Carob agroforestry industry: an assessment of its potential for the low-medium rainfall Murray Valley region

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\textbf{Summary.} This paper reports the key findings of a study examining the potential viability of a carob agroforestry industry in the low rainfall Murray Valley region. The carob fruit, typically produced on female and hermaphrodite trees older than 6 years, is valued for a range of products derived from the seed and pod. From the seeds, the endosperm is extracted for a galactomannan, which forms an edible gum (termed ‘carob bean gum’ or ‘locust bean gum’) and has become a valuable natural food additive. Carob powder, made by grinding the roasted pod, is used for the human food industry (with cocoa products and syrups). Ripe pods also have potential as a high energy stockfeed. The gum is used extensively in Australia as a thickening or binding agent, particularly for canned pet food products, with current imports valued at A$10 million/year. The current Australian demand for ‘pet food’ and ‘technical’ grade gum is estimated at 1200 t/year, with a further 200 t/year of the higher quality ‘food’ grade gum. Assuming a modern plant was built in Australia, the current Australian demand for carob gum could be met with about 2250 t of carob seed (seed value at $1600/t). This equates to 5405 ha of trees (at 104 trees/ha) with medium rainfall and low technology management (yielding 40 kg pods/tree); or 1080 ha of trees (at 208 trees/ha) with supplementary irrigation and fertilising (yielding 100 kg pods/tree). As such, carob could be a commercial tree crop for landholders in the Murray Valley region. This could be through the sale of seeds and pods, or as a supplement to livestock feeding. Economic analyses were undertaken to assess the relative viability of commercial returns when trees had access to adequate water through medium rainfall or irrigation, and growers had access to both the carob gum and powder markets. Commercial opportunities for carob growers within Australia vary considerably depending on establishment and maintenance costs, yields and access to markets.

\begin{tabular}{|l|l|}
\hline
Introduction & 326 \\
Potential of an Australian carob industry & 326 \\
Carob production & 326 \\
Commercial products & 326 \\
Markets & 326 \\
Whole pods & 327 \\
Carob bean gum or LBG production & 327 \\
Carob powder (flour) and syrup & 328 \\
Other products & 328 \\
Processing industry & 328 \\
Cultivation of carob plants & 328 \\
Distribution & 328 \\
Water use & 328 \\
Temperature & 328 \\
Soils & 329 \\
\hline
\end{tabular}

\textbf{Pests} 329
\textbf{Propagation} 329
\textbf{Cultivars} 330
\textbf{Pod yield} 330
\textbf{Harvesting} 330
\textbf{Factors affecting product quality} 330
\textbf{Economic analyses} 331
\textbf{Analysis scenarios} 331
\textbf{Method of analysis} 331
\textbf{Economic returns for production scenarios} 331
\textbf{Fixed assets} 332
\textbf{Future research} 333
\textbf{Conclusions} 333
\textbf{Acknowledgments} 333
\textbf{References} 334

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Introduction

Carob (*Ceratonia siliqua* L.) is a perennial leguminous tree native to the Mediterranean basin and south-west Asia. It has been cultivated throughout the Mediterranean region for over 4000 years (Catarino 1996). The carob tree is an evergreen shrub growing to a height of 12–15 m, with a productive life span of more than 100 years. World carob pod production is about 320000 t/year (Tous et al. 1996). The main carob bean producers and exporters are Spain (42%), Italy (16%), Portugal (10%), Morocco (8%), Greece (6.5%), Cyprus (5.5%) and Turkey (4.8%) (Tous et al. 1996).

Potential of an Australian carob industry

Carob has been intermittently explored over the last 20 years as a potential tree crop industry in low rainfall areas of Australia (<500 mm rainfall/year) (ACIL 1984; Esbenshade and Wilson 1986; Bulman et al. 1991; Esbenshade 1994). Preliminary investigations indicate that carob pod–seed mix has considerable commercial value as a livestock fodder supplement, as a gum that acts as a thickener or binding agent [termed ‘carob bean gum’ or ‘locust bean gum’ (LBG)] in canned products such as pet food, and as an ingredient for human foods (Hogan 1995).

Farm experience indicates carob trees are suited to the marginally productive agricultural land in the Murray Valley. Carob has an extensive tap root system that can grow to depths of 20 m, enabling production with just 250 mm rainfall/year. However, conditions for commercially viable yields appear to require at least 500 mm (Esbenshade and Wilson 1986) or supplementation from irrigation. Carob begins to produce a commercial yield after about 10 years (A. Gebhardt pers. comm.).

The importance of investigating the potential of a carob agroforestry industry was heightened by the limited options for low rainfall agroforestry and the need to improve management of low rainfall areas in the Murray–Darling Basin (MDB). A viable carob industry would improve low rainfall agricultural productivity (shelter and fodder) and diversify farm incomes, assist in the management of land and water degradation (extensive and increasing dryland salinity emerging in this region of the MDB), allow reuse of domestic, industrial and farm waste water for its irrigation, and contribute to regional industry development and import replacement (Esbenshade 1994). Carobs regenerate after burning and in Spain, are frequently grown close to villages because they can slow down the path of a grass fire.

Carob processing in key regional locations could contribute to regional employment and so enhance the viability of rural communities. A viable carob industry could contribute to LBG import replacement (estimated at A$4.5 million/year for the major importer and A$10 million/year Australia-wide) and have the potential to compete in a world LBG market worth A$100 million/year (Hogan 1995).

Efforts to develop a carob industry in Australia have been impeded by lack of detailed biotechnology and economic data, and poor linkages between research and industry. In particular, there has been no investigation of the requirements to establish the critical mass for a viable regional carob industry. This paper draws upon the findings of a feasibility study that sought to make a preliminary assessment of the minimum requirements of a carob industry in the Murray Valley region of south-east Australia. The study was conducted by Charles Sturt University, Albury, New South Wales in association with Booth & Associates, Hay, New South Wales. The feasibility study was conducted between August 1996 and May 1997. The project team included the authors, and key carob grower and industry participants in the study’s design and completion. Readers should note that many of the biophysical and economic aspects of carob production remain speculative, so caution needs to be applied when assessing the potential of carob for individual situations.

Carob production

Commercial products

The carob tree is cultivated primarily for the commercial products that are derived from the mature fruit. These are from the: seeds; and pod or pulp.

Carob also yields a moderately dense timber, which can be used for specialty furniture purposes. However, this is a minor product with little market information and thus is not covered in any detail.

Coarse grinding of whole pods, termed kibbling, allows the seeds to be separated from the pod and represents the first stage of processing. After kibbling, the pod can be cleaned, roasted and further ground to produce a carob powder or ‘flour’. Alternatively, from the seeds, the endosperm is extracted for a galactomannan, which forms an edible gum (termed ‘carob bean gum’ or LBG) and has become a valuable natural food additive (Tous et al. 1996). The seeds represent about 10% of the total fruit weight (Esbenshade and Wilson 1986).

Markets

The major markets for carob products are shown in Figure 1. Current world production of carob seed averages about 30000 t/year, or 320000 t pods/year.
Carob agroforestry industry

before processing. More than 95% of this production originates in the Mediterranean. Production of carobs in the traditional growing areas of the Mediterranean is expected to decrease in the future in response to increased labour costs and more favourable landuse options. In these areas, harvesting is accomplished by hand. It is unlikely that carob growers in the Mediterranean will be able to adopt mechanical harvesting techniques for existing plantings due to the unsuitable nature of the land, cultivars and orchard design. However, the few new orchards being established in the Mediterranean and Australia are reportedly being designed to allow mechanical harvesting.

Whole pods. The pods are used extensively throughout the Mediterranean as a fodder supplement, with the seed passing through livestock undigested. Whole pods and the pod powder are considered to have the same nutrition value as feed barley. While the long-term trend price for feed barley sold to the New South Wales Grains Board is A$150/t, the price received for feed substitutes will be determined by the quantity of supply, the cost of bulk handling and transport, the preparedness of livestock managers to change to a new product, and other factors. Some have even argued that kibbled carob could replace molasses, with a potential value of $170-280/t. Of value is that pods are usually ripe and dropping from the tree in late-summer and autumn, typically when feed for livestock is in shortest supply.

Kibbled pods can be fed direct to livestock as a supplement. However, due to the high ratio of carbohydrates to proteins it is necessary for livestock to have access to additional sources of protein and roughage. Overfeeding of carob may result in constipation and growth rate reductions. For the purpose of the study, the kibbled pods have been given the value of A$150/t. Esbenshade and Wilson (1986) estimated that kibbling would cost the grower 25% for processing and 15% for transporting and marketing, returning growers about $90/t for kibbled pods going to the stockfeed market.

Carob bean gum or LBG production. Carob bean gum or LBG is a valuable food additive and is used extensively in Australia as an binding agent for canned pet food products (Esbenshade and Wilson 1986). Other uses include the manufacture of chemicals, paper, cosmetics and pharmaceutical drugs. World demand for the gum equates to about 30,000 t of carob seed, with current Australian imports of LBG valued at A$10 million/year (Hogan 1995). The current Australian ‘pet food’ and ‘technical’ grade markets require an estimated 1200 t/year and a further 200 t/year of ‘food’ grade LBG. The yield of LBG from seed varies with the technology used and the desired grade (or LBG quality). Indicative yields of LBG as a proportion of seed weight are: ‘pet food’ grade, 70-90%; ‘technical’ grade, 55-65%; and ‘food’ grade, 45-50%.

Assuming a plant was built in Australia, with modern processing techniques, the current Australian LBG demand could be met with about 2250 t of carob seed. This equates to 22,500 t of pods, or the yield from trees on 5405 ha (at 104 trees/ha) with medium rainfall and low technology management (yielding 40 kg pods/tree); or 1080 ha of trees.

![Diagram of Carob fruit processing](image1)

**Figure 1.** Major markets for products of carob fruit.
(at 208 trees/ha) with supplementary irrigation and fertilising (yielding 100 kg pods/tree). In the Mediterranean, seed prices average around A$1600/t delivered to the milling plant (Hogan 1995). After processing, prices for LBG 'pet food' grade during recent years have ranged between $2940–3450 (Hogan 1995).

**Carob powder (flour) and syrup.** Carob powder is commonly used as a substitute for cocoa. The current Australian market for this product is between 60 and 100 t/year (Hogan 1995). Growth of this market for domestic carob growers is viewed with scepticism as surpluses frequently exist in the Mediterranean. Carob pod powder imported to Australia is valued at A$1500/t. Processing and marketing costs have been estimated at 40% of this value, with the subsequent returns to a grower of about $900/t of powder (Gebhardt 1995). Processing losses are estimated at 2% of pod weight. Carob syrup has a range of uses, including as a sweetener or flavouring agent in foods and beverages. Carob syrup from remains in suspension in liquids and may have greater application in the food industry than carob powder (Gebhardt 1995).

**Other products.** Market technical research is continuing into other carob products (requiring pod powder/syrup and LBG), both in Australia and internationally.

The primary interest in carob for industry in Australia centres on the supply of seed for LBG production.

**Processing industry**

To supply companies with LBG would require a kibbling and/or LBG processing industry. A kibbling industry could be established from a centralised kibbling plant as suggested in this review, or growers obtaining on-farm kibbling facilities. The processing of seed to LBG would require the establishment of a plant. It has been estimated by industry informants that a plant capable of processing 1500 t of seed/year would require an investment of A$2 million.

The demand for carob products will only continue while they remain competitive against other products and if new markets emerge. For example, LBG is currently a competitive product for use as a flavouring and emulsifier agent in pet foods. However, developments of substitutes or changes in the carob industry may see the current market conditions change over time.

**Cultivation of carob plants**

**Distribution.** While carobs grow in all Australian mainland states and territories, there are few large-scale plantings. In most cases, carob is planted as a shade tree or as shelterbelts. Carob is growing in many sites in the Murray Valley, including: Yackandandah (rainfall 700 mm/year), Dookie, Swan Hill (Vic.), Deniliquin (NSW), and Burra (rainfall 350 mm/year) (SA). This suggests that environmental conditions (e.g. rainfall, soils, frosts) of the Murray Valley do not impose significant limitations on carob growth. However, continuous commercial yields will require detailed attention by growers to water requirements, temperature and soils.

**Water use.** Mature carobs are drought tolerant, in that they are able to survive in areas with a rainfall of 250 mm/year (Esbenshade and Wilson 1986). However, carobs have rarely been intensively cropped and there is little information available on optimum water requirements. Esbenshade and Wilson (1986) reported that for commercial carob yields without irrigation, a minimum rainfall in 500 mm/year is required, yet this data is not related to evapotranspirative demand, so there needs to be some caution in interpreting reported water usages. Illustrating the level of irrigation and corresponding yield is the example from the Catalina region of Spain (rainfall 500 mm/year), where mature trees with drip irrigation receive about 300 L of additional water per tree per year over 9 irrigations. Average yields for this approach are between 6 and 7 t/ha after 11 years.

The authors believe carob’s ability to ‘survive’ under marginal rainfall conditions should not be the basis for commercial production. In low rainfall areas, carobs will simply perform as an alternative shade or shelter tree, or ‘bio-pumper’ of groundwater. Carobs are reported to withstand moderately saline conditions and so may have considerable merit as a tree crop for saline catchments (ACIL 1984). In low rainfall areas, irrigation will be a critical factor in obtaining consistent yields and establishing desirable growth characteristics, particularly during the early years of development (Esbenshade 1994). However, there remains much uncertainty regarding the optimum volume and frequency of irrigation for commercial carob yields, so long-term monitoring will be required to determine optimum irrigation practices.

**Temperature.** Young carob trees are sensitive to frost, with temperatures below -4°C reported to have killed young trees and destroyed flowers and ripening fruit on mature trees (Esbenshade and Wilson 1986). Given a similar preference for agroecological zones, citrus, grape vines and olives may prove to be useful indicators of regions suitable for carob production in southern Australia.
Esbenshade and Wilson (1986) reported that fruit ripening requires "... 5000 to 6000 degree hours (above 10°C). Hot dry weather during the late summer and autumn ripening period is critical to achieve maximum sugar content." Carob is found growing in warm, coastal environments. In these environments trees do not have a regular winter dormancy, making propagation by budding and grafting difficult. However, generally carobs are easily grafted as long as good nursery and agronomic practices are observed. They can be readily grafted over the main growing season (September–March), but care must be taken with the selection of budwood to ensure that it is of sufficient maturity and is not itself growing.

**Soils.** Carobs prefer a calcareous, well-drained, low-clay soil, yet will tolerate a wide range of soil characteristics. Esbenshade and Wilson (1986) reported that carob can be found growing on "... almost any soil type that is well drained and aerated, including sands, clay loams, limestone, and alkaline or moderately acid soils."

The extent carob will tolerate highly acid soils (pH <4.5) in the Murray Valley remains uncertain. Based on field observations and available literature, carob production should not be limited by the dominant soil types of the Murray Valley. Again, carob may tolerate harsh soil conditions, but these sites would not produce reliable commercial yields. Esbenshade and Wilson (1986) stated that appropriate slow release fertilisers or manures applied at planting will provide adequate nutrition for seedlings. Phosphorus is required for seedling root development, with nitrogen and phosphorus applications valuable for mature trees. However, fertiliser rates should be tailored to individual sites. Nutrient requirements for mature carob trees can be monitored through the use of leaf tissue analysis. Results from these analyses should indicate levels of 1.6% nitrogen, 0.2% phosphorus and 0.6% potassium (Tous 1994).

**Pests.** There are no major existing pests for carob in Australia, although potential pests include the carob moth (*Ectomyelois ceratoniae*) and citrus red scale on growing trees, and dried fruit moth and rodents on ripe pods in storage. The Rutherglen bug has been reported as defoliating seedlings in Western Australia, forcing a complete replanting. The Rutherglen bug is common in the Murray Valley and will require close attention by those establishing carob orchards in this region.

**Propagation.** The most common and recommended practice for establishing carob orchards is to graft selected varieties onto seedling rootstocks (grafting represents about 10% of total production costs). Grafting has been the cultivation technique in the Mediterranean region for centuries, originally with shepherds completing the grafting while minding their flocks.

Over the centuries growers have selected trees suited for their requirements and environmental conditions. Selection pressure has primarily applied to females, with the aim of increasing fruit bearing quantity and quality. Although carob is a triocoeous tree, with male, female and hermaphrodite inflorescences (usually on different trees), the "... most important trees in commercial orchards are usually the female cultivars" due to their higher yield (Tous *et al.* 1996). Hermaphrodite varieties tend to have lower yields, with the male varieties established for use as pollinators. Currently it is not possible for genetic analysis to determine tree gender from seeds. In the field, pollination can occur by: (i) planting 1 hermaphrodite tree for every 8 female trees. This has been reported to maximise pollination. (ii) grafting of a male or hermaphrodite scion wood on to female trees. This occurs in Spanish orchards to maximise the number of female trees. Hermaphrodites are preferred as pollinators as they have a longer flowering period than males. Although hermaphrodites appear more susceptible to disease, particularly the fungal disease oidium (oidium is not evident in Australia at this time) (Gebhardt 1995).

Opinions vary as to the optimum ratio of male to female trees for pollination in an orchard (5–20% of orchard with male trees), although about 1 : 8 (12%) is the most popular ratio (Race 1996). Research on pollination of carob suggests the lack of available pollen for female trees may be a primary cause of low fruit production (Martins-Loucao *et al.* 1996). It was also noted that despite carob having a long pollen period (i.e. several months), the quantity of airborne pollen was low. A greater number of male trees within an orchard may therefore be beneficial. Wind and insects were noted as important pollinating agents (Martins-Loucao *et al.* 1996).

Carob appear to have highly variable flower and fruit production within orchards and between years, although there have been few comprehensive studies of this behaviour. Recent research by von Haselberg (1996) on the fluctuations of flowering and fruiting of carob, found the presence of fruit had an inhibiting effect on the formation of the current season's flowers and fruit production the following year. Although harsh climatic conditions appeared to reduce flowering and fruiting, von Haselberg (1996) believed unspecified physiological factors played a more important role.

Mature carob trees with desirable characteristics can be found in a variety of locations. Micropropagation of
Table 1. Development and operating costs for scenario analyses

The costs used for the economic analyses were based on an 'orchard' design, with harvest beginning in year 6 and increasing until year 14, then steady production at 100 kg/tree.

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost (AS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development costs</td>
<td></td>
</tr>
<tr>
<td>Land value (25% used for roads, fences, sheds)</td>
<td>$300/ha</td>
</tr>
<tr>
<td>Establishment (deep-ripping; weed control; layout design; fencing)</td>
<td>$405/ha</td>
</tr>
<tr>
<td>Grafted carob trees</td>
<td>$8/tree</td>
</tr>
<tr>
<td>Irrigation system (for 'irrigated' options only)</td>
<td>$800/ha</td>
</tr>
<tr>
<td>Machinery (small farm truck, tractor, slasher and other implements)</td>
<td>$52,000</td>
</tr>
<tr>
<td>Mechanical harvester and second tractor (purchased at year 6)</td>
<td>$177,000</td>
</tr>
<tr>
<td>Annual operating costs</td>
<td></td>
</tr>
<tr>
<td>Machinery renewal</td>
<td>$2,000/ha</td>
</tr>
<tr>
<td>Labour, weed control, fertiliser, equipment repairs, fuel</td>
<td>$1,077/ha</td>
</tr>
<tr>
<td>Irrigation charges and repairs (for 'irrigated' options only)</td>
<td>$158/ha</td>
</tr>
<tr>
<td>Contract fertilising and harvesting</td>
<td>$754/ha</td>
</tr>
<tr>
<td>Overhead and management items (e.g. rates, office expenses, insurance, manager)</td>
<td>$505/ha</td>
</tr>
<tr>
<td>Variable operating costs</td>
<td></td>
</tr>
<tr>
<td>Cartage (weight of pods will vary)</td>
<td>$10/t</td>
</tr>
<tr>
<td>Pruning</td>
<td>$200/ha in years 1–6, then $20/ha from year 7</td>
</tr>
</tbody>
</table>

return less than the 'seed + stockfeed' market, and so have near-zero or negative IRRs. Table 2 presents a summary of the IRR analyses for the scenarios.

As discussed earlier, the current Australian demand for carob products is equivalent to about 2250 t of seed/year. This equates to about 22,500 t of pods, or the yield from 5405 ha of trees (at 104 trees/ha) with medium rainfall and low technology management (yielding 40 kg pods/tree) at a gross return of AS4000/ha; or 1080 ha of trees (at 208 trees/ha) with supplementary irrigation and fertilising (yielding 100 kg pods/tree) at a gross return of AS20,000/ha.

Of importance is that the current Australian demand for carob powder is just 60–100 t/year (valued at A$900/t for growers). Such a demand could be met from about 2800 trees yielding 40 kg pods/tree, or about 1100 trees yielding 100 kg pods/tree. This equates to about 27 ha of trees in medium rainfall areas, or 5 ha of trees with irrigation. As such, this demand for carob powder would require just 0.5% of the carob pods needed to supply the seed to satisfy the domestic demand for LBG. As mentioned previously, access to both markets is critical if a viable carob agroforestry industry is to develop. Consequently, unless the domestic demand for carob powder can be considerably increased (by expanding existing markets or creating new markets) or substantial overseas markets for carob powder can be accessed, there will be an inconsistent supply of carob powder (i.e. excess) and seed if the domestic LBG demand is met.

Fixed assets

While the cost of land and machinery could be excluded, it was decided that the cost of land must be included as there are alternative investments available.

Table 2. Summary of 30-year 'internal rate of returns' for each of the production scenarios

A uniform carob yield of 100 kg of pods/tree was assumed for each scenario.

<table>
<thead>
<tr>
<th>Product</th>
<th>Irrigated orchard 100 ha</th>
<th>Irrigated linear planting 100 ha</th>
<th>Medium rainfall orchard 100 ha</th>
<th>Medium rainfall linear planting 100 ha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18.1%</td>
<td>15.5%</td>
<td>17.9%</td>
<td>13.9%</td>
</tr>
<tr>
<td>Seed + powder</td>
<td>16.8%</td>
<td>15.2%</td>
<td>16.5%</td>
<td>11.5%</td>
</tr>
<tr>
<td>Seed + stockfeed</td>
<td>2%</td>
<td>0.3%</td>
<td>1.1%</td>
<td>-1.7%</td>
</tr>
<tr>
<td>Stockfeed only</td>
<td>-5.6%</td>
<td>-5.6%</td>
<td>-7.1%</td>
<td>-4.4%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product</th>
<th>20 ha</th>
<th>Medium rainfall orchard 20 ha</th>
<th>Medium rainfall linear planting 20 ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed + powder</td>
<td>18.1%</td>
<td>15.5%</td>
<td>17.9%</td>
</tr>
<tr>
<td>Seed + stockfeed</td>
<td>2%</td>
<td>0.3%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Stockfeed only</td>
<td>-5.6%</td>
<td>-5.6%</td>
<td>-7.1%</td>
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<tr>
<td>Seed + powder</td>
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<td>16.5%</td>
</tr>
<tr>
<td>Seed + stockfeed</td>
<td>0.3%</td>
<td>-1%</td>
<td>-7.1%</td>
</tr>
<tr>
<td>Stockfeed only</td>
<td>-5.6%</td>
<td>-5.6%</td>
<td>-7.1%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product</th>
<th>20 ha</th>
<th>Medium rainfall orchard 20 ha</th>
<th>Medium rainfall linear planting 20 ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed + powder</td>
<td>-1.7%</td>
<td>-4.4%</td>
<td>-4.4%</td>
</tr>
<tr>
<td>Seed + stockfeed</td>
<td>-7%</td>
<td>-11%</td>
<td>-11%</td>
</tr>
<tr>
<td>Stockfeed only</td>
<td>-7%</td>
<td>-11%</td>
<td>-11%</td>
</tr>
</tbody>
</table>
Including the cost of some machinery items (already owned by farmers) incorporated into the analysis may be debatable. In this analysis, these costs are included so that the orchard planting (100 and 20 ha) could operate separately to the original farming investment. This is not likely to be the case with linear plantings.

Future research

This research was based upon field observations, discussions with key stakeholders, and a review of Australian and international literature. While it has been possible to develop indicative parameters of a viable carob agroforestry industry, there remains some uncertainty about the precise potential due to information gaps. In particular, attention should be given to research and development in the areas of:

(i) refining the optimum biophysical conditions for reliable commercial yields, in terms of carob's response to: water requirements for reliable commercial yields, soil pH, soil fertility, fertiliser application, waterlogging, irrigation volume and frequency, irrigation with treated waste water, irrigation of recycled drainage water or moderately saline water, and biopumping of high groundwater in dryland and irrigation areas;

(ii) tree breeding (increase the selection of carob varieties available for varying agroecological zones) and propagation techniques (e.g. grafting, direct seeding);

(iii) assessing the impact of mechanical harvesting on flowering and subsequent yields for the major carob varieties;

(iv) developing guidelines to assist commercial growers record varietal agronomic characteristics (e.g. bearing age, yield, regularity of yield, growth habit, harvesting ease, disease resistance);

(v) investigating product qualities (e.g. kernel + endosperm yield, gum quality, pod size, sugar content);

(vi) increasing effort to market carob syrup (this should link market research with product development);

(vii) assessing the value of growers aggregating supplies to support industry development (e.g. growers association/operative).

Conclusions

This paper suggests there are areas in the Murray Valley where the environmental characteristics (e.g. rainfall, soil type) are suitable for carob production. However, a viable carob agroforestry industry will require reliable yields that can only be achieved with rainfall ≥500 mm. In areas of low or unpredictable rainfall, irrigation will be necessary to achieve required yields. While carob is reported to be tolerant of moderately saline water, it is uncertain what impact this has upon yield. Best practice horticulture suggests correct silviculture and fertiliser applications will also be required to achieve optimum yields, although the extent these practices will enhance carob agroforestry remains uncertain.

Mechanical harvesting has the potential to halve the current harvesting costs (currently 30% of total production costs) and will considerably increase the viability of carob agroforestry. The mechanical harvesting trial proved effective in efficiently collecting ripe pods. However, further monitoring of trees is required to determine the impact upon long-term flowering capabilities, and therefore yields. This trial has aroused considerable interest within the carob industry in Spain and Portugal, where harvesting still occurs by hand.

The market prices used in the analyses are A$1600/t for seed, $900/t for powder, $150/t for stockfeed (whole pod and kibble). The calculated financial returns under the various scenarios varied considerably depending on the nature of the carob markets. The best financial returns for growers depend on consistent access to the carob powder market.

In summary, economically feasible returns were generated when trees had access to adequate water through medium rainfall or low rainfall with irrigation, and the grower had access to both the LBG and carob powder markets. As the current Australian demand for LBG is far in excess of demand for carob powder, growers may require cross-subsidisation for the excess pod material produced or the markets for carob powder to be considerably increased.

Carobs do offer the possibility of providing a positive return on the grower’s investment but this largely relies on securing access to the carob powder market. Carobs also provide another option for plantings that will increase the aesthetic value of the property or may assist the management of rising ground water levels. Although this research suggests a viable carob industry that would satisfy Australia’s current carob demand will involve a relatively small area of plantings (5405 ha or less), export opportunities may emerge and so require a far larger area to be established. Nevertheless, landholders and natural resource managers should view carob production as an important tree crop option, with an opportunity for enterprising individuals or companies to develop a successful niche industry.

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