GROWTH, LITTER YIELD AND LITTER NUTRIENT COMPOSITION OF *CASUARINA OLIGODON* IN THE PAPUA NEW GUINEA HIGHLANDS

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ABSTRACT

Casuarina Oligodon *is the most common planted tree species in Papua New Guinea Highlands. A growth study of* C. oligodon *was carried out at the three sites at different altitudes (2000, 1750 and 1300 m above sea level). Another unreplicated observation study examined litter yield and nutrient composition of* C. Oligodon *using a three year old stand (4444 trees/ha) over a three year period. At the 2000 m site, the height and diameter growth was slower initially but reached 4.5 m and 47 mm respectively at 33 months. The site also recorded 100% survival of seedlings. At the 1750 m site, the height growth slowed after 12 months which was mainly due to the continuous die back of growing apical tips. The diameter showed almost positive linear growth. About 69% of the plants had dead apical growing tips with 6% mortality. At the site at 1300 m, height and diameter at 12 months were 3.0 m and 34 mm respectively. The results of the litter yield study show that monthly average ranges between 200 and 400 kg/ha (dry matter) from a three-year-old plot. Although the nutrient content in dry leaf litter was low, it returned to the topsoil 45.6, 2.4 and 9.6kg/ha of N, P and K respectively.*

Keywords: Casuarina oligodon, *litter yield, nutrient composition, agroforestry, multipurpose tree.*

INTRODUCTION

Casuarina oligodon (L. Johnson) is endemic to New Guinea. It is found mostly in the upland valleys over an altitudinal range of 700-2600 meters above sea level (m.a.s.l.), occasionally as high as 2820 m.a.s.l., and is most common at 1400 to 2100 m above sea level in Papua New Guinea (PNG) (Bourke 2000). Since the arrival of Europeans in the early 20th century, both the government agencies and non-government organisations have played a major role in encouraging adoption and spread of this species. *C. oligodon* is now the most common tree species in the highlands and is planted as a fallow species, to provide shade for coffee, for rehabilitation of grasslands and for various wood products). Casuarina has been well accepted into the traditional farming systems and since habitation and cultivation of crops is found up to an altitude of 2850 m.a.s.l. (Ghodaka 1994), this species may play a vital role in the higher altitude farming systems. Between 1400 and 2000 m.a.s.l. is where most of the indigenous agroforestry systems using *C. ologodon* are found (Bourke 1985).

The Highlands Agriculture Experiment Station (HAES) under its agroforestry research program has a mandate to develop low input sustainable farming systems for subsistence farming. One part of the program includes collection and evaluation of different multipurpose tree species (MPTS) under varying agro-ecological conditions. *C. oligodon* was included in seveal such studies. The broad objective was to identify the best performing MPTS with desirable attributes for use in agroforestry systems.

The first part of this paper reports the growth performance of *C. oligodon* at three sites at different altitudes. The second part reports a study of *C. oligodon* leaf litter production and nutrient turnover at Aiyura.

MATERIALS & METHODS

Study Sites

Trials assessing the growth performance of *C.oligodon* together with other MPTS were carried out at 2000 m.a.s.l. at Gumine, Simbu Province, 1750 m.a.s.l. at Aiyura, Eastern Highlands Province (EHP) and 1300 m.a.s.l. at Tabibuga in Western Highlands Province (WHP).

The site at Gumine (6° 14' S, 144° 59' E) was located on a 40-50% slope with a NE-SW aspect. The top soil depth is about 30-50 cm and is mostly made up of volcanic ash. The subsoil is made up of moderately drained, dark yellowish clay. The mean annual rainfall is about 2100 mm. The land was previously used to grow sweet potato and was under *Imperata cylindrica* dominated grass and shrubs.

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The Aiyura site (6° 19' S, 145° 35' E) has a mean annual rainfall of 2100 mm. The tiral was established on 25-30% slope. The top soil is about 15-25 cm in depth and the subsoil is mostly made up of poorly drained heavy clay.

The trial site at Tabiguba (5° 50' S, 145° 50' E), is wetter with a mean rainfall of about 3000 mm/year. The trial was laid out on a 50-60% slope. The top soil is quite shallow probably as a rresult of soil erosion which resulted from frequent cultivation of the site. The subsoil is a moderately drained light orange clay.

All seedlings were raised in a central nursery. Seedlings were transported to the Growth measurement trial sites for planting when they were four mouths old and about 30-50 cm high. *The trials were planted using a randomized complete block design and were replicated three, four and three times respectively.* At the 2000 m.a.s.l. and 1300 m.a.s.l. sites, there were 15 seedlings *per replicate* planted at 1.5 m x 1.5 m spacing (three seedlings per row by five seedlings per column in a rectangular block) with nine measurable plants excluding the border plants. At the 1750 m.a.s.l. site, there were 20 seedlings *per replicate* planted at 1.5 m x 1.5 m spacing (two seedlings per row by 10 seedlings per column rectangular block) with 16 measurable plants excluding border plants. Growth data (height and diameter) were recorded at three monthly intervals.

The study of litter yield and nutrient composition was carried out at Highlands Agricultural Experiment station at Aiyura. It used a three year old plot of *C. oligodon* planted at 1.5 m x 1.5 m (4444 trees/ha) triangular spacing. The total area of the stand is 7.5 m x 9.0 m (67.5m^2). The trees were on a moderate slope of about 30%. The top soil is about 30 cm deep and the subsoil is a moderately drained light to heavy clay.

Twelve litter traps each measuring 1.5 m x 1.5 m were randomly placed under the plot of *C. oligodon*. This was an unreplicated observation study due to the small size of the casuarina plot. The litter traps were made with 1 mm mesh shade cloth and supported off the ground, to retain fine litter fraction and allow free drainage of water. Litter was collected every four weeks starting November 1990 for three years. The samples were oven dried to constant weight and sub samples were sent to the Department of Agriculture and Livestock chemistry laboratory for analysis.

RESULTS AND DISCUSSIONS

Growth measurements

There was 100% survival of *C. oligodon* at 2000 m.a.s.l. and 1300 m.a.s.l. sites while at 1750 m.a.s.l. site, 6% (1) of the seedlings died and 69% (11) had dead apical growing tips. The height at 1750 m showed steady growht for the first 12 months but slowed down to 21st month, and gradually picked up to the 33rd month. (Figure 1). This may be due to the thick layer of iron/manganese concretions found at the depth of 30 cm which impeded root penetration. The root network of some plants uprooted from the

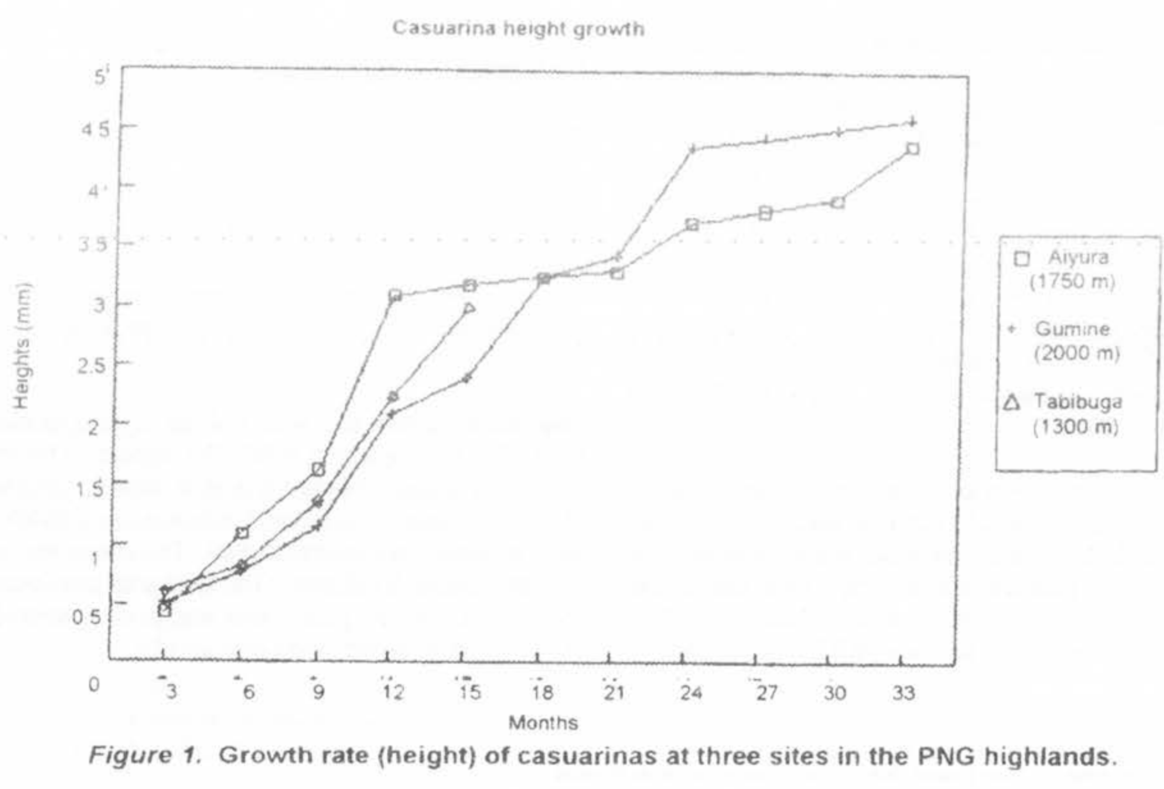

Figure 1. Growth rate (height) of casuarinas at three sites in the PNG highlands.

adjacent areas showed the taproot and lateral roots were growing in a horizontal fashion to find a space to penetrate the lower soil horizons. Meanwhile the diameter growth (Figure 2) of these trees was unaffected and reached more than 50 mm by 33 months.

At the highest site, the height growth rate (Figure 1) was less initially but reached more that 4 m in 33 months while the diameter (Figure 2) grew at a slower rate. This growth rate was much higher than other MPTS tested as observed on the same site. Altitude may be limiting growth of other multi-purpose tree species. At the 1300 m.a.s.l. site, the height and diameter growth (Figure 1 and 2) at 12 months was slow but rapidly increased after that.

At the 2000 m.a.s.l. site, *C. oligodon* was able to achieve growth comparable to the other MPTS at the site at 33 months. At 1300 m, where more tree species are suited to the altitude, the climate, humidity and other enviornmental factors, other MPTS were able to compete with *C. oligodon*, decreasing its growth rate.

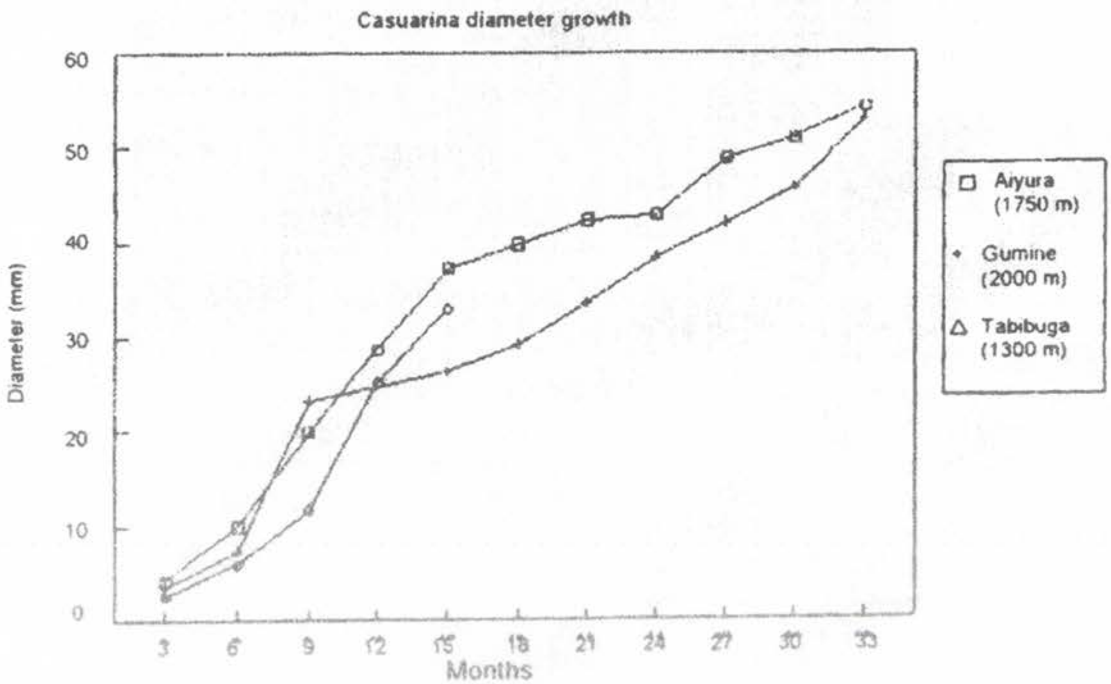

Figure 2. **Growth rate (diameter) of casuarinas at three sites in the PNG**

Litter yield and nutrient composition

The mean monthly leaf litter yield of *C. oligodon* based on three years of data is depicted in Figure 3. There was no relationship between litter yield and month of the year. The mean monthly yield ranged between 200 and 400 kg/ha (dry matter). Harding (1994) reported, from a similar study using *C. oligodon* as coffee shade and planted at 5x5 m (400 trees/ha) in the Kainantu area, that higher litter yields were obtained in the wetter months between October and February. He found a *C. oligodon* litter yield of 7000 - 8000 kg (dry matter) ha/yr from 10-15 year old stand. This is two to three times higher than that reported in this study. This may indicate that older stands produce more litter than the younger stands. The enviornmental factors that influence the growth of the trees may also determine the performance of the trees and hence the litter production.

The *Casuarina oligodon* litter had an average N content of 1.2% (Table 1) which corresponds well to that reported by Harding (1994) of 1.0-1.4%. The N, P and K contents in *C. oligodon* leaf litter are low. This could be due to the translocation of plant nutrients to the actively growing areas of the tree before leaf fall.

The monthly means litter yield (274 kg/ha) and data from Table 1 were used to estimate mean montly nutrient inputs in *C. oligodon* leaf litter (Table 2). It shows *C. Oligodon* can return 39, 3 and 10 kg of N, P and K per ha per year of the respective nutrients. The N is about half the amount reported by Harding (1994) who estimated it to range between 84 to 123 kg/ha/year in *C. oligodon* leaf litter. This could largely be due to the age of the stand. It is possible that, as the trees grow older, the litter production of the trees also increases. In addition, the density of the stand may also have some influence on the litter production, that is, the widely planted trees may have wider

Figure 3. **Average monthly *C. oligodon* litter yield (dry matter) based on three year data.**

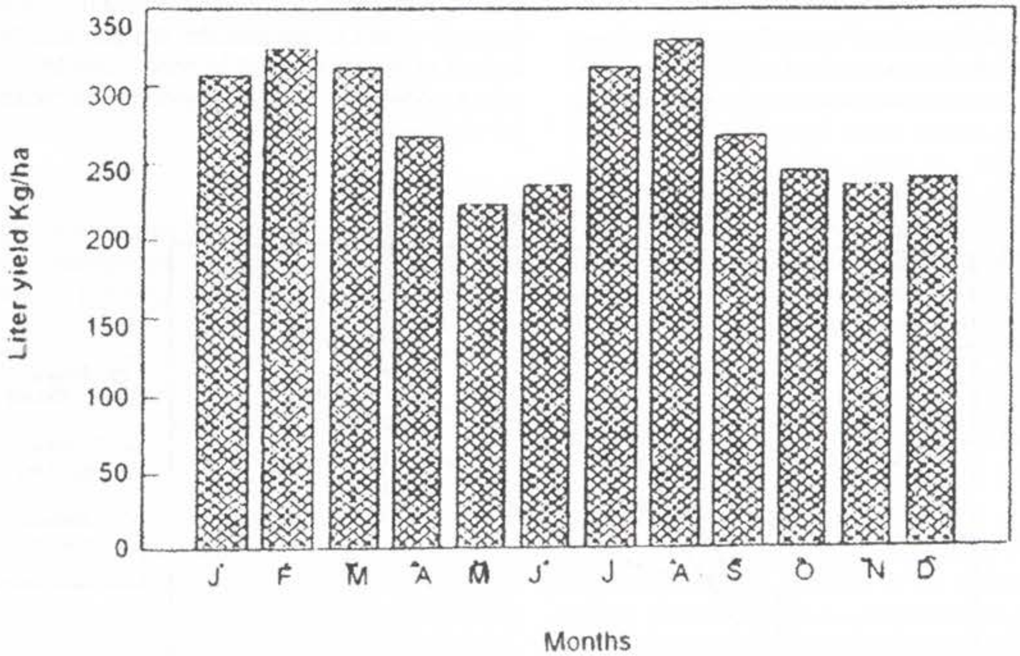

Table 1. **Average nutrient content of *Casuarina oligodon* leaf litter**

% of dry matter					
N 1.2	P 0.1	K 0.3	Ca 1.2	Mg 0.2	S 0.2
Microgram/g of dry matter					
Mn 370	Fe 184	Zn 34.0	Cu 7.0	B 32.0	

Table 2. **Mean annual nutrient inputs Kg/ha in *Casuarina oligodon* leaf litter**

N 39	P 3	K 10	Ca 39	Mg 7	S 7
Mn 1.37	Fe 0.68	Zn 0.13	Cu 0.03	B 0.12	

and larger canopy with the capacity to produce more litter than closely spaced trees with narrow canopy.

CONCLUSION

C. oligodon is likely to remain the most important multipurpose tree in the traditional farming systems at altitudes of 2000 m.a.s.l. and above. This was demonstrated when it had a 100% survival at 2000 m.a.s.l. However, when comparing its performance at three different sites at different altitudes, it achieved the best growth at 1750 m.a.s.l. The most suitable altitudinal range for best performance of *C. oligodon* is possibly between 1400 and 2000 m.a.s.l.

The litter yield study from a stand of *C. oligodon* when it was three, four and five years old shows that it can return 200-400 kg (dry matter) /ha/month of litter. The results did not show clear evidence of a relationship between litter yield and month of the year, although this may be due to the disruptions in the normal weather pattern. The nutrient content of *C. oligodon* leaf litter apperars to be low with average N, P and K contents of 1.2%, 0.1% and 0.3% respectively. However, the nutrient contribution in leaf litter is 39, 3 and 10 kg/ha/yr for N, P and K respectively. It is possible that the litter yield and nutrient contribution would increase as the stand grows older.

RECOMMENDATIONS

It would be useful to know the nutrient content of fresh *C. oligodon* leaf litte to assess its potential as green manure. According to Thiagalingam (1983), soil nutrients under *C. oligodon* increase with the age of the trees. However, there is no information on the actual amount of nitrogen fixed by *C. oligodon*. Also it would be useful to know the rate of *C. oligodon* litter breakdown in the soil to understand the process of soil nutrient contribution by this species.

The following is recommended:

- The biological nitrogen fixation ability of *C. oligodon* should be quantified;
- The nutrient content of fresh *C. oligodon* leaves should be determined;
- The break down rate of both fresh and dry *C. oligodon* litter should be studied;
- The effect of *C. oligodon* on the soil fertility maintenance and its effect on crop production should be studied;
- Management of *C. oligodon* in agroforestry systems should be described; and
- Some of the wood and non-wood properties should be studied.

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REFERENCES

BOURKE, R.M. (1985). Food, coffee and casuarina: an agroforestry system from the Papua New Guinea highlands. Agroforestry Systems 2 (4): 273-279.

BOURKE, R.M. (2000). Managing the species composition of fallows in Papua New Guinea by planting trees. In *Voices from the Forest: Farmer Solutions Towards Improved Fallow Husbandry in Southeast Asia. Proceedings of a Regional Conference on Indigenous Strategies for Intensification of Shifting Cultivation in Southeast Asia.* M.F. Cairns (ed.) International Centre for Research in Agriforestry, Bogor.

GHODAKE, R.D. (1994). Adjustments in the highlands agriculture of Papua New Guinea. Paper presented at the International workshop on evolution of mountain farming systems, Pokhara, Nepal.

HARDING, P.E. (1994). A comparison of the nitrogen requirement of two coffee (*Coffee arabica L.*) management systems in Papua New Guinea. Unpublished PhD thesis. Department of Soil Science, University of Reading.

THIAGALINGAM, K. (1993). Role of casuarina in agroforestry. In: Midgley, S.J., Turnbull, J.W. and Johnston, R.D. (eds.). Casuarina Ecology, Management and Utilization. CSIRO, Melbourne. pp 175-179.