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PINUS OOCARPA SCHIEDE INTERNATIONAL PROVENANCE TRIAL IN KENYA AT EIGHT YEARS

by

E.M. Chagala/1 and G.L. Gibson/2

/1 Forest Research Department, Kenya
/2 Commonwealth Forestry Institute, Oxford

Introduction

Pinus oocarpa Schiede has a very wide distribution in its native range which extends 12°N from Nicaragua to 27°N in Mexico. The first introduction of this species to Kenya was in 1968, but this was a total failture because the provenances were poorly adapted being from the extreme northern part of the distribution. Seed originating from latitudes greater than 18°N in Mexico does not thrive in Kenya. Subsequent introductions in 1971 and 1972 included seed from the southern part of the natural range, this is, Southern Mexico, Guatemala and Honduras. In these trials, two provenances from Chiapas State in Southern Mexico were outstanding. This paper discusses the international provenance trial established in 1972 with seed supplied from the Commonwealth Forestry Institute, (CFI), Oxford, which has been replicated in many tropical countries. This trial comprised fifteen provenances from Honduras, Guatemala, Belize and Nicaragua and a provenance of P. caribaea var. hondurensis from Alamicamba, Nicaragua was included for inter-specific comparison, and the provenance source details and provenance codes are shown in Table 1.

Trial sites

This experiment was replicated on two sites; Nzoia compartment 2J and Turbo compartment 10G. However, results, analyses and discussions in this paper only deal with the Nzoia replicate because the Turbo replicate failed probably due to the proximity of the murram pan to the surface, a serious problem in the Turbo Afforestation Scheme. Nzoia compartment 2J is situated on latitude 0°56'N and longitude 35°4'E at an altitude of 1700m. The mean annual rainfall if 1250mm with a four months dry season which is very severe with humidity below 40% and ptential evapotranspiration reaches 1800mm/year. The mean annual temperature, mean maximum emperature of the hottest month and mean minimum temperature of the coldest months are 22°C, 26°C and 14°C respectively. The soil is a shallow medium clay which may be deficient in nitrogen and phosphorus. The depth is mostly over 1m but there are shallow patches to 10cm. The underlying parent rock is laterite and the vegetation is grassland dominated by Hyparrhenia filipendula and Themeda triandra with Acacia spp. and Combretum spp. sprouting from cut stumps.

Experimental design

The trial was planted as a balanced lattice with 16 treatments (see Table 1) and five blocks, but due to several missing values it was analysed as a randomized complete block. The trial was planted at a spacing of 2.5 x 2.5m, and the individual plot size was 5 x 5 trees.

Management

Seeds were sown at Londiani nursery during August 1971. The main germination started after about 3 weeks and pricking out was done into tubes 4 weeks after sowing. Culling of weak and damaged plants was done in the nursery. The seedlings were planted in the field in July 1972, aged 11 months and tubes were removed. Subsequent beating up was done in August 1972. Spot hoeing was done in August, September and December 1972. Survival was good and pruning was done in November 1976 to half height.

Assessment

The trial was assessed for height in 1972, and height and diameter in 1974 and 1977.

In march 1980, the trial was assessed in great detail as part of the co-operative assessment programme between the CFI and various participants in the international provenance trial series of P. oocarpa and P. caribaea. Twenty-nine field traits were assessed in total, and details of assessment; philosophy, methods and formulae for trait derivation may be found in Gibson (1982). The range of traits assessed is beyond the scope of this paper but a group of the most important measured and derived traits for provenance selection are considered below:

Trait derivation

1. Height (HGT). Measured to the nearest decimetre by use of a height rod.
2. Diameter breast height (DBH). Measured to the nearest millimetre by standard diameter tape.
3. Stem straightness (STR). A weighted rating based on the length and position of straight sections in the first six metres of stem, with

straight sections contributing more to the overall score the lower they were found on the stem. This score was adjusted up or down 10% depending on whether the upper stem form (above 6m) was better or poorer than the basal 6m.

4. Volume under bark (VUB). Mean tree value in cubic decimetres, derived from under-bark basal area (bark thickness was measured on opposite sides of the tree by gauge), the height and a form quotient culculated from the ratio between diameter at breast height and an estimate of diameter at six metres.

5. Branch index 1 (BI1). An index of branching excellence constructed from mean number of branches per whorl, branch diameter, branch angle and branch order in such a way that the higher the index, the better the branching.

6. Index of the average tree (IAT). An index of overall productivity, weighted for qualitative traits. It is constructed from volume production under-bark, stem straightness and branching index.

Results and discussions

Provenance performance for these traits was examined by analysis of variance, and Table 2 and 3 present the ranked means, grand means, strandard errors, significance of the F-ratio for provenance effects, and the percentage of total variance attributable to provenance effects.

1. Height. From Table 2 the three Nicaraguan provenances YUC, CAM and RAF are significantly the most productive. This is in line with previously published results (Greaves, 1980) and underlines the superior vigour of these southerly provenances. It can also be seen that with the notable exception of LAG, the Guatemalan origins are the least vigorous. The MPR provenance was also productive, maintaining a position in the top four provenances over the life of the trial.

2. Diameter. The provenances YUC, CAM, MPR and RAF had the largest mean diameter, and are significantly more productive than the other provenances. The majority of Guatemalan provenances which had ranked low for height were higher for diameter but may be associated with thicker bark or a different degree of stem taper.

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3. Stem straightness. This was a trait under strong genetic control, with 51% of tatal variance attributable to provenance effects, and Table 3 shows the large range of mean values. The least straight sources were all from Guatemala and this is in agreement with the findings of Kageyama (Kageyama, 1977) who identified a significant and negative correlation between latitude of provenance source and auality of stem form. There was also a high degree of similarity between the rankings at the CFI co-ordinated trial in Brazil assessed by Kageyama and the Nzoia trial. In both trials the three highest ranking provenances were RAF, ZAP and LAG, and of the provenances common to both trials, the three poorest HUE, BUC and SJE were also the same. The highly productive MPR provenance was in the middle of the range for stem straightness at both locations suggesting that though its volume production may be amongst the most productive, its poorer stem form may count against it as a potential breeding provenance.
4. Volume under bark. This trait is expressed as mean tree values in cubic decimetres and highly significant provenance differences occurred. The ranking for volume over bark varied from that of diameter due to different bark thickness or stem taper. At existing stocking rates, theese productivity figures are equivalent to an under bark annual increment ranging from 9 to 31 m^2/ha^{-1}, with YUC significantly the highest producer. The implication of such a range of productivity figures to production levels of an afforestation scheme cannot be overstressed.
5. Branch index 1. For this trait, the provenance of P. oocarpa were all better than the P. caribaea provenance, and again the provenances with the highest index were YUC, CAM, RAF and MPR, with LAG exhibiting the most desirable branching habit of Guatemalan provenances. Branch size, angle and distribution are important traits influencing the quality of timber and the magnitude of the provenance effect correct provenance selection for this trait, in conjunction with STR, will have on the quality of wood produced.

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5. Index of the average tree. This index can be considered as preliminary selection index as it combines a series of the most important quantitative and qualitative characteristcs. The provenance YUC was significantly better than all other provenances, and the next best were CAM, RAF and MPR. The poorest provenances were all from Guatemala and their index values were almost 50% lower. Although PCH ranked high for volume production, it was low on this index on account of its poor scoring for stem form and branch habit, reducing the utilisation value of the product at this site.

It is clear from the results to age eight that the Nicaraguan provenances YUC, CAM and RAF, and MPR from Belize would be the desirable provenances upon which to base a breeding population, though the relatively poor stem form of MPR is certainly a disadvantage of this provenance. Greaves (1980) reported essentially the same results in his review of the CFI co-ordindated trials, and the constant superiority, combined with the phenotypic differences, and different needle number per fascicle cast doubt on the identity of these provenances. Styles (1984 in press) suggested that the Nicaraguan provenances may actually be P. patula subsp. tecunumanii though he did not mention MPR in this context. MPR may be a hybrid with P. caribaea var. hondurensis with which it occurs on the Mountain Pine Ridge, longer mean internode lengths (Gibson, unpubl. data) would tend to support this, as that is a characteristic of P. caribaea var. hondurensis. Of the "true P. oocarpa" provenances, Lagunilla, Guatemala performed well for the range of traits and should not be discarded as a possible provenance for breeding population establishment, particularly as if species differences really are present in this trial, then performance could alter later in the rotation. With the exception of LAG, the other Guatemalan provenances on test can be dismissed as unsuitable for breeding population and plantation establishment in this region. Likewise the Honduran provenances do not appear to be sufficiently vigorous though ZAP had a high rating for STR, but it is low in volume production. There is no doubt that provenance selection for plantation and base breeding population establishment must consider the characteristics of volume production, stem strightness and branching habit, with weighting being given to each of these traits relative to their importance to local objects of management.

..plication for future strategy

P. oocarpa appears to have a lot of potential in the mid-latitudes of Kenya between 1200 and 1500 m above sea level. The four provenances recommended - Yucul, Camelias, Rafael and Mountain Pine Ridge do not suffer from fox-tailing, are fast growing and have good form. However the nomenclature and taxonomy of these provenances as discussed above must be clarified as these provenances appear morphologically different from P. oocarpa in terms of branch number per whorl, needle number per fascicle and tranching habit. Some of the earlier introductions for species trials, provenance trials and conservation plots also may be of P. patula subs. tecunumanii. The The conservation plots established in 1977 and 1978 with seed from Green wood, Mountain Pine Ridge, Belize could be used as a future source of breeding material and the importance of correct identity of these provenances need not be overstressed.

From the results, it is noted that P. caribaea has pporer form and branching habits than the P. oocarpa provenances. However, it is among the best for volume production and average for diameter breast height. As there is evidence of successful cross pollination between these species, the resulting hybrids may be of great importance.

Provenance conservation is also important. At the present time there are conservation plots of P. oocarpa of only two provenances and there is need to increase the area to include other valuable provenances. Since there are now positive results from the provenance trials, and these are in broad agreement with those found in other countries, it is now essential to establish base breeding populations selected on the basis of these results and large areas of the best provenances should now be established. Conservation stands must be established in unreplicated identitied blocks in the field, if possible kept separate by family within provenance. From these conservation stands, superior individuals can be selected for establishment of a breeding population and the maintenance of the identity of half-sib families within provenances would avoid inbreeding between later selections.

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Though some provenances have performed poorly there is generally a high degree of within provenance variability and plus trees can be selected from the plots of these provenances and be included in the breeding population. To further broaden the genetic base of the breeding population, new provenance material must continue to be introduced into the existing breeding population. Also, some countries are already well advanced in the breeding of P. oocarpa and their improved material should be included in the breeding population while this is being established. The already established provenance trials can serve as seed sources or any other breeding material like scions and pollen. A great problem in Central America has been the intense felling and dysgenic selection in some of the provenance areas which has led to the virtual extinction of certain provenances including Camelias, Nicaragua which performed very well in this trial. The only pool of this material is the CFI provenance trials and ideally, to expand the available national gene pool of this provenance, exchange of scions or seed with other countries should be arranged.

The traits described in this paper are the most important economically. Height and diameter contribute to the volume production while branch index and stem straightness affect timber quality. Height and diameter are highly correlated traits and are also highly correlated to volume production. Measurement of height becomes increasingly tedious and time consuming when tree height exceeds 10 and it would therefore be easier to then assess only diameter to calculate basal area as an index of volume production. In a breeding programme reproduction needs to be closely studied and an assessment of male strobilus production, conelet and cone production is required to provide essential information. Assessment of these traits must be carried out at fortnightly intervals throughout the year to provide essential information on precocity and periodicity of individual clones is fundamental to breeding programme development, and ultimately seed production.

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...e international approach to provenance testing, conservation and population development is of greatest importance in view of the problems of seed supply because individual countries cannot cope with seed collection. The importance of CFI, DANIDA Forest Seed Centre in Denmark and Central American countries in this matter cannot be overstressed and the main needs of the immediate future will be the co-ordination of exchange of material and procurement of sufficient seed of proven provenances to establish breeding populations.

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Table 1. Source details of provenances of Pinus oocarpa planted at Nzoia, Kenya (From Greaves, 1978).

Provenance name	Code	Lat. °N	Long. °W	Alt. (m)	Mean ann. rainfall (mm)	Dry season /1	Mean ann. temp. (°C)
Camelias (N)	CAM	13°46'	86°18'	1000	1500	5B	22.4
Yucul (N)	YUC	12°55'	85°47'	900	1400	5B	22.4
Rafael(N)	RAF	13°12'	86°06'	1100	1500	5B	20.8
Bonete (N)	BON	12°50'	86°18'	1000	950	5A	21.4
Mountain pine Ridge (B)	MPR	17°00'	88°55'	700	2100	1	21.2
Zapotillo (H)	ZAP	14°37'	87°02'	1100	1200	5B	21.8
Angeles (H)	ANG	14°07'	87°04'	1300	950	6A	20.6
Zamorano (H)	ZAM	13°58'	86°59'	1000	1100	6A	20.2
Siguatepeque (H)	SIG	14°32'	87°45'	1100	1250	6B	19.9
Conacaste (G)	CON	15°10'	89°21'	650	1900	5B	24.6
Bucaral (G)	BUC	15°01'	90°09'	1000	800	6A	21.6
Lagunilla (G)	LAG	14°42'	89°57'	1300	950	6A	19.5
Chacus (G)	CHA	15°02'	90°16'	1400	800	6A	22.5
San Jose (G)	SJE	14°23'	89°28'	1000	1000	6A	22.4
Huehuetenango (G)	HUE	15°13'	91°23'	1700	1000	6A	16.9
Alamicamba (N) (*P. Caribaea*)	PCH	13°34'	84°13'	25	2600	1	27.3

/1 Dry Season. The figure is the number of months in the year with an average rainfall of less than 60 mm, and the letter is a comparative rating of severity of dry season, A being more severe than B.

N = Nicaragua, B = Belize, H = Honduras, G = Guatemala able 2. Provenance mean height showing grand mean, standard error and significance level of provenance effects.

	1980
	YUC (12.8)
	CAM (12.8)
	RAF (11.7)
	MPR (11.6)
	LAG (11.2)
	PCH (11.0)
	SIG (10.9)
	BON (10.8)
	ZAP (10.8)
	ZAM (10.8)
	CON (10.6)
	CHA (10.4)
	SJE (10.4)
	ANG (10.4)
	HUE (10.3)
	BUC (10.0)
Grand mean	11.0
Standard error	0.3
Sig. of diff.	***

*** = significant at the 0.1% level

Vertical lines indicate provenances not significantly different at the 5% level.

Table 3. Ranked provenance means for diameter (DBH), stem straightness (STR), volume under bark (VUB), branch index I (BII) and index of the average tree (IAT).

	DBH	STR	VUB	BII	IAT
	YUC(17.7)	RAF(9.0)	YUC(175)	YUC(14.4)	YUC(113)
	CAM(17.3)	ZAP(8.5)	RAF(143)	CAM(14.1)	CAM (98)
	MPR(16.6)	LAG(8.4)	PCH(132)	RAF(14.1)	RAF (93)
	RAF(16.3)	CAM(8.1)	CAM(130)	MPR(13.6)	MPR (91)
	LAG(15.9)	YUC(7.7)	LAG(103)	LAG(13.5)	LAG (78)
	PCH(15.6)	ANG(6.7)	MPR(101)	BON(13.0)	BON (73)
	CON(15.4)	BON(6.5)	BON (93)	CHA(13.0)	PCH (71)
	BON(15.4)	SIG(6.0)	ZAM (89)	ZAP(13.0)	SIG (68)
	HUE(15.0)	MPR(5.6)	CHA (86)	ZAM(12.8)	ZAM (66)
	ZAM(14.9)	ZAM(5.4)	HUE (85)	BUC(12.7)	ANG (66)
	SIG(14.8)	SJE(4.7)	CON (82)	ANG(12.7)	CON (65)
	CHA(14.8)	BUC(4.7)	SIG (79)	CON(12.6)	ZAP (64)
	SJE(14.6)	PCH(4.0)	BUC (77)	SJE(12.5)	HUE (61)
	ANG(14.6)	CHA(4.0)	ZAP (73)	CHA(12.5)	SJE (59)
	ZAP(14.4)	CON(3.8)	SJE (73)	HUE(12.1)	CHA (59)
	BUC(14.0)	HUE(2.6)	ANG (70)	PCH(10.9)	BUC (57)
Grand mean	15.4	6.0	100	12.9	74
Standard error	0.7	1.2	13	0.4	7
Sig. of diff.	***	***	***	***	***
VC% provs.	39	51	54	61	56

Vertical lines indicate provenances not significantly different at the 5% level.