

DANSA

**RESEARCH PROGRAM REPORT**

**FOR**

**NEW ANHYDROUS AMMONIA**

**DISTRIBUTOR**

**1989-1996**

## *Anhydrous ammonia distribution : laboratory and field verification experiments*

### Background

In answer to a request in 1989 by the (then) Regional Director of Research, Trangie, for engineering research project ideas, the Australian Cotton Growers Research Association nominated a major problem of "striping" and the resultant lost production in cotton crops. "Striping" is manifested as a growth disorder/discolouration within cotton rows.

"Striping" was thought to be caused by either or both of the following two factors :

- (i) soil compaction (or other damage)
- (ii) poor anhydrous ammonia metering and/or distribution and/or application to the soil.

"Striping" due to compaction was seen to be very regular in the field (ie. confined mainly to the central trafficked rows of each pass) and as such was easily detected and separated from "striping" due to (ii), which was seen to be more widely distributed across each pass and more irregular within passes and fields. Whilst the attributed causes of "striping" are many, the major problem highlighted for initial engineering research input was the distribution of anhydrous ammonia ( $\text{NH}_3$ ) in the field.

Discussions with local cotton growers and with Incitec (the sole manufacturers of  $\text{NH}_3$  in Australia) continued to support the belief that anhydrous metering and distribution equipment was inaccurate (up to 30% too high at high rates of application had been reported on a number of occasions on recently calibrated meters). Clear evidence was also visible of "striping", particularly in the Macquarie Valley, NSW. Unfortunately, attempts by the parent companies (eg. John Blue and Continental) in the USA to overcome these problems have not been successful.

The ultimate goal for the Agricultural Engineering Research Unit, based at Trangie ARC, was to ensure an adequate but not excessive supply of anhydrous ammonia ( $\text{NH}_3$ ) to the crop in conditions which allow full utilisation by the crop. By so doing, this would either reduce or eliminate the presence of "striping" in cotton. To achieve this, a research program was initiated in 1989, with the specific aim to :

- (i) determine the level and cause of variability in  $\text{NH}_3$  flow and distribution from the outlets of rigs, and
- (ii) modify the  $\text{NH}_3$  application systems to ensure even flow and distribution.

since 1989 to address the area of distribution and B) have compared 10 different metering and metering systems fitted with their commercial metering systems fitted with a range of prototypes used during the previous experimental phase (see

on systems was set-up to simulate a conventional test set-up. Each of the 8 hoses emanating from the manifold drums (specifically designed for these tests) were fitted with a flow meter. The flow rate for each hose from measurements of the pressure drop caused by the flow of anhydrous ammonia

at a flow rate of 2000 lbs/hr NH<sub>3</sub> for a period of 60 seconds. The prototypes were compared to the standard Continental test set-up for a period of 120 seconds, consisting of 2 tests. Each treatment was replicated 2 times using a manifold B compared other new prototypes, against the standard run being replicated 3 times on this occasion

collected and analysed for variation between outlets for each application system. The results are shown in

"C" developed as part of this research program proved to be more consistent. These laboratory experiments conducted (coefficient of variation) of flow from the 8 manifold outlets, compared to around 15-20% from the Continental and John Blue.

## **Experimental methodology**

### **Laboratory experiments**

#### **Aim**

A number of laboratory experiments have been run since 1989 to address the area of distribution variation. Of these experiments, the latest two (A and B) have compared 10 different metering and distribution systems, compiled of current commercial metering systems fitted with their commercial distribution/manifolds systems and the same metering systems fitted with a range of prototype manifold distributors or other attachments developed during the previous experimental phase (see Table 1).

#### **Materials and methods**

The anhydrous ammonia metering and distribution systems was set-up to simulate a conventional 8-row system. The anhydrous ammonia distributed down each of the 8 hoses emanating from the manifolds was collected in individual collection drums (specifically designed for these experiments). The flow rate could then be determined for each hose from measurements of the height increase in the water level in each drum (mm) caused by the flow of anhydrous ammonia during a 60 second interval.

These different combinations were tested at a flow rate of 2000 lbs/hr NH<sub>3</sub> for a period of 60 seconds. In experiment A, a number of new prototypes were compared to the standard Continental and John Blue setups. Each treatment was tested for a period of 120 seconds, consisting of 2 separate 60 second runs performed contiguously. Each treatment was replicated 2 times using a fully randomised experimental design. Experiment B compared other new prototypes against the standard Continental and John Blue setups, each run being replicated 3 times on this occasion using a fully randomised experimental design.

Data from these 2 experiments were then combined and analysed for variation between outlets for each run for the various treatments. The flow rates were analysed using a General Linear Models procedure where comparisons were made of the coefficients of variation. The results were then compared to show the level of variation across each application system. The results are shown in column 3 of Table 1.

#### **Results and discussion**

The prototype manifold distribution device "C" developed as part of this research program proved to be the most successful during laboratory experiments. These laboratory experiments conducted at Trangie found that variation (measured as coefficient of variation) of flow from the 8 manifold outlets was less than 5% of the mean distributed flow, compared to around 15-20% from the current commercial manifolds offered by Continental and John Blue.

any of the passes performed with the new manifold. There was also less variation (significant at  $P < 0.1$ ) in row yield within each pass when the new manifold was used (5.39% vs 5.96%) again suggesting that crop growth was more even within each pass of the new manifold as a result of more even nitrogen application.

### Discussion

The inability to manage for timeliness and other factors in these two experiments may well have overridden any yield advantages which may have accrued due to the use of the new distributor. It was clear from observations at defoliation and picking at the Trangie site that the areas which had anhydrous ammonia applied with the new distributor were later and more even in growth and colour and contained more green leaf and bolls.

This effect was also observed at the Bourke site but in areas outside the experimental plot. In addition to the experimental plot, the new manifold was also used to apply anhydrous ammonia to over 1000 acres of a total area of 5000 acres sown to cotton on this property, requiring 72 hours of use in the field. This area was the only area on the property (outside the experimental area) which did not show "striping". The areas where the current commercial system required subsequent treatment with water-run urea.

### Conclusions

Both experiments provide positive indications that improved distribution performance can be achieved with the new distributor. This is provided both by the lack of "striping" and the reduced yield variation within treatment passes. Whilst overall yields and yield variations were not significantly different from each other, the data suggests that there may be yield advantages and that there is potentially large savings to be realised through less management and additional nitrogen requirements.

Table 1 : Details of the various metering and distribution systems and their relative distribution variation

Treatment No	Description	Mean Coefficient of Variation(%) <sup>*</sup>	T-test grouping <sup>*</sup>
1	John Blue A-3910 Nitrolator fitted with John Blue manifold, linked by a 500 mm long x 25 mm ID vertical stainless steel tube	28.93	A
2	John Blue A-3910 Nitrolator fitted with John Blue manifold	21.74	B
3	Continental Metermatic C-4100 fitted with the multiple outlet C-4100 RPR manifold	15.92	C
4	Continental Metermatic C-4100 fitted with an 8 outlet prototype manifold "B" linked via the C-4103 single 1" outlet and 90 degree elbow by a 500 mm long x 25 mm ID vertical stainless steel tube	11.00	D
5	Continental Metermatic C-4100 fitted with an 8 outlet prototype manifold "A"	9.24	E
6	John Blue A-3910 Nitrolator fitted with an 8 outlet prototype manifold "A"	8.88	E
7	John Blue A-3910 Nitrolator fitted with an 8 outlet prototype manifold "A" linked by a 500 mm long x 25 mm ID vertical stainless steel tube	7.22	F
8	Continental Metermatic C-4100 fitted with an 8 outlet manifold "A" linked via the C-4103 single 1" single outlet and 90 degree elbow by a 500 mm long x 25 mm ID vertical stainless steel tube	5.35	G
9	John Blue A-3910 Nitrolator fitted with an 8 outlet prototype manifold "C"	4.42	G
10	John Blue A-3910 Nitrolator fitted with an 8 outlet prototype manifold "C" linked by a 500 mm long x 25 mm ID vertical stainless steel tube	3.55	H

\* Means with the same letter are not significantly different, lsd (0.05) = 0.011

Table 2 : Seed cotton yields (t/ha) at Darling Farms, Bourke

	Seed Cotton Yield (t/ha)	Seed Cotton Yield (t/ha)	Seed Cotton Yield (t/ha)	Seed Cotton Yield (t/ha)	Seed Cotton Yield (t/ha)	Seed Cotton Yield (t/ha)	Seed Cotton Yield (t/ha)	Seed Cotton Yield (t/ha)	Seed Cotton Yield (t/ha)	Seed Cotton Yield (t/ha)	Seed Cotton Yield (t/ha)	Seed Cotton Yield (t/ha)	Seed Cotton Yield (t/ha)	Seed Cotton Yield (t/ha)	Seed Cotton Yield (t/ha)	Seed Cotton Yield (t/ha)	Seed Cotton Yield (t/ha)	Seed Cotton Yield (t/ha)
Manifold type	RPR	RPR	RPR	NEW	NEW	NEW	RPR	RPR	RPR	NEW	NEW	NEW	RPR	RPR	RPR	NEW	NEW	NEW
Nitrogen rate (g N/ha)	100	100	100	100	100	100	150	150	150	150	150	150	200	200	200	200	200	200
Rep No	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Row 1	6.175	6	*	5.95	5.675	*	6.325	6.238	*	6.538	6.588	*	6.45	5.55	*	6.225	5.788	*
Row 2	6.05	5.863	*	6	5.925	*	6.463	6.025	*	6.075	6.163	*	6.675	6.788	*	6.513	5.988	*
Row 3	5.988	5.525	*	6.525	6.05	*	6.913	6.154	*	6.321	6.375	*	6.575	6.388	*	6.525	6.238	*
Row 4	5.788	5.488	*	6.013	5.55	*	6.788	6.462	*	6.154	5.85	*	6.3	6.175	*	6.688	5.975	*
Row 5	6.563	5.45	*	5.888	5.725	*	6.763	6.363	*	6.35	6.375	*	6.038	5.875	*	6.55	5.788	*
Row 6	6.563	5.013	*	6.588	6.15	*	6.813	7.419	*	6.838	6.4	*	6.213	6.4	*	6.35	6.175	*
Row 7	6.425	5.488	*	6.188	5.938	*	6.3	5.65	*	6.158	6.013	*	6.388	6.125	*	6.55	5.675	*
Row 8	5.35	5.275	*	6.188	5.713	*	6.363	6.038	*	6.313	5.75	*	6.525	5.475	*	6.25	6.375	*
Mean (reps)	6.113	5.513	*	6.167	5.841	*	6.591	6.293	*	6.343	6.189	*	6.395	6.097	*	6.456	6	*
Mean (all)			5.813			6.004			6.442			6.266			6.246			6.228
Mean (manifold)		RPR	6.167		NEW	6.166												
Variation (CV)		RPR	5.84%		NEW	3.85%												
= missing data due to heavy rain during picking																		



**PROPOSED RESEARCH PROGRAM**

**FOR**

**NEW ANHYDROUS AMMONIA**

**DISTRIBUTOR**

**1996-1998**

## Introduction

The enclosed research report details the results of laboratory and field experiments to May 1996. These experiments show clearly that the new distributor has significant potential in alleviating the distribution problems associated with current anhydrous ammonia distribution systems. However, these experiments have only addressed just a few of the potential scenarios likely to arise in commercial use of the distributor in Australia and overseas.

The following experimental schedule provides detail on the research believed to be required by the researchers to fully evaluate the potential of this new distributor.

## Experimental aims

- To assess the performance of the distributor across a wide range of flow rates and tank pressures with both conventional gas and cold-flo product.*

The new distributor has only been assessed in conjunction with the Continental C-4100 meter in the field and the John Blue Nitrolator in the laboratory. Additionally cold-flo systems have only been used in conjunction with the new distributor in the field under a limited range of flow and tank pressure conditions.
- To assess the performance of the distributor in conjunction with a range of metering devices (ie. controllers).*

Current controller systems for metering anhydrous ammonia in Australia and USA (eg Dickey John, Raven, Microtrak) use the distribution manifolds from other manufacturers eg Continental or John Blue. The rapid adoption of these systems necessitates the testing of the new distributor in conjunction with these metering systems to ensure the widest possible adoption of the technology.
- To develop an effective distribution and measurement system for broadacre agricultural equipment requiring secondary distribution systems.*

The current experimental work has been primarily directed at the Australian irrigated cotton industry. Considerable potential exists for use of the new distributor in other cropping enterprises, namely other row crops (particularly maize in the USA) and in broadacre crops (particularly wheat in Australia).
- To assess the potential for measurement of mass flow.*

With the introduction of controller systems, the determination of instantaneous mass flow rate became possible. However, regulator system (eg Continental and John Blue) which are predominant in Australia do not provide this facility. On-field application rates are therefore difficult to determine. In an atmosphere of stronger environmental protection, the issue of accurate application rates becomes paramount.
- To assess the potential for the determination of differential flow in distributor lines.*

Even with accurate metering and distribution now potentially available the issue of differential flow occurring through improper manufacturer, use or damage to the distribution system is still a fundamental problem for anhydrous ammonia users. A system which is able to detect and alert the operator to problems may therefore be a valuable device in the quest for more cost effective and environmentally sensitive application systems.

## Project Budget

	Year 1	Year 2
<u>Staff:</u>		
Technical Officer	35 000	35 000
Post graduate scholarship	18 000	18 000
<b>TOTAL SALARIES</b>	<b>53 000</b>	<b>53 000</b>
<u>Operational :</u>		
Data acquisition (hardware & software)	7 400	2 000
Plumbing & drums	2 750	1 000
Pump	1 000	
Load cell componentry	19 040	
Anhydrous ammonia	2 000	2 000
Electronics and cabling	20 320	2 000
Distributor consumables	2 200	500
Field experimentation consumables	1 500	1 500
<b>TOTAL OPERATIONAL</b>	<b>56 210</b>	<b>9 000</b>
<u>Travel/Conferences :</u>		
Field experimentation (Qfleet)	3 000	3 500
Conferences & travel (local)	4 000	4 000
Conferences & travel (overseas)	8 000	9 000
<b>TOTAL TRAVEL</b>	<b>15 000</b>	<b>16 500</b>
<b>BUDGET SUMMARY : TOTAL</b>	<b>124 210</b>	<b>78 500</b>

## **Budget justification for required resources**

The resources required to achieve the objectives outlined above will include funding for :

### *(i) Salaries*

A technical officer (preferably with a trade certificate in fitting and turning) will be required to assist with the fabrication of extra distributors and in the performance of experiments in the laboratory and in the field. A post graduate scholarship (Masters) is required to support electronic development work on the mass flow measurement system and the differential flow sensor/warning system.

### *(ii) Operational*

Funds will also be required for the purchase of components for the development of a more appropriate distribution measurement system to accommodate the increased number of distribution outlets in broadacre application systems. This will include an enhanced data acquisition and storage system, load cell componentry, plumbing and pumping upgrades and material for the manufacturer of extra distributors. Funding or supply of free anhydrous ammonia for laboratory experiments may also be sought from Incitec (and other organisations) to facilitate joint activity in the further development of the distributor. Componentry for the field evaluation of the distributor and potential mass flow rate or detection systems will also be required.

### *(iii) Travel/conferences*

A travel allocation is also required to enable attendance at local and international conferences and to maintain an operational research and development link with collaborative organisations and individuals both in Australia and overseas (eg University of Nebraska-Lincoln, Alberta Farm Machinery Research Centre). Field verification of distributor performance will require the establishment of experimental/demonstrational areas in Australia and overseas.

## **NSW Agriculture staff involved in the program**

### *Joint Principal Investigator - Mr Pat Weldon (Senior Technical Officer, Engineering)*

Responsible for the day-to-day activity of the project and the development of the technical details relating to the distributor and measurement equipment and procedures. He will be responsible for the guidance of the Technical Officer in the manufacture of the extra distributors and the measurement systems.

### *Joint Principal Investigator - Mr Neville Gould (Team Leader, Agricultural Engineering)*

Responsible for research and development methodology and conduct in the laboratory and the field and in the establishment and maintenance of links with collaborative organisations in Australia and overseas (Professor Bobby Grisso - University of Nebraska-Lincoln, Garry Hnatowich - Saskatchewan Wheat Pool/ Alberta Farm Machinery Research Centre).

## **Timetable for meeting experimental aims**

These milestones are defined in 6 monthly intervals for researchers involved in this program.

### *0-6 months (July/Aug 1996)*

Recruitment of technical officer and post-graduate student. Manufacture of extra distributors for further field assessment in the Australian cotton industry. Acquisition of regulators and controllers and conduct of further experimentation in conjunction with new distributor across a wide range of operational conditions. Establishment of scaled up version of drum collection system. Development of initial mass flow measurement prototypes. Initiation of laboratory assessment of new distributor in the Australian grains industry.

### *7-12 months*

Assessment of mass flow measurement systems. Development, manufacture and assessment of differential flow measurement prototypes. Initiation of field assessment of new distributor in the Australian grains industry.

### *13-18 months*

Continue field assessments in Australia and overseas of new distributor in the cotton, grains and other industries. Continued assessment of mass flow measurement system and of differential flow measurement prototypes.

### *19-24 months*

Complete experiments, data processing and write up Masters thesis, reports and further patent applications if warranted.