Comparative growth of *Pinus taeda* and *Pinus patula* in Penhalonga, Zimbabwe.

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Abstract

Growth and yield comparisons of *P. patula* (Patula pine) and *P. taeda* (Loblolly pine) commonly grown on Zimbabwean plantations were carried out on four sites in Penhalonga. Measurements were done in observation sites at 10, 15, and 20 years where mean height, DBH and dominant height were obtained with the subsequent calculation of volumes. Results indicated that growth of the Pine species significantly ($P < 0.05$) varied by site and species. However volume productivity at 20 years did not differ significantly ($P>0.05$). It was concluded that site productivity was masked by silvicultural interventions as well as species tolerance limits within a narrow environmental range. The study recommends that the two species under comparison can effectively be grown in the study area to sustain the timber industry.

Keywords: Diameter at breast height, Mean height, Site productivity, Dominant height

Introduction

Growth information is of paramount importance to the commercial timber industry for sustainable timber production and informed decision-making. The prediction of plantation growth is necessary for estimating yield on particular sites and comparing yield and growth of exotic tree crops under different management regimes and silvicultural practices. The use of growth performance characteristics together with appropriate economic analysis tools enables forest managers to make sound decisions on optimum harvesting ages, planting densities, timing of thinnings and other management interventions (Clutter et al., 1983). This is not only critical in the estimation of sustainable yield of timber resources but more importantly in directing the planning of sustainable forest management and utilization (Hangula, 1999).

Pine plantations located in the Eastern Highlands of Zimbabwe, occupy an area of 80 989 hectares which constitute 68% of the commercial timber plantation area
and only 0.19% of the total country area (TPF, 1999). This is expected to meet timber product requirements of a population of approximately 12 million. Most pine species are grown on a saw-log regime with just 10% grown primarily for pulpwood (Crockford, 1995). The generalized mean annual increment (MAI) for the pines ranges from 16 to 26 m^3/ha/annum (TPF, 1999).

Pinus taeda and *Pinus patula* are the most commercially important softwoods in the country followed by *Pinus elliotii* and *Pinus kesiya. Pinus patula*, a native of the Mexican Highlands (Crockford, 1995), was introduced in Zimbabwe's Eastern Highlands in 1919 but is now grown in other provinces (Troup, 1932; Mitchell, 1967; Barret and Mullin, 1968; Crockford, 1995). *Pinus taeda* is a native of the southeastern part of the United States, where it is a leading commercial timber (Fowells, 1965; Hunt, 1967).

However, these introduced species have only been grown over one or two rotations with limited site-specific monitoring of growth and yield. Growth data obtained through regular recordings assist in the derivation of growth and yield models. This study therefore seeks to determine the growth performance and yield of the species on the different sites where they have been established since site-specific research tends to provide more relevant information than models developed for much larger areas (Bredenkamp, 1997).

Materials and Methods

Site description

The study was carried out in Penhalonga (32.40E,

18.52S) on four observation sites, namely Lambton, Sheba, Harrisville and Epsom. The environmental characteristics of the sites are shown in Table 1.

Mean daily temperatures are 15°C during winter and 21°C in summer. Humid summers alternate with cold winters with incidences of frost and frequent mist. Soil pH values range from 5 to 5.5 mainly as a result of leaching.

Tree establishment and management

Tree establishment on the observation sites was done in 1981, 1986 and 1991 and measurements were taken in 2001 when the trees were 20, 15, and 10 years of age respectively. The planting espacement was 2.4 m x 2.4 m giving a stocking of 1736 stems/ha. The species were on such a silvicultural prescription that by 10 years, both species had their first and second thinnings executed, reducing them to 450 stems/ha, then to 300 stems/ha by 15 years following third thinnings, and finally to 250 stems/ha by 20 years after the final thinning prescription.

Measurements

In 2001, an inventory was carried out to ascertain growth and yield. The data were collected from plots measuring 0.04 hectares per age group and species at 3 % sampling intensity. Growth variables measured were, mean height (Ht), diameter at breast height (DBH) and volume (V), and dominant height (H_{dom}) to determine site productivity. Tree height was measured to the nearest metre using a Suunto hypsometer and DBH by a diameter tape to the nearest centimetre. Yield calculation was done using volume tables.

Data analysis

Data were statistically analysed using SPSS 10, for Windows 1996. Species and site variations were tested for significance among treatments in one-way ANOVA. Differences between means were tested using LSD post-hoc tests with a level of significance $P<0.05$. The following model was used:

$$Y_{ijkl} = \mu + S_i + P_j + (SxP)_{ij} + e_{ijkl}$$

Where ø is the population mean; s, the site; p, the species; i, the DBH; j the mean height; k the H_{dom} ; l, the volume and e the random error.

Results

DBH performance

Site comparison

At 15 years, *P. patula* recorded a higher (P=0.009) mean DBH at Lambton compared to Sheba only. At 20 years, Sheba had a higher DBH than Lambton (P=0.001) and Harrisville (P=0.005). At 10 years, *P.taeda* at Sheba had a higher DBH than at Lambton (P=0.003) and Epsom (P=0.001). The Harrisville observation site recorded a higher (P=0.022) mean DBH in comparison to Epsom. At 20 years, Epsom showed a significantly higher (P=0.034) DBH than Sheba.

Species comparison

A comparison of DBH performance at 10 years, indicated *P. patula* (21.77 cm) superior (P=0.032) to *P. taeda* (19.44 cm). However, at 15 years, *P. taeda* (30.11 cm) outperformed (P=0.001) *P. patula* (23.08 cm). Interactions of species and site indicated that at Epsom, *P.patula* (22.25 cm) was superior (P=0.003) to *P.taeda* (15.10 cm) at 10 years, and at Harrisville *P.taeda* (32.77 cm) was superior (P=0.001) to *P.patula* (22.93 cm) at 15 years. At Sheba, *P.patula* (33.95 cm) was superior (P=0.03) to *P.taeda* (28.87 cm) at 20 years. Results for the measured parameters are shown in Table 2.

Dominant height

Site Comparison

At 10 and 20 years, site variability did not influence ($P > 0.05$) the growth of *P. patula*. However, at 15 years, Lambton appeared more productive (P=0.033) in comparison with Sheba. For *P. taeda* at 10 years, Lambton proved more productive (P=0.013) in comparison to Sheba. At 15 years, Sheba was inferior (P=0.019) to Harrisville.

Table 1: Environmental characteristics of the four study sites.

Research site	Mean annual precipitation (mm)	Altitude (m)	Geology	Effective rooting depth (cm)
Lambton	1623	1740	Dolerite, granite	>70
Harrisville	1640	1720	Granite	>70
Epsom	1605	1700	Dolerite, granite	>70
Sheba	2073	1700	Granite	<70

Table 2. Growth and yield indicators by site and species.

Site	Species	Age (Yrs)	Mean DBH (cm)±SE	Mean dominant height (m)± SE	Mean height (m)±SE	Mean volume (m^3)±SE
Lambton	**P. patula**	10	20.51±0.85	18.59±0.75	17.28±0.83	168.5±8.42
		15	25.20±0.46	29.83±0.69	26.25±0.47	206.9±34.4
		20	27.90±0.34	28.88±0.73	27.60±2.14	425.0±21.9
	P. taeda	10	17.10±1.51	19.94±1.00	15.06±0.70	150.2±12.8
Harrisville	*P. patula*	10	22.43±0.97	20.03±0.96	19.18±0.99	166.0±12.0
		15	22.93±0.40	27.38±0.71	24.23±0.43	273.5±53.8
		20	31.33±0.47	28.88±0.99	28.28±1.07	311.8±16.9
	P. taeda	10	21.60±1.70	18.15±1.25	16.85±0.65	177.5±4.50
		15	32.77±0.52	23.73±0.39	23.50±0.36	277.3±23.9
		20	31.45±0.34	24.90±0.86	24.08±0.40	305.9±35.0
Epsom	*P. patula*	10	22.25±0.49	21.08±2.29	19.98±2.71	189.5±29.6
		15	23.60±1.31	27.27±2.13	23.40±0.74	222.9±22.1
	P. taeda	10	15.10±1.37	21.10±1.15	15.27±1.20	128.3±25.3
		15	28.90±2.40	21.15±1.65	20.20±2.10	219.5±19.5
Sheba	*P. patula*	10	21.88±2.37	18.33±1.89	17.38±1.86	157.8±29.2
		15	20.60±1.70	24.30±3.10	22.85±1.85	238.4±43.1
		20	33.95±0.45	25.85±2.35	25.10±2.80	265.4±30.9
	P. taeda	10	23.98±0.69	16.28±0.36	15.78±0.34	134.8±5.66
		15	28.68±2.82	20.65±0.53	19.65±0.45	225.7±11.9
		20	28.87±0.98	23.17±0.72	22.87±0.67	250.3±64.8
Significance	Site		***	***	***	***
	Species		***	***	***	ns
	SitexSpecies		***	* *	**	ns

** significant at 0.01, *** significant at 0.001 and ns, not significant

Species comparison

A comparison between the two species at 15 years, showed *P. patula* (27.19 m) to be more responsive to site (P=0.001) compared to *P. taeda* (21.84 m) across all sites. Consistently, at 20 years, *P. patula* (27.87 m) performed better (P=0.005) than *P. Taeda* (24.70 m). The interactionof site and species indicated that at the age of 15, *P.patula* (27.38 m) was more responsive to site (P=0.01) compared to *P.taeda* (23.73 m) as well as at 20 years (P=0.023) with 27.88 m and 24.90 m for *P.patula* and *P.taeda* respectively at Harrisville.

Mean height

Site comparison

At Lambton, *P. patula* had significantly taller trees than at Epsom (P=0.018) and Sheba (P=0.014) at 15 years. *P.taeda* at Harrisville recorded taller trees than at Epsom (P=0.014) and Sheba (P=0.012).

Species comparison

Species mean height comparison across the sites indicated that *P. patula* consistently outperformed *P. taeda* at 10 years (P=0.008) with a mean height of 18.45 m against 15.74 m, and at 15 years (P=0.001) with 24.18 m against 21.12 m and finally at 20 years (P=0.004) with 26.99m against 23.87 m. The interaction of site and species at 20years showed

that *P.patula* (28.28 m) was more superior (P=0.01) to *P.taeda* (24.08 m) at Harrisville.

Volume

At 20 years, *P. patula*, at Lambton had the highest volume compared to Harrisville (P=0.003) and Sheba (P=0.001). No significant difference was observed between species.

Discussion

Monitoring the growth of introduced species viable on a narrow ecological range is essential to strategically supply timber to the nation and for export. Sustainable timber production can only be achieved once the exotic species adapt themselves to the site and produce meaningful yields under prescribed silvicultural treatments. Growth trends indicated the superiority of *P. patula* to *P. taeda* at all ages (Mullin et al., 1978, Crockford, 1995). *P. taeda* is regarded as the most site demanding of all the summer-rainfall pines (Schutz, 1994, Bredenkamp, 1997). This explains its inferiority to *P. patula* which is less site demanding on the highveld (Van der Sijde, 1994) and typical of the study area. *P.patula* is the most widely planted of all the pines throughout summer rainfall areas of South Africa mainly due to its environmental elasticity and growth vigour (Schutz, 1994).

Site productivity is overshadowed by the selective removal of poorly performing individuals subjecting the best trees to comparison. These thinnings are not merely based on systematically removing trees in a specific spatial sequence that would bring about uniformity across the sites but on allocating the production to some optimum number of trees of highest potentiality to increase in value (Smith et al., 1997). In this case damaged, deformed and decaying trees even if they have substantial volumes are selectively removed during the process of thinning to salvage anticipated losses of merchantable volume (Harrington, 2001). This is further complicated by the elasticity of the species such that the little site variability cannot easily be detected. However, *P.patula* at 15 years and *P.taeda* at 10 years seem to indicate the highest productivity to be skewed towards Lambton. The volume further confirms this at 20 years where Lambton significantly surpasses the volumes produced at Harrisville and Sheba.

Conclusions

Site variability for species that have a high plasticity within a narrow range is difficult to detect especially where silvicultural interventions are intensive. Consistent with the results, the two species under comparison can effectively be grown to sustain the timber industry.

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