

**Evaluation Strategies for  
varieties derived from  
Australian breeding projects  
or imported varieties**

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Diversity Arrays

Project Number: AH06012

## AH06012

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*Know-how for Horticulture™*

Report on

**Varietal Evaluation for Horticulture Workshop**

held on

5<sup>th</sup> March 2008

at

Horticultural Australia Limited offices  
Level 7, 179 Elizabeth Street Sydney

prepared by

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## Summary

A workshop was held by Horticulture Australia limited (HAL) on the 5<sup>th</sup> of March 2008 to: (i) explore opportunities for developing best practice evaluation methodologies and supporting systems across horticulture and (ii) identify opportunities to progress to the next phase. Attendees included researchers and commercial operators involved in horticultural variety evaluation and genetic improvement programs, and experts from relevant disciplines in other crops. The facilitator was Dr Andrzej Kilian.

The first part of the workshop comprised eight formal presentations, three from non-horticultural crops and five from horticultural crops. Issues highlighted in these presentations were: (i) source of germplasm for evaluation, (ii) separation of breeding and evaluation programs, (iii) evaluation methods, (iv) management of Genotype x Environment (GxE), (v) data management methods and approaches, (vi) gains from application of modern statistical methods, (vii) uptake of new varieties, (viii) gains in efficiency from cross industry collaboration and coordination of genetic evaluation activities, and (ix) autonomous approach to evaluation activities.

The second part of the workshop was a facilitated discussion on opportunities for implementation of systems support approaches to horticulture evaluation. This discussion identified the opportunities for this approach as: (i) centralised database system for horticulture, (ii) access to modern statistical approaches, (iii) information accreditation system, (iv) climate modelling, (v) sensory evaluation, (v) importation of material into Australia, and (vi) IP management.

The benefits from this approach were identified as: (i) increase in efficiency of HAL and individual crop programs, (ii) increased staff focus, (iii) increased confidence in results, (iv) greater knowledge sharing, (v) opportunity to develop projects of size that can deliver significant outcomes to Australian horticulture, (vi) better communication of program activities, and (vii) decreased risk of having all information concentrated within a single staff member.

Barriers to implementation were identified as: (i) perceived speciality of horticulture crops, (ii) lack of awareness of technology and benefits, (iii) funding structures, (iv) barriers to collaboration, (v) apparent success of simple approaches, (vii) apparent specificity of the Australian environment, and (viii) lack of vision and resistance to change.

The strategies identified to progress the concept were: (i) education, (ii) improved networking among horticultural scientists, (iii) pilot studies, (iv) funded across industry position (s), and (vi) across industry research projects.

## Introduction

Horticulture is an important Australian industry. The role of HAL is to benefit Australian growers by judicious investment in R&D in the area of genetic improvement. A major component of this investment is evaluation of varieties bred in Australia or overseas.

Access to a superior evaluation system with the most up to date technologies is out of reach of individual horticulture industries. However, this is a fundamental area in the variety development continuum that is relevant across horticulture crops, requiring an integrated approach with clear linkages to commercialisation and variety management entities. A significant fraction of the cost of developing any new cultivar is the agronomic research required to evaluate and maximise its performance under specific conditions. There are variable policies within state governments in Australia in their support of late stage evaluations. However, the general trend is a move away from state government co-investment in this area. Commercial and industry investment is now often encouraged.

To examine whether there are opportunities to undertake these activities more effectively, Horticulture Australia Limited (HAL) is undertaking the project "Evaluation strategies for varieties derived from Australian breeding projects or imported varieties" (AH06012). As part of this project a workshop was held on the 5<sup>th</sup> of March 2008 at the offices of HAL to: (i)

explore opportunities for developing best practice evaluation methodologies and supporting systems across horticulture and (ii) identify opportunities to progress to the next phase. The outputs from this project will contribute to ongoing planning activities of the organisation.

### Attendees

Scientists and commercial operators (growers, marketers, germplasm companies) across a cross-section of Australian horticulture industries were invited, along with experts in relevant field from other industries.

### Program

The program for the workshop is presented in Table 1. The facilitator for the workshop was Dr Andrzej Killian, CEO of Diversity Arrays Technology (DART). A range of presentations were initially made to provide an overview of supporting systems approaches undertaken in other agriculture industries and to review current strategies and approaches in a range of horticulture programs.

The second part of the program was an open discussion to identify opportunities and develop strategies for developing best practices evaluation methodologies and supporting systems across horticulture.

Table 1. Proposed program for the HAL workshop Evaluation workshop

	TOPIC	PRESENTER
8.45	Arrivals/registration (coffee)	
9.20	Meeting Commences	
	Welcome and introductions	Andrzej Killian /All
9.40	Scope of the meeting and expectations from HAL	Marian Sheehan- HAL
9.50	National Varietal Trials for Grains; challenges, achievements and opportunities for horticulture industries	Alan Bedggood, NVT Manager - ACAS
10.20	Industry wide genetic analysis systems for forestry	Tony McRae & Richard Kerr- PlantPlan Genetics.
10.50	Break	
11.00	Varietal Evaluation: Building on the grains experience,	Arthur Gilmour & Brian Cullis (Gilmour presenting)- NSW DPI
11.30	Independent Apple & Pear Evaluations	Garry Langford, Greg Cramond-APFIP
11.45	Stone fruit evaluations in Queensland DPI&F breeding projects	Bruce Topp- QDPI&F
12.00	Citrus Evaluations for Australian Conditions	Graeme Sanderson- NSW DPI
12.15	Importing and exporting fruit varieties and rootstocks and the processes involved in the selection criteria from different breeding programs.	Craig Perring -ANFIC
12.30	Lunch	
Post lunch	McCain Foods Variety evaluation	

	General discussion	
	<p><i>1. Perception of need and opportunities for the Evaluation system among industry representatives</i></p> <p>a. Current status in the industries not represented before lunch</p> <p>b. Commonality versus Specificity among industries</p> <p>c. The resources available for the programs but not tapped into</p>	
	<p><i>2. Potential impediments</i></p> <p>a. Capabilities/technologies missing</p> <p>b. Resources required</p> <p>c. Key people/organisations to get behind the concept</p>	
	<p><i>3. Technical discussion on issues presented in the scoping paper:</i></p> <ul style="list-style-type: none"> <li>• Mapping of the Environment</li> <li>• Trial Design</li> <li>• Data capture, storage analysis and display</li> <li>• Further Integration Opportunities and other issues</li> <li>• Across Agriculture Industry Collaboration</li> </ul>	
	<p><i>4. Plan for the next step and selection of steering committee</i></p>	

### Summary of issues identified in formal presentations

Eight presentations were made as background for discussions (Table 2). Summaries of these presentations made from horticulture and evaluation programs are presented in Appendix 1. Several major themes for variety evaluation were identified from these presentations.

Tables 2. List of organisations and crops represented in eight presentations made as part of the Horticulture Evaluation workshop.

Organisation	Crops
National Variety Trials (NVT)	wheat, barley, tritcale, oats, chick pea, faba bean, field pea, lentil, lupin
PlantPlan	forestry, potato, general
NSWDPI	crops, general
Australian Pome Fruit Improvement Program (APFIP)	apple, pear, nashi
QDPI&F	low chill stone fruit
AusCitrus	Citrus
Australian Nurserymen's Fruit Improvement Company (ANFIC)	Pome fruit, citrus. stone-fruit, mangoes, avocados, grapes, persimmons, bananas, olives, nut trees
McCain	Potatoes

### *Germplasm source*

The source of germplasm evaluated in programs described by NVT and QDPI&F were generally domestic breeding programs, although exotic germplasm may have been used in the original breeding activities. In contrast, varieties from both domestic and international

sources were evaluated in the APFIP, Auscitrus, McCain and ANFIC programs. The large cost and time involved in importing international material and passing AQIS quarantine was noted.

### ***Separation of variety evaluation from commercial breeding***

Separation of variety evaluation from breeding activities was described for the NVT, APFIP, Auscitrus and ANFIC programs. The major driver for separation appeared to be the need to reduce the influence of commercial interests from breeders on evaluation results.

In contrast, breeding and variety evaluation were vertically integrated within the one organisation for the QPDI&F stone fruit program. This appeared to be due to economies of scale and the smaller program size.

### ***Evaluation methods***

A diversity of evaluation methods was described. Obviously, this is due, in part, to differences among the crops and the product produced. Budgetary constraints were also identified as an important driver, particularly as the evaluation of perennial fruit trees was described as being long and costly.

Experimental designs were applied in some programs, although not all, and genotypes were replicated in most evaluation programs. Generally, the performance of new varieties was compared against that of standard or currently commercial varieties.

Traits assessed in the horticulture programs were field performance and quality attributes including appearance, flavour and storage effects. Several programs relied heavily on observational data, with limited objective assessment of traits. Observational data were often recorded as present or absent, or using an ordered scale with 3-4 categories. This appeared to be a compromise between the cost and value of observational data compared to quantitative data. In some cases, instrumental assessment methods had been developed to reduce cost and improve objectivity.

Several stages of evaluation were described for some programs. Less rigorous initial evaluations were undertaken to reduce number of individuals prior to the implementation of a large commercial evaluation to identify possible production barriers and build market interest in the new varieties. In some cases, a difficulty in accessing grower collaboration for these large commercial scale evaluations was reported.

### ***Management of GxE***

Most programs recognised the importance of considering the interaction between genotypes and the environment, and most programs evaluated varieties over several sites, at least in the latest stage of testing.

It was suggested that the cost of importing and evaluating international varieties in Australia could be reduced if there was better knowledge of how the performance of this germplasm in exotic environments related to its performance in Australian environments.

Heat sum units were used by the Auscitrus program to classify Australian growing regions for citrus production and variety selection

### ***Data management***

The importance of good data management systems was emphasised by several of the presenters. They indicated a flexible system was required to facilitate data checking, combine data from different scales, accommodate different types of data and genetic relationships (e.g. seedling, clonal, DNA assay), interrogate, store results from analyses, and output reports in a format that could be easily used. The ability of databases to hold photographs and link to particular units was also described. A web based information reporting system,

with appropriate access constraints to maintain security, was used by several programs to provide clients with great flexibility in accessing information.

### ***Gains from application of modern statistical methods***

Gains of over 30% due to application of modern statistical methods for the design and analysis of evaluation trials were reported in presentations by PlantPlan, NSW DPI and the NVT programs. This was achieved through the application of sophisticated experimental designs, and data analysis methods that accounted for missing entries, spatial heterogeneity in environmental effects and competition, and pedigree relationships among genotypes.

In contrast, it was suggested that the presence of single gene effects in stone fruit supported the observational approach adopted in this program. In other programs, it appeared that limited data processing was undertaken and raw assessment data was used for decision making.

### ***Uptake of new varieties***

Both the ANFIC and Auscitrus presentations described rapid adoption of new varieties by their respective industries.

### ***Gains in efficiency from support systems approach to genetic evaluation***

Gains in efficiency due to the collaboration and coordination of genetic evaluation activities across crops were outlined in a number of presentations. The primary benefits from this approach were identified as application of specialised skills and knowledge sharing.

### **Coordinated field management and assessment**

Coordinated management of the field evaluation for 10 grain crops was described as one of the initial successes of the NVT program. The PlantPlan presentation described how the Southern Tree Breeding Association coordinated the breeding activities of *Pinus radiata*, *Eucalyptus globulus* and *Eucalyptus nitens*. ANFIC described how evaluation programs were coordinated for varieties and rootstocks for Pome fruit, citrus, stone-fruit, mangoes, avocados, grapes, persimmons, bananas, olives and nut trees.

Some of the challenges of undertaking this approach were described as: managing the entry of genotypes into the field trials (inclusivity, equity, eliteness), management of different crops, maintenance of unbiased data collection and reporting methods, and customisation of variety information reports for different types of clients.

In the NVT program, entry was open to all germplasm irrespective of size or market share and there was no quota on entries. No charges to breeders were applied. However, to ensure that only elite varieties were included, a criterion of the ability to produce commercial qualities of seed in the 2<sup>nd</sup> year after nomination was imposed.

Entry into ANFIC trials was determined by selection by company representatives or from breeders sending new varieties to the company. ANFIC is a member of AIGN (Associated International Group of Nurserymen) which was formed, in part, to develop better avenues for the international exchange of information on genetic material. The cost and delay of the quarantine process was described as a significant barrier to the export of exotic varieties to Australia by overseas breeders.

Strategies employed to maintain the quality and absence of bias of evaluation in the NVT program included: tendering for selection of service providers, development a system of accreditation and excluding breeding programs from evaluation activities. It was suggested by several presenters that the management of multiple trials by a single entity would improve the consistency of data collection and trial management, which in turn would better enable comparison of variety performance across these trials. Trials undertaken by APFIP and ANFIC are located in commercial fruit farms to ensure outcomes were applicable to commercial

practices. APFIP suggested that the independence of their program was maintained by not making variety recommendations.

#### **Coordinated database system**

A centralised database system that was applied across crops has been implemented in the NVT, PlantPlan, APFIP, NSW DPI and ANFIC programs. PlantPlan also described a model where data base management was undertaken by dedicated staff separate from staff undertaking the field operations.

#### **Platform approaches to statistical input**

Centralised data analysis by specialists using best practice statistical methods were described by NVT, PlantPlan and the GRDC national statistical program (NSWDPI). Each of these programs worked across multiple crops. This allowed sophisticated methods to be adapted to individual crop issues and the efficient development of new methodology as specific issues were identified. A team of research scientists was involved in these projects to reduce staff isolation and maintain close interaction with the operational breeders.

#### **IP management**

ANFIC described an across crop coordinated approach to the management of IP. Linkages with AIGN provided access to defined structures and processes for germplasm exchange, and expert IP legal knowledge.

#### ***Autonomous evaluation activities***

In contrast to the platform approach to genetic evaluation described above, an autonomous approach to variety evaluation activities was described for the QPDI&F, Auscitrus and McCain programs. The benefits of this approach appeared to be more specific application of crop knowledge to evaluation and stronger control of IP.

#### **Summary of issues raised during open discussion**

Following the presentations, a discussion was undertaken with the aim of exploring opportunities and developing strategies for the implementation of a support system approach for variety evaluation in horticulture.

Much of the discussion was focussed on the characteristics of individual programs, and the differences between horticulture and other agriculture crops and among individual horticulture crops. However, it was possible to identify four relevant themes from the discussion; (i) opportunities for implementation of a support systems approach, (ii) benefits from this approach, (iii) barriers to implementation, and (v) strategies for implementation.

#### ***Opportunities***

##### **Database system**

The development and support of a database system that was tailored for variety improvement but was sufficiently flexible to accommodate different crops and data types including molecular data was identified as an opportunity for the implementation of across horticulture coordinated support systems approach.

##### **Access to modern statistical approaches**

Several participants suggested access specialised biometric skills, particularly in the areas of experimental design, and spatial and pedigree analysis methods, could have a major impact on variety evaluation in horticulture.

### **Information accreditation system**

It was suggested that an accreditation system based on best practice methodologies for data collection and processing could be used to support the quality of information provided to growers. This could be used to identify and explain the impact of any gaps in the methodology on information quality, and thereby assist the users of information (e.g. growers) to judgements on the risk inherent in the data provided, without the need to understand the breadth of issues related to data collection and management. It was suggested this could be particularly important for trials undertaken on growers farms.

### **Climate modelling**

It was suggested that a support system approach could be applied to climate modelling to evaluate the similarity between overseas environments and Australian environments to enable better targeting of overseas bred germplasm for trialling in Australia. This could be further refined by incorporating results from crop evaluation into the climate models to identify the important environmental drivers of GxE and using this to assist overseas or indigenous programs better target varieties for Australian environments.

### **Sensory evaluation and market testing**

Sensory and market testing was recognised as an important area to support the development and marketing of new varieties, but testing may be ad-hoc and not rigorous. It was suggested that there may be an opportunity to implement a support system approach in these disciplines to support the application of best practice evaluation methods and take advantage of economies of scale for market research.

### **Importation of material into Australia**

The cost and time of quarantine regulations and process for importation of exotic germplasm into Australia were identified. It was suggested this may be done more efficiently if there was a central specialised position to deal directly with AQIS.

### **IP management**

The discussion noted that IP management was a major activity for commercialisation. It was suggested that a specialist in this area would be a valuable resource for programs to access for advice, particularly for those that had not yet undertaken commercialisation.

### ***Benefits***

General benefits from a support systems approach identified in the discussion were:

- (i) improvement in overall HAL program efficiency through economies of scale,
- (ii) access for individual crop programs to specialised skills for the application of contemporary and new technologies,
- (iii) increase in the efficiency of individual crop programs by appropriate application of specialised skills,
- (iv) increased staff focus and opportunities for specialisation into particular crop or discipline areas,
- (v) increased confidence in the accuracy, repeatability and unbiasedness of results,
- (vi) greater knowledge sharing including sharing of solutions developed in one crop to another crop consequently reducing time spent in individual crops developing solutions in isolation,
- (vii) potential to develop research projects that have the size to make significant impact on Australian horticulture,

- (viii) better communication of program activities and methods with decreased risk of loss of information from staff turnover compared to situations where all knowledge of a program is held by a single staff member,
- (ix) opportunities to develop better succession plans for, and react more efficiently to, changes to individual program staff,
- (x) increase in the viability of current small programs

### ***Barriers***

Much of the afternoon of the workshop was spent discussing barriers to the implementation of a collaborative support system approach to variety evaluation in horticulture.

#### **Perceived specificity of individual crops**

One of the main barriers to the implementation of a support system approach appears to be the apparent belief that issues considered important for each horticulture crop were specific to that crop and the exclusivity of horticulture crops (compared with non horticulture crops). Differences between crops were based on life-cycle (vegetable, annual or perennial) and type of product (fresh fruit or commodity). It was suggested that the value of new varieties for fresh fruit crops came from the novelty of the product, whereas value from varieties for products used for processing came from reduction in costs.

It was also suggested that most crops were at the early stages of breeding compared to annual crops and thus were mostly concerned with removing deleterious alleles. However, it is noted that forest crops are also only 2-3 generations from the wild, but this has not excluded these from implementing a rigorous approach, based on common underlying principles, to genetic improvement.

#### **Lack of awareness and understanding of modern technology and benefits**

There appeared a general lack of understanding of the value of some of the specialist technology proposed. This lack of knowledge and distrust in the benefits appears to be a major barrier to the adoption of new approaches. This barrier is illustrated by the lack of communication within research organisations between scientists developing advanced statistical approaches for variety evaluation in non horticulture crops and others working on variety evaluation in horticulture.

Several participants also expressed the opinion that scientific rigour was not a necessity for variety evaluation. This may in part, be a consequence of the difficulty of communicating the value of a scientific approach to industry partners, and the different approach to problem solving between the scientific community and the commercial sector.

In addition, there was general perception that the application of specialist skills and scientific rigour would be more expensive. This may also be due to the lack of knowledge of the benefits of this technology, as several examples were discussed where application of technology reduced costs of programs and increased program efficiency. For example, it was noted that the size of a macadamia kernel sensory analysis was reduced by 50 times through the use of a sophisticated experimental design, and gains of over 30% were achieved through the use of modern statistical approaches.

#### **Funding structure**

The funding structure in Horticulture Australia Limited may be a barrier to adoption of across industry support system projects. Clearly, there is a strong relationship between industry and research scientists and this is beneficial for maintaining the applied direction of projects, ensuring selection criteria are relevant and ensuring new varieties are marketable.

However, this structure reduces the opportunity to build across crop projects as industry partners are particularly focussed on improving the performance, and maintaining the control

of the direction of research, for their individual crop. In addition, industry partners may not have the necessary technical skills to evaluate different options.

### **Barriers to collaboration**

It was also suggested during the discussion that the success of platform approaches may be hindered if barriers to collaboration develop. For example, these may develop if there is a culture of elitism among research organisations or from competition for funding.

It was also suggested that a good relationship of mutual trust and respect between specialists and crop focussed researchers was essential for the success of a system support approach. It was felt that the adoption of a platform approach would not be successful unless it was inclusive and supported by the individual crop operational researchers. This support needed to be developed through mutual trust and respect.

### **Apparent success of simple approaches**

Clearly, simple approaches have worked for some traits in some horticultural crops. This may have created an impression that this approach will work in all crops with all traits. However, many of the key traits for improvement in horticulture crops, such as fruit quality, disease resistance and yield, are unlikely to be controlled by simple genes. It is therefore unlikely the progress that could otherwise be achieved will be made in these traits, unless appropriate quantitative methods are applied.

### **Apparent specificity of Australian environment**

When opportunities to implement more sophisticated approaches to the management of GxE were discussed the general reaction was that the Australian environment was unique. This was supported by reports of experience of poor performance with exotic elite varieties.

There was limited interest in investigating the generality of this concept or reviewing the opportunities for identifying areas overseas of similar environment to increase the efficiency of management of exotic germplasm.

### **Lack of vision and resistance to change**

During much of the discussion there appeared to be a general unwillingness to embrace change. It appeared that many participants from the horticulture sector felt that current methods and approaches were satisfactory and much of the discussion was on reasons why alternative approaches would not work in horticulture crops.

### ***Strategies for progressing concept***

Several strategies were identified from the discussion to progress the concept of a platform approach to supporting genetic evaluation projects. However, there was no clear agreement on need or direction from the group.

### **Education**

It was suggested that improved knowledge of the benefits from the specialised skills available through a support system approach could generate interest in these technologies. For example, the inclusion of plenary lectures at horticultural science conferences was suggested as a means of raising the awareness of new technologies and approaches that could be used in variety evaluation in horticulture.

### **Improved networks among horticultural research scientists**

The discussion also identified improved networking among horticultural scientists as a method to increase the awareness of the benefits from using specialist skills and novel solutions to common issues that had been developed in other crops.

### **Pilot studies**

Pilot studies were identified as a mechanism that could be used to demonstrate the methodology and benefits of specialist advice available through a platform approach. For example, PlantPlan suggested they would be interested in applying their system to some test data.

### **Funded cross industry position**

One of the main ideas discussed during the workshop was support of an across industry position to interact with individual programs to deliver specialised advice and skills to horticultural crops, particularly in the areas of experimental design and statistical analysis, information accreditation, and specialised IP and commercialisation advice. One model that was discussed for statistical support was the support of a junior scientist (post doc level), located within a team of scientists for mentoring, to interact with individual evaluation programs to adapt current methodology and identify specific areas where development of current methods was required.

### **Cross industry research projects**

The possibility of cross industry research projects was mentioned but not developed in any detail. One area that seemed to be of interested was a review of the applicably of currently available genetic evaluation database systems to variety evaluation in horticulture.

## Appendix 1. Summary of presentations

### *Introduction*

Marian Sheehan, Horticulture Australia Limited (HAL)

Horticulture is an important Australian industry. HAL invests significant funds into breeding and evaluation programs, across some 20 industries. How can this be done more efficiently to return greater impact? This project will feed into new across industry planning activity: Future Focus.

Presentations were made from a number of evaluation programs in other industries and selected horticulture industries to give a background to the issues. The scope of these presentations included:

- Mapping the environment
- Trial design
- Data capture, storage, analysis and display
- Further integration opportunities
- Across agriculture industry collaboration

### *National evaluation trials for grains*

Alan Bedggod, National Variety Trials (NVT)

- Set up in 2005 with GRDC funding to *independently evaluate* and *report* on varieties as wheat breeding moved from public good to commercial base. Now includes other crops
- Data collection - Performance compared to existing cultivars. Analysis conduct by central agency. Single trial analysis then combined trial analysis at end of season.
- Challenges
  - *inclusive* of breeding programs irrespective of size (how include foreign varieties?)
  - *equitable* access (no quota, but see 'elite material' below),
  - *non-compulsory* (breeders not charged and not legislated),
  - *unbiased* (no breeding program can conduct NVT trial),
  - only *elite material* included (not another evaluation trial for breeder, must meet acceptance criteria),
  - *diversity of users* (trial managers, breeders, advisors, growers),
  - *reporting* format (tailored for advisors and growers, internet based, what data is included, commonality v. flexibility)
- Successes
  - trial management, assessment, genetic id management,
  - efficiency of combined operations, increase information sharing
- Acceptance
  - accepted by all breeding programs from start,

- accreditation system to gain industry acceptance

### ***Industry wide genetic analysis systems for forestry***

Dr Tony McRae, Southern Tree Breeding Association (STBA) and Dr Richard Kerr, PlantPlan

- Developed in response to desire for consolidation of genetic improvement in forest sector
- Integrated methods and software focussed on key components of breeding strategy
  - data recording and information management (DATAPLAN)
  - data analysis and genetic evaluation (TREEPLAN and ASReml)
  - selection decisions for breeding (MATEPLAN) and deployment (SEEDPLAN)
- DATAPLAN features
  - web based (allows multiple users with different access levels)
  - handles all data types and scales
  - flexible definition of genetic relationships
  - flexible definition of trial unit (progeny trials, variety trials, DNA assays)
- Features of Data analysis approach
  - Mixed model methods with appropriate genetic, GxE and residual models
  - ASReml employed for estimation of trial parameters
  - TREEPLAN designed to predict genetic values from handle large data sets (eg 2.8 million genotypes, 1500 trials, 21 million measurements)
- Summary
  - gains of 30% by adopting integrated approach
  - rapid adoption of research findings
  - allows operational breeders to access specialised assistance in area of data management/analysis

### ***Varietal evaluation – building on the grains experience***

Dr Arthur Gilmour, NSW DPI

- Experience of NSW DPI from investment in statistical approaches:
  - Data useless unless interrelated correctly
  - Many areas where statistics is crucial
  - Development of flexible approaches to address trial conditions
  - Resulted in dramatic increase in genetic gain
  - Improved design for multi-phase experiments
- Platform approach to application of statistics by GRDC
  - 9 positions across Australia supporting delivery (trial design and analysis) and method development for phenotypic and QTL analyses
  - 10 crops supported

- Database requirements
  - access
  - management of data quality (data checking)
  - flexibility to hold trial details (including design), pedigree, field and DNA data, processed data
  - reporting (ease and flexibility for interrogation)
- Issues for Horticulture
  - diverse crops (different systems, different traits)
  - small industries (difficult to develop specialised knowledge within each industry)
  - extension of method to handle repeated measures
  - fund position for delivery but mentored by established group (investment in young scientists)

***Australian pome fruit improvement program (APFIP)***

Garry Langford and Greg Crammond, Australian Pome Fruit Improvement Program Ltd.,

- Established in 1997 to deliver ***independent evaluation*** and ***reporting*** program on variety performance to the pome fruit industries. Supported by Apple and Pear levies and HAL. Prompted by decline in State department support.
- Independence offers evaluation unbiased by commercial interests. Does not make recommendations
- Evaluation program
  - Characterised as not scientific
  - Crops = apple, pear, nashi
  - 14 sites across 6 states, working commercial fruit farms, 30 varieties, 3-7 rootstocks per site,
  - Evaluation group = local growers and state department staff, data collected in-field and in-lab
  - Tree characteristics (tree vigour, health, growth habit, rootstock compatibility), disease resistance
  - Fruit characteristics (shape, symmetry, variability in shape among fruit, russet density and position), visual/taste assessment (16 descriptors, perceived sweetness), fruit post harvest condition (average dimension, weight, starch score, pressure, TSS%, stem length, open calyx, core size, seed colour, flesh browning, water core, mouldy core, other disorders) and storage (shrivelling, perceived juiciness, sweetness, crispness, texture, water core, mouldy core, bruising, overall quality since harvest).
  - Most data assessed as presence/absence, scale with limited (3-4) classes, or non-ordered rating. Quantitative characters assessed = tree vigour (length and diameter of 1 year old shoot, trunk diameter), and fruit dimensions, weight, starch score and TSS%.
  - Photos submitted by observers
  - No market testing
- Reporting program

- Web based database. Access controlled.
- Issues
  - how to control bias?
  - no analysis of data, how to control non-genetic effects?
  - how to make valid comparisons?
  - how to deal with variability on assessments, how to summarise?

***Stone fruit evaluations in Queensland DPI&F breeding programs***

Dr Bruce Topp, QDPI&F

- Objectives = adaptation and high fruit quality
- Program characteristics (individual trees occupy large area, long juvenile period, short time frame, small budget)
- Crop segmentation controlled by single genes
- University of Florida germplasm to generate hybrids
- Stage 1: High density planting of hybrids (2,500 seedlings planted at 14,000/ha). Assessment of chilling requirement by presence of flowering. Subjective assessment of 21 traits to reduce population to 1% for objective assessment of 6 traits and selection for stage 2.
- Stage 2: Commercial density planting density of 2 replications of selections + commercial varieties at single site. Subjective assessment methods again used.
- Stage 3: Commercial density, 1 rep per site of selections, 8 sites, Growers assessment of 7 traits and overall commercial potential rating over 5 years.
- 4<sup>th</sup> stage testing: Large scale commercial testing, multiple sites. 100-2,000 trees per selection. Consumer evaluation of fruit quality.

***Citrus variety evaluation programs (Auscitrus)***

Graeme Sanderson, NSW DPI

- Industry open to adoption of new varieties (34% of sales)
- Issues affecting citrus evaluation
  - Climatic zones. Modelled as heat sum units
  - Used to indentify gaps in supply
- Evaluation methods
  - Use top working to evaluate new varieties.
  - Single site
  - Assessment = phenological stages affected by environment
  - Evaluate juice characteristics
  - rootstock compatibility
- Marketing of new varieties
  - Farm walks

- Fruit displays
- Wholesales markets
- Growers markets
- Look at export

### ***Australian Nurserymen's Fruit Improvement company (ANFIC)***

Craig Perring

- National company formed in 1983. Composed of 12 nursery members.
- Objective = undertake, promote and further the improvement, import and export of fruit varieties and rootstocks on it own behalf, of for the behalf of others (member or non-member)
- Manage: IP, royalty, supply.
- Crops = pome fruit, citrus, stone-fruit, mangoes, bananas, avocados, grapes, persimmons, olives, nut trees.
- Aligned with AIGN: Markets and manages new varieties at global scale. Facilitates information and material exchange across world.
- Cost of importing varieties. More work done prior to importation to better target
- Data management. Heartha DB = tracking sales, IP management, information from evaluation, photographs
- GxE at international level. Specificity of Australian conditions
- Evaluation systems: Indicated that evaluation programs included field and evaluation programs were undertaken.
- Unwillingness of growers to establish trial blocks
- Platform approach would assist with economies of scale in areas of field trial, understanding what drivers consumer choice of new varieties, post-harvest,

### ***McCain foods Potato Variety Evaluation***

David Ryan, Agronomist McCain Foods (Aust) Pty Ltd

- Source of germplasm = National Breeding Program, international varieties
- Stages of testing = replicated commercial field trials over multiple sites -> large scale commercial testing
- Diverse environments (climate, soils, disease pressure, supply schedules, storage parameters)
- Objective assessment of shape, size, disease resistance, cooking properties, yield potential.

### ***Evaluation of exotic tomato varieties***

Elizabeth Mann, Industry Development Manager, APTRC Inc.

- Southern tomato production is located in two main growing regions (Northern Victoria southern NSW). Two main productions systems are used: seed and furrow and drip.

- Program undertakes evaluation of overseas varieties as no breeding in Australia.
- In the past, whatever was provided by seed companies was accepted but currently, only varieties with some evidence of Australian performance were accepted, due to resource constraints.
- Evidence of GxE between growing regions and production systems was reported. It was also reported that heat unit modelling was used to predict growing areas.
- A significant cost source to the program is loss of trial through adverse weather events
- A major trait of interest is difference in phenology to maintain the length of the season.

### ***Table grape and dried fruit***

Peter Clingleffer, CSIRO

- Two different crops. Table grapes are a fresh product grown over several production regions, seedlessness main selection criteria. Dried fruit more of a commodity, grown in single production region, differences in ripening phenology major selection criteria.
- Strong industry steering committees to set direction and criteria, and involved in release and commercialisation.
- Commercialisation is a major issue, particularly if looking at release in USA as commercialisation there requires patent and unable to get patent if any public disclosure.

### ***Macadamia breeding program***

Andrew James, CSIRO

- First varieties selected from program in 2007
- Heavily based on quantitative approach but undergoing re-evaluation