Summary
The Vetch Breeding Program (VBP) focused on vetch variety improvement nationally to develop disease resistant and low toxin varieties for low to medium rainfall areas. Each year, the program made approximately 120 crosses which produced about 450 pods. During this three year project, a new early maturing, rust resistant and ascochyta tolerant vetch variety, Rasina, was released. Rasina’s grain contains 0.67% of cyano-glcoside compared with 1.2% in Blanchefleur.

Exploratory lamb feeding demonstrations showed advantages in lamb growth when vetch grain was included as the high protein component in their diet. Further research is needed to confirm vetch’s role as a feed grain.

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Conclusions

The project achieved all outcomes and milestones

- During the three years of the project, the Vetch Breeding Program recombined germplasm by crossing high yielding, disease resistant, low toxin, non-shattering, soft seeded, early maturing and beige cotyledons traits into new lines. Approximately 350 pods were harvested annually. Seventy to 90 lines showed excellent potential, reaching the F4 and F5 stage.
- VBP collaborators in South Australia, Victoria, New South Wales and Western Australia tested vetch lines and organised field days to assess the program's achievements and specific requirements for different production areas and different end-uses of vetch.
- Two extremely dry years (2006 and 2007) were used to select 12 lines that yielded better than current varieties in areas that had 115 mm (Lameroo 2006) and 127 mm of rain (Peake 2007) from seeding to harvesting.
- Preliminary results from feeding lambs with vetch grain and mixtures with cereal grains are very promising.
- Vetch in crop rotations improved soil nitrogen, reduced weeds and diseases and reduced inputs of mineral fertilisers in the following crops. Project collaborators from Blyth, M Smitham and B Whitehead, reported that they reduced nitrogen inputs by 15 to 30% in following cereal crops after vetch for grain and hay, respectively.
- Vetch grain and hay are very good sources of crude protein, dry matter digestibility and metabolisable energy.
- The breeding effort in this project focused on releasing a new vetch variety, Rasina that
  1. is high yielding in low to medium rainfall areas
  2. is more tolerant to drought than Morava and Blanchefleur, maturing 10 to 15 days earlier than Morava. In 2006 and 2007, it escaped the dry finish of the seasons and yielded better than Morava in low rainfall areas i.e. Lameroo, Blyth, Peake and Walpeup
  3. is disease resistant and can be grown without fungicides for control of rust and ascochyta
  4. contains 0.67% anti-nutritional components in the grain
  5. possesses soft seeds and can be included in crop rotations without the problem of it emerging as a weed in following crops
  6. has pods which are non-shattering, allowing farmers to delay harvesting for seven to 15 days without grain losses.
- VBP has so far released two vetch varieties, Morava and Rasina, both disease resistant and well accepted by Australian vetch producers and end-users. Seed prices over the past three years were very high at more than $1,500/t.
- During this project, a number of scientists reported the benefits of vetch in crop rotations. Their names and articles are listed at the end of this report.

Recommendations

Plant vetch cv. Rasina in areas with rainfall less than 350 mm/yr for grain production rather than Morava. For early grazing, Rasina has better initial growth than Morava, Blanchefleur and all hairy and purple vetches.
In areas with 350 mm to 400 mm/yr precipitation, Rasina and Morava can be planted for multi-purpose use; grain, hay/silage, pasture or green manure.

In areas with greater than 400 mm rainfall, Morava performs better than Rasina, particularly for hay or silage.

Pregnant sheep or cows should not be grazed on vetch varieties infected with rust. In 2005, rust occurred in a Blanchfleur crop. Many pregnant sheep that grazed this crop aborted (2006 Blyth vetch field day - farmer personal/anecdotal comment).

Use vetch crop as green manure to provide nitrogen for following cereal crops.

During the season, producers can make decisions to use vetch as hay or silage or as a grain crop. In years that have dry finishes to the season (moisture deficit from September), it is better to cut vetch for hay or silage than keep it for grain. Vetch hay and silage is in high demand in many livestock areas and can be more profitable than grain production.

**Outcomes**

**Economic benefits**

Australian vetch producers in low rainfall cropping regions benefit with improved gross margins in cropping rotations. In addition to viable grain and forage production from vetch, cereal crop yields following vetch are usually at least 30 to 50% higher than those derived from continuous cropping with cereals. Farmers, M Smitham and M Martin from Blyth, and G Pearce from Lameroo reported wheat yields increased by 30 to 35% while reducing nitrogen fertilisers by 20 to 25%. The benefits of pulses in a crop rotation are widely recognised. This project helped make these benefits available to farmers in low rainfall cropping regions.

In mixed farming systems, farmers are able to use their own grain, high quality pastures and/or hay for livestock (I Migel, Lameroo, South Australia). Therefore, substantial money can be saved on transport if livestock farmers use their own feed.

This program released two grain varieties, Morava® and Rasina®, both resistant to the main vetch diseases, stem and leaf rust, excluding the need to use expensive fungicides. Lower toxin levels in the grain (around 0.65%) may allow livestock farmers to include grain from these varieties in the diet at a higher percentage than other grains.

**Environmental benefits**

Disease resistant varieties can be successfully grown without fungicide use. As a pulse component in the farming system, vetch can assist with managing diseases and weed resistance in following crops. Vetch also returns significant amounts of nitrogen back into the soil and promotes microbiotic activity. Depending on the end-use, vetch can return 57, 97, and 136 kg/ha of nitrogen after production for grain, hay/grazing and green manuring respectively (Vetch Breeding data for three years x five sites). Reducing on-farm reliance on chemicals and mineral fertilisers has a positive environmental and economic benefit on-farm and can provide significant marketing advantages.

Wheat production systems in southern Australia use large quantities of synthetic fertiliser, generated by energy from fossil fuel. These systems also have growing soil-borne disease and weed control problems. Vetch is one of the best nitrogen fixing crops, reducing the requirement for fertiliser application. It also acts as a disease and weed break for cereals. Pulse based cropping systems also have a lower global warming potential (GWP) from combined greenhouse gas outputs (CO$_2$ + N$_2$O + CH$_4$ ) compared to fertiliser based cropping systems (Robertson et al. 2000).

**Social benefits:**

The social benefits of this research are delivered from increased profit on-farm and to the community as a whole through greater profitability and prosperity from vetch production (in all its different forms) in a cropping rotation and versatile end-uses.

Benefits from high yielding, disease resistant, versatile vetch varieties for Australian farmers have been, and continue to be, considerable.

**Achievements/Benefits**
During this project VBP developed 12 lines that performed better than any current variety in dry finishing seasons such as 97% germination after seven to 10 days in the field. It is highly palatable as a green plant from emergence to maturity. Shattering and harvest can be delayed for five to 10 days without losing grain. Rasina is a soft seeded variety with more than dark beige green cotyledons, which is targeted by VBP so the cotyledons are not similar to lentil. It is tolerant to pod 1.6%, respectively. Rasina is rust (Uromyces viciae-fabae) and were between 0.56 to 0.78%, similar to Morava (0.65%) and notably lower than Blanchefleur and Languedoc - 1.2% and growth similar to Languedoc and better than Blanchefleur and Morava. Toxin levels in the grain were analysed in 72 samples grain production outyielded all current varieties in areas with annual rainfall less than 350 mm per year. Rasina has initial low-medium rainfall areas in most Australian soils. Rasina flowers approximately 10 to 15 days earlier than Morava, and in Major achievements of the project include commercialisation of a lower toxin variety, now named Rasina. It is well adapted to growers in these areas, particularly lower rainfall parts of the target regions. Vetch adoption in these regions significantly improved after the release of two disease resistant varieties, Morava and Rasina. However, problems with grain marketability and seed price have still not been overcome.

In areas that aim to sow vetch at 60 to 65 plants/sq metre, Rasina should be planted at 40 to 45 kg/ha, compared with Morava at 50 to 60 kg/ha. This is due to Rasina’s 100 seed weight of 6.5 to 7.0 g compared to Morava’s 7.5 to 8.3 g.

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Vetch is a legume of Mediterranean origin that has shown agronomic potential in a range of Australian cropping environments. The main species in many Mediterranean regions (as well as Australia) are common vetch (Vicia sativa) and hairy vetch (Vicia villosa). Subsequent agronomic research work carried out in southern Western Australia has demonstrated that common vetch and hairy vetch are well adapted to the low fertility soils of the Australian cereal belt with short winter rainfall growing seasons.

Common vetch is a multi-purpose crop for use as a grain, hay/silage, pasture and green manure crop. This species also has better initial growth and early vigour and better palatability from emergence to mature plants when compared with hairy, bitter and purple vetches and narbon bean.

Vetch hay and silage is a very good source of highly digestible crude protein and high in metabolisable energy. 105 samples analysed averaged 20.2% crude protein, 62.9% dry matter digestibility and 9.0% metabolise energy. A Gippsland hay supplier for dairy farmers, G. Thompson, reported at a Rural Industries Research and Development Corporation (RIRDC) meeting in 2006: “remains of vetch hay are 0, compared with lucerne hay where 10-15% remains after feeding”. G Thompson also estimated that “we have reached just 40% of vetch hay demand in Australia”.

Vetch plays a valuable role in rotations within the low rainfall wheat growing zones of Australia that do not currently have a viable grain legume option for farmers (Esperance region of WA, northern Eyre Peninsula and Murray Mallee in South Australia, and the Victorian Mallee). Productivity of cereal cropping enterprises in these environments is constrained by the lack of suitably adapted crop legumes that can act as a disease break in rotations and increase soil nitrogen reserves for subsequent cereal crops. Field pea, chickpea, lentil, faba bean and lupin are not considered to be viable options by many growers in these areas, particularly lower rainfall parts of the target regions. Vetch adoption in these regions significantly improved after the release of two disease resistant varieties, Morava and Rasina. However, problems with grain marketability and seed price have still not been overcome.

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Project objectives were to:

1. Release a rust and ascochyta resistant vetch variety by 2008 for low to medium rainfall cropping zones.
2. Release variety(s) that have less than 0.65% toxin in their grain to allow inclusion of vetch grain in poultry and pig feed.
3. Recommend cost effective mixtures of vetch and cereal grain for sheep and cattle.

Vetch contains the anti-nutritional component, amino acid gamma-glutamyl-beta cysteine. D. Enneking in his PhD thesis, “The toxicity of Vicia species and their utilisation as a grain legume”, cited many scientists who work with common vetch grain. In summary, no major toxicity problems are known to occur with feeding grain of V. sativa to sheep, provided that care is taken when used as a supplement with other feeds and the animal’s feed intake behaviour is allowed to operate normally. However, with the intended use of these crops as a grain feed for monogastric animals, or even as a human food, grain toxicity becomes a highly relevant problem. This needs to be investigated thoroughly before further development of these crops for such end-use can be contemplated. VBP is breeding vetch with less than 0.65% anti-nutritional level in the grain, however we have never considered vetch should not be recommended for human consumption. Other crops such as lentil, pea and different bean species are readily produced by Australian farmers for this purpose, therefore vetch needs not to be targeted at the human food market.

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The results from the lamb feeding experiments with Rasina grain, as well as Tables from the Technical Information Dossier of Rasina are attached.

**Other research**

With reduced water allocations for lucerne irrigators, VBP needs to collaborate more with farmers looking to replace lucerne in irrigated areas with a dryland option. Dairy farmers are demanding vetch hay as a highly valuable hay or silage for dairy cows to replace lucerne (Pers. Comment: R Sonogan district agronomist, Swan Hill, Victoria).

Very high mineral fertiliser prices have encouraged farmers to increase nitrogen levels in the soil with legume crops, reducing or excluding the need for nitrogen fertilisers in following crops. Vetch is one of the best crops for nitrogen fixation in many soil types (M Smitham and B Whitehead, Blyth; G Pearce, Lameroo; A Brown, Maitland; I Rochester, Narrabri). VBP needs to investigate nitrogen fixation at different growth stages of vetch plants, to establish the potential/viability of planting vetch very early (March/early April) and ploughing it into the soil in early June before planting cereal crops.

CSIRO Plant Industry, Narrabri scientist I Rochester reported in several journals that vetch green manure increased cotton profits by 18%. Overseas scientists (Bulgarian, Hungarian, Serbian, Russian) reported the inclusion of vetches in orchards and vineyards improved soil fertility with small or no other inputs of mineral fertilisers. VBP will investigate possibilities for this use in Australia.

Many reports are published about nitrous oxide emissions from nitrogen fertilisers and vetch production will reduce the need for these fertilisers.

More agronomic research needs to be carried out on:

1. nitrogen fixation at different crop stages, and investigation of different varieties and advanced breeding lines to determine if there are differences in nitrogen fixation rates
2. herbicides for broadleaf weed control
3. herbicide and other management options for herbicide resistant grass weeds
4. seeding times and seeding rates for current varieties in different areas
5. vetch production for grain and hay with and without nitrogen fertilisers.

A new guide for growing and the production of vetch in Australia is needed that includes up-to-date information on new varieties and species, as well as chemicals and agronomic practices and end-uses.

**Intellectual property summary**

GRDC has existing intellectual property in the germplasm developed in the vetch breeding program. The germplasm and progeny are owned by GRDC and SARDI.

Rasina, the new variety from this program, is protected by PBR.

**Additional information**

The project will continue its emphasis on breeding varieties that are tolerant to drought and heat stress, resistant to rust and ascochyta and with grain toxin less than 0.6%.

This project will address the potential of vetch to provide a grain legume in regions where currently there are no reliable grain legumes.

The project will test advanced breeding lines for:

1. Adaptability to low rainfall (water deficiency) at flowering and post flowering stages.
2. Diseases (rust and ascochyta) resistance and tolerance in Kingsford and Charlick disease nurseries.
3. Analyse feed quality of hay and grain (Hamilton, Pasture and Veterinary Institute).
4. Optimum plant density seeding rates for low and high rainfall, for grain and hay.
5. Herbicide tolerance - high and low rainfall areas, sandy and heavier loamy soils.
6. Toxin level in the grain.
7. Seed softness in demonstration strips.
8. Nitrogen fixation for common vetches compared to hairy vetches.
10. Replacement of present varieties with new superior germplasm.

Varieties need to have beige, green or yellow cotyledons so substitution of vetch for lentil does not occur. Morava\(^\text{\textregistered}\) type varieties (big plants) will still be very popular for grain production in areas of rainfall greater than 350 mm per year and as hay or silage in areas from 300 mm to 650 mm rain per year.

This project will include the two main vetch species, common vetch (\textit{Vicia sativa}) and hairy vetch (\textit{Vicia villosa}).

Breeding of hairy vetch (\textit{V. villosa}) will concentrate on developing varieties that can grow in areas with rainfall between 375 mm and 650 mm per year. New varieties will be characterised by high dry matter production, soft seeds, good early establishment, ascochyta and botrytis resistance, non-shattering, good seed producers, palatable as green plants, and with good leaf retention.

Grain from this species cannot be used as feed for any livestock.

All current hairy vetch varieties possess a high percentage of hard seeds. Germplasm selection is underway to replace the hard seeded varieties, Capelo\(^\text{\textregistered}\) and Haymaker\(^\text{\textregistered}\). Breeding of \textit{V.villosa} germplasm is also underway for new varieties.

The Vetch Breeding Program currently has and will keep collaborations with all Australian and international institutions/scientists involved with vetch breeding/production and use.

Papers derived from or related to this project


R. Matic, Vetch Breeder; Stuart Nagel, Research Officer; Gregg Kirby, Senior Ag Officer. Australian National Vetch Breeding Program - Directions and Research, 2006. Characteristics of two common vetch varieties - Morava and Rasina. NSW CFWS Compendium

R. Matic, S. Nagel & G. Kirby, K. McDougall. 2007. Australian National Vetch Breeding Program - Directions and Research. NSW CFWS

Vetch (\textit{Vicia spp}) adoption and utilization in Australia (presented at X11 International Symposium for forage crops in Krusevac, Serbia)