Supplementation - Getting bang for buck

*Key Points of interest Marked in Red.

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Abstract. Supplements provide one option for cattle producers to increase growth rate of their cattle and target desired market opportunities but both the costs of feeding and risks are high. Although urea—based supplements are the most widely used throughout northern Australia, they are not formulated to achieve high growth rates required to increase weight for age of cattle. In this paper the emphasis is on production feeding of male cattle. The successful implementation of a cost—effective feeding programme can be achieved with attention to several strategies, viz., choosing the most appropriate supplement type, feeding supplements under appropriate pasture conditions, optimising use of the pasture base and timing the use of supplements and the marketing of cattle to optimise growth responses and minimises erosion of responses through compensatory growth. These aspects are discussed in the context of contributions from our own research findings. Where the feeding standards and their derived decision support models have been assessed, they have not been successful in predicting growth performance of cattle grazing tropical pastures due to their poor predictions of intake but not through inadequacies in the equations describing energy utilisation, which were sound.

Introduction

Over the last 2-3 decades the markets for northern Australian cattle and beef have changed and expanded greatly. Although the more traditional markets of USA manufacturing and Japanese high quality beef still dominate the market scene northern cattle are also now directed to prime beef markets in South Korea, live export markets in south—east Asia and northern Africa, and are backgrounded for the rapidly growing feedlot industry supplying both export and domestic markets.

Having the flexibility to access the most profitable of these markets at any time often requires that producers have strategies to change their production system, notably to increase cattle growth rates, at short notice and the feeding of supplements provides an important option for this.

In order to increase growth rates it is necessary to increase intake of digestible energy (see later) and there are various options outside supplementary feeding by which to achieve this. These include changing the pasture base to incorporate a higher quality forage, e.g., a legume such as stylo or leucaena. This option is one being used in some parts of Queensland in particular, for instance leucaena in southern and central Queensland, and can result in large increases in per head and per hectare production (Shelton *et al.* 2005). However, limitations of rainfall, temperature and soil type will restrict the expansion of most of these improved species into all but a relatively small proportion of northern Australia and will not provide a practical option for many producers. In this paper the emphasis is given to the supplementary feeding alternative.

Historically, urea—based supplements have predominated the northern beef cattle scene since the mid—1960s and continue to be the major supplement types used today. Originally based on the urea-molasses roller drum system, variations have included dry loose salt—based licks and urea dispensed directly into the drinking water, as well as the myriad of commercial urea—based licks available in loose or block form. These supplements increase growth rate by increasing intake of the available pasture. However, only relatively modest increases in intake are usually achieved (up to about 30%; Winks *et al*. 1970) and the pasture is of such low digestibility that the corresponding increase in energy intake, and thus growth response is relatively low. The early 1980s saw the introduction of fortified molasses survival feeding system. The most notable example being the M8U system (molasses/urea; 100:8, w/w). These innovations were supported, if not initiated, by key research from Swans Lagoon Research Station, Ayr. Qld (e.g. Winks *et al*. 1970; McLennan *et al*. 1991). However, both the urea and M8U supplements were mainly intended for ensuring survival of the animal, primarily weaners and cows, and were not formulated to achieve the high growth rates required for production feeding. It is important to recognise that they are not production supplements and for higher growth rates the only real feeding option available to producers is to provide the additional energy required, balanced for other nutrients, in the supplement rather than rely on increased pasture intake alone. This form of feeding is expensive and requires a careful examination of the costs and benefits for an economically favourable result to occur.

Increasing the efficacy and profitability of supplementary feeding or the "bang for the buck" will be a function of three main principles: (i) choosing the supplement which will provide the highest growth response per unit cost; (ii) optimising use of the available pasture: and (iii) integrating the chosen supplementation strategies into a longer term growth path through to when the animal is sold or slaughtered. Some of the issues relating to these aspects are discussed below in the context of recent research findings from our own research group. The major emphasis in this paper is given to feeding male cattle for production.

Growth responses to supplement

The choice of supplement is based on several factors, the main nutritional considerations being the growth response per unit intake and per unit cost, but the overall aim does not deviate from that of increasing total nutrient, and specifically energy, intake. The importance of this key principle is further examined later. Energy intake is most commonly increased by feeding a supplement high in energy content, for instance grains or molasses, or by feeding a high protein supplement which stimulates intake of the pasture as well as providing energy per se. Reference to the former supplements as "energy sources" and the latter as "protein sources", as is common practice, can provide a misleading conception of their relative contributions to the nutrient supply to the animal.

For instance, McLennan *et al*. (1995) calculated that whilst cottonseed meal (1 1.1) MJ metabolisable energy (ME)/kg DM; 37.5% crude protein (CP)) had a three-fold higher CP content than barley (12.8 MJ ME/kg DM; 11.4% CP) the amount of metabolisable CP it supplied to the animal was only 1.6 times and 1.8 times greater per kg DM or per MJ ME, respectively, by virtue of the high capacity of the rumen microbes to use the energy from barley for microbial protein production. Thus both supplement types provide both energy and protein to the animal but it is the proportion in which these are supplied that seems most important as is shown by results considered below.

The growth responses to various supplement types have been compared in a series of pen feeding and grazing trials with young growing cattle (McLennan 1997; 2004). These experiments, without exception, used a dose response approach so that the various supplements could be compared over a wide range of supplement intakes. The advantage of this approach compared to that of using only one or two levels of feeding is that the resultant dose responses can be used to 'tailor a response under practical grazing conditions. The results are discussed below.

Comparison of supplement types

For our research, supplements were grouped into major types, for instance grains with low (sorghum, corn) or high (barley, wheat) starch degradability in the rumen, high sugars (molasses), and protein meals with low (cottonseed meal) or high (copra and palm kernel expeller (PKE) meals, whole cottonseed) lipid content, and were fed over about 70 days to young growing cattle given low quality tropical hays in pens. An example of the resultant response curves is shown in Fig. 1A. From a number of similar experiments, generic response curves were developed (Fig. 1B) comparing protein meals and "energy sources" (grains and molasses). These results suggested a linear response to the energy sources across the full range of supplement intakes whereas the response to the protein meals tended to be curvilinear, with a much greater response (kg gain/kg supplement) at low intakes than at higher intakes of supplement. Notably, growth responses were similar for the two supplement types when intakes of supplement were high. These responses in our own studies were consistent with cumulative published data, as reviewed by Poppi and McLennan (1995) and Poppi *et al*. (1999).

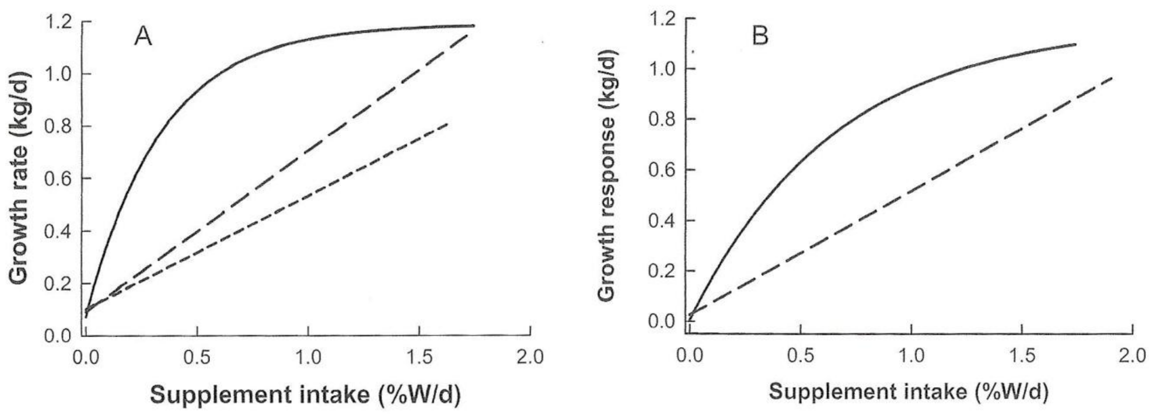

Fig. 1. (A) Effect of supplements of cottonseed meal (solid line), barley (long dash) and sorghum (short dash) on the growth rate of steers fed a low quality hay in pens; and (B) generic relationships between the growth response (gain in excess of unsupplemented control) and supplement intake for protein meals (solid) and "energy sources" (dashed) based on the results of several experiments.

The higher responses with protein meals relative to energy sources suggests a requirement for protein in young, rapidly growing cattle which is not being met completely from microbial protein production alone. Orskov (1970) showed that ruminants undergoing rapid growth required more protein than could usually be provided as microbial protein produced in the rumen. Furthermore, cattle deposit proportionally more protein than fat at a younger age (ARC 1980) and their requirements for protein per se are thus greater then than during the finishing phase of growth. The derived response curve (Fig. 1B) can be translated into one for use in comparing supplement requirements for a particular growth response by rotating this figure through 90" and these comparisons can be made on a cost basis if the cost per unit weight of supplement is included.

Obviously, supplement costs will vary widely with seasonal availability, distance from source etc., so the response trends have been incorporated into a spreadsheet ("WhichSupp'") which allows individuals to directly input the supplement costs. The limitations of these comparisons is that they currently apply only to young cattle and only to low quality forages and they do not include all of the variable costs associated with feeding. Nevertheless, they provide a starting point in the decision process on the appropriate supplement to feed.

Within supplement types, there were differences between supplements in response. For instance, the response to barley was greater than to sorghum across the full range of supplement intakes

(Fig.1A), presumably reflecting the greater digestion of starch in the rumen and total tract with barley (Huntington 1997). Responses to molasses supplements were even lower and highlight the low net energy value of molasses relative to grains (Lofgreen 1965). The practical significance of these findings is that producers can afford to spend more for barley compared to sorghum or molasses although the results with sorghum in particular will be variety specific (S. Bird, pers. comm.). This highlights the need for a simple assay by which grains can be screened for both ruminal and postruminal digestion prior to use in ruminant diets.

Protein meals vary widely in composition, especially CP content, yet research carried out by our group (McLennan 2004) showed similar performance by steers receiving supplements of cottonseed meal (42.8% CP) and copra meal (24.2% CP) across the full range of supplement intakes (0-1% W/day); PKE meal (16.9% CP) had slightly lower performance. Other workers have similarly shown similar performance of copra and cottonseed meals albeit at only 1-2 levels of feeding (Hennessey *et al*. 1989; Gulbransen *et al*. 1990). Rumen ammonia concentrations were linearly increased 3 li post—feeding by cottonseed meal but not copra meal but both supplements were associated with elevated plasma urea concentrations albeit at higher levels with cottonseed meal. These results suggest different modes of action of the protein meals with copra protein perhaps bypassing initial digestion in the rumen to be absorbed as amino acids post—ruminally and slowly recycled back to the rumen as urea. Support for this recycling of urea was provided by the linear increases in microbial protein production (22l—65l g/d) in the rumen with increasing intake of copra

Effect of pasture quality

Research carried out with young Brahman crossbred steers grazing a buffel grass pasture on brigalow soils in central Queensland showed that responses to supplements were highly dependent on the quality of the basal forage diet. When the steers grazed dry season pasture the unsupplemented controls gained 0.2 kg/d and the responses to a barley—based supplement (including urea and minerals) and cottonseed meal were substantially greater than when the steers grazed wet season pasture and the unsupplemented steers gained 0.9 kg/d overall (Fig. 2). Differences in supplement type were generally small in this study perhaps indicating that, with these pastures, even during the dry season microbial protein provided most of the protein requirements of the cattle when a source of readily fermentable energy and rumen degradable protein (barley supplement) was available. Based on these results and those from the pen studies described above, a theoretical relationship is offered between base pasture quality (and growth of unsupplemented steers), supplement intake and liveweight gain response (Fig. 3). This figure suggests that, under commercial conditions, the likelihood of a cost effective response to feeding protein/energy supplements diminishes directly with increasing pasture quality. An economic response is highly unlikely during the wet season and doubtful even during the wet/dry transition period in some regions and years.

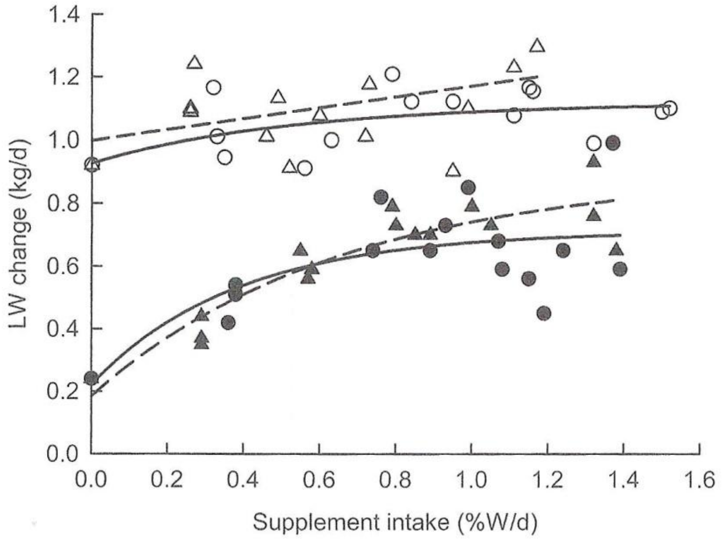

Fig. 2. Growth responses by steers grazing buffel grass pastures during the dry season (closed symbols) and wet season (open symbol) and receiving supplements of barley fortified with urea and minerals (circle; solid lines) or cottonseed meal (triangle; dashed lines).

Prediction of the growth response to supplementary feeding

It is obviously not feasible to evaluate every supplement combination under every set of conditions so an alternative is required to predict the performance of cattle given a particular supplement, or to formulate a supplement to achieve a desired production response. The various feeding standards relate the performance of animals to nutrient intake and thus provide a basis for assessing the nutritional requirements of animals in various physiological states. It should, therefore, be possible to use these feeding standards or the decision support systems (DSS) derived from them, to achieve the outcomes outlined above. However, there has been some scepticism about the usefulness of the feeding standards for predicting performance of *Bos Indicus* cattle grazing tropical pastures as most feeding standards have largely been developed from feeding experiments carried out with British European cattle consuming temperate diets.

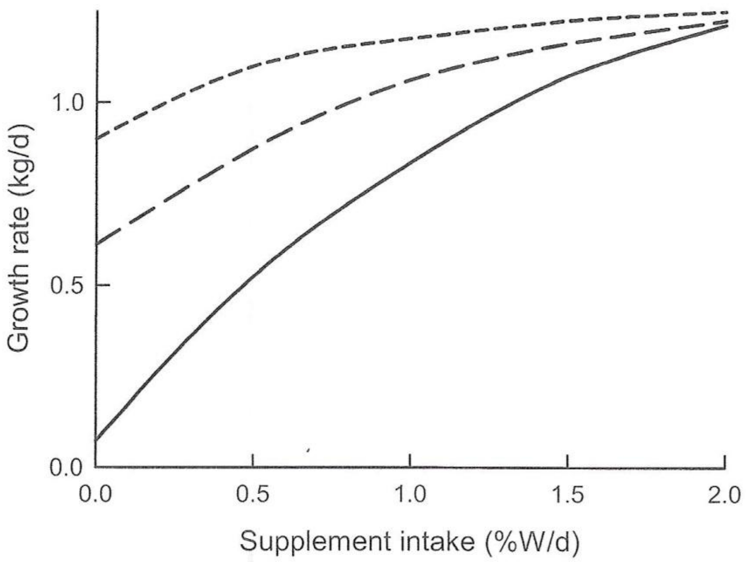

Fig. 3. Theoretical responses to a protein meal supplement for steers grazing low (e.g. dry season; solid line), medium (e.g. wet/dry transition; long dash) and high (e. g. wet season; short dash) quality pastures.

The basic premise underpinning the feeding standards is that liveweight gain is a function of intake of metabolisable energy (MEI). This concept was examined recently by pooling data of our own research group (see McLennan and Poppi 2006) derived from a number of pen feeding experiments with young growing cattle given tropical grass hays and a wide range of supplements. The results confirmed the close relationship between liveweight gain and MEI and indicated that, despite the large range in responses to different supplements, the major difference was in their effect on MEI and not on the relationship of MEI with LWG *per se*. The relationship was as follows:

Growth rate (kg/d) = - 1.061 + 0.0020 MEI (kJ/kg $W^{0.75}$ .d), (R^2 = 0.80; rsd = 0.144).

This work was expanded to assess how well the DSS predicted liveweight gain of cattle given tropical diets, using the same data sets. Two DSS were used; the Australian feeding standards, SCA (l990), based on the ME system and from which the GrazFeed model (Freer and Moore 1990) was derived and the Cornell Net Protein and Carbohydrate System (CNCPS; Fox *et al* 2004) based largely on the NE system and used also by NRC (1996). The results indicated that, providing intake and diet composition of the cattle was known, both SCA (1990) and the CNCPS gave reasonably good predictions of liveweight gain thereby suggesting that the principles of energy utilisation were sound and applied equally well to cattle and diets of tropical and temperate origin. However, both systems provided poor estimates of voluntary intake based on diet composition suggesting that, under field conditions where intake was unknown but diet composition could be estimated using, for instance, the faecal near infrared reflectance spectroscopy (NIRS) method (Coates 2004), these models would no: accurately predict animal performance. The lack of a reliable and accurate method to estimate intake will, it appears, continue to jeopardise the use of the feeding standards and derived DSS for predicting cattle performance in northern Australia.

Effects of supplement on pasture intake

For most cost-effective production, livestock producers should aim to maximise use of the pasture base, being the low cost component of the animal's diet, and use supplements as an addition to the nutrients provided by the pasture. However, the reality is that as supplement intake increases pasture intake by the animal declines; that is, the animal substitutes supplement for pasture. This substitution effect is well documented (e. g., Horn and McCollum 1987; Schiere and de Wit 1995; Dixon and Stockdale 1999) although the reasons for it are less well understood. Whilst pasture intake is reduced, in this way it is common for total intake of DM to increase and for energy intake to increase even more steeply by virtue of the usually higher energy density of the supplement relative to the pasture it replaces. Nevertheless, the efficiency of use of supplements would increase if a more additive rather than substitutional effect of supplement on pasture intake prevailed.

Research undertaken by our research team (Marsetyo 2003; McLennan 2004) has, in support of other evidence (Schiere and de Wit 1995; SCA 1990), demonstrated that different supplements vary in the degree to which they substitute for pasture, and that as pasture quality increases so too does the extent of substitution for any supplement type. Marsetyo (2003) described a two-phase effect of feeding supplements on intake of the base forage. When rumen degradable protein (RDP) supply from the forage base was limiting for the animal provision of a small amount of a supplement (up to about 0.5% W/d) which reduced this deficit in the rumen resulted in a small or nil decrease in intake of forage. However, as supplement intake increased and the deficit of RDP was eliminated forage intake declined linearly. Where supplements did not correct a deficiency in RDP content, for instance because they also had low RDP content or were fed with forages not limiting in RDP supply, there was a linear decrease in forage intake across the full range of supplement intakes. In the linear phase of this relationship, differences between supplements in their substitution effects were broadly related to their ME content such that supplements with the highest ME content resulted in the greatest depression in forage intake. This finding was consistent with the conceptual model of intake regulation proposed by Weston (1996) who suggested that ME intake is regulated by the balance between the capacity of the animal to use net energy (NE) and the useful NE intake. An example of these effects is shown in Fig. 4 where supplements low (barley) and high (barley/cottonseed meal/copra meal, 2:1:1, w/w) in RDP content were fed with a low quality tropical hay. The barley supplement was associated with a linear depression in hay intake whereas the barley/protein meal mix had minimal effect on hay intake at low intakes but a linear depression thereafter.

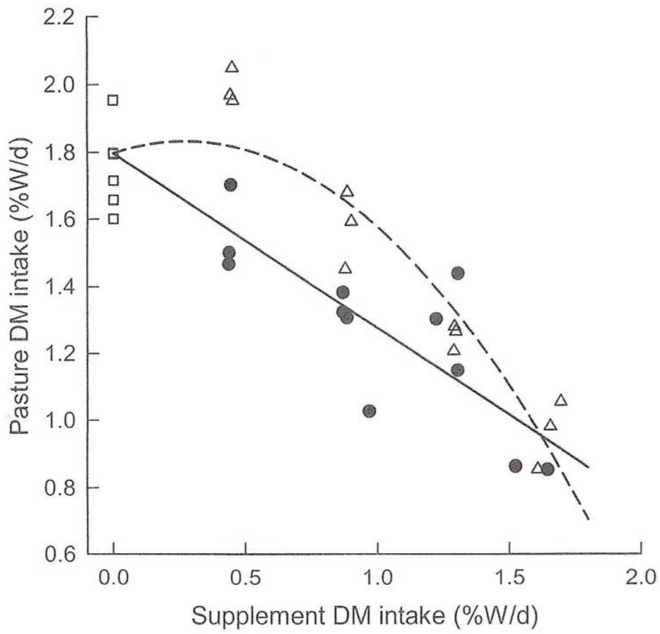

Fig. 4. Effect of supplements of nil (square symbol), barley (circles; solid line) or barley/cottonseed meal/copra meal (2: 1 : 1; triangles; dashed line) on the intake of pasture by steers in pens.

In our studies, other approaches to reducing substitution effects such as changing the site of digestion of the supplement were not successful. Consequently, at this stage the most effective strategy available to limit substitution and maximise pasture utilisation is to ensure that RDP supply in the rumen is not limited when supplements are fed. This would include ensuring adequate inclusion of an RDP source such as urea in energy—rich concentrates such as grain and molasses.

Integration of supplementation events into growth paths

The fore-going discussion has detailed some of the component research aimed at optimising the efficiency of supplement use within discrete phases of the total growth path of the cattle. In practice, most supplementary feeding occurs during the dry seasons when growth of the cattle is otherwise low and these feeding events are interspersed by wet seasons when growth is comparatively higher but supplementation uncommon (except perhaps for phosphorus feeding). When cattle growth is restricted, for instance during the dry season, the animal often grows at a faster rate in the period following restriction, i.e., the wet season, than it would if there was no previous restriction. This phenomenon is known as compensatory growth. A common example is that cattle that are not supplemented during the dry season often grow faster during the following wet season than those which received dry season supplements and had high growth rates accordingly. Winks (1984) suggested that wet season compensatory growth could erode O—lOO% of the weight advantage from dry season supplementation with urea—based mixes. This was supported by other research at Swans Lagoon Research Station, Ayr (J .A. Lindsay, pers. comm.) using supplements providing higher levels of energy and protein. Obviously, any diminution of the growth response to supplements reduces the cost effectiveness of feeding.

An example of the compensatory growth effect is shown in Fig. 5 where grain—based supplements were fed during the dry winter—spring months to cattle grazing buffel pastures on brigalow soils (T.James, pers. Comm.). In the first year of feeding the liveweight response of 69 kg at the end of the dry season was reduced to 29 kg by the end of the following wet season. The corresponding dry season response in year 2 of 168 kg was reduced to 37 kg by the end of the next wet season. The net effect of these feeding and compensatory growth events was a feed conversion ratio of 2.5 t of grain for an additional 37 kg liveweight gain, demonstrating the importance of considering the potential effects of compensatory growth in determining the ultimate cost—efficacy of feeding. In this case feeding only in the second year and marketing the cattle at the end of the second dry season would have markedly improved the economics of feeding.

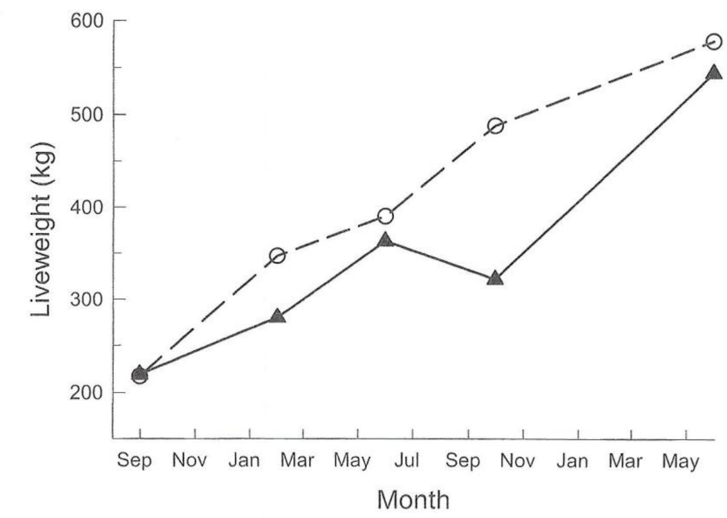

Fig. 5. Comparison of the growth of steers given a barley—based supplement (circle; dashed line) during two successive dry season compared with that of unsupplemented steers (triangle; solid line) grazing buffel pastures on brigalow soils.

Conclusions

This paper has described some of the research that has been aimed at improving the efficiency and profitability of supplementary feeding. Various strategies can be taken to improve these aspects, including making the right choice of supplement, formulating supplements to optimise use of the pasture base, feeding for the right pasture conditions, and reducing the inefficiencies of feeding associated with compensatory growth by marketing cattle at appropriate times. However, these decisions should only be taken after a full appraisal of the production system establishment of a clear target for production, and a realistic evaluation of whether the target is achievable or economically realistic.

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