SURVIVAL, GROWTH, YIELD AND WOOD DENSITY OF THREE *PINUS PATULA* PROVENANCES AT LUSHOTO, TANZANIA

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NASSER, S.M., CHAMSHAMA, S.A.O. & IDDI, S. 1993. Survival, growth, yield and wood density of three *Pinus patula* provenances at Lushoto, Tanzania. A *Pinus patula* provenance trial containing seeds from Rhodesia (now Zimbabwe) and Tanzania (Kigogo in Mufindi and Old Moshi in Moshi) was established at Lushoto, Tanzania in 1968 to determine provenance differences in survival, growth, yield and wood density. Data on these parameters were collected from the experimental plots in 1990 at the age of 22 years. The main results were:

- After one thinning, stocking was 54% for the Rhodesia and Kigogo provenances and 51% for the Old Moshi provenance. Before thinning, which was done at 11 *y*, the survivals were 91.3% for the Rhodesia, 96.7% for Kigogo and 94.2% for the Old Moshi provenances respectively.
- Mean height ranged from 23.1 to 23.9 *m*. The Rhodesia provenance had the highest mean height value.
- Diameter at breast height (DBH) ranged from 22.5 to 23.3 *cm*, the Rhodesia provenance again having the largest DBH.
- Standing basal area ranged from 34.26 to 38.3 $m^2\ ha^{-1}$ with the Rhodesia provenance having the highest mean basal area.
- Total volume production ranged from 452.6 to 516.6 $m^3\ ha^{-1}$ with the Rhodesia provenance having the highest total volume production.
- Basic density ranged from 389 to 423 $kg\ m^{-3}$ with Old Moshi provenance having the highest basic density value.

Statistical analysis, however, showed no significant differences between provenances in all the parameters assessed ($p = 0.05$). It is recommended that since the Kigogo and Old Moshi provenances are already being used in afforestation programmes, the Rhodesia provenance be also used as a seed source to broaden the genetic base.

Key words : *Pinus patula* - provenance - survival - growth - yield - wood density

NASSER, S.M., CHAMSHAMA, S.A.O. & IDDI, S. 1993. Kemandirian, pembesaran, hasil dan ketumpatan kayu tiga provenans *Pinus patula* di Lushoto, Tanzania. Satu ujian provenans mengandungi biji benih dari Rhodesia, Tanzania (Kigogo di Mufindi dan Old Moshi di Moshi) telah ditubuhkan di Tanzania pada 1968 untuk menentukan perbezaan provenans dalam kemandirian, pertumbuhan, hasil dan ketumpatan kayu. Data parameter-parameter tersebut dikumpulkan pada 1990 dalam usia 22 tahun. Keputusan-keputusan penting adalah:

- Setelah penjarangan pertama, penstoran adalah 54% untuk provenans Rhodesia dan Kigogo dan 51% untuk provenans Old Moshi. Sebelum penjarangan dijalankan pada usia 11 tahun, kemandirian provenans-provenans

Seedlings were raised at the Silviculture Research Station, Lushoto, using standard cultural techniques (Forest Division 1982).

Experimental design

The experiment was laid out in randomized complete block design with three treatments (the provenances) and six replications. Each plot had 49 trees planted at spacing of 2.4 × 2.4 *m*. The inner 25 trees form a sample plot.

Field procedures

The site was prepared by complete clearing of all vegetation in the area, followed by stacking and pitting. Pit size was 30 × 30 *cm*. Planting was done on 4th April 1968. Only one pruning was carried out at the end of March 1972 where trees were pruned to half height. Thinning was done in 1979, removing 18 trees in each plot. According to Technical Order No.24 of 1970, thinning should have been done in 1977, 1981, 1985 and 1989 (Forest Division 1982).

Data collection

In February 1990, data were collected on diameter, height and wood basic density. Data on previous assessments of survival, diameter, height and volume were obtained from files at the Silviculture Research Station, Lushoto.

All trees remaining after thinning (excluding the surrounds) in all treatments and replications were measured for diameter at breast height using a diameter tape. The diameter tally also gave survival data.

The height of the two largest trees (dominant height) and heights of four other trees representing the diameter range in a plot were measured using a Suunto hypsometer.

Four trees representing the diameter range in a plot were sampled per plot for basic density measurement. Only straight trees with no obvious defects were sampled. Potential sample trees with obvious defects were not taken and instead, the nearest tree with the same diameter class was sampled. One increment core was taken at breast height from each sampled tree using an increment borer. Successive trees were bored at right angles in order to minimize any possible effect of compass direction on wood density. The cores were stored in polythene bags and sterilized with 95% alcohol to prevent biodegradation while awaiting further treatment.

In the laboratory, each core was measured for length and divided into three equal parts representing inner core, middle core and outer core wood. After cutting, the core sections were soaked in distilled water for at least 24 *h* to regain green condition. The green volume of each section was measured by water displacement.

After green volume measurements, the sections were dried in the oven at 103 ± 2 C° to constant weight. They were then transferred from the oven and kept in a desiccator over dry silica gel for about 10 *min* and weighed to obtain oven dry weight.

Data analysis

Data were analyzed for survival (%), diameter at breast height (*cm*), height (*m*), basal area per hectare ($m^2\ ha^{-1}$), volume ($m^3\ ha^{-1}$) and basic density ($kg\ m^{-3}$) using routine procedures. Volume of individual trees was obtained using standard volume tables for the species (Ackhurst & Micksi 1971). Basic density was calculated as sample oven dry weight divided by sample saturated volume. The tree basic density value was obtained as arithmetic mean of the sections. Provenance values were calculated as means of all trees.

Analysis of variance was done on survival, diameter at breast height, basal area, volume and basic density. For all parameters, block means were used. Arc sine transformation of percentage values was done before analysis of variance.

Table 2. Survival trends and stocking after thinning of three provenances of *Pinus patula* at Lushoto, Tanzania, at various ages after planting

	Survival %						Stocking after thinning %		
Age (*y*)	1	2	3	4	6	10	15	20	22
Rhodesia (A)	98.0	96.6	94.0	94.0	92.0	91.3	54.0	54.0	54.0
Kigogo (B)	100.0	98.6	98.7	98.0	97.0	96.7	56.7	55.3	54.0
Old Moshi (C)	99.0	98.6	96.7	94.7	94.7	94.7	54.7	52.7	51.3

Results and discussion

Survival, growth and yield

Survival trends of the provenances are shown in Table 2. Statistical analysis showed that there was no significant difference between provenances at all assessment occasions.

Survival assessment carried out one year before thinning (age 10 *y*) showed high survival, exceeding 90% for all provenances. The high survival of the provenances at Lushoto is comparable to reports in the literature (Burley & Nikles 1972). As an exotic, *P. patula* generally shows high survival when planted on suitable sites. However, clean weeding is necessary as the species is sensitive to weed competition (Wormald 1975).

Mean heights, mean diameter at breast height, mean basal area and total volume production of the three *Pinus patula* provenances are shown in Table 3. For all the parameters and at all assessment occasions, statistical analysis did not reveal any significant differences between provenances. Except for breast height diameter, values for the other parameters are comparable to those indicated in the yield tables for an average site (dominant height of 24 *m* at 20 *y*) (Wormald 1975, Adegbehin & Philip 1979). Breast height diameters at 20-22 *y* of age are lower than those indicated

Table 3. Breast height diameter, mean height, standing basal area and total volume production of three *Pinus patula* provenances at Lushoto, Tanzania

Trait	Provenance	Age after planting (*y*)						
		3	4	6	10	15	20	22
Breast height diameter, DBH *(cm)*	Rhodesia	7.8	10.6	14.0	14.7	–	22.8	23.3
	Kigogo	7.3	10.0	13.0	16.3	–	22.6	23.1
	Old Moshi	7.6	10.2	13.4	16.3	–	22.2	22.5
Mean height *(m)*	Rhodesia	5.2	6.7	9.5	–	19.4	23.2	23.9
	Kigogo	5.2	6.7	9.6	–	19.2	21.0	23.5
	Old Moshi	5.3	6.9	9.9	–	19.3	23.3	23.6
Standing basal area $(m^2\ ha^{-1})$	Rhodesia	48.3	–	–	33.7	–	34.9	38.3
	Kigogo	42.3	–	–	31.7	–	35.0	37.4
	Old Moshi	44.8	–	–	30.8	–	31.8	34.3
Total volume production $(m^3\ ha^{-1})$	Rhodesia	–	–	134.0	–	–	–	516.6
	Kigogo	–	–	124.0	–	–	–	479.7
	Old Moshi	–	–	130.0	–	–	–	452.6

in the yield tables. This is not unexpected, as the experiment received only one thinning instead of four.

Wood basic density

The basic density values of wood of 22-*y*- old *P. patula* provenances are presented in Table 4. Overall, the Old Moshi provenance had the highest basic density of 423 $kg\ m^3$, and the least is 389 $kg\ m^3$ for the Rhodesia provenance. However, statistical analysis showed that there was no significant difference in wood basic density between provenances ($p = 0.05$). As stated by Zobel and van Buijtenen (1989), "the

Table 4. Wood basic density of three *Pinus patula* provenances at Lushoto, Tanzania

Provenance	Basic density $kg\ m^{-3}$		
	Range	Mean	sd
Rhodesia (A)	387–445	415	26
Kigogo (B)	348–415	389	26
Old Moshi (C)	367–449	423	31

usual observation is that tree to tree variation in wood properties is greater than that resulting from provenance differences". Hence the lack of significant difference in basic density is not surprising, but may still be a potential in selecting individuals with a high wood basic density as a base for further breeding. The basic density values obtained in this study are within the ranges reported in the literature for *Pinus patula* grown in Eastern and Southern Africa (Wormald 1975, Lema *et al.* 1979, Ringo & Klem 1980, Banda & Ringo 1984).

Conclusions and recommendations

The assessment of performance of three provenances, Rhodesia, Kigogo and Old Moshi in a provenance trial at Lushoto in terms of survival, DBH, basal area, standing and total volume production and basic density showed that there were no significant differences between the provenances. As both the Kigogo and Old Moshi provenances are already used in afforestation, it is recommended that the Rhodesia provenance also be used as a seed source as a way of broadening the genetic base.

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