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REVIEW OF DPP MAIZE RESEARCH 1954-1986

Anna Roberts
Maize Agronomist

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SUMMARY

Maize research in the NT has been conducted since 1954 but no clearly defined long term objectives have been either set down or adhered to until 1982-83. As a result research work was of a preliminary nature and heavily biased towards cultivar evaluation with little emphasis on other important agronomic problems. In 1982-83 a 10 year joint QDPI/DPP program started with the aim of producing hybrids with improved tropical adaptation and thus a higher yield potential.

The small amount of nutrition research conducted has largely been *ad hoc* and not definitive. Most has been conducted on the heavier soil types looking at responses to N and P. With the opening of ADMA project farms on light textured soils in 1982-83 gross micro-nutrient problems became apparent and to date these have not been adequately addressed. No research work on the economics of fertiliser application, of both macro and micro nutrients has been conducted for either soil type. Research into the economics of N, P and S application on both light and heavy soil types, and better definition of Zn problems on light soils is seen as the highest research priority for maize.

Establishment problems with maize, due to soil erosion, soil crusting and high soil temperatures have been experienced for many years. When early experiments suffered establishment problems they were written off and no conclusions were drawn. Possible methods of improving establishment and yield, using zero tillage have only recently been addressed with the initiation of a long term crop rotation/tillage method/N application rate experiment.

Research into other areas, herbicides, time of planting, plant population studies and plant diseases have been conducted occasionally. Such research, unless a major problem arises, should be given low priority compared with nutrition and tillage work.

INTRODUCTION

Maize research in the NT commenced in 1954 when the first observation plots of this crop were sown by the Agricultural Branch. Until recently, research has concentrated largely on cultivar evaluation, apparently because of the emphasis given to this aspect in both NSW and Queensland. Maize research in these States has attracted greater resources for many more years than in the NT so that other agronomic problems have largely been solved. This fact appears to have gone unnoticed by those responsible for maize research in the NT. Local emphasis on cultivar trials seems to have been justified by the simple desire to see whether or not maize could be grown successfully in the NT. Consequently, an *ad hoc* approach to research has persisted. This applies to cultivar evaluation as well as to the limited work on nutrition. A long term joint breeding project was, however, started with QDPI in 1982-83.

There has been no assessment of maize research in the NT since Airey's review in 1972, and his recommendations appear to have gone largely unheeded. The purpose of this paper is to review the present state of knowledge of maize agronomy in the NT, to highlight gaps in this knowledge and to reassess the priorities for future research given limited labour resources. Significantly, only one paper on maize research, (Pitkethley 1973), has been published outside the DPP in the NT since 1954. Thus, any review of past work is necessarily restricted to unpublished reports and the files of individual experiments. For sake of completeness, all recorded experiments, as well as Airey's conclusions, have been included in this review. Much of the early work, however, could have been omitted because it was inconclusive due, either to failure of experiments, or to poor experimental design and lack of replication. A summary of all known experiments and test strips has been included as Appendix 1.

MAIZE RESEARCH PRIOR TO 1972

From 1954 to 1972 a total of 19 experiments and observation trials were conducted with maize. Of these 13 were cultivar evaluation experiments, with 4 cultivar observation trials and 2 fertiliser experiments. Doug Airey reviewed NT maize research in 1972. He found the results from cultivar trials difficult to interpret as the experiments had been conducted under various and poorly documented conditions. Only the poorer varieties could be identified with any certainty. Results from the two fertiliser experiments indicated that more detailed work on fertiliser was warranted.

Airey believed that much of the blame for failure of agricultural enterprises in the NT could be attributed to a lack of understanding of the environment and that a systematic research program was needed to improve knowledge of the crop environment interrelationships.

Airey concluded that future experimentation would have to accommodate considerable inter-seasonal variation in growth and yield due to climatic variations and that meaningful results would be obtained only if these could be explained. He suggested that observations on soil moisture (at sowing, silking and harvest), rainfall, evaporation, plant wilting, and planting emergence, tasselling and silking and harvest dates should be recorded as a matter of course.

In summing up, Airey thought that the climate of the NT would prevent maize from achieving its full potential in all but a few seasons, but that given sound agronomic practices maize should have a future as part of the NT cropping scene.

Airey's review provided a good opportunity to reassess the direction of maize research especially as the results of earlier poorly planned and conducted variety experiments were so inconclusive. Unfortunately it appears that the opportunity was not taken and work continued without clearly defined objectives.

MAIZE RESEARCH FROM 1973 TO 1986

From 1972 to 1981 the major emphasis was again on cultivar assessment with limited nutrition work. Isolated work was also conducted on herbicides, time of planting, Downy Mildew evaluation and southern leaf blight monitoring.

Since 1982 the joint QDPI/DPP breeding program has been the major emphasis in maize research by DPP. Nutrition experiments were also conducted in the 1982-83 and 1983-84 seasons. A long term crop rotation/tillage method/ nutrition experiment began in 1984-85 and a plant population experiment was conducted in 1983-84.

CULTIVAR EVALUATION 1973 TO 1986

Both a study tour report (Madin, 1973*a*) and an internal review (Madin, 1975*a*) stated that the greatest immediate gains for maize production in the NT could be made through identification of hybrids better suited to the environment. Cultivar evaluation was therefore identified as the highest research priority.

Cultivar evaluation research work was conducted on a largely *ad hoc* basis until 1982. Experiments have been summarised in Appendix 2.

Madin concluded from experiments at Tipperary conducted in 1972-73 and 1973-74 (Madin, 1973*b*, 1974*a*) that late maturity Kairi material should be more adaptable to areas north of Tipperary (above 1200 mm rainfall) and that Grafton and other late NSW and Qld material may be suited to areas as far south as Katherine in favourable seasons or to the Darwin area under less than optimal cultural conditions. Madin speculated that early and mid-season material may be well suited to the Katherine area and that this would no doubt be confirmed or refuted in later trials. The comment was also made by Madin that the commercial and experimental hybrids available at the time had sufficient yield potential and adaptability not to be limiting for yield under current agronomic practices and with present agronomic knowledge (Madin, 1974*a*).

In 1975-76 experiments were conducted at both Berrimah and Katherine. At Berrimah, waterlogging and lack of nutrients caused extremely poor growth and severe *Heliothis* and mould infestations compounded the problems. The authors suggest an upper rainfall limit to growing maize in the NT and postulated that the regular failure of maize at Berrimah may be largely due to waterlogging. At Katherine, high yields were positively related to plant population rather than maturity type and indicated that the question of plant population under local conditions merited attention (Kilpatrick and Airey, 1977).

Experiments conducted between 1978 and 1981 experienced a number of problems as outlined in Appendix 2, making it difficult for any conclusions to be drawn (Buchanan and Kernot, 1980; Kernot and Kernot, 1981*a*; Schultz, 1981*a*).

Conclusions drawn by the various researchers from the varietal assessment work till 1981 were:

1. That maize yields in the NT were generally lower than those obtained in NSW and Queensland.

2. That rainfall at Katherine, particularly in December, March and April was too unreliable for successful maize production. For maximum chances of obtaining a yield, crops should be sown before the end of December and relatively early maturing types were the most suitable for this less reliable environment.

3. That later maturing hybrids were better suited to the Douglas Daly area. Hybrids from the Kairi breeding program performed well in favourable seasons, but possibly some late maturing hybrids from the Grafton-program may have been more reliable in poorer seasons.

4. That maize generally performed poorly in the Darwin area mainly due to waterlogging problems. This raised the question of an upper rainfall limit for maize production on soils with relatively poor drainage.

In 1982 a joint breeding program between QDPI and DPP was formalised and a systematic approach to maize evaluation started. The aim of the project is to breed maize hybrids with tropical adaptation specifically suited to NT conditions, the hypothesis being that poor ecophysiological adaptation is the cause of the generally poor yields obtained in maize grown in the NT.

DPP experimental plot yields have rarely exceeded 6 t/ha under dryland conditions. The program is scheduled to run for 10 years and the yield gains are expected to be 5-6% per 3 year cycle of the recurrent selection method employed. Thus a potential yield gain of 15-20% is hoped for (Schultz, 1984*a*). In addition to the yield gains, improved Downy Mildew tolerance, reduced root and stalk lodging, improved cob weights and grain quality are also selected for. Yield results of the program are summarised in Appendix 3.

At this stage it appears that mid maturing lines are more promising for the Douglas Daly area than later maturing lines, based on the 1983-84 results where the top mids yielded better than top late maturing lines. Also within the mid experiments in 1984-85 there were a few lines which yielded better than either of the commercial cultivars Hycorn 9 or Pioneer 6875. Mid season lines which appear most promising are a cross between material from Florida (with some tropical material from the Caribbean) and the Burnett region in southern Queensland.

To date, late maturing non-commercial lines are not out-yielding commercial varieties of similar maturity such as QK 657. They therefore do not appear particularly promising. It is anticipated that late lines will be compared with mids again in the 1986-87 season, and if they do not perform as well as the mids, breeding research will concentrate on mid-season lines from 1987-88.

NUTRITION

Of the trials and experiments which have been conducted on nutrition in maize, explanations of responsiveness were often unclear or inconclusive because soil chemical analyses were not taken, either before treatments were applied or after the response was expected. Likewise plant analyses have generally not been performed and climatic conditions not adequately recorded or interpreted.

Because soil fertility status in most past DPP maize nutrition experiments has been so poorly recorded, it is felt necessary to refer to other studies where fertility has been more accurately assessed. This information assists in interpreting results of past maize nutrition work. Relevant soils are referred to first, followed by a review of experimental work.

Since 1981-82 observations of nutritional problems in maize from the ADMA project farms have been made. Such observations on large scale commercial properties provide the best guidance for determination of priorities for nutrition work, as well as indicating the importance of crop nutrition to economic production.

Relevant Soils

Soils of the Tipperary land system have been described by Stewart (1956). Stewart (1965) considered that the only potentially arable soils in the region were in the loamy or sandy red and yellow earth groups. The agriculturally important red earths have been described in greater detail by Van der Graaff (1965).

Aldrick (1972) classified the soils based on the outlines given by Stewart and Van der Graaff. The soils where maize has been grown (and therefore which will be considered in this review) fall into the red earth group; Tippera and Tindall in the loamy subgroup and Blain and Oolloo in the sandy sub group as classified by Aldrick (1972).

Currently in the Douglas Daly area farms exist on both loamy and sandy surfaced soils. Most research work has been conducted by both CSIRO and DPP, on Tippera soils with limited research on Blain soils. In attempting to extend research to farms, results from nutrition research conducted on Blain soil is likely to be most relevant to farms on sandy surfaced soils south of the Douglas River. Within the loamy subgroup, research conducted on both Tippera and Tindall families is of direct relevance to Tippera soils as defined by Aldrick (1972).

Soil Chemical Status

Day (1977) described the morphological, physical and chemical characteristics of Tindall and Blain soils as part of the National Soil Fertility Project initiated by CSIRO in 1967. Lucas (1983) described in more detail the soils of the Douglas Daly area.

With respect to chemical status of arable soils, responses to nitrogen (N) are very likely on Tindall/Tippera soils and sandier surfaced soils. (Lucas, 1983; Price and Garside, 1983; Day, 1977). The supply of N to crops on Blain soil is a larger problem than on the heavier soil types due to the high nitrate leaching rates on sandy soil. This raises the question of split N application rates for improved efficiency of N fertiliser on both soil types (Day, 1977).

Phosphorous (P) responses are very likely on both loamy Tippera/Tindall soils and sandier surfaced soils (Lucas, 1983, Price and Garside, 1983, Day, 1977). Sodium bicarbonate extractable P values of virgin soils sampled (0-15 cm depth) were 5-8 ppm P for loamy soils and 5-7 ppm for light soils (Price and Garside, 1983).

Potassium (K) is generally adequate on Tippera/Tindall soils but sometimes low on lighter soils (Lucas, 1983; Price and Garside, 1983; Day, 1977). Ammonium acetate extractable K values of virgin soils sampled (0-15 cm depth) have been found to be 142-289 ppm K for loamy soils and 48-114 ppm for light soils (Price and Garside, 1983).

Sulphur (S) responses are very likely to occur on lighter soils (Lucas, 1983; Price and Garside, 1983) and could occur on Tippera/Tindall soils (Lucas, 1983). Potassium phosphate extractable S values of 0-15 cm samples of virgin soil were 5-21 ppm S for loamy soils and 7-10 ppm S for light soils (Price and Garside, 1983).

Zinc (Zn) deficiencies are likely to occur on lighter soils whereas Tippera/Tindall soils can have acceptable Zn levels initially but may require Zn applications after several crops (Price and Garside, 1983; Lucas, 1983). Diethylene-triamine-penta-acetic acid (DTPA) extractable Zn values of 0-15 cm virgin soil samples sampled prior to cultivation varied from 0.4-1.4 ppm Zn for loamy soils and 0.1-0.8 ppm Zn for light soils (Price and Garside, 1983).

Copper (Cu) deficiencies are likely on lighter soils (Lucas, 1983; Price and Garside, 1983). DTPA extractable Cu values of virgin soils sampled (0-15 cm depth) were 0.4-4.0 ppm Cu on loamy soils and 0.1-1.2 ppm Cu for lighter soils (Price and Garside, 1983).

Crop Requirements

Crop requirements in terms of N, P and K, for a 5 t/ha maize crop are in the vicinity of 100 kg/ha N, 18 kg/ha P and 95 kg/ha K as calculated from Larson and Harway (1977). Although such crop requirements cannot be used to predict fertiliser rates, as they ignore economic considerations and the difference in soils capacity to supply nutrients (Aldrich et al. 1978), the figures may help to give a rough guide as to proportions and amounts of these nutrients required for a crop and thus help to interpret results obtained in some of the past maize nutrition work.

Maize Nutrition Research

The major emphasis for maize nutrition research has been on N and P rates on loamy soils however this work has been sporadic and generally inconclusive. Potassium has been occasionally included. One minor nutrient experiment has been conducted on Blain soil. All nutrition work has been summarised in Appendix 4.

Conclusions which have been drawn from the 1973-74 Tipperary N work were that maize was responsive to N where soil N status is low and that economic rates of N, (where P fertilisation was adequate), were likely to be in the vicinity of 80-100 kg/ha N. Split applications of N were not found to have a significant effect on yield which surprised the author in view of the high expected N leaching rates (Madin 1974*b*). Most of the other work conducted on N to date has been largely inconclusive (Kent, 1960; Madin, 1970; Madin, 1975*b*; Kilpatrick, 1976; Wesley-Smith and Sawyer, 1980; Schultz, 1981*a*; Williams, 1983; Gould, unpublished data) for various reasons.

Phosphorous nutrition work has been sporadic. Maize has been found to be responsive to P (Williams et al. 1984). From the 1972-73 Tipperary experiments it was concluded that on previously well fertilised paddocks no more than 20 kg/ha P was required for that crop. Biosuper was not found suitable as a P source for maize due to its slow release of P (Madin, 1975*b*). Other P work has been inconclusive (Kent, 1960; Madin, 1970; Wesley-Smith and Sawyer, 1980; Schultz, 1981*a*; Williams, 1983, Garside and Buchanan, 1985).

A test strip at Katherine in 1975-76 found that K fertiliser was not required on Oolloo soil (Kilpatrick, 1976) but other work where K has been a treatment has been inconclusive (Kent, 1960; Williams, 1983, Garside and Buchanan, 1985).

Although no firm conclusions could be drawn results from a pot experiment conducted in 1982-83 results indicated that S deficiency in maize was likely on Blain soils (Garside and Buchanan, 1985).

On light soils minor nutrient deficiencies have been observed (Schultz, 1981*a*; Flint, 1984; Garside and Buchanan, 1985, Gould, unpublished data). Zinc has been found to be most limiting to production (Flint, 1984).

Observations of Maize Nutrition Problems on Douglas Daly Project Farms

As DPP research on maize nutrition has been piecemeal and often inconclusive due to inadequate data or experimental failure, it is important to include observations made on the Douglas-Daly Project Farms. In fact it is essential to include this information as it can provide the basis for setting priorities for future maize nutrition research.

The 1981-82 season was the first year of the ADMA Douglas Daly Farms Project and two farms (Ceres Downs, Kumbyechants) on Tippera soil were cropped for the first time. Maize was sown on each farm and generally 25-30 kg/ha P and S as single-superphosphate and 50 kg/ha N as urea was broadcast at planting with an additional 80 kg/ha N as urea applied post-planting. Plant stands were poor from emergence and plant growth was variable due mainly to poor nutrition. Plant analysis confirmed that both P (0.17-0.24%) and S (0.10-0.17%) were low (N 3.7-4.0%, K 4.3-5.0%, Zn 30-129 ppm, Cu 11-16 ppm were adequate) and this was probably partly due to the fertiliser being broadcast other than banded near the seed. (Schultz and Garside, 1982).

In 1982-83 four more ADMA farms (Ruby Downs, Theyona, Bonalbo and Maneroo) were brought into production. Apart from Ruby Downs these new farms were on predominantly Oolloo sandy loam soil. Chemical analyses of these soils revealed that P, S and Zn were low and deficient, S and Cu were low and probably deficient and K was variable but probably deficient in some areas. By contrast the Tippera/Tindall clay loam could be regarded as having acceptable levels of K and Cu, and initially at least, acceptable Zn levels (Price and Garside, 1983). Soil analyses figures of virgin country have been outlined in the section Soil Chemical Status.

Nutrient problems in maize were observed in 1982-83 and these are summarised with fertiliser applications in Appendix 5. Nitrogen and Zn deficiencies were observed on Ruby Downs (Tippera) and Maneroo (Oolloo). Nitrogen concentrations of 4 week old whole plants were 3.0% at Ruby Downs and 2.2-3.5% for 3 week old plants at Maneroo. Zinc concentrations were 11-15 ppm and 13-24 ppm respectively. P (0.16-0.29% for 3 week old whole plants) and S (0.20-0.26%) deficiencies were also a problem at Maneroo. Nutritional problems generally were not as severe as in the previous season, as they were probably masked by overall dry conditions. The authors felt fertiliser cost and efficiency of use was emerging as a very important immediate issue, particularly with respect to fertiliser banding and potential S deficiencies resulting if high analysis P fertilisers were used to reduce costs. They also felt that research was required particularly on Oolloo soils to establish type and quantity required (Price and Garside, 1983).

Three Douglas Daly farms (Ceres Downs, Kumbyechants, and Theyona) were cropped to maize in 1983-84. The season was considered favourable for cropping. No major nutritional problems were encountered on Tippera soils except in windrow areas where maize grew extremely poorly (T. Price, pers. comm.). On Oolloo soil (Theyona) severe nutrient deficiencies, (of which S and Zn are thought to be primarily involved) were observed from early establishment onwards. Nutritional problems for the 1983-84 season are summarised in Appendix 6.

The problems on Oolloo soil (suspected S and Zn) were found mainly on virgin ground with no major nutritional problems being found on land which had been fertilised and cropped the previous season (Price and Garside, 1984). Sulphur had been applied in the 1982-83 season at 22 kg S/ha on previously cropped paddocks at Theyona. The 4.3 kg/ha Zn in the Special Mix + S fertiliser applied in 1982-83 appeared to be sufficient to meet the 1983-84 maize crops requirements as the 4 kg/ha Zn applied post-planting in 1983-84 would be expected to be largely unavailable.

Plant analyses on nutrient deficient plants was confounded by dead plant tissue and gave no real answers to the major nutrient deficiencies. There was a large visual response in plants which received a dressing of Fertica (Mg 1.3%, B 0.1%, Mn 0.1%, Cu 0.04%, Zn 0.02%, N 11.4%, P 4.8%, K 14.6%, S 7.5%, Ca 4.3%) which indicated that one or more of these elements was lacking (Price and Garside, 1984).

In 1984-85 four properties (Ceres Downs, Kumbyechants, Theyona and Bonalbo) grew maize. The season was reasonably favourable for maize except for heavy rains in December which delayed planting on Tippera soils. Reasonable rains fell from mid January to the end of March with a heavy fall in mid April (Price, 1985).

No major nutritional problems were seen on Tippera soils except one area in paddock S5 on Ceres Downs which showed apparent signs of nitrogen tie up after a large amount of mulch was ploughed in pre-planting.

On Oolloo soils maize grown on Bonalbo showed visual signs of Zn deficiency. Symptoms were on scattered plants throughout paddocks. Zinc oxide was applied pre-planting at 5 kg/ha Zn, but as Zn in this form is not readily available, Zn deficiency was not surprising. All maize grown on Bonalbo, except in paddock V3, was on new country. Windrow areas showed the worst signs of nutrient stress (Price, 1985).

No major nutrition problems were seen at Theyona. All maize grown on Theyona was grown on previously cropped areas. Nutritional problems in 1984-85 are summarised in Appendix 7.

An exceptionally dry season was experienced in 1985-86 which was extremely poor for cropping. Maize was grown again on four properties (Ceres Downs, Kumbyechants, Theyona and Bonalbo). Crops on Oolloo soils (Theyona and Bonalbo) experienced more severe water stress than crops on Tippera soil farms. Oolloo farms received less rain as well as having inherently lower water holding capacity soils (T. Price, pers. comm.).

Nutritional problems in 1985-86 are summarised in Appendix 8. No major nutritional problems were experienced on Tippera soils except for windrow areas in which maize grows particularly poorly. Although the nutritional problems in windrows are gradually becoming less evident as paddocks are cropped more, yields are still reduced quite markedly in such areas (T. Price, pers. comm.).

On both Theyona and Bonalbo, suspected Mg deficiency symptoms were observed in late January 1986.

Unreplicated test strips were applied (Mg + S, S and control treatments). In late February on Bonalbo there was a marked S response and Mg deficiency symptoms had disappeared. Plant analyses revealed that while the magnesium sulphate application increased both Mg (from 0.6 to 0.11% in late vegetative stage whole plant samples) and S (from 0.09 to 0.26%) concentrations, the S treatment also increased concentrations of both (Mg 0.09%, S 0.23%). This suggests that S may have been indirectly affecting plant Mg uptake and that once S was applied Mg uptake resumed. Mg levels however were fairly low in all treatments. The small area of soil explored by roots of drought stressed plants and/or possibly unidentified nutrient imbalances are possible reasons as to why plants developed a temporary Mg deficiency in the early stages of growth. (Roberts, unpublished data).

No visible S or Mg response was evident on Theyona although S concentrations were increased after application (from 0.17-0.19 to 0.21-0.26%). Mg concentrations did not change (0.7-0.9%). Zn and Cu levels were extremely variable over the test strip areas and made results difficult to interpret. All that could be concluded was that other unidentified factors were initially limiting plant growth and drought stress was a likely contributing factor (Roberts, unpublished data).

State of Present Knowledge of Maize Nutrition and Future Needs

Maize nutrition research work is required on both heavy and light soil types. While the reliability of maize production on light soil types is questionable at this stage, the fact that substantial areas of maize are grown on these soils (650 ha out of 2 000 ha in the 1985-86 season, Price pers. comm) justifies the need for nutrition research on light soils.

Visual deficiency symptoms on farms generally appear to correspond reasonably well with soil and plant chemical analyses prediction. The yearly soil sampling conducted on paddocks along with the records of fertiliser inputs, crop varieties, crop yields and some plant analyses, will allow better prediction of potential nutrition problems in the future. This information should be able to be readily accessed by computer. The data collected to date is accessible in the ADMA Farm Reports. Prior to 1982-83 very little soil or plant analyses data was either collected or used to predict or diagnose nutrient problems. Accessing such data to give a better baseline picture for predicting nutrient deficiencies and fertiliser responsiveness should be a very high priority.

Whilst gross nutritional deficiencies on Douglas Daly farms correspond reasonably well with soil test assessments there is no information on assessment of economic fertiliser rates of any element. As fertiliser is one of the major input costs involved in cropping, this information is of great importance to farmers. In order to predict economic rates of fertiliser, response curves of N, P and S need to be known for both soil types. To construct response curves, a planned, long-term fertility project needs to be undertaken instead of the *ad hoc* efforts which have in the past yielded so little information.

At present, on Tippera soils, on previously cropped paddocks total (pre-planting and top-dressed) N rates of 50-100 kg/ha are not producing visual symptoms of N deficiency, however crop yields have generally been low and therefore crop requirements have not been high. There is no accurate information at present from which farmers can decide most economic rates of N.

The existing crop rotations/tillage systems/N application rate experiment should be used to construct N response curves for the different crop rotation and tillage systems. Most economic rates of N could then be determined from the response curves.

Common rates of P applied pre-planting or at planting in maize are approximately 30-40 kg/ha P on previously cropped paddocks. Such rates are not producing P deficiency symptoms, but it is not known whether these rates are the most economic. Phosphorous response curves need to be first constructed on both soil types.

Sulphur nutrition is emerging as a very important issue. Sulphur deficiency has occurred on Oolloo soil (Bonalbo) despite relatively high application of S fertiliser both in the year the deficiency was observed and the previous year. On light soils, information is needed both on rates to alleviate gross deficiencies as well as to predict economic S rates. On Tippera soils it is suspected that maize is responsive to S as farmers appear to be getting better results from using sulphate of ammonia than urea.

S response curves and economics of S application need to be determined on both soil types. Because both P and S are likely to be limiting maize responsiveness, a research project could either study each element independently plus their interactions in the one project, or independent studies could be conducted. Non-limiting amounts of the other element would have to be applied for single element treatments. For both elements, the effect of single and repeated applications would have to be studied to determine response curves and residual values.

Leaching rates, particularly of sulphur should also be incorporated in case the residual values of single applications are dependent upon a particular wet seasons' rainfall.

Potassium deficiency has not been observed on either heavy or light soils to date, however K problems are likely on some light cropping soils in the future if no K is applied. Work on K responsiveness should be a relatively low priority at this stage.

Zinc nutrition is certainly a problem on light soils and potentially a problem on Tippera soils. Work on Zn nutrition is a relatively high priority although large initial applications would overcome much of the nutritional problems in the short term. Zinc responsiveness, application rates and residual values on light soils particularly need to be studied.

There will no doubt be other elements which become limiting to production - Cu and Mg are potential problems in the near future. Soil and plant testing should be used on farmers samples to develop better correlations between deficiency symptoms and plant and soil concentrations of minor nutrients. Nutrient problems should be confirmed in the field through use of fertiliser test strips and farmers should be advised accordingly. Whilst it would be desirable to embark on a large scale minor nutrient experiment, with limited personnel it would probably be more practical to concentrate on major nutrients plus zinc at this stage with limited emphasis on other minor nutrients.

TILLAGE RESEARCH

As background to this work, research conducted by CSIRO at Katherine from 1978 onwards has indicated that no-tillage cropping methods offered considerable benefits compared with traditional tillage methods. An outline of the principles involved in the soil surface management aspects involved are outlined by Lal (1985) and the CSIRO work itself is reviewed by McCown et al. (1985). Briefly, the success of no-tillage depends heavily on the ability to retain a mulch of undisturbed dead vegetation on the soil surface during crop establishment. The function of the mulch is to conserve soil and water, reduce the maximum soil temperature, prevent raindrop impact and maintain soil organic matter at adequate levels (Lal, 1985).

Only three trials conducted by DPP in the past have considered tillage as a major constraint to maize production. The first two trials (conducted in 1970-71 and 1980-81) were inconclusive and the third trial, begun in 1984-85 is the first serious attempt by DPP to evaluate a no tillage versus a conventional system.

In 1970-71 a variety x hilling trial was conducted at Tipperary Station (Kilpatrick, 1971*a*). As the hilling treatments were either incorrectly randomised or unreplicated the effects could not be statistically analysed. Results indicated increased water infiltration with hilling.

At Douglas Daly in 1980-81 tillage evaluation trials were conducted with maize on a previously cropped Tippera paddock and on three Blain soil paddocks with varying previous histories. The Tippera site had three treatments (A. no tillage; B. deep chisel ploughing + repeated ploughing + scarifying; C. disc ploughing + scarifying). Yields for the three treatments were 0.2, 5.3 and 4.6 t/ha for the respective treatments (Schultz, 1981*a*).

Of the three Blain sites two had been cropped for a minimum of two years, the other had been under Sabi pasture which was badly infested with Sida. One previously cropped Blain site (Paddock 17) had three tillage treatments (A - no tillage; B - deep chisel ploughing + several cultivations; C - offset discing + several cultivations). Yields were 0.6, 1.5 and 2 t/ha. The other two Blain sites had only cultivation treatments and yielded 1.8 and 2.1 t/ha. All Blain sites suffered severe nutrient problems (Schultz, 1981*a*).

Inadequate weed control and an inadequate planter were attributed as the major reasons for the failure of no tillage. Plant populations (in plants/ha) for each paddock where the three treatments had been applied were Tippera: A - 38 000; B - 48 000; C - 48 000 and Blain: A - 38 000; B - 38 000; C - 39 000 (Schultz, 1981*a*). This possibly suggested overall establishment problems for unidentified reasons on cultivated Blain soils - high soil surface temperatures would be a possibility although no temperature measurements were taken.

In 1984-85 a long term tillage method (no tillage, conventional cultivation) by crop rotation (rotations - continuous maize, continuous soybeans, maize-soybeans, soybeans-maize) experiment was initiated on Tippera soil. A site on Blain soil was initiated in 1985-86.

The objectives of the present study are:

1. To determine the effect of tillage system on the yield of continuously cropped maize, continuously cropped soybeans, a maize-soybean rotation, and a soybean-maize rotation.

2. To assess the effect of tillage system and crop rotation practice on the requirements of maize nitrogen fertiliser.

3. To observe the impact of tillage method, crop rotations and fertiliser input on long term soil fertility and soil pH.

The fertiliser nitrogen aspects of the experiment have been discussed in the section - Maize Nutrition Work.

In the first season of the experiment on the Tippera site (1984-85) there were no major differences between treatments. The second season (1985-86) was exceptionally dry and marked differences between treatments were evident on both maize and soybeans. In maize, there were no differences in plant establishment between tillage treatments, but large differences were found in maize grain yield. (No-till continuous maize 2.33-3.38 t/ha; No-till soy-maize rotation 2.33-2.87 t/ha; Conventional tillage continuous maize 1.04-1.56 t/ha; Conventional tillage soy-maize rotation 0.91-1.52 t/ha. The yields given range over the five N treatments and previous Verano or Siratro ley pasture). Whilst large yield increases are expected from a no-till system in a dry year due to improved soil moisture conditions such yield increases may not be obtained under more favourable conditions (N. Gould, pers. comm.).

The Blain site was established in the 1985-86 season. Due to exceptionally dry conditions, minor nutrient deficiencies and weed problems, yields from all treatments were extremely low. Unexplained site variability was also thought to have confounded results. Of note though were the large establishment differences between tillage treatments in both maize and soybeans. No-till maize had 18% better establishment than conventionally cultivated maize. The future of maize and soybeans being used as the test crops in this experiment are in doubt as is the site due to the variability. It is thought that the experiment may be re-established on a new Blain site using sorghum and peanuts as the test crops as these are presently grown more successfully on light soils. The question of whether maize, given the current state of knowledge, can be grown successfully on light soils is beyond the scope of this review.

It is hoped that these experiments will be continued for longer than the allotted four years as both long term treatment effects on soil structure and soil fertility may not be evident for a number of years. The effects of mulch residues on the soil surface may also provide a more suitable micro environment for insect fauna (Allwood et al. 1985) and diseases (R. Pitkethley, pers. comm.).

PLANT POPULATION STUDY

Only one experiment (see Appendix 1) has been conducted in 1983-84 on attempting to define base line data on populations and row spacing. Results were inconclusive (Schultz, 1984*b*).

Farmers are currently aiming for populations of 50 000 - 55 000 plants/ha (T. Price, pers. comm.), whereas in earlier years harvest populations of 45 000 plants/ha were recommended (Schultz, 1981*b*).

Because there is a better comprehension of nutritional problems than in the 1970's and farmers are applying more appropriate types of fertiliser (but not necessarily at the most economic rates), yield increases have been observed with the higher plant populations. Plant spacing within rows has been found to be a major problem in the past (as well as overall population/ha) and much extension effort has been concentrated on precision planting within rows as well as harvest populations per se (T. Price, pers. comm.).

TIME OF PLANTING STUDY

One time of planting experiment was conducted in 1972-73. There were 5 planting dates (24.11, 14.12, 09.01, 25.01, 01.03) using 2 varieties (GH390 - late maturity, XL-81 early maturity). Due to extreme replicate variability results could not be statistically analysed. Replicate variability was mainly due to the 24.11 and 14.12 sowings suffering from lack of moisture followed by soil crusting. Conclusions drawn from the trial were that the value of this type of research must be doubted as the clearly defined and limited growing season dictated to a large extent when planting must take place (Madin, 1973*c*).

The generally accepted practice for maize was that planting should be carried out as early as possible, consistent with the arrival of the regular tropical rains (Madin, 1973*c*). Current recommendations for mid to late maturity hybrids are to plant as soon as possible after good rains from mid-December to minimise the risk of a dry spell occurring over the critical tasselling/silking period. If planting was delayed till after the first week in January then early maturity hybrids would have greater yield potential, although this is not generally practical due to farmers not having seed on hand (T. Price, pers. comm.).

HERBICIDE RESEARCH

Only three herbicide experiments have been conducted with maize. The first was conducted at Tipperary in 1973-74 and evaluated broadleaved weed and grass control. Atrazine was applied at 3 rates (2, 4 and 6 kg a.i./ha) alone and atrazine at 2 kg a.i./ha in combination with propachlor (1.5 and 3 kg a.i./ha) or linuron (2 kg a.i./ha) and compared with a control. All treatments were applied post planting/pre-emergence (Madin, 1974*c*).

Atrazine at 2 kg a.i./ha gave good long term control of broadleaved weeds and 6 kg a.i./ha gave excellent broadleaved + grass weed control for almost the entire season. Propachlor in combination with atrazine gave no better control of grass weeds than atrazine alone at 2 kg a.i./ha. Atrazine (2 kg a.i./ha) + linuron (2 kg a.i./ha) gave similar control to atrazine at 6 kg a.i./ha. Grain yields ranged from 1.9 t/ha in the control to 4.6 t/ha for both atrazine 6 kg a.i./ha and the atrazine + linuron combination (Madin, 1974*c*).

Herbicide breakdown was beginning to show about 50 days post planting although weed growth was sparse and stunted compared with control plots. At harvest there were no significant differences in plant populations, indicating no severe phytotoxic effects (Madin, 1974*c*).

Conclusions were that propachlor could not be recommended for economic grass weed control. Despite its effectiveness, the price of linuron would probably go against it compared with the lower cost of atrazine, however the possible residual effects of high rates of atrazine should not go unheeded. Under normal commercial infestations, atrazine alone at 3 kg a.i./ha should be recommended for commercial maize plantings (Madin, 1974*c*).

The second and third herbicide experiments were conducted at Katherine in 1980-81 and 1981-82. In 1980-81 three rates of Atrazine (1.5, 3, 4.5 kg a.i./ha) and three rates of metolachlor (1.44, 2.88, 5.76 kg a.i./ha) were applied, alone and in combination, pre-emergent to a crop of maize. Phytotoxicity as measured by plant height at three weeks was not significant for any treatments. Metolachlor Dual® gave good grass weed control but did not significantly reduce the number of broadleaf weeds. Atrazine controlled the broadleaf weeds present but had no effect on the dominant summer grasses Digitaria and Brachiaria. Combinations of the two herbicides as low as 1.5 kg a.i./ha atrazine with 1.4 kg a.i./ha metolachlor gave excellent pre-emergent weed control. (Kernot and Kernot, 1981*b*).

A follow up experiment in 1981-82 evaluated 4 rates of atrazine (0, 0.75, 1.5, 3 kg a.i./ha) and metolachlor (0, 0.72, 1.44, 2.88 kg a.i./ha) alone and in combination pre-emergent. The economically optimum yield was obtained by using 0.75 kg a.i./ha (1.5 l/ha product) atrazine and 2.88 kg a.i./ha (4 l/ha product) metolachlor. Again no phytotoxic effects were observed (Kernot and Kernot, 1982).

At present atrazine and metolachlor/atrazine combinations are the only herbicides being used in commercial crops with reasonable success (T. Price, pers. comm.). The major potential problems with atrazine are that residual control is suspected to be reduced in some seasons due to heavy rainfall intensity rapidly washing the herbicide below the root zone of germinating plants (K. Young, pers. comm.).

The major research priority for herbicide work at Douglas Daly in maize should be for better residual control of broadleafed and grass weeds. *Hyptis suaveolons* and *Sida acuta* are common weed contaminants in the crop at harvest, from germinations which have occurred after atrazine has ceased to be effective. *Crotalaria* spp. in maize are also not adequately controlled by atrazine (K. Young, pers. comm.). At Katherine, provided a good initial result was achieved and the plant population was adequate, residual weeds are generally not a problem (J. Kernot, pers. comm.).

If dry season cropping under irrigation becomes more common then atrazine carryover could affect dry seasons crops, following wet season application, and this problem may need attention (K. Young, pers. comm.).

Herbicide application techniques have been somewhat dubious in some circumstances in the past. It is a major extension priority for herbicide application techniques and herbicide awareness to be improved.

DISEASE RESEARCH

Relatively few diseases of maize have been recorded in NW Australia. The extremely limited scale on which cropping has been conducted may be the main factor limiting the number of diseases and their severity. It might be expected that as the area under cropping increases, there may be a concurrent increase both in the number of diseases recorded and the severity of individual diseases (Irwin, et al. 1985).

To date the fungal diseases Downy Mildew (presently thought to be *Peronosclerospora javanica*), Southern Leaf Blight (*Bipolaris maydis*), Northern Leaf Blight (*Exserohilum turcicum*) and Tropical Rust (*Puccina polysora*) have been recorded. Wallaby Ear (thought to be caused by a virus transmitted by the leaf hopper *Cicadulina bipunctella*), and maize stripe virus (transmitted by the leaf hopper *Peregrinus maidis*), have also been recorded (Conde, 1981).

A bacterial rot has been also recorded in the NT. The rot can effect the central emerging leaf of both seedlings and large plants. As yet the bacterium is unidentified, and it is not proven to be the primary cause of rotting (R. Pitkethley, pers. comm.).

Present and potential diseases of maize in NW Australia have been listed by Irwin et al. (1985).

Of the diseases recorded in maize in the NT, research work has only been conducted on Downy Mildew and Southern Leaf Blight.

Downy Mildew

Downy Mildew was positively identified for the first time in the NT (and Australia) in 1979-80 at Katherine. It was identified as Java Downy Mildew (JDM) (*P. maydis*), however the present taxonomy of maize downy mildews is under review, and *P. javanica* is thought to be the fungus responsible (R. Pitkethley, pers. comm.)

A cultivar experiment at Katherine was sown on 21.12.79 with a second experiment being sown on 07.01.80 due to poor establishment of the first. Seasonal conditions were very wet and overcast from mid-January to the end of February. Downy Mildew badly affected the later sown experiment, with 5.2% - 46.2% plants infected. No variety sown on 21.12.79 showed symptoms of Downy Mildew. The conclusions stated that the importance of planting date on Downy Mildew infection should be investigated (Buchanan and Kernot, 1980).

Three trials were conducted at Katherine in 1980-81. Downy Mildew incidence was much lower than in the previous year. The season was very short with lack of rains delaying sowing till 05.01.81 and effective rainfall ceasing on 24.02.81. Conclusions from Trial 1 were that some plants showed possible tolerance to Downy Mildew. Trial 2 revealed that a later planting date increased the incidence of Downy Mildew. No conclusions could be drawn from the fungicide (metalaxyl) experiment due to the negligible incidence of disease (Kernot and Kernot, 1981*a*).

In 1981-82 no Downy Mildew was observed in trial plots at Katherine and only low levels were observed in plots at Douglas Daly. All commercial grain seed was treated with metalaxyl Apron® and no Downy Mildew was observed on farms (B. Conde, pers. comm.).

The QDPI/DPP joint Maize Breeding Program began in 1982-83 with the aim of developing hybrids better suited to NT conditions. JDM infection rates are being monitored and there is a range of tolerance to Downy Mildew. Some degree of tolerance/resistance is hoped to be included in any future commercially released hybrids.

Presently recommendations to prevent Downy Mildew are to treat seed with metalaxyl prior to sowing (Conde and Pitkethley, 1980) or to sow Hycorn 9 which has been observed to be resistant to Downy Mildew (B. Conde, R. Pitkethley, pers. comm.).

Downy Mildew has been observed in both dryland maize grown in a number of wet seasons in the NT and in irrigated maize grown during the dry season at Kununurra. It is thought that dewiness in the mornings aids sporulation and, therefore, spread of the disease, rather than rainfall and humidity per se (R. Pitkethley, pers. comm.)

Southern Leaf Blight

Southern leaf blight (caused by the fungus *Bipolaris maydis*) appeared for the first time in Australia in February 1972 and in the NT in March 1982. Maize hybrids containing Texas male sterile (TMS) cytoplasm were particularly susceptible to the fungus. During 1972-73 experiments were conducted at Berrimah Research Farm to assess the reactions of maize cultivars both in the field and to artificial inoculation of seedlings in pot experiments. Hybrids containing TMS cytoplasm or a blend containing TMS cytoplasm were more susceptible to both field and artificial inoculation than hybrids containing normal (N) cytoplasm. (Pitkethley, 1973).

In 1972-73 sites at Darwin, Adelaide River, Tipperary and Katherine were sown to monitor the spread of *B. maydis*. Infection was only found at Darwin (Madin, 1973*d*).

As it was possible to produce promising TMS cytoplasm containing genotypes using N cytoplasm, southern leaf blight has not been considered a major problem in years since the early 70's (R. Pitkethley, pers. comm.).

INSECT PESTS

The major pests of maize in the Northern Territory are Heliothus caterpillar (*Heliothus armigera*), army worms, (*Spodoptera exempta* (Walker), *Mythimna separata* (Walker)), locusts (*Austracris guttulosa, Gastrimargus musicus, Locusta migrataria*), corn aphid (*Rhopalosiphum maidis*), leaf hoppers and mites (Allwood, 1981). No direct entomological research with maize has been conducted to date in the NT. Insect pests in legume crops are considered as a much greater problem. Queensland results and recommendations have generally been applicable in the NT (A. Allwood, pers. comm.).

CONCLUSIONS AND PRIORITIES FOR FUTURE RESEARCH

There is no doubt that any improvement in the yield potential of maize hybrids has long term value for the crop in the NT. However, the allocation of substantial resources to the present breeding program while so many basic nutritional problems remain unsolved, is questionable. Early nutrition work was piecemeal and generally inconclusive. Arable soils in the NT are known to be deficient in N, P and S with the light textured soils probably deficient in K also. Yet, fertiliser response curves have not been determined for either soil type. Little is known of the economics of fertiliser application or the efficiency of banding versus broadcast applications.

Nitrogen response curves can be obtained from the current crop/tillage/N rate experiment, but new research projects will be required to determine P and S response curves on both soil types. Once response curves have been obtained the economics of fertiliser application can be assessed. Problems limiting crop production on farms should be the basis for setting priorities in nutrition research. At present the most urgent and obvious nutrition problems on farms are those associated with S and Zn deficiencies on the light textured soils. On these soils investigation of K response should receive low priority compared with P, S and Zn.

Whilst problems with micro-nutrients other than Zn may develop over time, particularly on light soils, extensive micro-nutrient trials at this stage would be premature given the meagre resources available and the lack of knowledge of N, P, S and Zn requirements. Instead, efforts should be directed to correlating soil and plant chemical data with visual symptoms as problems arise. Fertiliser test strips on farms should be used to verify suspected deficiencies and the farmers advised accordingly.

The establishment of a computer data base collating the existing farm paddock records of soil types, fertiliser inputs, crop varieties and yields, rainfall and sometimes plant analyses, would provide valuable information for both research and extension worker alike. Such a project would provide a good basis for predicting nutrient deficiencies and fertiliser requirements and would enable long term changes in soil fertility with cropping to be monitored with ease.

In the long term, tillage practices, through their effects on soil conservation and plant nutrition are equally important in crop production particularly on the lighter soil types. This aspect has only recently received attention from the DPP. No-till farming may not be adopted immediately by all farmers despite promising results. Such research, however, should be given high priority if sustainable long term agricultural productivity in the NT is the goal. Continued input from, and liaison with, CSIRO is vital for the success of this work.

Research into other areas such as determination of optimal plant populations and time of planting for recommended hybrids, as well as longer residual weed control are not a priority for maize research at this stage. Pest and disease problems may become an increasing problem with time and with further expansion of cropping areas and such challenges need to be met as they arise.

SUMMARY OF CONCLUSIONS

Highest Priorities for Maize Research

a) Nutrition

- construction of N response curves on both soil types (existing project).

- construction of P and S response curves on both soil types (new project or projects).

- Zn responsiveness application rates and residual value (new project).

b) No tillage and crop rotation (existing project)

Lower Priorities for Maize Research

a) Breeding - QDPI/DPP Maize Breeding Program (existing project)

b) Nutrition

- Broad micro-nutrient project (new project)

- K response curves on light soils (new project)

No Priority for Maize Research at this Stage

a) Nutrition - K response curves on heavier soils

b) Other areas - herbicides, time of planting, plant populations, pests and diseases.

High Priorities for Extension Projects

a) Increase farmer awareness of the importance of herbicide application techniques

b) Collation of farm soil fertility data.

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APPENDIX 1: SUMMARY OF RECORDED GRAIN MAIZE EXPERIMENTS AND TEST STRIPS

Season	Type of Experiment or Test Strip	Location	Comments	Reference
1954 Dry Season	Observation Area of 1 Cultivar	Berrimah	Maize grew well	Anon, 1955
1954-55	Observation area of 1 Cultivar	Berrimah & Batchelor	Failure - few cobs formed	Anon, 1955
1959 Dry Season	Fertiliser - NPK mix	Berrimah	Response to NPK Mix	Kent, 1960
1959-60	Cultivar	Berrimah	Max yield 1.9 t/ha	Kent, 1960
1960-61	Cultivar	Berrimah	Poor growth and no yield	Kent and Friend, 1961
1960-61	Cultivar	Batchelor	Max yield 3.4 t/ha	Mentz et al. 1961
1961 Dry Season	Cultivar	Tortilla	Uneven establishment	Turnour, 1961
1961-62	Cultivar	Berrimah	Wallaby ear disease	Anon, 1962
1963 Dry Season	Cultivar	Berrimah	Leaf diseases and Heliothus attack	Kent, 1963
1968-69	Cultivar	Tipperary	Trial grazed but recovered well	Kilpatrick, 1969
1969-70	2 Cultivars	Tipperary	Erosion and uneven plant stands	Madin, 1970
1969-70	N x P		Runoff probably caused N movement between plots	Madin, 1970
1970-71	Cultivar + Hilling	Tipperary	Max yield 4.6 t/ha Hilling effects not statistically valid	Kilpatrick, 1971a
1970-71	2 Cultivars	Coomalie Ck	Plots variable. No statistics performed. Max yield 5.4 t/ha	Kilpatrick, 1971b

APPENDIX 1: Cont'd

Season	Type of Experiment or Test Strip	Location	Comments	Reference
1971-72	Cultivar	Berrimah	Wallaby ear & Southern leaf blight a problem. No yield taken	Madin, 1972
1971-72	2.Cultivar Observation Areas	Katherine & Labelle Dns	Yield estimated 4.3 t/ha at Katherine. Low yields Labelle Downs due to Wallaby Ear	
1972-73	Cultivar	Tipperary	Lates better than early maturing lines	Madin, 1973b
1972-73	Cultivar	Katherine	Poor yields of all hybrids	Madin & Kilpatrick 1973
1972-73	<u>H. maydis</u> monitoring	Various sites	Infection only at Darwin	Madin, 1973b
1972-73	N x P factorial	Tipperary	No response	Madin, 1975b
1972-73	Time of planting	Tipperary	Extreme replicate variability results not statistically analysable	Madin, 1973c
1973-74	Cultivar	Tipperary	Late hybrids best	Madin, 1974a
1973-74	N rates x split applic	Tipperary	N response	Madin, 1974b
1973-74	Herbicide	Tipperary	Atrazine gave good control	Madin, 1974c
1975-76	Cultivar	Berrimah	Poor yields - waterlogging	Kilpatrick & Airey, 1977
1975-76	Cultivar	Katherine	High yields related to to plant population	Kilpatrick & Airey, 1977
1975-76	N x K	Katherine	No K response, no conclusions about N	Kilpatrick, 1976
1978-79	N x P	Tortilla	No conclusions - waterlogging	Wesley-Smith & Sawyer, 1980
1978-79	Cultivar	Katherine	Early maturing best (I. Kernot, pers. comm)	No reference

APPENDIX 1: Cont'd

Season	Type of Experiment or Test Strip	Location	Comments	Reference
1978-79	Cultivar	Douglas Daly	Later maturing hybrids best (I. Kernot, pers. comm.)	No reference
1979-80	Cultivar	Douglas Daly	Nutrient stress (I. Kernot, pers. comm)	No reference
1979-80	Cultivar	Katherine	JDM identified for first time	Buchanan & Kernot, 1980
1980-81	JDM evaluation	Katherine	Little JDM observed	Kernot & Kernot, 1981a
1980-81	Cultivar	Douglas Daly	No conclusions	Schultz, 1981a
1980-81	N and P (5 sites)	Douglas Daly	Severe minor nutrient stress on 4 Blain sites No differences on Tippera site	Schultz, 1981a
1980-81	Herbicide	Katherine	Dual & Atrazine gave good control	Kernot & Kernot, 1981b
1980-81	Tillage	Douglas Daly	Failure of no tillage	Schultz, 1981a
1981-82	Herbicide	Katherine	Dual & Atrazine gave good control	Kernot & Kernot, 1982
1982-83 to date	Joint QDPI/DPP Breeding Program	Douglas Daly	Mid season lines more promising at this stage	Schultz, 1984a Kernot, 1985 Unpub data
1982-83	N, P, K, (3 sites)	Douglas Daly	No grain yields taken	Williams, 1983
1983-84	Plant population study	Douglas Daly	No conclusions	Schultz, 1984b
1983-84	P types	Douglas Daly	No conclusions	Williams, et al. 1984
1983-84	Minor nutrients	Douglas Daly	Zn deficiency on Blain soil	Flint, 1984
1984-85	Tillage Method x N rates x rotation system	Douglas Daly	Response to no-till in 1985-86 (N. Gould pers. comm.)	Unpublished data

APPENDIX 2: SUMMARY OF MAIZE CULTIVAR EVALUATION EXPERIMENTS 1973 - 1982

No. and Maturity Types Sown	Sowing Date	Location	Yield Range (t/ha)	Comments	Reference
42 Mid & Lates	05-06.01.73	Tipperary	1.7 - 4.7	Some lates performed better than early lines despite a January sowing. Grafton material performed better than the later Kairi hybrids probably due to a dry spell when Kairi hybrids flowered	Madin, 1973b
8 Early	08-09.01.73	Tipperary	1.9 - 3.2		
5 Early & Lates	12.01.73	Katherine	1.0 - 1.7	Short season. Despite poor yields of all hybrids, later types were recommended due to superior husk coverage and cob size	Madin & Kilpatrick, 1973
14 Early, Mid & Lates	19.12.73	Tipperary	3.0 - 5.8	Season wet and overcast. Late maturity Kairi hybrids yielded higher than Grafton hybrids. Early & mid season hybrids inferior in this season at the early sowing date	Madin, 1974a
5 Early, Mid & Lates		Berrimah	0.7 - 1.4	Poor yields due to severe Heliothus and waterlogging	Kilpatrick & Airey, 1977
5 Early, Mid & lates	14.12.75	Katherine	3.8 - 6.1	Favourable moisture conditions at end of season. High yields positively related to plant populations	Kilpatrick & Airey, 1977
11 Early, Mid & Lates	1978-79 Season	Katherine		Low plant populations a major problems. Earlier types performed better (I. Kernot, pers. comm.)	No ref. found
11 Early, Mid & Lates	1978-79 Season	Douglas Daly		Later types performed best (I. Kernot, pers. comm.)	No ref. found
12 Early to Medium & Late	07.01.80	Katherine	1.7 - 3.3	Heavy infestation by Downy Mildew	Buchanan and Kernot, 1980

APPENDIX 2: Cont'd

No. and Maturing Types Sown	Sowing Date	Location	Yield Range (t/ha)	Comments	Reference
16 Lines	1979-80 season	Douglas Daly	Av 1.8 (I. Kernot, pers. comm.)	Experiment sown on Blain soil and severe nutrient stress experienced (I. Kernot, pers. comm.)	No ref. found
2 Replicated Exp. Early & Lates Sown	05.01.81	Katherine	0.8 - 2.3	Very short season. Earlier types better than lates Downy Mildew incidence low.	Kernot & Kernot 1981a
1 Observation Trial	05.01.81	Katherine	0 - 1.0	Very short season. Downy Mildew incidence low	
8 Lates sown in unreplicated trial	19.01.81	Douglas Daly	2.6 - 5.1	Difficult to draw conclusions due to lack of replication. Irrigation used at end of season	Schultz, 1981a

APPENDIX 3: SUMMARISED YIELD RESULTS JOINT QDPI/DPP BREEDING PROGRAM - WET SEASON EXPERIMENTS

SEASON	MATURITY TYPE	YIELD RANGE (t/ha)	SOWING DATE	COMMENTS	REFERENCE
82-83	Lates Series 1	2.4 - 5.5	28-29.12	Dry Jan and Feb Good rains in March & April. High temps. at flowering	Schultz, 1984a
82-83	Lates Series 2	1.1 - 4.3	28-29.12	As above	Schultz, 1984a
83-84	Late Elites	3.6 - 7.2	04-06.01	Excellent Season	Schultz, 1984a
83-84	Mids Series 1	1.2 - 8.5	04-06.01	As above	Schultz, 1984a
83-84	Mids Series 2	2.9 - 7.8	04-06.01	As above	Schultz, 1984a
84-85	Late Elites	3.6 - 6.2	21.12	Dry late Dec and early Feb. April cyclone Reasonable season	Kernot, 1985
84-85	Mid Elites (DDRF)	2.6 - 6.3	22.12	As above	Kernot, 1985
84-85	Mid Elites (Kath)	3.1 - 5.1	06.01	As above	Kernot, 1985
85-86	Lates Series 1	Not harvested due to insig-nificant grain fill	20.12	Extremely dry Dry conditions over flowering	Unpub. data
85-86	Lates Series 2	As above	21.12	As above	Unpub. data
85-86	Mid Elites	Est. 0-1 t/ha	21.12	As above	Unpub. data
85-86	White maize	Est. 0-1 t/ha	21.12	As above	Unpub. data

APPENDIX 4: SUMMARY OF MAIZE NUTRITION EXPERIMENTS

Elements Used and Rates	Season	Location	Soil Type	Comments and Conclusions	Reference
NPK mix (4-12.5-12%) used at 4 rates. Top rate supplied 4 Cu kg/ha) 40N, 126P, 120K	1959-60	Berrimah	Tippera	Increased responses to increased rates of fertiliser	Kent, 1960
N x P Factorial	1969-70	Tipperary	Tippera	No main treatment or interaction effects were observed, probably due to runoff water causing N movement between plots	Madin, 1970
N (0, 45, 67.5, 135 kg/ha N) x P (0, 20, 40 kg/ha P) factorial Two biosuper treatments (20 and 40 kg/ha P) included at high N rate	1972-73	Tipperary	Tippera series Emu clay loam	When analysed as a whole increasing rates of N and P had no significant effect on grain yield. Concluded that no more than 20 kg/ha P should be required on previously well fertilised country and biosuper should not be recommended as a P source due to its slow release of P	Madin, 1975b
N (0, 40, 80, 120 kg/ha) x Split application (at planting, 26 days post planting) factorial	1973-74	Tipperary	Tippera series Emu clay loam	Grain yield responded significantly from 2.75 t/ha at zero N to 5.2 t/ha at 120 kg/ha N. Timing of N application had no significant effect on yield even though rapid leaching would have been expected in the wet season. Conclusions were that under adequate P fertilisation the economic N application rate was likely to be 80-100 kg/ha N and that split applications were not economic	Madin, 1974b
N and K test strip	1975-76	Katherine	Oolloo	No conclusions could be drawn from N rates. No K response measured	Kilpatrick, 1976
N x P test strip	1978-79	Tortilla		No conclusions due to waterlogging effects	Wesley-Smith & Sawyer, 1980
N and P comparison (superphosphate, DAP, urea)	1980-81	Douglas Daly	Tippera (1 site) Blain (4 sites)	Low yields (0.8-1.6 t/ha) with no significant treatment differences on Tippera site. Severe nutrient deficiencies observed on all Blain sites. Nutrient problems most likely to be S and Zn (T. Price, pers. comm.). Conclusions were that a detailed study of fertiliser requirements was needed on both soil types	Schultz, 1981a

APPENDIX 4: Cont'd

Elements Used and Rates	Season	Location	Soil Type	Comments and Conclusions	Reference
P (0, 20, 40) applied 1982-83 after P x S rates being applied the previous season	1982-83	Douglas Daly	Tippera	No valid conclusions could be drawn due to season	Garside & Buchanan, 1985
Basal complete nutrient and basal minus are nutrient treatments	1982-83	Douglas Daly	Blain pot experiment	Suspected large depressive effect of chlorine making other nutrient comparisons difficult. Results suggested P, S and K likely to be deficient.	Garside & Buchanan, 1985
Nil, Basal Nutrients, minus Zn, Cu treatments, plus iron chelate, plus iron chelate + sulphate	1982-83	Douglas Daly	Blain pot experiment	Indications that Zn was required. Cu depressed yields although firm conclusions could not be drawn.	Garside & Buchanan, 1985
N, P, K rates	1982-83	Ceres Downs Kumbyechants Theyona	Tippera Tippera Oolloo	No grain yields taken	Williams, 1983
3 types rock phosphate (Duchess, Christmas Island 'A' & 'C') each at 3 rates (1,2,3 t/ha P) compared with superphosphate (0,10,20,30 kg/ha P)	1983-84	Douglas Daly	Tippera	Significant differences between treatments in first year (experiment discontinued)	Williams, et al, 1984
Minor nutrient experiment -K, Zn, Mg Mn, Cu, Fe, Mo, B. Treatments applied were control, full minor nutrients and 'minus one' nutrient treatments. Treatments applied in 1983-84 after identical treatments applied to peanuts in 1982-83	1983-84	Douglas Daly	Blain	Zn found to be the main nutrient deficient. Minus Zn and control treatments yielded significantly less than other treatments. Mo content in kernels low in minus Mo and control treatments and this should be considered when producing or planting seed in Blain soil	Flint, 1984
2 tillage methods (conventional tillage, no-tillage) x 5 N rates (0, 20, 40, 80, 160 kg/ha N) x 2 rotations (maize-soys, maize-maize)	Est. 1984-85	Douglas Daly	Tippera	No major differences in no-tillage in 1984-85. Large tillage differences but no differences between N treatments in 1985-86 either in vegetative growth or yield. Regardless of tillage or N treatment, maize vegetative growth and yield was better where ley had previously been Siratro compared with Verano stylo (Gould, pers. comm).	Unpub. data
	Est. 1985-86	Douglas Daly	Blain	Severe drought and minor nutrient deficiency stress. No differences in N treatments apparent (N. Gould, pers. comm.)	Unpub. data

APPENDIX 5: OBSERVED NUTRIENT PROBLEMS IN MAIZE ON DOUGLAS-DALY PROJECT FARMS 1982-83
Ref: Price & Garside, 1983

Farm	Paddock	Cropping History	Soil Type	Fertiliser Applied with Crop	Time of Application	Units Element Applied (kg/ha)	Av Yield (t/ha)	Nutritional Problems Observed and Comments
Ceres Downs	S1 + S2	Cropped 81-82, 82-83	Tippera	DAP Urea	Pre plant Post plant	33N 35P 5S 59N Total 92N 35P 5S	1.8-2.5	No major problems except irregular growth in patches
Kumbyechants	D2	Cropped 81-82, 82-83	Tippera	Crop Lift 20:10 Crop Lift 20:10 Urea	Pre plant At planting Post plant	30N 15P 20S 30N 15P 20S 46N Total 106N 30P 40S	0-0.5 1 small area 4.4	Poor seasonal conditions limited yield
Ruby Downs	V1	Virgin 81-82 Cropped 82-83	Tippera	GFN2 DAP GFN2 GFN2	Pre plant At planting At planting Post plant	38N 25P 30S 11Ca 9N 10P 2S 30N 20P 25S 9Ca 15N 10P 12S 4Ca Total 92N 65P 69S 24Ca	2.65	N and Zn deficiency observed. Plant analyses revealed low levels
Manneroo	1,2	Virgin 81-82 Cropped 82-83	Oolloo	Super CuMoZn Urea	Pre plant Post plant	28P 37S 66Ca 2.8Cu 2.8Zn 69N Total 69N 28P 37S 66Ca 2.8Cu 2.8Zn		NPSZn plant analyses showed P S and Zn low, possibly due to fertiliser being spread not banded
Theyona	2	Virgin 81-82 Cropped 82-83	Oolloo	Special Mix +S DAP	Pre plant Post plant	10P 45K 22S 4.3Zn 4.3Cu 24N 25P 4S Total 24N 35P 45K 5S 4.3Zn 4.3Cu	2.2	Poor season - potential nutrient deficiencies masked

APPENDIX 6: OBSERVED NUTRIENT PROBLEMS IN MAIZE ON DOUGLAS-DALY PROJECT FARMS 1983-84
Ref: Price and Garside, 1984

Farm	Paddock	Cropping History	Soil Type	Fertiliser Applied with Crop	Time of Application	Units Element Applied (kg/ha)	Av Yield (t/ha)	Nutritional Problems Observed and Comments
Ceres Downs	S1	Cropped 81-82,82-83 83-84	Tippera	MAP & Sulphur Urea	Pre plant Post plant	23N 40P 21S 74N Total 97N 40P 21S	2.5	No major problems
	S3(part)	Cropped 82-83,83-84	Tippera	MAP & Sulphur Urea & Zn Oxide	Pre plant Post plant	23N 40P 21S 60N 4Zn Total 83N 40P 21S 4Zn	Av 3.2 Pig damage reduced harvested yield	No major problem
	S3(part)	Cropped 82-83,83-84	Tippera	MAP & Sulphur Sulphate of Amm	Pre plant Post Plant	23N 40P 21S 31N 36S Total 54N 40P 57S	"	Mr Royle thought this part of the paddock yielded better than where urea had been top dressed
	S5(part)	Cropped 82-83,83-84	Tippera	MAP & Sulphur Urea	Pre plant Post Plant	20N 33P 21S 60N Total 80N 33P 21S	3.0	No major problem
	S6	Virgin 82-83 Cropped 83-84	Tippera	MAP & Sulphur Urea	Pre plant Post Plant	20N 33P 21S 62N Total 82N 33P 31S	2.8	No major problem
Kumbyechants	D2	Cropped 81-82, 82-83 83-84	Tippera	MAP Urea Sulphate of Amm. Urea	Pre plant At planting Post plant Post plant	18N 30P 4S 6N 10N 12S 46N Total 80N 30P 16S	3.2	No major problem

APPENDIX 6: (Cont'd)

Farm	Paddock	Cropping History	Soil Type	Fertiliser Applied with Crop	Time of Application	Units Element Applied (kg/ha)	Av Yield (t/ha)	Nutritional Problems Observed and Comments
Kumbyechants (Cont'd)	D2 ext	Cropped 81-82, 82-83 83-84	Tippera	MAP Urea MAP Sulp. Amm + Urea	Pre plant At planting Post Plant Post plant	18N 30P 4S 8N 4N 7P 1S 56N 12S Total 86N 37P 17S	3.2	No major problems
	H2	Cropped 82-83, 83-84	Tippera	MAP Urea MAP + Urea Sulp. of Amm.	Pre plant At planting Post plant Post plant	16N 28P 4S 4N 45N 7P 1S 10N 12S Total 75N 35P 17S	3.4	No major problems
	H5	Virgin 82-83 Cropped 83-84	Tippera	MAP Urea Sulp. of Amm. Urea	Pre plant At planting Post plant Post plant	18N 30P 4S 8N 10N 12S 46N Total 82N 30P 16S	2.8	No major problems
Theyona	Liddys	Part Cropped 82-83, 83-84 Part virgin 82-83 Cropped 83-84	Oolloo	MAP Sulphur Urea Zn Oxide	Pre plant Pre plant Post plant Post plant	23N 40P 5S 10S 74N 4Zn Total 97N 40P 15S 4Zn	1.5	Area which had been cropped to soybeans the previous year had no major problems. Virgin country severe nutritional problems - at least S and Zn
	Bucknell	Virgin 82-83 Cropped 83-84	Oolloo	As above	As above	As above	0.5	Severe nutritional problems - at least S and Zn

APPENDIX 6: (Cont'd)

Farm	Paddock	Cropping History	Soil Type	Fertiliser Applied with Crop	Time of Application	Units Element Applied (kg/ha)	Av Yield (t/ha)	Nutritional Problems Observed and Comments
Theyona (Cont'd)	Front	Virgin 82-83 Cropped 83-84	Oolloo	MAP Sulphur Urea Zn Oxide	Pre plant Pre plant Post plant Post plant	23N 40P 5S 10S 74N 4Zn Total 97N 40P 15S 4Zn	1.5	Severe nutritional problems at least S and Zn
	Centre	Cropped 82-83 83-84	Oolloo	MAP Urea Zn oxide	Pre plant Post plant Post plant	23N 40P 5S 74N 4Zn Total 97N 40P 5S 4Zn	1.5	No major problems

APPENDIX 7: OBSERVED NUTRIENT PROBLEMS IN MAIZE ON DOUGLAS-DALY PROJECT FARMS 1984-85
Ref: Price, 1985

Farm	Paddock	Cropping History	Soil Type	Fertiliser Applied with Crop	Time of Application	Units Element Applied (kg/ha)	Av Yield (t/ha)	Nutritional Problems Observed and Comments
Ceres Downs	S2	Cropped 81-82, 82-83 83-84, 84-85	Tippera	DAP Sulp of Amm.	Pre plant Post plant	29N 30P 5S 36N 42S Total 65N 30P 47S	4.3	No major problems
	S5	Cropped 82-83, 83-84 84-85	Tippera	DAP Sulp. of Amm. Urea	Pre plant Post plant Post plant	29N 30P 5S 36N 42S 46N Total 111N 30P 47S	3.6	N deficiency observed thought due to be N tie up by mulch - this crop had 82N at topdressing cf S2 which grew well using 36N at topdressing
	S6	Cropped 83-84, 84-85	Tippera	DAP Sulp. of Amm.	Pre plant Post plant	29N 30P 5S 36N 42S Total 65N 30P 47S	1.1	No major problems
Kumbyechants	H1	Cropped 81-82, 82-83 83-84, 84-85	Tippera	GFN6 Sulp. of Amm.	"	91N 29P 3S 10N 12S Total 101N 29P 15S	5.1	"
	H2	Cropped 82-83, 83-84 84-85	Tippera	"	"	"	4.9	"
	H3	Cropped 81-82, 82-83 83-84, 84-85	Tippera	"	"	91N 29P 3S 20N 24S Total 111N 29P 27S	3.3	"

APPENDIX 7: (Cont'd)

Farm	Paddock	Cropping History	Soil Type	Fertiliser Applied with Crop	Time of Application	Units Element Applied (kg/ha)	Av Yield (t/ha)	Nutritional Problems Observed and Comments
Kumbyechants (Cont'd)	H4	Cropped 83-84, 84-85	Tippera	GFN6 Sulp. of Amm.	Pre plant Post plant	91N 29P 3S 36S Total 91N 29P 39S	0.7	No major problems
	D2	Cropped 81-82, 82-83 83-84, 84-85	Tippera	"	"	91N 29P 3S 10N 12S Total 101N 29P 15S	4.2	"
	D2 Ext	Cropped 81-82, 82-83 83-84, 84-85	Tippera	"	"	"	4.2	"
	D3	Cropped 81-82, 82-83 83-84, 84-85	Tippera	"	"	"	4.3	"
	A2	Cropped 83-84, 84-85	Tippera	"	"	"	1.6	"
Bonalbo	V3	Cropped 82-83, 84-85	Oolloo	DAP Sulp. of Amm. Potash Zn oxide Urea	Pre plant Pre plant Pre plant Post plant	34N 30P 5S 30N 36S 25K 5Zn 46N Total 110N 30P 41S 25K 5Zn	3.0	Zn deficiency

APPENDIX 7: (Cont'd)

Farm	Paddock	Cropping History	Soil Type	Fertiliser Applied with Crop	Time of Application	Units Element Applied (kg/ha)	Av Yield (t/ha)	Nutritional Problems Observed and Comments
Bonalbo (Cont'd)	V4	Virgin 83-84 Cropped 84-85	Oolloo	DAP Sulp. of Amm. Potash Zn oxide Urea	Pre plant Pre plant Pre plant Pre plant Post plant	38N 40P 6S 30N 36S 25K 5Zn 46N Total 114N 40P 42S 25K 5Zn	3.0	Zn deficiency
	V6	Virgin 83-84 Cropped 84-85	Oolloo	"	"	"	1.3	"
	V7	Virgin 83-84 Cropped 84-85	Oolloo	"	"	"		"
Theyona	Liddy	Cropped 82-83, 83-84 84-85	Oolloo	DAP Urea Zn sulp. hepta as spray	Pre plant Post plant Post plant	32N 34P 5S 69N 1Zn Total 101N 34P 5S 1Zn	1.8	No major problems
	Centre	Cropped 82-83, 83-84 84-85	Oolloo	"	"	40N 42P 6S 69N 1Zn Total 109N 42P 6S 1Zn	2.3	"
	Fleming	Cropped 83-84 84-85	Oolloo	DAP Urea Sulp. of Amm. ZN Sulp. hepta	Pre plant Post plant Post plant Post plant	32N 34P 5S 30N 20N 23S 1Zn Total 82N 34P 28S 1Zn	1.3	"

APPENDIX 8: OBSERVED NUTRIENT PROBLEMS IN MAIZE ON DOUGLAS-DALY PROJECT FARMS 1985/86
Ref: Price, 1986 (in prep)

Farm	Paddock	Cropping History	Soil Type	Fertiliser Applied with Crop	Time of Application	Units Element Applied (kg/ha)	Nutritional Problems Observed and Comments
Ceres Downs	S2	Cropped 81-82,82-83 83-84,84-85,85-86	Tippera	DAP and Zn Sulp. Sulp. of Amm.	Pre plant Post plant	29N 30P 5S 5.3Zn 28N 32S Total 57N 30P 37S 5.3Zn	No major problems observed
	S3	Cropped 82-83,83-84 84-85,85-86	Tippera	"	"	"	"
	S5	Cropped 82-83,83-84 84-85, 85-86	Tippera	"	"	"	"
	S6	Cropped 83-84,84-85 85-86	Tippera	"	"	"	"
Kumbyechants	H1	Cropped 81-82,82-83, 83-84,84-85,85-86	Tippera	Dawes Special Mix	Pre plant	71N 25P 7S 7Zn	"
	H2	Cropped 82-83,83-84, 84-85,85-86	Tippera	"	"	"	"
	H3	Cropped 81-82,82-83 83-84,84-85,85-86	Tippera	"	"	"	"
	H4	Virgin 82-83 Cropped 83-84,84-85 85-86	Tippera	"	"	"	"

APPENDIX 8: (Cont'd)

Farm	Paddock	Cropping History	Soil Type	Fertiliser Applied with Crop	Time of Application	Units Element Applied (kg/ha)	Nutritional Problems Observed and Comments
Kumbyechants	H5	Cropped 83-84,84-85 85-86	Tippera	Dawes Special Mix	Pre plant	71N 25P 7S 7Zn Total 71N 25P 7S 7Zn	No major problems
	H6	Cropped 84-85,85-86	Tippera	"	"	"	"
	D2	Cropped 81-82,82-83 83-84,84-85,85-86	Tippera	"	"	"	"
	D3	Cropped 81-82,82-83 83-84,84-85,85-86	Tippera	"	"	"	"
	A1	Cropped 82-83,83-84 84-85,85-86	Tippera	Dawes Special Mix Sulp. of Amm. DAP	Pre plant Pre plant Post plant	71N 25P 7S 7Zn 24S 10N 10P Total 81N 35P 31S 7Zn	"
	A2	Cropped 83-84,84-85 85-86	Tippera	Dawes Special Mix	"	71N 25P 7S 7Zn Total 71N 25P 7S 7Zn	"
Bonalbo	V3	Cropped 82-83,84-85 85-86	Oolloo	DAP Urea Sulp. of Amm. Zn sulphate Cu sulphate Urea Sulp. of Amm.	Pre plant Pre plant Pre plant Pre plant Pre plant Post plant Post plant	29N 30P 5S 10N 10N 12S 15Zn 7Cu 25N 11N 13S Total 85N 30P 30S 15Zn 7Cu	Mg deficiency observed late Jan. S deficiency observed late Feb. See text for comments

APPENDIX 8: (Cont'd)

Farm	Paddock	Cropping History	Soil Type	Fertiliser Applied with Crop	Time of Application	Units Element Applied (kg/ha)	Nutritional Problems Observed and Comments
Bonalbo (Cont'd)							
	V4	Virgin 83-84	Oolloo	DAP	Pre plant	29N 30P 5S	Mg deficiency observed late Jan.
		Cropped 84-85,85-86		Urea	Pre plant	10N	S deficiency observed late Feb.
				Sulp. of Amm.	Pre plant	10N 12S	See text for comments
				Zn sulphate	Pre plant	15Zn	
				Cu sulphate	Pre plant	7Cu	
				Urea	Post plant	25N	
				Sulp. of Amm.	Post plant	11N 13S	
						Total	
						85N 30P 30S 15Zn 7Cu	
	V6	Virgin 83-84	"	"	"	"	"
		Cropped 84-85,85-86					
	V7	Virgin 83-84	"	"	"	"	"
		Cropped 84-85.85-86					
Theyona	Liddys	Cropped 82-83.83-84	Oolloo	DAP	Pre plant	14N 15P 2S	Nutrition problems observed, compounded by
		84-85,85-86		Urea	Pre plant	25N	dry conditions. Suspected Mg deficiency
				Sulp. of Amm.	Pre plant	11N 13S	observed, other problems unidentified.
				Potash	Pre plant	12.5K	
				Elemental S	Pre plant	15S	
				Zn sulphate	Pre plant	7.5Zn	
				DAP	Post plant	14N 15P 2S	Elemental S largely unavailable therefore
				Urea	Post plant	25N	approx. 30 kg/ha available S applied
				Sulp. of Amm.	Post plant	11N 13S	
				Potash	Post plant	12.5K	
				Elemental S	Post plant	15S	
				Zn sulphate	Post plant	7.5Zn	
						Total	
						100N 30P 60S 25K 15Zn	

APPENDIX 8: (Cont'd)

Farm	Paddock	Cropping History	Soil Type	Fertiliser Applied with Crop	Time of Application	Units Element Applied (kg/ha)	Nutritional Problems Observed and Comments
Theyona (Cont'd)	Front	Virgin 82-83 Cropped 83-84,84-85 85-86	Oolloo	DAP	Pre plant	14N 15P 2S	Nutrition problems observed, compounded by dry conditions. Suspected Mg deficiency observed, other problems unidentified.
				Urea	Pre plant	25N	
				Sulp. of Amm.	Pre plant	11N 13S	
				Potash	Pre plant	12.5K	
				Elemental S	Pre plant	15S	
				Zn sulphate	Pre plant	7.5Zn	
				DAP	Post plant	14N 15P 2S	Elemental S largely unavailable therefore approx. 30 kg/ha available S applied
				Urea	Post plant	25N	
				Sulp. of Amm.	Post plant	11N 13S	
				Potash	Post plant	12.5K	
				Elemental S	Post plant	15S	
				Zn sulphate	Post plant	7.5Zn	
						Total 100N 30P 60S 25K 15Zn	
	Centre	Cropped 82-83,83-84 84-85,85-86	Oolloo	"	"	"	"
	Flemings	Cropped 83-84,84-85 85-86	Oolloo	"	"	"	"