Indian J. Pl. Genet. Resources 12(3): 317-323, 1999

GENETIC RESOURCES OF *Terminalia* : THEIR MAINTENANCE, EVALUATION, UTILIZATION AND CONSERVATION

P. K. SRIVASTAV, B. R. R. PRASAD SINHA[1], K. THANGAVELU[1] AND S. S. SINHA[1], Regional Tasar Research Station, Imphal 795 002 (Manipur); [1]Central Tasar Research & Training Institute, Ranchi (Bihar)

Studies on 130 accessions of *Terminalia* species complexes and their hybrids exhibited continuous variation. Maintenance of their genetic resources through *ex situ* conservation at various stations and their systematic characterization and evaluation and yield and quality trials have been discussed in detail. Strategies for effective utilization and conservation of germplasm and superior varieties of Pentaptera have also been earmarked.

Key words : *Terminalia arjuna, T. tomentosa*, genetic resources, maintenance, evaluation, utilization and conservation

Cultivation of *Terminalia arjuna* and *T. tomentosa* (section: Pentaptera) is the most important for tasar culture since economics of this agroforestry enterprise mainly depends on the total quality leaf produced in an unit area over an unit time. Of the three yield contributing factors viz., cultivating high yielding varieties, providing better agronomical practices and protecting crop from pests and diseases, usage of high yielding varieties is the cheapest and effective method. Lately, the need for a global plan of action for the conservation and sustainable utilization of forest genetic resources has been realized and *Terminalia* is not an exception to this.

Origin and distribution of *Terminalia*

Vavilov (1926) in his "Centre of Origin" hypothesis generalized that the genetic variability in populations is the greatest in the territory wherein the species arose and from where it subsequently spread elsewhere. Hence, Central India may be regarded as the centre of origin of section Pentaptera of genus *Terminalia*, despite of the fact that centre of origin of *Terminalia* may be probably Malayasia since as many as 40 species have been reported from there. In addition, twenty seven species were reported from India whereas 11 species from tropical Africa (Srivastav *et al.* 1998). Accordingly, Indo-Malayan region may be regarded as the "ancestral home" of genus *Terminalia* from where it spread to all other biogeographical regions of the world. Conversely, all the 18 Australian species of *Terminalia*, appear to be endemic with the exception of *T. microptera* which occurs in Timor also. Hence, genus *Terminalia* probably differentiated independently in two or more regions and appears to have bitopic or polytopic rather than monotopic centres of origin. (Srivastav *et al.* 1997 a).

Genetic resources in Pentaptera

Due to predominant out-crossing, sexual recombination and segregation, mutations and natural selections, lot of inter as well as intraspecific variations occur in this genus which are sometimes so conspicuous that more than one species may be involved forming species complexes in *T. arjuna, T. tomentosa, T. bellerica, T. chebula* and

T. citrina. In section Pentaptera, according to Parkinson (1936), affinity and intergrading is evident among various varieties and forms of *T. arjuna* and *T. tomentosa* complexes. Hooker (1878) has described three varieties under *T. tomentosa* viz., *typica (alata), crenulata* and *coriacea*, while Roth, Wight and Arnot (quoted by Hooker, 1878), Gamble (1915, 1920), Blatter (1929), Parkinson (1936), Bahadur and Gaur (1980) and Srivastav *et al.* (1997 a, b) have treated them as distinct species. Likewise, *T. arjuna* var. *arjuna* and *T. arjuna* var. *angustifolia* described by Hooker (1978) have also been treated as distinct species as *T. glabra* W & A and *T. berryi* W & A respectively (Parkinson 1936, Srivastav *et al.* 1997 a, b). Besides, hybrids between entities from both the complexes have also been reported (Haines, 1922; Parker, 1920). On the basis of natural variation encountered, a total of twelve taxa and/or biotypes have easily been recognized in section Pentaptera viz., *T. berryi, T. glabra*, small leaf form and putative hybrids closer to *T. arjuna* in *T. arjuna* complex and *T. alata* var. *alata, T. alata* var. *nepalensis, T. crenulata* with big and small leaf forms, *T. coriacea* with small and big leaf forms and putative hybrids closer to *T. tomentosa* in *T. tomentosa* complex (Table 1).

Exhaustive explorations of genetic resources through plus tree selection (*ex situ* conservation) and observations recorded on 130 accessions of *T. arjuna* and *T. tomentosa* collected from tropical Central India (M.P., Orissa and Bihar) and their hybrid complexes have been found to exhibit continuous rather than discontinuous variations in fruit, foliar and stem/bark characteristics (Table 2). However, further explorations covering sub-tropical regions viz, Doon valley, Garhwal, Kumaon and Rohilkhand (Uttar Pradesh) and North-east India may be planned to collect valuable genotypes.

Maintenance of genetic resources

The maintenance of genetic resources is a pre-requisite for conservation and evaluation and subsequent utilization for tasar culture. The major varieties of *Terminalia arjuna* are multiplied through air layering from common ancestors (ortets) and cultivated in RBD, each block consisting of 20-25 ramets for evaluation through bioassay studies in at least 180 × 180 cm or 120 × 180 cm spacing instead of 120 × 120 cm spacing for easy management. Besides, 10 ramets from each genotype/variety should separately be maintained as *ex situ* germplasm reservoir at 450 × 450 cm or 360 × 360 cm spacing and they should be allowed to grow freely without undertaking any rearing on them. Germplasm maintenance for *ex situ* conservation as well as for evaluation purposes may be resorted at each Regional Taser Research Station (RTRS) for indigenous as well as exotic biotypes as far as possible.

Ex situ field genebanks of Pentaptera species may be established at suitable localities viz., CTR & T.I., Ranchi, Tropical Forest Research Institute/State Forest Research Institute, Jabalpur; Kerala Forest Research Institute, Peechi; Institute of Forest Genetics and Tree Breeding, Coimbatore; Forest Research Institute, Dehradun and Botanical Survey of India, Shillong/R.T.R.S., Jorhat (Srivastav *et al.*, 1996). A consolidated *ex situ* germplasm bank of *Terminalia arjuna* and *T. tomentosa* like SMGS, Hosur may be established in due course of time at a suitable place, preferably in Central India through cloning those genotypes e.g., *T. arjuna* which respond favourably to air layering/cutting and through half sib seedlings (*T. tomentosa*) till clonal propagation technology is not developed for them.

Research on clonal propagation through cuttings/air-layerings and tissue culture may be intensified on priority basis in order to multiply and conserve true to type genotypes. Tissue culture technology may also be utilised for *in vitro* conservation as well as evaluation for salt resistance

Table 1. Distinguishing features of taxa in *Terminalia* (Section : Pentaptera)

Species	Taxa	Distinguishing features
1. *Terminalia arjuna* Bedd. (Species complex)		Fruits comparatively very big 1-2 inches,bark smooth grey,flaking off in large thin layers. Wings of the fruit not very broad,their striation curving upwards. Leaves glabrous.
	1. *T. berryi* W. & A. syn. *T. arjuna* var *angustifolia*	Leaves narrow elongate-oblong suddenly narrowed into petiole with drooping branches L/B = > 4
	2. *T. glabra* W. & A. syn. *T. arjuna* var. *arjuna*	Leaves often cordate
	3. Small leaf form	Leaves elliptic to lanceolate L/B = 3.0 - 3.5.
	4. Putative hybrids closer to *T. arjuna*	Bark grey,slightly rough,leaves broader than those of *T. glabra* and not perfectly smooth.
2. *Terminalia tomentosa* *W. & A.* (Species complex)		Bark rough, grey-black, not flaking in this layers. Wings very broad in fruits, striations of wings carried horizontally to the edge. Leaves tomentose rarely glabrous
	1. *T. alata* syn. *T. tomentosa*	Leaves cordate or oblong suddenly narrowed into the petiole. Adult more or less hairy beneath,bark grey to black. Young ovary villous,fruits glabrous.
	i). *T. alata* var. *alata* Heyne ex Roth syn. *T. tomentosa* var. *alata*	Leaves elliptic to oblong or ovate to oblong 5 × 8 cm., thinly wooly beneath,found in Central India
	ii). *T. alata* var. *nepalensis* (Haines) Fernandes *T. tomentosa* var. *nepalensis*	Leaves oblong to elliptic or lanceolate,13-30 × 4-10 cm,strongly tomentose beneath,distributed in northern India.
	2. *T. crenulata* Heyne ex Roth syn. *T. tomentosa* var. *crenulata*	Leaves narrowed into the petiole,obovate to elliptic,adult nearly glabrous beneath,young ovary and fruits glabrous,Common in Western Ghats.
	a) Big leaf forms	Obovate leaves
	b) Small leaf forms	Oblong leaves
	c) Kahvi	Elliptic leaves
3. *T. coriacea* (Roxb.) W & A. syn. *T. tomentosa* var. *coriacea*		Bark dark coloured like crocodile skin,leaves like *T. alata* but beneath with a close hard fulvous tomentum rather than villous.
		Fruits pubescent between wings. Common along Eastern Ghats.
	a) Big leaf forms	Obovate leaves
	b) Small leaf forms	Oblong leaves
4. Putative hybrids closer to *T. tomentosa*		Bark greyish black, rough and slightly cracked. Leaves bigger than those of *T. glabra*, nearly glabrous, veins protruding

genotypes in less space and for indefinite period. Attempts may be made to declare *Terminalia* species a national tree genus. Government of India may enforce laws to ban cutting etc. This will fascilitate *in situ* conservation and also protect the ecological balance (Srivastav *et al.*, 1996; Priya Ranjan *et al.*, 1994).

Evaluation of genetic resources

The conservation through maintenance and use of genetic resources are the two inseparable components of varietal improvement. Without systematic evaluation of existing genotypes, the available genepool in the germplasm collections can not be fully utilized to full extent. Objective oriented multidisciplinary efforts should be made involving three major steps viz. descriptive recording, systematic characterization and empirical testing.

(I) **Descriptive recording** : Descriptive recording is an essential step which provides the morphological details of each accession for cataloguing and classifying the material systematically. For descriptive recording, *Terminalia* (Pentaptera) descriptor is a must and the same has been prepared based on the observations on 130 accessions collected from Central India. The descriptor list is divided into nine major groups of characters pertaining to phytogeography, gross morphology, reproductive biology, anatomy, cytology, growth/yield attributes, quality parameters, responses to different cultivation practices and resistance to various pests and diseases (Srivastav *et al.* 1997 b). Format presented is similar to the one designed and approved by FAO and IPGRI for other crops and based on Mulberry descriptors (Dandin and Jolly, 1986) with certain modifications as applicable in case of *Terminalia* (Section: Pentaptera).

(II) **Systematic characterization** : The objectives of *Terminalia* (Pentaptera) breeding are production of more foliage of high palatability and nutritional value throughout the year, and with high ca-capacity of regeneration and amenable to vegetative propagation and genotypes with thick succulent leaves and high moisture content. Parameters contributing to above objectives in "Pentaptera" like mulberry may be as follows :

a. Fast growth and high regenerating capacity
b. Bushy nature i.e., production of maximum primary and secondary branches with short internodes.
c. Thick succulent gummy leaves.
d. Quick sprouting and high rooting capacity.
e. Good response to agronomical practices like repeated pruning, manuring etc.
f. High moisture content of leaves with better moisture retaining capacity.
g. Better root initiation, growth and proliferation.
h. Resistance to drought.
i. Resistance to pest 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 of all the collected accessions need to be done.

Yield trials and Quality evaluation

After assessment of all the individual characters contributing to growth and yield, the varieties/genotypes performing better can be taken for yield testing in RBD with three replications, each block clonally propagated as discussed earlier through air layering and uniform package of practices for manuring, pruning and leaf harvest may be adopted. While doing initial tests, material may also be multiplied for subsequent tests.

Quality of varieties can be tested both by bioassay and chemical analysis. Feeding trials can be conducted both by moulting as well as full rearing tests. In moulting test, observations on number of worms going for normal moulting, number of worms delayed to undergo moulting and coming out of the moult within the specific

Table 2. Species wise composition of *Terminalia* (Pentaptera) genotypes being studied at Central Tasar Research & Training Institute, Ranchi, India

Years of exploration		Taxa	No. of accessios	Location
1987	1.	*T. glabra* syn. *T. arjuna* var. *arjuna*	12	Dhamtari, Jagadalpur (M.P.), Sundergarh, Nowrangpur (Orissa)
	2.	Putative hybrids	10	Sundergarh, Nowrangpur (Orissa) and Jagadalpur (M.P.)
1989	1.	Putative hybrids	2	Nowrangpur (Orissa)
1990	1.	*T. glabra*	14	Ranchi (Bihar)
	2.	*T. berryi* syn. *T. arjuna* var. *angustifolia*	2	Ranchi (Bihar)
	3.	*T. alata* var. *alata* syn. *T. tomentosa* var. *alata*	8	Ranchi (Bihar)
	4.	*T. coriacea* syn. *T. tomentosa* var. *coriacea*	3	Ranchi (Bihar)
	5.	*T. crenulata* syn. *T. tomentosa* var. *crenulata*	1	Ranchi (Bihar)
	6.	Putative hybrids	11	Ranchi (Bihar)
1993	1.	*T. glabra*	18	Ranchi (Bihar), Balaghat, Bilaspur and Jagadalpur (M.P.)
	2.	*T. berryi*	4	Ranchi (Bihar), Balaghat (M.P.)
	3.	*T. alata* var. *alata*	2	Jagadalpur and Bilaspur (M.P.)
	4.	*T. alata* var. *nepalensis*	2	Ranchi (Bihar)
	5.	*T. coriacea*	1	Balaghat (M.P.)
	6.	*T. crenulata*	22	Ranchi (Bihar, Bilaspur & Raigarh (M.P.)
	7.	Putative hybrids	12	Ranchi (Bihar), Balaghat, Jagadalpur and Bilaspur (M.P.)

period must be observed. In this test, healthiness or otherwise of the worms reflects on the nutritive quality of the leaves which can be taken as an index. Hence, this test may be utilized for preliminary testing of large number of varieties at a time to assess the nutritional quality. In full rearing test, a constant number of worms may be kept. Their growth rate, and general healthiness are observed till fifth stage and ERR, SR per cent, filament length etc. should be recorded to correlate silk quantity to the nutritional quality of the leaf.

Besides, chemical analysis of leaves for primary as well as secondary metabolites may also be conducted. Analysis of specific contents like amino acids, isozymes, phenolics, β-sitosterol etc. may also be made to correlate with feeding trial results and also for establishment of phylogenetic relationships of varieties/biotypes.

Consequently, various Regional Tasar Research Stations may also conduct similar yield and bioassay trials through full rearing and moulting tests for assessing suitability of various superior varieties to different agroclimatic conditions for recommending region/location specific varieties/biotypes following the same procedure alongwith local genotypes for at least three years. The superior ones performing well could be recommended later to the respective regions.

Utilization and conservation of genetic resources

For effective utilization of germplasm and superior varieties of Pentaptera intensive training to scientific personnels on characterisation, maintenance, documentation, evaluation and clonal

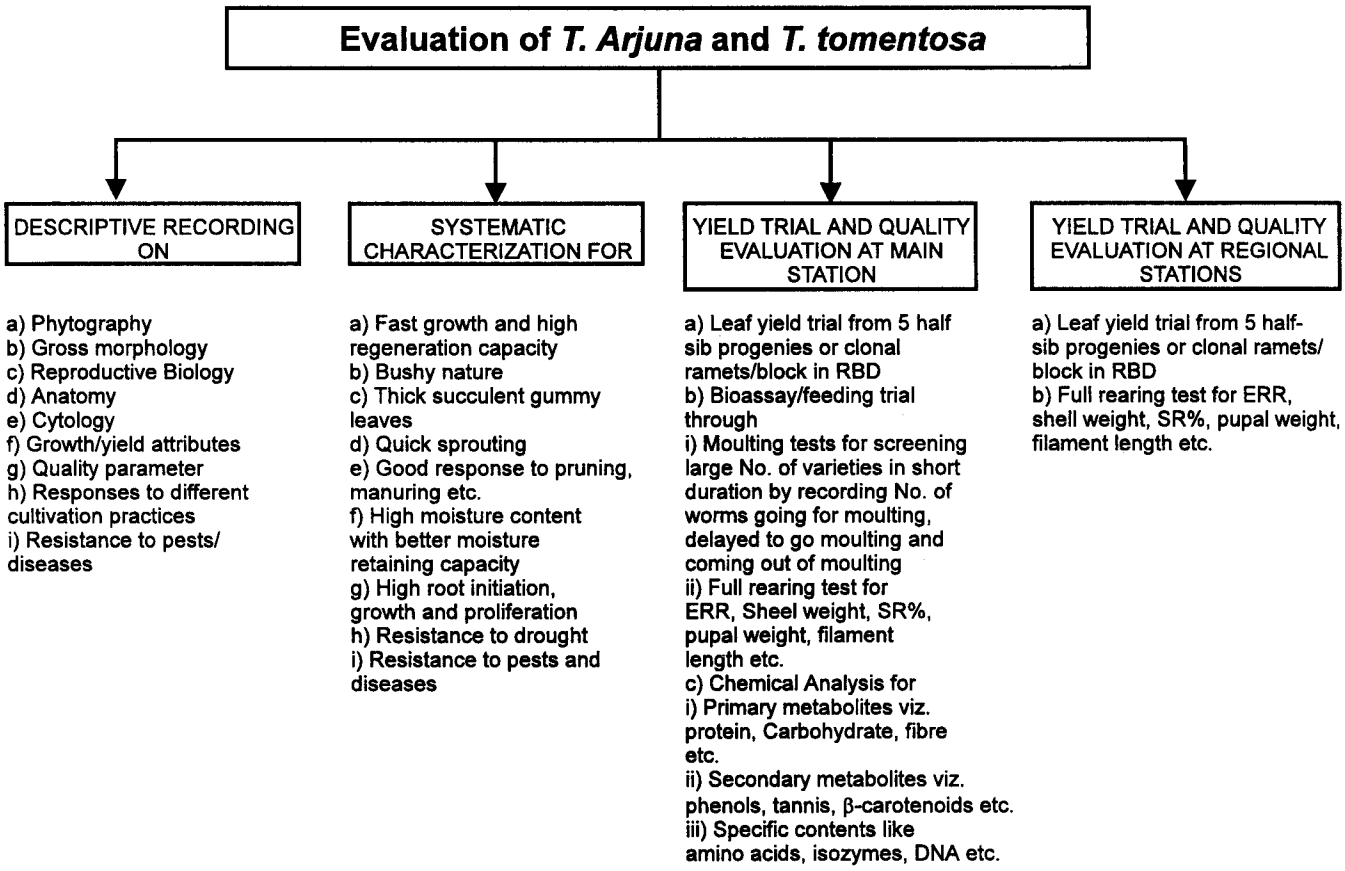

Fig. 1. Proposals for evaluation of *T. arjuna* and *T. tomentosa*

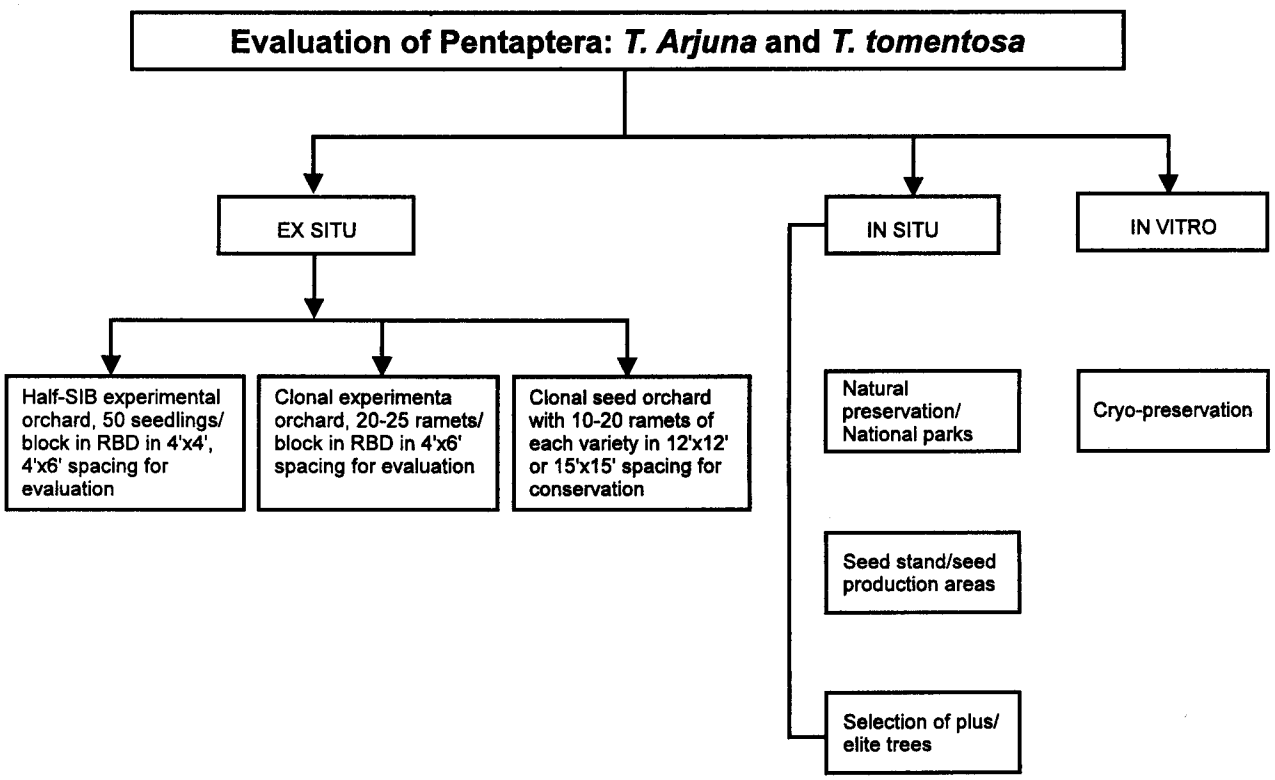

Fig. 1. Proposals for maintenance of *T. arjuna* and *T. tomentosa*

propagation technology including tissue culture is urgently required. To achieve above goals, an All India Co-ordinated Project may be initiated under Non-mulberry Silkworm and Plant Germplasm Station which may be established somewhere with units at various places for different non-mulberry food plants. Following strategies may be adopted for utilization and conservation of genetic resources of Pentaptera :

1. Explorations covering subtropical regions viz., Doon valley, Garhwal, Kumaon, Rohilkand and North-east India and tropical regions of South India should also be conducted.

2. Preliminary systematic characterization of all known varieties/accessions of Pentaptera should be done

3. Greater emphasis should be laid on under utilized and endangered varieties/genotypes like Kahvi from Bilaspur, Ulta Saja from Amarkantak (Madhya Pradesh) and spontaneous hybrids from Central India as local varieties.

4. Small and big leaf forms of *T. crenulata* and *T. coriacca* may be introduced from Western/eastern Ghats to Central India for various afforestation schemes.

5. A consolidated *ex situ* germplasm bank of Pentaptera should be established through cloning/half sib seedlings in Central India.

6. Research on clonal propagation and tissue culture should be intensified for breeding and utilization of true to type genotypes.

7. Collaboration with Indian Council for Forest Research and Education (ICFRE) institutions, state forest deptts. and NGOs should be established/increased.

8. Collaboration between different RTRSs should be enhanced for exchange of germplasm.

9. Genus *Terminalia* should be declared as a National Tree genus to protect environment and encourage tasar culture.

10. Potentialities of *T. arjuna* for reclamation of alkaline/saline soils, water-logged/peaty soils and ash dykes from thermal plants and *T. tomentosa* for reclamation of barren rocky lands should be publicised for inclusion under social forestry programmes by Railways, SECL, CCL, WCL, NTPC private industries and NGOs.

11. Religious sanctity of Arjuna of Mahabharata period may be publicised among rural populace to check cutting.

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