"A REVIEW OF PHOSPHORUS NUTRITION - RESEARCH AND DEVELOPMENT"

PROJECT DAQ-077

FOR THE MEAT RESEARCH CORPORATION

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CONTENTS

Summary and Recommendations

This review was commissioned by the MRC to collate relevant data on phosphorus nutrition, particularly as it relates to the beef breeding herd, and to recommend additional R&D required to meet industry needs in northern Australia.

The project was conducted January - April 1992 and the process and findings were:-

- 55 scientists, extension officers, consultants and producers were interviewed and a further 10 questionaires returned.

- a literature review concentrating on associations of phosphorus and reproduction using CAB and AGRIS data bases back to 1974. The literature review did not provide any new directions or ideas for phosphorus research. The September 1990 issue of Tropical Grasslands covers the topic of phosphorus and beef production very comprehensively for northern Australia and should be the basis for recommendations to industry.

- examining a number of projects funded by MRC since 1985. These included mineral nutrition of legume based cattle production systems in northern Australia; effects of dietary nitrogen and phosphorus deficiencies in yearling cattle; phosphorus absorption and excretion rates and reproduction in pregnant heifers/lactating first calf cows; diagnosis of bone mineral density; soil fertility surveys of central and north Queensland and the results of the 1990 North Australia beef producer survey.

- the main current activities in phosphorus nutrition involve the development of a crush side measurement of P status based on tail bone density and a number of PDS activities which have P supplementation incorporated as part of an improved management package. Overall there has been a general disintergration of resources and staffing involved in phosphorus nutrition.

The major recommendations of this review concerning potential areas of R&D with phosphorus are:-

- MRC funding over the next 5 years should concentrate on animal, particularly the breeding female, rather than plant or soil responses with additional P as a supplement rather than as a fertiliser source.

- a high priority is given to providing financial support for continued field studies into simultaneous work with breeders determining the P requirements of different classes and for the further development of diagnostic technology based on both blood metabolites and tail bone density measurements.

- the production of a Technical Manual of phosphorus deficiency, diagnosis and correction for advisors to industry is recommended as a high priority.

- the provision of financial support for the establishment of additional or enhancement of existing herd management demonstrations in varying P deficient situations, of which P supplementation is one input, is supported as a medium priority. These sites must be involved with the more detailed research aspects outlined above to enable verification/modification of breeder P requirements and diagnostic methodology.

- a medium priority is given to financially supporting workshops to develop a wider appreciation of the land type surveys of central and north Queensland.

- MRC funding for additional work on better P delivery systems and case studies was not supported.

1. INTRODUCTION

This project was a contract review for the Meat Research Corporation conducted in January - April 1992. A survey conducted by QDPI in 1990 for MRC indicated extensive usage of phosphorus supplements in some areas of northern Australia. Many producers indicated a supplementation practice contrary to recommended advice and less than 25% of producers identified P supplementation as an issue requiring further research. During the same period, a number of research projects related to phosphorus nutrition were completed with results relevant to industry. This review was commissioned to collate relevant data on phosphorus nutrition, particularly as they relate to the breeding herd and to recommend additional R & D required to meet industry needs.

There were a number of specific objectives:

i) to identify existing knowledge relevant to the use of fertilisers and supplements for phosphorus nutrition of both breeding and growing cattle;

ii) to indicate R & D that is being undertaken at present;

iii) to comment on the situation with diagnosis of phosphorus status in cattle;

iv) to identify the value of a case study approach as a methodology in determining further R & D; and importantly

v) to identify and prioritise worthwhile R & D required to increase the uptake of phosphorus nutrition technology in breeding and growing cattle.

In all, 55 scientists, extension officers, producers and consultants were interviewed. A further 10 written replies to a questionnaire were received.

Although there were common threads, the types of questions being posed about P nutrition varied according to the groups. Producers tended to ask - should I feed; how, when and to what animals; what are the economic consequences? Extension officers queried the economic return of supplementing breeding and growing cattle; frequency of feeding during the wet; better delivery methods and the necessity to supplement with early weaning. Researchers were particularly concerned with the biological response to P and P requirements of different classes of animals.

Answers to many of these questions are site and management specific and will not necessarily be answered by further R & D. Rather research can provide answers to generic questions embodied in the "should I, when, how much?" type questions which may lead to their local solution. Notwithstanding, many answers are provided in the 1990 Tropical Grasslands review and the final reports of PO.19, AP.UQ.03 and CS.148. There is an attitude out 'there' that we know very little about phosphorus. We have come a long way in the last five years of our understanding of P kinetics, requirements and anticipated responses mainly for growing cattle. We need to communicate this better.

2. BACKGROUND

a) Literature Review

Literature searches were done back to 1974 using both CAB and AGRIS data bases. This date was chosen as it provided information as a sequel to the reviews of Cohen (1975) and Teleni (1976). In addition, a number of journals published in 1991-92 were perused.

The review concentrated on phosphorus and reproductive associations. Despite the effort, there is little to show for it, as the eleven papers in the September 1990 issue of Tropical Grasslands cover the topic of phosphorus and beef production very comprehensively and should be the basis for recommendations to the northern Australian beef industry. The recent reports of AP.UQ.03 and CS148 add further to that knowledge.

My literature search did not provide any new directions or ideas for phosphorus research to those suggested by the Tropical Grasslands review.

The literature review did highlight some areas not mentioned by the Tropical Grasslands review. These were

- positive reproductive responses to P supplementation of breeders;
- associations between blood P and various reproductive disorders;
- continued lack of evidence of a direct effect of P deficiency and reproduction.

These findings are detailed in Appendex 1.

Cohen, R.D.H. (1975). Phosphorus for grazing beef cattle, AMRC Review No. 23.

Teleni, E. (1976). Veterinary Reviews and Monographs 3. Phosphorus nutrition of cattle grazing Australian tropical pastures, JCUNQ.

b) Studies Funded by MRC Since 1985 That Influence This Review

CS.PO.19 Mineral nutrition of legume based cattle production systems in northern Australia.

This was conducted by CSIRO, QDPI and in the latter stage UQ at Springmount, Lansdown and Narayen. These studies followed previously funded work at Katherine during 1981-84.

The participating scientists were: Mr David Coates (Co-ordinator), CSIRO, Townsville
Dr Mike Gilbert, QDPI, Mareeba
Mr Ron Hendricksen, QDPI, Mareeba
Dr Peter Kerridge, CSIRO, Brisbane
Mr Ron McLean, CSIRO, Brisbane
Dr Joe Miller, QDPI, Mareeba
Dr John Ternouth, UQ, Brisbane joined the project team in 1988

The project received MRC funding for five years, July 1986 to July 1991. The project developed integrated pasture and animal management recommendations for growing cattle grazing legume based pasture systems. A final report was presented in 1991.

A summary of the major findings were:-

- sown legume pastures were adapted to this environment but required additional phosphorus to be productive.

- cattle productivity from legume-grass pastures was closely related to soil phosphorus. Soil P levels of 8 ppm produced near maximum legume yield and animal liveweight gain.

- phosphorus was the primary dietary limitation during the wet season whereas nitrogen/ energy intake was the major limitation during the dry season.

- a residual soil phosphorus model was validated and can be used to develop efficient fertilizer programs for producers.

AP.UQ.03 Investigation of the effects of dietary nitrogen and phosphorus deficiencies in cattle.

This was conducted as pen feeding trials in yearling cattle at Pinjarra Hills and Mt Cotton.

The participating scientists were: Dr J.H. Ternouth, Dept. of Agriculture, UQ; Dr N.P. McMeniman, Dept. Farm Anim. Med., UQ and Mr G. Bortolussi, Dept. of Agriculture, UQ.

The project received funding from 1987 to 1991 with a final report presented in 1992. The major findings and conclusions were:-

- under nitrogen deficient conditions, the P requirements of yearling cattle are low but should be increased when more N is fed.

- on low P legume-based pasture (eg. Stylo), there is a greater requirement for P than on grass pastures.

- a P intake of 5.5g/d is adequate to prevent P depletion of young growing cattle but inadequate for repletion of cattle exposed to a long term deficiency.

- existing estimates of P requirements of growing cattle consuming roughage-based diets are inappropriate.

- the combined use of plasma urea N and inorganic P are of value in determining dietary deficiencies of N and P and prediction of intakes of DM, N and P.

CS.148 Effect of P status on phosphorus absorption and excretion rates and reproductive function in pregnant and lactating beef heifers.

The project was conducted at Lansdown. The participating scientist were Mr David Coates, CSIRO and Dr John Ternouth, UQ.

The project was conducted in 1990/91 with pregnant heifers and lactating first calf cows grazing pasture of variable soil phosphorus status. A final report was presented in 1992.

The main findings were:-

- cows on low P pasture utilized phosphorus very efficiently.

- P deficiency had adverse effects on cow liveweight, milk production and calf growth rates but there was no direct effect of P deficiency on *post partum* reproductive function.

- current recommended P requirements for this class of animal appear to be substantially overestimated based on absorptive efficiency and endogenous faecal P excretion rates.

Project Report QO89025 (1989) The soil fertility of Capricornia grazing lands by P.G. Shields and E.R. Anderson.

The study was conducted from 1987 to 1989 and the soil fertility of the region's grazing lands was related to 16 land types which were grouped on the basis of similar vegetation, soils, parent material and extractable phosphorus levels. These land types were comprehensively described and their distribution was mapped.

North Australia Beef Producer Survey 1990 by P.K. O'Rourke, L. Winks and A.M. Kelly. (1992)

The survey provided information on property infrastructure, practices (including P supplementation and fertiliser usage) and issues of importance to producers. Some interesting outcomes were:-

- most producers who considered their properties deficient, fed P supplements. However only half of these producers feed during the wet season when requirement for P is greatest.

- whilst P supplementation was identified as one high priority area for improving profitability in northern areas, less than 25% of producers identified it as a topic requiring further research.

UNQ.NAP.AP3 Investigation of diagnosis of bone mineral disease using bone densitometry based on single photon absorption.

The principal scientists involved were: Dr M. Murray, Mr R. Heard amd Mr T. Boniface, all of JCUNQ.

The final report in 1989 indicated that the densitometer may be able to measure real differences in bone mineralisation. This project was taken further by Dr Peter Hopkins (Wooltech Ltd) and Mr David Coates, (CSIRO) comparing ultrasound speed with photon absorption superimposed upon the cattle at Lansdown grazing different P fertility levels. Cattle could be classified by both techniques into adequate, marginal and low P states.

c) Current Studies in Phosphorus Nutrition of Beef Cattle

There has been a general disintegration of resources and staffing involved in the previously funded project areas on phosphorus nutrition. This could have consequences for any future work. Dr P. Kerridge and Mr R. McLean, CSIRO, Brisbane have finished their field commitments and their efforts are now directed towards the GLASS project at Narayen. Mr R. Hendrickson, QDPI has been transferred from Mareeba to Rockhampton where his principal commitment is to diet selection studies in the stocking rate and legume augmentation studies in central Queensland. Mr D. Coates' role in future phosphorus studies is uncertain.

Ongoing activities include:

a) Dr J. Ternouth has one postgraduate student working on aspects of P and N metabolism in sheep. His experimental work has scaled down because of lack of funding, with his efforts directed towards scientific documentation of PO19, AP.UQ.03 and CS.148.

b) Dr Joe Miller is proposing, funds permitting, to demonstrate to producers the benefits of effective P supplementation in a number of northern Australian herds. Recent research results from PO19 and AP.UQ.03 have confirmed that plasma inorganic P measured at the end of the wet season and compared to locally developed reference values (e.g. supplemented cattle) can accurately diagnose P deficiency in steers. This needs to be validated with cows, and he is proposing to co-ordinate activities with various extension officers in NQ, NT & WA. A small pilot study commenced this financial year but was hampered by drought conditions.

c) The Springmount site is still available for P studies. Currently it is being maintained in limbo. This site contains 200 ha (16 paddocks of legume based pastures (each of 12.5 ha) of the old experimental site) plus an additional 150 ha of native pasture.

d) The classification of land types in north Queensland for soil fertility is continuing, based on the same principles as developed in central Queensland. This work is being done by Peter Shield's group, Land Research Branch, Indooroopilly with input from CSIRO, Townsville. This project will be completed by 1993 and this study plus the previous central Queensland report, will cover almost 50% of the cattle population of Queensland.

e) Work by Dr Peter Hopkins, Wooltech Ltd and Dr R. McCarthy, University of Melbourne on the crush-side diagnosis of bone density status of cattle using photon absorption and ultrasound velocity is on hold pending the outcome of this review. Dr Bill Ryan and Dr Jim Rowe of WADA, Perth are continuing preliminary studies in measuring coccygeal bone density using either a dual X-ray source or dual photon absorption. Tails of cows from various properties in the Kimberley are being collected and their bone density is being measured at the Q.E. II Hospital, Perth using the facilities of Dr Richard Princes' group. Their opinion is

that a dual source is more accurate and the preferred technique. They intend to monitor herds of varying P levels inputs and may link in with Dr Miller's survey in northern Australia.

f) Mr Geoff Fordyce, at Swans Lagoon, is looking at the effects of providing additional nitrogen to wet season supplements of P and Na to lactating first calf cows. This study is based on previous work from Swans Lagoon and Mt Bundey (McCosker *et al* 1991) that nitrogen may be limiting during the wet season and that responses to P occur when nitrogen is not limiting. This is being funded by DAQ.62 within the section of strategic supplementation of lactating first calf cows.

g) Mr Bruce Mutch from Cheetham Rural is conducting a heifer supplementation trial at Playfields, Dululu with animals being supplemented with P in the wet season and P and N in the dry season.

h) Dr Jim Hogan is currently reviewing nutritional activities of the CSIRO Division of Tropical Animal Production. Recommendations on the direction of this group's activities in P research, are directed towards strategic research areas.

i) There are some 34 ongoing or proposed PDS activities which have phosphorus incorporated as part of the management package. These can be grouped.

Improved breeder management packages.

Dagworth, Georgetown; Millungerra, Julia Creek; Fern Hills, Bajool; Craigilee, Mornish; Swanlea, Aramac; Victoria River Research Station (Kidman Springs), Katherine district.

Improved herd management practices based on self mustering and attractants.

Pinnacle, Laura; Maitland Downs, Palmer River; Drumduff, Mitchell River; Reigate, Croydon.

Improving P supplement intakes by better delivery systems.

Landers Creek, Millaroo; Eucembene, Bollon; Central Mt Wedge, Alice Springs district; Rosewood, Camfield and Limbunya in Katherine district.

Improving growth rate through stylo pastures and fertiliser/supplement.

Spring's Road, Mareeba; Ida Creek, Bowen; Forest Home, Georgetown; Thalanga, Torrens Creek; The Springs, Yaamba; Wycheproof, Calliope; Cedarvale, Lowmead; Bronte, Gayndah; Hodgson River, Katherine.

Improving establishment of pastures.

10 sites located in the Gulf and VRD areas of the NT.

d) Animal Phosphorus Levels and Diagnosis

The main effect of a P deficiency in cattle is to depress feed intake, with flow on effects to growth and indirect effects on reproduction and skeletal abnormalities. Unlike protein or energy, an insufficient dietary intake of Ca or P may take some months, depending on body reserves, to influence food intake.

Plasma Pi is a reasonable indicator of dietary P intake during periods of positive weight gain whereas bone mineral density (or levels of P in bone), reflects history of intake over the previous months. Plasma Pi is highly correlated with liveweight gain of growing cattle and is recommended for the diagnosis of dietary P deficiency in grazing cattle provided that samples are collected in the late wet (growing) season and that local reference values are used (Wadsworth *et al* 1990). The inclusion of PUN as well as Pi measurements may give an even more accurate measurement of dietary phosphorus intake (Bortolussi 1992).

Other measurements of animal P status have included cortical bone thickness, faecal P and urinary hydroxyproline. Cortical bone thickness determination is by an invasive method and, thus, does not lend itself to being a practical test whilst Wadsworth *et al* (1990) concluded that faecal P and urinary hydroxyproline were of little diagnostic value.

There is considerable misunderstanding with advisory staff that blood measurements are useless for measuring phosphorus deficiency, which is contrary to the opinion of Wadsworth *et al* (1990) and Bortolussi (1992). Unfortunately these relationships of blood parameters haven't been validated for breeders. The inclusion of latest recommendations in the proposed technical manual would counter these misconceptions.

There seems to be no singular test which reflects both current P intakes and body reserves, although this might ultimately be required to accurately assess additional P needs. A combination of dietary intake and body reserves reflects animal phosphorus status.

The crush-side densitometry approach is a noninvasive and reasonably simple method of providing a measure of bone mineral density which is a reflection of Ca and P status of the bone. The perceived problem of extrapolating bone mineral density to P levels in bone doesn't seem to be an issue because we are concerned with ash per volume of bone and this reflects Ca/P levels anyway. The two techniques, which measure either photon absorption or ultrasound velocity give similar results. The use of ultrasound is favoured because of its relative portability. The radioisotope source requires licencing. The densitometry studies have demonstrated that this technique can differentiate at a group level, between mobs of cattle of high and low phosphorus status. However the SE's are quite large with considerable overlap on an individual animal basis.

Bortolussi, G. (1992) Dietary nitrogen and phosphorus deficiency in cattle. PhD Thesis. Univ. of Qld.

Wadsworth, J.C., McLean, R.W., Coates, D.B. and Winter, W.H. (1990) Phosphorus and beef production in northern Australia. 5. Animal phosphorus status and diagnosis. *Trop. Grassl.* **24,** 185-196.

The measurement of an animal or mob phosphorus status has not yet been linked with an assessment of the necessity to provide additional phosphorus and this in turn needs to be related to some improvement in productivity.

If further work with bone densitometry is continued, it should be linked with studies assessing P requirements in breeders. Such a study could also consider production relationships with dietary P intake, Pi and PUN. There is no value in continuing bone mineral density studies in isolation.

POTENTIAL AREAS FOR RESEARCH AND DEVELOPMENT

The emphasis of MRC funding over the next five years for phosphorus R&D of cattle should be:

(i) towards animal rather than plant or soil responses;

(ii) towards the breeding female rather than the growing male; and

(iii) towards providing additional P via a supplemental source rather than as a fertiliser.

(iv) having field studies conducted on native pasture where the majority of breeders are located. Legume based pasture could be used where it is clear that results will not be compromised by the higher nutritional status.

Potential areas of R & D, from the perspective of the MRC, are discussed in order of priority. Recommendations include further work in controlled field situations with breeders, expanded use of producer herds and the aggregation of existing knowledge.

The simultaneous development of P requirements and improvements in diagnostic technology for breeders is given highest priority. Lack of this information is the most important limitation to efficient and effective use of P supplementation and hence breeder performance.

(a) Phosphorus Requirements of Breeders

The phosphorus requirements of breeding females needs to be determined for different physiological classes and combinations (pregnant/empty, wet/dry) by age and by time of the year to facilitate management recommendations which are both efficient and effective. If accurate assessments of P requirements can be developed, then sound managerial practices can be devised to overcome deficiencies.

Continued absence of this information is a substantial barrier to the efficient use of P supplementation. This information will not however overcome the problems of uneven distribution thoughout the herd, palatability and the need to segregate different classes of animals. These are managerial or application problems rather than research problems which would be considered in the publication of the Technical Manual.

Techniques are now available to obtain a better estimate of P requirements of grazing breeders. Bortolussi and Ternouth (summarised in the Final Report of AP.UQ.03) have developed predictive equations based on measurements of Pi and PUN that enable estimates of N and P intake and dietary N concentration. Additionally, Coates and Ternouth (CS.148, 1992) have provided estimates of P requirements of first calf cows grazing pastures of different P status using measurements of phosphorus absorption efficiency and endogenous faecal P excretion rates. Their results suggest that current recommended requirements for this class of animal are substantially overestimated. These studies show that we have feasible techniques to assess P requirements of the grazing

breeder. Further development of these techniques needs to be financially supported to enable an assessment of P requirements of other classes of breeders.

Studies in determining P requirements for breeders may give an indication of reproductive responses to providing additional P. Because of the necessity for more intensive field measurements, the anticipated number of breeders for requirement studies (60-80) are less than necessary to determine a statistical response in pregnancy rate. Therefore some other measure of reproductive activity needs to be built into P requirement studies e.g. progesterone assays, ovarian ultrasonography, etc.

Recommendation 1. High priority.

Financial support be provided for continued field studies into the determination of P requirements and for the further development of diagnostic technology for breeders, based on both blood metabolites and tail bone density measurements.

This work could be done with an MRC input of about $130,000/year for three years. Possible sites could be Lansdown or Springmount, Mareeba. Univ. of Qld, QDPI and CSIRO are potential participants. The work must lead the reproductive studies outlined in (c).

(b) Production of a Technical Manual

There is a considerable body of scientific and producer knowledge on phosphorus nutrition of grazing cattle in northern Australia which could valuably be drawn together in a Technical Manual for advisors to industry and producers. The last two years has seen the publication of considerable detail on soil, plant and animal relationships of phosphorus nutrition. viz Trop grasslands Vol 24 (1990); Final Reports of CS.P019, AP.UQ.03, and CS148 and the project report by Shields and Anderson on "The Soil Fertility of Capricorn Grazing Lands". These reports provide very sound recommendations on phosphorus nutrition and diagnosis in beef cattle. In addition, my interviews with researchers/extension officers/consultants, producers and commercial industry have revealed a wealth of anecdotal, circumstantial and biological (not statistically significant) evidence from people's experience, property records, property trials and PDS that collectively provide information on methods of supplementing, herd responses, etc. that can't be substantiated in the strict experimental sense. A Technical Manual would collate knowledge from a wide variety of sources.

Recommmendations would have a local (regional) flavour which seems to be essential for local acceptance and uptake. This activity could start immediately and be completed in twelve months.

Recommendation 2 - High priority

That a Technical Manual of phosphorus deficiency, diagnosis and correction, on a regional basis for northern Australia, be produced. The target audience should be advisors to industry with producers being a secondary target.

The manual should build on the efforts of Durand (1974) and Boorman (1991) and should provide details of what is considered the best available advice on issues such as diagnosis of deficiecy, phosphorus deficient areas, methods of providing phosphorus, choice of supplements, delivery options, interacting management and supplementation factors and anticipated cattle responses. It should have a northern Australia perspective with regional sections of relevance.

Material can be derived from a variety of sources. These are identified in Appendix 2. The manual would provide a short term solution to improving the efficiency of phosphorus nutrition of cattle. The success of the manual would be highly dependent upon the person or persons asked to perform this task and the degree of co-operation by industry advisors and producers. The format should be such that updates can be provided as new and relevant information becomes available. The anticipated cost is $80,000.

(c) Field Reproductive Studies

Wink's (1990) summary of the literature indicates that responses in reproductive rates from P supplementation are variable. Positive effects have been considered to be a function of improved liveweight rather than a direct effect at the ovarian or hypothalamic level. This hypothesis is supported by the recent work of Coates and Ternouth (CS.148, 1992) at Lansdown, where P deficiency had adverse effects on cow liveweight, milk production and calf growth rates, but there was no direct effect of P deficiency on *post-partum* reproductive function.

Variability of responses to P supplementation are most likely associated with concurrent deficiencies of protein and energy as well as a variety of management practices, especially under northern Australian conditions. Extension officers are of the general opinion that for the adoption of results there needs to be a local flavour. Thus, even if one could demonstrate a significant or marked biological response to phosphorus in one locality (e.g. north Queensland), it will have little influence on adoption say in north west Queensland or south east Queensland. Therefore, I am not supportive of field reproductive studies whose major objective is to measure a response to additional phosphorus. This is because of the confounding effects of concurrent N and energy deficiencies, variations in management procedures and of the site specificity and scepticism of extension staff and producers to extrapolation of results.

However, more wide reaching R & D is supported which demonstrates improved management practices, of which supplementary P is one of the inputs. Combinations of early weaning, dry season nitrogen supplementation, botulism vaccination and phosphorus supplementation at Dagworth and Burlington have consistently demonstrated improvements in branding rates of 10-15%. These can be widened into other areas considered marginal for P. I recognise that this approach still bases the use of additional phosphorus on best bet technology and will never answer the question of how much of the response is attributable to phosphorus. But is this important? I don't consider so, because there are a whole series of inputs that contribute to a final branding rate level.

Winks, L. (1990) Phosphorus and beef production in northern Australia. 2. Responses to phosphorus by ruminants - a review. *Trop. Grassl.*, **24**, 140-158.

Recommendation 3 - Medium priority

Provide financial support for the establishment of additional or enhancement of existing herd management demonstrations in varying P deficient situations of which P supplementation is one input providing that there is an involvement with the requirements/diagnostic studies outlined in Recommendation 1. These would cover localities not addressed by current PDS.

Studies of this nature should be established with producers who are prepared to give guaranteed (i.e. some form of leasing agreement) access over a number of years. This allows planning by tertiary institutions for slotting in postgraduate student activities. A key feature must be involvement with the more intensive reseach associated with determination of P requirements. This will enable field verification/modification of P requirements and diagnostic mehodology and may provide answers to questions such as the value of dry season feeding of P supplements.

d) Soil Fertility Surveys of Capricornia and NE Queensland Grazing Lands

There was a general perception from my interviews of research and extension officers that the soil fertility survey could not be used at the property level and is only of value from a research planners perspective of providing the 'big picture'. On the contrary, Peter Shields claims that there would not have been this effort put into defining the land types unless they could be recognised at the property/paddock level. The text of this report describing vegetation and land class associations is the important material rather than the map. This description of land types can be used at the property or paddock level for managerial planning, e.g. where to plant legumes, how to subdivide etc.

The report of Shields and Anderson has not been widely used by field staff because of the perceived inadequacies. This needs to be rectified through follow-up workshops with the aim of developing a wider appreciation by extension officers and producers, of the value of this project.

The soil fertility survey of North Queensland should continue in its present form. This, plus the Capricornia report, will cover about 50% of the Queensland cattle populations. A workshop for field staff is planned at the conclusion of the NQ survey. This should be broadened to include the Capricornia survey findings. Future soil survey activities of other regions of the state should not be commenced unless the NAP2 management group is satisfied that the previous survey reports are being used by industry.

The groupings for P levels for the North Queensland survey have yet to be decided. The considered opinion that soil P levels in North Queensland are generally lower than Capricornia would suggest that the three tier system < 10 mg/kg, 10-25 mg/kg and

Coates, D.B., Kerridge, P.C., Miller, C.P. and Winter, W.H. (1990) Phosphorus and beef production in northern Australia. 7. The effect of phosphorus on the composition, yield and quality of legume-based pasture and their relation to animal production. *Trop. Grassl.* **24**, 209-224.

Miller, C.P., Winter, W.H., Coates, D.B. and Kerridge, P.C. (1990) Phosphorus and beef production in northern Australia. 10. Strategies for phosphorus use. *Trop. Grassl.* **24**, 239-249.

>25 mg/kg is inappropriate. Consideration should be given to grouping land types based on anticipated responses to supplements and soil P levels required for successful establishment of stylos (see Miller *et al* (1990) and Coates *et al* (1990) for recommendations). Appropriate groupings for land types might be <5ppm, 5-8ppm, 8-15ppm and >15ppm.

(e) Delivery systems and alternative sources of phosphorus

There is a considerable amount of practical ingenuity presently looking at better delivery methods for P supplements, e.g. John Boorman with large sheltered troughs (see Bonechewing Country); Jack Peart in Alice Springs with his electronic water medicator and Alan Laing improving the palatability of DCP based supplements at Landers Creek, Millaroo. There may be value in putting more effort into training weaners to take supplements.

The confusing side of developing better delivery systems is that although the distribution of supplement intake is highly variable through the herd, there appears to be no correlation between individual animal supplement intake and subsequent performance or requirements.

Sewerage as an alternative source of P was considered in this review. The opinion is that this source is unsuitable because of contamination from heavy metals, organochlorines and viral pathogens.

MRC funding for additional work to look at better delivery systems is not warranted given the ongoing activities. It is unlikely that there is one solution but rather a number of methods. The proposed technical manual would highlight the successful techniques.

f) Case Studies

By definition, a case study examines previous property records and monitors past and future trends in both productivity and financial states, as a result of some change in management practice. A comparison over a number of years may give an assessment of progress.

Bill Holmes (1990) presented a case study approach to the economic assessment of P supplementation. In three areas of north Queensland (Tropical Grasslands Vol. 24: pp 250-255), P supplementation with or without husbandry improvements was shown to be profitable.

Several more of these case studies could be done using the technique of Holmes (1990) but these should be the normal responsibility of district extension officers, rather than requiring MRC funds. Such case studies could be developed comparatively easily and incorporated into the manual. Many of the interviewed extension officers claim that local visual demonstrations of management practices have the best impact on adoption of new technology. Case studies will provide good back up for local demonstrations of management practices.

g) Projected Costs of Recommendations

Year 1	1992/93	- P requirements of breeders + diagnostic techniques	$60,000
	$170,000	- Production of technical manual	$80,000
		- Field reproductive studies and validation of requirements/diagnostics	$30,000
Year 2	1993/94	- P requirements of breeders + diagnostic techniques	$130,000
	$170,000	- Workshop on soil fertility survey	$10,000
		- Field reproductive studies and validation of requirements/diagnostics	$30,000
Year 3	1994/95	- P requirements of breeders + diagnostic techniques	$130,000
	$160,000	- Field reproductive studies and validation of requirements/diagnostics	$30,000

TOTAL COST $500,000

APPENDIX 1 - Literature Review of Reproductive Associations

The following references were not cited by the 1990 Tropical Grasslands review.

A number of grazing studies have shown positive reproductive responses to P supplementation of breeders, the responses being attributable to improved liveweight.

- Plasto *et al* (1976) at Hungerford, Q; each year over a four year period, P supplementation through the water increased pregnancy rates. Mean increase of 4% units.

- McDowell *et al* (1984) in Bolivia, found a 12% increase in pregnancy rates of Zebu cross lactating first calf cows but not in heifers.

- Alegria *et al* (1988) in Peru, found 24% increase in pregnancy rates in Zebu cross heifers.

- McCosker *et al* (1991) at Mt Bundy, Northern Territory, reported a lift in breeder herd productivity of Brahmans with a wet season combination of minerals (including P) and NPN/protein but not to minerals alone.

- Rios *et al* (1977) in Panama, showed that oral P supplements and P fertilised pastures lifted calving rates by 6% and 11% units respectively.

- Gonzalez *et al* (1988) in Cuba increased birth rates and reduced calving to conception intervals with mineral supplementation.

In contrast, Hofer *et al* (1985) in Argentina, reported no improvement in fertility in Hereford cows supplemented on P deficient pastures.

Laredo *et al* (1976) in Colombia, showed that the addition of a trace mineral mix to a P supplement was of little consequence. This differed with Rosu *et al* (1985) in Romania, in which a mineral mix of which P was a major component, improved pregnancy rates.

Smith *et al* (1982) found that P supplementation of 10 g/day to lactating beef cows in the Victorian Mallee had no effect on subsequent calving rate although P supplementation produced small but significant liveweight responses in steers.

There have been a number of reports, mainly in dairy cows of associations of various reproductive conditions with either P deficiency, blood P levels or imbalances of blood Ca:P ratios, viz:

Silent heats	- Boiti *et al* (1984), Italy
Repeat breeders	- Agrawal *et al* (1985), India

Delayed return to service	-	Preinberg *et al* (1988), Russia; Surendra - Singh and Vadnere (1987), India; Mathai *et al* (1974), India; Marinov (1978), Hungary; Dindorkar and Kohli (1979), India; Hunter (1977), NSW
Impaired embryo survival	-	Doyle *et al* (1990), USA
Conception rates	-	Avidar *et al* (1980), Israel; Rapstad *et al* (1988), Sweden
Milk fever	-	Ghergariu *et al* (1986), Russia; Kubinski (1986), Poland; Gardner and Park (1973), USA; Dehning (1981), Germany
Retained placenta	-	Vukovic *et al* (1987), Croatia
Stillborn calves	-	Planski and Abrasher (1987), Bulgaria

Most of these reports are associations rather than contributing causes.

In contrast to the above, Rutjawaate - Taharnklaiew *et al* (1985) in Thailand found no significant differences between serum concentration of various minerals including P in small groups of infertile and fertile cows.

There is still no supportive evidence that a P deficiency *per se* has any direct effect on reproduction. Lamothe *et al* (1976) concluded after a study of uterine fluid that any field improvement of reproductive performance should be associated with some indirect effect rather than from a modification of uterine environment. Entwistle (1976 - unpublished data) found that, after a series of pen studies, an uncomplicated P deficiency did not influence ovarian or pituitary function in Shorthorn heifers or cows.

This work is supported by evidence from dairy cattle studies (Hecht *et al* 1977, Oklaholma; Carstairs (1978), Michigan; Call *et al* (1978), Utah; Hurley (1980) and Hurley *et al* (1982), Kentucky; Williams *et al* (1989)) that dietary P inadequacy does not alter reproductive endocrine function or oestrous intensity. However Ross Walker's 1985 survey of Atherton Tableland dairy farmers found that P supplementation improved oestrous display but this was not reflected in increased conception rates.

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APPENDIX 2 - Sources of Material for Technical Manual

This list is by no means exhaustive but it contains material and useful contact people most relevant to this review.

Publications

Tropical Grasslands (1990) **24,** pp 129-255. A series of eleven papers by various authors summarising state of the art knowledge on phosphorus and beef production in northern Australia.

Ternouth, J.H., McLean, R.W., Macdonald, R.N. and Adamu, A. (1990) - Field estimates of the phosphorus kinetics of grazing cattle. *Proc. Aust. Soc. Anim. Prod.*, **18,** 396-399.

Ternouth, J.H. (1990) - Re-estimation of the phosphorus requirements of cattle fed roughage diets. *Proc. Aust. Soc. Anim. Prod.*, **18,** 560.

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Final Reports

Project CS.PO.19 - Mineral nutrition of legume-based cattle production systems in northern Australia (1991).

Project AP.UQ.03 - Investigation of the effects of dietary nitrogen and phosphorus deficiencies in cattle, by J.H. Ternouth, N.P. McMeniman and G. Bortolussi (1992).

Project CS.148 - Effect of P status on phosphorus absorption and excretion rates and reproductive function in pregnant and lactating beef heifers, by D.B. Coates and J.H. Ternouth (1992).

Project Report - The soil fertility of Capricornia grazing lands, by P.G. Shields and E.R. Anderson (1989).

Technical Bulletins

Durand, M.R.E. (1974) - *Phosphorus deficiency in cattle.* Beef Cattle Husbandry Branch, QDPI. Tech. Bull. No. 3.

Boorman, J.A. (1991) - *Bonechewing country*, QDPI, Brisbane.

Producer Demonstration Sites

Interim or final reports from:
Angle C, Inglewood; Cheriton, Weengallon; Omeo, Weengallon; Dagworth, Georgetown; Kirkland Downs, Laura; Swanlea, Aramac; Ida Creek, Bowen; Landers Creek, Millaroo; Burlington, Mt Surprise, Millungera, Julia Creek; Spring's Rd, Mareeba; Forest Home, Georgetown; Thalanga, Torrens Creek; Reigate, Croydon; Maitland Downs, Palmer River; Drumduff, Mitchell River; Pinnacle, Laura; Fern Hills, Bajool, The Springs, Yaamba; Wycheproof, Calliope; Cedarvale, Lowmead; Hodgson River, Katherine; Central Mt Wedge, Alice Springs.

Field Trials

McArther River Station, Gulf district of Northern Territory - wet season phosphorus supplementation with phosrite (1984-1990). Contact A. Schlink, CSIRO, Perth or M. Carpenter, NTDPIF, Tennant Creek.

Galloway Plains, Calliope. Contact W. Burrows, QDPI, Rockhampton.

Kidman Springs (1990-1991) - phosphorus supplementation of breeders. Contact Tom Stockwell, NTDPIF, Katherine.

Playfields, Dululu. Contact Bruce Mutch, Cheetham Rural, Wacol.

Circulated Trial Reports by Beef Cattle Husbandry Branch Officers of QDPI

These reports were not cited in either the Tropical Grasslands review or Durand's technical bulletin.

88/2 - Standfast, N.F. and Gulbransen, B. - Evaluation of a dry powder dispenser for medicating stock water supplies.

79/6 - Loxton, I.D. - Phosphorus deficiency observation, Swan's Lagoon.

78/7 - Venamore, P. and Plasto, A.W. - Faecal phosphorus survey of the Balonne Shire.

76/6 - Plasto, A.W., Venamore, P. and Weller, M. - Phosphorus supplementation of breeders at Moombidary, Hungerford.

75/1 - Weller, M.C., Venamaore, P.C. and Plasto, A.W. - Phosphorus survey, Charleville area.

74/8 - Clarke, M.R. - Some observations of acceptance of P supplements by breeders at Swan's Lagoon.

73/7 - Edwards, W.J., Venamore, P.C. and Plasto, A.W. - Performance of breeders on red soil country, "Woodlawn", St George.

Consultants

Terry McCosker, Resource Consulting Services, Yeppoon.
Allan Holmes, Mareeba.
Peter McKeague, Mareeba.
Alastair Henderson, Taylor Byrne, Brisbane.
John Armstrong, Stanbroke, Brisbane.

Producers

Jim Lindsay, Prairie; Don Heatley, Home Hill; David James, Torrens Creek; David Steele, Burlington; John Andison, Bowen; G. Brabon, Townsville; Rodney Barrett, Bowen; Kerry Butler, Georgetown; Mick Anning, Bill Carter, Ernest Bassingwaithe and Roger Landsberg all of Charters Towers; J. Stewart, Townsville; P. Emmery, Marlborough.

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Commercial Companies

Bruce Mutch and Dean Newman, Cheetham Rural, Wacol
John Knights, Toowoomba.
Gary Kuhn, Incitec, Brisbane
John Gibbs, Brisbane
Dr Peter Hopkins, Wooltech Ltd, Launceston