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EXPERIMENTAL PLANTINGS OF ARAUCARIA SPP. IN EAST AFRICA AND COSTA RICA

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SUMMARY

Members of the genus Araucaria were introduced as exotic trees to East African countries and to Costa Rica over 70 years ago. In Costa Rica, Uganda and Tanzania they were used only as ornamentals until the 1950s, but in Kenya, forestry trial plots were established in 1911 and 1927. These early trial plots were used as local sources of seed for further trials and to establish field scale plantations during the period 1956-1962. Timber cut from Kenya trial plots had similar properties to native grown material.

Seed collection and storage requires attention to detail but can be achieved by carefully planned work. Araucaria can also be grown from cuttings of young terminal shoots, but shortage of seed, or suitable cutting material severely limit field scale plantings. In East Africa, growth rates of Araucaria plantations are lower than those of Pinus spp., on the same time. Results from twelve-year old trial plots established by CATIE on the Atlantic slope of Costa Rica suggest that there Araucaria may be more productive than pine.

RESUMEN

Arboles del género Araucaria se introdujeron como exóticos en los países de Africa Oriental y Costa Rica hace más de setenta años. En Costa Rica, Uganda y Tanzania se utilizaron únicamente como árboles ornamentales hasta la década de 1950, pero en Kenia, se establecieron parcelas experimentales para referencia en 1911 y 1927. Estas primeras parcelas produjeron semillas para el establecimiento de más parcelas experimentales y aún para plantaciones comerciales

durante el período 1956-62. La madera cosechada de las parcelas más antiguas tenía propiedades similares a la madera proveniente de árboles que crecieron en su habitat natural.

La recolección y el almacenamiento de semillas exige cuidado y atención en los detalles, pero es factible si se planea cuidadosamente. La Araucaria también se puede enraizar por estacas de rebrotes jóvenes. Sin embargo, la escasez de semillas o rebrotes aptos para estacas, limita la extensión de plantaciones a gran escala.

En Africa Oriental el crecimiento de plantaciones de Araucaria es menor que el de plantaciones de Pinus en los mismos sitios; en cambio, las mediciones efectuadas en parcelas experimentales del CATIE en la Vertiente Atlántica de Costa Rica acusan un crecimiento más rápido que Pinus.

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INTRODUCTION

Trees of the genus Araucaria Juss. have attracted gardeners' attention since they were first introduced to Europe during the last decade of the 18th century and early part of the 19th century. By 1900, the "Monkey Puzzle", or Chile Pine, Araucaria araucana (Molina) K. Koch was a common garden plant in the milder parts of Europe and most other species, which do not withstand hard frosts, were in use as glasshouse plants (Chittenden, 1956).

The features which gardeners prized in members of this genus were: their erect, symmetrical, monopodial growth and the beautifully regular arrangement of their branches and foliage. The fact that most species could be propagated by cuttings also favoured their distribution by gardeners. After World War I, timber from the Paraná Pine A. angustifolia (Bert.) O. Kuntze began to be exported from Brazil and entered the U.S.A. timber market about 1926 and European markets some ten years later (Howard, 1951; Record 1943). During World War II Hoop Pine timber from Australia (A. cunninghamii Sweet) and Chile Pine (A. araucana) also entered the world timber trade, in small amounts, and was used for building wooden aircraft (Rendle 1969). Araucaria timber rapidly acquired a reputation for good seasoning properties and stability when dry, for smooth texture and easy working properties, for its pale colour, low resin content and ability to accept most kinds of surface finishes and, in export grades, freedom from knots. Brazilian material was particularly well graded and came to be used for first class joinery and plain furniture.

The excellent reputation of Araucaria timber and the success gardeners had achieved in growing specimen trees soon tempted tropical foresters to include species in their arboreta and, when they could obtain sufficient plants, to establish small trial plots. The self-pruning ability of most species, when grown in closed stand, by a unique branch abscission mechanism, stimulated further interest.

Experience with specimen trees and single trial plots in the British Commonwealth has been well summarized by Streets (1962). The purpose of the present paper is to document more recent sets of comparative plots in East Africa and Costa Rica and to describe attempts in Kenya to overcome the seed supply problem and progress to commercial scale plantations.

Early Introductions & Trial Plots

The first introduction of Araucaria to East Africa seems to have been made by the Germans to Tanzania (then Deutsch Ostafrika) about 1902, when plants of Araucaria heterophylla (Salisbury) Franco were established at Amani and Lushoto in the Usambara Mountains. A few trees survive at both sites from this introduction, but further trials were deferred for many years.

In Kenya, seeds of A. angustifolia, A. araucana, A. bidwillii Hooker and of A. heterophylla were all introduced about 1909. From this introduction, avenues of Paraná pine were successfully established on five sites above 2,200 m elevation, but the other species failed, with the exception of a single A. bidwillii tree which survives in Nairobi Arboretum.

Further introductions were made to Kenya and Uganda about 1920-22 and specimen trees and small groups of A. cunninghamii Sweet, A. columnaris (Forst.) Hooker and of Paraná pine remain from these introductions in many places in Kenya and a few sites in Uganda and Tanzania. More elaborate trials were not undertaken until after 1950.

In Costa Rica, the first Araucaria introductions were also made by a German settler, Alfred Anderson, about 1909, who introduced A. heterophylla, A. columnaris and A. bidwillii (Dr. Alicia Jiménez; Dr. L.R. Holdridge, personal communications) as garden ornamentals. Individual trees survive from the original plantings, and younger specimens of the two former species are common in gardens. Forestry trial plots were not established before 1960.

The main conclusions drawn from these early, unsystematic trials were that A. angustifolia must be grown, near the equator, at sufficient elevation to provide a temperate climate, that is above 2000 m.a.s.l. and where annual potential evaporation does not greatly exceed mean annual rainfall. This species will not withstand severe drought. It survives in hotter, more humid, tropical conditions, but grows poorly. Araucaria heterophylla, A. columnaris and A. cunninghamii thrive under much warmer conditions, from near sea level to 2000 m.a.s.l. and can withstand periodic severe droughts. Trees of the two latter species, in Nairobi Arboretum withstood three successive years, 1931-34, with rainfalls of less than 600 mm in an area where annual potential evaporation is about 1300 mm. In Costa Rica, by contrast, specimen trees have grown well under rainfalls of up to 3000 mm per year.

The early trials sufficed to give confidence that Araucaria species merited serious trial as exotic trees for forestry plantations. (Plantations of native species had already been established in Australia and Brazil). Moreover in Kenya, the early trial plots also served as an invaluable local source of seed for more intensive trials. Timber obtained from thinnings in the old plots was tested for physical and wood-working properties and found to have similar characteristics to native grown timber.

COMPARISON OF SPECIES

With rapid development of air transport, after World War II, it became possible to accumulate sets of seed batches for comparative trials of Araucaria species. In Kenya, Tanzania and Costa Rica such trials took the form of small single plots of several species grown in close proximity in an arboretum. Plots usually comprised 25 to 100 trees planted at a normal forestry espacement (e.g. 2.5 m x 2.5 m or 8ft x 8ft) and subject to a general prescription that the plot should be managed as if it were part of a larger plantation intended for timber production. This represented a substantial improvement on the earlier trials where the few plants available were usually planted in widely spaced rows or

avenues so that their ornamental virtues were displayed to advantage. It should be noted however that even in the late 1950's it was still difficult to raise sufficient seedlings from imported seed to plant replicated comparative trials. (Pudden, 1957).

The following table 1 shows 10 year-old growth data from sets of comparative plots at Muguga in Kenya, Lushoto in Tanzania and Juan Viñas in Costa Rica. These sites have been selected because five or more species were planted at each site, but other sets of comparative trials exist in all three countries. Data from 6 Tanzania plots and one Kenya plot have been linearly interpolated from the figures originally published, or adjusted by subsequent unpublished data, in order to facilitate comparison at a common age of ten years. (Combe & Gewald 1979); Thogo & Dyson (1974); Borota (1971); Owino & Dyson (1971).

Table 1. Standing crop data of *Araucaria* spp. on three sites interpolated to 10 years old and converted to a per hectare basis.

SPECIES	MUGUGA, KENYA			LUSHOTO, TANZANIA			JUAN VIÑAS, COSTA RICA								
	N	h _d	\bar{d}	G	SDI	N	h _d	\bar{d}	G	SDI	N	h _d	\bar{d}	G	SDI
<i>A. angustifolia</i>	419	9	17.7	10.3	62	950	12*	18.8*	26.4	31	618	11	24.7	29.6	37
<i>A. bidwillii</i>	593	8	15.2	10.7	59	800	6*	5.3*	9.5	56	-	-	-	-	-
<i>A. columnaris</i>	790	8*	12.7*	10.1	45	1325	10*	12.1*	15.2	32	544	12	18.0	13.8	41
<i>A. cunninghamii</i>	593	8	12.4	7.2	48	2600	12*	12.6*	32.4	19	2400	13	18.0	64.0	19
<i>A. heterophylla</i>	890	8	12.8	11.4	48	1950	14	11.8	21.3	19	755	17	19.7	23.7	24
<i>A. hunsteinii</i>	1080	8	15.4	16.1	44	2425	11*	13.0*	32.2	21	1404	16	16.2	34.0	19
<i>Pinus patula</i> (for comparison)	1080	11	14.7	18.3	24	1850	16*	16.4*	39.1	17	1052	14	15.1	28.6	25

h_d = Dominant H.t., 100 largest trees/ha (m); G = Basal Area m²/ha; N = n° of trees/ha.

\bar{d} = Mean Diameter (cm); S.D.I. = Stand Density Index (Hart, 1928).

* = Values linearly adjusted for an age difference of more than 1 year.

Too much reliance should not be placed on data derived from unreplicated plots on only three sites, but the table serves to illustrate three points. Araucaria bidwillii grows more slowly than its congeners; Araucaria hunsteinii is consistently good on all three sites and is apparently a versatile species and, thirdly, that A. heterophylla usually thought of as a garden ornamental, may well also be suitable for timber production in forest plantations.

LOCAL SEED PRODUCTION

Araucaria introduced to Costa Rica do not yet appear to have produced seed, but in Kenya and Tanzania the older trees were carefully watched for signs of flowering and seedling.

There are difficulties in collecting Araucaria seed. Firstly the trees take many years to reach fruiting age. Experience in Kenya was that the first fertile seed was produced at age 17 from A. angustifolia, at age 27 from A. cunninghamii and A. columnaris and at about age 40, from a single A. bidwillii tree. In each case the trees bore apparently normal female cones for some years before fertile seed could be obtained from them. Specimen trees of A. cunninghamii and A. heterophylla at Muguga had reached this stage by age 22 and A. hunsteinii by age 20. Even after fertile seed is produced, it takes some years more before useful quantities can be collected.

Secondly, because the ripe cones fragment on the tree, seed must either be collected from the ground or be obtained by gathering nearly ripe cones from the standing trees. Fallen seed deteriorates rapidly, if it is exposed to hot, bright sunlight, and is quickly eaten by small rodents and insects. If it falls on damp shady ground it quickly goes mouldy. Arrangements must therefore be made to collect seed every morning during the seed shedding period. Kenya practice was to dry the seed carefully under shade until risk of it going mouldy was past, followed by storage in cotton bags for as short a time as possible until it could be planted.

The alternative of collecting nearly ripe cones from the trees is also difficult and was seldom attempted in Kenya. Climbing the trees is unpleasant because of their prickly foliage and sometimes dangerous because of their facility of shedding large branches. Because the cones do not ripen simultaneously the trees have to be climbed several times during the season, and it is difficult to know precisely which cones are at the correct stage of maturity. These problems have been carefully studied for A. cunninghamii in Queensland and for A. hunsteinii in New Guinea (Nikles, 1965 and Havel, 1965, quoted in Ntima 1968), but this information was not available in Kenya in the mid-1950's when seed was required in quantity for plantation projects. Up to that time, seed had been occasionally collected from the ground and small batches of planting stock raised on the initiative of individual foresters.

VEGETATIVE PROPAGATION

In Kenya, trees felled in the older trial plots frequently produced coppice shoots from the stumps. In some cases these coppice shoots were grown on to develop an understorey crop. Shoots of A. cunninghamii about 2 m tall were also occasionally harvested and sold as cut Christmas trees. Others were set as cuttings. From time to time, when a sufficient supply of young basal shoots became available, small rooting experiments were made. It was found that Araucaria angustifolia cuttings could be easily rooted in nurseries at 2,500 m elevation, where a period of mountain mists occurred during July and August. Terminal shoots, 15-20 cm long, were simply pushed into earth-filled nursery beds and kept shaded and watered until they showed signs of growth. Thereafter they were treated in the same way as seedling stock of similar size. Araucaria cunninghamii shoots were similarly rooted in a warmer nursery at about 1680 m elevation. The technique was not developed further because supplies of coppice shoots were sparse and irregular. However, since stumps can produce repeated crops of shoots, it should be feasible to fell a plantation and maintain the stumps as a source of new rooted cuttings planting stock (Wormald 1967).

In Tanzania, Willan (1966) used the patch graft method described by Nikles (1964) to produce A. heterophylla transplants on A. cunninghamii rootstocks, when seed of A. heterophylla was not available. These plants were easily transplanted to the Lushoto arboretum and grew well for a few years. Unfortunately, A. heterophylla grows faster at Lushoto than A. cunninghamii and the scions invariably outgrew the rootstock so that by age 10 many grafts had become unstable and broke off at the union. This technique however, might be used a method of generating suitable cutting material without having to sacrifice scarce, large, parent trees to produce coppice shoots. During the present year the writer has made cuttings from odd coppice shoots available from plots of A. cunninghamii, A. columnaris, A. hunsteinii and double leaders from seedlings of A. bidwillii at CATIE, Turrialba. Small pieces were used, 5-10 cms long and set in a sand/sphagnum moss mixture in a mist propagator. Numbers are small and the trials incomplete, but all four species seem likely to root well.

FIELD SCALE PLANTATIONS

In 1956, there was a demand for substantial numbers of Araucaria angustifolia seedlings to plant certain high altitude, 2,500 - 2,750 m.a.s.l., sites on the eastern slope of the Kenya Aberdare Mountains. A deliberate effort was made to collect all seed available from the 1911 and 1927 plots. Systematic daily collection of fallen seed was organized and the seed planted promptly in high altitude nurseries. During the next few years collections varied between 360 and 540 kilos of fresh seed and very high germination percentages were achieved. As collected in Kenya, a kilo of Parana pine seed contains about 120 viable seeds and between 50 and 60 acres (20.2 - 24.3 ha) could be planted annually at the then usual spacing of 8 x 8 ft (2.44 x 2.44 m). The trees were established in taungya cultivation areas and grew steadily at about 0.3 m height growth per year. With changes in planting policy in the early 1960s, interest in the species waned but several hundred hectares of promising plantations remain from this programme.

About the same time a softwood planting programme was called for on the Kenya coast near Mombasa. Among early trials, only Araucaria cunninghamii showed any promise and again a special effort was made to collect all seeds available from old highland trial plots. Fewer parent trees were available but some 10-15 kilos of seed

was collected annually for the next few years and produced sufficient seedlings to plant about 10 ha per year. Attempts to increase the area planted annually by importing seed from Queensland by air were expensive and not very successful and Araucaria planting at the coast was discontinued as soon^{as} Pinus caribaea could be successfully planted and was found to be much faster growing. (There had been a mycorrhizal problem which took some years to solve).

Plantations of both species have remained healthy for over twenty years, and are a potential source of high quality timber. In the dry Kenya climate, however, they are much slower growing than Pinus species adapted to the similar sites, and are likely to be reserved for specialist uses. (Chapman & Wormald, 1966). This conclusion has also been drawn from trial plots in Uganda (Stuart-Smith, 1965) and Tanzania. Under the more humid tropical conditions of the Atlantic slope of Costa Rica, by contrast, trial plots suggest that Araucaria cunninghamii and A. hunsteinii may outyield Pinus species on the same site (Combe & Gewald 1979). The possibility of growing Araucaria as an understorey in Pine plantations, as experimentally practiced in Queensland has not yet been tested in any of the four countries.

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