A demonstration of the diversity in *Vigna* — the cultivated mung bean (left) and the Australian native *Vigna*, V. lanceolata (above). It exists in annual and perennial forms and is found from the coast to the arid centre; flowers and pods form above and below the ground.

FROM BUSH TUCKER TO BEANS

Australia's native *Vigna* species are very adaptable. Their genes, in particular those that relate to hard-seededness, seed protein, disease resistance and flowering times, will have a ready application in improving both seed crops like mung bean and the various species exploited as forage.

by Wayne Ralph

Until now the Australian flora's contribution to international cuisine has been limited to the fruits of the macadamia and the quandong, but the bush-tucker collection hides many potential gems. Almost certainly the native *Vigna* genus will make the next contribution to the world's food basket; its relatives include the mung and adzuki beans (*V. radiata* and *V. angularis*) and the cowpea (*V. unguiculata*).

The genus has a wide distribution across Africa, Asia and the Pacific, with the Indians domesticating the mung bean at least 3500 years ago. It is diverse and productive, with its members providing everything from flour to tubers and green vegetables; many species have proved to be valuable forage crops in the tropics and subtropics.

Aborigines exploit all five of the species found in Australia, with the tubers being prominent in the diet of certain tribes when they are in season. In fact the *Vigna* species seem to have reached an accommodation with the original inhabitants, with their hard-seed and tuberous characteristics putting them among the very first plants to appear after human-inspired fire.

The Australian *Vigna* species are a valuable genetic resource. For example, *Vigna lanceolata*, the only one unique to Australia, is incredibly adaptable; it has a distribution that ranges from the tropics to the sub-tropics and from the coast to some of the most arid parts of the interior. Hidden away in the genes of Australia's *Vigna* are some valuable traits, but the pace of development in Australia's north — including urban development and extensive pasture improvement as well as degradation of the native pastures, even the incursion of cultivated mung beans into the region — threatens this resource.

Dr Bob Lawn of the CSIRO Division of Tropical Crops and Pastures with his wife and colleague Ms Alison Cottrell of the University of Queensland have studied the natural history of Australia's *Vigna* spp. and collected specimens from across northern Australia. With fellow members of the Division Dr Bruce Imrie and Dr Van Bushby, then PhD student Dr Rex Williams and Dr Don Byth of the University of Queensland, Dr Lawn has expanded the search and conducted sophisticated genetic studies to find out how these native plants can contribute to modern agriculture.

The sprawling growth of *Vigna marina* helps stabilise coastal sand dunes.

To date more than 400 samples of Vigna have been collected from across northern Australia and nearby islands in Indonesia, Papua-New Guinea and Oceania, and the activity is continuing. The scientists are also attempting to collect the nitrogen-fixing *Bradyrhizobium* associated with the legume's nodules. Little is known about this bacterium and its adaptation to the difficult tropical environment; some of its characters may prove useful to legumes elsewhere in Australia.

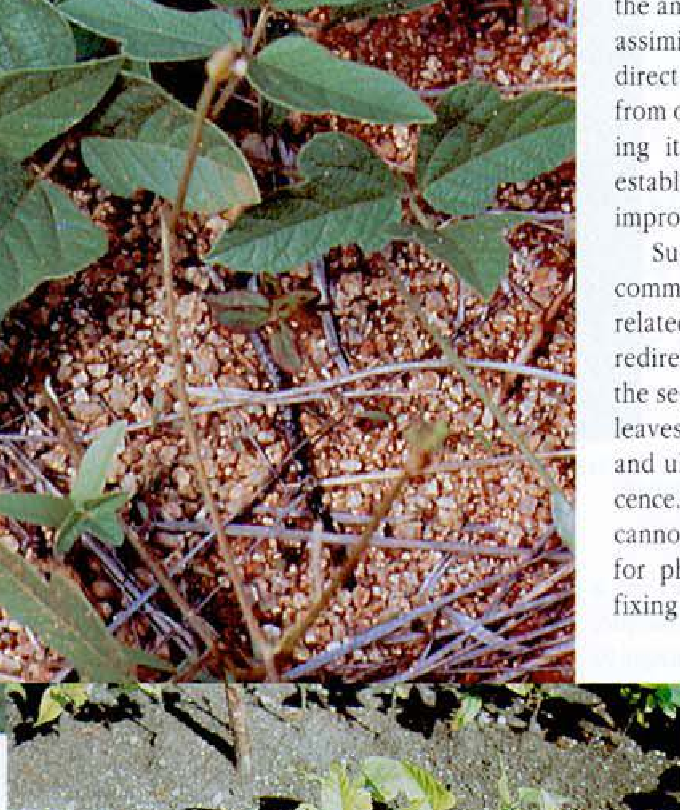
In the case of the wild mung bean (*Vigna radiata* ssp. *sublobata*), some of the more interesting accessions are those collected from degraded saline soils; compared with cultivated varieties, these plants have a remarkable ability to survive in saline conditions. Similarly, collections made from limestone-derived soils in Timor are very tolerant of alkaline calcareous soils, in which modern cultivars suffer severe chlorosis due to alkaline-induced iron deficiency.

Of most immediate interest and use is the hard-seeded trait found in some of the wild mung beans. During the process of domestication, where the emphasis has been on readily germinable seed — both for planting and sprouting purposes — hard-seededness has slowly been bred out of the cultivars. Unfortunately this results in serious, recurring problems due to seeds deteriorating in quality or sprouting in the pod following any late-season rain.

The wild mung bean crosses readily with its cultivated relatives and Dr Lawn, Dr Williams and Dr Imrie have analysed the progeny of such liaisons and suggest that only a single dominant gene controls hard-seededness. A backcrossing program is currently in progress to introduce the trait into a modern cultivar to see just how effectively the 'wild' gene can do so.

The process of domestication is a complex one, and only relatively recently has the mung bean been improved enough to be able to fit into modern mechanised

The wild mung bean is a twining, viny plant that is often found beside the roads of tropical Australia.



Cultivated mung beans growing on a calcareous soil show micronutrient deficiency symptoms whereas, at the bottom of the photograph, the wild mung bean — a weed in the area — grows normally.

agriculture. Previously, all the domestication effort was concentrated at the Asian village level, with the focus being on fitting the species to the small local plots.

Despite being adapted to mechanised agriculture, the modern mung bean still retains some genetic hangovers from its wild old days. Prominent among these are un-even flowering and pod development and maturation, coupled with a relatively low yield potential and harvest index.

Encouraging synchronous flowering and seed production, and a higher harvest index, creates a major problem — it inevitably pushes up the demand for carbon and nitrogen compounds from the mother plant. If this demand exceeds the amount supplied through its current assimilation, the plant may have to redirect or remobilise carbon and nitrogen from other sinks, ultimately compromising its physiological functioning and establishing another important barrier to improved yield potential.

Such a functional problem is not uncommon. For example, in the closely related soybean the remobilisation and redirection of nitrogen from the leaves to the seed is a key factor in triggering the leaves' loss of photosynthetic activity, and ultimately the whole plant's senescence. Similarly, the soybean's root nodules cannot compete with the developing seed for photosynthate and their nitrogen-fixing activity often declines at a time when it is most needed.

Very little is known about what happens in mung bean during that important seed-fill period. To find out more, Dr Bushby and Dr Lawn have looked at what happens within mung bean genotypes with differing histories of domestication. Their test subjects included a wild mung bean collected from south-eastern Queensland, an Indian landrace representative of the sorts of lines that are grown in subsistence agriculture and, finally, the recently developed CSIRO cultivar Satin.

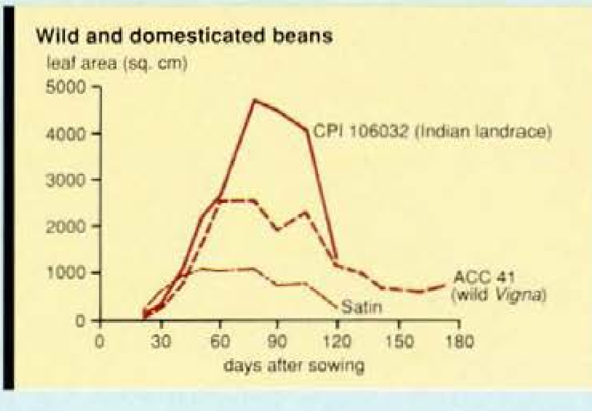
The scientists found marked differences in the way the genotypes put their seeds together. The wild type was unusual in that it proved to be weakly perennial, but under the field conditions it experienced it still put most of its nitrogen-fixing and photosynthetic effort into the period around flowering and seed-set. This multi-branched trailing vine had an extended flowering period, with nodules and green leaves still active at the end of the experiment; clearly these active organs were waiting for the next favourable period to continue with the plant's reproduction.

Satin also experienced marked changes around flowering. According to the scientists, flowering was a critical plant-development milestone for the cultivar. It signalled the end of vegetative dry matter accumulation, while nitrogen fixation fell into a progressive decline.

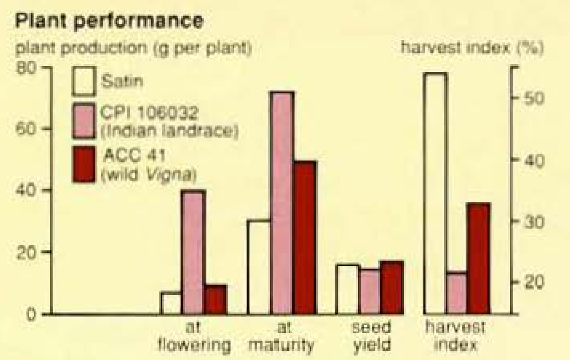
In marked contrast, the flushes of flowers and pod-fill in the Indian landrace were way out of 'synch'; in fact nitrogen-fixation activity seemed to be quite independent of the flowering activity. Vegetative growth was prolonged and flowers slow to develop, and the plant had a markedly lower harvest index than its experimental compatriots.

As the scientists remark, it is perhaps not surprising that each genotype's behaviour reflects its fitness to the environment from which it came. Thus the Indian landrace has a stable reproductive strategy suited to the needs of village agriculture; its sustained (and larger) vegetative growth provides a store of nitrogen and carbon compounds that can be mobilised if adverse conditions threaten its reproductive success. Even in tough seasons the villagers will still get some grain.

The Australian native mung bean can rely on either stored reserves or current assimilation to meet the nitrogen and carbon demands of its developing seeds. In the scientists' view, this dual strategy,



In growth terms, Satin ranks a poor third but, as the accompanying chart shows, the bulk of its energy is devoted to grain production.



The Indian landrace and wild *Vigna* have a conservative growth habit — large biomass accumulation to help ensure that some seed is produced each year. Satin, by contrast, is a small plant that concentrates its efforts on grain production.

Australia's five

scientific name	common name	existing or potential uses
V. radiata ssp. *sublobata*	wild mung bean	source of tolerances for mung bean breeding, native pasture legume, bush tucker
V. lanceolata	western vigna	native pasture legume, tuber crop, source of drought adaptation (?), bush tucker
V. luteola	Dalrymple vigna	native and improved forage legume
V. marina	dune bean	beach protection and dune stabilisation, medicinal plant, forage legume (?)
V. vexillata	wild cowpea	pulse and tuber crop, native pasture and improved forage legume, bush tucker

Australian *Vigna* species and some existing and potential uses.

A crop of mung beans in the Dawson Callide region.

coupled with an indeterminate and weakly perennial habit, shows an opportunistic (and realistic) approach to reproduction in a competitive bush habitat.

Satin reflects the breeders' efforts to develop a robust plant suited to a high-input mechanised agriculture. It produces early, heavy flushes of flowers that depend upon current assimilate to sustain the seed's growth; it puts very little away for hard times. This high-risk — albeit productive, when successful — strategy emphasises how important it is for breeders to develop cultivars that can maintain photosynthetic and nitrogen-fixing activity well into seed-fill.

Another major concern for breeders is regulating the flowering of modern mung bean cultivars. Typically, a large proportion of the seed yield develops from a second flowering flush — in the study described above, 42% of Satin's seed came from the second flowering. Consequently, the products of the first flush are exposed to weather damage while the second lot matures; the uneven ripening — with some pods ready to shatter while others still have a tinge of green — also poses problems at harvest time.

Mung bean breeders are looking to control these flushes and make the plant more like the closely related soybean, where an extended vegetative phase allows the accumulation of dry matter and nitrogen that is subsequently poured into the seed after a period of synchronous flowering.

In effect, breeders are looking to develop a composite cultivar that combines the best attributes of the wild types — hard-seededness, adaptability and late and synchronous flowering — with the established high yield potential of modern cultivars like Satin. Dr Bushby and Dr Lawn speculate that for many Australian environments the ideal may be a cultivar that combines many of the attributes of the Indian landrace described above with those of Satin.

Such a composite cultivar would take the enhanced storage capability from its Indian parent and combine it with Satin's strong reproductive potential and ability to allocate nearly all its current assimilate to the needs of the developing seed. Take this combination of two reproductive strategies and mix in the wild genes for hard-seededness and juvenile behaviour, add when necessary genes for traits like salinity tolerance or ability to tolerate cold snaps, and you're looking at the ideal cultivar. Watch this space.

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Further food for thought

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