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The Prospect of Commercialising Boab Roots as a Vegetable

A report for the Rural Industries Research and Development Corporation

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Foreword

Current consumer trends are looking for a more diverse range of products. This has spurred an increasing interest in native Australian foods leading to a number of small-scale successes in developing new food products based on native flora species.

A number of annual and perennial native species have the potential to be commercialised as vegetable crops with the possibility of mainstream horticulture production.

This publication examines the potential for commercialising one of the well-known native flora species from the Kimberley the Boab tree *Adansonia gregorii*. It examines the indigenous uses, analysis the chemical composition and examines the results of small-scale agronomic trials. A preliminary economic evaluation of its commercial potential has been produced.

This project was funded from RIRDC Core Funds, which are provided by the Federal Government.

This report, a new addition to RIRDC's diverse range of over 700 research publications, forms part of our New Plant Products R&D program, which aims to facilitate the development of new industries based on plants or plant products that have commercial potential for Australia

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Peter Core
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The following report examines the potential for commercialising *Adansonia gregorii*, it is important that any person wishing to undertake commercial production of *Adansonia gregorii* must contact the Department of Conservations and Land Management to seek current regulations in regards to commercial production of native flora species.

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Executive Summary

The Australian boab *Adansonia gregorii* is indigenous to the Kimberley region of Western Australia. Although the tree is recognised for its iconic value amongst non-indigenous Australians it is well known amongst the indigenous populations of the Kimberley as a tree with a vast array of uses including food, medicine and shelter.

Adansonia gregorii is closely related to eight other Adansonia species found in Africa and Madagascar. These related species have also long been used a regular food source by the indigenous populations of Africa forming part of the staple diet. Studies on the African species have identified parts of the tree being rich in Vitamin C (ten fold that of oranges) and Vitamin A. However in spite of this *Adansonia gregorii* has to the most part been over looked for its potential commercial value. Although some enthusiastic local residents in the Kimberley region of WA have been cultivating the tree.

The purpose of this study is to have a preliminary evaluation of the Boab roots to assess its potential as a cultivated vegetable crop. The study examined the chemical composition of the crop, which has identified no known toxic compounds exist in the roots. The nutritional breakdown has identified the roots are rich in Potassium and are a moderate source of starch and sugars.

Small-scale trial planting's gave mixed results with excellent germination during the wet season and very poor germination during the dry season. Trialing various techniques to improve germination identified that sulphuric acids dip and manual scarification of the seed gave improved results.

Samples from the initial trials were sent to the Hyatt hotel in Perth for an assessment by the chefs for its culinary potential. This was combined with a promotion that was featured on a Channel nine documentary giving the project high profile. Feed back from the assessment was very positive both from the chefs and the consumers. Whilst conducting the assessment a post harvest breakdown of the product was identified, when stored at higher temperatures. Rapid cooling to 1 to 2 degrees Celsius post harvest rectified this problem. The assessment also identified wide spread interest in the leaves as a salad vegetable.

Larger scale trials identified that seed extraction, planting and harvesting can be mechanised thus keeping the production costs at a minimum. These trials examined several different pre seed treatments and the benefits of incorporating fertiliser at planting. Interestingly the sulphuric acid gave poor results in this trial, which is believed to be due to the timing of the treatment. Twelve-month-old seed and double density planting gave the highest results. Extrapolating these results gives to 18-20 tonnes per hectare of marketable product. The addition of fertiliser did not significantly improve the yields. Weed control during the first few weeks of planting presents a problem and will require further evaluation of herbicides.

The economic analysis has identified the seed represents the largest single production cost. The analysis based on yields of 8.9 t/ha and a price of $5.00kg gives a gross margin of $22,267 ha. The sensitivity analysis indicates that the break-even price per kg at 8.9t/ha is $3.01 and at 13.3t/ha is $2.47/Kg. Improved germination rates has a significant positive effect on the gross margin.

The prospects for commercialising the crop look very promising with positive market response for the roots and leaves, the ability to mechanise production, short production time 6 to 8 weeks and a favourable economic analysis. The major limiting factors initially with developing an industry is securing a seed supply (time taken to establish a seed stock.) and undertaking the promotion required to introduce the product to the wider community.

1.0 Introduction

Native Australian flora has contributed very little to the range of commercial horticultural food crops currently produced around the world today. The only noticeable exception to this is being *Macadamia intgafolia* the Macadamia nut. This is somewhat surprising as a great number of Australia’s flora species not only constituted a major role in the diet of Aborigines but some such as the quandong have been used non commercially by Europeans since the time of settlement. However in recent years there has been a growing awareness in the horticultural industry that some of Australia’s unique diverse flora has commercial potential. This has initially given rise to a small bushfoods industry, which emerged in the 1980’s

Australian bushfoods have come along way since early experimentation by chefs and Australian food enthusiasts. The demand for unusual and very Australian dishes has identified a range of Australian flora that can be useful food resources. Up until now the Australian Boab, *Adansonia gregorii* has had a very low profile as a bush food, unlike its related species in Africa, *A.digitata*, and Madagascar, *A.greandidieri*. The use of *A. gregorii as a* root crop food has so far been restricted to some local enthusiasts and the Aborigines of the region who have traditionally used different parts of the tree as part of their diet.

Figure 1 Adansonia gregorii A common sight in the Kimberley region of Western Australia

The Australian Boab (also known as baobab) is part of the genus Adansonia and is classified under the small family group of Bombacaceae. The genus consists of eight species – six are endemic to Madagascar, one occurs both in Africa and Madagascar, and the final one, *A. gregorii*, is endemic to northwestern Australia (Bowan, 1997 and Du Puy, 1996).

The name Adansonia is came from M. Adanson who was a French naturalist and gregorii from the explorer AC Gregory. (www.farrer.csu.edu.au/ASGAP/a-gre.html, 2001) It known to the local population as a calendar plant due to the fact that when its large fragrant white flowers start blooming it means that the rain or wet season is on its way. (www.ozemail.com.au/~sirius2/boab.html.)

A.gregorii is a large spreading tree to 15m high and the branches radiate from the top of the swollen barrel like trunk that can be up to 20 metres in circumference (Brock, 1988). The tree has very smooth grey-brown bark and compound leaves that comprise of 5-9 leaflets that are elongated with a pointed tip. Flowering occurs anytime from October through to December with fruit set from January to April. (Brock, 1988)

The fruit of the Boab are small to large woody capsules that are brownish with a fine hair layer and contain many kidney-shaped seeds embedded in white pith like substance. Boabs will grow where there is free draining soil, predominantly on sandstone country in dry regions. (Brock, 1988)

Cultivation of the Boab is by seed although specimens are not often seen outside its natural geographical range. It is best suited to cultivation in the tropical climates where it requires well-drained soils. (Brock, 1988 and www.farrer.csu.edu.au/ASGAP/a-gre.html, 2001)

A gregorii is unique in that it is only found in the Kimberley region of Western Australia and has become an icon for the region.

The tree is deciduous and its range extends from the sandy plains on the Logue River between Broome and Derby, to the Victoria River Basin in the Northern Territory (www.ozemail.com.au/~sirius2/boab.html).

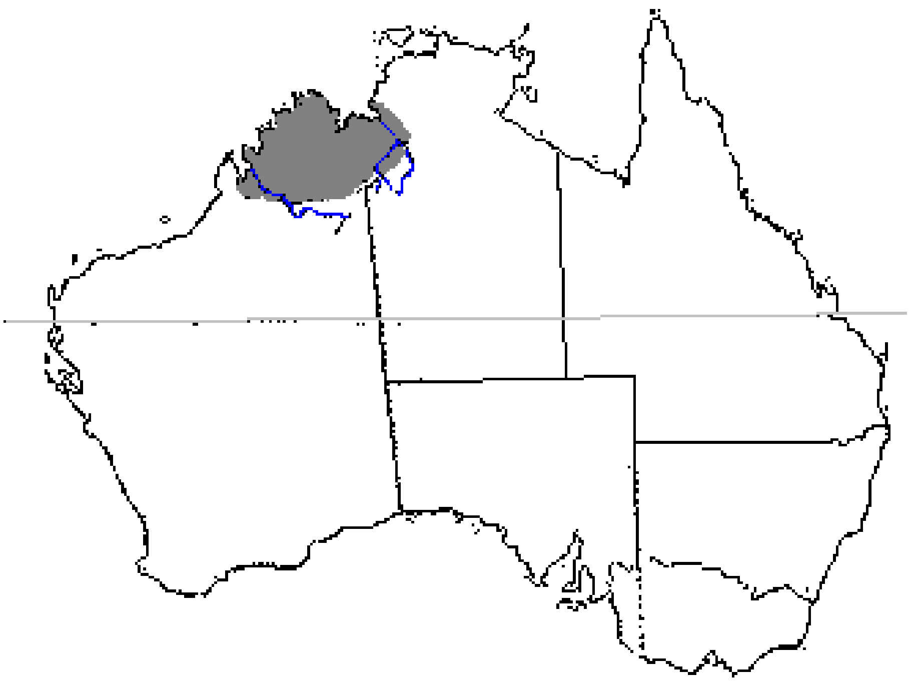

Figure 2. Geographic range of *Adansonia gregorii*.

The Australian Aborigines found *A. gregorii* to be of economic importance as various parts of the tree provided food, medicine, emergency supplies of water, fibre, glue and shelter (Bowan, 1997). Almost every part of the tree was found to have some use. The gourd like fruit is rich in protein and Vitamin C and carved as an ornament. The bark of the tree is used for making twine and the gum as glue. (www.ozemail.com.au/~sirius2/boab.html)

Local aboriginal people have traditionally used the nuts as decorative ornaments depicting aboriginal cultural scenes. The dark hairy surface of dry boab nuts is scratched away to reveal the lighter smooth surface of the nut in order to create a pictorial story. (www.discoverwest.com.au/derbyptr.html)

Brock (1988) states in his book that the Aboriginals used the seeds and the pith of the fruit for eating and the bark from the roots, which is beaten, to make string. Sap from the trunk and branches is eaten and in emergencies and the fibrous pith from the trunk and branches can be eaten after boiling.

Early European settlers to the region soon found uses for the tree in the form of shelter, stock food in times of drought and even turning the hollowed centres of the trees into the occasional prison. Cattle will eat most parts of a fallen tree. (Brock, 1988)

To date little to no research has been conducted on *A gregorii*, which is in contrast to the African baobab species *Adansonia digitata*. Significantly more research has been completed on *A digitata* with regards to the use of the tree as a food source as it has been an important food source for the African people especially in times of drought and famine.

Cannell (1989) states that the Baobab (*A. digitata*) of Africa provides a balanced diet from its leaves, sap, fruit pulp and seeds.

In Africa parts of the *A. digitata* species that are eaten as a food include;

- the leaves, especially the young leaves that are popular as a spinach or are dried and powdered and made into soups and sauces. Fresh leaves are very rich in vitamin C and A;
- the fruit pulp, which has a high vitamin C content which is at least tenfold that of oranges;
- flour, rich in protein and oil, is made from the seeds and kernels;
- the Roots, young tender roots are cooked and eaten;
- the fresh flowers are sometimes eaten raw.

Figure 3 Boab Flower

Figure 4 Boab seed pod

All of the produce is treated as a vegetable or as a seasoning (Booth et al, 1998., Dupriez et al, 1989., FAO Food Nutrition Paper, 1998., and Wickens, 1980).

In Madagascar the swollen taproot of the seedling, particularly the seedling of the species *Adansonia rubrostipa* that grows to approximately 7 centimetres in length and 4 centimetres thick, is sought after and eaten by locals. (Du Puy, 1996)

The primary aim of the project in researching *A. gregorii* was to identify the potential of commercialising the root of the young plant as a crop. The research carried out has to satisfy product potential in all aspects of crop production through to the end market.

Figure 5 Mature Boab tree

2.0 Objectives

The objective of the project is to undertake some preliminary studies to determine the commercial potential for the Boab as a novel vegetable line with the aim of establishing itself into the a gourmet vegetable market. To achieve this the following objectives need to be achieved

- Examining the indigenous uses for the plant
- Produce a small trial planting
- Ascertaining the chemical composition and potential nutritional value
- Conducting a market appraisal of the product
- Produce an economic model to examine the potential commercial benefits
- Conduct preliminary studies on agronomic aspects
- Publicise result and information

3.0 Methodology

3.1 Preliminary Assessment

3.1.1 Seed Collection

In order to identify the commercial viability of collecting *A. gregorii* seed a collection was undertaken that identified the availability, time required to collect, processing time – removing the seed from the pods - and the quantity of seed gained including mean number of seed per seed pod.

3.1.2 Germination Assessment

The seed collected was then used to conduct propagation experiments at different times of the year. The results would ascertained the ease or difficulty in propagation and identify the viability of being able to produce a year round crop.

3.1.3 Chemical Analysis

Young Boab roots were collected and sent away for nutrition and toxicology analysis – the root samples were analysed by the WA Chemistry centre which ascertained the nutritional breakdown and identified if there were any toxic compounds.

3.1.4 Product Assessment

A small planting was then conducted to assess the product. Looking at the product's appearance, nutritional content, flavour and texture.

3.1.5 End User Evaluation

An end user evaluation assessment was then conducted with a larger planting undertaken to be able to supply over a number of weeks. Samples of the product were distributed to potential end users and feedback was gained.

Follow up samples were sent to the market and to large potential customers

The ease of storage and transport of the Boabs was assessed, to identify what would be the optimum temperature that the product should be kept and transported at to keep it at its best.

3.2 Larger scale Trial

Smaller trials previously undertaken identified that the germination of the Boab seed during certain parts of the year is problematic and more assessment of germination levels through seed pre-treatments, nutritional requirements and planting densities of the Boab were required.
Identification is also required, determining the suitability of commercial machinery for the mechanisation of seed cleaning, planting and harvesting of the crop.
Harvest figures would provide identification of total yield potential and percentage of marketable product.

3.2.1 Site Details

An area on the Department of Agriculture Frank Wise Institute (FWI) Kununurra was used for this trial. The area of the trial consisted of 6 beds 40m long on a sandy loam soil type. The beds were 1.8m wide and raised to 16 cm high. The trial area was sprayed to remove all the weeds prior to planting and the seed was planted in four rows per bed.

3.2.2 Aim

To identify an effective germination level, using pre seed treatment and different aged seed. Assess the effect of incorporating fertiliser at planting time and planting density for the Boab. Identify and assess the potential for mechanisation of various aspects of production.

3.2.3 Treatment

The trial was planted as a randomised replicate design with four replicates and six treatments.

Table 1. Planned treatment layout for the trial

Rep 1	T3	T4	T1	T5	T6	T2
Rep 2	T4	T6	T1	T2	T5	T3
Rep 3	T1	T3	T4	T5	T2	T6
Rep 4	T2	T1	T3	T6	T4	T5

Road

The treatments were:
1. One year old seed Source 1 Pith removed
2. One year old seed Source 2 Pith remaining.
3. Fresh seed from tree.
4. Fresh seed pre-treated with sulphuric acid for 12 hours
5. Fresh seed planted at double density
6. Fresh seed planted at single density plus nutrition

The seed for treatment 4 was soaked in 98% sulphuric acid for 12 hours then rinsed. From prior experimental work this appeared to be the best practical seed pre-treatment for an increase in germination rates.

Plots of 5m were sown with the seed spaced at 4cm apart or 25 seeds per metre (except treatment five that was at double density 2cm apart). Each plot had a one-metre gap between the end of the five metres and the next plot starting. The seed was sown at a depth of 3cm using a cone seeder, with four rows per plot. At each of the ends of the six rows a 5m buffer was placed using FWI seed.

The plots were all spayed with Glyphosate to control weeds prior to planting. Treatment 6 had the fertiliser Kristalon® applied at 500g/plot with the ratio 3g N, 11g P, 38g K, 4g MgO and micronutrients before planting.

3.2.4 Measurement

The trial was monitored on a weekly basis with germination rates recorded. A visual scout of the plants was also undertaken to identify any potential pests or diseases on the Boab seedlings.

Record data on harvest date, number of plants, total weight of roots harvested, marketable number of plants. Also noting the number of forked, broken, undersized and other deformities. such as bends and their weight. The weights of the leafy tops was also recorded.

A harvest trial will be undertaken over a number of weeks to identify the best harvest time, the amount harvested in a specified area and the marketable yield for each treatment.

3.3 Economic Analysis

An economic model has been developed utilising the production cost structures of similar root crop, eg carrots and parsnips. Specific costs that are unique to this crop and can be quantified have been used. However as this crop has never been produced commercially the model can only be used as a guide and will need further refinement once commercial production commences. The model works on the assumption that there is an existing enterprise on the land and much of this machinery can be utilised.

A sensitivity table has been developed to assess the viability of commercial production under several yield/price scenarios. Yields of 4.4, 8.8, 13.3, and 17.7 tonnes per hectare were used in comparison with prices of $2.5, $3.75, $5.00, $6.25 and $7.5.per Kg.

For the model itself yields of 8.8 and prices of $5.00 Kg were used it is believed that both these are realistically achievable.

4.0 Results

4.1 Preliminary Results

The first seed collection and small plot trial occurred in February 2000, to establish seed viability and germination at the time that Boabs normally germinate under natural conditions. A high germination level was noted.

The second seed collection occurred in July 2000. From that collection 64 seedpods were collected and after processing 3137 seeds were gained, that is an approximate mean of 50 seeds per seedpod.

The second small plot trial was planted on the 20th August to determine the viability of the seed, germination rates and assess the need to conduct germination tests. Table 2 shows the planting's that took place, including the two planting dates and germination dates. The results in the table indicate a low germination rate in the Kimberley dry season.

Table 2. Germination outcomes of second trial planted

	Germination		
Planting's	24/8/00	13/9/00	4/10/00
20/7/00	7	30	29
20/7/00 (G)	4	6	11
9/8/00	4	8	24

20/7/00 – approx 300 seeds planted
20/7/00 (G) – green seed pods – approx 150 seeds planted
9/8/00 – approx 300seeds planted

A germination trial was conducted on the 13th of September 2000. The results of the trial can be seen in Table 3. The germination treatments were based on successful outcomes of boab seed germination from Danthu, P. et al 1995 (8). Each treatment was conducted using 100 seeds.

Table 3. % Germination of Boab seed utilising seven different seed treatments.

Treatment	7 days	14days	28days
Control	0	0	1
Manual scarification	14	29	43
Oven	0	0	2
Boil	3	6	13
Sulphuric Acid 6hrs	15	39	41
Sulphuric Acid 12hrs	14	19	44
Heat bed	0	0	1

The third trial conducted incorporated the Sulphuric acid 12 hour treatment, which was identified as having the best germination levels and also used older seed that had been allowed to sit for a year. An increased number of seed were planted over three planting dates to coincide with end user evaluation requirements. The results of germination are presented in Table 4. The sulfuric acid treated seed had relatively high germination rates but the one year old seed provided the best germination.

Table 4. Germinating numbers of plants

	No. of seed germinating			
Planting	22 days	31 days	41 days	50 days
9/2/01	60	67	100	101
23/2/01		0	114	127
10/3/01			0	229

9/2/01 - NA
23/2/01 – 1340 seeds planted
10/3/01 – one year old seed (no sulphuric acid)

Figure 6 Initial test planting

4.1.1 Characteristics

At 40 days of age some of the Boabs were picked at random to be measured for length of root, diameter of root and leafy top height, the measurements were used to provide a general plant description at time of harvest and the measurements are presented in Table 5. Growth rates during this time of year appear to be slower than with wet season planting's.

Table 5. Measurements taken from the second planting 9/2/2001 taken on the 21/3/2001

	1	2	3
Length of root (cm)	16.9	19.8	18.0
Diameter	0.83	0.95	0.87
Height of leafy top	20.9	19.1	20.8

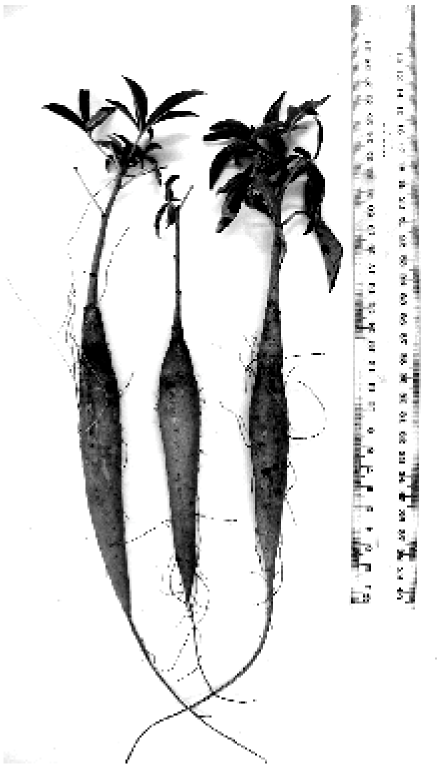

Figure 7 Typical swollen roots at 40 days of age.

4.1.2 Analysis

Table 6 presents the results gained from the Chemistry Centre for the boab root samples.

Table 6. Nutritional and toxicological analysis

Analyte	Analysis
Protein (crude)	5.4 %ar
Protein (crude)	0.26 %ar
K	2.73 %ar
Na (ICP)	0.05 %ar
Ca (ICP)	0.68 %ar
Mg (ICP)	0.36 %ar
S (ICP)	0.06 %ar
Cl (ICP)	0.61 %ar
B (ICP)	13 mg/kgar
Cu (ICP)	4.6 mg/kgar
Fe (ICP)	630 mg/kgar
Mn (ICP)	28 mg/kgar
Zn (ICP)	20 mg/kgar
CN	<0.5 mg/kgar
H2O	6.7 %ar
Ash	7.9 %ar
Fat	3.6 %ar
Starch	16.7 %ar
CHO	16 %ar
Fibre (crude)	21 %ar
Sugars	19 %ar
F	<0.05 %ar
SO$	<0.2 %ar
Tannin (catechin)	2.8 %ar
Tannin (Total)	0.95 %ar
TIA	130 mg/kgar
CTIA	0.14 %ar
Phytate	1.02 %ar
pH	5.5
EC (1:5)	380 mS/m

From the analysis it appears as would be expected that roots area a moderate source of starch and sugars. Potassium levels are also reasonably high. No toxic compounds were identifies in the samples.

Based on the results of the above analysis the following tests were not required due to the conclusions of related test results; amino acid analysis, lectin analysis, fatty acid profile, cyanoglucosides alpha galactosides analysis or saponin analysis.

4.1.3 Temperature

High postharvest temperature results in a rapid degradation of the product. Roots become discoloured and develop rubbery slimy texture. This was able to be over come by rapid post harvest cooling to 5-7 degree Celsius appears to be able to resolve this issue.

4.1.4 End User Evaluation

To obtain an appreciation of the market potential for the Boab trials were conducted in conjunction with the Hyatt hotel in Perth as part of the end user evaluation.

The various chefs from the hotel were able to sample the product and develop some potential culinary uses for it. The Boab's were also included in an Australian Bush Tucker promotion at the hotel in April 2001. Two 5.0kg amounts of produce were sent over a two week period. Feedback from the trial was very positive after the post harvest problem was resolved. With a high amount of interest raised in both the tuber and surprisingly the leaf as well.

Part of the assessment included promotions on Channel nine's Postcards segment.

The chefs of the hotel commented that Boabs are "new, unique and interesting" and that they would suit an "up market" or "fine dining" style of restaurant. General comments made by the restaurant's guests described the Boab as definitely unusual and very interesting, and it was quite clear that there was no negative feedback received.

The trial has already created a demand for the product in the restaurant trade.

A suggested cost pricing by the restaurant was that if they were to purchase the product they would be prepared to pay around $2.80 - $3.50 per kg.

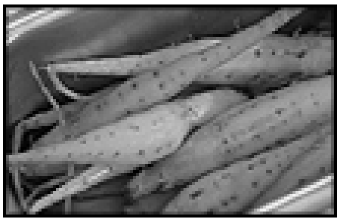

Figure 8 Freshly prepared roots

Figure 9 Test cooking Hyatt hotel

4.2 Larger Scale Trial Results

The planting date occurred on the 11th October 2001. Due to a lack of seed for treatment 1 only two plots were planted with the remaining two planted with buffer seed. Table 7 identifies the final treatment layout of the trial.

Table 7. Treatment layout of the trial.

	Row 1	Row 2	Row 3	Row 4	Row 5	Row 6
Rep 1	T3	T4	Buffer seed	T5	T6	T2
Rep 2	T4	T6	T1	T2	T5	T3
Rep 3	Buffer seed	T3	T4	T5	T2	T6
Rep 4	T2	T1	T3	T6	T4	T5

Row 1 Replicate 4 accidentally had some of the seed caught up in the cone seeder and was subsequently planted in the buffer; this should be taken into account when germination counts take place.

The seed weights for 100 seeds are as follows:
Treatment 1: 49g
Treatment 2: 56g
Treatment 3: 42g
Treatment 4: 42g
Treatment 5: 102g
Treatment 6: 42g

125 seed per row per plot were planted. A total of 500 seed per plot were planted at a distance of approximately 10 centimetres apart.

4.2.1 Problems encountered

Weeds in all rows of the trial plots became a problem, competing with the germinating Boab seedlings and subsequently shading out the seedlings.

Selective spraying with a herbicide Sprayseed, spraying the weeds that were away from the germinating boab seedlings. The rest of the weeds around the boab seedlings were chipped and pulled out by hand. This process was repeated as the crop developed further.

Figure 10 Double density planting

Figure 11 SO_4 treated seed

4.2.2 Harvest results

Several harvests occurred over three months to determine the optimum plant maturity that provides a marketable size product whilst still being tender and not woody.

The first harvest occurred on the 24th of December 2001 and half a metre square plots were assessed. The second harvest occurred on the 22nd of January 2002 this time sampling metre square plots.

Table 8 Germination results trial 2

Treatment	Germination Total	Germination %
Harvested from ground 12mth old Source 1	110*	22.0%
Harvested from ground 12mth old Source 2	173	34.6%
Fresh seed from tree	91*	18.2%
Fresh seed SO4 treatment 12 hours	29.2*	5.9%
Fresh seed double density	177.5*	35.5%
Fresh seed single density with addition of fertiliser	73.5*	14.7%
LSD P=5%	45.4	

* significant

Plants that were forked, broken when harvested, undersized or had other deformities such as bends determined the non-marketable status of the product. However it is important to note that the product was hand harvested, during this process a number of roots were broken. With correct harvest equipment this number could be substantially less.

The use of old seed (Table 8) appears to have significantly ($p \geq 0.05$) improved the germination when compared to the use of fresh seed harvested from the tree. Although there was some variation in the germination rates between seed from source 1 and source 2. Planting the fresh seed at double density whilst not necessarily improved the individual seed germination rate significantly improved the plant numbers per m^2. Interestingly the SO_4 treatment significantly ($p \geq 0.05$) reduced the germination rate below all other treatments. Which is contradictory to the results obtained in the preliminary trials. It is possible that the 12-hour treatment was too long for the fresh seed.

The double density planting significantly ($p \geq 0.05$) increased the yields when compared to the single space planting with seed from the same source Table 9. However it wasn't significant over seed obtained from source two, thus indicating that higher yields can be obtained at single density planting if the seed has been conditioned correctly prior to planting. This is an important factor as seed availability and cost of collection is a large cost factor.

Interestingly the incorporation of the fertiliser at planting did not significantly improve the yields of the crop. Although this is not entirely unexpected due to the large seed, short growth period and being an indigenous tree that has evolved under low soil fertility conditions.

Table 9 Harvest results trial 2 22 January 2002

Treatment	Yield M^2 Plot (gms)	Marketable Yield (gms)	Weight of leafy tops	Extrapolated marketable yield T/Ha
1	1922	1254	3470	12.5
2	2661	1871	3350	18.7
3	1561	1105	2629	11.0
4	1396	684	2882	6.8
5	2625	2090	2985	20.9
6	1716	1479	2441	14.8
LSD P=5%	611	681	1529	

Figure 12 8 week old plants

4.3 Economic evaluation

Indicative results from the economic model indicate that the production of Boab's commercially is viability producing a gross margin of $22,267/Ha based on $5.00 Kg and yielding 8.9 tonnes Ha Table 10. The model indicated that seed is the single largest production cost component at $ 5333 per hectare comprising of almost 25% of the total costs. This therefore puts a heavy emphasis on improving germination rates, selecting and/or conditioning the seed. A double density planting will significantly reduce the commercial viability of the operation.

At 8.8 tonnes /Ha the breakeven price is $2.00 Kg. The trial results indicate that 8.8 tonnes of marketable product is fairly conservative with some where between 12 to 18 tonnes achievable. At $5.00 kg this makes the commercial prospects look very promising. However it is important to recognise that this crop has never been grown commercially and the model will still need some refining as further results from commercialisation are produced.

Table 10 Gross margin Budget 1 Hectare Boabs.

	Unit	Unit Cost (Kg)	Total ($)
Income			
Sales	8889 kg Ha	$5.00	44,444
Direct Costs			
Seed	444444Ha	0.012	5333
Fertiliser:	Ha	1.29	411
Herbicide:	Ha	8.40	43
Insecticide:			0
Trickle Irrigation			310
Machinery: Tractor Hours	Ha	0.51	1533
Labour:	Ha	13.44	1935
Marketing Costs	8889kg		
Picking	Kg	0.13	1195
Washing and grading	Kg	0.13	1195
Freight	Kg	0.23	2000
Cartons	1778	0.25	2222
Commission	13.5%	0.65	6000
TOTAL DIRECT COSTS THIS ENTERPRISE			22177
GROSS MARGIN /ha			**22267**

4.3.1 Sensitivity analysis

Table 11 Gross Margin ($/Ha) Sensitivity To Yield And Price

Yield T/Ha	Average Price $ Kg $2.50	$3.75	$5.00*	$6.25	$7.50
4.4	-4,992	564	6,119	11,675	17,230
8.8	-290	10,821	21,932	33,043	44,155
13.3	4,619	21,286	37,952	54,619	71,286
17.7	15,730	37,952	60,174	82,397	104,619

Table 12 Gross Margin Breakeven - $ / Kg

Yield T/Ha	Average Price $ Kg $17,742 $/Ha	$19,960 $/Ha	$22,177 $/Ha	$24,395 $/Ha	$26,613 $/Ha
4.4	3.99	4.49	4.99	5.49	5.99
8.8	2.00	2.25	2.49	2.74	2.99
17.7	1.33	1.50	1.66	1.83	2.00

			COST OF PRODUCTION	RETURNS	
Yield kg/ha	Direct cost $/kg	Total cost $/kg	Total Cost Including Capital Cost $/kg	"profit" ** $/ha	Return less cost of capital $/ha
4444	3.55	4.58	6.66	$1,851	($7,372)
8889	2.49	3.01	4.05	$17,667	$8,444
13333	2.13	2.47	3.17	$33,684	$24,461

** i.e. net of cash costs, but before depreciation & opportunity costs.

Total overhead cost allocation =	$13,823	$13823 /ha
Total o/h non-cash allocation =	$9,223	$9223 /ha
Total o/h cash allocation =	$4,600	$4600 /ha

5.0 Discussion and recommendations

The boab has wide spread use amongst the indigenous population of the Kimberley, this is similar to the African/Madagascan species of *Adansonia sp.* Where the local populations have long since used various parts of the tree as part of their diet.

From the work conducted it can be concluded that the Boab roots contain no known toxic compounds and have reasonably high levels of starch and sugars whilst being, potentially a good source of potassium. Interestingly for a vegetable crop it also contains relatively high amounts of protein. Whilst it doesn't appear to have any outstanding nutritional features it compares well with similar vegetables. A surprisingly unexpected result from the trial work was the popularity of the foliage on the young plants. The leaves with a characteristic nutty flavour and crisp texture were seen to have great potential for salads and as a garnish. Unfortunately a nutritional breakdown was not conducted on the leaves so it is unclear what the nutritional benefits would be. Although the African species contain very high amounts of Vitamin C.

Significant problems were encountered with germinating the seed particularly during the dry season. Under natural conditions seeds normally germinate during the wet season, soil temperatures are often slightly higher during this time of year. This lead to the trialing of several different germination techniques. Of these sulphuric acid dips and manual scarifying appeared to have the best result. This was conducted on older seed. However when fresh seed was treated with SO_4 it produced a negative result. This may have been due to the extended time in the solution or some variation in the composition of the seed coating between fresh seed and one year old seed. Unfortunately with the results from the trial it is not possible to isolate the cause of this. It appears that the seasonal timing of planting has a major impact on germination percentages. Planting's between October and February achieved high germination results as opposed to planting's during May to August achieved low results. There appears to be some potential to extend this season through further refinement of germination techniques. Wet season planting's indicate a shorter production cycle approximately 6 to 8 weeks where as during the dry season this may be extended beyond 10 week.

Seed collection presents itself as a initial limiting factor, currently the only source of seeds available are from natural stands of the trees in the bush and the occasional tree grown on farm. Whilst a large supply of seed exists in the bush current WA legislation requires a permit to collect and that only a maximum of one third of the seed be allowed to collected of any given tree. It is would therefore be essential for any prospective long term producer to establish a seed source on farm. Initially a small industry would offer a much need source of employment for remote aboriginal communities in the Kimberley.

Preliminary market testing and end user evaluation of the product has created enormous interest in the tubers and the leaves from the hospitality trade. This may well be the best approach to developing a product such as this. Developing wide spread consumer education and acceptance of the product will require considerable promotion champagne. Undertaking this would be rather costly and unlikely that a small producer could develop this alone. If the hospitality trade runs with the product it will soon come to the attention of influential food promoters.

The preliminary economic look at growing the crop commercially looks very promising. Much of the production activities such as seed cleaning, planting and harvesting can all be mechanised. Keeping the overall costs low. It is interesting to note that the model was conducted on roots only and it appears that the market for the fresh leaf could have equal or better potential. This could potentially add another 15 to 20 tonnes per hectare of additional production. Thus making the crop commercially viable at a much lower cost than the sensitivity analysis suggests. The analysis does highlight the importance the cost of seed and therefore the germination rate has to its commercial viability. Consistent germination rates greater than 60% would halve the cost of seed.

The work conducted in this report is only the preliminary step to commercialising the crop. It has clearly identified that the crop has good commercial prospects.

- To achieve the commercialisation of the crop further work is required in refining the germination techniques and the production windows available. Information generated from this would also be able to be feed into the economic mode

- Some assessment of pre and post emergent herbicides is necessary.

- A reliable seed source need to be secured which may need some long term planting of parent trees as a seed source

- Once these issues are resolved a strategic promotional and marketing campaign will be required to introduce the product into the mainstream market. This may not be as difficult as with some other products judging by the wide spread interest the project has generated and the genuine interest of the public in the Kimberley region of Western Australia.

6.0 Extension Activities/ Publications

The project has generated a number of successful extension activities and publicity.

Boab roots and leaves were sent to the Hyatt Regency Hotel in Perth for their Kimberley promotions week. The Hyatt put the produce together with other Kimberley products including Barramundi and Red Claw to make a dish that was provided for the public to try.

During the Kimberley Week promotions at the Hyatt Regency Hotel a team from the Channel Nine station's show Postcards presented a story on the Boab and the recipe that included the Boab produce. The program was aired a few weeks later on their Sunday 6.30pm timeslot.

The Channel Nine show Postcards have included the story on their website including a brief description of the Boab and a page on the Hyatt Regency Hotels Boab recipe. The address of the website is www.postcardswa.com.au/news.asp?news_id=733&action=.

The 1999 Kununurra Horticulture Review saw the presentation of the Boab project to the horticultural industry.

The Prospect of Commercialising the Boab Roots as a Vegetable Johnson, P.R, Robinson, C. and Green E (2001) 'Horticulture Program, Leading today, shaping tomorrow' Biennial Conference Book.

The Department of Agriculture of Western Australia's Agmemo, a print media for all the produce growers in the Kimberley region, presented a front page article identifying the potential for this new crop and outlined the positive research findings of its products.

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