IPEF INTERNATIONAL, Piracicaba (2): 1 – 9, 1992

POTENTIAL FOR BREEDING PROGRAMMES, GENETIC PARAMETERS ESTIMATES AND PROGENIES X ENVIRONMENT INTERACTION IN *Eucalyptus urophylla* S.T. BLAKE POPULATIONS

PAULO EDUARDO TELLES DOS SANTOS
CARLOS HENRIQUE GARCIA
IPEF – Caixa Postal 530
13400-970

EDSON SEIZO MORI
UNESP – Caixa Postal 237
18603-970 – Botucatu – SP

MÁRIO LUIZ TEIXEIRA DE MORAES
UNESP – Depto. de Agricultura
15378-000 – Ilha Solteira – SP

ABSTRACT – Open pollinated progenies of *Eucalyptus urophylla* S.T. Blake, arising from harvests carried out in natural stands in the original areas of its distribution, were studied in respect of growth traits (DBH, height and volume) in two environmental conditions, near Linhares, ES (19°22'S and 40°04'W) and Grão Mogol, MG (16°34'S and 42°54'W), In areas belonging to Florestas Rio Doce Company. The main objectives of this paper were to evaluate the potential of these sources, gathered as provenance/progenies trials for Flores is., Timor is. and Other Islands (Lomblem, Alor, Adonara and Pantar) to estimate the genetic parameters and to analyse the effects of genotype x environment interaction, giving data for the development ar a genetic improvement programme. In Linhares, ES, the productivities obtained for all sources, in terms of volume (m^3/ha), were superior than those ones found in Grão Mogol, MG. The land races (controls) were superior to the sources introduced in most comparisons, showing the benefits of adaptation for the productivity increase. The individual variance analysis showed through F - test for provenances results highly significants in both sites for most comparisons. The joint variance analysis showed F values for the Interaction genotype x environment being highly significant for DBH and height for Flores and Timor sources and for volume for Flores and Other Islands sources. For genetic parameters estimates, the medium values for heritability coefficients obtained (at restricted level for Individual plants) in general followed the same tendency, that is, being greater for height (0.34 for Flores, 0.61 for Timor and 0.50 for Other Islands) and exhibiting the same magnitude for DBH (0.25 for Flores, 0.59 for Timor and 0.43 for Other Islands) and volume (0.26 for Flores, 0.49 for Timor and 0.44 for Other Islands). These coefficients were in general higher than those obtained for joint analysis, reflecting the influence ar effects related to genotype x environment interaction. The results showed that there were losses of 11.14% up to 45.28% in genetic gains caused by these effects. The potential of these sources for genetic improvement program is very large because of the high genetic variability available for the breeder. Nevertheless, the identity of the sources must be maintained (Flores is., Timor is. and Other Islands), because there are genetic differences among them, reflecting that the breeding programmes must be conducted separately. The strategy for *Eucalyptus urophylla* breeding in Linhares, ES and Grão Mogol, MG is the multiple populations scheme.

RESUMO - Progênies de polinização livre de **Eucalyptus urophylla** S. T. Blake, oriundas de coletas efetuadas em populações naturais existentes nas regiões de origem da espécie,

foram estudadas em relação às características de crescimento (DAP, altura e volume real com casca) em duas condições ambientais, próximas aos municípios de Linhares - ES e Grão Mogol - MG, em áreas pertencentes à empresa Florestas Rio Doce S.A.. O presente estudo teve como objetivos principais analisar o potencial desses materiais, reunidos na forma de testes de procedências/progênies para Ilha Flores, Ilha Timor e Outras Ilhas (Lomblem, Adonara, Alor e Pantar), estimar os parâmetros genéticos e analisar os efeitos da interação progênies x locais, visando fornecer subsídios para o desenvolvimento de um programa de melhoramento genético. Na localidade de Linhares - ES, a produtividade média de todos os materiais em avaliação em termos de volume real com casca em m^3/ha foi bastante superior em comparação com a localidade de Grão Mogol - MG. As raças locais (testemunhas) foram superiores ao material introduzido na maioria das comparações, evidenciando os benefícios da adaptação para o aumento da produtividade da floresta. As análises de variância individuais mostraram pelo Teste F para procedências resultados altamente significativos nas duas localidades para a maioria das situações. As análises de variância conjuntas apresentaram valores de F para interação progênies x locais como sendo altamente significativos para DAP e altura no material de Flores e Timor e para volume no material de Flores e Outras Ilhas. Na estimativa de parâmetros genéticos, os valores médios obtidos nas análises individuais para os coeficientes de herdabilidade no sentido restrito a nível de plantas seguiram em geral uma mesma tendência, ou seja, serem maiores para a característica altura (0.34 para Flores, 0.61 para Timor e 0.50 para Outras Ilhas) e da mesma ordem para DAP (0.25 para Flores, 0.59 para Timor e 0.43 para Outras Ilhas) e volume (0.26 para Flores, 0.49 para Timor e 0.44 para Outras Ilhas). Esses coeficientes foram também em geral superiores àqueles obtidos a partir das análises conjuntas, o que reflete a influência de efeitos devidos à interação progênies x locais. Os resultados encontrados mostraram que ocorreram perdas da ordem de 11.14% a 45.28 % nos ganhos genéticos esperados devido a esses efeitos. O potencial dos materiais para a condução de programas de melhoramento é muito grande, face à alta variabilidade genética disponível para o melhorista. Contudo, a identidade dos materiais deve ser mantida (Ilha Flores, Ilha Timor e Outras Ilhas), pois existem diferenças genéticas importantes. Sendo recomendável que os programas de melhoramento sejam conduzidos separadamente. A estratégia ideal para o melhoramento genético da espécie em Linhares -ES e Grão Mogol - MG é o esquema de múltiplas populações.

INTRODUCTION

Eucalytpus urophylla is one of the most strategical species of the genus **Eucalyptus** in Brazil, because of its potential for pulp, board, charcoal production and other uses. The large adaptation capacity to several tropical environmental conditions is other favourable attribute of the species, associated to its tolerance to **Eucalyptus** canker (**Cryponectria cubensis).**

The initial Brazilian visits to **E. urophylla** natural populations, were distributed later to various entities, constituting a series of provenances/progenies field trials.

This paper presents the growth and genetical performances obtained from two provenances/progenies trials established in two sites belonging to Florestas Rio Doce S.A., near Linhares, ES and Grão Mogol, MG cities.

LITERATURE REVIEW

E. urophylla is a tropical species that occurs spontaneously in several Islands of Sonda Archipelago. Over these Islands, the species distribution ranges from latitudes of 7°30'S to 10°00'S and longitudes of 122°00'E to 127°00'E (MARTIN & COSSALTER, 1976).

In accordance with the referred authors, the species exhibits mountainous and submountainous characteristics, occurring at altitudes ranging from 300 m (Wetar Is.) to 2960 m (Timor Is.). In natural stands regions, the mean annual rainfall ranges from 600 mm to 2500 mm, with a markedly water soil deficiency, while the mean annual temperature ranges from 14oC to 26oC. The frost occurrence is rare, taking place onl at more elevated sites of its natural distribution (MARTIN & COSSALTER, 1976).

The soils of these islands are very variable, prevailing the basaltic, xistic and sandy soils types. Calcareous soils are rare (CORBASSON & COSSALTER, 1983).

According to FERREIRA[1], **E. urophylla** is a very important economic species for humid tropical areas, and the typical tropical sources exhibits more interest. Several provenances field trials established in various tropical countries revealed a great stability. In shor, the following aspects were pointed out: 1°) The acceptable sources of Timor Is. Are from Dili, Remexio region, located at altitudes of 800m; the other Timor sources of higher altitudes are not well adapted; 2°) The best sources are from low altitudes of Flores Is.: Egon Mountain (315 – 515 m) and lewotobi Mountain (325 – 500 m); 3°) There are some good stem straightness; 4°) The Adonara Is. And Lomblem I. sources are vigorous, but exhibit a bad stem straightness, 5°) The Wetar Is. And Pantar Is. Sources exhibit a bad performance, with poor adaptation.

Despite these generalizations, while there is a progress in terms of genetic studies, it is possible to observe the occurrence of genotype x invironment interaction phenomenon. SHELBOURNE (1972) defined the genotype x environment interaction as the response variation of the genotypes to distinct environmental conditions. In turn, QUIJADA (1980) described the phenomenon as a lack of response uniformity of two on more groups of plants growed in two or more sites, making possible that one group can show a good growth in one site and exhibit a bad growth in the other.

The way we assume this troubles in a breeding programme is intimately related to the utilization and selection strategies to be applied to the genetic source available.

In literature, several procedures to analyse the genotype x environment interaction are presented. Basically according to QUIJADA (1980), there are three main methods: position on genotype classification, variance analysis and regression analysis.

In Brazil, the **E. urophylla** provenances evaluated were, in several trials, gathered in three groups: Flores Is., Timor Is. And Other Islands (Lomblem, Alor, Adonara and Pantar). The experimentation was established as provenances/progenies trials, utilizing the ´Compact Family Blocks" design, in various edaphic – climatic situations.

CAPITANI et alii (1987) reported that at age 4 years, the best sources in Belo Oriente – MG for cilyndric volume were: Egon I and lleged (Flores Is.), Lelogama (Timor Is.), Woipui and Moimang (Other Is.).

Also PINTO (1984), studying Flores Is. Sources at four locations (Aracruz, ES, Anhembi, SP; Bom Despacho, MG and Planaltina, DF), found superiority of sources lleged and Egon I for height and DBH, which are strongly correlated with volume. In respect to

[1] FERREIRA, M. – Personal comunication (1990)

genetic parameters, the author found the following medium values for heritability at restricted level for individual plants: height = 0.36, DBH = 0.24 for individual analysis and height = 0.18, DBH = 0.11 for joined analysis.

Other detailed investigation about provenances and progenies from Flores Is., MORI et alii (1988) found superiority of llegele provenance for cilyndric volume at age 7 years for most locations of experimentation: Bom Despacho, MG; Grão Mogol, MG and Belo Oriente, MG. At Aracruz – ES, this source was the second better, however, without significant statistical difference in comparison with the first positioned source. The medium heritability at restricted level for individual plants was 0.39 for height, 0.24 for DBH and 0.25 for cilyndric volume. For joined analysis these values decreased to 0.19, 0.01 and 0.05, respectively.

In other investigation, MOURA (1981) evaluated the performance of some provenances of **E. urophylla** belonging to a broad altitudinal range from the East of Timor Is. And nighbouring Islands, in several localtions of Brazilian centra – east region, under different climate and soil fertility conditions. The results permitted to conclude that, disregarding the field tirals locations, high or low altitude on soil type, the sources from low and intermediate altitudes showed a better performance for height, DBH and survival.

MATERIAL AND METHODS

The present paper was developed from experimentation carried out with open-pollinated progenies collected in natural stands of **E. urophylla** growing at Flores, Timor, Lomblem, Alor, Adonara and Pantar Islands.

The controls utilized were commercial sources of **E. urophylla** planted in Brazil, here named “land races”.

The table 1 exposes the latitude, longitude and altitude data for each population evaluated.

TABLE 1 – Latitude, longitude and altitude for the evaluated populations.

Island	Provenance	Latitude	Longitude	Altitude
FLORES	Wukoh	8.23'S	122.40'E	800m
	Llegele	840'S	122.20'E	720-850m
	Ende	8.43'S	122.40'E	1030m
	Londangwuang	8.40'S	122.20'E	890-940m
	Egon II	8.40'S	122.26'E	750-790m
	Ara Detung	8.35'S	122.30'E	700-720m
	Saler wukoh	8.23'S	122.40'E	940m
	Lewotobi	8.31'S	122.40'E	480-700m
	Llimandiri	8.18'S	122.58'E	400-850m
	Egon I	8.40'S	122.26'E	750-780m
TIMOR	Lelogana	9.42'S	123.58'E	1110m
	Timau	9.36'S	123.54'E	1100-1300m
	Debaha I	9.43'S	123.59'E	1100-1200m
	Debaha II	9.43'S	123.59'E	1100-1150m
	Fatusunam	9.43'S	123.59'E	1250m
	Nautsusu	9.42'S	124.14'E	1230m
	Kekneno	9.39'S	124.13'E	1400m
	Fatumnasi	9.39'S	124.13'E	1640m
OTHER ISLANDS	Lleape (Ilha Lomblem)	8.18'S	123.53'E	700-980m
	Woipui (Ilha Alor)	8.16'S	124.42'E	790-640m
	Moimang (Ilha Alor)	8.15'S	122.44'E	780-860m
	Waikui (Ilha Alor)	8.11'S	124.47'E	580-800m
	Raululand (Ilha Alor)	8.20'S	124.30'E	400-420m
	Wetuna (Ilha Adonara)	8.21'S	123.15'E	800-890m
	Oseama (Ilha Adonara)	8.20'S	123.16'E	750-910m
	Gulmen-Palmen (Ilha Pantar)	8.23'S	124.12'S	580m
CONT	Salesópolis – SP	23.32'S	45.51'W	860m
	Casa Branca – SP	21.46'S	47.04'W	670m
	Camaquã – SP	22.20'S	46.09'W	520m
	Linhares - ES	19.22'S	40.04'W	50m

By establishing the field trials, the provenances were gathered in three groups: Flores Is., Timor Is. And Other Is. The field trials establishment were made in two locations, totatilizing six tests.

The statistical design utilized was "Compact Family Blocks", whose plots were represented by provenance and the subplots by progenies. The scheme was as follows: three replications, rectangular plots and linear subplots containing 10 mesurable plants. The spacing adopted was 3.0 x 2.0 m.

The characteristics of the two locations are show in Table 2.

TABLE 2 – General characteristics of the two experimental locations.

Locations	Latitude	Longitude	Altitude (m)	New Anual Rainfall (mm)	Mean Anual Temp. (^{o}C)
Linhares	19.22'S	40.04'W	50	1360	23.6
Grão Mogol	16.34'S	42.54'W	850	990	20.0

The Table 3 presents the number of progenies for each provenance evaluated at each locality as well as the number of common progenies to both situations.

TABLE 3 – Number of progenies for each source evaluated at two locations and common progenies to both sites.

Island	Provenance	Progênie Number		
		Linhares	Grao Mogol	Common
FLORES	Wukoh	8	7	7
	Llegele	13	13	12
	Ende	5	4	4
	Londangwuang	16	15	15
	Egon II	12	12	12
	Ara Detung	8	8	8
	Saler wukoh	7	6	6
	Lewotobi	18	17	16
	Llimandiri	17	17	17
	Egon I	5	5	5
	TOTAL	109	104	102
TIMOR	Lelogana	10	10	9
	Timau	9	6	6
	Debaha I	6	6	5
	Debaha II	10	9	8
	Fatusunam	6	5	5
	Nautsusu	9	10	7
	Kekneno	10	10	8
	Fatumnasi	8	7	7
	TOTAL	68	63	62
OTHER ISLANDS	Lleape (Ilha Lomblem)	27	25	22
	Woipui (Ilha Alor)	10	9	9
	Moimang (Ilha Alor)	6	5	5
	Waikui (Ilha Alor)	11	11	11
	Raululand (Ilha Alor)	6	6	6
	Wetuna (Ilha Adonara)	10	10	10
	Oseama (Ilha Adonara)	12	12	12
	Gulmen-Palmen (Ilha Pantar)	5	5	5
	TOTAL	87	83	80

A few populations were used for genetic parameters determination and genotype x environment interaction studies. It were provided some groups that joined an appropriate number of sources located very close to each other and under similar environmental conditions. This way, 60 progenies from Flores, 55 from Timor and 31 from Other Islands were utilized.

Regarding this procedure, three populations were constituted, from now designed Flores, Timor and Other Is. In last case, there are just soruces from Alor Is.

The present paper was developed from data obtained at 8 years age for DBH, total height and wood volume with bark.

For volume estimation, the following equation was used for both locations (SILVA, 1977):

$$WV_{W/B} = 0.0000890184x (DBH^2 \times 1.69884 \times TH^2 \times 0.984822) \times 1.00489$$

Where: $WV_{W/B}$ = wood volume with bark
DBH = diameter at breast height
TH = total height

The statistical analysis of the trials were made in accordance with randomized complete blocks design procedures individually for each location, for all the locations and the genetic parameters estimates were based on KAGEYAMA (1983) and MORAES (1987). In statistical procedures the aleatorium model was considered.

The genetic gains estimates were calculated according to the expression:

$$Gs\% = ixVCp \times h^2$$

Where: Gs% = gain selection in percentage
I = selection diferential standard
VCp = phenotypic variation coefficient in percentage
h^2 = heritability coefficient at restricted level for individual plants.

In present paper, a selection proportion of 1:30 was applied over the population as a whole. The correspondent “i” value is 2.23.

RESULTS AND DISCUSSION

The results of variance analysis, means and experimental variation ofr each trait at both locations are shown in Table 4.

TABLE 4 – Results of variance analysis, means and experimental variation coefficients for each trait evaluated at two locations, involving all sources belonging to each Island group. Age: 8 years.

Charac.	Prov.	Locations						Average
		Linhares			Grão Mogol			
		Aver.	F Test Prov.	C.V. (%)	Aver.	F Test Prov	C.V. (%)	
DAP (cm)	Flores	15.91	4.31**	10.52	10.37	1.59ns	15.97	13.14
	Timor	16.60	5.69**	11.96	10.38	4.67**	15.76	13.49
	O. Ilhas	14.85	9.35**	10.07	11.13	7.16**	17.99	12.99
ALT (m)	Flores	20.32	1.46ns	17.96	11.82	4.24**	19.21	16.07
	Timor	20.01	4.86**	15.39	11.54	3.99**	16.85	15.78
	O. Ilhas	17.59	6.01**	11.25	12.25	6.79**	17.55	14.92
VOL. REAL C/C (m^3/árv.)	Flores	0.22	3.48**	28.58	0.06	1.67ns	44.85	0.14
	Timor	0.22	4.61**	31.33	0.06	5.02**	35.51	0.14
	O. Ilhas	0.18	10.67**	21.71	0.08	6.12**	43.04	0.13

Prov – Provenance
C.V. – Coefficient of Variation

It is feasible to conclude that the growth were quite better at Linhares in comparison to Grão Mogol, showing a better situation for their development in terms of soil properties and climate conditions.

At Linhares, the sources from Flores and Timor Is. Exhibit a very similar performance and superiority to Other Is. At Grão Mogol, the differences were less evident among the sources from the three groups of Islands.

In natural stands of **E. urophylla**, the sources from Timor Is. Have a higher percentage of bark than sources from Flores Is. This way, comparing the sources from Flores Is. And Timor Is. The most utilized economically, the advantage of a clinal variation.

The experimental variation coefficient were greater at Grão Mogol and in general elevated for all evaluated traits. At Linhares, the values were of medium magnitude, in accordance with GARCIA (1989) classification.

The F-test for provenance were highly significant in majority of cases.

The Table 5 presents the mean values of plots for each provenance for the traits evaluated at two locations and the general means.

At Linhares, the controls were classified in most cases at first position, despite the statistical differences were non-significant in some cases. Otherwise, at grão Mogol, the controls appeared well only in comparison with Timor Is. Sources.

The superiority of the controls in several cases does not implicate any relevant advantage comparing with the introduced sources. One factor responsible by this apparent advantage is the pre-existing adaptation in controls, what is not occurring with the exotic sources. In this sense, starting the consolidation of new land races with the exotic material, the gains in terms of productivity will be evident each generation changing, specially because an appropriate genetic basis is available.

The productivity values for wood volume (m^3) with bark per hectare are presented in Figures 1 to 6, which were obtained from data transformation of the individual trees volume presented in Table 5.

TABLE 5 – Mean values of plots for the traits evaluated at two locations and the general means.

Provenance **F – Flores** **T – Timor** **L – Lomblem** **Al – Alor** **Ad – Adonara** **P – Pantar**	**Locations**								
	Linhares – ES			**Grão Mogol – MG**			**Average**		
	DBH (cm)	**Height (m)**	**Wood Vol W/B (m^3/tree)**	**DBH (cm)**	**Height (m)**	**Wood Vol W/B (m^3/tree)**	**DBH (cm)**	**Height (m)**	**Wood Vol W/B (m^3/tree)**
Wukoh (F)	15.90B	20.59A	0.21B	10.13A	11.18AB	0.05A	13.02	15.88	0.13
Llegele (F)	15.62B	21.38A	0.21B	10.62A	12.09AB	0.06A	13.12	16.74	0.14
Ende (F)	15.70B	20.62A	0.21B	10.73A	12.87A	0.07A	13.22	16.75	0.14
Londangwuang (F)	16.12B	19.87A	0.21B	10.72A	12.66A	0.07A	13.42	16.27	0.14
Egon II (F)	16.04B	19.97A	0.21B	9.49A	10.72AB	0.05A	12.77	15.35	0.13
Ara Detung (F)	14.66B	18.91A	0.18B	10.64A	12.98A	0.06A	12.65	15.95	0.12
Saler wukoh (F)	15.91B	19.98A	0.20B	10.62A	12.23A	0.06A	13.27	16.11	0.13
Lewotobi (F)	16.21AB	20.00A	0.22B	10.34A	12.01AB	0.06A	13.28	16.01	0.14
Llimandiri (F)	15.54B	19.51A	0.20B	10.41A	11.38AB	0.06A	12.98	15.45	0.13
Egon I (F)	15.55B	20.74A	0.20B	10.37A	12.10AB	0.06A	12.96	16.42	0.13
CONTROLS	17.78A	21.96A	0.28A	10.02A	9.83B	0.05A	13.90	15.89	0.17
Lelogana (T)	16.79AB	20.92AB	0.23AB	10.69AB	11.43AB	0.06AB	13.74	16.18	0.15
Timau (T)	17.32AB	20.75AB	0.24AB	10.71AB	12.04AB	0.06AB	14.02	16.40	0.15
Debaha I (T)	16.83AB	21.16AB	0.23AB	9.95B	11.31AB	0.05B	13.39	16.24	0.14
Debaha II (T)	16.08AB	18.98AB	0.20AB	9.44B	10.92AB	0.07AB	12.76	14.95	0.14
Fatusunam (T)	16.03AB	20.94AB	0.21AB	10.85AB	12.66A	0.05B	13.44	16.80	0.13
Nautsusu (T)	18.00A	19.35AB	0.23AB	9.72B	10.28B	0.05B	13.86	14.81	0.14
Kekneno (T)	15.49B	18.15B	0.18B	10.06B	10.89AB	0.05B	12.77	14.52	0.12
Fatumnasi (T)	15.27B	18.33B	0.17B	9.97B	11.50AB	0.05B	12.62	14.92	0.11
CONTROLS	17.58A	21.53A	0.27A	11.99A	12.84A	0.08A	14.78	17.18	0.18
Lleape (L)	14.00DE	17.36B	0.16BC	11.59ABC	13.59A	0.08AB	12.79	15.48	0.12
Woipui (Al)	15.79ABC	17.70B	0.19AB	12.43AB	13.28A	0.09AB	14.11	15.48	0.14
Moimang (Al)	15.82AB	18.24B	0.19AB	13.53A	13.52A	0.10A	14.68	15.88	0.15
Waikui (Al)	14.37CDE	17.29B	0.16BC	10.96BCD	12.34AB	0.06BC	12.67	14.82	0.12
Raululand (Al)	13.35E	16.57B	0.13C	10.64BCD	12.08AB	0.06BC	12.00	14.33	0.10
Wetuna (Ad)	14.87ABCD	17.03B	0.16BC	10.36CD	11.46AB	0.06BC	12.62	14.25	0.11
Oseama (Ad)	14.52BCDE	17.31B	0.16BC	10.56BCD	11.87AB	0.06BC	12.54	14.59	0.11
Gulmen-Palmen (P)	14.88ABCD	16.55B	0.16BC	9.36D	10.29B	0.05C	12.12	1342	0.11
CONTROLS	16.08A	20.27A	0.23A	10.81BCD	11.89AB	0.07ABC	13.45	16.08	0.15

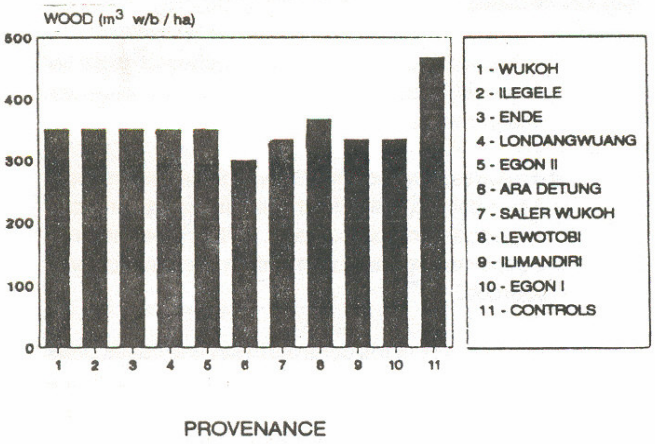

FIGURE 1 - Results of productivity expressed as wood volume with bark per hectare for Flores Is. sources at Linhares, ES. Age: 8 years.

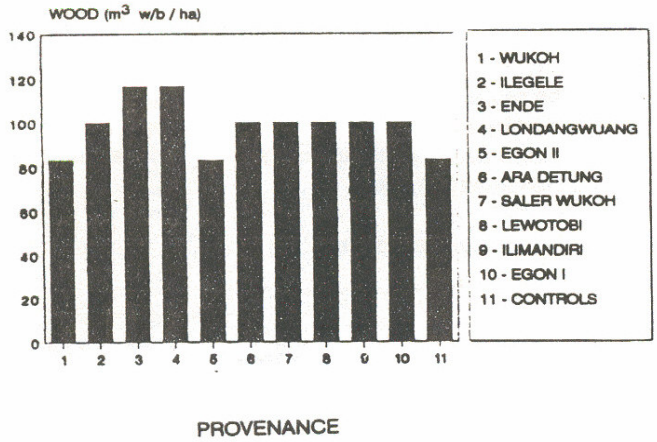

FIGURE 2 - Results of productivity expressed as wood volume with bark per hectare for Flores Is. sources at Grão Mogol, MG. Age: 8 years.

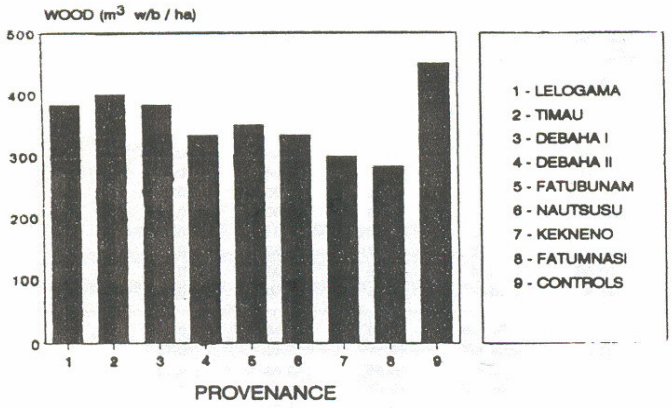

FIGURE 3 - Results of productivity expressed as wood volume with bark per hectare for Timor Is. sources at Linhares, ES. Age: 8 years.

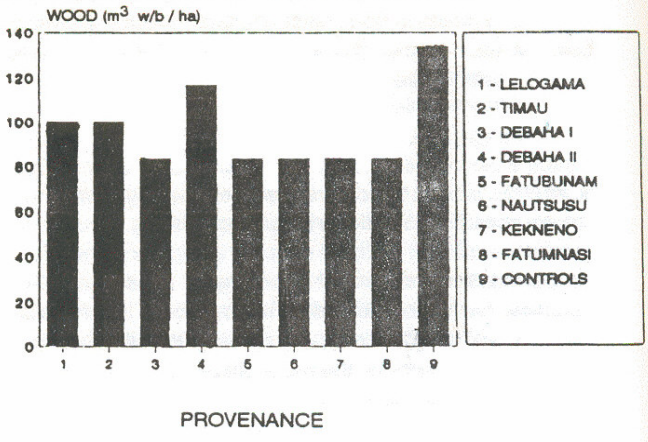

FIGURE 4 - Results of productivity expressed as wood volume with bark per hectare for Timor Is. sources at Grão Mogol, MG. Age: 8 years.

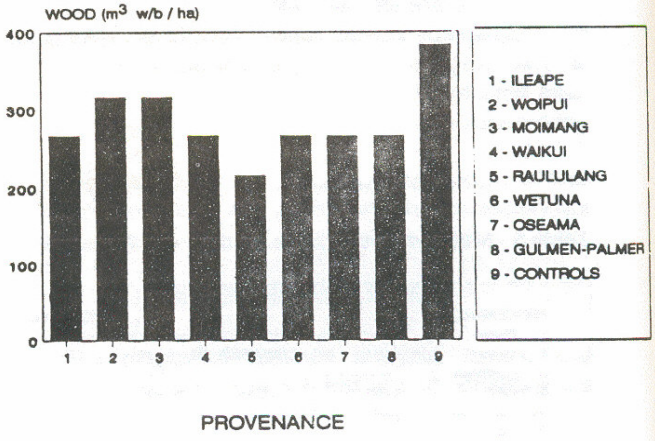

FIGURE 5 - Results of productivity expressed as wood volume with bark per hectare for Other Is. sources at Linhares, ES. Age: 8 years.

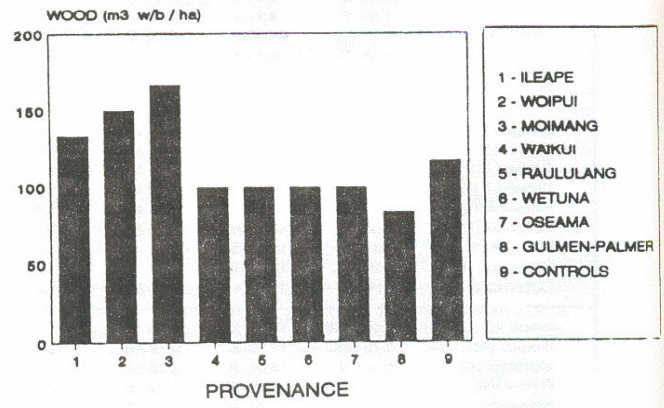

FIGURE 6 - Results of productivity expressed as wood volume with bark per hectare for Other Is. sources at Grão Mogol, MG. Age: 8 years.

The experimental variation coefficients maintained acceptable, in accordance with GARCIA(1989). The trait volume presented the greater values (23.76% to 30.66%), as verified for the most situations.

The F-test values for locations were highly significant for all evaluated traits and the highest as compared with F-test values for progenies and for progenies x locations interaction. This shows that the environmental factors contribute markedly for response of a determined trait with the environmental changes. These findings emphasize the importance of multiple population strategy.

Analysing the values obtained for F-test for progenies x locations interaction, in most situations the values were highly significant. However, according to MATHESON & RAYMOND (1984), this significance can not represent a significant loss of gain potential for a specific trait. A complementary parameter that gives better conditions for understanding these effects is the progenies x locations interaction variation coefficient.

The joined variance analysis results, means, experimental variation coefficient and progenies x locations interaction for all traits are show in Table 6.

TABLE 6 – Results of joined variance analysis means, experimental variation coefficients and progenies x locations interaction for different traits involving the progenies belonging to each group of Island. Age: 8 years.

Island	Character.	Aver	C.V. (%)	Teste F			C.V. (%) (P X L)
				Prog. (P)	Locat. (L)	Inter. (P X L)	
FLORES	DBH (cm)	13.21	11.51	1.38**	54.04**	2.14**	7.50
	H (m)	16.12	10.48	1.49**	31.76**	172**	5.46
	Wood Vol W/B (cm^3/tree)	0.14	27.73	1.20ns	82.53**	2.31**	19.17
TIMOR	DBH (cm)	13.37	11.84	2.42**	287.08**	1.70**	6.25
	H (m)	15.56	9.75	2.97**	167.07**	1.49**	4.30
	Wood Vol W/B (cm^3/tree)	0.13	30.66	1.78**	154.02**	1.30ns	11.12
OTHER ISLANDS	DBH (cm)	12.10	11.53	2.67**	318.27**	0.29ns	0.00
	H (m)	13.88	9.87	1.09ns	132.49**	0.36ns	0.00
	Wood Vol W/B (cm^3/tree)	0.12	23.76	2.59**	105.90**	1.93**	14.27

According to Table 6, for Flores sources, although all F-values for interaction P x L had been highly significant, the values of variation coefficient P x L were relatively low (7.50% for DBH, 5.46% for height and 19.17% for volume), and the trait volume was the most affected by interaction. The same happened in relation to Timor sources (6.35% for DBH, 4.30% for height and 11.12% for volume) and Other Is. Sources (0.00% for DBH, 0.00% for height and 14.27% for volume), despite some F-values were non-significant.

The restricted level heritability coefficients for individual plants, for all traits evaluated separately at two locations and joined, are shown in Table 7.

TABLE 7 – Restricted level heritability coefficients for individual plants (h^2) for all traits at two locations separately and joined. Age: 8 years.

Island	Location	Characteristic		
		Dbh h^2	**HEIGHT** h^2	**WOOD VOL W/B** h^2
FLORES	Linhares – ES	0.24	0.22	0.23
	Grão Mogol - MG	0.25	0.45	0.29
	Average	0.25	0.34	0.26
	Joined Analysis	0.16	0.20	0.13
TIMOR	Linhares – ES	0.58	0.57	0.33
	Grão Mogol - MG	0.60	0.64	0.65
	Average	0.59	0.61	0.49
	Joined Analysis	0.34	0.46	0.25
OTHER ISLANDS	Linhares – ES	0.36	0.23	0.29
	Grão Mogol - MG	0.49	0.76	0.59
	Average	0.43	0.50	0.44
	Joined Analysis	0.47	0.34	0.33

For progenies from Flores Is., the biggest medium heritability coefficient was found for height, followed by volume and DBH, the last quite similar to each other. There results agree with those ones presented by PINTO (1984) and MORI et alii (1988), who also studied progenies of **E. urophylla** from the same island.

In case of Timor Is. Sources, the same tendencies were observed, except a medium heritability values for DBH a little bit higher in comparison with the other traits. The medium heritability coefficients for individual and joined analysis were approximately the double of those ones obtained for Flores Is. sources.

For other Is. Progenies, the medium values of heritability coefficient also followed the same tendency of Flores Is. Progenies, but they were markedly bigger.

The heritability coefficients decreased in joined analysis, showing the occurrence of effects associated to progenies x locations interaction. The only exception was the trait DBH for Other Is. Sources, but this fact can be related to the error associated to the estimates, since the number of progenies studied was small.

It was verified lack of bibliographic references about heritability estimates for genetic sources from Timor Is. And Other Is., allowing no comparisons with literature data.

The most recommended procedure for provenances/progenies trials is not to submit the exotic sources to a strong selection in the beginning, since the sources must have the opportunity to be submitted to an appropriate genetic recombination, improving their adaptation to the new environmental conditions, as shown by the results obtained for the controls or “land races”. One option is to practice a weak selection during two generations, in a kind of strategy named “Seed Production Area” (rate of selection 1:10 for both sexes), contributing substantially for improving adaptation of the species and the future results of a genetic improvement programme.

The expected genetic gains are shown in Table 8.

TALBE 8 – Expected genetic gains (%) for different traits, on both locations and joined, and the losses (%) caused by progenies x locations interaction.

Island	Character	Location		Aver	Joined Analysis	Losses
		Linhares	Grão Mogol			
FLORES	DBH (cm)	15.54	19.27	17.41	6.27	11.14
	HEIGHT (m)	11.59	25.16	18.38	6.52	11.86
	WOOD VOL W/B (m^3/tree)	33.76	41.44	37.60	12.29	25.31
TIMOR	DBH (cm)	32.66	48.10	40.38	13.15	27.23
	HEIGHT (m)	22.47	36.61	29.54	13.68	15.86
	WOOD VOL W/B (m^3/tree)	39.22	96.06	67.64	22.36	45.28
OTHER ISLANDS	DBH (cm)	26.28	35.56	30.92	17.94	12.98
	HEIGHT (m)	14.16	34.71	24.44	9.99	14.45
	WOOD VOL W/B (m^3/tree)	49.25	80.21	64.73	28.36	36.37

Analysing the presented data, it is possible to observe that the larger genetic gains were obtained for trait volume followed by height and DBH for Flores Is. Sources and the opposite for Timor Is. and Other Is. sources. The losses volume caused by interaction P x L shows that the ideal is to conduct two district breeding programmes, taking account the obtained results of joined analysis. When selecting for attending both locations simultaneously, it occurs some significant losses on genetic gains. This fact emphasizes the convenience for multiple population strategy (NAMKOONG et alii, 1980) utilization, which has been applied several forest trees species.

For the measured traits, the gain potential is very remarkable, specially by the high genetic variability available for selection on different sources.

CONCLUSIONS

The obtained results show that:

1º) The growth verified at Linhares, ES was markedly superior to that one found at Grão Mogol, MG, reaching values about 50%, 40% and 200% for traits DBH, height and wood volume with bark, respectively.

2º) The “land races” (controls) showed superiority over the exotic sources in most comparisons, reflecting clearly the benefits of adaptation for incorporating genetic gains on breeding programmes;

3º) The identity of the different sources (Flores Is., Timor Is. and Other Is.) must be maintained, because the existence of important genetic differences and a large genetic variability, suggesting that the breeding programmes must be conducted separately;

4º) Significant losses occurred on expected genetic gains when considering both locations together, caused by the effects of progenies x locations interaction. The losses were about 11.14% to 45.28%, smaller for DBH and height and bigger for wood volume with bark;

5º) The ideal strategy for genetic improvement programme of **E. urophylla** at Linhares, ES and Grão Mogol, MG is the multiple population scheme.

ACKNOWLEDGEMENTS

The authors express their gratitude to technical team of Florestas Rio Doce S.A. from Linhares, ES and Grão Mogol, MG headquarters, by furnishing the data that allowed the elaboration of present paper.

REFERENCES

CAPITANI, L.R. et alii - **Eucalyptus urophylla** da Indonésia na Vale do Rio Doce. **CVRD**, Rio de Janeiro, 8 (27): 37-52, 1987.

CORBASSON, M. & COSSALTER, C. - Essais de provenances d'**Eucalyptus urophylla** realisés a partir des provenances recoltées par le Centre Technique Forestier Tropical. **Silvicultura**, São Paulo, 8(31): 424-6, 1983.

GARCIA, C.H. - Tabelas para classificação do coeficiente de variação. **CircularTécnica IPEF**, Piracicaba (171): 1-11, nov.1989.

KAGEYAMA, P.Y. - **Seleção precoce a diferentes idades em progênies de *Eucalyptus grandis* Hill ex Maiden**. Piracicaba, 1983. 147 p. (Tese-Livre-Docência -ESALQ).

MARTIN, B. & COSSALTER, C. - Les Eucalyptus de lles de la Sonde. **Bois et forêts des tropiques**, Nogent -Sur-Marne (165): 3-20, 1976.

MARTIN, B. & COSSALTER, C. - Les Eucalyptus de lles de la Sonde. **Bois et forêts des tropiques**, Nogent- Sur-Marne (166): 3-22, 1976.

MATHESON, A.C. & RAYMOND, C.A. - The impact of genotype x environment interactions on Australian **Pinus radiata** breeding programs. **Australian forest research**, Melbourne, 14(1): 11-25, 1984.

MORAES, M.L.T. - **Variação genética da densidade básica da madeira em progênies de *Eucalyptus grandis* Hill ex Maiden e suas relações com as características de crescimento.** Piracicaba, 1987. 115 p. (Tese-Mestrado-ESALQ).

MORI, E.S. et alii - Variação genética e interação progênies x locais em *Eucalyptus urophylla*. **IPEF**, Piracicaba (39): 53-63, 1988.

MOURA, V.P.G. - Resultado de pesquisa com várias procedências de **Eucalyptus urophylla** S.T. Blake, no centro-leste do Brasil. **Boletim de Pesquisa EMBRAPA CPAC**, Planaltina (3): 1-22, 1981.

NAMKOONG, G. et alii - **A philosophy of breeding strategy for tropical forest trees.** Oxford, Commonwealth Forestry Institute, 1980. 67 p.

PINTO JÚNIOR, J.E. - **Variabilidade genética em progênies de uma população de *Eucalyptus urophylla* S.T. Blake da Ilha Flores - Indonésia**. Piracicaba, 1984. 164 p. (Tese-Mestrado-ESALQ).

QUIJADA, R.M. - Interacion genotipo x ambiente. In: FAO/DANIDA. **Mejora genética de arboles forestales**. Merida, 1980. p. 231-5.

SHELBOURNE, C. - Genotype environment interaction: its study and its implications in forest tree improvement. In: IUFRO GENETIC SABRAO JOINT SYMPOSIA, Tokyo, 1972. **Proceedings**. p. 8-1 (I): 1-27.

SILVA, J.A.A. - **Análises de equações volumétricas para construção de tabelas de volume comercial para *Eucalyptus* spp, segundo a espécie, região e método de regeneração**. Viçosa, 1977. 93 p. (Tese-Mestrado- UFV).