*Cotton Research and Development Corporation*

# PROJECT 79C

# TRAVEL

# ATTEND AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS SUMMER MEETING

# FINAL REPORT

**Neville Gould**

**Agricultural Engineer**
**Trangie**

## TABLE OF CONTENTS

## EXECUTIVE SUMMARY

In June 1993, Mr Neville Gould, Team Leader, Agricultural Engineering, NSW Agriculture, Trangie travelled to the USA for 30 days to investigate for the Australian cotton industry the following issues :

a) To discuss with researchers and manufacturers of anhydrous ammonia ($NH_3$) application equipment means of improving the current performance of metering systems and associated technology and to pursue potential commercialisation prospects arising out of our research.
b) To present a paper at the American Society of Agricultural Engineers Summer meeting arising from research conducted in Projects DAN55C and DAN59N. This will enable the establishment of contacts with various engineers in related fields.
c) To observe and assess both research and commercial endeavours in the area of cotton stalk pulling, collection, removal, transport, storage and usage of cotton stalk and cotton ginning trash (CGT) for alternative purposes (eg. ethanol fuel, paper).
d) To assess and research and commercial efforts in the area of non-chemical weed control to ascertain the appropriateness of their developments to the Australian cotton industry.
e) To discuss with manufacturer companies the problems of compaction caused by heavy harvesting and cotton picking equipment running on inappropriate wheel spacings and/or tyre sizes.

These issues relate directly to soils, nutrition and tillage, which are the three most important components of cotton production. Successful cotton production depends to a large extent on the way that these three components are managed. Visits were made to the principal contributors to the Australian cotton industry in these areas, either in terms of manufacturing or research.

Engineers within various sections of John Deere and Case IH were visited, with major emphasis being placed on their need to address design criteria suited to Australian conditions rather than USA. Inherent in these discussions was the need to provide equipment to metric specification, which suited the growing numbers of Australian cotton growers who are using permanent bed/minimum tillage production techniques combined with rotation crops. Equipment needed to be robust, flexible and compatible.

Research engineers were also visited at the Universities of California, Davis and Arizona (Tucson) to discuss their latest developments in non-chemical weed control and cotton stalk management respectively. These developments provide considerable potential, especially in improving the environmental effects compared to that offered by the current systems.

The two major providers of anhydrous ammonia application equipment, John Blue and Continental, were also visited. These companies were in stark contrast, with Continental having a strong development program whilst John Blue were keen to remove themselves from this industry to concentrate on the metering and distribution of less hazardous materials.

Additionally a visit was also made to the USDA Cotton and Ginning Mechanisation Centre in Memphis where a substantial amount of information was gained on the alternative uses of cotton ginning trash, ginning technology and other areas of cotton production and processing.

The recommendations from this report are as follows :

**Machinery manufacturing**

1. Contact with the USA engineering resource base be maintained and that funds be provided by both NSW Agriculture (and QDPI) and the Australian cotton industry to allow engineering staff the opportunity to make better use of it. This can not only be done effectively through the visitation of members of this resource base, such as has already been done in other disciplines in recent times, namely cotton agronomy, but by continued funding of overseas travel of Australian staff.

2. Continued pressure be brought to bear by the Australian cotton industry on overseas manufacturers, to endeavour to have them visit local growers and researchers and hence understand more implicitly the needs of Australian cotton growers.

**Anhydrous ammonia**

3. Tests should be conducted on the Continental Vertical Dam Manifold system to verify, under Australian conditions, the improved distribution performance claimed by Continental.

4. Further work is needed to determine whether the use of EVA synplastic Visall-flo™ V-1180 plastic tubing meets Australian Standards and can be used in anhydrous systems.

5. Curves for determining pressure drop from tank line through meter to manifold need to be established for the various meters currently on the Australian market.

6. Distribution properties of the proposed new John Blue cast manifolds need to be established. These new designs included a) swirl plates to generate centrifugal force which it is hoped should reduce the impact of "streaming" and gravity on distribution pattern, and (ii) increase in the depth to diameter ratio of the manifold to increase the possibility of flooding of the manifold outlets, thus reducing the effect of vapour on distribution pattern.

7. Consideration should be given to maintaining the $NH_3$ test facilities at Trangie beyond the period of the current CRDC funded project (ie. June 1994), to allow further testing to continue with Continental $NH_3$ Products, John Blue, Incitec and/or other interested companies or researchers, on a contract or collaborative basis.

8. Consideration should also be given to the joint funding with NSW Agriculture of the overseas visiting scientist on sabbatical, Associate Professor Robert Grisso (University of Nebraska, Lincoln) in the area of anhydrous ammonia application.

**Cotton stalk management**

9. The joint funding with NSW Agriculture of Professor Wayne Coates (University of Arizona, Tucson) on sabbatical, in the area of cotton stalk management, should be considered.

10. The co-ordination of the efforts of both manufacturing and research bodies in producing the appropriate technology for cotton stalk management should be encouraged. Currently, at least three companies are working on producing products to meet this perceived need. It is crucial that this technology be promoted and brought to bear on the industry in an appropriate fashion. The appointment of an advisory engineering position to assist in this process is therefore recommended.

11. Continued research (including economics) to elucidate the role of cotton stalks in sustaining soil fertility, and the potential for cotton ginning trash as a value added product in composting, paper, ethanol etc.

**Weed Control**

12. A field day for current commercial guidance and weeding devices be organised to both demonstrate and compare their effectiveness in cotton. This field day should form part of an overall research program to look at improved methodologies for weed control and should be combined with the work being done elsewhere.

13. Relevant experts in the field of vision control/mechatronics and row crop tillage systems be invited to attend a special meeting to address weed control in row crops (horticultural, cotton and others). This meeting should be held following the International Conference on "Mechatronics and Machine Vision in Practice", which is to be convened by the University of Southern Queensland and held in Brisbane from 13-15 September, 1994. This may include industry funding for Dr David Slaughter to visit Australia for the conference and the subsequent discussions.

14. In the light of the progress by the University of California, Davis in intelligent weed control systems, and the availability of a number of commercial weeding devices as yet untested in cotton, no further research be conducted in Australia in the area of non-chemical weed control.

**ABSTRACT**

In June 1993, Mr Neville Gould, Team Leader, Agricultural Engineering, NSW Agriculture, Trangie travelled to the USA for 30 days to investigate for the Australian cotton industry the issues of anhydrous ammonia application, cotton stalk and ginning trash management, non-chemical weed control, machinery design and soil compaction. Discussions were held with engineers from both John Deere and Case IH, the two machinery manufacturing companies contributing to the Australian cotton industry with the view to increasing their awareness of Australian industry needs. Mr Gould also attended the American Society of Agricultural Engineers (ASAE) Summer Meeting in Spokane, where contacts of substantial future benefit were made and liaison between the ASAE and its Australian counterpart, the Society For Engineering In Agriculture was formally enhanced.

## PROJECT DETAILS

**Project Title :** Travel - Attend American Society of Agricultural Engineers Summer Meeting

**Project No. :** DAN 79C

**Research Organisation :** NSW Agriculture

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## 1.0 Introduction (industry significance)

Soils, nutrition and tillage are important components of cotton production. Successful cotton production depends to a large extent on the way that these three components are managed. In 1989, the Australian Cotton Growers Research Association nominated the major problem of "striping", and the resultant lost production, in cotton crops as an issue requiring agricultural engineering input. The major problem highlighted for initial engineering research was the distribution of nitrogen, in the form of anhydrous ammonia ($NH_3$), in the field. A CRDC funded engineering research project was initiated by the travelling officer on this problem in December, 1990. A technique to measure the mass flow rate of $NH_3$ in current 'gas', 'cold-flo' or 'liquid' systems is being developed in this project. This technique, based on the mass flow rate sensors and suitable for calibrating and monitoring $NH_3$ metering and distribution, will enable easier, more accurate and reliable field application of $NH_3$.

As an ongoing internal investigatory process, the Australian cotton industry, principally through the Australian Cotton Foundation and the CRDC has recently conducted a number of reviews, the most notable being the independent Environmental Audit in 1991. Three principle issues of environmental concern are that of cotton residue (stalk and ginning trash), chemical use and soil compaction. Cotton residue is disposed of primarily through burning, which is considered as a non-sustainable practice. The alternative use of this residue, either as a feedstock for ethanol fuel production, as is currently being investigated through the State Energy R&D Fund by the travelling officer, or for other uses such as a soil ameliorant or for paper, is considered to be a worthwhile venture for maintaining the long-term sustainability of the industry.

The reduced use of chemicals for weed control has always been a strong area of the cotton industry. The common use of manual chipping throughout the season however is becoming increasingly expensive and less expensive and quicker means of weed removal need to be found to assist growers in their move towards lower production costs.

Soil compaction, caused by the use of either excessively heavy and/or inappropriately wheeled equipment, is an on-going issue, both in cotton production and in the production of rotation crops used in the cotton industry. A "Controlled Traffic/Bed Farming" workshop, chaired by the travelling officer, was convened by the CRDC in October, 1992. At this workshop, it was identified that little consideration was given by the (overseas) manufacturers of row crop equipment of the effect of their designs on issues such as soil compaction and field efficiency. It was also argued that a local manufacturing industry may be required to design specific equipment, such as gantries, for Australian farmers to allow them the option of addressing such critical issues in a more sustainable fashion.

## 2.0 Objectives of the proposed visit

a) To discuss with researchers and manufacturers of anhydrous ammonia ($NH_3$) application equipment means of improving the current performance of metering systems and associated technology and to pursue potential commercialisation prospects arising out of our research.

b) To present a paper at the American Society of Agricultural Engineers Summer meeting arising from research conducted in Projects DAN55C and DAN59N. This will enable the establishment of contacts with various engineers in related fields.

c) To observe and assess both research and commercial endeavours in the area of cotton stalk pulling, collection, removal, transport, storage and usage of cotton stalk and cotton ginning trash (CGT) for alternative purposes (eg. ethanol fuel, paper).

d) To assess and research and commercial efforts in the area of non-chemical weed control to ascertain the appropriateness of their developments to the Australian cotton industry.

e) To discuss with manufacturer companies the problems of compaction caused by heavy harvesting and cotton picking equipment running on inappropriate wheel spacings and/or tyre sizes.

## 3.0 Results and discussions

### 3.1 Anhydrous ammonia application equipment

#### 3.1.1 Continental $NH_3$ Products (Dallas, Texas)

Continental are one of the two primary suppliers of anhydrous ammonia application equipment to the Australian cotton, processing tomato and other row crop and broadacre industries. Discussions were held with Messrs David Ward (President), Davin Ward (Vice President), Lincoln Ward and Jim Jones (Chief Design Engineer) at their research facility at London, Texas. A comparative demonstration of their old application manifolds, namely the RPR multiple outlet manifold connected to a RPR single 1" outlet which is the typical situation in Australia, and the newly developed "vertical dam manifold" (VDM) system was conducted. Using their visual collection and display system (they do not have any capacity to verify instantaneous flow) for checking manifold distribution, it was immediately obvious that the VDM manifold is a quantum leap forward in this area of $NH_3$ distribution. Not only did these tests show that the VDM system was capable of distributing (visually) equal amounts of $NH_3$ to the 7 rows tested, it also showed up the overall poor distribution patterns achieved with the current system over a wide range of flow rates.

Videos of these tests were made and, along with technical information and a promotion video developed by Continental, have been sent to Incitec Toowoomba (Mr Chris Dowling), for their consideration with regard importation and sale of this technology to Australian growers. (Sales to at least 50 growers have been made in the USA since their recent release).

Continental were particularly interested in the monitoring and collection system being developed by the AERU in Trangie, the overall research and development program and potential collaboration in the future. They indicated that they were keen to collaborate in further testing and will be sending 6-, 8- and 12-row manifolds to Trangie for testing in the near future. They would be particularly keen to receive comparative data on performance between the RPR system currently used and the new VDM system.

The Continental company are also working on a electronic meter, with capacity for flow control on-the-go, similar to the Dickey-john CCS100 system. They (as does the John Blue Company) uses clear plastic hose for distribution of $NH_3$ from the manifold to the outlets. The supply details for growers in Australia of this product are being organised with the USA parent company, Goodall, and with Incitec.

#### 3.1.2 John Blue Co. (Huntsville, Alabama)

John Blue are one of the two primary suppliers of anhydrous ammonia application equipment to the Australian cotton, processing tomato and other industries. Discussions were held with Mr Ervin West (Vice President, Engineering/OEM and Foreign Sales) with regard the technology being developed in Trangie, their research and development and potential collaboration in the future.

John Blue, who are primarily a pump company (since 1886), would prefer to opt out of anhydrous ammonia equipment. It is only a small part of their overall activity, and yet through product liability insurance costs, is one of their most expensive areas of business. Product liability costs has already meant the demise of a number of hose manufacturers. Indeed, it has also meant that some new developments by small R&D companies eg $NH_3$ monitor developed by Baker Electronics, could not be put on the commercial market. This is of great concern and something that may need to be watched in terms of commercialisation problems with any new technology.

John Blue have found anhydrous ammonia application to be very elusive and without accurate measurement facilities, they have found it difficult to (i) know quantitatively the variation in distribution, and (ii) evaluate any design features.

They have through field testing noticed that they were not able to always repeat tests, indicating changes without and within equipment. This led them to conclude that :

(a) the gas-liquid mixture is not homogeneous either with regard direction change or in terms of flow characteristics with time,
(b) the gas-liquid mixture in low rates (low velocity) is more erratic than at high rates.
(c) plumbing configuration is the most helpful means in eliminating the visual effects of distribution. ie the distribution pattern is acceptable only because they have no accurate means of detecting variation other than by sight.

Distribution can only be accurate with a pressurised-orificed system; gravity flow will have many factors which will effect distribution. The John Blue publication "Guide to Metering Anhydrous Ammonia in Cold Weather" is available for assisting in solving plumbing /distribution problems.

John Blue make the following plumbing recommendations:

(i) Supply line as large as possible, 1-1/4" minimum is recommended. Pressure drop from tank to mater causes formation of gas, changing mixture density.
(ii) Use a meter (regulator) that has a low pressure drop. The John Blue meters have only a 5 psi drop, the smallest in the industry.
(iii) Plumbing from meter to manifold should be large, as straight as possible, and as free from elbow fittings as possible.
(iv) Manifolds should be orificed by means of fittings which should be adjustable to have a pressure drop of between 10 and 15 psi.
(v) All hoses from the manifold to the ground are to of the same length.
(vi) Any excess hose should be coiled horizontally at the manifold, keeping any hose to the ground as straight as possible and running only down.
(vii) Successive shanks (from left to right from the outlet on the ground) should be plumbed at 180° apart at the manifold.

In pursuing some of these recommendations with Mr West, I was not convinced that he had reasons for or even strong convictions about some of them. Plumbing of supply lines with hose larger than 1" diameter is still a contentious issue in Australia, following recommendations by Jim Smith (from Special Crop Systems, Wellington and John Blue distributor). This issue is the subject of current experimentation in CRDC Project No. DAN59N. The reasons for their method of plumbing from the manifold to the ground apparently are based on studies with water. The principles for water flow and anhydrous ammonia flow are NOT the same, especially with regard to the effect of gravity, and so even these simple recommendations need to be considered questionable.

### 3.2 ASAE Meeting - Spokane

Mr Gould attended the American Society for Agricultural Engineers (ASAE) Summer Meeting in Spokane, Washington, USA from June 20-24, 1993. This was a joint meeting with the Canadian Society (CSAE) and was attended by around 1200 engineers from over 20 countries (down on the 2000 engineers which normally attend these functions). It provided an excellent opportunity to pursue a number of issues, none less than the establishment of substantial contacts with eminent engineering researchers. Mr Gould had been given the responsibility by the SEA (Australia) of canvassing the idea of regular visitation of engineering researchers to Australia on sabbatical leave to both conduct their own research but also to raise the profile of agricultural engineering in this country.

Mr Gould has also been given the task of advertising the next SEA conference, to be held in Christchurch New Zealand in August 1994.

Whilst Mr Gould had a paper accepted for presentation at this conference on his anhydrous ammonia research, this paper was withdrawn and nominated for presentation at the World Cotton Research Conference in Brisbane in February, 1994 (Note : The paper "The effect of equipment design on the flow properties of Anhydrous Ammonia" was accepted and presented as a poster paper along with another poster paper on "The use of cotton stalks and cotton ginning trash as feedstocks for ethanol fuel production").

Mr Gould was able to attend various technical committee meetings and meet with many engineers working in various areas of agricultural activity. Of particular note was Associate Professor Robert Grisso from the University of Nebraska-Lincoln, who is the only other known researcher working with anhydrous ammonia application equipment, although not necessarily in cotton. Discussions with him were extremely beneficial and he has since expressed considerable interest in performing a 6 month sabbatical period in Australia with the Agricultural Engineering Research Unit at Trangie. This desire is being pursued by NSW Agriculture at present.

Also of considerable interest was a discussion with Mr Kevin Robertson, Ag Division Manager, Baker Electronic Enterprises, Edmonton, Canada, who recently developed an anhydrous ammonia monitoring device. Upon offering the device to the major companies, he has since declined to sell the device due to exorbitant product liability insurance costs associated with equipment use in the anhydrous ammonia industry. This apparently is a typical USA problem and in recent times a number of companies making anhydrous ammonia hose have ceased manufacture of their range for the same reason.

## 3.3 Cotton stalk and ginning trash management systems

### 3.3.1 University of Arizona, Tucson

Discussions were held with Professor Wayne Coates of the Agricultural and Biosystems Engineering Department on cotton residue management and on collaboration between the ASAE and the SEA (Australia). Professor Coates has been conducting research into the alternative use of cotton residue (principally as an energy source) for two decades. Professor Coates is a senior member of the ASAE Board and has been nominated as the Director of the International Committee which oversees involvement of ASAE members with engineers in other countries. Mr Gould, as a member of the Australian SEA Committee, has been given a similar responsibility in Australia.

Professor Coates (and a co-inventor) have developed and are currently testing a prototype mulching device, called "Pegasus". The device, whose design was prompted due to the high maintenance and energy requirements of the Israeli S. Ben-Dor Automotive Industries Ltd USM machines, also has the capacity to pull, shred, mulch and bury. Further details were unavailable at the time due to patent pending restrictions.

Professor Coates reported on his previous cotton stalk research activities in an article in the Australian Cottongrower Nov-Dec, 1990 pp 66, 67, 69 and 70. He is extremely interested in pursuing a sabbatical in Australia, having realised the benefits of a well devised cotton stalk management system during his previous visits to Australia. This is currently being pursued by NSW Agriculture, with the preferred dates for his stay in Australia being from March to August, 1995 to coincide with the end of the 1994/5 cotton season. It is likely that he may also be visiting Australia again in September following the Conference on Engineering In Agriculture, 1994 in Christchurch, New Zealand.

### 3.3.2 USDA Cotton Ginning and Mechanisation Centre (Memphis, Tennessee)

Discussions were held with Mr William Mayfield, National Program Leader - Cotton, on engineering research issues in the cotton industry, with particular emphasis on the issue of cotton residue management, as well as tillage and compaction, controlled traffic and ammonia application. Whilst he was unaware of any major engineering research in $NH_3$ in cotton in the USA, he has substantial influence in particularly picking and ginning processes and indeed had assisted Ron Jett in establishing the Australian Cotton Ginners Association during his recent visit to Australia.

Mr Mayfield was able to provide a considerable amount of information on the engineering aspects of cotton ginning (especially on the management and potential uses of CGT), which has since been forwarded to Dr Mark Porter at the University of Southern Queensland (given Mark's interest in engineering research in Australian cotton gins). Mr Mayfield was particularly interested in the picking guidelines produced by the Macquarie Valley Cotton Growers Association in 1993, and a copy has been supplied to him.

Considerable discussion was had on the issue of converting cotton stalks and ginning trash (waste) into ethanol and other products. The USA researchers had not considered ethanol as an alternative by-product, but have instead concentrated on its energy value for firing of furnaces for power generation.

As an engineer with considerable respect, both in the professional engineering and cotton disciplines (eg. John Deere sponsor the annual Mayfield Cotton Engineering Award), continued liaison with him is proving to be of considerable benefit. He has already provided contacts and information (videos) with regard no-till cotton in the USA and is willing to assist in locating and encouraging engineers in the USA to take an active interest in the Australian cotton industry. This may prove extremely beneficial in the future, especially if the perceived need by growers for a "Cotton Development Engineer" continues to gain attention.

## 3.4 Non-chemical weed control systems

### 3.4.1 University of California, Davis

Discussions were held with Dr David C. Slaughter, Biological and Agricultural Engineering Department, University of California [Room 3042, Rainier Hall, Rainier Hall Drive, Davis, California 95616-5294 USA; Phone : (916) 752 5553, Fax : (916) 752 2640] on June 22 at the American Society for Agricultural Engineers Summer Meeting in Spokane, Washington and again on June 25 and 28 at UCDavis. On the latter date, we were joined by Lauren Thompson, Industry Development Manager, Australian Processing Tomato Research Council Inc. from Tatura, Victoria.

Their industry funded project on the newly developed "vision cultivator" system was the main topic of discussion. Despite development for the processing tomato industry, this system has application to most, if not all, row crops, as a replacement for hand chipping and other less precise or environmentally unfriendly weed control systems.

This research project is being conducted by Dr Slaughter in cooperation with Messrs Paul Chen, Jim Mehischau, Burt Vannucci, Clay Brooks, Gene Miyao and John Inman from the University of California. The overall goal of this research project was to develop new non-chemical techniques of weed control for California tomato growers. Specifically, this project sought to develop an intelligent machine using advanced machine vision technology, knowledge-based decision theory and robotics to provide non-chemical weed control.

Because of the large number of significant changes in the design of the cultivator the new prototype was not completely operational before the tomato cultivation season ended. UCD were granted a small amount of money by the Integrated Pest Management (IPM) program to try the cultivator in lettuce. In early August they successfully demonstrated the new cultivator on a Yolo clay at Salinas in a lettuce field at speeds up to ten miles per hour. The results from this test were quite good and the cultivator was able to position the cultivation tools within +/-0.3 inches of the desired location 68% of the time and within +/-0.6 inches 95% of the time. The measurements taken for accuracy of the cultivator are taken from the centre of the plant line to the edge of the cultivated strip.

However, other crops such as garlic may be difficult due to the closeness of their row spacing; some lettuce may also cause the same problems. Of the three crops investigated with this system, Dr Slaughter would rate lettuce the easiest to view, followed by cotton and then tomatoes. The ideal situation is found with a plant having a compact structure, round leaves, which is able to be planted to achieve even plant establishment. Some cotton has a shiny, waxy leaf coating and needs a polarising lens on the camera.

According to Dr Slaughter, it will take another 2-3 years to develop the system further, making it more robust. The company which purchases the technology and licence to manufacture will require further research to turn it into a commercial product. Other refinements may be required at the operator interface, camera mounting, manual control etc. Additionally, any vision and electronic technology changes which may enable the system to be improved will need to be investigated.

Dr Slaughter is moving toward a system which will cultivate at very early growth stages, from the cotyledon stage up to the 1-3 true leaf stage (ie. before the plants start to touch and close over the interplant space). With this system, growers will need to plant every 3" in single or double rows. Dr Slaughter may also look at using high pressure water to remove weeds rather than ground engaging tools, but this is not his area of speciality and so may well be left to other researchers.

### 3.4.2 **John Deere Ltd** (East Moline, Illinois and Des Moines and Waterloo, Iowa)

Tours of the Harvester Works and Technical Centre - Moline, the Engine, the Tractor Works and the Technical Centre - Waterloo, the Cotton Picker, Stripper and Planter Works - Des Moines and the Technical Centre were made during the period of Monday June 14 to Friday June 18. John Deere have supplied precision tillage equipment to Australian row crop growers in the past and discussions revolved around their continued development of this equipment, and in particular their potential involvement in the commercialisation of the technology arising from research at the University of California, Davis.

Discussions were held with Glenn Olsen (Ex Manager, Cotton and Tillage Product Planning) initially and later with Marvin Bigbee (Manager, Engineering) and Russell Copley (Senior Division Engineer, Cotton) regarding the John Deere 200 Series Thinners and their plans for weeding systems in the future. Like the Eversman thinners, the 200 Series Thinners have been used by a number of Australian growers to both thin tomato plants and weed the plant line. However, these thinners have ceased being manufactured and it is unlikely that a device of similar function will be manufactured by John Deere again due to their new production philosophy. They have reduced their workforce from 60,000 to 30,000 people within the past two decades with major restructure of production lines meaning that small scale lines such as the thinner were contracted out or taken out of production.

John Deere were interested in the UCD "vision cultivator" technology and sent some of their engineers to investigate its potential. They have delayed further investigation until additional refinements are made to the system to overcome the aforementioned problems. According to Dr Slaughter, the John Deere company are interested in being able to use a non-contact method, and are rumoured to be testing an ultra-sound system.

### 3.4.3 Case IH (East Moline and Hinsdale, Illinois)

Discussions were held with Ingemar Andersson, Chief Engineer, Implement Engineering and Jimmy Kreftmeyer, Project Engineer, Implement Engineering on Friday June 18. Case have very little interest currently in row crop tillage systems. They are aware that a number of other USA manufacturers are using guidance systems for inter-row weed control. Of these, the Buffalo Fleischer, Hiniker and Orthmann all use lateral shift equipment and contact finger sensors.

## 3.5 Soil Compaction and equipment

### 3.5.1 John Deere Ltd (East Moline, Illinois and Des Moines and Waterloo, Iowa)

John Deere, along with Case IH, are the principle suppliers of much of the large equipment used in the Australian cotton industry, namely pickers, tractors, planters and grain harvesting equipment (for rotation crops) and spraying equipment. Discussions centred on the development of equipment to meet Australian farming system and climatic requirements, with primary concern for the use of controlled traffic principles in the design process.

Discussions were initially held on June 14 with Rich Johnson (Principal Scientist, Manager Product Science, Moline) and Jack Wiley (Principal Engineer) at the John Deere Head Office ("Rusty Palace") in Moline. These were then followed by further discussions at the Technical Centre, Moline with Jack Wiley and Lyle Stephens (Product Technology Engineer). These discussions centred mainly on the application of the newly released 60 and 70 series 4WD tractors and the optimisation of their performance both in broadacre and rowcrop conditions. These new tractors have recommended weight splits of 51-55% (front) - 49-45% (rear) [for towed implements] and 55-60% (front) - 45-430% (rear) [hitch mounted implemented], compared to around 62% over the front axle in older models. John Deere stipulate preferably that no liquid fill is required in the tyres (40% fill at maximum) and that no additional equipment (eg tanks) be carried on the tractor frame (this may lead to axle breakages). Cast iron wheel weights however could be added. These tractors are fitted with radials (see below for details), with 20.8R x 42 tyres being the most common tractor tyre in the USA now. The use of radial tyres has grown considerably in recent times as a result of action by the Tyre and Rim Association to ensure closer tolerances on the knurling of the tyre rims by the manufacturers. This deletes tyre slip on the rim, a common complaint with earlier designs. The next objective is to eliminate tubes altogether.

Another major breakthrough in tyre manufacturer has been the ability to use tyres under full power at low inflation pressures. John Deere have worked very closely with the Tyre and Rim Association and are recommending tyre inflation pressures as low as 6 psi. They have done considerable research into the effect of radial tyre inflation pressure on compaction, especially in relation to the comparative effects by rubber tracks. This research has been conducted mainly by Randall K. Wood (Extension Agricultural Engineer) from Ohio State University, and a close working relationship has also been established with James Nagorka, from Waltanna Tractors, Australia.

These engineers gave an assurance that these tractors were designed with Australian row crop farmers in mind, and as a majority of their development was performed in Arizona, the conditions for use should approximate the extremes of Australian conditions. Yet upon closer study of the technical detail of the tractors, some severe shortcomings soon became apparent. These problems were most evident in the area of wheel spacings which were sometimes inappropriate for our most common 1 metre row spacings, especially in the dual formation, as the following information shows.

| | | | |
|---|---|---|---|
| eg. | 18.4R x 42(46) duals | Inner tread spacings | 1453 - 1910 mm |
| | | Outer tread spacings | 2891 - 3348 mm |

Other wheel sizes however could accommodate the required spacings for 1 metre beds.

Considerable time was then spent in detailing the development of row crop systems in Australia, and particularly the increasing popularity of the wide (2 metre) bed system. In the above example, neither the 2 or 4 metre spacings needed for this system could be accommodated. The John Deere engineers were again encouraged to produce machines in metric configuration for Australian conditions (as Case IH are now doing with the 9250 tractor - see below) and also, when visiting Australia, were encouraged to meet with farmers and other engineering groups outside their own company.

It was also suggested that Australian row cropping power needs were reducing slowly through the introduction of permanent beds and that the power range of the 60 and 70 series 4WD's was therefore too large. Whilst John Deere suggested that a 200 hp 4WD was likely in the near future, even smaller tractors were not being considered and therefore would need to rely on tractors within the MFWD series. Additionally their irrigation systems were slightly different in most cases than those used in Australia with only 2.5" syphons being used. This meant that every furrow at the head ditch end of the field was "rotobucked", making turning at the head ditch end even more difficult. This was given as a reason for the move towards articulated tractors.

On June 14, further discussions were held with Glenn Olsen (Ex Manager, Cotton and Tillage Product Planning) initially and then later with Jerry Griffith (Product Support Representative - Cotton), Marvin Bigbee (Manager, Engineering), Russell Copley (Senior Division Engineer, Cotton) and Tim Deutsch (Project Engineer, Cotton Harvesters) at the John Deere Des Moines Works on issues relating to alternative traction systems, cotton pickers, cotton planters and ground based spraying. Correspondence with various members of this group, particularly Russell Copley had been carried out prior to this meeting. John Deere suggested that it was company policy now that their engineers visit Australia to address Australian needs in their machinery design. Russell Copley had indeed visited Australia on a number of occasions but never south of Moree, which is where compaction related issues initially received the most attention by researchers and growers. The engineers were therefore encouraged to travel further south on their next visit and talk to wider range of farmers and researchers.

In relation to compaction caused by cotton pickers, John Deere had been attempting to address this in their latest designs. However, any attempts to modify the pickers to reduce weight were offset by requirements by growers for increased capacity, especially in storage due to longer runs and higher yielding crops. When discussing the idea of on-board densification of the cotton, John Deere felt that this was not a reality in light of weight restrictions and therefore would rather see systems developed off-picker, such as the module builders.

John Deere had attempted to address this problem of compaction through the introduction of the concept they have called the "Unit Tractor", but which we would refer to as the "gantry". The philosophy behind this idea is correct and will remain so, both in relation to reducing or isolating the effect of wheel track compaction from the crop growth zone. However, despite a number of attempts over the past decade to develop ideas in this area, the USA farmers were not reacting positively due the perception that it was too easy to obtain and use the current tractor based systems.

John Deere have also released recently in the USA their 6500 series high clearance ground based spray rig. John Deere USA had perceived little need for this machine in Australia given information that they had received from their Australian marketing people. Aerial application was believed to be the means by which most Australians would continue to apply chemicals to crops. However, following discussion on the CRDC funding of the Mason Hyspray project, the continued pressure following the Environmental Audit to reduce the impact of spray drift, especially close to rivers and towns and through the increasing area of dryland cotton, they may in fact consider its availability in Australia.

Planting of cotton was performed in a different manner in the USA with "solid plant", rather than "drop plant" being the conventional method. The John Deere vacuum planter system was considered to be a major step forward in planting technology, due to its ability to plant more accurately over a wider operating speed range. However, Australian farmers had first to realise the importance of the planting operation to the overall success or failure of their crop before they would be willing to pay for any improvement in planting technology. John Deere USA would request their Australian marketing people to address this issue.

### 3.5.2 Case IH (East Moline and Hinsdale, Illinois)

Discussions were held in East Moline with Monroe Barrett (Project Engineer - Crop Harvesting), Kevin Johnson (Senior Project Engineer - Cotton and Combine Test and Development) and Donald Olmsted (Chief Engineer - Current Combine and Header Engineering) following a tour of their picker, stripper and tillage manufacturing plant. Discussions were also held in Hinsdale with Rich McMillen (Chief Engineer - Combine Development), Kevin Richman (Manager, Cotton Equipment Engineering), Mike Covington (Senior Project Engineer, Crop Harvesting Equipment) and Neil Thedford (Project Engineer - Cotton Development Engineering) following a tour of their Technical Centre.

Case IH have reduced their workforce from 60,000 to 30,000 people within the past two decades with major restructure of production lines meaning that small scale lines such as the thinner were contracted out or taken out of production.

Discussion centred (essentially as with John Deere) on the development of equipment (namely pickers, tractors, planters and grain harvesting equipment (for rotation crops) and spraying equipment) to meet Australian farming system and climatic requirements, with primary concern for the use of controlled traffic principles in the design process.

Case IH have made considerable efforts to improve their pickers in recent times. The addition of the new "Navigator Guidance system" (as with the John Deere pickers but with a different mounting arrangement) added tremendous advantages in increasing picking efficiency. In the same mould was the "Doff-clean" urethane doffer. They are continuing to work on a new picking head, but were quick to point out that the spindle picker design was patented in 1898 and no major inroads into other (lighter and less costly) systems had been made since then despite considerable effort. They also are looking at other changes to their pickers including a new distribution system and a wider unloading door for unloading cotton into module builders from pickers fitted with duals.

With the introduction of new field layouts, away from the most commonly used 38" rows, Case IH have been forced to also look at tyre systems. They now are offering a log skidder tyre (24.5 - 32) on the 2055 pickers. They have experienced "rocking" problems when using standard radials on pickers, and so have moved to also fit a special R1.5 category tyre to their pickers, using a special rim.
A Pirelli/Armstrong (R2 category) radial with an inflation pressure of 55 psi has also been considered. The option of mounting duals has also been considered, along with increasing ply ratings and lowering inflation pressures. Increasing tyre diameter from the standard 38" to 42", to increase the contact length, is also being tried.

Case IH have been collaborating with researchers at Clemson University, South Carolina who are looking at new traffic control systems, involving 5 row arrangements on wide beds with alternating row spacings (36", 3x30", 36"). This system requires a 96" wheel spacing (normally 90" for standard 5 row arrangement). Even 5 row 40" is being considered.

Very little discussion was forthcoming on tractors as most expertise on this topic was located at Fargo, North Dakota. Mention of the need to get metric with Australian models was made and it is pleasing to note that the newly released 9250 articulated row crop tractor is fitted with special row crop tyres

designed for Australian conditions with exact one metre row spacings. The "QuadTrac" is still in prototype form. Due to expected exorbitant manufacturing costs associated with this interesting design, involving a track on each corner of an articulated 4WD (4 idlers between each of the bottom corner idlers with the drive at the apex), it is perceived that it may never be made available commercially or, at best, not in the next 4-5 years.

Case IH have no interest in spraying equipment and suggested that Texas A&M University were the experts on this subject.

## 4.0 Conclusions, Recommendations and Application to Industry

### 4.1 Introduction

The USA cotton industry has at its disposal an incredible resource base. This base is widespread being contained within the University and Government systems as well as in private companies. A major bonus over the Australian agricultural industry is the presence of some of the major manufacturing companies who are able to provide new technology appropriated to local conditions.

The engineering sector of the USA resource base covers a much larger sector of the industry than what our Australian engineering resource could ever hope to cover. It is therefore absolutely essential that contact with this engineering resource base be maintained and that funds be provided by both NSW Agriculture (and QDPI) and the Australian cotton industry to allow engineering staff the opportunity to make better use of it. This can not only be done effectively through the visitation of members of this resource base, such as has already been done in other disciplines in recent times, namely cotton agronomy, but by continued funding of overseas travel of Australian staff.

There is still a continuing requirement to put pressure on the large manufacturing companies, who have only marketing personnel essentially based in Australia, to have their R&D personnel frequent the production areas and associated R&D facilities in this country. For the first time for many years it is obvious that a distinctly different design philosophy is developing between the two major USA manufacturing companies, John Deere and Case IH. Clear choices are now being offered in the area of grain harvesting (cleaning mechanisms), planting (seed delivery systems), cotton picking (head design) and potentially with tractor design.

Only in applying this pressure will Australian growers begin to see technology offered that better suits Australian production conditions rather than the conditions of the country or region of manufacture. The latest tractor release by Case IH of its 9250 Row Crop Special stands as testimony to the fact that they are willing to listen.

### 4.2 Anhydrous ammonia

The Continental company have a large and long-term investment in anhydrous ammonia and hence have devoted a deal of time and effort to research and development. This has resulted in the new VDM manifold. However, much of their analysis of results is visually based and it therefore felt that there is considerable scope for collaboration in the future as suggested below :

(i) Tests should be conducted on the VDM manifold system to verify, under Australian conditions, the improved distribution performance claimed by Continental .

(ii) Further work is needed to determine whether the use of EVA synplastic Visall-flo™ V-1180 plastic tubing meets Australian Standards and can be used in anhydrous systems .

On the other hand, the overall impression of the John Blue Company was one of dismay. Their design engineer responsible for the current metering technology (which has not changed substantially since the 1950's) has since retired, with no records left of the design criteria used in the establishment of this metering technology. Their future involvement in the $NH_3$ industry will essentially be in maintaining the status quo, given the cost of public liability insurance. There is however some opportunity to perform contract research and development work for them and this was discussed with Mr West. This is likely to be in the following areas :

(i) establishment of curves for determining pressure drop from tank line through meter to manifold.

(ii) establishment of distribution properties of new cast manifolds. Preliminary designs were made with Mr West following discussions about problems with current manifold design. These new designs included a) swirl plates to generate centrifugal force which it is hoped should reduce the impact of "streaming" and gravity on distribution pattern, and (ii) increase in the depth to diameter ratio of the manifold to increase the possibility of flooding of the manifold outlets, thus reducing the effect of vapour on distribution pattern.

It is therefore recommended that consideration be given to maintaining the $NH_3$ test facilities at Trangie beyond the period of the current CRDC funded project (ie. June 1994), to allow further testing to continue with Continental $NH_3$ Products, John Blue, Incitec and/or other interested companies or researchers, on a contract or collaborative basis.

Consideration should also be given to the joint funding with NSW Agriculture of the overseas visiting scientist on sabbatical, Associate Professor Robert Grisso (University of Nebraska, Lincoln) in the area of anhydrous ammonia application.

### 4.3 Cotton stalk management

The issue of cotton stalk management is of critical importance to the continued sustainability of the Australian cotton industry. The collaborative approach currently being shown towards assessing the value of cotton stalks, both in terms of nutrients and as a source of organic matter, is to be commended. Current options for Australian growers are tending towards incorporation rather than collection and conversion and the appropriate machinery still remains as the missing link. Whilst the USA cotton stalk management systems differ substantially from the Australian current or proposed systems, due their different insect control strategies and farming practices, some of their engineering developments may still have something to offer to the Australian industry.

Consideration should therefore be given to :

(i) the joint funding with NSW Agriculture of the overseas visiting scientist on sabbatical, Professor Wayne Coates (University of Arizona, Tucson) in the areas of cotton stalk management.

(ii) the co-ordination of the efforts of both manufacturing and research bodies in producing the appropriate technology. Currently, at least three companies are working on producing products will meet this perceived need. It is crucial that this technology be promoted and brought to bear on the industry in an appropriate fashion. The appointment of an advisory engineering position to assist in this process is therefore recommended.

(iii) continued research (including economic) to elucidate the role of cotton stalks in sustaining soil fertility, and potentially in cotton ginning trash as a value added product.

### 4.4 Weed Control

The removal of weeds by non chemical means from cotton crops is addressed as a high priority due to the need to :

* to protect the crops against pests while reducing chemical dependence (objective 1), including the development of practical low cost and flexible integrated weed control plans and systems for the different growing areas, with early attention being given to the control of nut grass,
* to develop and promote the adoption of environmentally sound, sustainable farming practices (objective 2) aimed at reducing costs of production and/or increasing the quality and value of production and at developing new "non-chemical" methods of pest management.

The "vision cultivator" system being developed by UCD addresses these priority areas. Whilst it is perhaps the most sophisticated of the proposed new technology weeding systems and offers considerable potential, their are some serious drawbacks to be considered.

Of major concern is the fact that the vision cultivator is not a complete system for weed removal but rather a guidance system. It therefore may only be as good as the toolbar it is fitted to, as it does not address the issue of what is the ideal manner of removing weeds which are very close to young cotton plants. Whilst the system appears to accurately follow the plant line at high speeds in California, tillage tools (discs placed 20-30 mm in the soil) through their method of action will impart a high degree of sideways load on the soil in the direction of the cotton plant, most likely shearing off young cotton root systems. This occurrence will be exacerbated on some of our cotton growing soils due to their tendency to crust.

It's real potential will be realised if it were to be combined with other such management or tooling systems. For example, if the method for Metham Sodium fumigation is further perfected by the officers of the Department of Agriculture at Tatura and by the University of California (see World Cotton Conference paper 180), then there is tremendous potential to use a narrow (100 mm instead of the 300 mm used currently) strip of metham sodium to control weeds in and immediately adjacent to the plant line. Weeds in the inter-row space can then be controlled precisely and at high speed using the "vision cultivator" system. Tillage, chemical or other forms of weed removal, such as the Truetrack Row Guidance system, could be used to perform this operation. Through this approach, costs are reduced and speed, accuracy and flexibility in weed removal are retained or increased. It is unlikely that the major manufacturers, such as John Deere or Case IH, will develop their own technology in this area and so much is dependent upon institutions such as UCDavis, and other specialist companies such as Automatic Equipment Inc. to develop this specialist equipment.

Research is also being performed by engineers at the University of Southern Queensland for the cotton industry into tractor guidance systems. It is understood that a similar technology to the "vision cultivator" is being used to guide the machine not only in a straight line but in exactly the same line as previous passes made for the performance of other operations, such as planting. If this Queensland system is perfected it may either prove the "vision cultivator" system to be unnecessary, or it may be combined with it to form a more comprehensive machinery guidance package.

Of major importance in the quest for grower acceptance will be the cost of purchase and the complexity of its maintenance and operation in comparison to current or other proposed systems. Whilst the overall expense of "tooling-up" with such a system may at first appear great, its cost relative to the benefits is potentially very small.

It is therefore recommended that :

(i) a field day for current commercial guidance and weeding devices be organised to both demonstrate and compare their effectiveness in cotton. This field day should form part of an overall research program to look at improved methodologies for weed control and should be combined with the work being done elsewhere.

(ii) relevant experts in the field of vision control/mechatronics and row crop tillage systems be invited to attend a special meeting to address weed control in row crops (horticultural, cotton and others). This meeting should be held following the International Conference on "Mechatronics and Machine Vision in Practice", which is to be convened by the University of Southern Queensland and held in Brisbane from 13-15 September, 1994. This may include industry funding for Dr Slaughter to visit Australia for the conference and the subsequent discussions.

(iii) in the light of the progress by the University of California, Davis in this highly technical and exciting area, and the availability of a number of commercial weeding devices as yet untested in cotton, no further research be conducted in Australia in the area of non-chemical weed control.

## 5.0 Communication of Results

Presentations have been made at the CRDC Soils Co-ordination Meeting (December 8-9, 1993) on the issues of "Traffic and Furrows" and "Cotton Stalk Management". An article was also written for the September-October, 1993 issue of the Australian Cottongrower on cotton stalk management options. A visit to most of the members of the ACGRA Soils, Nutrition and Tillage committee was made in early December, 1993 to communicate findings from the study tour as well as from on-going research.

Further, an article is currently being drafted for "The Land" on developments and differences in various makes and models of tractors. This article will also appear in more detailed form in the nest issue of "The Australian Cottongrower" along with an article on "striping". Poster papers were also presented at the 1st World Cotton Research Conference on "The effect of equipment design on the flow properties of Anhydrous Ammonia" and "The use of cotton stalks and cotton ginning trash as feedstocks for ethanol fuel production". Presentations of the anhydrous ammonia poster will also be made at the Bourke cotton field day (March 11) and the Macquarie Valley cotton field day (March 17).

Appendix (i) Budget

| Funding Organisation | Stores | Travel | Total |
|---|---|---|---|
| Horticultural R&D Corp - Project TM301 | $100 | $1776 | $1876 |
| Cotton R&D Corp - Project DAN79C | $100 | $3402 | $3502 |
| Total | $200 | $5178 | $5378 |

## Appendix (ii) Royalty and Intellectual Property Arrangements

**NOTE : Discussions with Dr David Slaughter of University of California-Davis (UCD), with regard the "Vision Cultivator", were bound within the confines of a "Secrecy Agreement" due to a request by UCD lawyers to refrain from discussing technical details of the system whilst undergoing patent application and additional law suits.** Further technical information on the system are available upon request and signing of the "Secrecy Agreement".

**Appendix (iii) Further Supporting Data**

*(a) Latest Developments in Non-Chemical Weed Control Research at UCDavis*

The UCDavis experimental vision guided cultivator was tested in cotton fields at the West Side Field Station on May 19, 1993. The trials were set up on 40" beds which were approximately 200 feet in length. The furrow bottoms and the edges of the beds had been previously cultivated, leaving a 12" strip along the centre of each bed in its natural uncultivated state. At the time of cultivation, the cotton plants were at the two true leaf stage and were planted about three inches apart. Four replicate tests were conducted on randomly selected rows of cotton. For all four tests the tractor was operated at a constant speed of 5 mph. The vision guided cultivator was equipped with an "Alloway type" pair of cultivation discs. These discs were adjusted to be 2" apart at the point of soil entry. Prior to each test run the number of weed plants present on each bed was counted. The vision guided cultivator was then used to cultivate each bed. After each run the number of uncultivated weeds remaining were counted. The uncultivated weeds were segregated into two categories, those in the seedline and those outside the seedline. A weed was judged to be in the seedline if it could be removed by a cultivator disc without also removing cotton plants in the seedline as well. Steering accuracy evaluations were conducted by measuring the width of the uncultivated bed from the seedline to the right edge. These measurements were recorded every eight feet along the row. If the cultivator was guided perfectly, the distance between the seedline and the right edge should be one inch. The results of these tests are shown in Tables 1 and 2 below.

Table 1. Weed Control Results

| Trial | Before | | | After | |
|---|---|---|---|---|---|
| | Total Weeds (Counts) | Weeds In Seedline (%) | Weeds Outside Seedline (%) | Weeds Outside Seedline (%) | Cotton Plants Killed (Count) |
| 1 | 464 | 17.2 | 82.8 | 79.2 | None |
| 2 | 492 | 14.2 | 85.8 | 89.0 | None |
| 3 | 558 | 11.5 | 88.5 | 87.8 | None |
| 4 | 343 | 33.5 | 66.5 | 90.4 | None |
| Ave. | 464 | 19.1 | 80.9 | 86.6 | None |

The results show that the vision guided cultivator removed about 86% of the weeds outside the seedline and killed no cotton plants at a ground speed of 5 mph. The steering of the cultivator was very accurate, with the cultivation discs located within +/- 0.23 inches 68% of the time, and never coming less than 0.5 inches or more than 1.5 inches from the seedline.

Table 2. Steering Accuracy Results

| Trial | Distance from Centre of Cultivator to Seedline | | Distance from Cultivator Disc to Crop | |
|---|---|---|---|---|
| | Average (inches) | Standard Deviation (inches) | Minimum (inches) | Maximum (inches) |
| 1 | 0.09 to left | 0.19 | 0.5 | 1.5 |
| 2 | 0.01 to left | 0.19 | 0.5 | 1.5 |
| 3 | 0.18 to right | 0.28 | 0.5 | 1.5 |
| 4 | 0.11 to right | 0.24 | 0.5 | 1.5 |
| Ave. | 0.05 to right | 0.23 | 0.5 | 1.5 |