TACTICAL USE OF FERTILIZER NITROGEN

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ABSTRACT

Evidence gained from N fertilizer trials indicates that, despite the N inputs from legumes, developed, well managed grass-clover pastures are subject to continual N stress.

Nitrogen responses are largest and most reliable in the early spring. Tactical fertilizer N applications in late winter/early spring have been shown to overcome limitations of seasonal feed supply in dairy, beef and sheep systems. Use of N during spring has been quite widespread, in association with pasture conservation.

Nitrogen fertilizer inputs offer little scope for overcoming feed deficits directly due to summer droughts.

Tactical use of fertilizer N in autumn often results in significant DM responses. These are generally too late to meet specific feed requirements at this time. The extra pasture growth produced can, however, lead to improved winter feed supplies.

Incorporation of tactical N inputs into the general management of a variety of grassland farming pursuits is briefly discussed.

INTRODUCTION

In most developed countries of the world intensive pastoral farming is based on production from pure grass swards, with dependence on heavy and continuing inputs of artificial N. By contrast, the use of fertilizer N in the New Zealand pastoral industry has been confined to a minor, tactical role. Differences in agricultural cost/price relationships, between New Zealand and other countries, explain our unique position only in part. From an agronomic viewpoint, associations between temperate grasses and clovers, particularly ryegrass and white clover, are extremely successful in this environment. With well managed pastures, the clover-rhizobium symbiosis is able to maintain the large reserves of organic N in soils, necessary to sustain the growth of associated non-legumes, mostly grasses (Sears, 1962; Ball, 1969). There is no evidence, experimental or conjectural, to suggest that replacement of this function of clovers by manufactured N could provide an economically viable alternative to our pastoral industry.

Symbiotic fixation only satisfies the immediate N requirements for clover growth. Before becoming available to associated non-legumes, most of the fixed N joins the soil organic N pool. Grasses, by far the major constituent of developed pastures, obtain the bulk of their N requirements only following mineralisation of soil organic matter. Mineralisation, the biological transformation of organic N compounds to mineral N (NH^{4+} and NO^{3-}), is a temperature-moisture dependent process (Harmsen and Kolenbrander, 1965). In a general way, this process tends to release N from fertile soils in phase with the seasonal requirements of the principal grass species and cultivars used in our pastures. Excess dietary N excreted by grazing animals provides an alternative pathway for clover N to be made available to grasses. The bulk of this is excreted as urine, which immediately enters the mineral N pool. However, the relatively small area affected by urine at any one time and the large N losses associated with this aggregation of N into urine patches, suggest that this aspect of transfer has been over-emphasised in the past (Ball, 1977).

N STRESS AND N RESPONSES

Throughout this paper we are emphasising N relationships in well developed pastures on fertile soils, typical of those used for intensive grassland farming. Factors influencing the size of N responses, including season and weather, pasture characteristics and grazing management, have been reviewed in detail elsewhere (Ball and Field, in press). In the following discussion, emphasis is placed on the manner in which N responses vary with season and weather, assuming that one is considering acceptable pastures under appropriate management.

In view of the numerous reports of N responses from farming situations involving permanent pastures, we consider N deficiency to be a widespread feature of the New Zealand pastoral industry: dairyfarming (Ball, 1970; During, 1972; Holmes and Wheeler, 1973; O'Connor and Cumberland, 1973); sheepfarming (Scott, 1963; Harris *et al.*, 1973; Ball *et al.*, 1978; Carran, 1978); hill country farming (Sherlock and O'Connor, 1973; Ball *et al.*, 1976), and in the South Island high country (O'Connor, 1961a, b). In many situations, net mineralisation is obviously not proceeding at a rate sufficient to meet fully the requirements for potential growth rates of grass-dominant pastures.

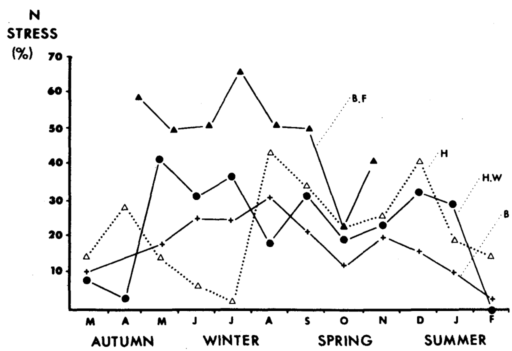
N stress

In order to consider the possibilities for using tactical inputs of fertilizer N to relieve seasonal deficits in feed supply, it is necessary to identify the extent and seasonality of N stress encountered in developed pastures. Patterns observed at Palmerston North and Gore are presented in Figure 1. From the four sets of data included in the figure it is apparent that N stress (the percentage shortfall in growth rate of a control pasture, compared with that in a comparable pasture where N deficiency has been relieved) restricts pasture growth throughout most of the year. Only when low temperatures (e.g. mid-winter at Gore; Harris *et al.*, 1973) or moisture stress (e.g. mid-summer/early autumn at Palmerston

North; Ball and Field, in press) becomes the primary limitation to plant growth has N stress ceased to be appreciable. We are of the view that grass plants in grass-clover associations are subject to chronic N stress, under our conditions of intensive grassland farming.

Figure 1. Annual trends in nitrogen stress in ryegrass-clover pastures. (Nitrogen stress is defined as the percentage shortfall in growth rate of a control pasture, compared with that in a pasture where N deficiency has been relieved.)

Key:
B.F. Ball and Field (unpubl), Palmerston North, dairy pastures, 180-220 kg N/ha as single applications.
H. Harris *et al.*, (1973), Gore, sheep, 101 kg N/ha as single applications.
H.W. Holmes and Wheeler (1973), Palmerston North, dairy, 400 kg N/ha/an as continuous inputs over 2 years.
B. Ball (unpubl), Palmerston North, sheep, 450 kg N/ha/an as continuous inputs over 3 years.



N responses

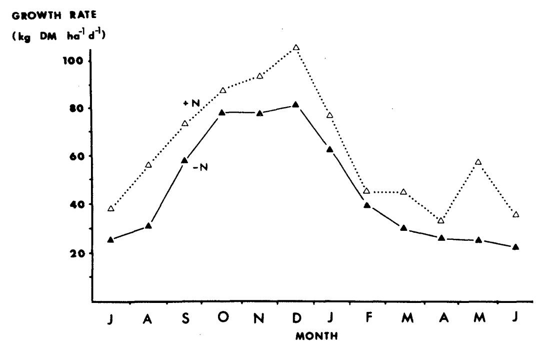
Responses of varying magnitude and reliability have been measured in pastures throughout New Zealand (see During, 1972, and O'Connor, in press). While the actual pattern of responses will depend on climatic region and weather vagaries within seasons, Figure 2 serves to illustrate a general pattern. It is based on N responses measured in grazed, ryegrass-white clover pastures in Manawatu (Ball and Field, in press). Responses have been consistently recorded to N applied before regrowth in the late autumn/early winter period, late winter/early spring, and again in late spring/early summer. The extent of these responses to applied N has largely depended on the degree to which prevailing climatic conditions have regulated potential growth of the grass component of this mixed sward.

Late autumn/early winter

We have obtained fairly consistent responses to N applied following the autumn 'break'. A temporary immobilisation of soil mineral N, which we have found to occur when the autumn rains arrive (Ball and Field, in press), causes a severe restraint to ryegrass recovery, especially tiller formation. This can be alleviated by fertilizer N application immediately after arrival of significant autumn rain.

Others have reported that autumn responses to N are small and unreliable (Holmes and Wheeler, 1973; O'Connor and Cumberland, 1973). We consider that they can be satisfactory with careful attention to

Figure 2. Mean monthly growth rates of a ryegrass-white clover pasture, with (+N) or without (-N) 50 kg N/ha applied following each grazing by sheep, at Palmerston North.



timing of N application. The immobilisation of soil mineral N referred to above is transient, with mineralisation gaining ascendancy over immobilisation 3-4 weeks after the initial rains. The longer the delay between the arrival of substantial rains and any N input the smaller the response, both because soil N availability is improving with time and because the weather is becoming less well suited to grass growth.

Obviously, the autumn 'break' must come early enough to allow a response to occur before cold temperatures restrict plant growth. This is not always the case. During (1972) reported that trials in the South Island gave little confidence for any general recommendation for autumn N use. By contrast, good responses were recorded to applications in late May, in the milder Pukekohe district.

Late winter/early spring

Responses to N applied before regrowth over the period mid-July, August and September have been consistent and appreciable. The main effect is to advance early season growth rates by 2-4 weeks, this effect becoming less pronounced as the season progresses. At this time it appears that soil N mineralisation is the rate-limiting factor to pasture production, with the climatic potential for N uptake and growth by pastures greatly exceeding the rate of N supply.

We are of the view that the reliability of spring growth can also be improved by N use over this period. The adverse effects of a so-called 'late start' to the growing season, epitomized in the appearance of 'spring yellows' in pastures, can be substantially offset by use of fertilizer N.

Our Manawatu results appear to give a fairly typical pattern for the milder farming districts of New Zealand. A similar seasonal pattern, but delayed 3-4 weeks, is reported from trials in colder districts: Wairarapa (Hudson and Woodcock, 1931); Southland (Harris **et al.**, 1973); Canterbury and elevated parts of the North Island (During, 1972).

Late spring/early summer

In our experience, and reviewing other information available, N stress appears to decline consistently from peak values in late winter/ early spring to low mid-spring values, and then to increase again over late spring/early summer (see Figure 1). This lack of responsiveness in mid-spring may be associated with faster mineralisation as soil temperatures rise (Harmsen and Kolenbrander, 1965). However, we believe that it is also linked to physiological changes associated with reproductive growth, which occur in temperate grass species at that time (Ball and Field, in press). With the reinstatement of vegetative growth by late spring, N responses again become substantial, and will continue into mid-summer providing that soil moisture stress does not severely limit pasture growth.

The initial effects of drought, in restricting plant growth, are brought about by a reduced availability of nutrients in the surface layer of soil and it dries progressively (Mitchell and Butler, 1956). Dressings of N, which must be in, rather than on, the soil when consistent surface drying occurs, can offset the initial retardation to growth and extend grass growth rates some 3-4 weeks into the summer.

Under Manawatu conditions, dry soil conditions generally limit any potential for N use from early January. Alternatively, when the summer growing season remains moist, the high potential growth rates of white clover at that time offset any gains to be made by stimulating grass growth with applied N. Use of N over the mid-summer/early autumn period can increase ryegrass yields, but at the expense of clover yields, with little effect on total pasture production.

There are few reports in the New Zealand literature of assessment of N responses at this time of year, so it is difficult to comment on likely district variations. Good responses have been reported following January application of N to mixed swards (Harris *et al.*, 1973) and pure grass swards (Carran, in press) in Southland. However, weather vagaries can substantially negate responses over this late spring/early summer period. As the 1969-70 drought progressed, we recorded no significant result from N applied later than October.

TACTICAL USES FOR FERTILIZER N

The tactical role for fertilizer N in intensive grassland farming is one of single applications, timed to increase immediate pasture production, thus helping to overcome a foreseeable deficit in feed supplies. As with all cost inputs, an appropriate increase in farm output must occur for any profit to accrue. Fertilizer N has greatest relevance to those farming situations where output is limited by consistent and predictable feed shortages, because most effective use requires a considerable amount of forward planning (Ball, 1970). It is our view that fertilizer N is not a particularly appropriate input for 'rescue' operations, brought about by within-season weather vagaries. By the time a problem is recognised, it is too late to alleviate it with tactical inputs of N unless a confident forecast can be made that feed shortages and appropriate weather conditions will persist for a further 4 - 6 weeks.

Throughout this paper, we have confined ourselves to presenting appropriate agronomic information to assist individuals in formulating their own on-farm decision. We are well aware that decisions are finally made by farmers, on economic grounds. In what follows we are simply documenting farm practices, involving tactical inputs of fertilizer N, either reported in the New Zealand literature or encountered by the authors. No recommendations are given or implied, as cost/price relationships have fluctuated dramatically over the past decade. For instance, recommendations for N use to overwinter beef cattle on hill country in the early 1970's may have much less relevance today. Our aim is simply to illustrate some of the tactical uses to which fertilizer N has been put, and to indicate how these have been viewed as of immediate benefit to animal production and/or of longer term implication to the farming system involved.

In the animal production systems outlined in the opening papers of this session (Reardon, 1978; Rattray, 1978; Campbell and Bryant, 1978) three periods were highlighted during which seasonal deficits in feed supply impose constraints to farm production: autumn, winter/early spring, and during summer drought. We will consider farm practices under those seasonal periods.

Meeting autumn feeds deficits

In our experience, most N use in autumn is directed towards building up winter feed supplies. Tactical N use appears to have little relevance to the immediate autumn problems of insufficient feed for milking cows, or for ewes prior to mating. The main determinant of the seriousness of any feed deficit over autumn is the length and severity of the preceding dry spell. Little can be done about that with applied N, which can only be used to accelerate pasture recovery once substantial rains have arrived. If the autumn 'break' is early, the autumn feed deficit substantially rights itself. If late, N-boosted pastures can only be converted inefficiently by cows in late lactation on seasonal supply farms, and will be too late to increase the body weight of ewes before tupping.

There is some tactical use of N to provide extra feed over this period on town milk supply farms.

Meeting feed deficits over winter/early spring

There is considerable scope for N use over this period, particularly in our warmer climatic areas. Although we have occasionally recorded quite good responses to June applications in Manawatu, winter use of N is fairly unreliable and out of the question in colder districts. The preferable tactic is N use in autumn, while growing conditions still suit pasture growth, coupled with appropriate management to carry feed over and utilise it carefully during winter. As discussed previously, N responses are substantial and consistent where N is applied from mid-winter onwards in the warmer areas of the country and about a month later in colder areas.

There are numerous recommendations for tactical N use over this period in the literature (Elliott, 1953; Lynch, 1953; Ball, 1970; Cumberland *et al.*, 1970; McKenzie, 1970; Rose, 1970; During, 1972; O'Connor and Cumberland, 1973; Neilson, 1974; Ball *et al.*, 1976). Most relate to meeting immediate feed shortages or reducing the time paddocks have to be retired for pasture conservation.

This practice is widespread in the town milk industry, and reasonably common on seasonal supply dairyfarms. During (1972) reviewed the longer-term advantages obtainable in dairy production, where N-boosted pastures are used to meet feed deficits during early lactation. We are aware of one seasonal supply dairyfarm where stocking rates were progressively increased, with the aid of autumn and late winter N applications and adjusted calving dates, to the point where almost all the spring flush was being utilised by milking cows (two bales of hay cow^{-1} were conserved). A feature of the N study on the Massey No. 3 dairyfarm (Holmes and Wheeler, 1973), was the accumulation of genuine feed surpluses over mid/late winter, where heavy rates of N were used in a highly stocked, seasonal supply dairyfarming system. These two observations indicate that tactical N use, on a planned basis, can significantly alter management policy on dairy farms.

Similar strategy has been reported to alter substantially beef cattle policies on North Island hill country (Neilson, 1973, 1974). N was applied to warm, well protected paddocks following a 'clean up' grazing in mid-autumn. Pastures were then spelled until set-stocked with in-calf cows in mid-winter. The accumulated growth, topdressed again in late winter if considered necessary, supported 5-7.5 cows ha^{-1} over the pinch feed period from late winter to mid-spring. Substantial savings in labour and hay costs were claimed. A related hill country practice involved similar tactical inputs of N to better pastures, then spelled to provide late winter/early spring feed for weaner cattle. Pastures may be set-stocked, or 'rotationally grazed' on a 2-4 paddock system, supporting 7.5-10 weaners ha^{-1}. The advantages claimed include a switch from autumn store sales of weaners to fat sales the following summer, and better pasture control with increased cattle numbers over the late spring/early summer flush.

A study on a heavily stocked sheepfarm in Southern Hawkes Bay concluded that a 10% increase in stocking rate, with sheep set-stocked over the late winter/early spring period, could be sustained by an application of 55 kg N ha^{-1} as urea in late winter (Ball *et al.*, 1976). As this was considered the period which limited year-round carrying capacity, mid-winter N use effectively allowed for farming intensification.

A dressing of N when closing a paddock for ensilage is a tactic in fairly widespread use in many farming systems. The preferred objective is a shortened closing time, rather than a heavier crop, because prolonged closure coupled with heavy yields is likely to penalise subsequent pasture performance (Ball and Field, in press). Among farmers who have regularly used this practice, some report a lack of consistency in responses. This may be explained through interference by reproductive growth of grasses, in situations where N was applied in late September/early October.

Meeting feed deficits during summer droughts

Tactical inputs of N offer little or no scope to increase pasture growth under such conditions. However, there is the possibility of transferring feed, either standing or conserved, as a result of N use prior to the onset of drought conditions. It should be appreciated that in the latter case, associated costs and feed losses would diminish the attractiveness of this option.

Some fertilizer N is applied at closing to late hay crops. Providing that they are not then over-spelled, thereby penalising subsequent clover performance, our experience would suggest that substantial yield increases could be expected. However, the practice is not widespread. We have also encountered one enterprising farmer, on drier hill country, who topdressed protected paddocks with N in November. The resulting N response, he claimed, allowed him to relieve grazing pressure on the more exposed parts of his property, thereby gaining better pasture performance over his farm through to mid-summer.

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