13th Australian Sunflower Association Conference Proceedings, 2001

Private Seed Company Sunflower Research

Alan Scott – Research Manager, Pacific Seeds. Senior Breeder – Advanta.

Introduction.

The scope and role of the Private Seed Company Research activities will always be defined by the market's size, stability, seed price, growth potential and the sunflower crops competitive status. The scope of private seed company research in Australia will also depend on these market forces, but with the added seed export opportunities available in mind. This is normally restricted to African and Asian opportunity markets.
The normal range of research spending in the private seed company sector remains between 10 and 15% of market sales value, but this can be influenced by any of the market forces described. Variation from these guidelines will vary enormously depending on each market situation. The rule of risk and reward normally applies.

The long term composition and structure of private seed company research remains unclear at this point in time? Most of the major seed companies active in seed variety research in Australia are or were part of multi-national agrochemical companies. Cultural differences and different financial expectations between the agrochemical and seed businesses continue to dampen some technical developments. Which is generally based on risk and return issues.

A total of 38 breeding programs from around the world feed germplasm into the Australian private seed research programs. This provides the Australian industry with massive genetic stocks that it would never have had available as a stand-alone industry. This breeding effort plus the results of new technologies, such as molecular markers and transformation systems could never be justified otherwise.

A 35% decrease in the past five years in the area planted to sunflower in the major markets available to the major private companies has forced many companies to review their levels of funding to sunflower research. The available global 1999 sunflower seed

market was estimated to be around $A384 million with a global R&D spending of approximately $A50 million. The Australian market estimated at 120,000HA in 1999 had a seed market value of $A2.9 million with an estimated R&D expenditure of approximately $A1.3million. This represents a research expenditure of 44% of sales, which is disproportionately high by international standards. The only other country in the world where a similar scale of research expenditure is maintained is in France, where seed prices are three times Australian prices.

Research Strategies.

The private sector defines its participation strategy into three broad outlines:

a) Defined use or target. Can it develop an IP position.

b) Value added chain. Can it share in down stream income.

c) Ability to compete – access to high performance germplasm, access to new technology, the ability to integrate appropriate technology and the ability to protect elite germplasm and technology.

Key Traits

Table 1 outlines the key target traits for the Australian sunflower industry and the developmental techniques employed to address these target.

Table 1: *Trait Strategies for major Australian targets.*

Trait	**Technology.**
Yield	Primarily through traditional plant breeding.
Rust Resistance	Traditional pathology screens are the primary screens but with the increasing use of molecular markers. These molecular markers are being developed and utilised by both the private and public sector and utilised through collaborations with public Institutions and their own global research programs.

Trait	Technology
Modified Oils	Oleic acid profile is the main target and GC and refractometer testing are the main techniques used. Molecular markers are also being used by some for the detection of major gene action in breeding populations.
Albugo and alternaria tolerance.	Traditional breeding. This remains a target for molecular marker developments.
Sclerotinia tolerance	This target has been very difficult to breed traditionally and achieve high levels of resistance. Transgenic approaches have recently provided increased levels of resistance.
Other modified oils	Both high palmitic and stearic acid targets have been addressed in collaborations between private and public Institutions using both mutagenesis and transgenic approaches. Neither of these outcomes is commercial as yet but it is expected that molecular markers will be needed to handle these breeding targets effectively.
Downy Mildew resistance	This is one of the main sunflower diseases in the world. It is not in Australia but is one of the main reasons we have a severe quarantine system in place. Working behind a quarantine system can have benefits but can also restrict expedient germplasm exchange and the ability to pro-actively participate in any projects that require fast seed transfer. Molecular markers now exist for this disease and are being used in line conversion and trait fixing in breeding programs. It will also facilitate breeding systems in Australia to breed for targets that cannot be screened for with traditional methods.

Conventional Plant Breeding

This continues to play the most significant part of providing the genetic diversity required for elite hybrid development with positive genetic gain, in both the private and public sectors. In some eyes the recent deterioration of the public research programs, especially in Eastern Europe has dampened the progress of sunflower research, although this has not been proved or widely agreed upon. In some situations the private seed companies have recruited some of the skilled researchers from the public system and have been responsible for a gap in this research segment. This situation has forced some public institutions to become more like private companies and market lines and hybrids accordingly, with royalty arrangements and technology transfer agreements becoming commonplace.

A precarious situation also exists at present among the international private seed company researchers. Company mergers and changing ownership will shape and determine the scope and direction of future research. There are four private companies involved in sunflower research in Australia, three of these companies are in the six major companies listed in the summary in Table 2. The development of this situation is being forced by several factors:

a) Access to Intellectual Property, differentiated product or trait.
b) Perceived competitive biotechnology position.
c) The high cost of research needed to remain competitive.
d) Industry alliances forcing changing research scope.

Biotechnology.

The debate over this technology having the ability to provide the genetic gains needed to match nutrition and population growth may never be clear. However, one thing is clear,

unless we use this technology effectively, we as a nation or a crop will not be competitive without it. Other crops utilising this technology are providing better management systems and market driven traits that are causing sunflower to become uncompetitive. Safe, well regulated traits such as herbicide tolerance, modified oil profiles, insect and disease tolerance must be incorporated into sunflower's crops portfolio of characteristics if it is to grow and develop. Private research has to date, been the major delivery vehicle of this technology and if predictions are correct will continue to do so.

Molecular Markers. This technology has advanced at a very rapid and very expensive pace in recent times. Five marker systems and their relevant maps have been developed, evaluated and discarded in the past ten years. RAPD, RFLP, AFLP, SSR and SNP's have been evaluated by the private sector in recent times with relatively few commercial products on the market as a result of this technology. However, the focus of this technology is still being defined with utilisation different across the private sector. This technology is being used to incorporate gene recovery, gene position and linkage on the relevant chromosome, trait recovery in conversion programs, background recovery in backcross projects, accelerated breeding focus and fixation. SSR's or micro-satellites seem to be the main marker system now in use in the private sector.

Transformation: Three transgenic targets have been addressed successfully with a commercial outcome possible in sunflower.

i) *Herbicide resistance* (IMI and RR). This research target has been addressed with both mutation and transformation systems and is now in the final stages of evaluation. However, because of the industry concerns regarding the possibility of gene leakage into the wild species and the general GMO concerns in society it is unlikely the transgenic material will be available to the sunflower grower for some time. IMI resistance, sourced from wild species mutants is now available, but will be withheld until product registration and clearance for use of the chemical is provided by Government regulators.

ii) *Insect resistance*. A Bt insect tolerant event has been developed. However, because of the GMO concerns already mentioned and an unlikely financial income apparent, it remains fairly unlikely this trait will be made available to the farming community in the short term.

iii) *Sclerotinia tolerance*. One of the biggest problems sunflower producers around the world share is the fungal disease sclerotinia. It attacks over 350 species of plants and has proved to be the toughest challenge sunflower plant breeders have faced. Natural genetic resistance has not been strong enough to rely on when severe sclerotinia disease pressure exists.

A joint research project involving Advanta (Pacific Seeds), Syngenta and Pioneer targeted this disease, specifically the head rot infection phase. This project has been ongoing for several years and is referred to as OXOX and takes its name from the wheat oxalate oxidase gene that has provided the resistance mechanism not previously available in the sunflower plant. If the promising results continue and the regulatory clearances are forthcoming a far superior natural/transgenic sclerotinia safety net may soon be available to producers. This collaboration has been taking place across several continents throughout the world with a very encouraging level of success.

In trials carried out over the past few years, transgenic lines containing the OXOX genes have demonstrated significantly enhanced sclerotinia tolerance. Even more promising levels of tolerance have been recorded when natural resistance sources are combined with the OXOX resistance genes.

This technology may also help other crops, such as soybeans and canola that also have sclerotinia or similar disease problems, especially those diseases where the fungi produces oxalic acid, the pre-cursor to the sclerotinia fungi's development. The oxalic acid actually breaks down the plant cells by chelating calcium from the host cell walls. This weakens the cell wall thus allowing the fungal enzymes to

further degrade the plant tissue. The oxalate oxidase enzymes provided by these transgenics actually degrade the oxalic acid before it seriously damages the plant tissue.

The focus of ongoing research work is to determine the ability of the gene to enhance the transgenic plant tolerance levels, especially when combined with natural genetic sources of tolerance. This joint research collaboration is breaking new ground in developing this technology and should in the near future, be in a position to provide producers an enhanced tolerance level or protection level, not previously available. However, acceptance of this technology is in a very sensitive evolutionary phase. Markets in Europe are especially cautious about this type of technology and the research partners involved in the various phases of this sensitive process are cautious not to endanger markets that demand GMO free purity. Responsible management of this technology is paramount to the collaborators in the project if this technology is to be utilised effectively. One of the major objectives of any research program whether it be public or private is to develop and deliver products that will benefit the producer and not restrict it's chances of success.

Collaboration Research

Collaborations and alliances between government research programs (exclusive and non-exclusive) and the private sector are growing rapidly. This has been a steady trend that should continue, although this has not been developed to any meaningful commercial level in the sunflower seed sector in Australia.

Alliances between downstream industry, biotechnology IT providers and the seed companies themselves are also becoming more commonplace.

Table 2 : *Summary - Private Company Sunflower Research*

	COMPANY					
Technology.	**Advanta**	**Soltis**	**Syngenta**	**Pioneer**	**Dow AgroSciences**	**Monsanto**
Traditional Breeding	Yes – 9 breeding programs with associated testing in an additional 12 countries	Yes – 5 breeding stations in France and Spain	Yes – 3 breeding programs	Yes – Currently conducted in nine countries	Yes – 4 breeding programs	Yes-8 breeding Programs
Molecular Markers	Yes – Labs in Belgium and Argentina	Yes – characterizatio n and M.A.S.	Yes – Lab in France. Strong direction to mol markers in breeding	Yes – in USA	Yes – Indianapolis Lab	Yes- Labs in France & Argentina
Transformatio n Capability	Yes – Labs in Rilland, Netherlands	Yes – through Biogemma company France	Yes – Lab in USA	Yes – in USA	None so far. System in development	Yes-Labs in St.Louis
Main Targets	Yield potential and stability thought improved drought and disease resistance with modified oil profiles	European market focus. High yield and disease resistance	Yield capacity and stability, disease resistance Modified oil profiles	Yield, oil %age and profile, disease/ pest resistance, agronomic traits	HO Sunflower. Confection Sunflower. Modified Oil profiles. Insect Resistance (Bt)	Yield, Disease resistance & Oil quality

Acknowledgments

Dr Jerry Miller – President of the International Sunflower Association, Fargo, North Dakota, U.S.A

Dr Dominique Perret, Research Leader, Soltis, Toulouse France.

Dr Guillermo Possi – Senior Breeder, Dow AgriSciences, Venado Tuerto, Argentina

Dr Luka Cuk, Principal Breeder, Syngenta Seeds, Toulouse, France

Dr John Soper, Sunflower Research Director, Pioneer Seeds, Johnson, Iowa, U.S.A

Dr Anibal Fernandez, Sunflower Research Director, Belgrano, Argentina.