



Developing Collaborative Studies with China

Meixue Zhou¹ and Neville Mendham²

¹Tasmanian Institute of Agricultural Research, P.O Box 46, Kings Meadows, Tas
7249

² School of Agricultural Science, University of Tasmania, GPO Box 252-54, Hobart,
Tas 7001

Barley is an important cash crop, for malting and feed, in mixed farming systems in higher rainfall parts of southern Australia. Australia has distinctive soils that contrast with most northern Hemisphere soils because of climate and geomorphic history. Increasing soil acidification is one of the major problems. In some areas of southern Australia pH levels have declined from slightly acid or neutral to very acid during a 20-50 year period. The solutions to the soil acidification problem include management options, minimising the use of acidifying fertilisers and liming, but plant breeding to develop cultivars tolerant to acidity offers the most efficient answer. Salinity and waterlogging are other major problems in southern Australia.

China holds a substantial proportion of the world's barley germplasm with more than 20,000 accessions which include 1,500 wild barleys. A large number of Chinese barley accessions have been selected for waterlogging, saline soils and acid soil tolerance for centuries particularly in the lower Yangtze Valley. For the cooler, high rainfall areas of Australia, it is important to obtain some Chinese germplasm with waterlogging and acid soil tolerance (possibly also frost tolerance) and introduce them into the Australian breeding programs. The resources also include disease resistances and salinity tolerance which would be of value to the whole Australian program. It is necessary to establish collaborative studies with Chinese scientists to accomplish this. For this purpose, an Australian mission funded under the Australia China Agricultural Co-operation Agreement, including the Tasmanian breeder, Dr Meixue Zhou, Mr Ian Mackinnon, GRDC Southern Region Chairman, Dr Neville Mendham of TIAR, and Mr Greg Platz, QDPI cereal pathologist visited several Institutes and Universities in China in April/May 2000. Arrangements were initiated to exchange cereal germplasm between China and Australia and to develop collaborative studies with Chinese scientists. The Chinese Universities and Research Institutes are prepared to sign a Material Transfer Agreement with TIAR to facilitate exchange of genetic resources.

Summary of the trip

**Institute of Crop Germplasm Resources,
Chinese Academy of Agricultural Sciences:**

Institute of Crop Germplasm Resources is a national research centre on crop genetic resources. Functions of the institute are to collect, conserve, characterise, evaluate, document, enhance and utilise crop germplasm resources throughout the country. Mandates of the Institute are: (1) to plan for the national cooperative program on crop germplasm resources and to take the responsibility of organising its implementation; (2) to coordinate and participate in the activities of seed propagation, characterisation and evaluation for agronomic characters, grain quality, stress resistance, disease and pest resistance of staple food crop germplasm to be of service to crop breeding, biotechnology study or agricultural production; (3) to take charge of nationwide long-term conservation, viability monitoring and regeneration of crop genetic resources; (4) to process the germplasm introduction and international exchange with foreign countries; (5) to organise and participate the nationwide germplasm exploration and collection and the research activities on the origin, taxonomy and ecology of crops; (6) to fulfil the management and service of national database of crop germplasm resources and (7) to undertake the collection, compilation and publication of scientific literature on crop germplasm resources and to perform academic exchange activities.

The institute possesses the National Genebank with the capacity being more than 400,000 accessions and the National Introduced Germplasm Testing and Quarantine Base as well as modern facilities for crop germplasm analysis. The germplasm collections for barley includes 20,000 accessions, of which about 1500 are wild barleys. Most are 6 row. Most of the accessions need to be evaluated for agronomic characteristics such as height, kernel number and size, and disease resistance, mainly powdery mildew, barley stripe and barley yellow mosaic virus. Funding is the limiting factor for the full evaluation.

State Administration for Entry-Exit Inspection and Quarantine of P.R. China, Beijing

Discussions were made on the current state of negotiations on import of Australian wheat and barley. Concern was expressed about the import or growing of GM cultivars in China, and it was suggested that caution was needed. China was looking at ways to detect GM imports and in future will require a statement of origin and export to exclude imports of GM commodities.

Beijing Yanjing Beer Group Corporation:

Beijing Yanjing Beer Corporation is the biggest beer producer in China. It is state owned, and since 1980 has built up from 10,000 t/annum beer initially to 1.2 m t, 5% of the total Chinese market, and 1.5 m bottles are produced daily. They use 140,000 t of barley annually with 98% being imported, which is chosen on the basis of price and quality (mainly protein content and diastatic power). β -glucan is not regarded as important, as they use charcoal filters, and a proportion of rice in the mash adds extra

starch. The 2% local barley used is for head retention (foam), as Canadian barley is poor in this regard. The research in Australia on foam positive proteins at the Waite Institute is relevant in this regard. Of the imports, 50% is from Australia since the quality of Australian barley is considered very good. However, in recent years, the price of Australian barley has been higher than Canadian barley prices and higher than European countries such as France, thus China has been buying barley from France and Canada. If the price is not too high they are still willing to use barley from Australia.

Jiangsu Agriculture and Forestry Department:

Jiangsu is a sister province of Victoria. The province has about 5% of the arable land in China, but produces over 8% of the food grain, and 10% of China's GDP. The province is only 1% of China in area, but has 72 m people on its 100,000 km², (720/km²), which is the highest population density other than in Beijing and Shanghai.

Jiangsu is the leading barley producing province, with 310,000 ha particularly in the saline soils of the coastal areas (120,000 ha). The barley area has declined from 1.5 m ha in the 1950s. Average yields are 4 t/ha which is 70% higher than the national average, with up to 6 t/ha in more favourable areas and a potential of 7.5 t/ha. Jiangsu has 10-15% of the Chinese barley area, and 30-40% of production. In this area most of the crop is autumn/winter sown, compared to low yielding spring sown crops in the western provinces of China. Currently about 50% of the barley is used for malting, using Japanese varieties to some extent. The main problem with barley from small producers is variability in germination.

Institute of Food Crops, Jiangsu Academy of Agricultural Sciences, Nanjing:

The Institute of Food Crops is one of the oldest institutes in Jiangsu Academy of Agricultural Sciences. The objectives of the institute are to develop new varieties or hybrids of rice, wheat, maize and sweet potato with good quality, high yield, multiple resistance to disease and pests or other environmental stress, and to evaluate, conserve and utilise germplasm resources of rice and wheat. Most of the major breeding programs operate in conjunction with IRRI, CIMMYT and others, and since the 1980s, JAAS has collaborated with Michigan State University in breeding, agronomy, livestock husbandry and remote sensing. There is an active exchange program of visiting scholars, and about 10 students from this institute went overseas last year. The Ministry was optimistic that the signing of the WTO agreement will facilitate links with Australia in the whole agricultural science field in the near future.

Yangzhou University:

Yangzhou University is a key comprehensive university at provincial level. The university has 54 research and development centres. Agricultural Science is one of the major discipline with over 100 research programs in place, including genetics and crop breeding in rice, maize, wheat and barley.

The Barley Research Laboratory in Yangzhou University has evaluated over 1000 barley lines for their malting quality, yield traits, resistance to lodging, disease and waterlogging. Several varieties have been registered, which are resistant to the major diseases and have either good feeding quality or malting quality. Some breeding lines such as YUQS, SN9607, SN9602 and SN22 have very good lodging resistance. SN6472 has high tolerance to salinity, and grows well in coastal areas. Some waterlogging resistant varieties were identified. These valuable materials would be sought after by foreign programs such as ours in exchange for lines with improved quality. Resistance to barley yellow mosaic virus (BaYMV) is also a major goal of the local barley program, with good sources now available (Australian varieties in plots here were nearly killed by BaYMV). The University conducts a BaYMV nursery which may be useful for further screening of Australian varieties. Barley stripe is also a major concern, with farmers treating seed to control this disease at present. Lines with good lodging resistance are available, mainly semi-dwarfs of about 70-80 cm (compared to 100 cm normally).

Yancheng Agricultural Research Institute:

The Institute was founded in 1959, and is also called the Institute of Agricultural Sciences in the Coastal Areas. Yancheng is translated as "salt city", due to its coastal position. Barley is much more evident in the vicinity due to its salt tolerance, and there are around 180,000 ha sown each year in the county, the biggest area in China. The barley improvement program has been in place since 1959, with over 10 varieties released, most of the local crop being of varieties from this program. The emphasis is again on high yield, early maturity, strong lodging resistance and disease resistance, particularly to BaYMV. Management packages have been developed to support the new barley varieties, with appropriate fertiliser strategies for malt or feed crops. The crops aimed at malting quality receive N only at sowing, and K later.

College of Life Sciences, Zhejiang University

This College originated from Hangzhou University. The main emphasis has been on research rather than applied breeding work. Work has been extensively published on resistance to and characterisation of BaYMV. Aluminium and acid soil tolerance has been another major activity, as many soils are acid with high Al levels in the Zhejiang area and south of the Yangtze River. Work has included selection in cell culture and in hydroponics. Of over 3,800 barley lines they hold, about 100 have some tolerance to Al through various mechanisms. Some can change the pH in the root zone, some

can exclude AI, and others produce a special protein to combine with AI in plant cells. A tissue culture technique was used to screen the AI resistant cells.

College of Agriculture and Biotechnology, Zhejiang University:

Work here on barley was more focussed on applied breeding and associated studies. The emphasis since the 1980s has been on malting quality for barley in the mid-lower Yangtze River and east coast areas, following the rapid increase in the brewing industry. The high rainfall environment is the main limitation, with low kernel weight, discoloration and delayed drying. The main diseases are BaYMV, scab and powdery mildew (the "yellow, red and white" diseases). It was pointed out that varieties from Australia can not survive pressure from these diseases. The program has addressed these problems as well as malting quality. They are concerned with the reaction of the crop to soil problems, including waterlogging, acid soils and salinity. A series of studies have been conducted to investigate the mechanism of stress tolerance. Research is also being conducted on the malting process, for example using α -amylase to stimulate germination.

According to Prof Guoqing He who specialises in brewing technology, requirements for good malting quality were stated as: high germination, DP about 300, extract >78%, kernel weight 42-45 mg, 80-90% retained on 2.5 mm screen, protein 12-13%, low β -glucan, and low price! With the increased emphasis on quality, Prof He expressed an eagerness to collaborate with Australian researchers to improve local varieties.

Institute of Crop Breeding and Cultivation, Shanghai Academy of Agricultural Sciences

The Institute of Crop Breeding and Cultivation is one of the biggest institutes in Shanghai Academy of Agricultural Sciences, including 7 research groups (Rice, Barley and Wheat, Rape, Tissue Culture, Maize, Agronomic Physics and Processing of Agronomic Products). Problems being addressed in the barley program were the same as at Zhejiang, although there was more emphasis on waterlogging tolerance, as there had been a project in place for several years and a good collection of germplasm had been built up. One line 97120 showed particular promise. Since Shanghai is located in the lower reaches of the Yangtze River, the high rainfall during the growth of barley in Shanghai may lead to severe waterlogging and low yields in barley. SAAS is the leader in research into waterlogging tolerance in barley. 4572 tolerant lines were identified between 1986 and 1990. A set of methods to assess tolerance has been set up. Some germplasm with good waterlogging tolerance has been screened out, and varieties bred by SAAS have good waterlogging tolerance.

Follow-ups from the trip

Material Transfer Agreement

The Material Transfer Agreement was initiated after the trip. It has been translated into Chinese and will be signed by both University of Tasmania and the individual Chinese universities or Institutes.

Establishment of collaborative studies

After the trip, a preliminary evaluation of Chinese barley germplasm was arranged in Yangzhou University for Waterlogging tolerance. Results showed significant differences on waterlogging tolerance between varieties. Crosses were made between Chinese waterlogging tolerant varieties and Australian varieties.

The Grains Research & Development Corporation (GRDC) has now funded a project "Australia China Collaboration on Barley Genetic Resources". The aims of the project are: exchange of barley germplasm between China and Australia; evaluation of the germplasm for disease resistance and stress tolerance; identification of molecular markers for waterlogging and acid soil tolerance and to implement scientific co-operation with China. Eight Chinese Universities and Institutes and four Australian Universities and Institutes are involved in this project. Three to four years' evaluation of barley resources and doubled haploid populations will be mainly conducted in China:

Institute of Crop Germplasm Resources: Up to 500 selected varieties (mainly from China) plus Franklin and Gairdner as control varieties will be evaluated for drought resistance, barley stripe, crown rot resistance and lodging resistance.

Zhejiang University, Yangzhou University, Zhejiang Academy of Agricultural Sciences, Yancheng Agricultural Research Institute, and Shanghai Academy of Agricultural Sciences: Up to 500 selected varieties (mainly from China including some known waterlogging tolerant varieties) plus Franklin and Gairdner as control varieties will be evaluated for waterlogging tolerance in four sites and acid soil tolerance in one site. Part of the germplasm will be evaluated for salinity tolerance in Yangzhou University and Yancheng Agricultural Research institute. Other disease resistance and agronomic traits will also be recorded.

The construction of DH populations will be conducted by Agriculture Western Australia and the Chinese Academy of Sciences. One PhD student will be conducting physiological studies on waterlogging tolerance and another PhD student will be investigating molecular markers for waterlogging or acid soil tolerance.

Joint education of postgraduate students and exchange of research scientists

Since the proposal of the new project, Chinese Universities or Institutes have been applying for funding from the Chinese Government for the collaborative studies. Zhejiang University has been successful in a funding application. They will also conduct physiological and molecular marker studies on waterlogging and acid soil tolerance. Two PhD students will be working on the project. They will be based in China and may spend some time in Australia. Yangzhou University has appointed a Masters student for evaluating waterlogging resistance. Negotiation on the exchange of research scientists and joint training of postgraduate students is underway.

Acknowledgements

We thank the Australia-China Agricultural Cooperation Agreement (ACACA) for funding the trip to China and GRDC for funding the collaborative project.
