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IMPROVEMENT THROUGH SELECTION OF PLUS TREES IN *GMELINA ARBOREA*

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KUMAR, A., CHAWHAAN, P. H. & MATHAROO, A. K. 2003. Improvement through selection of plus trees in *Gmelina arborea*. The genetic improvement of *Gmelina arborea*, a native of north-eastern India was investigated. A total 60 plus trees of *G. arborea* were selected from the states of Assam, Arunachal Pradesh and Mizoram using point grading method of selection. Superiority of these plus trees over the comparison trees was 18.77, 20.68 and 46.48% for height, girth at breast height (gbh) and clear bole height (cbh) respectively. Plus trees selected from the state of Arunachal Pradesh showed maximum improvement for gbh (31.52%) and cbh (67.28%) whereas plus trees from Mizoram attained maximum improvement for height (25.22%).

Key words: Point grading method - comparison trees - superiority

KUMAR, A., CHAWHAAN, P. H. & MATHAROO, A. K. 2003. Perbaikan melalui pemilihan pokok terbaik *Gmelina arborea*. Perbaikan genetik *Gmelina arborea* iaitu pokok asli di timur laut India dikaji. Sebanyak 60 pokok terbaik *G. arborea* dipilih dari negeri Assam, Arunachal Pradesh dan Mizoram menggunakan kaedah pemilihan pemeringkatan titik. Keunggulan pokok terbaik berbanding pokok bandingan adalah masing-masing sebanyak 18.72, 20.68 dan 46.48% untuk ketinggian, lilitan aras dada (gbh) dan ketinggian batang bersih (cbh). Pokok terbaik dari Arunachal Pradesh menunjukkan perbaikan maksimum untuk gbh (31.52%) dan cbh (67.28%) sementara pokok terbaik dari Mizoram memperoleh perbaikan maksimum untuk ketinggian (25.22%).

Introduction

The requirement of various woods in India by the year 2010 has been projected to be 344 million tonnes of fuelwood and charcoal, 37 million m^3 of industrial wood, 33 million m^3 sawn timber, 5.7 million m^3 pulp and paper wood and 1.3 million tonnes of wood-based panels (FAO 1993). However, the annual total productivity of the forests in India is only 15 million m^3 of industrial timber and 195 million m^3 of firewood (Chadha *et al.* 1992). There are limited options to meet the ever growing wood demand, i.e. either by increasing the total forest cover or increasing the productivity of man-made forests substantially. Unlike the former, the latter is a viable option. Therefore, reforestation must be carried out only with genetically improved planting material coupled with improved technical inputs, scientific management and effective protection measures.

Clonal technology has been instrumental in increasing the yield of forest species including conifers, populous and eucalypts. Using this technique, Aracurz Florestal, a forest plantation company in Brazil, has achieved dramatic yield increment in eucalypts from 7 to 45 $m^3 ha^{-1} year^{-1}$ (Campinhos & Ikemori 1983). The productivity of *Eucalyptus tereticornis* in India has increased from 7.7 to 18.7 $m^3 ha^{-1}$ $year^{-1}$ through simple selection and cloning option (Lal *et al.* 1994). Selection of superior genotypes for desired characteristics is the key for the success of clonal technology.

Gmelina arborea belongs to the family Verbenaceae and is distributed eastwards from Pakistan throughout India, Bangladesh and Myanmar to parts of Sri Lanka, Thailand, Laos, Cambodia, Vietnam, China and Yunnan (Nasir 1972). *Gmelina arborea* has been an important species of deciduous and moist deciduous forests, and found occasionally in evergreen forests up to an altitude of 1500 m. In India, it is found in eastern sub-Himalayan tract, Indo-Gangatic plains, Aravalli Hills and western Himalayas (Tewari 1995) and grows to a height of 30 m with girth of 4.5 m and clear bole length of 15 m (Rodger 1913). This fast growing species produces reliable timber and has greater potential in tropical plantations (Zobel & Talbert 1984). A wider acceptability worldwide has resulted in tremendous increase in plantation area of this species. In Nigeria, for example, more than 41% of the plantations are stocked with *G. arborea* (Anonymous 1991) with an average volume productivity of 376.65 $m^3 ha^{-1}$ at the age of eight years (Onyekwelu 1995). *Gmelina arborea* is an excellent wood for timber and pulping, is a good source of fodder, and can be grown on persistently poor sites. The species shows variation in growth and form, and thus needs immediate genetic improvement for higher productivity.

High variations for yield in *G. arborea* present greater potential in identifying superior performers and propagating them by clonal means to be introduced in plantation forestry. Improved plantations of the species can play a complementary role in conservation through compensatory afforestation and provide necessary timber and industrial raw material which otherwise would come from natural forests. Thus, *G. arborea* can contribute significantly towards bridging the gap between demand and supply, particularly in timber and pulp industries. Keeping this in view, the present paper emphasises (1) a selection methodology for selecting plus trees and (2) the gain achieved through selection of plus trees over comparison trees.

Materials and methods

An extensive survey of *G. arborea* plantations, aged about 20 years old, was carried out in the north-eastern states of Arunachal Pradesh, Assam and Mizoram at different locations (Table 1). The plantations were divided into various grids for effective selection of plus trees. In each grid, trees with good height, girth at breast height (gbh), clear and cylindrical bole, with good health without any disease and pest attack were marked using point grading method of selection (Zabala 1993). The candidate trees were selected and awarded marks accordingly. A minimum

Table 1 Geographical details of different locations of study sites

State	Location/ forest range	Latitude	Longitude
Arunachal Pradesh	Medo	96° 15' E	27° 11' N
	Chowkham	96° 04' E	27° 46' N
Assam	Lanka	93° 00' E	25° 50' N
	Langting	93° 28' E	25° 28' N
	Lumding	93° 28' E	25° 41' N
Mizoram	Bilkhawthir	92° 42' E	23° 52' N
	Kolasib	92° 39' E	23° 16' N

distance of 100 m between two candidate plus trees (CPTs) was always maintained. Equally good looking phenotypically superior trees (three to five) growing nearby the CPTs were selected as comparison trees. Height, gbh and clear bole height (cbh) were measured both for CPTs and comparison trees. Other characteristics, namely, straightness, bole form, branch angle, branch diameter, crown shape and health of the tree were subjectively scored by visually comparing candidate and comparison trees. Trees infected with disease or insect were not selected. The points for different characteristics were awarded as described in Table 2.

The CPTs that received more than 90 points were finally selected as plus trees and analysed for superiority over comparison trees. Tree height, gbh and cbh were recorded for all plus and comparison trees in all the states. The trees selected in a particular state were analysed for the individual state, and then pooled together for north-eastern region. The statistics for average, range (minimum and maximum), standard deviation (SD), standard error (SE) and coefficient of variation (CV) were carried out using Microsoft Excel Version 2000.

Results and discussion

The mean, range, SD and CV for tree height, gbh and cbh for Arunachal Pradesh, Assam, Mizoram and north-east region both in plus and in comparison trees are presented in Tables 3 and 4. The height, gbh and cbh of plus trees for north-eastern region ranged from 18–34, 0.70–1.62 and 12–26 m against 12–32, 0.56–1.72 and 1–25 m in comparison trees respectively. Generally, the CV values for height, gbh and cbh in comparison trees were higher than in plus trees for all states and north-east region.

The percentages of improvement in plus trees over comparison trees are presented in Figure 1. On average, height, gbh and cbh improved by 18.72, 20.68 and 46.48% in all the locations respectively. Plus trees selected from Arunachal Pradesh showed maximum improvement for cbh (67.28%) and gbh (31.52%) while those from Mizoram, for height (22.74%). In contrast, plus trees from Assam showed minimum improvement for height (13.93%) and cbh (26.27%).

Table 2 Points awarded for different characteristics of candidate and comparison trees

Characteristic	Description	Points
Vigour (30 points)		
Girth at breast height (15 points)	Smaller than average	0–4
	Between average and tallest tree	5–10
	Equal to largest tree	11–12
	Larger than largest tree	13–15
Height (15 points)	Shorter than average	0–4
	Average	5–10
	Equal to tallest tree	11–12
	Larger than tallest tree	13–15
Bole form (20 points)	Basal sweep	Deduct 0–3
	Trunk bend, spiral boles	1–6
	Trunk curved	1–5
	Per degree curved	1
	Cross section or circular	1–3
Branching habit (20 points)		
Branch angle (10 points)	80° – 90°	10
	70° – 80°	8
	60° – 70°	6
	50° – 60°	4
	40° – 50°	0
	less than 40°	Deduct 3
Branch diameter (10 points)	Bigger than average	0–4
	Intermediate	5–7
	Remarkably small for vigour of tree	7–10
	Points for excessive branch length	Deduct 1–3
	Points for evidence of ramicorn	1–2
Apical dominance (10 points)	Over 70%	10
	55–69%	7–9
	40–54%	4–6
	25–39%	3–3
	Below 25%	0
Forking (5 points)	5–10 m above ground	Deduct 4–5
	10 m from above the ground	1–3
Health (15 points)		

The success of a genetic improvement programme depends on the existence of variability in the base population. By selecting superior performers using a proper selection methodology, significant improvements have been achieved in a number of forestry species. A number of studies have been carried out to select plus trees of various forest tree species in many countries. However, the genetic gain through selection programme has not been very encouraging basically due to lack of proper selection methodology. Emmanuel & Bagchi (1988) selected

Table 3 Height, girth at breast height (gbh) and clear bole height (cbh) of plus tree of *Gmelina arborea*

	Arunachal Pradesh			Assam			Mizoram			North-east India		
	Height (m)	Gbh (m)	Cbh (m)	Height (m)	Gbh (m)	Cbh (m)	Height (m)	Gbh (m)	Cbh (m)	Height (m)	Gbh (m)	Cbh (m)
Mean	27.00	1.21	20.91	27.81	1.10	17.83	23.26	0.90	16.95	26.02	1.07	18.56
SE	0.82	0.08	1.13	0.53	0.02	0.46	0.76	0.03	0.70	0.47	0.03	0.41
Range												
Minimum	22.00	0.95	15.00	22.00	0.93	13.00	18.00	0.70	12.00	18.00	0.70	12.00
Maximum	30.00	1.62	26.00	34.00	1.37	23.00	28.00	1.16	22.00	34.00	1.62	26.00
SD	2.72	0.25	3.75	2.92	0.13	2.52	3.31	0.14	3.06	3.66	0.20	3.21
CV (%)	10.08	20.65	17.95	10.49	11.90	14.12	14.25	15.42	18.08	13.75	18.51	17.72

SE = standard error; SD = standard deviation; CV = coefficient of variation

Table 4 Height, girth at breast height (gbh) and clear bole height (cbh) of comparison trees of *Gmelina arborea*

	Arunachal Pradesh			Assam			Mizoram			North-east India		
	Height (m)	Gbh (m)	Cbh (m)	Height (m)	Gbh (m)	Cbh (m)	Height (m)	Gbh (m)	Cbh (m)	Height (m)	Gbh (m)	Cbh (m)
Mean	22.40	0.92	12.50	24.41	0.95	14.12	18.95	0.79	11.40	21.29	0.89	12.67
SE	0.94	0.05	1.10	0.25	0.01	0.30	0.44	0.02	0.37	0.27	0.01	0.26
Range												
Minimum	15.00	0.65	1.00	15.00	0.64	5.00	12.00	0.56	5.00	12.00	0.56	1.00
Maximum	32.00	1.32	25.00	32.00	1.72	24.00	25.00	1.10	17.00	32.00	1.72	25.00
SD	4.78	0.17	5.59	3.03	0.16	3.36	3.39	0.13	2.78	4.04	0.17	3.90
CV (%)	21.32	18.48	44.70	12.41	16.46	25.93	17.37	16.02	24.35	16.91	18.27	27.59

SE = standard error; SD = standard deviation; CV = coefficient of variation

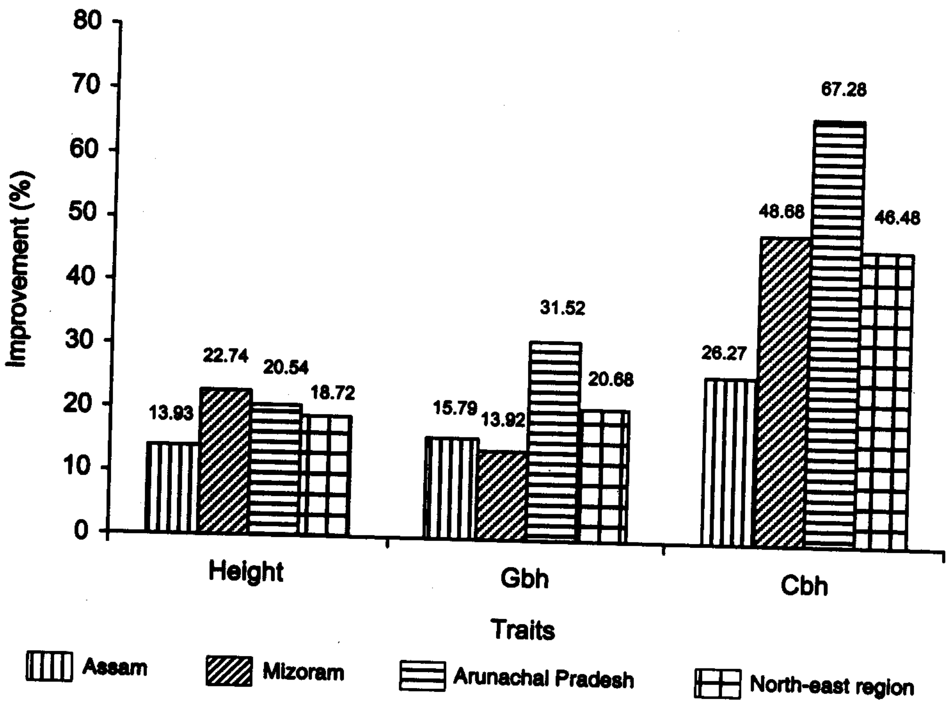

Figure 1 Per cent improvement in *Gmelina arborea* through selection of plus trees

about 600 plus trees of *Tectona grandis* on the basis of simple measurement and scoring without adopting a scientific methodology and, as a consequence, the methodology used for selection did not give scoring patterns for any traits. Thus, no inference in terms of extent of improvement over base population could be obtained. In the present study, a total of 60 plus and 238 comparison trees were selected from different locations in three states of north-east India using point grading method. The yield of a tree is influenced by many associated characteristics, and thus it is a highly complex trait to be used for selection. Moreover, selection based on a single trait may not be very effective to screen elite genotypes in many forest species (Cotterill & Dean 1986). However, selection based on yield and yield attributing characteristics results in higher expected response (Baker 1986). In multitrait selection method, each trait plays an important role and all the individuals are ranked according to one scoring system. The phenotypes selected through this methodology are expected not only to have desired qualities but will also have genetically divergent base for future genetics and breeding programmes.

In the selected phenotypes of our study, a high degree of improvement in height, gbh and cbh (18.72, 20.68 and 46.48% respectively) was achieved over the comparison trees. As the comparison trees were equally good trees selected nearby to the plus trees, the extent of improvement over seed-raised plantation would be much higher than these values. The described gain through direct selection may be used as an indicator of possible genetic gain after field testing through clonal and progeny trials. The extent of variability for all traits in question remains very high with wider genetic base, and provides further opportunities to improve this population in subsequent generations. Further, by multiplying these improved genotypes through clonal means, the genetic gain due to additive and non-additive characteristics can be exploited for immediate plantation purposes. As the success of clonal forestry depends on the base material used for multiplication, availability of exceptional clones becomes imperative. The availability of these clones, however, depends on various factors like selection criteria used, effectiveness of field testing (Zsuffa *et al.* 1993) and rejuvenation of old trees for smooth clonal propagation.

All the selected biotypes described have been established in the hedge orchard of the Institute, and coppiced for further propagation. At the time of this study, a thorough genetic and breeding programme has been designed for achieving higher genetic gains in *G. arborea* and deployment of elite genotypes in the shortest possible time. This includes rejuvenation of the old trees through repeated vegetative propagation and hedging, clonal and progeny testing. Extent of inbreeding in different clones will also be studied. Synthesising new recombinants through hybridisation of most divergent genotypes needs be taken up once genetic diversity of different clones is calculated. In the breeding strategy, secondary vegetatively rooted branch cuttings will be planted in the hedge orchard and coppiced after attaining one year of age. Field testing of these clones in different geographical locations from the secondary propagation has also been initiated to test the superiority, adaptability and stability.

Plantations raised through intensively selected and tested clonal material have many advantages over plantations raised from unknown seed source. These genetically improved plantations produce higher utilisable biomass and significantly reduce wastage during wood processing. It was reported that 50 to 400% of volume increase was achieved for redwood using intensively selected planting material compared with seed-raised plantations (Rydelius & Libby 1993). Similarly, selection and clonal deployment of eucalypts in Brazil resulted in significant improvements in many traits (Havomoller 1993). The author reported 112, 135 and 25% increment for total yield, pulp productivity and basic density respectively in eucalypt clonal plantations compared with plantations raised from seeds. It was also reported that wood from clonal material reduced wood consumption by 19% due to uniformity of material coupled with reduced wastage.

In the present investigation, all the characteristics studied, namely, height, gbh and cbh were positively correlated with the yield attributes. They also showed significant increases over comparison trees. At the time of selection of plus trees, straightness and the bole form were equally important qualitative traits and plus trees were selected with cumulative effect which include these characteristics. Plantations raised from these plus trees are expected to perform well. Nevertheless, the multilocation clonal/progeny testing is inevitable to test the adaptability and superiority of these plus trees (Kumar *et al.* 2002). Testing of clonal stock and progenies are equally important to ascertain suitability of various genotypes in various wood-based industries, as all the clones may not be uniformly useful for all end uses (Gurumurthi *et al.* 1994). In Brazil, as many as 625 of 5000 plus trees had the required standards and were suitable for different industrial purposes (Lal 1993). These plus trees were further screened and finally only 25 trees were recommended for large-scale multiplication to raise clonal plantations. Similarly in *Casuarina equisetifolia*, out of 15 high yielding clones only five were found suitable for pulp industry (Kumar *et al.* 1996). These case studies indicate the fact that although the plus trees were selected with the greatest care, superiority *per se* needs to be tested.

Conclusions

The success of a genetic improvement programme largely depends on the existence of variability in the base population which can easily be utilised through selection of proper genotypes. Hence, a selection methodology for *G. arborea* has been evolved so that significant improvements are achieved in yield and other traits of economic importance. Further, these genotypes are of immense use when multiplied through clonal technique and established in the clonal seed orchards to meet the immediate demands for seed. The wider genetic base and high variability in *G. arborea* plus trees for various traits provide further opportunities to improve the population in subsequent generations.

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