NSW DPI
primefacts
PROFITABLE & SUSTAINABLE PRIMARY INDUSTRIES www.dpi.nsw.gov.au
APRIL 2006 PRIMEFACT 140

Agronomy of the durum wheats Kamilaroi, Yallaroi, Wollaroi and EGA Bellaroi

Dr Ray Hare

Principal Research Scientist, Durum Wheat Breeding

Rural Innovation, Tamworth

These detailed notes on the cultivation of Kamilaroi, Yallaroi, Wollaroi and EGA Bellaroi durum wheats have been prepared from the latest available information. The author, Ray Hare, or your local District Agronomist would welcome further enquiries.

Ground selection

Nitrogen fertility

It is important to select ground that consistently produces high-protein grain of 13.0% or above, where possible. It is recommended that soil tests be conducted to establish what nitrogen is available, and that a nitrogen budget for the crop be calculated. There are nitrogen budgeting packages available from NSW Department of Primary Industries, other departments of agriculture, or your local agronomist. When these requirements and levels available are known, an application of nitrogenous fertiliser will most likely be needed.

Highest premiums are paid for plump, hard, vitreous grain which is free from mottling. A small percentage of mottled grains can be tolerated in top grades but a greater proportion of mottled grain is undesirable and will result in downgrading and a reduced premium. The top grade ADR1 must be 13.0% or greater in protein (minimum 90% vitreous kernels), while ADR2 has to be equal or better than 11.5% protein (min. 80% vitreous kernels).

Vitreous grain contains sufficient protein to combine together all the starch granules; however, a shortage of protein will give a mottled grain. Grain protein is a function of available soil nitrogen, hence adequate soil nitrogen is essential to produce vitreous grain. The application of nitrogenous fertiliser may be necessary but this cost should be offset by the higher premium payments and yield.

EGA Bellaroi wheat heads

Crown rot

The ground should contain very little crown rot inoculum caused by the fungus *Fusarium pseudograminearum*. The most conspicuous broadacre symptom of crown rot is the

appearance of ‘white heads’ in the crop. However, not all white heads are due to crown rot infection. Insect attack on stem tissues, frost and moisture stress damage could lead to white heads. Stems that exhibit a brown (honey) discolouration on the lower internodes is a good indicator of crown rot infection. On severely affected plants, pink fungal growth is often present on the lower part of the stem and crown. New ground out of natural pasture should not be used, as the native grass species harbour the crown rot fungus. These precautions are the same as those observed in breadwheat cultivation.

Ground known to carry high levels of crown rot inoculum should be sown to an alternative crop such as sorghum or the broadleaf crops (e.g. chickpeas, faba beans, mung beans, canola, sunflowers) over a period of 2 years before replanting durum. The sowing of a durum crop following bread wheat is not recommended, as inoculum will be increased by both susceptible species.

Fusarium head blight

It is not advisable to plant maize in the rotation prior to durum, as maize is a susceptible host of the Fusarium head blight fungus *Fusarium graminearum.* Inoculum carried by the maize trash may pass the disease to the following durum crop if suitable weather conditions for infection, such as an extended wet period, prevail during and following flowering. Significant Fusarium head blight infection can lead to serious grain yield losses and grain quality downgrading.

Crop rotations

Rotations with non-cereal species, including pulses, canola, sorghum, pasture legumes (especially lucerne) and sunflowers, are essential in order to:

- control root disease, especially crown rot;
- provide for the biological fixation of nitrogen through legumes;
- control weeds and contaminant crop species, and aid in herbicide group rotation.

Durum should be the first cereal crop after a non-cereal species. Avoid successive durum crops.

Ground preparation

Ground preparation is the same as that for bread wheat. Adequate cultivation and/or spraying should eliminate all volunteer plants of bread wheat, barley and other crop/weed species.

Seed

Use sound seed that is true to type (varietal purity) — free of diseased seed and weed seeds, cracked and small grain, and barley and **breadwheat grain**. Ensure that the initial seed of a variety that is purchased is of high quality, preferably from certified seed stocks, with a germination percentage exceeding 80%. Before harvesting seed stocks for the following season, rouge all off-types and contaminant crop and weed plants.

Seed grain kept for sowing in subsequent seasons must be stored in clean silos capable of aeration, sealing for insect control and keeping grain dry and as cool as possible. Such storage conditions will assist the maintenance of high-viability seed for the following season. Treat seed with an appropriately registered product just prior to sowing, if required. Some chemical constituents can reduce viability and seedling vigour if they remain in contact with the seed for any length of time. All current durum varieties are highly resistant to loose smut, flag smut and stinking bunt. Seed treatment will offer protection to the establishing seedlings from damping-off diseases and insect attack such as army worms, cutworms, false wireworms and wireworms.

Sowing time

Best yields are obtained when the crop is sown from about mid May to mid June depending on your location. The optimum sowing date will depend on the maturity rank of the variety, north/south latitude of the sowing site, topographic aspect (e.g. north/south facing slope, elevation). The maturity ranking of the current durum varieties is as follows: sow EGA Bellaroi first (longer season), followed by Yallaroi, then the quick-maturing Kamilaroi and Wollaroi. Durum wheats will perform well if sown later, but grain yields will depend on seasonal conditions, especially during the flowering and grain filling stages.

The sowing time of a variety is a critical factor in crop risk management. Growers should aim to have a balanced minimisation of the combined risks of frost damage around flowering / grain filling, moisture stress at this time, and rain or storm damage just prior to harvest. Crops sown earlier than optimal will be exposed to an elevated frost risk, while those sown later than the optimal period could encounter high moisture stress and harvest spoilage. None of these risks can be completely eliminated, but a degree of minimisation is manageable.

The sowing of several varieties that have different maturity ranks over several weeks

should spread the risks associated with flowering, grain filling and harvest. Given differing rates of growth development, each variety should not be exposed to the same degree of risk at any specific critical stage, e.g. at flowering.

Sowing

Use conventional sowing equipment; however, the larger grain size may necessitate appropriate adjustments. A sowing rate of 45 kg/ha (45 lbs/ac) is given as a general guide. However, growers may consider a variation, either up or down, to be of benefit in their particular situation. A reduced germination percentage or a late sowing will make it necessary to increase this rate.

In a well-prepared seedbed, the sowing depth should be about 3–6 cm (1″–2.5″) and not exceed 8 cm (3″). As the current durum culitivars are semi-dwarf cultivars, the length of the coleoptile is reduced and so cannot penetrate greater soil depths.

Sowing rate can be considered as a risk management tool. Dense stands of plants tend to produce few tillers per plant (i.e. the primary and a few secondaries), while stands at a reduced density have plants that produce a larger number of tillers per plant. Such reduced-density stands have greater flexibility in response to changing growing conditions. For example, if moisture is limiting, fewer tillers are initiated; however, if seasonal conditions improve, additional tillers may develop.

In addition, low-density crops tend to have heads flowering over a longer time interval. Such a prolonged flowering period may reduce the impact of a frost around flowering. Protracted moist weather at flowering can have an adverse effect on pollination by inhibiting the release of pollen from the anthers. If the female part of the flower (the stigma and ovule) is not fertilised while in its receptive phase, a grain will not develop.

Low-density crops are likely to use available soil moisture reserves at a slower rate compared with the more dense crops. Avoidance of moisture stress before and at flowering is critical for satisfactory grain set, as pollen will abort during stress periods as part of a natural survival mechanism of the plant.

Extended flowering could reduce the risk of pollination failure caused by frost or extended moist weather.

The time difference in reaching full maturity between the early-flowering and late-flowering tillers is normally fairly small; therefore, the early heads are not likely to be dead ripe for many days ahead of the later heads. Harvesting should not be delayed significantly.

Fertiliser

Durum wheat should be regarded as a high quality product. As such, nutrition plays a significant part in the finished product. Ideally durum should be placed in a rotation following a legume after a significant break from a cereal crop to avoid crown rot problems. A well-nodulated legume crop / pasture ley will provide an adjunct source of biological fixed nitrogen, while the break period following the previous cereal crop will allow for the remineralisation of stubble-bound nitrogen.

Fertiliser rates should be aimed at producing a finished protein level at ADR1 (13% and above). This may necessitate soil tests to establish base N (nitrogen) levels. Reasons for a high grain-protein content are given in the section 'Factors influencing grain and pasta quality – protein content' below. As a rule of thumb, for every tonne per hectare of high-protein grain harvested, about 50 kg of N is removed in the grain. This amount of N must be replaced, together with other N losses such as from leaching and denitrification. The amount of nitrogen fertiliser required can be calculated when the percentage of elemental N is known for the fertiliser product, e.g. urea N 46%, anhydrous NH_3 82%.

Soil zinc levels should also be checked. Zinc deficiency may be evident given certain circumstances. Poor zinc nutrition may also limit the plants' uptake of other nutrients.

Kamilaroi, Yallaroi, Wollaroi, and EGA Bellaroi are usually not sensitive to low zinc levels when grown on very heavy self-mulching black earth (pH 8–8.5). When a crop is growing in a very wet high-phosphate soil for several weeks, zinc deficiency symptoms may be evident.

Elongated necrotic (dead) lesions on the lower leaves may indicate the onset of zinc deficiency; however, this problem is difficult to identify. If the soil is known to be low in zinc (soil and plant tests available), a 1% aqueous solution of zinc sulfate heptahydrate applied as a foliar spray (i.e. approx. 1 kg/ha applied 2–4 weeks after sowing will completely ameliorate the deficiency in the crop). Zinc oxide (5 kg Zn/ha) applications can provide 4–5 years' supply of this essential micronutrient. The white oxide powder can be spread with nitrogen fertilisers but not with phosphate fertilisers as the phosphate can bind with the zinc and could render the zinc unavailable. A range of zinc-fortified fertiliser products are available for consideration.

Appropriate nutrient management will help reduce the risk of producing grain that does not meet the rather strict quality receival standards for durum grain, including low grain-protein content, mottled grain and small grain.

Weed control

Good weed control is essential, as strong weed growth will compete with the crop for available moisture and nutrients causing yield reduction.

A range of broadleaf and grass herbicides are available for weed control in durum wheat crops, which are listed in NSW Department of Primary Industries' recent publication *Weed Control in Winter Crops*. This publication, together with advice from your agronomist/advisor, will assist your choice of the most appropriate and safe products and their respective application procedures.

The law requires that all chemical labels be read carefully before the product is used. New products and product formulations may change safety margins etc. Manufacturers or their representatives should be consulted for the latest usage information, especially if mixing chemicals or other products (e.g. zinc sulfate heptahydrate). The effectiveness of certain chemicals can be adversely affected when mixed with other compounds. Zinc sulfate heptahydrate can coagulate certain chemicals, with the coagulant causing major blockages in spray equipment which can be difficult to clear.

Stem rust

Kamilaroi, Yallaroi, Wollaroi, and EGA Bellaroi are fully resistant to all existing field strains of stem rust. While stem rust infection is not expected, a new virulent strain may occur and NSW Department of Primary Industries Durum Wheat Breeder, Dr Ray Hare, would greatly appreciate receiving infected Kamilaroi, Yallaroi, Wollaroi and EGA Bellaroi specimens. Identification tests would be conducted and the sender will receive a report.

Leaf rust

Kamilaroi, Yallaroi, Wollaroi and EGA Bellaroi possess slow rusting resistance to all field strains of leaf rust. A small level of infection may be evident as the plant approaches maturity; however, this disease level will not affect yield.

Stripe rust

The current durum varieties all express adequate resistance to field strains of this disease, at present.

The breeding program endeavours to predict virulence changes in all three rust organisms and incorporate appropriate resistance genes into future varietal releases, so as to remain one or two virulence changes ahead of the rust. The earliest possible detection of new virulent strains, if in the unlikely event that they arise, will greatly assist the disease resistance breeding activities. When such a strain is found, steps can be taken to warn growers of a new virulence change and suggest changes to variety recommendations.

It is very important to maintain effective resistance to all field strains of each rust organism in each of the released varieties. Such a comprehensive effective resistance will significantly reduce the build-up of inoculum, leading to less disease both within and between growing seasons. In addition and more importantly, the likelihood that a new virulent strain will arise is greatly reduced. By reducing the chance of the development of a new virulence, the life of the current resistances is greatly prolonged. This amounts to effective conservation of our valuable genetic resources. If breeders are not required to spend considerable breeding resources on developing improved resistant varieties, those resources can be redirected to the improvement of other economically important traits.

Yellow leaf spot

Yallaroi and Wollaroi are moderately resistant to yellow leaf spot (caused by the fungus *Pyrenophthora tritici repentis*); however, Kamilaroi is susceptible. EGA Bellaroi shows high levels of adult resistance to yellow leaf spot. As yellow leaf spot inoculum is carried over on wheat straw, Yallaroi, Wollaroi and particularly EGA Bellaroi are a better proposition in stubble-retained situations.

Harvesting

Kamilaroi, Yallaroi, Wollaroi and EGA Bellaroi are marginally more difficult to thresh than Hartog and Sunco, but easier than Sunlin; consequently, concave adjustments may be necessary. These durum varieties are not prone to shelling, a factor of significance when wind and rain periods prevail at harvest. All grain should be retained in the head despite these weather conditions.

Care needs to be exercised when threshing the crop, as the very hard grain has a greater tendency to fracture than bread wheats.

The crop should be stripped as soon as the grain reaches dead ripe maturity. Buyers of durum grain consider grain appearance important and pay premiums for large, well-filled, hard, vitreous grain with a low percentage of mottled and bleached seeds.

Kamilaroi is moderately susceptible to black point. Several per cent of infected, discoloured seeds will be present following a wet preharvest when the problem is most severe. This level of incidence should be below minimum dockage limits in most seasons; however, prolonged wet weather during grain filling will increase the incidence of black point. Breadwheat varieties will be similarly affected depending on their level of resistance. Yallaroi, Wollaroi, Tamaroi and

EGA Bellaroi carry significantly more resistance to this problem when compared to Kamilaroi, but this resistance may not offer sufficient protection in prolonged wet seasons.

Ensure that all grain handling equipment, e.g. headers, bins, augers, silos etc. are free of any contaminant grain, as the presence of foreign seeds (max. 3% breadwheat seed) can downgrade the crop grain.

Grain storage and disposal

Because durum grain must be strictly segregated, on-farm storage will be necessary if delivery to a grain accumulator or buyer facilities cannot be arranged.

High standard on-farm storage in the form of elevated conical-based sealable silos with controlled temperature and humidity aeration are strongly recommended. Sealed silos provide the opportunity to use insect fumigants without the risk of residual contamination. An increasing number of food processors require very low or nil tolerances on specified pesticide residuals. Good control of temperature (<15°C) and moisture within the grain stack will preserve grain viability, enabling good germination of seed grain and aiding insect management. Insects usually appreciate warm moist grain, especially durum, which is very hard. Moist grain tends to be soft and more easily attacked by grain-chewing insects. Ensure cleanliness within and about the silo system to reduce the risks of insect and rodent survival and build-up.

Durum wheat growers association

All durum growers are advised to become members of their local grower association as the group provides a forum for the exchange of information like marketing prices, which are of mutual benefit to growers of this crop. Meetings are held regularly, and grower associations are active in northern NSW, South Australia and Western Australia.

Factors influencing grain and pasta quality

The grain

The endosperm section of the grain is the important part, as it is this fraction that is processed into semolina (a coarse flour) and, in turn, mixed with a little water to form a stiff dough under vacuum and extruded under pressure into pasta, forming various shapes — both long and short goods.

The endosperm is the food supply or life support system for the developing embryo. The endosperm and embryo are ‘wrapped up’ in several layers of tissue called the aleurone, pericarp and testa.

The embryo and outer grain layers are removed, during milling, into the bran and pollard fractions, while the endosperm is reduced to semolina. The endosperm is composed of numerous constituents including starch, sugars, proteins, amino acids, minerals, fats, vitamins, enzymes, pigments and fibre.

Grain and pasta quality

Six aspects of grain and pasta quality are considered at receival:

1. Grain size and shape
2. Preharvest sprouting resistance
3. Black point
4. Weed seed contamination
5. Protein
6. Colour

1. Grain size and shape

- Require a large, well-filled grain.
- Bright amber colour.
- Oval, plump with minimal crease depth.

2. Preharvest sprouting resistance

Compared with current breadwheat varieties, Kamilaroi, Yallaroi, Wollaroi and EGA Bellaroi express a satisfactory level of preharvest sprouting resistance.

- Kamilaroi — most sprout resistant.
- Yallaroi
- EGA Bellaroi
- Wollaroi
- Suneca
- Sunelg
- Sunstar
- Sunco
- Hartog — least sprout resistant.

Weather-affected grain is soft, which reduces the semolina extraction in the mill.

Weathered semolina gives a weak pasta-dough strength due to the partial enzymatic breakdown of starches and proteins. These small protein and starch molecules have reduced cohesive properties. Weak doughs make inferior pasta.

High-protein durum grain with a bright amber bloom is certain to attract the best available premium price.

It is not advisable to leave your durum harvest until last and rely on its weathering resistance. Its resistance is only relative compared with other varieties and will eventually fail. Weathered durum is not valuable and may be received as feed grain.

3. Black point

Black point is a discolouration of sections of the external layers of the grain (i.e. pericarp/testa). Several per cent of discoloured seeds will be present following a wet preharvest period when the problem is most active. This level of incidence should be below the minimum dockage limits in most seasons. Black point tolerances are as follows:

- ADR1: 3%
- ADR2: 3% to 5%
- ADR3: 3% to 5%

Because small fragments of bran are included in semolina, discoloured grain will leave small black specks which can be seen in the vitreous (translucent) pasta. The overall appearance of pasta with black specks is diminished and there is some consumer reluctance to purchase the product. Black specks can be perceived as contaminants (e.g. soil, insect parts).

If sown, grain with black point will germinate satisfactorily.

Yallaroi, Wollaroi and EGA Bellaroi are significantly more resistant to black point when compared to Kamilaroi and many of the current bread wheats.

Current research findings suggest that black point is not a disease caused by fungi, but a physiological character resulting from the formation of dark compounds in the outer layers of the grain. Some varieties are more prone to develop these dark compounds when appropriate conditions prevail, e.g. warm and moist.

4. Weed seed contamination

It is most important to control weeds in the crop, as some weed species, such as bindweed and New Zealand spinach, have small black seeds that can be difficult to remove from the grain. These seeds have the same effect on consumer acceptance as black point contamination. The black seeds shatter during milling to leave numerous small black fragments mixed in the semolina.

AWB Limited can advise on maximum and minimum levels of foreign seed and contaminants over the range of receival grades for durum.

5. Protein

(a) Protein content

Receival

Protein content is an important factor in grain classification at receival.

- Classes:
  - ADR1 > 13.0% protein on an 11% moisture basis.
  - ADR2 > 11.5%
  - ADR3 > 10.0%
  - Below 10.0% received into feed, usually.
- Premiums:
  - ADR1 attracts a premium around APH or better.
  - ADR2 attracts a premium around AH or better.

Milling

- Grain with adequate protein is very hard, vitreous and free from mottling. A small percentage of mottled grains can be tolerated in top grades, but a greater proportion will result in downgrading and a reduced premium.
- Vitreous grain contains sufficient protein to combine together all the starch granules; however, a shortage of protein will give a mottled softer grain. Protein can be envisaged as the equivalent of cement which binds the starch granules or, in this analogy, the aggregate together. With insufficient cement, the aggregate will not all bind and thus the concrete will be weak and break down readily. The same is the case with mottled sectors in grain. The degree of mottling in individual grains, together with the percentage of mottled grains in the seed lot, both contribute to the ‘flour’ formation and consequent milling losses. ‘Flour’ or ‘fines’ has a lower economic value to that of semolina.
- Hard, vitreous grains shatter into rough aggregates and produce a high semolina yield.

Pasta making

- The canning industry specifies high-protein semolina for canned pasta. High-protein pasta withstands the high pressure/temperature cooking and retorting processes in an acidic tomato pasta. Further, this pasta retains its consistency on warming and serving by the consumer.
- Dry pasta manufacturers require acceptable levels of protein but not as high as those required by the canning industry.
- Low-protein semolina is unsuitable for pasta making as it has insufficient protein to give the product acceptable keeping, cooking and eating consistency.

- The pasta quality of EGA Bellaroi exceeds that of Wollaroi, which is regarded by many Italian manufacturers as being equivalent to the best in the world. EGA Bellaroi is suitable for pasta and couscous production.

Control of protein content

- The protein content of grain is largely under environmental control. Plants growing in soils with adequate nitrogenous fertility will lay down acceptable protein levels in the grain. Kamilaroi and Wollaroi usually yield grain with a higher protein content than Yallaroi. EGA Bellaroi has the genetic capability to achieve a higher protein content (up to 1%) at a similar or slightly higher grain yield compared to Wollaroi.

(b) Protein composition

The grain protein is composed of a large number and complex range of protein types. The proteins go from short molecules to long, folding molecules. The long molecules adhere to each other and form an interlocking network which prevents the starch and other components from moving freely. The degree of interlocking (chemical bonds) between these long-chained proteins determines the mobility of the pasta dough, which is called the 'dough strength'.

The pasta dough strength, or the resistance of the dough to move under work (force), is mainly under genetic control. Cultivars that offer strong to very strong pasta doughs are released. EGA Bellaroi, Yallaroi and Wollaroi have a stronger protein than Kamilaroi.

The dough strength, which is equivalent to protein strength, is a key determinant of pasta quality through its effect on the internal consistency of extruded products. Pasta made from strong protein doughs retain their shape and consistency on cooking and eating. Weaker pastas tend to break down during cooking to a rather unpalatable mess. Breadwheat pastas are of this undesirable type.

6. Colour

The colour of pasta is a factor in consumer acceptance. Pale to white or brown pastas do not have a pleasing appearance and are passed over for the bright clear yellow pasta by the consumer. Only durum wheat can provide this colour without the addition of expensive synthetic pigments or egg products.

The addition of artificial colours is banned in Italy and France. The law dictates that durum wheat must be used for dry pasta in these countries.

Pasta colour is principally under genetic control, therefore only highly coloured varieties are released, i.e. EGA Bellaroi, Kamilaroi, Yallaroi and Wollaroi.

EGA Bellaroi is able to achieve a higher yellow pigment colour than the other released durum varieties, in particular Wollaroi.

Detailed notes on the latest durum release: EGA Bellaroi

EGA Bellaroi was released in October 2002 by Enterprise Grains Australia. It is the latest release in the suite of durum varieties bred by NSW Department of Primary Industries at Tamworth.

EGA Bellaroi is a high-yielding, disease-resistant, high-quality durum wheat cultivar suitable for pasta and couscous production in Australia and overseas countries. The pasta quality of EGA Bellaroi exceeds that of Wollaroi, which is in turn regarded by Italian manufacturers as being equivalent to the best in the world.

The primary target areas for the cultivation of EGA Bellaroi are the main production areas of northern NSW and southern Queensland (sowing from mid May to mid June). However, it will be suitable for durum growing areas in South Australia, Western Australia and central Queensland. EGA Bellaroi is best suited to a rotation following a legume where there has been a break from cereal cropping. EGA Bellaroi is a longer-season cultivar (1–2 weeks in northern NSW, approx. 3 weeks in more northern latitudes, e.g. central Queensland) compared to Wollaroi. It is adapted to neutral and alkaline soils and has excellent lodging and shedding resistance.

EGA Bellaroi has a high level of resistance to stem rust, flag smut and yellow leaf spot, moderate (adequate) level of resistance to leaf rust, stripe rust, stinking bunt, root lesion nematode (*P thornei*), common root rot and black point. Yellow pigment content in the endosperm is significantly higher than in Wollaroi, the best quality check. Together with a low browning reaction, this translates to bright, clean yellow semolina, highly desirable for pasta production. EGA Bellaroi has dough rheological properties equivalent to or greater than Wollaroi.

Table 1. Yield and average protein for durum wheat varieties

Variety	Relative yield 1999–2005	Average protein (%) 2000–2005*
EGA Bellaroi	100	14.6
Wollaroi	99.8	13.9
Kamilaroi	99.5	13.3
Yallaroi	102.3	13.3

*Northern NSW data

EGA Bellaroi is a registered PBR variety and production is subject to End Point Royalty. It is commercialised under an exclusive licence to Graintrust. PlantTech jointly tendered for EGA Bellaroi with Graintrust and is responsible for all seed sales and marketing functions.

Published by NSW Department of Primary Industries

ISSN 1832-6668

Job number 6376

Updates of this Primefact are available at
www.dpi.nsw.gov.au/primefacts