RESULTS OF MICROPULPING WOOD SAMPLES OF SEVEN PINE HYBRID FAMILIES IN ZULULAND

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Abstract.--Micropulping of increment cores was used to assess families of *Pinus elliottii* Engelm., *P. caribaea* var. *bahamensis* Barr. and Golf. and hybrids of P. *elliottii* crossed with P. *caribaea* var. *hondurensis* Barr. and Golf. and P. *cubensis* Griseb. growing in Zululand, South Africa. Families were significantly different for screened pulp yield(%), total pulp yield(%), stretch(%), tear index, bulk specific and tensile energy absorbed. The high tear index and superior volume production of two families of the hybrid between P. *elliottii* and P. *caribaea* var. *hondurensis* relative to P. *elliottii* indicates the potential of these hybrids for sites similar to the one evaluated here.

The hybrid between *Pinus elliottii* Engelm. and P. *caribaea* var. *hondurensis* Barr. and Golf. has certain advantages relative to the parent species for a range of soil and climatic conditions. On swampy sites in Queensland, Australia, the hybrid has exhibited better growth than P. *elliottii* as well as superior stem quality and wind resistance when compared to P. *caribaea* var. *hondurensis* (Slee, 1969;1971). It was decided by the Queensland Forestry Department in 1985, to use seedlings of the hybrid for routine planting on swampy sites (Nikles et al., 1987).

In South Africa, the development of this hybrid was undertaken to combine the rapid growth of P. *caribaea* var. *hondurensis* with the superior stem form and higher wood density of P. *elliottii*. A trial of numerous pine species and hybrids was established by the South African Forestry Research Institute (SAFRI) on a uniform site in 1970, at the Futululu Forestry Research Station, Zululand. The trial was measured in 1984 at an age of 13.5 years and the four families of P. *elliottii* crossed with P. *caribaea* var. *hondurensis* were found to have twice the mean annual increment (M.A.I.) of P. *elliottii* families (van der Sijde and Roelofsen, 1986).

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The wood quality of these hybrids is of considerable interest in South Africa since at least one industrial organization will purchase only small quantities of P. caribaea Mor. due to the inferior paper resulting from wood of that species. A comparison of the wood, pulp and papermaking traits of P. elliottii and hybrid families from the Futululu trial was undertaken by Du Plooy (1984). He concluded that high density trees of the hybrid families were comparable to trees from families of P. elliottii for pulp yield and all of the paper strength traits except tearing strength. That study did not maintain family or tree identity and hence no superior genotypes with regard to pulp and papermaking traits could be identified.

METHODS

The families chosen for micropulping in the SAFRI trial at Futululu were selected for volume at the 1984 assessment when they were 13.5 years old (Table 1). Represented in this study are four families of the P. elliottii by P. caribaea var. hondurensis hybrid as well as single families of P. elliottii, P. caribaea var. bahamensis Barr. and Golf. and the hybrid between P. elliottii and P. cubensis Griseb. The trial is at a latitude of 28°21'S and an altitude of 70m. The trial design was a randomized complete block with four replications using row plots of ten trees at a square spacing of 2.7m. The trees had been pruned to 5m in three stages and a 40% silvicultural thinning was undertaken at the age of 10 years by the removal of four trees per row (van der Sijde and Roelofsen, 1986). In each replication, the largest diameter tree in the selected families was sampled by removing seven increment cores of 12mm diameter at about breast height (1.3m). This sampling took place in June, 1985, at the age of 14.75 years and a total of 28 trees were thus sampled for micropulping at Sappi's Enstra research centre[1]. The micropulping technique has been previously used by Sappi to assess trees of fast-growing tropical pines in South Africa (Wright, 1987a,b).

Table 1.--Sample identification for micropulping.

Family	Source (sample numbers)	Volume/tree at 13.5 years (m^3)	M.A.I. at 13.5 years(m^3/ha)
E1XC5	hybrid(95-98)	0.434	24.8
E503XC23	hybrid(99-102)	0.382	21.8
E38XC6	hybrid(87-90)	0.370	21.2
E1XC23	hybrid(91-94)	0.360	20.6
E1XCUB14	hybrid(83-86)	0.294	16.8
AND	P. caribaea var. bahamensis-Andros, Bahamas(79-82)	0.275	15.7
E49XM	poly-cross(75-78)	0.179	10.2

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The increment cores were chipped into small segments and placed in a controlled temperature and humidity room where they were allowed to come to a moisture content of approximately 10.5%. A kraft cook was used and the cooking conditions are listed in Table 2. The pulp was beaten for 15,000 revolutions in a Lampen beater. Hand sheets were made using the Frank Sheet Machine and were conditioned to constant temperature and humidity prior to sheet testing. The micropulping procedures used at Enstra are similar to those developed by Mr. E.R. Palmer at the Tropical Development and Research Institute, London, and require a minimum of 65g of air dried wood.

The pulp and papermaking traits were analyzed using analysis of variance (ANOVA) with families as fixed effects. Sampling the largest diameter tree in each family was considered to be an observation rather than a replication and this source was a random effect. Differences between families and trees were compared at the 5% level using the Q statistic as described by Chew (1977). The amount of pulp from one tree of family E38XC6 was insuffcent for beating in the Lampen beater and the degrees of freedom in the residual term have consequently been reduced for certain traits.

Table 2. Cooking conditions.

Maximum temperature (°C)	170
Time to 170°C (minutes)	110
Time at 170°C (minutes)	60
Liquor to oven dry wood ratio	5.4:1
Active alkali as Na_2S % of oven dry wood	22

RESULTS AND DISCUSSION

The results of the ANOVA are contained in Table 3. The most important kraft pulp and papermaking traits for Sappi are burst index, tear index and total pulp yield(%). Family means of these traits as well as M.A.I. values are presented in Figure 1. The values of these pulp and papermaking traits for individual trees are given in Figure 2 as are family means of M.A.I.

Families were significantly different ($p<0.05$) for screened pulp yield(%), total pulp yield(%), stretch(%), tear index, bulk specific and tensile energy absorbed (T.E.A.). The high probability (p) values for family differences in all of the traits except wetness and Canadian standard freeness (C.S.F.) would suggest superior families could be selected for papermaking properties. However, no individual family was found to be above the trial mean for all of the traits presented in Figure 1.

It is interesting that the families E1XCUB14 and E38XC6 rank first and last for burst index, respectively, but the ranking is reversed for tear index. This indicates the likely difficulty in attempting to improve these two traits simultaneously. It should

Table 3.--ANOVA of micropulping results from seven pine hybrid families in Zululand, South Africa.

Trait	Source	df	Mean square	(p value)
Kappa no.	Observations	3	12.56	
	Families	6	14.97	(p=0.074)
	Residual	18	6.36	
Screened yield(%)	Observations	3	18.17	
	Families	6	43.97	(p=0.009)
	Residual	18	10.65	
Reject yield(%)	Observations	3	7.84	
	Families	6	3.01	(p=0.207)
	Residual	18	1.89	
Total yield(%)	Observations	3	6.60	
	Families	6	54.03	(p=0.005)
	Residual	18	11.51	
Spent liquor(AA)	Observations	3	0.05	
	Families	6	1.69	(p=0.184)
	Residual	18	1.01	
Spent liquor(NA)	Observations	3	0.82	
	Families	6	2.26	(p=0.244)
	Residual	18	1.54	
Total solids(%)	Observations	3	0.04	
	Families	6	0.54	(p=0.150)
	Residual	18	0.29	
Wetness	Observations	3	12.79	
	Families	6	5.35	(p=0.851)
	Residual	17(1)	12.55	
C.S.F.	Observations	3	6.33×10^3	
	Families	6	1.36×10^3	(p=0.907)
	Residual	17(1)	4.01×10^3	
Stretch(%)	Observations	3	0.04	
	Families	6	0.37	(p<0.001)
	Residual	17(1)	0.05	
Breaking length	Observations	3	2.76×10^5	
	Families	6	6.29×10^5	(p=0.126)
	Residual	17(1)	3.18×10^5	
Burst index	Observations	3	0.17	
	Families	6	0.35	(p=0.132)
	Residual	17(1)	0.18	
Tear index	Observations	3	0.20	
	Families	6	3.12	(p=0.006)
	Residual	17(1)	0.67	
Bulk specific	Observations	3	1.14×10^{-3}	
	Families	6	7.58×10^{-3}	(p=0.003)
	Residual	17(1)	1.44×10^{-3}	
Porosity	Observations	3	2.23×10^6	
	Families	6	4.53×10^6	(p=0.129)
	Residual	17(1)	2.32×10^6	
T.E.A.	Observations	3	2.02×10^3	
	Families	6	5.98×10^3	(p=0.001)
	Residual	17(1)	9.34×10^3	

be noted, however, that family E38XC6 had almost twice the M.A.I. and was also superior for tear index and total pulp yield(%) to the P. elliottii family E49XM. The most commonly planted conifer in Zululand is currently P. elliottii. The high tear index and M.A.I. of the hybrid families E38XC6 and E1XC23 would suggest that they be included in future afforestation programs. There were no individual trees which were ranked above the mean for all of the papermaking traits presented in Figure 2. One tree from each of family E38XC6 and E1XC23 was ranked above the mean for tear index and total pulp yield(%) and was only slightly below the mean for burst index.

CONCLUSIONS

The use of gravimetric density may not be a satisfactory method of assessing wood quality since trees with high wood density may have reduced breaking length and burst index relative to trees with lower density (Barefoot et al., 1972;Burley and Palmer, 1979;Wright, 1987b). Micropulping can be used to sample individual trees non-destructively for their papermaking properties. The use of micropulping to determine superior phenotypes for pulp and papermaking traits is being used by two organizations (Sappi and Aracruz in Brazil) to indicate those trees which should be included in seed orchards and/or used for the production of vegetative propagules. For the pines, we do not have heritability values for the pulp and papermaking traits and these are urgently needed before the onset of breeding activities. However, it is expected that selection and silvicultural management can significantly increase the quantity and quality of the kraft paper produced from these plantations.

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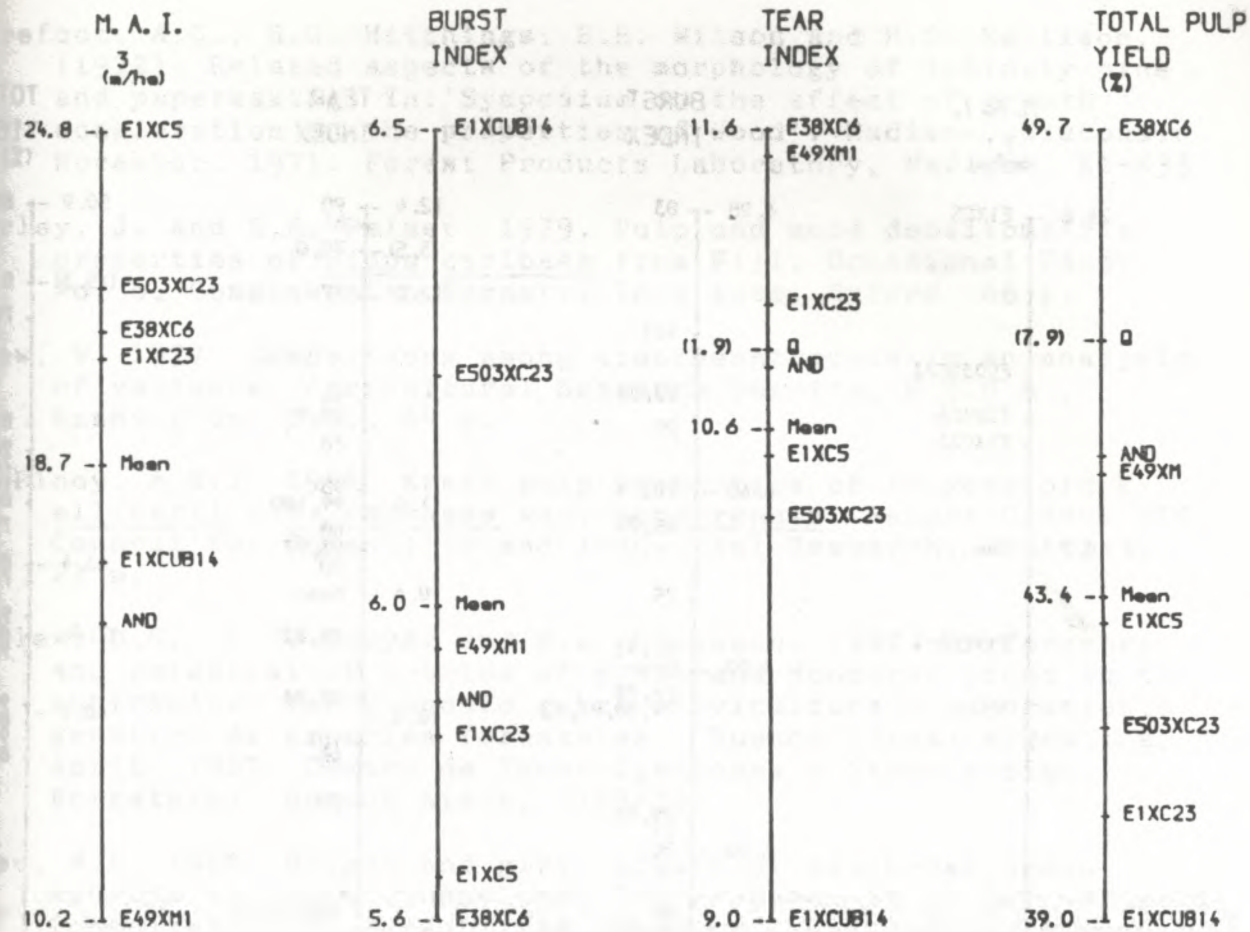
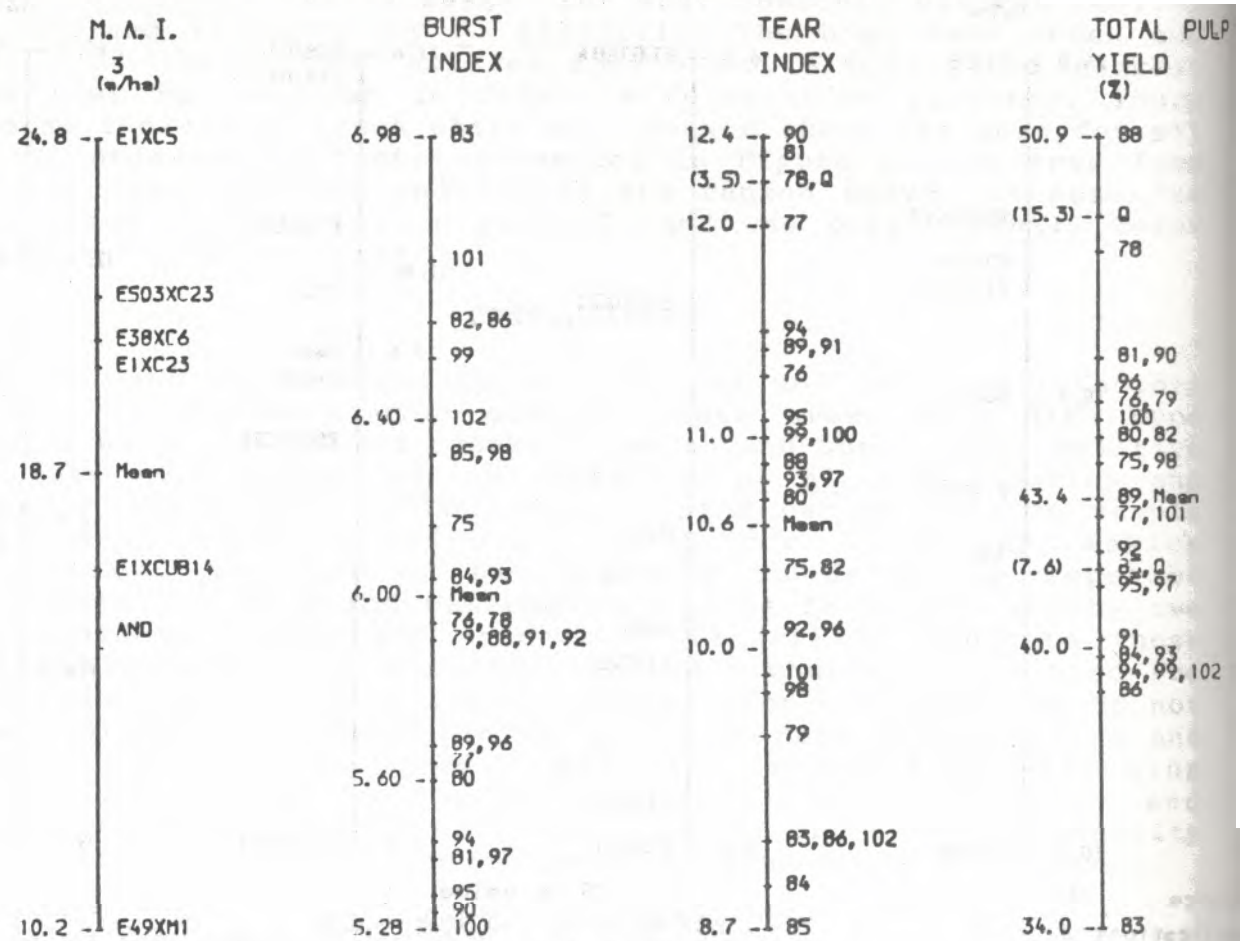


Source	df		MS (p value)		
Replications	3	-	0.17	0.20	6.60
Family	6	-	0.35 (p=0.132)	3.12 (p=0.006)	54.03 (p=0.005)
Residual	17 (1)	-	0.18	0.67	11.51
s.e. family		-	0.21	0.41	1.70

FIGURE 1. Analysis of varalance, ranked means and the critical difference, (p-.0. 05) , for M. A. I. , burst index, tear Index and total pulp yield (%) of seven pine families in Zululand, South Africa.



Source	df		MS (p value)		
Family	6	-	0.35 (p=0.119)	3.12 (p=0.003)	54.03 (p=0.003
Residual	20 (1)	-	0.18	0.60	10.81
s.e. tree		-	0.42	0.77	3.29

FIGURE 2. Analysis of varlance, individual tree means and the critical difference (p .0. 05) , for M. A. I. , burst index, tear Index and total pulp yield (%) of seven pine families in Zululand, South Africa.

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