AGRONOMIC FACTORS IN PASTURE AND FORAGE CROPS FARM MANAGEMENT IN TROPICAL AUSTRALIA

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INTRODUCTION

The major factors that limit the ability of a dairy cow to produce, in any environment, are the quantity and quality of feed available to it, and its genetic ability to produce. In tropical environments, feed quality is undoubtedly the major factor, though the adaptability of particular breeds to the environment is also of some importance.

In this review, emphasis is placed on agronomic factors, especially as they influence quality. For much of the year quantity is more than adequate in sub-tropical and tropical areas, but there are periods in the year when, due to restrictions imposed by lack of rainfall, low temperatures, or frost, both feed quantity and quality are lacking. Most frequently though, the major feature of forage that is available over much of the year to dairy cattle in the tropics is its low quality compared to temperate areas.

The high production that can be obtained from paspalum (*Paspalum dilatatum*)—white clover (*Trifolium repens*) pastures in temperate areas such as northern Victoria compared to the difficulty in getting high production from a similar pasture in the sub-tropical areas, highlights this difficulty in maintaining feed quality.

ESTABLISHMENT OF PASTURES AND FORAGE CROPS

Generally, the environment in the tropics or sub-tropics is dominated by the relative vigour of the herbage. Either as a forest, or as rampant weed regrowth, or as a degenerated pasture, the established species are generally persistent and difficult to eradicate. The success of efforts to establish species in any environment depends on the ability of the establishment technique to reduce or eliminate competition, or, as most frequently occurs in the tropics, the ability of the introduced species to compete with the regrowth of the existing species.

Cultivation

Several points relating to cultivation and its influence on establishment of pastures and forage crops should be noted.

Unfortunately, research scientists do not have a mortgage on "good farming" techniques. Though these techniques are almost impossible to define, there is little doubt that there have been examples where soundly conceived trials have met with disappointing or negative results due in large part to inadequate farming techniques.

Requirements for establishment

Defining the requirements under which the introduced species will most likely establish is often particularly difficult. A generally accepted axiom in agronomy is that the smaller the seed of the introduced species the better the seedbed that is required. This type of perfect seedbed is often quite incompatible with the other requirements of the environment, where a rough seedbed may be highly desirable to minimize erosion and runoff in high intensity rainfall situations. In this situation, for example, if lotononis (*Lotononis bainesii*) is the species to be established, inadequate information is generally available on the effect of this rough seedbed on the establishment of this species, or even whether it can reasonably be expected to establish at all.

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Minimum cultivation techniques

The extremely unreliable results that have been obtained with both sod seeding, and chemical seedbed preparation in sub-tropical and tropical areas highlight the lack of definition, once again of the conditions under which individual species are most likely to establish. From the point of view of reducing competition, chemical seedbed preparation may provide an answer. However, it would appear that other factors such as the competition of the still living or only partly killed root system for both nutrients and moisture reduce the ability of the introduced species to compete effectively. In addition, the physical environment in which the seed germinates also has some influence although it is hard to see why a chemical seedbed would be much less hospitable an environment than some very hastily and roughly prepared seedbeds.

Rolling

The problem of whether to roll a seedbed or not is of quite significant importance. Generally it is considered that best results are obtained with sowing on a firm seedbed. This frequently involves, ideally, rolling before sowing, and possibly after. However, the conditions under which a choice must be made are inadequately defined. For example, in a situation where runoff is likely to be a problem, rolling before sowing could provide an erosion prone situation for a short time.

Weed control

In line with the thesis that the introduced species can only establish if they are able to survive the competition from existing species, weed control (in the sense that any unwanted vegetation is "weed") is highly important. Under sub-tropical conditions where persistent rainfall is a problem, it is virtually impossible to destroy the existing vegetation with normal cultivation techniques. Where repeated cultivation is needed for weed control, structure can deteriorate markedly, particularly on lower fertility soils, long before a weed-free seedbed is obtained. What application chemicals have in this situation is not defined, although the economics of chemical application procedures is questionable.

Nutrient requirements at establishment

With the more widespread adoption of soil testing on a wide scale some limited progress is being made towards defining the nutrient position of certain soils. At best soil testing is able to differentiate between major soil types and give an indication of whether the level of a particular nutrient, relative to other soils, is high or low. It is still not generally possible to define critical levels for particular nutrients, though the work on phosphate application levels on wheat soils has enabled quite precise recommendations to be made. Basic recommendations on fertilizers for establishment have changed very little in recent years. The general recommendation for mixed grass-legume pasture establishment with 2 cwts per acre (251 kg/ha) of molybdenised superphosphate is safe, but is unlikely to be the ideal application rate under all circumstances in such a complex biological system. However, it appears that it is, at best, not wrong. There are though, a number of situations where soil phosphate levels, as indicated by soil tests and, in a limited number of cases, by field trials, are high. Under these situations, it is quite probable that 2 cwts (251 kg/ha) per acre of superphosphate is wasteful. However, even on these soils, young seedlings may need some readily available phosphate, and some superphosphate is needed. Generally, field experience is that satisfactory establishment of a wide range of pastures and crops on these high phosphate soils can be obtained without the use of superphosphate at sowing.

There appears to be little hope for any improvement in the definition of nutrient requirements at establishment, as there are so many factors that influence the successful establishment, that the "not wrong recommendation" is probably the safest and sanest.

Placement of fertilizer

Problems associated with osmotic, toxic and other effects of fertilizers in relation to seed germination are reasonably well defined, though with the widespread use of new fertilizers, there have been some erratic and difficult to explain establishment results. Undoubtedly, with high analysis fertilizers, placement is more critical than with low analysis products, and problems can arise if the seedbed is prepared too hastily, or the sowing is not carefully undertaken.

Almost certainly there are species differences too, but the relatively large range of new fertilizers available in Australia now pinpoints the need for more information on the effect particular fertilizers have on germinating seedlings. The confusion that exists about the relative danger of di-ammonium phosphate and mono-ammonium phosphate at establishment on both acid and alkaline soils is an example of this situation.

Type and form of establishment fertilizers

Generally, high analysis fertilizer forms are preferable because of the reduced labour involved in shifting them, although often their higher price means a cost penalty. However, many of these have no sulphur. Sulphur responses at sowing are unlikely, and therefore, providing some limitations with regard to suppression of germination are accepted, there is little risk in using fertilizers without any sulphur for establishment.

Rate of fertilizer at establishment

Probably the most important aspect of fertilizer use at establishment, particularly with pastures, is whether or not some nitrogen is to be used. If a relatively spectacular, and more vigorous establishment is desired, nitrogen certainly is useful. However, it may lead to a competitive advantage of grasses over legumes, unless both the time of sowing and the rate of application used at that time are assessed. High nitrogen rates with tropical grasses sown in summer can lead to severe shading of legumes such as lotononis or white clover. Nitrogen appears to be critical on low organic matter soils and where rapid grass establishment is important. However, it is considered that the starvation of grasses for nitrogen to encourage legume establishment is often not a justifiable means to achieve the end. The increased early forage production coupled with the more reliable establishment usually outweighs the possible competitive effects on the legumes. In fact, providing shading is not severe nitrogen often appears to enhance tropical legume establishment.

Time of sowing

Generally, this must be considered in relation to fertilizer rate and the species selected. It is almost impossible to avoid a sowing time that is not a compromise between the species. For example, a favourable establishment time for lotononis appears to be in the autumn, whilst sowing at this time, may reduce the ability of companion grasses such as Rhodes grass (*Chloris gayana*) or Pangola grass (*Digitaria decumbens*) to adequately establish before the onset of the lower temperatures.

Sowing time of temperate, short term forage species such as oats or ryegrass is also of importance. Under subtropical conditions many of these species can prematurely run to head if sown too early, though this varies with seasons and makes general recommendations suspect.

Species variations

The competition between species in a pasture to be established is of critical importance. For example the ideal sowing time, and fertilizer rate to enable successful establishment of prostrate legumes such as white clover and lotononis with summer growing grasses is by no means clear. The exclusion of nitrogen from the establishment fertilizer will frequently lead to poor grass growth in both the spring and autumn, and even though the legumes may establish, the production from the paddock is very much inferior. Because of the different growth habits, and management requirements, competition between species such as lotononis and siratro (*Phaseolus atropurpureus* cv. Siratro) make them virtually incompatible in the same pasture mixture. Of these two species, lotononis has some significant advantages for dairy production. Its higher digestibility, palatability, frost tolerance, and ability to withstand heavy grazing pressure make it a very useful species for relatively high dairy production. Siratro, on the other hand, is frequently unpalatable to dairy cattle, but nevertheless on less intensively managed areas serves a very useful purpose in providing a reasonable level of nutrition for growing replacement dairy stock, or for dry cows at certain times of the year. Unfortunately, in the dairy situation, the attributes of lotononis seem to have been largely ignored. Little effort has been spent on defining the situations under which lotononis can be established under dairy farming conditions.

Nodulation

Successful legume establishment is particularly associated with successful nodulation. The basic requirements for satisfactory nodulation are quite well defined but at a farm level they frequently are not critically observed. Often the seed sown has been inoculated by seed merchants and is not sown soon enough, or simple rules to prevent deterioration and *Rhizobium* death are not observed prior to sowing. How important the nodulation techniques and subsequent seed handling are in legume establishment probably is difficult to assess. However, it undoubtedly has been responsible for some failures that have been blamed on other causes such as incorrect fertilizer use, sowing techniques or the species itself.

The position of legumes with highly specific *Rhizobium* requirements is also important, particularly in situations where there is a high population of strains that can compete with the specific strain. This competition appears to lead eventually to the decline of the legume with the specific requirement, either to be replaced by a legume with less specific needs (e.g. the decline of subterranean clover—(*Trifolium subterraneum*) in the face of competition from white clover in some sub-tropical areas) or to disappear altogether.

MANAGEMENT OF ESTABLISHED FODDER CROPS AND PASTURES

Supplementary watering

In this review, almost a negative emphasis is being placed on the value of supplementary irrigation. Though economic aspects of dairy production in the tropics are not considered in this conference, widespread experience is that the value of supplementary water is highly questionable on economic grounds, though there are some situations where agronomically it may be useful. In many cases it is simply used to prop up a temperate pasture system, such as ryegrasses (*Lolium spp.*) and white clover in a very artificial way. In fact, when it is considered in the

light of the build up of clover root weevil (*Amnemus quadrituberculatus*) in some irrigated white clover pastures, the situation can be so critically artificial that failure to irrigate every 48 hours in summer can mean the total failure of the pasture because of the severely damaged root system. Under these circumstances, irrigation is not only of marginal economic value but is only being used to maintain a dangerously sensitive pasture system that could fail very quickly with unfortunate effects on dairy production.

In addition, irrigation is generally accepted as being of little benefit in a drought as it is impossible to irrigate sufficient area of fodder crops or pastures to provide feed for the herd normally carried on the property. Under these circumstances, the only irrigation that is of use is supplementary irrigation, used recurrently in the tropical dry season. This can be particularly valuable, but unless it is in the true tropics where there is an absolute absence of rain in the dry season, rainfall is generally sufficient to quite high dairy production with just the use of fertilizers and good pasture and forage crop management techniques.

Mowing or slashing

The value of slashing in pasture management to maintain high dairy production or growth rates of growing young stock is ill defined. Farmers usually slash because they think it is a "good thing", or because the farm looks untidy. Almost certainly it is of value, but the inter-relationships between stocking rates, slashing height and frequency, and feed quality are not well known. In fact, in grazing trials involving a range of stocking rates, it is possible that some of the effects of the low stocking rates and high fertilizer rates where feed gets away from the animals, could be reduced with slashing. From a "first principles" basis slashing followed by topdressing with nitrogen on grass pastures is a satisfactory way of increasing feed quality, but there is a dearth of experimental evidence to support or reject this idea. In fact, for commercial field application it has been necessary to "invent" management and topdressing systems that seem likely to be successful rather than to apply research findings.

There is an abundance of information on the dry matter that can be produced at different levels of fertilizer applications, but this is generally not related to the quality of the feed offered to the animals, which is at least as important in determining dairy production. It is largely unknown what amount of potential dry matter has to be sacrificed to maintain feed quality, particularly protein content. Following topdressing with nitrogen the protein content of pastures allowed to grow out ungrazed, declines with time. If however, a slashing or grazing regime is superimposed on this system, it will have a marked effect on protein content and other aspects of feed quality. The magnitude of this effect is unknown.

Pasture renovation

The renovation or substantial physical disturbance of established pastures for no other apparent reason than to improve the paddock in some indefinable way is a long surviving farm practice. What renovation achieves is rather poorly known. Undoubtedly, one of its major effects is a release of nitrogen and possibly sulphur following the physical disturbance of the soil, and almost certainly it can be of value in increasing infiltration rates on so called "sodbound" pastures. Undoubtedly though, in the act of renovation, some mortality of the existing pasture must occur, and though this is probably compensated for by stimulated growth in the plants that survive, renovation is probably not all beneficial in its effects.

The question of when to renovate, if at all, compared to fertilizing is a critical one. Effective renovation with heavy equipment is relatively expensive. Generally, if deep renovation is undertaken, it must be carried out with a crawler tractor, probably at a cost of $5 to $7 per acre ($12-$17/ha). This sum of money would supply quite a substantial amount of fertilizer, such as sulphate of ammonia, which would supply both nitrogen and sulphur, if in fact these are the two major nutrients released during the renovation.

The problem of caking of surface soils has been overcome under some circumstances by the addition of gypsum to the soil surface. Certainly this approach will not work on all soil types. In many instances it is considered that more satisfactory long term results could be obtained by fertilizing rather than renovation unless there is a severe infiltration problem.

Nutrition of established pastures and fodder crops

Fodder crops

If the thesis is accepted that in the tropical environment it is unlikely to be possible to establish a stable, persistent temperate winter and summer growing pasture or forage crop system, it is still necessary to fill the feed gap created by low temperates, and frost. The annual resowing of temperate forage species seems most likely to succeed in this respect, and established practice now indicates that graminaceous species such as oats or ryegrass, fertilized with nitrogen, provide a commercially acceptable method of filling this low temperature feed gap.

However, the problems of establishment as pointed out earlier in this review, are only a small part of the overall problem of getting the maximum usable dry matter from the area concerned. Topdressing with fertilizers, especially nitrogen, together with other techniques such as mowing are also important. A substantial amount of work has been done on these temperate species, but at a commercial level there is still some doubt in the minds of farmers, particularly in respect of the rate of nitrogen that is most desirable, and how often it should be applied. Evidence is building up to suggest that the "little and often" approach to nitrogen, with relatively small amounts applied after each grazing give the best combination of quality and quantity. This however, is often incompatible with a farmer's workload, and it may not be possible for him to do this. The penalty he pays for using fewer applications in terms of deterioration in quality of regrowth after, say, the second grazing since topdressing is not well known.

Nutrition of established pastures

It has been difficult under grazing to maintain stable legume-grass pastures. With too heavy grazing pressure legumes tend eventually to be dominated by the companion grass or with light grazing, in areas where legumes persist satisfactorily, they can overgrow the grasses. Under circumstances where higher grazing pressures are indicated, a case can be made in favour of nitrogen fertilized grass with disregard for the legume. This has the additional benefit of producing far more dry matter, although the question of the quality of this dry matter is even more important. The combination of nutrients, including phosphate, nitrogen and other nutrients, as well as their time and rate of application as they influence feed quality is not well known. For example, with high producing dairy animals, it may be desirable to topdress more often than once per annum with fertilizers containing phosphorus and calcium even though there is no indication of a response in dry matter production from the paddock.

The "little and often" approach to a nitrogen topdressing as mentioned above, most probably applies even more so to established grass dominant pastures. However, the ability of grass dominant pastures to produce large quantities of dry matter at the peak of the summer but tapering off in the cooler spring and autumn months, indicates that the area that must be topdressed to provide a dairy herd with sufficient high quality feed will vary with the season.

Unpalatability of fertilized established pastures can be a recurrent and unpredictable though minor problem. Most commonly it is explained as "too high a nitrogen level", but it is not known whether this is either the only or major reason. It is a problem that would be extremely difficult to investigate because of the unpredictable nature of its occurrence, but at a commercial level it can be a deterrent to farmers to increase nitrogen use, especially after they have experienced the situation where high producing cows refuse to eat pasture that has been topdressed at considerable cost.

Species interactions

The problem of maintaining a legume in the pasture is a recurrent one. Aside from the arguments on whether a legume is necessary or not, the management aspects of maintaining legumes, particularly the twining sub-tropical ones in a grass pasture, are considerable. In the field the management of pastures containing twining legumes and grasses for both high dairy production and high dry matter production is virtually impossible. The maximum dry matter production from legumes occurs at extended grazing intervals, whereas maximum dry matter production and maximum feed quality from grasses occur with frequent and regular defoliation.

The question of topdressing to maintain a particular species balance is of great importance. The effect of nitrogen, for example, upon the persistence and production of legumes, is not well documented. It is generally assumed that too high a nitrogen rate would lead to the decline of the legume component. Whether this is due to straight competitive effects such as shading, or whether it is due to a nutritional effect is not clear, and it is by no means certain that the addition of nitrogen to a legume grass pasture will lead to the elimination or decline of the legume. There are numerous instances in the literature of nitrogen responses in apparently well established and healthy legume pastures, which indicate it may be possible to maintain some legume species in mixed pasture relatively heavily fertilized with nitrogen. Obviously though, management systems would need to minimize other competitive effects such as shading.

Grazing management

Even though many aspects of grazing management are beyond the scope of this review it is of considerable practical importance that an attempt be made to define a management system that may be applied at a commercial farm level. A routine for the management of grass dominant pastures is therefore proposed. The component parts are generally in commercial use and the suggested system is an attempt to integrate these components into a workable farmer acceptable system. The value of the integrated system is not fully supported by research but most of the component parts are.

In the idealised system it is assumed that nutrients other than nitrogen are not limiting.

1. The aim of the system is to provide a continuous supply of high quality feed of a height that allows near maximum intake.

2. To maintain an adequate level of protein in the grass, soil nitrogen must be kept at a moderate to high level.

3. Grazing should be undertaken when grass is not more than 8-9 in. high to minimise the intake of lower digestible, lower protein, over-mature feed.

4. Defoliation down to 3-4 in. should be rapid with a very high stocking pressure of approximately 50 beasts per acre where possible. Assuming a good grass pasture has 4000 lb of available dry matter per acre (4480 kg/ha) of which 50% is utilised, a stocking pressure of 50 beasts per acre (123.5 beasts/ha) would defoliate the area in 2 days.

5. Mowing will periodically be needed, in addition to heavy grazing to maintain feed in the desired height-quality range. However mowing should be kept to a minimum and should only be undertaken when grazing will not achieve the desired result.

6. To maximise the benefits of high stocking pressures stocking rates are increased as temperatures increase in spring to a maximum in late summer by reducing the area actually being grazed.

7. As temperatures and growth rate decline in autumn it is necessary to re-introduce to the grazing system areas that were allowed to grow out in summer.

8. At the stage where these over-mature areas must be re-introduced to the system, additional nitrogen must be applied immediately followed by mowing.

Based on the above principles the table below indicates a possible relationship between areas, fertilizer rates and cow numbers. It is assumed that a 120 cow herd is maintained on 100 acres of grass dominant pasture.

Month	*Area*	*Nitrogen applied*
July	100 ac (40.47 ha)	200 lb/ac (90.72 kg)
October	60 ac (24.28 ha)	50 lb/ac (22.68 kg)
January	30 ac (12.14 ha)	50 lb/ac (22.68 kg)
April	100 ac (40.47 ha)	200 lb/ac (90.72 kg)

The basic principles upon which the above system is based can be summarised as follows:

—Maintain high soil nitrogen levels (and other essential nutrients) and thus high protein levels and high growth rates.

—Graze at very high stocking pressures (say 50 to 100 beasts per acre) wherever possible to defoliate the pasture in 1-2 days.

—Maintain feed on offer to the animals in the height range 3-9 in. by a combination of grazing where possible and mowing.

It is realised that the above suggested system would require intensive subdivision and that, in practice at a commercial level, the defoliation time would vary considerably from the suggested "ideal" of 1-2 days.

CONCLUSION

From this review, the following important points, of commercial significance, emerge.

1. The sub-tropical and tropical environment must be accepted, and therefore techniques must be adopted to maintain feed quality in this environment. Attempts to maintain temperate pastures systems in it are unlikely to succeed.

2. Establishment of pastures and forage crops under sub-tropical and tropical conditions is made more difficult by additional competitive effects due to the general vigour of indigenous and established species.

3. Once established, without doubt, the most critical aspect of dairy production is maintaining the pastures at a level to provide sufficient quality to enable genetically high producing dairy animals to reach this genetic potential. It may well be impossible to get really high dairy production from tropical or sub-tropical forages, simply because of our inability to maintain them at a level of sufficient quality. The addition of some supplement, such as grain, of known high quality, may be essential in the tropical dairy situation if high production per cow is to be achieved.

4. Grazing management systems for tropical and sub-tropical pastures are not clearly defined but it appears likely that increasing emphasis will be placed on grass dominant pasture heavily topdressed with nitrogen, using higher stocking pressures than are currently accepted at a commercial level.