MAXIMIZING MILK PRODUCTION FROM PASTURE

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Abstract

Major factors influencing dairy production from pasture are briefly reviewed. Emphasis is on the results of New Zealand research on nutrition and management. Stocking rate, cow quality, liveweight' or condition at calving, level of feeding in early lactation, and nutritive value of pasture are considered to be important, but not grazing management during lactation. Limited evidence indicates that, in most instances, supplementary feeding during lactation is not economic. Modifications of management that are required as stocking rate increases are briefly discussed.

INTRODUCTION

THIS paper briefly discusses major factors influencing dairy production from pasture. A comprehensive review is not attempted in that emphasis is directed towards nutritional factors. The results of New Zealand research ate supplemented where necessary with those from other countries.

POTENTIAL LEVELS OF PRODUCTION

Estimates of the conversion on an annual basis of pasture dry matter (DM) are 25 kg DM/kg milkfat for twin cattle (Hutton,] 1971b) and 21 kg DM/kg fat for high genetic stock (Campbell, 1977) . Using an intermediate figure of 23 kg DM/kg milkfat indicates that, for highly productive land in the Waikato giving harvested yields of 15 t DM/ha/yr, attainable milk yields are the equivalent of 650 kg milkfat or about 1 800 kg milk solids for each grazed hectare. In Westland, where annual pasture yields of 10 t DM/ha are more appropriate, the potential is equivalent to 430 kg milkfat/ha, reducing to about 360 kg where all replacement stock are carried on the farm, Most importantly, yields of milk solids close to the probable potential set by pasture production are being achieved on some research and commercial farms (Hutton, 1978; Campbell et *al.,* 1977; Fowler, 1977; Davis et *al.,* 1979).

Undoubtedly scope exists in some areas for increasing potential yields of milk through increasing feed production. These include lucerne (Mace and Peterson, 1979), improved strains of legumes and grasses (Lancashire, 1978) irrigation (Hutton, 1978), and *use* of crops (Campbell et al., 1978). It is also certain that, for many years to come, most of New Zealand's dairy production will be obtained without widespread adoption of these inputs. Even in the case of nitrogen fertilizer, experimental evidence to show that its extensive use will profitably increase milk proudction is not available. Holmes and Wheeler (1973) applied 790-941 kg urea/ha/yr and obtained 34-150 kg milkfat/ha additional. In the first year of a farmlet trial at Ruakura, the average response to applying 187 kg urea/ha was an extra 19 kg fat/ha. These responses are not economic at present costs.

Clearly the amount of feed grown on a farm will depend not only on the inputs referred, to above but also on factors like climate, particularly summer rainfall (Scott, 1978), fertilizer usage, and topography. The more important factors that determine the amount of milk obtained from the feed that is grown are considered below.

STOCKING RATE

The dominating importance of stocking rate in determining animal output per hectare was recognized by McMeekan 25 years ago and has since been repeatedly confirmed. In 16 stocking rate comparisons with dairy cows in New Zealand milkfat per hectare was greater at the higher stocking rate on 15 occasions and equal on the remainder (Davis *et al.,* 1979; Scott and Smeaton, 1980). These data indicate that an increase in stocking rate of one cow per hectare increases milkfat by about 70 kg/ha.

A feature of farms with high output per hectare is the high stocking rate employed relative to the district average. This is shown by survey data (Clifford, 1967; Hutton, 1977; N.Z. Dairy Board, 1979) and by ICI award winners (Scott, 1978). The discrepancy between possible and average stocking rates in all areas emphasizes the tremendous scope for increasing dairy production by lifting stocking rates and thereby harvesting a greater proportion of the feed grown.

GRAZING MANAGEMENT

Campling (1974) reviewed systems of grazing management for dairy cattle and concluded that no single system was markedly superior. This result is perhaps no surprise when obtained in an environment where stock are housed for much of the winter. By contrast, where both high stocking rates and grazing during the winter are practised, careful rationing of autumn-winter growth by rotational grazing offers considerable advantages. McMeekan and Walshe (1963) concluded that optimum stocking rate with set-stocking is reached at a 5 to 10% lower level than with rotational grazing. When set-stocking in winter was attempted on two-thirds of a farmlet stocked at'4.9 cows/ha, the "folly" of this was apparent after one month (Hutton, 1966). The interval of grazing during winter may also be important. Thus Bryant and Cook (1980) demonstrated over two successive winters that, for a stocking rate of 4.31 cows/ha, a slow rotation system that established a pasture supply averaging about 2 000 kg DM/ha in June and July resulted in 10 to 15% more milkfat during the subsequent lactation than a system resulting in an average of 1300 to 1700 kg DM/ha at that time.

There is overwhelming evidence from plot trials that increasing the interval between harvests increases DM production substantially, particularly during summer. Despite this, farmlet trials with milking cows have shown. that differences in fat yields due to grazing interval during lactation are minor (Bryant and Parker, 1971; Miller, 1971; McFeely *et al.*, 1975). Avantages of rotationally grazing established ryegrass-white clover swards during lactation may be primarily as an aid to recognizing feed surpluses.

COW QUALITY

Substantial increases in milk production are possible through use of genetically superior stock (Carter, 1964; Murray, 1977). The significance of cow quality as-assessed by breeding index (BI) in terms of both cow and farm production is presently being further studied at. both Massey University and Ruakura. In the first year of this work at Massey, Friesians with an average BI of 128 had lactation yields of 150 kg fat, whereas those with an average BI of 102 produced 117 kg (Davey and Grainger, 1980) . Thirty-eight Jersey cattle at Ruakura with an average BI of 123 produced 172 kg fat compared with 127 kg fat for another 38 cows with an average BI of 101 (A. M. Bryant, unpub.).

To exploit these obvious advantages requires culling low producers and replacing them with genetically superior stock. How this can be achieved when only 50% of cows in New Zealand are inseminated through the service provided by the Dairy Board and only about 40% are herd tested (N.Z. Dairy Board, 1978-9) is not clear.

PRE-CALVING FEEDING

Scott and Smeaton (1980) reviewed New Zealand work where feeding pre-calving was varied and found that in 9 of 10 experiments the better fed cows produced at a higher level. Differences in weight at calving induced by differential feeding were 11 to 93 kg, whereas milkfat produotion varied by 5 to 25 kg/cow. They concluded that, for light conditioned stock, an extra 20 kg of liveweight at calving results in an extra 5 to 10 kg milkfat during the subsequent lactation.

Condition scoring, the subjective assessment of degree of fatness, has been used as a management aid at Ruakura since the 1960s and subsequently in Victoria (Earle, 1976). Recent estimates are that one condition score unit is the equivalent of 15 to 20 kg concepta-free liveweight (King et al., 1980; A. M. Bryant, unpub.). These estimates, together with those of Scott and Smeaton (1980) indicate that improving lightly conditioned cows by one condition score before calving can be expected to result in an extra 5 to 10 kg milkfat. Macmillan and Bryant (1980) surveyed 30 herds in the Waikato and found that, amongst cows within a herd, condition score at calving was significantly associated with production during September and October, and over the whole lactation. Trends for lactation production differed between age groups, being more pronounced amongst 2- and 3-year-old cows, one unit increase in score being associated with 4 and 5.5 kg extra milkfat, respectively.

There is no production advantage in increasing still further the liveweight at calving of heavy, well conditioned cows (Broster, 1971) . Rogers et *al.* (1979) found that condition or weight at calving is the important factor affecting milk production, not liveweight trends prior to calving. With lighter cattle, a low, followed by a high level of feeding may be superior (Hutton, 197 l-2).

POST-CALVING FEEDING

Many reports emphasize the importance of level of feeding in early lactation in determining dairy cow performance. The earlier. New Zealand work has been summarized by Geering and Young (1961); this and other work by Broster (1972, 1974). Nutrition that results in a decline in current yield may, on occasions, be followed by residual effects that persist throughout lactation. Broster (1974) concluded on the basis of available evidence that these residual effects were about four times the immediate effects. More recent work in New Zealand (see Bryant and Trigg, 1979), Ireland (see Gordon, 1977), and elsewhere (see Broster and Strickland, 1977) indicates that residual effects are not invariably present.

The validity to present-day conditions of the large residual effects obtained by Wallace (1957) is uncertain since whole lactation production was only 104 and 69 kg fat/cow for the high and low levels of feeding, respectively. Even so, O'Keefe (1979) concluded that realization of the importance of nutrient intake in early lactation has contributed substantially to the expansion of European milk output in the previous few years.

SWARD CHARACTERISTICS

A number of sward characteristics can be expected to influence the yield of milk from grazing cows. These include nutritive value, herbage mass and allowance, species and sward structure (Baker, 1974; Hodgson, 1977). Their interactions are complex and only in a few instances have relevant data been obtained with lactating cows.

HERBAGE ALLOWANCE

Individual milk yields of grazing cows increase with herbage allowance in an asymptotic manner (Le Du et al., 1979). Bryant, (1980) examined the relationship between yield of milk solids and herbage allowances ,of up to about 50 kg DM/cow/day at three stages of lactation. The relationship was linear in early lactation even though allowance was 4 to 5 times DM intake, but curvilinearity increased as lactation progressed. These relationships demonstrate that high daily yields of milk per cow require generous herbage allowances. A consequence is that lenient grazing is also essential since post-grazing herbage mass also increases with increasing herbage allowance (Bryant, 1980).

Similar principles apply with non-lactating cows. For example, Holmes and McClenaghan (1980) in a 42-day trial examined change in condition score of dry cows over allowances of 4.8 to 16.7 kg DM/cow/day. At lowest allowance, the cows lost 0.7 condition scores. but gained 0.5 scores at the highest allowance.

Nutritive Value of Pasture

Herbage digestibility is conventionally accepted as an index of voluntary food intake and hence animal response. The relationship between digestibility and intake originally proposed for housed animals (Balch and Campling, 1969) was that intake increased little once digestibility exceeded 6570%. Other evidence (see Hodgson, 1977) shows that, with cattle grazing temperate swards a constant rate of increase in herbage intake occurs up to the highest digestibilities studied, about 85%. New Zealand pastures show a seasonal pattern of digestibility, being high (75-85%) in digestibility in winter and spring, declining to 60-70% in summer (Hutton, 1962).

Since digestibility declines with increasing maturity, leaves are of higher digestibility than stems (see Corbett, 1969), and the nutritive values of legumes are generally higher than those of grasses (Thomson, 1977), milk yields are likely to be highest where an abundance of young leafy pasture with a high clover content is grazed. Differences in nutritive value among ryegrass varieties do not appear to be a significant factor in determining milk yields (Brookes and Lancashire, 1979).

SUPPLEMENTARY FEEDING AND CONSERVATION

A large number of experiments have shown that providing supplementary feeds to cows grazing ample pasture has little effect on cow performance (Leaver et al., 1968). Response averaged about 75 kg DM/kg milkfat. This emphasizes the suitability of pasture for milk production, at least for cows producing up to about 25 kg of milk daily.Where pasture is limited, short-term trials, in which production was measured -only during supplementation, have given a response of 18 to 60 kg DM/kg milkfat in early lactation (Hutton 1966-7; Hutton and Parker, 1966; McIntosh, 1970 Hutton and Douglas, 1975; Bryant, 1978-9), and about 65 kg DM/kg milkfat in summer (see Bryant, 1978a). These immediate responses have generally been uneconomic and overall profitability relies heavily on improved cow performance persisting when supplementation has ceased. As already described, these are not invariably present, at least when subsequent feeding is generous. In a farm situation, however, benefits may also accrue to the pasture because of less severe grazing and to the cows because of reduced liveweight loss. Further, the pasture restriction in short-term trials has often been achieved by limiting grazing time or area, and not because of low herbage mass as is usually so during supplementation on farms. Only a few farmlet trials which allow the significance of these effects to be assessed have been reported.

In a three-year farmlet trial, Hutton (1968) compared early- and late-calving herds stocked at 4.94 cows/ha with an early-calving herd stocked at 3.7 to 4.1/ha. At the high stocking rate feed used additional to that grown on the farm was about 1 150 kg meal and 49 bales of hay per hectare. Extra milkfat averaged 138 and 169 kg/ha for the early and late calving herds, respectively, but the effects of supplementation cannot be separated from those of stocking rate and calving date. No additional production was obtained when 0, 57 or 114 kg/cow of meal was fed to cows stocked at 3.6/ha (Campbell, 1966-7), or in the following year when 1.8 kg/day of meal was fed in early lactation to herds stocked at 3.1 and 4.3 cows/ha (Campbell, 1967-8). In another farmlet trial (A. M. Bryant, unpub.), 0, 2 and 4 kg DM/day as hay was offered during a feed shortage after 73 days' lactation to cows stocked at 3.7/ha. Total pasture at the start averaged 1 300 kg DM/ha compared with 2 300 kg DM/ha at the same time the previous year. Milkfat yields for the four weeks of supplementation averaged 5.01, 4.76 and 4.51 kg/cow/week ($P < 0.001$) for the 0, 2 and 4 kg DM/day levels, respectively. For the 20 weeks subsequent to supplementation, production was 74.8, 74.8 and 71.4 kg fat/cow ($P > 0.05$).

Based on this very limited evidence, it is debatable, to say the least, that financial benefits will accrue from using supplements when feed restrictions occur during lactation in seasonal dairying.

Even less evidence is available for basing decisions regarding the extent of conservation and whether this should be as hay or silage (Davis et *al.*, 1979: Marsh, 1978). In terms of cost, nutritive value, and suitability for the. early conservation that is necessary if pastures are to recover before the onset of dry weather, conservation as silage is probably preferable 'to that of hay.

CONCLUSIONS

On the basis of evidence presented, stocking rate, liveweight at calving, level of feeding in early lactation, and nutritive value of pasture are important factors in maximizing milk production from pasture.

A stocking rate that ensures utilization of most of the feed grown is clearly of paramount importance. As stocking rate increases, however, the margin between feed supply and herd requirements decreases and the need for good management increases. This management has often been outlined (Hutton, 1971a, 1972; Hutton and Bryant, 1976; Campbell *et al.* 1977) and also summarized into five basic principles (Bryant, 1977). The adoption of management that achieves target liveweight or condition at calving without prejudicing feed supplies for after calving appears particularly important. Three essential components of the required management are time of drying off, grazing management in autumn/winter, and calving date. Drying-off is one of the most critical decisions at high stocking rates. It determines the extent of loss in condition in late lactation (Bryant, 1978b) and therefore the amount of feed required during the dry period to replace that condition. It determines the time available not only to make good that condition but also to accumulate pasture reserves for use around calving time. Thus the determinant of when to dry off is not current level of production but rather cow condition, existing and expected feed supplies, and length of the dry period.

The advantages of grazing management that rations autumn and early winter pasture growth to accumulate feed on the farm has already been emphasized.

The beneficial effects of delaying calving date as stocking rate increases (Hutton, 1968) are now widely accepted. It has also been proposed (Macmillan, 1976) that the successful integration of feed supply and demand is more readily obtainable with concentrated calving.

The importance of achieving high levels of production from the herd in early laotation through the combined effects of adequate preparation for calving' and full feeding in early lactation cannot be over-emphasized. It ensures, more than any other input, the full and efficient use of pasture at a time when cow efficiency, pasture growth rate and quality are at or near maximum. It ensures that cows are capable of capitalizing on good summer growth should this occur; and it provides the best and least expensive insurance against the possibility of it not occurring.

The decrease in milk yield that accompanies restricted feeding in early lactation emphasizes that good feeding before calving will not compensate for poor feeding after calving. It is also, true that good feeding after calving will not entirely compensate for poor feeding before calving.

Evidence that qualitative constraints are important at high stocking rates are largely circumstantial. It may be speculated that, while high post-grazing mass ensures a generous herbage allowance at subsequent grazings, nutritive value of this may be reduced to the extent that cow performance also declines. Where the compromise is, and what the roles of topping and conservation are in maintaining quality await definition. Probably more certain is that, at low stocking rates, declining digestibility as uneaten pasture matures becomes an effective constraint to milk production.

High production per farm or per cow clearly involves more than stocking rate and nutrition. It requires also high quality, healthy cows with a satisfactory reproductive performance. They must be subjected to efficient milking machines and milking procedures. A deficiency in any of these factors can cause major losses in production but all must be optimum for high production.

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