



A Tremendous Innings: Paul Johnston's Legacy to the Barley Industry

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Introduction



On June 14th 2001, more than 500 people attended a memorial service to pay tribute to Dr Paul Johnston, who had tragically passed away a few days before at the age of 62. Paul was held in high regard by so many because of his outstanding personal qualities. He was a natural communicator, an excellent scientist and a great sportsman. He always had a positive attitude to life and was a true "people's person", making time for everyone. Paul's great passions were his family, science, the barley industry, cricket and racing.

Paul Johnston's involvement in the barley industry was broad and took in all aspects; or as he labelled it for the 1997 Barley Technical Symposium, "from conception to consumption". The breeding program he established in Queensland has an admirable record of released varieties. His knowledge of barley and the associated industries commanded worldwide respect. In Australia, Paul was regarded as the "elder statesman" of the barley community. His international reputation just as significant; he was Chair of the International Barley Genetics Symposium when he passed away.

It is important to remember that Paul was always a team player. In taking this opportunity to reflect on his life and career, we are not only looking at the contribution of Dr Paul Johnston, but also the work put in by the many people who interact to make up the Australian barley research community. To quote from a letter he wrote. "*We all know that the best research involves different disciplines and contributions from a group of innovative people and is seldom, if ever, the result of one person's brilliance.*" Paul believed and lived by this philosophy.

The Beginnings of Paul's Career.

Paul graduated with the qualification of B.Agr.Sc from the University of Queensland, in 1961. He was employed the following year at the Queensland Department of Primary Industries' Hermitage Research Station as a linseed breeder. It seems highly appropriate that a linseed variety developed by Paul will be released in 2002 as the result of a renewed interest in the crop for fibre-flax production.

In 1965-66, Paul participated in a CSIRO Division of Plant Industry training course in quantitative genetics in Canberra. The high-quality science, vibrant atmosphere and all night discussions with contemporaries such as Bill Scowcroft and Jim Peacock stimulated Paul's scientific interests to new heights. At the 1966 Australian Cereal and Pasture Plant Breeding Conference in Brisbane, Paul was particularly impressed with the work of Keith Finlay (1966). He went on to model his breeding strategy after Finlay's thoughts on breeding for yield and yield stability as separate parameters. This became the basis for the "cross evaluation" strategy applied to his linseed and barley programs.

In his study report from the CSIRO course, Paul commented on QDPI's insufficient winter cereal breeding resources and stated that the cereal program should:

- "1) work with a much wider range of material, both named varieties and breeding material,*
- 2) have a second look at the importance of breeding for rust resistance and possibly examine the feasibility of breeding for yield associated with tolerance to rust (this being related to his philosophy that yield should be the number one selection criteria),*
- 3) endeavour to become more closely associated with other research institutions, farmers and industry,*
- 4) carry out testing of breeding material on a large scale at several locations."*

The Northern barley breeding program still embraces these philosophies.

In 1967, Paul was asked to consider alternatives to linseed in his plant breeding endeavours. After careful thought, he proposed that his ideal breeding program would be a joint linseed/barley project with a 60% emphasis on barley. Having seen Finlay's progress in South Australia, Paul was confident that better barley varieties could be developed for Queensland by focussing on yield improvement. At that time, the principal barley variety grown in Queensland was Prior. Barley growers accepted its low yields and lodging as standard features of the crop. Powdery mildew was the only disease of any note.

Early Days of the Queensland Barley Breeding Program

Barley improvement in Queensland began in 1967 when Paul conducted a trial series that tested 8 varieties sown at 21 sites. The results were positive and attracted considerable interest from the industry. Paul wrote in his 1967-68 annual report, "*Since I have commenced work with barley, I have been very pleased with the cooperation and enthusiasm shown by the Barley Marketing Board (BMB) and by barley growers.*"



Right from the start, Paul worked closely with the BMB. They, in turn, introduced him to farmers, maltsters, brewers and marketers. Consequently, Paul very quickly came to appreciate the "why" behind the barley breeding program. He added to this interaction with industry by joining the Institute of Brewing a few years later. In all, these activities gave Paul the basis from which he understood the need to breed varieties for the whole industry; growing, selling and utilisation.

In 1968, the barley trial program included "*50 promising lines and varieties of barley*" provided by the South Australian breeding program. Paul's intention was to replicate Finlay and Sparrow's 1968 strain trial series in Queensland and investigate different varietal responses between the two environments. His purpose was to justify the establishment of a separate breeding program, rather than simply evaluating imported material. He succeeded, but at the same time established that the new South Australian malting variety, Clipper, could be grown as an immediate replacement for Prior. A newspaper article from 1969 states that "*during the past season ... Clipper barley has outyielded Prior ... in (individual) trials ... by up to 40 per cent*".

Paul secured a scholarship in 1969 from the Australian Barley Improvement Scheme for postgraduate study at the Waite Institute. His thesis was titled "Single Plant Selection for Yield in Barley" upon which his PhD was awarded in 1973.

He returned to Queensland in 1972 and put together a solid case to establish a barley breeding program at Hermitage Research Station. Industry support for the project was forthcoming, for example the QGGA State Council passed the motion: "*That research be provided into the improvement of dual purpose (barley) varieties, taking into account the 'itch' characteristic of the straw and grain compatibility.*"

Initially, Paul believed that the program would have to be split into two parts with the broad objectives of developing high yielding barley varieties with the malting characteristics of Clipper and developing high-yielding non-malting quality selections of barley for use as feed varieties and as parents in the breeding program. He wrote that "*I believe that it should be possible to combine high yield with the quality requirements of the malting industry, but probably there will always be lines of poor malting quality which have a distinct yield advantage over the best commercial malting varieties. These lines will be used as parents in the breeding programs in combination with the best malting quality varieties in an attempt to up-grade their*

quality level, but they could also find a place in the feed industry where yield is the first requirement. ... Probably the major incompatibility (between malt and feed requirements) is between the demands of the farmer and animal producers for high yields and the desires of the maltster in an increasing range of quality characteristics." (Johnston, 1974) However, it did not take long before Paul realised that a single breeding program could address both objectives.

Initial micromalting assays for the program were conducted in the Queensland Wheat Research Institute (QWRI) wheat quality laboratory with an annual capacity of approximately 4-500 samples. However, an independent micromalting laboratory was established at the QWRI in 1976/77 after Paul secured additional funding from the barley industry. The Barley Quality Laboratory is now one of the major strengths of the program, with achievements such as: providing micromalting data used for the registration and release of Schooner, Grimmett, Tallon and Lindwall, screening tens of thousands of breeding lines for the Northern breeding program, being the location for the Australian Malting Barley Centre and the first laboratory serving a state barley breeding program to achieve ISO9001 quality assurance accreditation.

The first variety released through the program was the blue aleurone feed barley Corvette (WI2355 - 1976). It had been identified through Paul's trials as high yielding in Queensland and was also resistant to powdery mildew. It was significantly higher yielding than Clipper and quickly became popular. By 1982, approximately 40% of Queensland's barley acreage was planted with Corvette.

Core Structure of the Queensland Barley Breeding Program

Paul Johnston's core breeding philosophy was to concentrate on breeding for grain yield, yield stability and grain quality before any other trait. He always felt that any problem areas, such as disease resistance, could be "*fixed up later*".

The core trial program that Paul established in the early 1970's still remains at the heart of the Northern Barley Improvement Program. It is centred around a cross-evaluation strategy in which thirty F₃ or F₄ lines are selected at random from each breeding population. Those lines are sown in multi-locational yield trials from which agronomic, yield and basic quality data are collected. The mean and variance of the yield data are calculated for each population. The cross statistics are then compared to find the populations with the best combination of high mean yield and wide variance. In theory and practice, those crosses have the greatest chance of producing high yielding progeny. The varieties Grimmett, Tallon, Lindwall and CK85 were specifically developed using this strategy. The system is still used with the only changes being increased cross numbers and improved trial designs.

Between 1973 and 1975 Paul tested the use of regular grid plots in early generation trials. Individual plot yields were adjusted in relation to the weighted mean of several nearby check plots. The results from replicated trials showed that the error mean square had been reduced in 14 of 17 trials analysed, although the adjustments reduced efficiency at uniform trial sites. The need to use the adjustment was tested by the

serial correlation between the yields of adjacent check plots. This technique was subsequently employed to assess F₃ and F₄ lines in unreplicated trials.

Further Development of the Northern Breeding Program

Following an epidemic of leaf rust in 1978, Paul began to campaign for improved plant pathology support for Queensland barley. In the same period, diastatic power (DP) was added to the breeding objectives. This was in response to an observation that the growing Asian markets for malt barley required high DP levels. In 1979, the linseed program was wound up with a final series of yield trials.

Another milestone in Paul's career occurred in 1981, when he attended an International Barley Genetics Symposium (IBGS) for the first time. He met and began to form relationships with many international colleagues. Many of these relationships developed into solid friendships, and at subsequent IBGS meetings Paul and Mary became regular members of the "barley army". Paul never tired of meeting new people, catching up with old friends and exchanging information.



These words from Canadian barley breeder Brian Rossnagel sum up Paul's international relationships very well. *"I would say that one of Paul's greatest contributions was that he, and Mary, have been a hub for connecting barley people, programs and industry on the global spokes of the barley wheel. I have come to know a lot of people through Paul and most importantly many of them too have become good friends as well as barley colleagues. Paul's exuberance for agriculture, for crop research and barley in particular just warmly and enthusiastically flowed and overflowed to other folks around him and I for one found his enthusiasm re-invigorating whenever we did have the chance to visit. It was always like some sort of tonic for me."*

The IBGS was also an opportunity for Paul to visit several European breeding programs. He returned to Queensland with many new ideas, particularly related to field plot and sample management, that gave him the opportunity to further expand the scope of the breeding program. Paul was also highly impressed with the European germplasm and began to import varieties for use in the program; marking the point where the Northern gene pool began to diverge significantly from that used by the other Australian breeding programs.



The first malting barley from Paul's breeding program was Grimmatt (Bussell/Zephyr), released in 1983. The variety was an improvement on both Clipper and Corvette; featuring higher yield, better malting quality than Clipper and resistance to powdery mildew and barley leaf rust. In the late 1980's, more than 80% of the Queensland barley crop and 26% of the NSW crop was sown with Grimmatt. The QBMB estimated that within five years from its release, Grimmatt had added 30 to 40 million dollars of value to the Queensland barley industry.

The variety was named after Clarrie Grimmatt, a wily Australian spin bowler who played during the Bradman era. Paul loved cricket more than any other sport and was an accomplished all-rounder, being an excellent batsman and capable of taking more than a few wickets with his off breaks. He played A grade in both Brisbane and Adelaide and on returning to Warwick played in the local team along with his close friend, sorghum breeder Bob Henzell. With such a passion for the game, it was only natural that Paul should combine two of his great loves and name his barley varieties after great Australian cricketers. Paul was a good selector; his three malting varieties, Grimmatt, Tallon and Lindwall all made Don Bradman's team of legendary players.

Development of the Northern Barley Improvement Program

Following the 1987 review of the QDPI barley breeding program and an epidemic of barley leaf rust in 1988, Paul negotiated and secured funding from the BMB to expand the program by the appointment of a second plant breeder and an additional technician. This was partly justified by the need to increase the program's rate of progress and partly by the requirement to pay more attention to disease resistance breeding. Several new diseases had begun to affect the Northern barley crop during the 1980's. Barley leaf rust, stem rust, powdery mildew and net blotch had all been detected in Queensland crops at levels which were causing concern.

The 1990's were the beginning of a new era for Paul's breeding program. The new appointments, together with advances in computing power, statistical techniques and plant breeding equipment brought about a substantial expansion of the program. Additionally, the amalgamation of the QDPI breeding program with barley variety testing in northern NSW under a "Memorandum of Understanding" further increased its scope. These developments were the precursor to the formation of the GRDC "Barley for Market - North" subprogram. By the year 2000, the Northern Barley Improvement Program had grown to incorporate up to 18,000 trial plots per annum with an additional 6,000 or more seed increase and early generation screening plots.

A series of new varieties were released through the 1990's. Three were derived from the European germplasm introduced by Paul; namely Tallon (Triumph/Grimmett - 1991), Gilbert (Koru reselection - 1992) and Lindwall (Triumph/Grimmett - 1996). A fourth variety, Kaputar (Arupo - 1993), was jointly released by NSW Agriculture and QDPI, being a CIMMYT line introduced by Paul and nominated for release by NSW Agronomist David Doyle. Tallon and Lindwall have been accredited as malting varieties under the MBIBTC protocols, while Kaputar and Gilbert were respectively released as quick and medium-slow maturing, high yielding feed varieties.

Comparison with Prior shows the substantial contribution of Paul's breeding program to the Northern Region barley industry. Crop yields have significantly increased because of the combination of new varieties and improved agronomy. In 1996, Australian record commercial yields were set in crops of Tallon and Gilbert, at 7.3 and 7.6 tonnes/hectare respectively. Cameo/Koru-85, to be released later this year, will be the highest yielding variety released by the program and demonstrates a 34% yield improvement from Prior, based on long term averages. This represents a genetic gain in grain yield of approximately 1% per year during the program's history. Resistance to lodging has been substantially improved. Additionally, growers now have a choice of varieties with different maturity classifications from quick (Kaputar) to medium-slow (Lindwall).

Quality has also improved dramatically. While Prior, Clipper and Schooner are susceptible to pre-harvest sprouting, Grimmett and Tallon possess sufficient grain dormancy to offer some protection against Queensland's spring weather. Grimmett and Tallon have achieved world-class malting quality, particularly with respect to malt extract. Langrell and Edney (1997) published data that showed Tallon among the worlds best malting barleys for malt extract levels. Unfortunately, a disastrous run of poor seasons in the Northern region during the 1990's meant that very little Queensland barley was available for the export market.



Improvements in disease resistance of Northern varieties have occurred more slowly than yield or quality. This reflects Paul's "yield first" philosophy and the gradual evolution of barley disease problems in the Northern Region. In the 1960's, the only significant disease was powdery mildew. Leaf rust became important during the late 1970's and stem rust in the 1980's. The blotches and soil borne diseases were present earlier, but only become significant during the 1990's. There has also been pathotype evolution in mildew, leaf rust and net form net blotch. However, each variety has been released with improved disease resistance characteristics to its predecessors.

During the second half of the 1990's, the Northern Barley Improvement Program began to implement new technologies such as doubled haploid production, molecular markers and NIR quality evaluation. A full time cereal pathologist was also dedicated to barley. At the same time, Paul's contribution to the program evolved from being a hands-on plant breeder to the leader of a multi-disciplinary research team that employed 20 people. However, he maintained an involvement in all aspects of the

breeding program whenever possible. In his new role, Paul became even more firmly established as the "Champion" of the Northern Barley industry, and was constantly encouraging his staff to follow the whole of industry approach in which he believed.

Paul's Role in the Development and Coordination of Australian Barley Research

Perhaps Paul's greatest career achievements were the use of his broad technical knowledge and remarkable interpersonal skills to assist the evolution of barley research in Australia. Through the unselfish efforts of Paul and the other research coordinators, we now work in an environment which, although being competitive, strives as a whole to achieve excellence in the Australian barley industry.

Because of his whole of industry approach, Paul became a key contributor to GRDC's coordination of its Australian research portfolio. The "Barley for Market - North" subprogram was essentially built through the teamwork of Paul and Deirdre Davis. The first step in the process was a workshop, held in 1993, to which all of the Northern Region industry members and research providers were invited. It established the framework for a coordinated barley research program covering Queensland and northern New South Wales. This became the first multi-organisational, commodity based research subprogram in the GRDC portfolio. The structure was so successful that GRDC used it as a model for other subprograms. Paul became the Northern Region Research Coordinator, and with his Southern and Western counterparts and colleagues from GRDC, was responsible for bringing about Australia's first nationally coordinated commodity based research program.

Paul's contribution to national barley research included a significant role in securing a substantial amount of funding from industry to support the position of Chair in Plant Breeding at the University of Adelaide. He was also influential in securing industry funds to establish the Australian Malting Barley Centre and was a key player in negotiating with GRDC to establish the National Barley Molecular Marker Program.

The current status of Hermitage Research Station as a leading centre for plant breeding also owes a lot to Paul Johnston. He was made Centre Leader some years ago and put many hours into securing funding for building up the station's facilities.

Paul's final role was as QDPI's Principal Research Scientist, with direct responsibility for the wheat, barley and oat breeding programs. Tragically, Paul passed away before he could see the groundwork he had put into place in this job come to fruition.

Conclusions

The depth and breadth of knowledge possessed by Dr Paul Johnston and his contribution to the Australian barley industry are irreplaceable. However, he has left the industry a legacy by passing much of his experiences on to his colleagues, particularly the team he developed and with whom he spent most of his professional time. He was a tremendous role model and his outstanding personal and professional qualities have influenced many people from the international research community. Paul's varieties are the foundation stones for the Northern Region barley industry and will have been used by breeding programs from around Australia, and indeed, the world. His non-parochial approach and ability to pull people together have significantly contributed to the highly coordinated, national barley research fraternity we work in today.



Paul, we will miss you.

References

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