**McLean, C.B., J. Anthony, R.A. Collins, E. Steinke,** and **A.C. Lawrie.** 1998. First synthesis of ericoid mycorrhizas in the Epacridaceae under axenic conditions. New Phytol. 139:589-593.

**McLean, C.B., A.C. Lawrie,** and **K. Blazé.** 1994. The effect of soil microflora on the survival of cuttings of *Epacris impressa*. Plant and Soil 166: 295-297.

**Royal Horticultural Society.** c.1995. RHS colour chart. Royal Horticultural Society, London.

**Scagel, C.F.** 2001. Stimulation of adventitious rooting on cuttings from woody perennial plants by exposure to inoculum of ericoid and arbuscular mycorrhizal fungi. Poster presented at the 3rd International Conference on Mycorrhizas, Adelaide, 8-13 July.

**Stribley, D.P.** and **D.J. Read.** 1974. The biology of mycorrhizae in the Ericaceae. IV. The effect of mycorrhizal infection of the uptake of $^{15}N$ from labeled soil by *Vaccinium macrocarpon* Ait. New Phytol. 73:1449-1455.

**Thompson, W.K.** 1986. Effects of origin, time of collection, auxins and planting media on rooting of cuttings of *Epacris impressa* Labill. Scientia Hort. 30:127-134.

# Domestication and Improvement of *Kunzea pomifera*©

**Tony Page, Greg Moore, James Will, and Gerald Halloran**
Burnley College - University of Melbourne, 500 Yarra Blvd, RICHMOND VIC 3121

**The Australian native shrub species *Kunzea pomifera* F.Muell. (muntries) occurs in south-eastern South Australia and far western Victoria on sandy calcareous soils and is generally of prostrate habit. It produces edible berries of commercial potential, which are borne on the apical meristems of the plant in clusters of 3 to 9. The berries are succulent and range in size from 5 to 13 mm in diameter. They are mottled in colour from green, red to purple and possess a unique apple-like flavour.**

***Kunzea pomifera* was sampled across the area of its natural distribution as cuttings, which were then grown in replication in the outdoor production area at Burnley College, University of Melbourne. Variation in plant habit, leaf and fruit traits, flowering time, and the nature of the breeding system were examined. Variation in plant and fruit traits are discussed in terms of the scope for breeding muntries for commercial production. Characters considered important in muntries improvement are, upright habit, wider soil-type tolerance, condensed flowering period, and consistent fruit qualities. These studies led to the proposal of an ideotype (ideal plant form) for the commercial production of muntries.**

## INTRODUCTION

Detailed studies of variation within and between natural populations of *Kunzea pomifera* (muntries) are discussed in terms of its domestication for commercial production, culminating in the proposal of a plant form considered ideal for its commercial production (ideotype). Important preliminary research in the domestication of a wild plant species is that which aims to evaluate its variation for a range of plant characters considered best suited for its eventual commercial production. To maintain objectivity in this research, it is useful to conceptualise an ideal plant form (ideotype) that embodies desirable characteristics, both for the plant and its commercial product.

There are two important sources of information in deriving a credible and potentially achievable ideotype for the potential domesticate. Firstly a detailed knowledge of the range of variation for all of the plant characters considered to constitute the ideotype must be ascertained. This knowledge can be gained from detailed sampling of the natural population of the species and the rigorous evaluation, in the one environment, of the ideotype characters of importance for the species. Secondly, another source of guidance in deriving an ideotype, which will be both of high practical and economic feasibility, is the experience gained in the recent domestication of other fruit crop species.

Over the last century, a number of fruits have been domesticated, including cranberry (*Vaccinium macrocarpon*), blueberry (*Vaccinium* sp.), and kiwi fruit (*Actinidia deliciosa*). In deriving breeding and selection strategies in the domestication of muntries, some of the experience gained with these species is relevant. Of these species, experience with blueberry domestication appears to be most relevant to muntries because of similarities in fruit size and plant habit between the two species.

The domestication process of a wild plant species can involve experimentation over a considerable time span. Initial domestication for blueberries took approximately 14 years from 1906 to 1920 (Galletta and Ballington, 1996). The commercial development of the Australian native species quandong (*Santalum acuminatum*) took approximately 12 years from 1973 to 1985, during which time the CSIRO made assessments of growth characters, phenotype variation, and propagation methods on three plantations established by 1981 (Sedgley, 1984; Possingham, 1986) Similarly for muntries, the assessment of desirable production traits from wild populations and the subsequent breeding to attain the ideal commercial plant form (ideotype) can be expected to involve a similar period of time.

An important rationale for the domestication of a plant species must be a perceived market demand, both locally and worldwide, for its commercial product. Small local and overseas markets currently exist for both the fresh and processed product of muntries. Current demand for muntries is supplied primarily through harvest from wild populations but the fruit is generally of variable quality. Future market growth depends upon a supply that is reliable and of consistent quality (Beal, pers. comm. 1999). Muntries have a unique taste that can supply a market that is interested in using its interesting and novel flavours. With horticultural production and market development, it is believed that the demand has the potential to expand substantially to possibly occupy a level of consumption approaching that of blueberry. In Australia, it took around 10 years of sustained marketing for blueberries to gain recognition in the marketplace (Patel, 1996). Muntries currently occupy a small niche market in Australia and because it is largely unknown, it will take time before there is wide public awareness and acceptance of its place as another berry fruit, both in Australia and worldwide.

## EVALUATION OF VARIATION

Over the last 2 years representative collections from natural *Kunzea pomifera* populations were grown at Burnley College and assessed for a number of traits considered to be important for (1) evaluating overall genetic variation in the species and (2) indicating the potential for breeding forms for commercial production.

**Plant Characters.**

***Upright Habit and Wide Tolerance of Soil Type.*** The most important issue facing the efficient commercial production of muntries is that of modifying its plant growth habit towards a more erect and more readily harvestable form. The species is of prostrate habit, which presents difficulties in terms of harvest, weed competition and foliar disease control. Trellising and grafting are two cultural ways currently used to overcome the disadvantages of the prostrate habit. Breeding of upright forms from variation within *K. pomifera* is a third, but longer-term, option for improving the habit of muntries in production horticulture. Although primarily prostrate, there is variation within the species for degrees of upright habit that can be used for breeding upright forms. A further consideration is the option for the possible incorporation of erect plant habit from *K. ambigua*, a related species (which is discussed later).

***Condensed Duration of Flowering.*** The species flowers during spring from mid-September to late November in south-eastern Australia. There seems to be considerable within-population variation in flowering time, providing the potential to develop early-, mid-, and late-fruiting cultivars. Flowering duration on an individual plant appears to extend over approximately 4 weeks, resulting in variation in the time of fruit ripening on a plant. It appears that selection for condensation in the flowering period on a plant could provide genotypes with more uniform fruit ripening time.

***Harvest Accessibility of Fruit.*** Floral bud initiation in muntries typically occurs just behind the apical meristem of each shoot during late autumn to early winter. These buds develop into flowers during spring, and following successful fertilisation, the fruit and seed begin to enlarge. In some accessions the vegetative apical meristem remains inactive and the fruit is consequently displayed towards the ends of the shoots on the "outside" of the bush. In other accessions, however, the vegetative shoots grow beyond the inflorescence and thus "enclose" the fruit within the bush making the fruit less accessible to harvest. Selection of genotypes with little, or no, vegetative re-growth after flowering would improve bush structure for more efficient harvesting.

**Fruit Characters.** Fruit traits in muntries are highly variable but its commercial production would demand greater uniformity, in both its fruit appearance and quality characters.

***Size.*** Fruit size in muntries is highly variable but consistency in fruit size is important for the visual appeal of muntries to the consumer. The overall size of fruit may be of minor significance if traits like taste, texture, and colour are of prime importance to consumer preference, and if there is incompatibility between fruit size and any of these characters. In blueberries large fruit has been more acceptable to the consumer and producer and has been found to be much easier to harvest and handle than smaller fruit when manual labour is used. However, smaller berries appear to tolerate the actions of "over-the-row" mechanical harvesters more than larger berries (Galletta and Ballington, 1996). Fruit size may also affect the seed-to-pulp ratio, and thus texture, which may be important in shaping its broad appeal to the consumer. However, anecdotal evidence suggests that larger berries may be associated with reduced flavour.

***Yield.*** Muntries berries are typically borne in clusters on the apical meristem. Although yet to be verified, cluster size and fruit size appear to be inversely related. As the number of berries in a cluster increases, the size of individual fruit decreases as each fruit competes for space and photosynthate. Both cluster number and fruit size would invariably influence the overall yield of the plant. Understanding the inter-relationships of these traits is important for future selection in attempting to achieve an optimum yield and uniform fruit size. Under irrigation and adequate nutrition, plants will maintain vegetative growth at the expense of reproductive growth (Glowinski, 1991; Elliot and Jones, 1993). Thus in its production under irrigation, it appears that careful management of moisture availability, just prior to and post-flowering will most likely be critical in optimising yield of muntries.

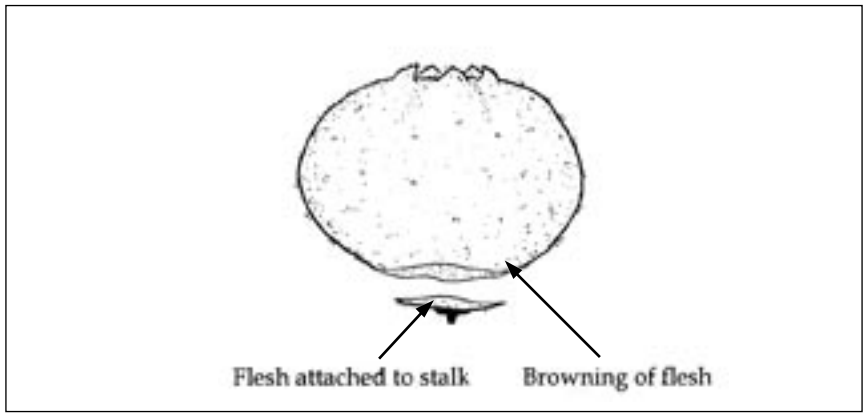


**Figure 1:** Fruit of *Kunea pomifera* showing defective stalk attachment.

***Fruit-Stalk Attachment.*** An important fruit quality trait is the strength of its stalk attachment to the fruit. Muntries fruits can become detached from their stalks partially or completely. With defective stalk attachment the fruit tears at the base, leaving a portion of the fruit on the stalk (Fig. 1). Defective abscission detracts from the appearance of the individual fruit, because the exposed fruit tissue turns brown. The opening left by this tear leaves the ovary exposed and allows the seed to drop from the fruit. The presence of free seed in the harvest adversely affects the overall appearance of the product. This trait of clean *versus* defective abscission of fruit from its stalk varies throughout the species and appears to be associated with fruit maturation. Therefore selection for condensed duration of flowering may lead to improvement in levels of clean fruit abscission.

***Fruit Surface.*** The colour of muntries fruit is typically a mosaic of green, red, purple, and white. It is a highly variable trait and the proportions of these colours result in a wide range of fruit appearance. Some plants can exhibit single-coloured fruit when growing in their clusters. However fruit often possess white skin patches from where they are closely adjacent in the bunches. This indicates that, as with many fruits, colour development depends on exposure to the sun. The acceptability of different fruit colours to the consumer is largely unknown and requires further investigation. As with highbush blueberries there may be a relationship between colour and taste, which may be an important consideration in selecting for a particular fruit colour, for consistent fruit quality in muntries (Galletta and Ballington, 1996).

The density of hairs on the fruit surface is another important trait that needs to be reduced in breeding and selection. All fruit have some degree of pubescence which ranges from dense to very sparse. The sparse hairs are generally not noticeable to the naked eye and such fruit is more visually appealing than moderately, or strongly, pubescent fruit. Bonney's arborescent selection of muntries bears fruit without hairs and thus would become a potentially useful parent in breeding for the glabrous-type fruit character.

***Culinary Traits.*** Fruit texture in muntries is quite a uniform trait, as most genotypes appear to have a firm and crisp texture. Although *K. pomifera* is a relatively dry-fruited species, its fruit moisture content between genotypes appears to be quite variable. Selection for high fruit moisture content would most likely help improve the market acceptability of the fruit.

Another important trait affecting fruit quality is seed-to-pulp ratio because high ratios can reduce the palatability of the fruit. With too high a proportion of small dry seeds the fruit texture becomes unacceptably gritty. Modification of the seed-to-pulp ratio in breeding is a matter requiring further investigation.

Fruit flavour is an important factor in marketing of muntries and there is considerable variability within the species, with a range in taste from sweet and "fruity" to bitter and astringent. Therefore attention to fruit taste is required during the breeding and selection process. Sugar content of fruit could possibly serve as a potentially useful early generation test to indicate sweetness level of fruit to reduce the population size in breeding, before the eventual use of taste tests, in latter-generation material.

The nutritional composition (including vitamins, minerals, antioxidants, and antibiotics) of the fruit would be of interest to the consumer and therefore testing for these would also need to be included in the selection and breeding for fruit quality.

The flesh of muntries is white like that of the apple, and also oxidises like an apple. One concern of processors is that muntries would oxidise when made into chutneys and jams. Selection of individuals with minimum tendencies for such oxidisation and thus more suited to processing, may be a worthwhile breeding goal.

## PROPOSED IDEOTYPE FOR MUNTRIES

Considering the detailed evaluation of variation in plant and fruit characters conducted over the last 3 years at Burnley, an ideotype is proposed for muntries for its commercial production, the components of which are detailed in Table 1.

## POTENTIAL FOR PRODUCING THE IDEOTYPE

**Breeding and Selection Within *Kunzea pomifera*.** The analysis of phenotypic and genetic variability in wild populations of *K. pomifera* indicates that there is considerable variation in the species for its domestication and improvement. Preliminary analysis of fruit characters has also revealed significant variation in this trait, which is also highly important for its successful domestication. While there is also likely to be substantial genetic variation in the species for yield characters another few years of growth is required to make an accurate assessment of such characters. Many traits proposed for the ideotype have been based on observations of natural variation in the species. A further assessment period is necessary to

**Table 1.** Proposed components of muntries ideotype.

| Plant Characters | Fruit Characters |
|---|---|
| ■ Upright habit, with straight firm stems. | ■ Consistent size and colour. |
| ■ Wide tolerance of soil types. | ■ Complete clean abscission from stalk at maturity. |
| ■ Condensed duration of flowering. | ■ High moisture and sugar content. |
| ■ Fruit borne on the outside of the bush. | ■ Low hair density on surface. |
| | ■ Low seed-to-pulp ratio. |
| | ■ Low oxidation or 'browning' of flesh. |

evaluate the genetics (e.g., heritability, inheritance, etc.) of these characters and their interaction in providing optimal levels of yield and fruit quality.

**Interspecific Hybridization with *Kunzea ambigua*.** Successful interspecific hybridisation has been achieved between *K. pomifera* and *K. ambigua* which increases the genetic resources available to a breeding program for muntries improvement. *Kunzea ambigua* has a natural distribution extending from eastern northern New South Wales to Tasmania. It is a variable upright ornamental shrub (1 to 5 m high) and grows vigorously in cultivation in a wide range of soil types (Elliot and Jones, 1993; Wrigley and Fagg, 1993). The overall seed set from controlled pollinations between the two species was greater than some crosses within *K. pomifera.* Seed from the interspecific crosses has been germinated and is now being subjected to preliminary selection based on the height-width ratio. It is feasible that crosses of *K. pomifera* and *K. ambigua* will provide the potential to combine the upright habit and apparent greater tolerance of different soil types of *K. ambigua,* with the fruit characters of *K. pomifera.* There is considerable variation in stem strength and habit in *K. ambigua*, but the juvenile stems are particularly "droopy" and may be unable to support developing fruit. However, the straight rigid stem characters of some *K. pomifera* accessions combined with the erect habit of *K. ambigua* should provide genotypes with erect and rigid stem conformation.

## CONCLUSION

The characters required to produce the ideotype for muntries appear to be present within natural populations of *K. pomifera* and the compatible species *K. ambigua.* It will take time for breeding and selection to achieve the ideotype, and to subsequently establish it in cultivation and open up and expand both local and world markets for its products. Both the potential appeal of its fruit and the promise for productive forms that would suit the needs of its commercial production, indicate that muntries could experience a successful future as a new food crop.

## LITERATURE CITED

**Elliot, R.W.** and **D.L. Jones.** 1993. Encyclopaedia of Australian Plants: Suitable for cultivation. 6(K-M):480. Lothian, Melbourne, Australia.

**Galletta, G.L.** and **J.R. Ballington.** 1996. Blueberries, cranberries and lingonberries. Fruit breeding: Vine and small fruits. 2: 471. In: Janick, J. and J. N. Moore (eds). John Wiley & Sons, Inc., New York, New York.

**Glowinski, L.** 1991. The complete book of fruit growing in Australia. Lothian Books, Port Melbourne.

**Patel, N.** 1996. Recent trends in Australasian blueberry production. Acta Hort., 446:53-55.

**Possingham, J.** 1986. Selection for a better quandong. Aust. Hort. 84(2):55-59.

**Sedgley, M.** 1984. Australia's first commercial fruit? Aust. Hort. 82(10):52-59.

**Wrigley, J.W.** and **M. Fagg.** 1993. Bottlebrushes, paperbarks and teatrees and all other plants in the Leptospermum Alliance. Angus and Robertson, Sydney.


# Seed Germination and Propagation of *Arachnorchis formosa*©


**T.T. Huynh and C.B. McLean**

Burnley College – University of Melbourne, 500 Yarra Blvd, RICHMOND VIC 3121

**A.C. Lawrie**

RMIT University, Dept. of Biotechnology and Environmental Biology, BUNDOORA VIC 3083



**Symbiotic and asymbiotic seed germination methods were investigated to maximise the production of the endangered orchid *Archnorchis formosa* (G. W. Carr) D.L. Jones et M.A. Clem. (Orchidaceae) for the re-establishment phase of its recovery plan. Mycorrhizal fungi were isolated from adult plants in the wild at various stages in the orchid life cycle (budding, leafing, flowering, capsule production, and senescence). Seed was germinated on minimal (oatmeal agar) and complex (PA5 containing coconut water) media with and without mycorrhizal fungi under axenic conditions. Germination and subsequent growth was recorded at monthly intervals for a period of 12 months. Mycorrhizal status of seedlings was determined by microscopic examination using SEM. Seed grown on minimal media inoculated with mycorrhizal fungi from the leafing, budding, and flowering stages gave fastest (within 1 month) and highest (>50%) germination rates. Seed grown on the complex media did not germinate in the 1st month, however those seeds that did germinate later achieved higher rates (>95%) than those on minimal media.**

**Symbiotic seedlings grown on minimal medium were able to be deflasked and survived to produce tubers under nursery conditions. Although seedlings produced on complex media had higher germination percentages than their counterparts on minimal media, none survived the deflasking process.**

**This study has shown that minimal media and mycorrhizal fungi isolated from actively growing adult plants (i.e., budding, leafing, and flowering stages) can enhance the germination and subsequent growth of seedlings of the endangered spider orchid *A. formosa.* This information can now be used to produce plants for re-introduction in the wild.**