Developing an Australian pearl millet industry

Summary
Pearl millet is a high value feed grain and a major food crop in the semi-arid tropics of Africa and India. A major achievement of this project was the introduction and selection of new pearl millet hybrids suitable for growing as a grain crop in Australia. The best hybrids matured in 85 days and yielded up to 4,800kg/ha of grain in irrigated trials. Computer simulation indicates that pearl millet is suited to early spring and late summer opportunity cropping in central and southern Queensland (QLD). Poultry nutrition trials showed pearl millet is worth a 25% premium over sorghum in least cost poultry diets. The Queensland Department of Primary Industries and Fisheries (QDPI&F) is seeking a seed company to commercially market the hybrids and establish a pearl millet industry.

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Conclusions
New pearl millet hybrids suitable for grain production have been selected and hybrid parent seed is available to commercial partners. The new hybrids mature in 85 days and have a yield potential of 4,800kg/ha. Simulation studies, using Whopper Cropper, conclude that the hybrids are best suited to spring and autumn opportunity cropping in Queensland and northern New South Wales (NSW), being at least as economical as early maturity sorghum hybrids.

Nutritional studies in which pearl millet grain replaced sorghum in the diet of layer hens demonstrated that pearl millet grain is worth a 25% premium over sorghum in the manufacture of least cost animal diets. Pearl millet is a high protein grain with a balanced profile of essential amino acids. The key market for pearl millet grain will be mono-gastric animals such as pigs and poultry.

Recommendations
Further work is required to successfully establish a pearl millet industry in Australia. QDPI&F is currently seeking a partner to commercialise and market the two elite hybrids developed in this project. The successful seed company will produce and market hybrid planting seed and will undertake further development and extension work to help growers successfully grow and market grain pearl millet. Further agronomic development is required to determine (1) planting methods to improve emergence, (2) optimum plant populations, (3) fertiliser requirements, (4) sowing dates in different locations, (5) weed control and herbicides, and (6) to conduct farm sized demonstrations of the new hybrids. Further development work will be required with the pig and poultry industries and feed grain manufacturers to demonstrate the suitability of pearl millet grain as a feed grain.

Outcomes
Economic outcomes
The adoption of grain pearl millet as an additional crop option for dryland cropping growers in northern Australia should spread the economic risk for these growers. The new short-season pearl millet hybrids mature in 85 days, 25 days earlier than current sorghum hybrids. Consequently, they offer a reliable February planting option for growers in central and southern Queensland.

Pearl millet grain is a potentially high value feed grain for the pig and poultry industries. The Australian poultry and pig industries are forecast to increase production, yet face increasing pressures from rising feed-grain prices. Feed ingredients currently account for 60% to 70% of the production costs in intensive poultry and pig production. These highly competitive industries currently rely on grain sorghum and feed-grade wheat as the main ingredient for their diets. Feed manufacturers must supplement these low-protein grains with more expensive soybean meal and meat/blood meal. In addition it is necessary to supplement the nine essential amino acids required by mono-gastric animals when feeding sorghum.

Grain pearl millet is a high protein cereal (14% protein) that contains a more balanced profile of the nine essential amino acids
than does sorghum. Due to its higher nutritional value it is calculated that pearl millet is worth a 25% premium over sorghum to feed manufacturers for use in the formulation of least cost diets. It is envisaged that some of the cost savings delivered to the feed industry by use of pearl millet will be passed on to growers as a premium for pearl millet grain.

Social outcomes

The use of pearl millet grain as an ingredient in poultry feed will deliver healthier egg products to consumers. Pearl millet grain is rich in omega-3 fatty acids (the building blocks of the 'fish oils' and cod liver oil) which have become recognised as important components of a healthy diet. Nutritional studies in the United States have demonstrated that laying hens fed on this grain have elevated omega-3 levels in their eggs.

The nutritional benefits of pearl millet grain also make it attractive as a niche product for breakfast cereals and health food snacks.

Achievements/Benefits

Dryland summer cropping in Queensland is currently based on sorghum plus smaller areas of sunflower. The viability of this sorghum-dominated farming system is being questioned by growers who are increasingly looking for alternative crops to spread their risk in the highly variable dryland cropping environments of central and south-western Queensland. In particular, growers are reporting uneconomic yields from late sown sorghum crops and those affected by sorghum ergot.

Pearl millet is a staple food grain in the semi-arid tropics of Africa and Asia. It is more heat and drought-tolerant than sorghum and will outyield sorghum in low rainfall, lighter soil environments. Previously, only forage varieties of millet have been commercially available in Australia. Plant breeding research over the past 20 years in Africa, India and USA has resulted in the development of new early maturing, dwarf stature, high yielding millet hybrids suited to mechanised harvesting. The challenge is to utilise these promising new hybrids to establish a grain pearl millet industry in northern Australia.

The domestic market in Australia for feed grain is increasing, with demand greater than supply. Pearl millet grain could meet part of this demand, especially for pig and poultry feed. It is an ideal high value feed grain for the rapidly expanding domestic pig and poultry industries. The high protein grain has a balanced amino-acid profile well suited to non-ruminants, thus substantially reducing the need for expensive protein additives used in sorghum-based pig and poultry feeds. In addition, pearl millet contains elevated levels of omega-3 fatty acids that will provide egg producers with access to the lucrative functional foods market.

An ideal opportunity exists to introduce grain pearl millet as a new grain crop in Australia.

Pearl millet - a new grain crop for northern Australia

The major achievement of this four-year project has been the introduction and selection of pearl millet hybrids suitable for growing as a grain crop in Australia.

In the first stage of this project, 91 lines of grain pearl millet were imported from the USA and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). These comprised 40 female parent lines, 24 maintainer lines, 19 male (restorer) lines and eight breeding populations. Lines were imported through post-entry plant quarantine and seed increase undertaken for both parents and hybrids.

Preliminary evaluation of 242 hybrids and 393 top-crosses concluded that the A1 cytoplasmic male sterility (CMS) system is unstable in cool conditions and probably of no commercial use in Australia. The A4 and A5 CMS systems were more stable.

Eighty six hybrids in the A4 cytoplasmic system were evaluated in replicated yield trials at Biloela Research Station in September 2002 and February 2003. In the February planted trial the best pearl millet hybrids yielded 4,800kg/ha and reached maturity in 85 days, 25 days less than early-maturity sorghum hybrids. In the September planted trial the top yield was 3,800kg/ha, with the crop reaching maturity in 82 days, which was two days quicker than early maturity sorghum hybrids. These trials suggest that the new grain pearl millet hybrids would be as economical as sorghum in early spring plantings and the preferred option, compared to sorghum, in late summer plantings.
While these results are across two seasons in one year at a single location, the grain yields of two hybrids are sufficiently promising to warrant their release to commercial interests for further development. QDPI&F has initiated an ‘Expression of Interest’ process to seek a company to develop and market these two pearl millet hybrids. Small quantities of seed (100 to 500 grams) of the two female parents (59041AA4 and 183A4) plus their maintainer lines and one male parent (4AmRm), used to make the two hybrids, are available for commercial release to the feed industry.

Detailed phenology experiments at Biloela in 2002/03 produced robust genotype-specific data to support the use of the APSIM millet model for grain type early maturity pearl millet hybrids under Australian conditions. Using the model, crop simulations based on 40 years of climate data gave median grain yields of 3,600kg/ha for October and February sowings in the Callide Dawson. Crops sown from November to January had lower yields. Median yields for the Central Highlands (2,600kg/ha) and Maranoa (2,000kg/ha) districts showed little differences between planting dates from October to February but large differences between high and low rainfall years, especially for Maranoa, where the risk is higher. Yield potential for pearl millet under a high rainfall season was 4,000kg/ha, which is consistent with field trial results from Biloela.

A herbicide screening trial was conducted in autumn 2002 to investigate the efficacy of two common sorghum weed control measures in grain pearl millet. Two rates of atrazine (2 and 4L/ha post-plant, pre-emergence) and two rates of a post-emergent mix of 1.5L atrazine plus 400ml or 700ml of fluroxypyr (trade name Starane®) were trialled against weedy and hand weeded controls. Higher rates of atrazine and atrazine plus fluroxypyr achieved the best weed control throughout the trial. There were no visual signs of phytotoxic effects with atrazine but the post-emergent mix of atrazine plus fluroxypyr caused some yellowing and splaying of tillers. No detrimental effects of either herbicide regime were detected in biomass, number of productive tillers, grain size or grain yields. Atrazine is commonly used for broadleaf weed control in sorghum and on the basis of this trial also appears safe for use in post-plant, pre-emergent applications in grain pearl millet. Further research would appear prudent to investigate intermediary rates of atrazine and to support an application for registration of atrazine for use in commercial pearl millet crops.

Grain of three pearl millet hybrids was analysed for nutritional quality in the Rural Industries Research and Development Corporation (RIRDC) Project DAQ-302A ‘Evaluation of new millet varieties as a poultry feed ingredient’. The results support previous research that grain from hybrid pearl millet is nutritionally superior to that of sorghum.

Dry matter protein content of pearl millets ranged between 13.7% and 14.8%, compared to 12.4% for sorghum. Actual metabolisable energy (AME) of pearl millet (14.3MJ/kg) was 1MJ/kg higher than sorghum (13.3MJ/kg). Pearl millet was richer in the essential amino acids lysine, methionine and tryptophan. In addition, pearl millet grain contained 3.2% omega-3 fatty acids, twice the 1.6% level in sorghum. There were no differences found between pearl millet and sorghum grain with respect to fat or fibre contents.

Benefits of pearl millet to the grains and livestock industries

For cropping growers in the semi-arid tropics of northern Australia, grain pearl millet will provide a short-season alternative to sorghum. The new grain pearl millet hybrids have a significantly shorter growing period (85 days) that will facilitate opportunity cropping in spring and late summer. Pearl millet is particularly adapted to lower rainfall, lighter soil environments.

QDPI&F has initiated an ‘Expression of Interest’ process to seek a commercial partner to develop and sell the grain pearl millet hybrids to growers and to conduct further development and extension work to help growers grow and market grain pearl millet.

Further agronomic development is required to determine (1) planting methods to improve emergence, (2) optimum plant populations, (3) fertiliser requirements, (4) sowing dates in different locations, (5) weed control and herbicides, and (6) to conduct farm-sized demonstrations of the new hybrids.

The addition of grain pearl millet to the existing feed grains industry should complement and increase the stability of feed grain supply in northern Australia, particularly the supply of feed grain to the pig and poultry industries. Pearl millet grain has 2-4% higher protein levels than sorghum grain, plus a balanced amino-acid profile. Calculations based on pearl millet and sorghum-based diets described in RIRDC Project DAQ-245A ‘Nutritional value of pearl millet for poultry’ indicate that pearl millet grain is worth a 25% premium over sorghum to the manufacturers of least cost poultry diets. In addition, the elevated levels of omega-3 fatty acids in pearl millet grain will open up access to the lucrative functional foods market for Australian egg producers. Further development work will be required with pig and poultry industries and feed grain manufacturers to demonstrate the suitability of pearl millet grain as a feed grain.
As a high protein cereal with a balanced profile of essential amino acids, pearl millet grain has potential applications outside the feed grain sector. Health food products such as muesli bars and gluten free breakfast cereals are an example.

**Other research**

Because pearl millet is a high-protein cereal with a balanced profile of essential amino acids, the grain has potential high-value applications outside the feed grain sector such as health food products and gluten free breakfast cereals.

Seed of more advanced A, B, and R parent lines have recently been imported through post-entry plant quarantine. The hybrids from these new parents have the possibility of outyielding the hybrids selected and identified in the past three years. Seed of these parent-lines is available for a further research project if required.

Further research would appear prudent to investigate the rates of application of atrazine needed to control weeds in pearl millet and to support an application for registration of atrazine for use in commercial pearl millet crops.

**Intellectual property summary**

QDPI&F has initiated an ‘Expression of Interest’ process to seek a partner agency for the commercial marketing and development of two elite grain pearl millet hybrids.

Through the proposed agreement, the successful seed company will pay a royalty to the University of Nebraska for the use of proprietary germplasm and to QDPI&F and GRDC in recognition of initial evaluation and development work completed on pearl millet during this project.