Utilization of Australian acacias for improving food security and environmental sustainability in the Sahel, West Africa

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Abstract

The Sahelian region of West Africa is among the poorest and least food secure regions of the world. Certain Australian *Acacia* species have been shown to have useful potential as multi-purpose tree species in Sahelian agro-forestry farming systems. These *Acacia* species produce nutritious seed for human and animal food. They thrive in adverse conditions, coppice after pruning, produce large volumes of biomass used for mulch, organic matter and firewood and can protect crops from strong winds. First introduced into the Maradi Region of the Republic of Niger in the early 1980s, *Acacia colei* var *ileocarpa* was the most promising species. Limitations, including shortlife span and competition with crops have hindered adoption. Provenance trials aimed at overcoming these limitations with *A. torulosa* from 2002-2007 have identified two types, a multi-branching wood and seed producer and a tall growing timber type which are now undergoing with provenance selection. Further trials from 2004-2007 with *A. tumida* have identified the var. *Kulparn* with promise for specialist seed production and the larger var. *Tumida* for multi-purpose use. The multiple benefits of these acacia trees are now being realized through their pivotal role in the recently developed Farmer Managed Agroforestry Farming System (FMAFS) which aims to improve food security and enhance environmental sustainability. The FMAFS builds on the biodiversity from Farmer Managed Natural Regeneration (FMNR) of local trees and introduces a range of agro-forestry trees including edible-seeded Australia *Acacia* species and a range of annual and perennial crops. The multiple benefits of FMAFS and recent results are described. Research is refining the FMAFS components and demonstration trials are assisting with the promotion and adoption in villages in the Maradi region as an alternative to traditional farming practices. Adoption of Acacias for human food has been slow up until 2006 when the Maradi Integrated Development Project (MIDP) and later, MIDP in collaboration with World Vision Niger, began promoting the trees in a more concerted manner. Acceptance of acacias in local diets is growing steadily. Attempts to facilitate market demand for the seeds have also heightened

farmer interest in planting acacia trees in their fields. In a region that is set to experience higher average temperatures, more extreme weather events and more frequent and longer lasting droughts, the Australian *Acacia* species could well play a pivotal role in food security in the Sahel.

INTRODUCTION

People living in the Sahelian region of West Africa are particularly vulnerable to hunger and periodic famines. This region is characterised by a short rainy season of 3-5 months and a dry season of 7-9 months (Bationo and Buekert, 2001), with mean rainfall below 600 mm per annum (FAO, 1995). Subsistence farming systems based on a few annual crops (millet, sorghum and cowpeas), high population growth and increasing grazing pressures from livestock have led to impoverished soils and poor crop yields. In addition, high rates of deforestation, soil erosion, climate change with diminishing and unreliable rainfall have resulted in severe environmental degradation and extreme poverty (Nash, 2000).Certain *Acacia* species from the dry tropical regions of inland northern Australia have potential as multi-purpose agroforestry trees in this region (Harwood et al., 1997, Rinaudo et al., 2002; Rinaudo and Cunningham, 2008). Australian *Acacia* species were first trialled in the Sahelian region in the 1970s and 1980s for use as fuelwood and windbreaks (Cossalter, 1987). *Acacia colei* from north western Australia was found to be the best adapted species with excellent survival and rapid early growth on sandy soils in the 400-700 mm rainfall zone (Harwood et al., 1999). In contrast to African *Acacia* species, many Australian *Acacia* species produce edible, nutritious seeds that were consumed traditionally by Australia's Aboriginal people (Harwood, 1994).

Field trials by the Maradi Integrated Development Project (MIDP) and local communities in the Maradi region of Niger from 1992 confirmed the superiority of *A. colei* and *A. elachantha* for early growth, survival and seed production (Rinaudo et al., 1995). *A. colei* var. *ileocarpa* which has coiled pods that aid seed retention, was chosen as the species for widespread promotion. During the 1994 famine, the MIDP facilitated the planting of over 100,000 *A. colei* trees in a food-for-work program (Harwood et al., 1999). A dietary trial in 1995 indicated that the flour from *A. colei* seeds incorporated at 25% by weight into the diet would be safe for human consumption and significantly improved the nutritional value of local diets (Adewusi et al., 2006). This finding led to significant promotion during the late 1990s by MIDP of acacia foods as a supplement in staple diets and as a famine reserve food.

Perceived advantages of *A. colei* included its good adaptation to infertile soils, high levels of seed production (an average 2 kg seed per tree was recorded in the seed harvest 20 months after planting) which can be easily harvested and processed into nutritious tasty food, the seed can be stored for long periods (eg. 5-10 years), rapid rates of wood production for fuel or small-sized building timber, use of foliage for mulch, excellent regrowth from coppicing, nitrogen fixation and the foliage is not eaten by livestock (Rinaudo et al., 2002).

Despite MIDP's active promotion of *A. colei* as a complementary crop to millet and a famine food, adoption rates during the 1990s were low. The main factors limiting adoption were found to be the short lifespan (5-7 years), competition with agricultural crops, susceptibility to wind damage, dieback, seedless years, lack of a market for seed and the high cost of propagation via tree nurseries (Rinaudo et al., 2002; Cunningham and

Abasse, 2004). Farmers did not see it as in their interest to adopt the new species on a large scale.

In addition to *A. colei*, at least 43 other Acacia species from Australia's tropical and sub-tropical dry zones are known, from the traditional consumption of their seeds by Australia's Aboriginal people to have potential for human food (Harwood, 1994). Species other than *A. colei* that appear most promising for human food and potential multi-purpose use include *A. torulosa*, *A. tumida, A. elachantha* and *A. victoriae* (Thomson, 1992).

It appears that *A. torulosa* lacks some the constraints that limited the uptake of *A. colei* (Doran & Turnbill, 1997). *A. torulosa* has grown well as windbreaks at the International Crops Research Institute for the Semi Arid Tropics, Sadore centre in Niger (Rinaudo et al., 2002). A provenance trial with six seedlots of *A. torulosa* was established at Danja (20 km E Maradi) and 30 ha of field borders were planted to *A. torulosa* in 1998. This trial showed that *A. torulosa* displayed rapid growth rates and had considerable genetic variation, as would be expected from its wide range of natural occurrence in northern Australia, from 11^{o} to 22^{o}S (Thomson, 1992). The potential existed to select tall tree-formed types capable of producing valuable building timber and shrubby, multi-stem types for seed production in agroforestry farming systems. Four-year-old multi-stemmed *A. torulosa* trees when grown at 5m spacing in field borders have produced up to 14 kg of seed per tree and useful wood yields, and have displayed excellent regrowth after coppicing. (Cunningham and Abasse, 2004).

A. tumida is highly variable with four main variants. The two varieties, Tumida which has moderate to large phyllodes from the Kimberly and adjacent Northern Territory region and the Kulparn variety which is a low coppicing shrub with good seed production from the Pilbara region (Maslin and McDonald, 1996; McDonald, 2003) appear to have similar potential to *A. torulosa* to overcome some of the constraints of *A. colei*.

A detailed review of MIDPs activities over 17 years of interventions, identified that the use of Australian acacias for human food showed great potential, but was not being adequately promoted. There were only two interventions that had reached a level of unqualified success and were sustainable (Evans, 1999). The first of these, Farmer Managed Natural Regeneration (FMNR) a system of selecting and pruning stems regenerating from living tree stumps has led to the re-vegetation of more than 3 million hectares of land in Niger (Rinaudo, 2001; 2007., Larwanou et al., 2006). The second intervention, Crop Residue Mulching (CRM) which improves soil structure and fertility and is used for restoring hard pan soils, had also spread widely.

If the farming systems of the Sahel are to be made more sustainable, then there is a need to develop alternative integrated systems in which the limiting factors are simultaneously addressed (Pasternak et al., 2005). One such system, The Farmer Managed Agroforestry Farming System (FMAFS) based on FMNR, CRM, multi-purpose Australian *Acacia* species and annual crops is showing considerable promise to improve food security and environmental sustainability (Rinaudo and Cunningham, 2008).

This paper outlines the evaluation of whether *A. torulosa* and *A. tumida* can overcome the perceived limitations of *A. colei*, and the integration of these species in agroforestry farming systems that are being compared with traditional farming methods. The Farmer Managed Agroforestry Farming System (FMAFS) is described and preliminary results presented, and a recent village survey on the use of *Acacia*-

incorporated foods in the Maradi area is presented to show that an important threshold in adoption has now been reached.

MATERIALS AND METHODS

Acacia provenance trials

Two field trials were established at Danja (13^{o} 24.49 N, 7^{o} 10.28 E), 20 km east of Maradi in south-eastern Niger. The two trial sites were adjacent, and the soil types similar with pH (KCl) of 5.8-5.9 and 0.8% organic matter.

The first trial aimed to evaluate a range of *A. torulosa* seedlots collected in northern Australia with likely potential to perform well in the Maradi region. There were 14 seedlots of *A. torulosa*. Ten seedlots were obtained from CSIRO's Australian Tree Seed Centre (ATSC), and four seedlots were collected from selected trees of *A. torulosa* of superior phenotype growing in previous plantings at Danja. The trial also tested three seedlots of *A. plectocarpa* and *A. eriopoda* species from north-western Australia expected to display similar growth performance and *A. colei* and a local tree species, *Bauhinia reticulata* were included as controls with known performance (Table 1).

The second trial aimed to assess a range of *A. tumida* seedlots collected in northern Australia with likely potential to perform well in the Maradi region. Ten *A. tumida* seedlots obtained from the ATSC. 4 seedlots were from the multi-stemmed shrub form of *A. tumida* var. *kulparn* and 6 seedlots were from the tree form *A. tumida* var. *tumida* (McDonald, 2003). One seedlot of *A. difficilis* (closely related to *A. tumida*) and one seedlot collected from trees believed to be of hybrid origin *A. difficilis* x *A. tumida* were included, along with five other Acacia species from the ATSC. The controls included one selection, of *A. tumida*, two selections of *A. torulosa* and one selection of *A. colei* from Danja, (Table 2).

Acacia seedlots for the first trial were treated with boiling water for 1 minute to promote germination and planted into black polythene bags, 7 x 15 cm in size using a nursery potting mix of 90% sand and 10% ground cow manure in April 2002 in the Danja tree nursery. Seedlots for the second trial were treated and raised similarly, except that seeds of ATSC seedlot 18646 required nicking with nail clippers to promote germination. Seedlots were planted into tree bags in May 2004. Significant problems with germination and seedling death were encountered in the tree nursery. Some seedlots were replanted in the nursery on 20th May.

In both trials, planting rows were 10 m apart and plants were 5 m apart within rows. Seedlots were tested using 9-tree row plots. The treatment layouts approximated randomised complete block designs, modified to accommodate shortfalls in numbers of some seedlots. Planting holes were prepared by digging holes 30 x 30 x 30 cm in late July and adding 1 kg of compost to each hole, mixed with topsoil.

The *A. torulosa* field trial was 4 ha in size with 4 replicates of 20 main plots. Not all seedlots were tested in every replicate, and some seedlots with surplus planting stock were represented twice in one or more replicates. This trial was planted in August 2002. The *A. tumida* trial was 2 ha in size with two replicates of 20 main plots. Not all seedlots were tested in both replicates and some seedlots were represented twice in one or both replicates. This trial was planted in August 2004.

The trials were intercropped with millet or sorghum in the first two planting seasons after establishment and the inter-rows then left fallow.

Trial assessment and analysis of data.

The trials were assessed for tree height and crown width at regular intervals after planting. Crown width was taken to be the distance at the widest point on the tree in an east-west direction. Survival percentages for each seedlot were calculated on the initial numbers of trees planted and surviving after four years. Branchiness was measured by counting the numbers of branches per tree originating below 0.25m above ground level. Growth habit was also determined by assigning a 9-point visual score to each tree ranging from 1 = prostrate through to 9 = fully erect. Coppicing ability was determined for the *A. torulosa* trial by assigning a visual score 1 = poor through to 9 = excellent fours months after pruning to a height of 1.2 meters in the third year of the trial. For the *A. tumida* trial a visual score of 1= poor to 5 = excellent for coppicing ability was given 6 months after pruning in the third year.

The *A. tumida* trial was assessed for early vigour three months after establishment by assigning a visual score to each tree where 1 = low and 9 = excellent.

Seed yield was recorded by collecting all the seedpods from each tree with seedpods, then thrashing and weighing total seeds weights per tree.

Statistical analysis for each measurement was carried out using the Genstat statistical software package and following the general approach outlined by Williams *et al*. (2002). First, individual seedlot means were estimated using the linear mixed model

$$Y = \mu + REPL + SEEDLOT + REPL.PLOT + ERROR \qquad (1)$$

where μ is the overall mean, REPL is the vector of fixed replicate effects, SEEDLOT is the vector of fixed seedlot effects, REPL.PLOT is the vector of random individual plot effects and ERROR is the vector of residual random effects. The significance of differences among replicates and among seedlots was determined using Wald tests. An average standard error of the difference of seedlot means was obtained from the analysis, but is only an indication of the significance of seedlot differences, as it varies according to which seedlots are being compared, being higher for under-represented seedlots and lower for seedlots represented by more than four plots in the first trial or more than two plots in the second trial.

Rainfall was recorded at the trial site during the experimental period and with the exception of 2004 and 2007, annual rainfall was above the long-term average of 460 mm (Table 3).

The Farmer managed agro-forestry farming system (FMAFS)

In continuing to explore how the potential of Australian acacia species could be realized, MIDP staff have developed the Farmer managed agroforestry farming system (FMAFS). The FMAFS is an agro-pastoral forestry system that incorporates a wide range of annual and perennial and indigenous and exotic plant species and livestock. The FMAFS incorporates FMNR of indigenous trees and rows of Australian acacias (*A. colei*, *A. torulosa*, *A. tumida*, *A. elacantha*), which are planted along the farm borders and in rows within the farm. Other valuable agro-forestry trees and shrubs such as the Pomme du Sahel (*Ziziphus mauritania* Lam.), Tamarind (*Tamarindus indica* L.) Baobab (*Adansonia digitata* L.) and Moringa (*Moringa oleifera* Lam.) complement regenerated indigenous trees and acacias. Annual cash crops such as millet, sorghum, cowpeas, peanuts, hibiscus, sesame, cassava and leafy vegetables (e.g. *Cassia obustifolia*) can then be planted in rotation between the tree rows. Soil improvement and protection is enhanced by CRM of crop and tree residues.

In the FMAFS farm layout, acacia trees are planted on the farm borders at five metre intervals and in rows 25 metres apart with trees within the row 10 metres apart. Rows of trees are planted orientated 90^o to the prevailing wind direction. The one-hectare model (Fig. 1) has 107 acacia trees per hectare and half-hectare models have between 69-72 trees. The *Acacia* trees are pruned every second year from the second year after planting and may produce edible seed every year from the second year after planting. The inclusion of a range of *Acacia* species increases the chance of seed production every year and enhances the multi-purpose function of these trees.

Whilst the FMAFS is being introduced as a model, its layout, components and process of establishment are flexible to ensure farmers can adapt the model to suit their particular needs and local conditions. This in turn results in greater farmer ownership of the FMAFs and sustainability over the long term.

Australian acacia seeds for human food: Village survey

Very few *A. colei* trees were planted in the Maradi region between 1999 and 2003. In 2003, a small market created by an Australian company, Kalkardi Pty Ltd, together with MIDP promotion of *A. colei*, led to renewed interest in acacias. The MIDP also developed the FMAFS and together with contracts from World Vision (WV) in 2006-7, some 358 FMAFS (0.5 to 1 ha) were established in 33 villages. Kalkardi Pty Ltd purchased 1,640, 200, 1,974 and 4,554 kilograms of seed in years 2004-2007 respectively.

In order to better understand community knowledge of acacia uses, attitudes to acacia foods and factors that were driving renewed economic and nutritional interest in Acacias an informal survey was conducted in twelve villages in three districts in the Maradi region in September 2007. Where possible, separate focus groups of men and women were formed for discussions.

RESULTS AND DISCUSSION

Acacia provenance trials

Acacia torulosa

The establishment of all species was successful. Significant differences ($P<0.001$) occurred between acacia species and between seedlots within species for all tree height and width measurements and for survival at 4 years (Table 4). With the exception of *A. plectocarpa* seedlot No. 16959, which died after the second year and *A. torulosa* seedlots Nos. 165959, 20364 and 19044, all other seedlots had over 67% survival after 4 years.

Considering growth and survival (adaptability), the best species were *A. colei* and *A. torulosa* Bulk A and Seedlot 20078. The tallest *A. torulosa* seedlot was 20360, which reached a mean of 6.32 m after 4 years.

Significant differences ($P< 0.001$) between species and seedlots within species for branchiness and growth habit were noted. (Table 5). A high level of variation, especially between the *A. torulosa* provenances, was recorded. Form varied from highly branched types (> 9 branches: *A. torulosa* 19044, 19930, 20078) to intermediate types (*A. torulosa* 222, Bulk A) to low branching more erect growing types (< 2 branches: *A. torulosa* 20360, 15964, 16959, 19978) (Fig. 2).

A. torulosa seedlot 20360 was the best adapted tall type and will be used for within-provenance selection for improved varieties aimed at timber and pole production (Fig. 2).

Seed yields for both *A. colei* and *A. torulosa* were generally poor compared to the results from previous trials and measurements from trees in farmers fields in the Maradi region (Harwood et al., 1999., Cunningham & Abasse, 2004)

A. colei displayed superior characteristics considering growth habit, seed yield and coppicing ability. However *A. torulosa* Bulk A (originating from *A. torulosa* ATSC No. 14620, New Castle Waters) and seedlot 20078 had excellent coppicing ability and the seed yield results showed potential for within provenance selection (Table 5).

Acacia tumida

There were significant differences (P<0.001) between acacia species and between seedlots/provenances within species for early vigour, all tree height and width measurements and for survival at 41 months after planting (Table 6). *A. colei* Port Hedland displayed the best early vigour, but *A. tumida* var. *tumida* seedlots 19936, 19938 and *A. tumida* x *A. difficilis* seedlot 20257 also displayed excellent establishment and early vigour. In general the *A. tumida* var *kulparn* seedlots had less early vigour and slower growth rates than the taller higher biomass *A. tumida* var. *tumida* seedlots (Table 6). *A. tumida* var. *kulparn* were lower growing highly branches types that produced seed (88-95 % of trees) in the first year after planting (Table 7, Fig 3). *A. tumida* var. *tumida* seedlot 19936 was the best seedlot for growth and adaptability. Potential exists for within provenance selection from this seedlot for tall timber-producing types and/or high biomass production for use in agroforestry farming systems (Fig. 3).

All the *A. tumida* seedlots displayed good adaptation (survival) at 41 months after planting, in contrast to *A. auriculiformis* and *A. difficilis*.

A. colei Port Hedland was the better *A. colei* seedlot in this trial and also the superior species overall for seed production (612 g/tree, 95% trees with seed). It also displayed excellent coppicing ability after pruning (Table 7). The *A. tumida* var. *kulparn* seedlots 15745 and 18646 produced an average of 339 and 514 g of seed and had 89 and 88% respectively of trees that produced seed.

Expressing seed yields on a kg per hectare basis, it can be seen that *A. tumida* seedlots 15745 and 18646 if planted as specialist seed production plantations (231 trees per hectare) could produce 78.3 and 118.9 kg seed per hectare. These figures would be significantly higher if within provenance selections increased the mean seed production to the best tree performance (e.g. 164 kg/ha and 258 kg/ha respectively)
Within provenance selections of both these low growing shrubby types for small scale plantations for specialist seed production commenced in 2006 and offers significant potential for improvement.

The performance of *A. torulosa* D222 was noteworthy. It displayed excellent coppicing ability (4.7) and although mean seed production per tree was 124 g, 67% of trees produced seed with a range per tree (12- 520g) indicating potential for within provenance selection for multi-purpose agroforestry use.

Farmer managed agroforestry farming system (FMAFS)

The FMAFS was first introduced on two farms in the Maradi district in 2005. A further 125 FMAFS were established in 10 villages in 2006, and in 2007, 263 FMAFS were established in 33 villages. Ongoing research and discussion with farming communities is helping to tailor the FMAFS to farmers expressed needs and actual field conditions.

The FMAFS addresses the principal contributors of vulnerability to food insecurity, namely lack of biodiversity, absence of ground cover and low soil organic matter content (Rinaudo & Cunningham, 2008). Implementation of FMAFS results in increased biodiversity, reduced wind and soil erosion, improved soil fertility, beneficial shading and habitat for pest predators and income generation through sale of wood and non-wood tree products. Practice of FMAFS results in increased fodder production over traditional farming systems while at the same time increasing the volume of crop residue and tree leaves are available for creation of soil improving and moisture retaining mulch material. Trees provide annual income, but also insure against food shortage years as tree products can be sold to buy food. The *Acacia* trees within the FMAFS provide multiple benefits including edible seed for human and/or animal consumption and sale for income generation and wood for fuel and/or construction and sale. They also fix nitrogen, provide mulch and reduce erosion. The range and rotation of high performing annual crops provide income and reduce disease incidence. Importantly there is a shift from reliance on one or two annual crops to a range of food and income generating crops thus spreading risk and reducing vulnerability to environmental shocks such as drought or insect attack. Additionally, labour requirements and income generation are spread throughout the year instead of being concentrated in an intense four-month period.

Important considerations in the development of FMAFS were that the system should overcome the main limitations to farming in the Sahel through an integrated approach and yet be readily adopted by farming communities. FMAFS builds on the strengths of two existing agro-forestry systems, the Sahelian Eco Farm (Pasternak et al., 2005) and FMNR (Rinaudo, 2001). After initial resistance FMNR is now widely practiced in Niger and farmers have now had up to 20 years of experience with growing indigenous trees in combination with annual crops. Adoption of FMNR required a significant paradigm shift from mono cropping of annuals to agroforestry. Today, introducing FMAFS to such farmers represents only an incremental graduation to a slightly more complex farming system. Since FMAFS can conservatively increase farm income by two to three-fold over traditional farming systems (Rinaudo and Cunningham, 2008) adoption should be relatively rapid once farmers begin to see the impact on their neighbours.

Research, discussion and evaluation with farming communities is ongoing and continues to inform how FMAFS can be tailored to meet farmers changing needs. Representative demonstration FMAFS established in 2006-7 have been selected in 11 villages with adjacent control farms for monitoring and evaluation purposes. These activities will also assist in the promotion and adoption of FMAFS in other regions.

Australian Acacias for Human food: Village survey

The main findings of the acacia food survey:

- In MIDP and WV villages of intervention the demand for *Acacia* trees exceeded supply.

- The price offered for acacia seed ($US 0.40 per kg) by Kalkardi Pty Ltd greatly stimulated interest in acacia planting and subsequent consumption of the seed.
- All villagers interviewed were fully aware of the potential benefits of acacias.
- Farmers were experimenting and innovating with acacias. New uses not promoted by MIDP include:

1. Seed pods used as fertilizer side dressings
2. Water from soaking acacia bark used for mud-plaster to increase render strength.
3. Medicinal use of acacia phyllode juice to reduce fever and stomach upset.

- Men were selling 90% of seed and retaining only 10% for home use.
- Women were selling 50% of seed while retaining 50% for home use.
- In all villages where families had *Acacia* seed, they were all enthusiastically consuming a wide variety of acacia based dishes.

Reasons given for the consumption of *Acacia* food were uniform across villages, sexes and age groups and included:

1. Delicious taste.
2. Good for the body, giving energy.
3. Wonderful aroma when cooking.
4. Since *Acacia* based foods are very filling, the rate of use of staple grains is reduced. Hence more of the staple grain is available for use at a later date or for sale. Acacia gruel fed to new mothers stimulates milk production.

No illness or bad side effects from longer-term consumption of acacia based foods were reported and in fact an interesting mythology on the beneficial attributes of acacia foods is emerging. Beliefs about acacia foods include:

1. Increased body strength.
2. Improved vision
3. Enhanced sexual performance
4. Increased egg and meat production by chickens fed on acacia seed.

These results show that acacia foods (local dishes with 25% acacia supplement) have become widely and enthusiastically accepted in MIDP and World Vision intervention villages in the Maradi area where *A. colei* trees are grown. The value of this relatively new food is well recognized 13 years after widespread promotion began. The small market created by Kalkardi Pty Ltd. in combination with intensive promotion by MIDP appear to be the main catalysts for this upsurge in adoption rates of acacias both as a food and as an integral part of the sustainable farming practice, FMAFS.

CONCLUSIONS

Edible-seeded Australian acacias are underutilized tree species with multi-purpose potential to improve food security and assist with environmental sustainability within the FMAFS in the Sahelian region of Africa.

Whilst *A. colei* has continued to perform well in the trials presented in this paper and in farmers fields in the Maradi region of Niger republic, considerable promise has been indentified within the diverse types of *A. torulosa* to overcome some of the limitations that have hindered the adoption of *A. colei*. Within provenance selection trials of *A. torulosa* (ATSC 14620 and 20078) have commenced and aim to develop/ domesticate this species for multipurpose use (seed/wood/biomass production) in agroforestry farming systems. In addition, within-provenance selection trials for ATSC seedlot 20360 aims to develop tall growing timber types producing valuable timber. within 6-10 years of growth. Both of these initiatives represent the development of new trees for agroforestry production suitable for semi-arid regions of Africa.

The potential to develop specialist plantation types of *A. tumida* var. *kulparn*, adapted to low rainfall areas (350-450 mm annual rainfall) for specialist seed production for human and animal food has been identified. Further research is need to determine methods for stable and sustainable seed production, pruning regimes and long term survival/adaptability for this species and suitability for intercropping with annual crops such as cowpeas. *A. tumida* var. *tumida* has potential to replace *A. colei* in farming systems, but further research is needed on seed production, coppicing ability, adaptability and long term survival. Evaluation trials for specialist timber production from this variety will commence in 2008.

The FMAFS represents a vehicle to enable the rapid adoption of acacias. Ongoing comparisons with traditional farming systems will enable direct economic assessments in village farms. Lessons learnt in Niger Republic should provide a valuable platform for wide scale promotion and adoption of multi-purpose acacias and adapted FMAFS in regions with similar conditions and needs.

Interest in acacias for human consumption has grown beyond expectations since 2003 in 33 villages in the Maradi Region of Niger Republic. Apart from intensive promotion by MIDP, a major driver of this renewed interest appears to be coming from the creation of a small market for the seed. For the cultivation of acacias and subsequent consumption of acacia seed to reach a critical threshold it is essential that markets for acacia seed and food products be developed.

Given the environmentally and climatically induced food shortages that plague many regions of Africa, the multiple benefits of the *Acacia* species under discussion deserve greater attention and investigation.

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Table 1. Acacia species and provenance details for seedlots tested at Danja 2002 to 2007.

Species	Seedlot	Provenance	Latitude (S)	Longitude (E)	Altitude (m)
A. torulosa	15964	Kennedy River, Qld	15 27	144 13	140
A. torulosa	16959	Nabarlek Arnhem Land, NT	12 19	133 19	80
A. torulosa	18420	71 k Maline Rd, NT	13 34	132 16	250
A. torulosa	18442	Town Ck, NT	15 03	135 12	30
A. torulosa	19044	Ali-Curang, NT	20 55	133 51	400
A. torulosa	19930	Mataranka, NT	15 00	133 09	140
A. torulosa	19978	SW Katherine, NT	14 38	132 07	100
A. torulosa	20078	Tanami Rd WA/NT Border, NT	19 54	129 02	425
A. torulosa	20360	Lake Buchanan, Qld	21 37	145 56	200
A. torulosa	20364	Warrigal Ck, Qld	20 39	145 17	420
A. torulosa	222	Single tree seln. Branching			
A. torulosa	313	Single tree seln. Tall			
A. torulosa	Bulk A	Bulk of 5 branching trees			
A. torulosa	Bulk B	Bulk of 5 tall trees			
A. plectocarpa	18443	Cox River, NT	15 20	135 21	20
A. plectocarpa	16957	Nabarlek, NT	12 20	133 26	86
A. plectocarpa	18800	Arthur Ck, WA	16 01	128 25	80
A. eriopoda	19183	Rundall River, WA	22 19	122 46	260
A. eriopoda	18665	33 k N Shay Gap, WA	20 09	120 13	160
A. eriopoda	17164	1 k N Broome, WA	17 57	122 14	10
A. colei		Port Hedland, WA			
Bauhinia reticulata		Local			

Table 2. Acacia species and provenance details for seedlots tested at Danja 2004 to 2007.

Species	Seedlot	Provenance/selection	Latitude (S)	Longitude (E)	Altitude
A. difficilus	19935	Kununurra, WA	15 56	128 56	100
A. tumida var. *kulparn*	15745	Balgo area, WA	20 09	127 57	380
A. tumida var. *kulparn*	17035	Gantheume Pt Broome, WA	18 00	122	6
A. tumida var. *kulparn*	18646	Tanami , NT	19 48	129 49	400
A. tumida var. *kulparn*	19996	N Carranye, WA	18 59	127 41	375
A. tumida var. *tumida*	15739	Gordon Downs Station, WA	18 44	128 36	400
A. *tumida* var. *tumida*	18827	Gibb River, WA	16 05	126 30	420
A. tumida var *.tumida*	19934	Dillon Springs, WA	15 55	128 25	300
*A. tumid*a var. *tumida*	19936	Kununurra, WA	15 56	128 56	100
A. tumida var. *tumida*	19938	Windjana, WA	17 23	124 45	200
A. tumida var. *tumida*	20306	Spear Hill, WA	21 30	119 24	250
A tumida x A. difficilus	20257	Mathison Cr Tributary, NT	15 17	130 42	170
A. colei		Port Hedand			
A. torulosa	D222	Seln from 14620, New Castle Waters			
A. torulosa	D313	Seln from tall type			
A. tumida var. *tumida*	Danja Seln	Seln from one large tree			
A. auriculiformis	16137	Piccaninny Creek Qld	13 09	142 48	40
A. colei var. *colei*	14637	E of Hooker Creek, NT	18 20	130 41	310
A. *holosericea*	16582	9 km SW Duaringa, Qld	23 48	149 36	400
A. colei var. *ileocarpa*	19992	Rockhole Station, WA	18 22	127 33	425

Table 3. Monthly rainfall (mm) at Danja, 2002- 2007.

Year	April	May	June	July	August	September	October	Total
2002	5	0	52	113	185	95	32	482
2003	4	2	70	82	325	95	6	584
2004	0	32	50	90	161	33	32	398
2005	0	11	57	159	168	92	33	520
2006	0	27	43	149	146	190	0	555
2007	0	68	94	44	140	15	0	361

Table 4. Growth and survival of *Acacia* species and provenances planted at Danja in 2002. Ht = height, Wd = crown width

Species	Seedlot	Time after planting						
		1 year		2 years		4 years		
		Ht (m)	Wd (m)	Ht (m)	Wd (m)	Ht (m)	Wd (m)	Survival (%)
A. torulosa	15964	1.90	1.98	3.34	2.57	4.72	3.21	72
A. torulosa	16959	1.13	1.69	2.70	2.16	5.24	2.26	26
A. torulosa	18420	1.47	1.74	3.09	2.39	5.41	3.28	85
A. torulosa	18442	1.18	2.20	2.35	2.54	2.06	3.97	70
A. torulosa	19044	0.92	1.53	1.87	2.31	1.70	3.90	48
A. torulosa	19930	1.61	2.03	2.45	2.73	2.98	3.47	93
A. torulosa	19978	1.61	1.67	3.29	2.22	5.72	3.14	74
A. torulosa	20078	1.37	2.07	1.98	2.75	2.32	3.49	70
A. torulosa	20360	**2.34**	1.91	**4.16**	2.38	**6.32**	3.41	67
A. torulosa	20364	2.19	2.27	3.55	2.85	5.63	**4.07**	41
A. torulosa	222	1.25	1.83	2.25	2.36	2.13	3.83	67
A. torulosa	313	1.65	1.84	3.09	2.31	5.35	3.31	81
A. torulosa	Bulk A	1.68	**2.39**	2.62	2.03	2.29	4.19	75
A. torulosa	Bulk B	1.64	1.90	2.96	2.45	5.04	3.69	89
A. plectocarpa	18443	1.84	1.58	2.88	1.94	5.24	2.54	**100**
A. plectocarpa	16957	1.82	1.89	2.52	2.42	-	-	0
A. plectocarpa	18800	1.82	2.10	3.45	2.60	5.55	3.33	81
A. eriopoda	19183	2.25	1.92	2.47	2.67	3.01	3.61	93
A. eriopoda	18665	0.97	1.69	1.61	2.39	2.35	3.21	89
A. eriopoda	17164	1.37	1.80	2.54	**2.77**	1.74	3.47	81
A. colei	Port Hedland	1.97	1.86	2.85	2.64	2.13	3.74	89
Bauhinia reticulata		0.50	0.89	0.59	1.14	1.43	1.83	96
s.e.d means		0.25	0.25	0.32	0.23	0.42	0.29	
Sign P<0.001		***	***	***	***	***	***	***

Table 5. Branchiness, growth habit, seed yield and coppicing ability of *Acacia* species and provenances planted at Danja in 2002.

Species	Seedlot	Time after planting				
		18 months	18 months	19 months		3 years & 10 months
		Branches at 25 cm	Growth habit (1-9)	Mean seed yield (g/tree)	% trees with seed)	Coppicing ability (1-9)
A. torulosa	15964	1.88	7.16	19	11	
A. torulosa	16959	1.58	6.38	0	0	
A. torulosa	18420	2.08	7.08	0	0	
A. torulosa	18442	2.54	4.96	3	4	3.4
A. torulosa	19044	7.22	3.74	150	57	2.6
A. torulosa	19930	8.88	5.04	146	67	3.8
A. torulosa	19978	1.82	7.53	7	8	
A. torulosa	20078	8.08	4.04	**261**	**76**	**5.3**
A. torulosa	20360	**2.29**	**7.62**	21	11	
A. torulosa	20364	3.28	5.81	32	13	
A. torulosa	222	4.15	**5.01**	128	54	4.9
A. torulosa	313	2.75	6.64	4	4	
A. torulosa	Bulk A	**5.04**	**4.53**	**256**	**86**	**5.7**
A. torulosa	Bulk B	2.72	6.19	57	30	
A. plectocarpa	18443	2.17	7.17	0	0	
A. plectocarpa	16957	9.89	5.57	26	43	
A. plectocarpa	18800	2.26	7.04	11	15	
A. eriopoda	19183	9.43	4.80	72	43	4.0
A. eriopoda	18665	4.69	4.10	127	70	3.6
A. eriopoda	17164	3.38	5.47	7	4	3.6
A. colei	Port Hedland	1.23	<u>5.58</u>	**823**	**85**	**8.3**
Bauhinia reticulata		3.63	3.77	0	0	
s.e.d means		0.8	0.46			
Sign P<0.001		***	***			

Table 6. Growth and survival of *Acacia* species and provenances planted at Danja in 2004.

		Age of measurement		
		29 months	29 months	41 months
Species and variety	Seedlot	Height (m)	Crown width (m)	Survival (%)
A. difficilus	19935	2.53	2.36	72
A. tumida kulparn	**15745**	**2.31**	**3.51**	**100**
A. tumida kulparn	17035	2.46	3.48	83
A. tumida kulparn	**18646**	**2.69**	**3.51**	**89**
A. tumida kulparn	19996	2.70	3.20	94
A. tumida tumida	15739	2.93	3.45	83
A. tumida tumida	18827	3.69	3.04	100
A. tumida tumida	19934	4.05	2.56	100
.*A. tumida* tumida	**19936**	**4.54**	**3.26**	**100**
A. tumida tumida	19938	4.52	3.12	100
A. tumida tumida	20306	4.15	2.79	93
A. tumida x A. difficilis	20257	4.41	3.15	94
A. colei	Port Hedland	4.11	1.88	89
A. torulosa	D222	3.95	2.11	100
A. torulosa	D313	4.27	2.02	94
A. tumida tumida	Danja Seln	3.67	3.25	89
A. auriculiformis	16137	4.68	2.59	11
A. colei colei	14637	3.88	1.97	89
A. *holosericea*	16582	2.80	2.76	89
A. colei ileocarpa	19992	3.05	1.52	89
s.e.d. means		0.50	0.36	
Significance of diffs. between seedlot means *** P< 0.001		***	***	***

Table 7. Seed production and coppicing ability of *Acacia* seedlots planted at Danja in 2004.

Species	Seedlot	Mean seed yield per tree. Mar 2006		% trees with seed	Coppicing ability (1-5). Dec 2007
		Total (g)	**Range (g)**		
A. difficilus	19935	0	0	0	3
A. tumida kulparn	15745	**339**	**70-710**	**89**	**4.4**
A. tumida kulparn	17035	232	15- 710	92	3.7
A. tumida kulparn	18646	**514**	**250-1118**	**88**	**4.3**
A. tumida kulparn	19996	315	100-675	95	4.0
A. tumida tumida	15739	194	5-675	83	4.0
A. *tumida* tumida	18827	0		0	_
A. tumida tumida	19934	0		0	_
.*A. tumida* tumida	19936	2		5	_
.*A. tumida* tumida	19938	15	5-115	33	_
A. tumida tumida	20306	8		5	_
A. tumida x A. difficilis	20257	6		11	_
A. colei	Port Hedland	**612**	**150-1370**	**95**	**4.3**
A. torulosa	D222	124	12- 520	**67**	**4.7**
A. torulosa	D313	0		0	3.7
.*A. tumida* tumida	Danja Seln	88	130-875	22	_
.*A. auriculiformis*	16137	0		0	_
A. colei colei	14637	0		0	_
A. *holosericea*	16582	75	30- 460	37	_
A. colei ileocarpa	19992	63		25	_

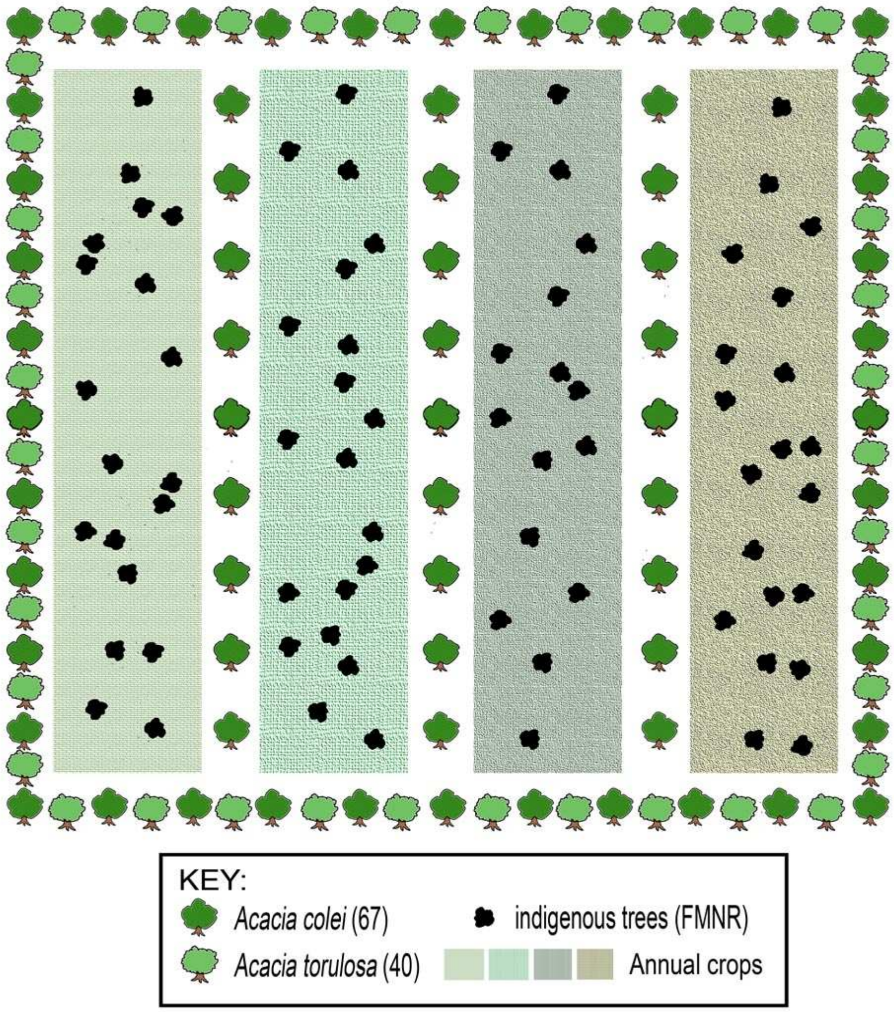

Fig. 1. The Farmer Managed Agroforestry Farming System (1 ha) model.

Fig. 2. Photo of *A. torulosa* branching type at 20 months. Left. *A. torulosa* tall, timber type at 3 years and 8 months. Right.

Fig. 3. Photo of *A. tumida* var. *kulparn* at 20 months growth (specialist seed producer) Left. *A. tumida* var. *tumida* at 20 months (multi-purpose) Right.