pulp and all other activities were similar to corresponding first treatment (Troup, 1950).

In the third treatment, after about three weeks, de-pulping was done by 'cut and peel' method. Nuts were dried in shade for a fortnight, pulp sticking was dislodged by soaking in water for a short while and rubbing against themselves. Nuts so gathered were stored with a sprinkling of contact insecticide and fungicide up to

April. During first week of April, nuts were repeatedly washed in running water and alternately soaked and dried at 48 hour cycle tied in cotton cloth. Signatures of nuts were maintained throughout the operations. Emergence of radical in a few nuts signals ready conditions for germination. Nuts were mechanically cracked there after by keeping them in nut-size slots made in a log of softwood using chisel and a hammer along a cryptic suture line. Successfully cracked nuts with healthy seeds without any damage were reconstituted as before and sown in vermiculite filled in 110cc HDPE composite tray of 40 cells for each CPT in three replications. Above setup was subject to intermittent spray of water through misting nozzle of 5 minutes duration for every hour during day time under open to sky situation. The first spray every day was for not less than 30 minutes to completely soak vermiculite to saturation. Mean maximum temperature during late May and June in 36 ± 6° Celsius and relative humidity varies between 45-60%.

Results and Discussion

Ripe fruits under all three treatments are giving half to two-thirds successful germination, raw fruits are giving one-fifth success (Table 2). Comparing similar pairs of treatments in ripe vs. raw, first and second pair are less consistent and third pair more consistent. Horny endocarp that is usually held out as reason for impeded germination is not the culprit in causing reduced regeneration. It is near complete extraction of fruits commencing from raw stage itself that is adversely affecting status of this species in all three provenances. Even if raw fruits themselves are bought and assisted to germinate by

Table 2

Germination (%) under different treatments

Treatment	Mean
Conditions nature simulated Ripe Fruits	59.00 (50.12)
Conditions of retting Ripe Fruits	76.00 (60.42)
Cracking of nuts Ripe Fruits	69.00 (56.20)
Conditions nature simulated Raw Fruits	13.00 (21.31)
Conditions of retting Raw Fruits	6.00 (13.48)
Cracking of nuts Raw Fruits	52.00 (46.26)
$CD_{(0.05)}$	Treatment = 6.38

Values within parenthesis are arcsine transformed values.

cracking, dysgenic extraction can be prevented as is being done at experimental level at present. ANOVA was got done and the results between ripe and raw fruits and within pairs of treatment show significant variation at 0.882 (Panse and Sukhatme, 1985).

Fruit collection rights of elite trees should be bought over by Forest Department well in advance (to prevent dysgenic extraction) and fruits should be allowed to mature on trees. At least 10% of fruits from all other trees should be compulsorily blocked from being picked raw or ripe so as to ensure availability of seeds that can germinate and regenerate. At Mandhna, customary rights of village give fruits of only one tree to the owner, rest of trees are part of Common Property Resource (CPR), therefore, frustrated farmers do not plant trees, private efforts

are afoot in other two provenances to plant trees.

(iii) ***Induction of roots in half-sib seedlings of elite trees using juvenile and mature stem cuttings (enhance number half-sib seedlings and ex-situ collection of elite trees)***

Stem cuttings of about one and two-year old juvenile seedlings that were raised using nuts of elite trees were used as experimental material. As availability of fruits of elite trees is not always guaranteed, a bed having closely planted seedling can be maintained in a nursery and stem cuttings taken from a small hedge year after year. Basal section of main axis above the collar and middle section was used as trials had indicated that rooting is better in such portion. Explants were surface sterilized, set in root trainers filled with vermiculite after a 24 hour basal dip in water solutions of plant growth regulators (PGRs) and subject to intermittent spray of water under misting nozzle in open to sky conditions. Four different treatments of Indole Butyric Acid (IBA) 2 m Mols; IBA and Naphthalene Acetic Acid (NAA) 2 m Mols each; IBA and pyro-catechol 2 m Mols each; with pyrocatechol and putresene (polyamine) 2 m Mols and a control was used for both juvenile and mature stem cuttings used as explants, observations were recorded at weekly intervals and statistical analysis done (Table 3) (Bharadwaj *et al.*, 1993; Chakrabarti *et al.*, 1992; Chauhan *et al.*, 1994; Dhir *et al.*, 1991, 1995; Hare, 1978; Isikawa, 1968; John, 1979; Mishra *et al.*, 1994; Rauter, 1971; Raulund, 1981; Rawat *et al.*,1994; Shamet, 1991).

The decapitated juvenile plants vigorously sprout and are not lost in the process. Explants sprout along with other seedlings during last week of April and first week of May when outdoor shade temperature is 36°C or more. After sprouting there is hardly any observable elongation of axis for about 45 days, there after those explants that have rooted show

Table 3

Root induction of stem cuttings under different treatments

Explants	Treatment					Mean
	IBA 2 m Mols	IBA+ NAA 2 m Mols each	IBA + Catechol 2 m Mols each	Putresene 2 m Mols	Control	
Juvenile	61.00 (51.26)	75.00 (60.05)	76.00 (60.58)	78.00 (61.68)	61.00 (51.25)	70.00 (56.96)
Mature	5.00 (12.92)	5.00 (12.92)	5.00 (12.92)	5.00 (12.92)	5.00 (12.92)	5.00 (12.92)
Mean	33.00 (32.09)	40.00 (36.48)	40.00 (36.75)	41.00 (37.30)	33.00 (32.08)	

Values within parenthesis are arcsine - transformed values.
$CD_{(0.05)}$ Explant = 1.34 Treatment = 2.143 Treatment x Explant = 3.00

comparatively rapid growth of stem and adventitious roots can also be observed at the lower portion of the root trainer.

Mature explants sprout vigorously upto 92% and the sprout lasts upto 30-45 days; thereafter they tend to lose vigour owing to loss of stored food and defoliate with minor callusing. Root formation is hardly ever evident. Lopping induced branches were set in root trainers during early spring some evidence of response was observed but later that also died down. Large diameter explants more than 3 cm sprout well and retain sprouts for longer duration (stored food is more). In juvenile explants there was indication of keel portion of new sprout rooting owing to accumulation of food and action of PGRs but so far in trials of mature explants this response is yet to be realized. Sprouts have been used as top grafts successfully.

Minimum number of elite trees, from unrelated families, that is recommended for a meaningful tree improvement programme is 33. Of the total expenditure that is incurred on all activities, repeated travel to elite tree for collection of data, plant material including fruits and seeds happens to be 65%. Reduction of travel expenses is possible by collecting fruits and raising seedlings of already selected elite trees. Rooting explants of juvenile cuttings taken from a hedge each raised from pedigree seeds gives sufficient room for expanding genetic base in a cost effective manner. Consolidation of fieldwork becomes easier year after year. ANOVA carried out on significance of treatments of juvenile explants indicates that control is almost as effective, confirming findings made earlier (Jose and Thomas, 1998). Despite best efforts to root mature explants, success has eluded so far.

(iv) ***Air-layering of juvenile and mature trees (ex-situ germplasm conservation for hedge garden)***

Air-layering of juvenile seedlings can be commenced effectively from third year as the growth of seedlings during first year is hardly 20 cm and girdling by peeling of bark of a wiry seedling manually was not found possible. Some of the more vigorous seedlings that strike roots into the soil out grow others and can be girdled and bark peeled during early autumn commencing from October. Most of the juvenile seedlings can be single air-layered during third year, thereafter commencing from fourth year seedlings grown in 30 x 45 cm containers, side branches can also be air-layered.

Vigorously growing main branches of diameter 0.5 to 2.5 cm were selected for air layering; 2.0 to 3.0 cm long bark was peeled and scrapped clean up to wood depth. Peeled portion was smeared with PGR carrier talc and PGR carrier talc was applied with a wrapping of sterile cotton and held in place in upper most portion of girdle. Entire set up was covered with three treatments viz., 'Red', 'Brown' and 'Green' covered with vermiculite held in place by air tight binding of polythene sleeve wrapped around securely tied air tight at both the ends. Observations were recorded at weekly intervals and data tabulated (Tables 4 a-b) (Chaudhuri, 1962; Kedarnath and Dhundiyal, 1963; Nagpal and Sehgal, 1985; Solanki *et al.*, 1986).

In plants that are less than five years, by the end of second week after air layering during month of October claw like unbranched roots in large number emerge from lenticels about 1 to 3 cm above cotton wrapping below the upper tied portion. At

present the results may be not very impressive as juvenile cuttings can also be rooted easily. By serial grafting technique juvenility can be induced, as *ex-situ* collection of 8 out of 13 elite trees has already been accomplished through peg grafting described elsewhere; work on that front would be taken up in near future. ANOVA carried out indicated explant and its interaction is significant and 0.035 indicates level of significance.

Air layering of juvenile seedlings was found successful but mature trees showed varied degrees of callusing and root initiation but so far failed to respond positively to propagation. One of the most important factors found necessary for successful root initiation in air-layers done on juvenile seedlings was presence of adequate moisture secretion indicated by succulent bark and emergence of roots from lenticels. In mature trees as a contrast this was evident to a lesser degree and root formation was from callused portion where well formed root initials did not elongate into roots and remained stubby. Efforts are afoot to overcome these

Table 4a

Air layering under different treatments to explants

Explants	Treatment				Mean
	Red	Brown	Green	Control	
Juvenile	68.00 (55.44)	51.00 (45.62)	22.00 (28.01)	8.00 (16.11)	37.00 (36.30)
Mature	4.00 (12.92)	5.00 (12.92)	5.00 (12.92)	5.00 (12.92)	5.00 (12.52)
Mean	36.00 (33.38)	28.00 (29.27)	14.00 (20.46)	6.50 (14.51)	

Values within parenthesis are arcsine - transformed values.
$CD_{(0.05)}$ Explant = 2.46 Vermiculite = 1.74 Vermiculite x Explant = 3.48

Table 4b

Description of vermiculite Treatment

Treatment	IBA (mg)	NAA (mg)	Boric acid (mg)	Bavistin (mg)
Red *, 100 g talc	250	125	31	250.0
Brown**, 100 g talc	125	63	16	125.0
Green,*** 100 g talc	63	31	08	62.5
Control, 100 g talc	0	0	0	0

limitations by air layering grafted elite branches maintained in large pot- cultures that can be manipulated with advantage and made wieldy, as trees in their native state have been found very costly, highly risk prone experimental material to negotiate. Degree of difficulty increases when elite trees is owned by private person or rights for fruit collection is sold out much before fruit setting.

(v-vi) ***Grafting of soft and hard bud wood***

The bud-wood of *Terminalia chebula* was collected from mature elite trees of age varying from 25-100 years. Bud-wood belonged to three different age classes :

(i) Current year's branch, sprouted during last week of April and was on an average one-and-a-half-months old, that was uniformly green without lenticels visible to naked eye;

(ii) Corresponding previous season's vegetative branch aged thirteen-and-half-months, that was greenish-brown with lenticels visible to naked eye; and

(iii) In between these two age classes, there was a third age class of branches used as bud-wood that sprouts after fruiting is advanced during October aged eight-and-half-months old.

The diameter of the branch was not indicative of age and varied from basal end to apical end. Every new branch has a bulbous basal part covered with numerous buds each corresponding to an axil of a scale leaf. New branch when it elongates tends to bear opposite leaves, numbering 3-5 nodes, thereafter because of rapid and unequal elongation of the axis leaves tend to become alternate, this basic pattern is repeated in every branch year after year. Before laying out the experiment trial studies were carried out, based on these trials following treatments were finalized as shown in the results (Table 5). Bud-wood collection was done commencing from the month of June and continued up to July end. Pretreatment of bud-wood by way of surface sterilization using 0, 0.3% aqueous solution of contact fungicide Emisan (methoxy-ethyle-mercuric chloride with 0.6% mercury) was done for ten minuted. Subsequent to that explants were bathed in 0.1% aqueous solution of systemic fungicide Bavistin (carbendazim) for ten minutes. Residues of fungicides were washed in running water and explants conserved with freshened cut ends immersed in containers having distilled water. Scions of appropriate size suited to diameter of stock plant at the point of proposed graft union were made (Table 8). Sharp knife/razor blade was used to shape the scion in the form of a peg symmetrical in one plane. The knife/razor blade was surface treated with ethanol before every operation to prevent possible contamination. A matching cut was made in the stock plant and peg of scion was snuggly fitted in to the matching cut. The stock and scion at the point of union was meticulously matched to ensure juxtaposition of cambium. The point of union was tightly wrapped around with 2 cm wide strips of low density poly ethylene (LDPE). Multiple rounds of wrapping were done to exclude air spaces where stock and scion had cut surfaces. Loose end was secured by a half knot. The grafted plant was enclosed in a LDPE bag that was used as a cap. The size of the cap was 15 x 20 cm, in the beginning it was longitudinally folded thrice, central fold held the grafted

Table 5

Grafting using Bud-wood with various bud conditions

Graft	Bud Conditions			Mean
	Opposite Buds	Alternate Buds	Cluster of Buds	
With cover	60.00 (50.77)	40.00 (39.21)	55.00 (47.87)	52.00 (45.95)
Without cover	4.00 (11.64)	5.00 (12.92)	5.00 (12.92)	5.00 (12.49)
With water	15.00 (22.73)	5.00 (12.92)	4.00 (11.64)	8.00 (15.67)
With pre-sprouted	8.00 (15.74)	4.00(11.64)	5.00 (12.63)	6.00 (13.43)
Mean	22.00 (25.22)	14.00 (19.10)	17.00 (21.34)	

$CD_{(0.05)}$ Graft = 1.89 Bud Condition = 1.64 Bud x Graft Condition = 3.27

Table 6

Pre-sprouted grafts

Graft with pre-sprouted leafy branch with cap	40	40	40	120	
(i) Bud-wood with opposite buds (half sprout)	1	0	0	1	
(ii) Bud-wood with base intact (entire sprout)	3	2	4	9	
(iii) Bud-wood with apical portion (tip of sprout)	0	0	0	0	
Sub total	1	2	4	10	
ANOVA					Significant

plant as the bud break and elongation occurred rest of two third of bag was unfurled. Lower portion of the bag was loosely constricted either with staples or with elastic rubber bands. Care was taken to allow free access to circulation of air. The cap was removed after the branch started growing vigorously. The capped grafted plant was left open to sky during 5 p.m. to 10 a.m. (cooler part of the day) and covered with 75% shade net during 10 am to 5 pm (hotter part of the day). Sprouting was recorded at weekly intervals and the strips of tape used at graft union/joint was cut and removed after a month or later to ensure proper union. In some instances the union was found to be fragile and incomplete even after two months of waiting and added disadvantage of binding tape induced girdling tendency was observed.

Under North Indian weather that prevails in plains, grafting in open to air conditions after March led to desiccation

Table 7

Yield of fruits in different provenances

Name of the village		Number of adult trees	Weight of green fruits qtls/year (a) 1999-2000 (b) 2000-2001 (c) 2001-2002	Price paid for buying fruit rights (Fr) (Rs.)
(i)	Mandhana Distt., Panchkula Haryana (Rainfed hence water stressed)	180	(a) 225	90000
			(b) 270	109000
			(c) 200	138100
			695	337100
(ii)	Brahmapur District Yamuna Nagar Haryana (agroforestry)	16 (mature)	(a) 160	6000
			(b) 300	8000
			(c) 350	7000
			810	21000
(iii)	Sahalyo, Distt. Panchkula, Haryana. (Rainfed but Sheltered Valley) less of water stress.	2350 (mature)	(a) 1645	180000
			(b) 1410	200000
			(c) 1293	210000
			4348	590000
			(a) 695	3,37,100
			(b) 810	21,000
			(c) 4348	5,90,000
			5853	8,48,000
		G. Total : 2546	5853÷ 3 years = 1951÷ 2546 mature trees =0.77 qtls/tree Average bearing	948000÷ 3 yrs. =316000÷ 2546 (no. of trees) =124÷ 77 kg fruits/tree =Rs. 1.61 kg (wholesale)

of scion and total failure of grafting in all the trials. Shade temperature during May and June is 35-40°C. When scion is grafted and stock responds, there is a time lag. Occularly it expresses within a week to ten days but physiologically it takes less time. Even this time lag is long enough for loss of endogenous moisture in the scion that is having a few ml of sap. When a small polyethylene cap is used to contain

Elite tree of *Terminalia chebula* Retz., grown under Farm Forestry; situated in Morni hills of Haryana State, 50 km North of Chandigarh

Harad in Farm Forestry

Elite nuts

Sprouted stem cuttings

Fruit size of parent and F1

Stabilization of sprouts

Elite grafted seedlings

Grafts covered with caps

Harad fruit

Table 8

Seedlings used as stock plants

Age (months)	Size of Polypot# (cm)	Collar Dia. (cm)	Top Ht. (cm)	Remarks
12	12x 22	0.4	25	# length and breadth of empty bag
12	20 x 30	0.8	50	Diameter and height; average of 100 seedlings
24	30 x 45	1.5	75	Details moderated for simplicity

the graft, initially there is more evaporation as cap acts as a miniature hot house by acting as a heat trap. Heat built up within cap beyond 40°C has sanitizing effect on enclosed volume as pathogenic fungi and bacteria get deactivated progressively beyond 35°C upward to 70°C at which temperature their activity is becomes negligible. Water vapour both from stock and scion gets stored and collects as mist with in the cap during day time and condenses during night. Greater heat forces greater physiological activity and helps graft union by reducing response time; reduced loss of endogenous moisture from scion gives additional time for union; and sanitizing temperature wards off possible infections.

To reduce water loss some water can also be artificially introduced into above arrangement that has been considered as a separate treatment. Once the bud break occurs and elongation begins water bubble causes leaf fall. It is better to shift to cap without water as discussed above soon after elongation of shoot begins. Pre-sprouted stem cuttings that are obstinate to root can be grafted to stock plants by this method.

(vii) ***Grafting of sprouts induced on stem cuttings***

In another experiment, scion used was about one month old sprouts on stem cuttings of elite trees. One to three year old branches of elite trees were surface sterilized and set in root trainers containing vermiculite in the month of May. This set up was subject to mist regimen in mist chamber that maintained a temperature of 42°C and 95% relative humidity; in fact the mature explants collected from elite trees were being treated to various PGRs for root induction studies were used in this study as they profusely sprouted and gave shoots but failed to root beyond minor callus formation. The sprouts at the time of grafting were 30 to 45 days old and mostly contained soft tissue. They were carefully severed with sterilized razor blade from the stem and shaped in the form of a peg and grafted on to top portion of one year old seedling as top mounts. Three treatments of scions viz., apical portion only, slightly longer sprout and entire sprout were used in the experiment. At the graft union all the precautions that are explained elsewhere were taken to a finer degree as scion used was fragile. In

this experiment the leaves were retained as they were very small and delicate and removal would have harmed the scion. Grafts were capped with LDPE bag as above and similarly treated. Graft union was monitored on daily basis and the binding tape was removed as explained above. Observations were tabulated and analysed.

A spin off occurred by utilizing sprouts as scion though the rate of success is not high; entire sprout could be successfully grafted in itself holds key to unlimited operational possibilities for *ex-situ* conservation of elite plant material of this and other species that are difficult to root.

Conclusion

Base population of 2,546 *Terminalia chebula* trees were studied in three provenances of Haryana State. Natural regeneration was found to be absent owing to complete extraction of raw and ripe fruits. It can be profitably grown as a farm forestry species in Siwalik hills, vast increase in magnitude of plantation activity using genetically improved seedlings is recommended. Adjacent districts in plains with well drained soils can also take up cultivation as a partial substitute to *Eucalyptus* and Poplars as it gives annual returns. Natural variations in fruit character that are economically beneficial are to be enhanced and genetic gains transferred to prospective growers without loss of time. A programme called 'TREIMP' focuses on fast track transfer of applied knowledge to prospective users on 'as is when is basis'. Fruit collection rights of elite trees ought to be bought in advance to prevent dysgenic extraction. More than half of raw fruits contain physiologically mature seeds. Those can be assisted to germinate, by alternate wetting and drying, followed by mechanical splitting of endocarp along cryptic suture line and sowing in sterile medium with constant supply of moisture. Large scale raising of elite tree-wise foundational seedlings is to be done to increase magnitude of planting. As field evidence indicates that fruit character is heritable as expressed in half-sib progeny trees that bear similar if not identical fruits; juvenile seedlings should be asexually propagated. True-to-type propagation is possible by mass vegetative multiplication of elite explants. Mature explants have so far not responded to root induction, horticultural techniques by way of peg grafting and grafting of pre - sprouted stem cutting can be furthered to induce juvenility by serial grafting technique. There after juvenile cuttings can be rooted. For farm forestry or raising of seed orchard grafted seedlings can be used as the intensity of management is personal and high. But routine forestry plantations raised using grafted seedlings without element of personal care have been found to revert to wild state. Considering above experience efforts are currently being focussed on producing entire plantlets of elite trees through macro-propagation.

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SUMMARY

***Terminalia chebula* Retz. is a multipurpose medicinal plant found in all deciduous forests of India. It is a hardy moderate size tree species that can grow with very little care and can be integrated in to farm forestry profitably. Full potential for revegetating Siwalik hills requires to be exploited throughout North India. Studies were carried out on three provenances of Haryana State to ascertain regeneration status of this important indigenous tree that was considered only as a source of NWFP of medicinal and dyeing fruits. Studies have indicated it produces firewood and, in scarcity time, fodder also. Natural variation in fruits have been found to be heritable and beneficial variations could be harnessed to make this tree more acceptable to farmers. Under a programme called 'TREIMP' sustained efforts are being made to produce seedlings and supply to the growers without loss of time involved in transfer of technology.**

भारतवर्ष की महत्वपूर्ण, बहुप्रयोजन औषधीय वृक्षजाति, *टर्मिनेलिया चिबुला* रेजि॰ में अनुवांशिक सुधार लाने वाली प्रविधियों का अध्ययन

डी॰आर॰ रमेश सिंह, के॰के॰ धीर, एस॰पी॰ विज, एच॰ नैय्यर व कमलजीत सिंह

सारांश

टर्मिनेलिया चिबुला रेजि॰ बहुप्रयोजन औषध वृक्ष है जो भारतवर्ष के पर्णपाती वनों में पाया जाता है । यह कष्टसहिष्णु मध्यम आकार की वृक्ष जाति है जिसे मामूली देखभाल से उगाया जा सकता है और कृषि वानिकी से सलाभ संयुक्त किया जा सकता है । शिवालिक पहाड़ियों को पुनर्वनित करने की संपूर्ण संभावनाओं को उत्तरी भारत में सर्वत्र उपयोग में लाने की आवश्यकता है । हरियाणा राज्य के तीन स्थानज विभेदों को लेकर इस महत्वपूर्ण देशज वृक्ष जाति की पुनर्जनन स्थिति ज्ञान करने के लिए अध्ययन किए गए, जिसे अभी तक केवल औषधीय और वस्त्र रंगाई फल देने वाली गैरकाष्ठ वनोपत्र ही माना जाता रहा है । अध्ययनों से संकेत मिला है कि इससे जलाऊ लकड़ी और दुष्काल में काम आने वाला पशुचारा भी मिलता है । फलों में मिलने वाली प्राकृतिक विभिन्नता पितृदायी पाई गई और किसानों के लिए इस वृक्ष को अधिक स्वीकार्य बनाने के लिए इसकी लाभप्रद विभिन्नताओं को उपयोग किया जा सकता है । 'ट्रेइम्प' कार्यक्रम के अधीन इसके पौधे तैयार करने और प्रौद्योगिकी हस्तान्तरण में कुछ भी समय बरबाद न होने देते हुए उन्हे पेड़ उगाने वालों को देने के लिए निरन्तर प्रयास किए जा रहे हैं ।

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