Supplementation of Dairy Cows Grazing Intensively Managed Tropical Grass Pastures at Two Stocking Rates[1]

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ABSTRACT

The effects of stocking rate and level of supplementation with concentrate on cows grazing intensively managed tropical pastures were measured with four treatments: grazing alone at 2.5 head per ha per year (T_1); grazing plus concentrate at the rate of 1 kg per 2 kg of milk irrespective of daily yield (T_2); grazing plus concentrates at the rate of 1 kg per 2 kg above 10 kg daily (T_3); and grazing at 5 head per ha plus concentrates at the same level as cows in T_2 (T_4). All three supplemented groups (T_2, T_3 and T_4) produced significantly greater yields of milk and fat. Average milk yields (kg, M.E. basis) were 3450, 5568, 4709 and 5462 for cows on T_1, T_2, T_3 and T_4, respectively. Cows on the higher level of supplement (T_2 and T_4) gained significantly more weight over the lactation period than cows on T_1 and T_3. The effect of the supplement appears to be greatest during the early part of lactation when physiological limitations on the consumption of pasture prevent sufficient nutrient intake to supply demand. Cows on T_2 produced only 105 kg more milk than cows on T_4, while the expected difference, based on increased pasture availability, was over 455 kg. The reduced difference in level of production is postulated as an effect of excessive pasture growth on both intake and diet selection. While milk production was highest for cows receiving the high levels of supplement (T_2 and T_4), expected return per lactation in income over the cost of supplements, lime and fertilizer were greatest for T_3 (medium supplement). Expected returns on a per ha basis were greatest for T_4 with 5 cows per ha. Results indicate that where land costs are high, most efficient use of pasture and concentrate resources may be reached by grazing at the rate of 5 head per ha and supplementing with concentrate at 1 kg per 2 kg of milk.

INTRODUCTION

Intensively managed pastures of improved tropical grasses are an important feed resource to dairymen in the tropics. The yield potential of tropical grass species is well-documented (3); yet, limitations of dry matter (DM) and crude protein (CP) content or rapid decline in digestibility with advancing maturity have prevented direct translation of high yields of forage into as large outputs of milk on a per animal or per ha basis as expected. According to earlier studies at the Gurabo Substation (7), fluctuations in total digestible nutrients (TDN) and CP content available to lactating cows which were grazing intensively managed pastures without supplementation, limited intake to below twice main-

[1] Manuscript submitted to Editorial Board March 6, 1978.

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tenance levels more than 50% of the periods investigated (7). Fluctuations in available nutrients from the grazing and CP content were shown to influence total lactation yields of milk, persistency of milk yield, time after parturition when highest yields were achieved, and, possibly, breeding efficiency. Such fluctuations may introduce a significant effect of season of calving. Supplementation may reduce those effects. The authors concluded that under most situations, some form of supplementary feeding should be included in the evaluation.

Supplementary feeding compensates for fluctuations in forage quality and provides nutrition required for maintenance and growth. McDowell et al. (4) showed significant increases in milk and fat yield from the use of molasses, molasses plus urea, ground whole corn and 20 percent CP commercial concetrate as supplements to fertilized, rotationally grazed pastures. They concluded that medium levels of supplementation, equivalent to 1 kg of concentrate per 2 kg of milk in excess of 10 kg daily, were economically feasible when cows were grazed at the rate of 2.5 head per ha. A higher level of supplementation, 1 kg of concentrate per 2 kg of milk irrespective of levels of production, produced a lowered response per unit of feed input and reduced breeding efficiency.

McDowell et al. (7) estimated intake of grazed forage as 12.2% of body weight for cows on grazing alone and 9.9, 9.0 and 5.5% for cows on grazing plus supplements of molasses, ground corn or commercial concentrate, respectively. Their results showed that unless stocking rate is increased when cows are fed supplements, a considerable amount of forage may be wasted, especially if stocking rate is no more than 2.5 head per ha.

The present study was designed to compare the response of cows grazing at 5 head per ha and receiving a high level of supplementation with cows grazing at 2.5 head per ha on a high or medium level of supplementation, and cows grazing without supplementation.

MATERIALS AND METHODS

The study was carried out over a 14 mo period (November 1974 to January 1976) at the Gurabo Substation (long. 66°12′ W and lat. 18°16′ N), located 42 km southeast of San Juan. The elevation is 24 m and the climate warm and humid. The mean annual maximum temperature is 30° C with monthly means of 28° in January to 32° in July to September. Minimum mean temperature is 19° C with monthly means ranging from 15° to 22° C. The average annual rainfall is 193 cm, ranging from a low in February of 6.4 cm to a high of 20.8 cm in July. An earlier report gives further details on climatic conditions (7).

FEEDING REGIMES

Four feeding regimes were used:

T_1—Grazing alone, 2.5 cows per ha.

T_2—Grazing with 2.5 cows per ha, plus 1.0 kg of commercial concentrate mix (20 percent CP; 72.5 percent average TDN) per 2.0 kg of milk irrespective of level of daily yield.

T_3—Grazing with 2.5 cows per ha and 1.0 kg of the commercial concentrate per 2.0 kg of milk in excess of 10 kg per day.

T_4—Grazing with 5.0 cows per ha and 1.0 kg of commercial concentrate per kg of milk irrespective of daily yield.

The cows were on pasture at all times except for milking twice per day. Those scheduled for supplementary feeding before being milked were stanchioned and were fed individually with the quantity of supplement adjusted according to milk yield at 10-day intervals. Feed refusals were recorded for each feeding. A mixture of 1:1 common salt and di-calcium phosphate was available in the holding area adjacent to the milking parlor. During the dry period all cows grazed on the same pastures without supplement.

The pastures consisted entirely of grasses, principally Pangola (*Digitaria decumbens*), Star (*Cynodon nlemfuensis*), Para (*Brachiaria mutica*) and some native species. Fertilizer, analysis 15-5-10, was applied at the rate of 2240 kg per ha per year in four applications, and lime applied at 2240 kg per ha per year in one application according to the recommendations of Vicente-Chandler et al. (3).

All pastures were in the same area and were grazed for 7-day intervals, with at least 21 days between grazings.

ANIMALS AND RECORDS

Beginning in November 1974, all cows and heifers calving at Gurabo were randomly assigned to one of the four treatments. There were 83 purebred or high grade Holstein cows that completed 80 satisfactory lactations. Lactations were 300 days in length, or until daily yield declined to less than 4.5 kg per day. Breeding by artificial insemination commenced at the first estrus following 60 days of postpartum.

Body weights were recorded on the day of parturition (initial weight), at monthly intervals during lactation, and on the last day of lactation (final weight). Differences between initial and final weights were used to estimate weight changes during lactation.

METHOD OF ANALYSIS

Total records included both actual and extended records. Actual records were up to 300 days, without noted abnormalities. Extended records were substituted where an identified health problem caused a 25% or greater decrease in milk yield for 3 days or more, and where it was evident that the disturbance influenced daily yields 50% or more for 10 days and later. If serious disturbances occurred within the first 30 days of lactation, the record was extended from the last normal day to a 300-day basis using age-season of calving extension factors derived from DHIA records of Puerto Rico (4) and substituted for the actual records. Of the 80 records used in the analysis, 18 or 22.5% were extended records.

A three-way analysis of variance (11) was used. The sums of squares were reduced by age and month of calving adjustments of milk and fat records, factors being used from DHIA records in Puerto Rico (2). Since year, month of calving, and age effects became nonsignificant after adjustment, a one-way analysis of variance model with treatment effects fixed was appropriate for determining treatment effects. Adjusted age-

TABLE 1.—*Means and standard errors of the means for various measures of performance by treatment groups*

	T_1	T_2	T_3	T_4
Cows (No.)	22	20	20	21
Total calvings	22	20	20	21
Records (No.)	20	19	20	21
Lactation length (days)	285 ± 6.0	295 ± 3.9	298 ± 1.6	299 ± 1.0
% Lactation 300 days	36.4	10.5	10.0	4.8
Milk yield (kg)	3,450 ± 97a[1]	5,568 ± 304b	4,709 ± 211b	5,462 ± 281b
% of T_1		161	136	158
Fat %	3.22 ± .08	3.03 ± .12	3.20 ± .09	2.94 ± .07
Fat yield (kg)	111 ± 5a	169 ± 11b	151 ± 7b	157 ± 8
Supplement (kg)	0	2,453	814	2,429
Body weight (kg)				
Initial	515 ± 16	540 ± 14	521 ± 12	515 ± 15
Final	489 ± 17	545 ± 14	480 ± 12	527 ± 13
Gain 0-240	−26 ± 6a	5 ± 7b	−41 ± 8a	12 ± 6b
Days				
Calving to first heat	67 ± 7	73 ± 19	55 ± 7	60 ± 7
1st breeding to conception	36 ± 12	50 ± 12	72 ± 18	72 ± 17
Services/conception	2.37 ± 0.46	2.32 ± 0.34	2.47 ± 0.41	3.19 ± 0.56
Calving interval	407 ± 18	431 ± 18	431 ± 18	445 ± 20

[1] Mean values in the same row with one or more letters in common do not differ significantly at the 5% level.

month of calving records was used for milk and fat yields, while actual values were used for body weights, fat percentage and measures of breeding efficiency.

Sires were ignored in the analysis, since sire progeny was assumed to be randomly distributed among treatments.

RESULTS AND DISCUSSION

LACTATION LENGTH AND PRODUCTION

Treatment effects were not significant for lactation length (table 1). On grazing alone (T_1), 36.4% had lactations of less than 300 days, but the percentage was much lower for those receiving supplement. This result is similar to that for earlier studies (4,7).

Treatment effects were significant ($P < .01$) for lactation milk yield. Average yields for the high supplement groups (T_2 and T_4) were similar and over 773 kg higher than that for the low supplement group (T_3); however, yields were not significantly increased with the higher feeding level (table 2). All three supplemented groups produced significantly higher yields than those on grazing alone (T_1). The highest individual lactation record was 4,550 kg for T_1 and 7,925, 6,177 and 7,100 kg for T_2, T_3 and T_4. Average milk yield for cows in group T_1, T_2 and T_3 was higher than that reported for similar treatments in a previous trial (4). This reflects in part the addition of heifers imported from the U.S. into the herd (9) together with some genetic gain in the domestic herd and in part to improvement in pasture management.

Cows on T_2 averaged highest in peak yield followed by T_4, T_3 and T_1 (fig. 1). The shape of the lactation curve for cows without supplement

TABLE 2.—*Incidence of health problems*

Treatment group	Mastitis	Foot problems	Anaplasmosis	Other	Total	Percentage of total records
T_1	2	3			5	25
T_2	5	6	1		12	63
T_3	9	4		1	14	70
T_4	7	4			11	57
Total	23	17	1	1	42	71

was distinctly different from that for cows receiving supplement (fig. 1). Cows on T_1 showed no distinct peak in production. Peak daily milk production was 16.3, 25.7, 20.9 and 22.6 kg for cows in T_1, T_2, T_3 and T_4. Cows in T_1 reached their peak within 30 days postpartum while the other groups peaked about 10 days later. The performance of T_1 cows in the early part of lactation indicates that nutrient intake from grazing was insufficient to support high levels of milk production. This deficit is a result of a limitation on the intake of pasture DM or a specific deficiency within the DM consumed. In either case, the use of supplement overcomes the deficit. Lactation curves (fig. 1) emphasize the impact of the deficit situation, especially with regard to early lactation. Cows on grazing alone showed essentially no peak in lactation between days 0 and 60 while cows receiving supplement (T_2, T_3 and T_4) showed a definite peak. Cows grazing at 2.5 heads per ha and receiving supplement averaged 52% (T_2) and 36% (T_3) higher over the whole lactation than for T_1, but the rate of decline in yield from day 60 to 160 was similar to that for grazing (3.2, 3.4 and 3.1 percent per 10 days for T_1, T_2 and T_3). Similarity in rate of decline by 160 days for T_1 and T_3 could be expected since few of the cows on T_3 were still receiving supplement; however, the rate of decline for T_2 from 160 to 240 days was 10 to 12% faster than expected for high level of feeding.

The major effect of supplementation appears to occur during early lactation. Relative to the grazing alone group (T_1), cows on the high level of supplement grazing at 2.5 heads per ha (T_2) produced 55.7% more milk

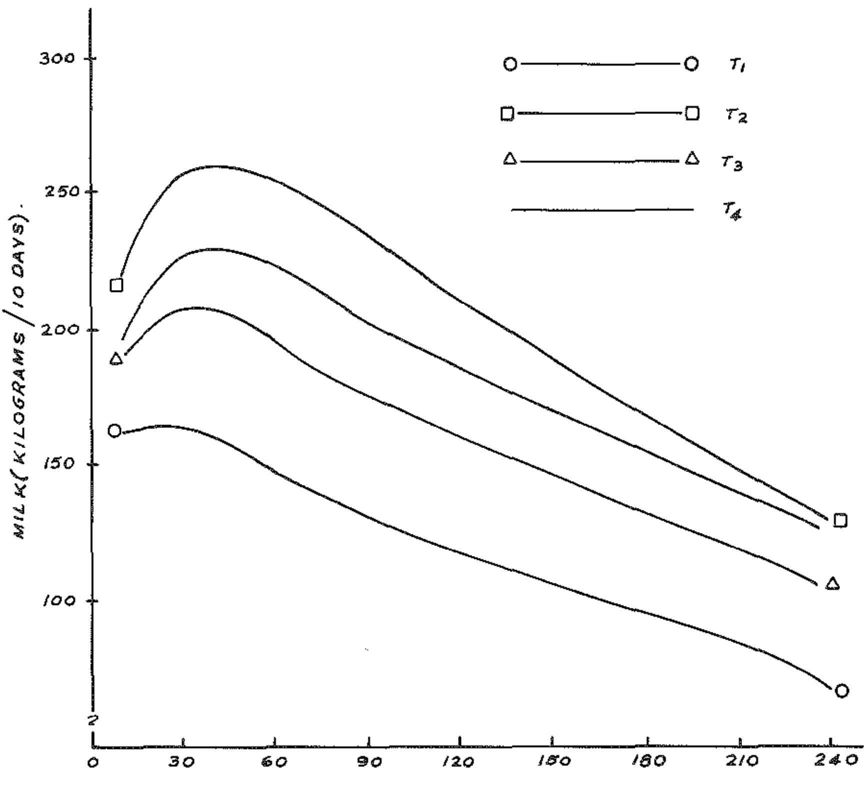

FIG. 1.—Lactation curves based on average 10-day yields from the 10th through the 240th day of lactation for the four treatment groups.

in the period 0 to 60 days, while those receiving the lower level of supplement (T_3) were 26.4% higher. This result is similar to that observed by McDowell et al. (5), where cows calving in July and August produced significantly less milk than winter-calving cows due to the depressing effect of high temperature on appetite in early lactation. The demands for high production in the first two months postpartum create a need for feed nutrients over and above body reserves, which supplements and/or increased appetite must supply. When a physiological limitation exists, such as rumen capacity for pasture grass, or a limitation on eating time, needs are not met and production in early lactation is depressed. It is possible that the fewer numbers of days in lactation for cows on grazing alone (T_1) relative to cows receiving supplement can also be explained by this effect.

Cows in group T_4 produced 12.8% less milk in days 0 to 160 than cows receiving the same level of supplementation but grazing at 2.5 heads per ha (T_2). However, cows in group T_4 declined at an average of 2.8% per 10 day period over days 60 to 160, in comparison to 3.4% for T_2 cows. By day 240 (fig. 1), production levels were essentially the same and production over the total lactation for the two groups did not differ significantly (table 1). The increased pasture available to the T_2 cows is, therefore, of greatest importance in days 0–60 and may have a stimulatory effect on early lactation causing the T_2 cows to use up body reserves necessary to sustain lactation beyond 60 days.

Previous experiments in Puerto Rico (1,13) showed intake of DM as 1.9 to 2.2 kg per 100 kg of body weight per day for lactating cows, leading to a recommended stocking rate of 2.5 lactating cows per ha for grazing heavily fertilized tropical grass pastures. However, McDowell et al. (7) found that cows receiving high levels of supplement had much lower intake, 1.33 to 1.41 kg per 100 kg of body weight. The less-intense stocking rate should have allowed for a higher quality diet due to greater opportunity for selection of higher quality pasture components. On this basis, the projected average milk yield for T_2 should have been at least 455 kg greater than for the higher stocking rate (T_4), whereas the actual difference was 105 kg (table 2). At the lower stocking rate (T_2) the pastures probably had, at times, excess growth, which possibly affected both intake and diet selection; while at the higher stocking rate, quality of forage might have been better due to more intense grazing. One possible reason cows on T_3 averaged higher in milk yield than expected in comparison to high supplement may have been that limited level of supplement resulted in considerably more grazing. St. Louis (12) found that growing Holstein heifers receiving grazing plus supplement had progressively lower gains over a 5 mo period than heifers on grazing alone. He attributed the less than expected gains to overgrowth of pastures for the supplemented group. These observations show that when supplementary feeding is planned with highly fertilized pastures, stocking rate should be adjusted correspondingly or else forage will be wasted and animal performance less than expected.

PERCENTAGE FAT AND FAT YIELD

Treatment effects for fat yield were significant but not for fat percentage in the milk (table 1). Cows receiving supplement had significantly higher fat yields than on grazing alone, but tended to have lower values for fat percentage (table 2). There was no significant difference between fat yield for stocking rate (T_2 and T_4). Fat percentage in the milk tended to be lowest for T_4 cows, reflecting the effect of the higher intake of readily digestible carbohydrates relative to the other three groups. The effect of high levels of supplement on fat percentage is evident in a comparison of the increase in fat yield for groups T_2, T_3 and T_4 over group T_1 and the corresponding increase for milk yield. On a medium level of supplementation (T_3), cows produced 36% more milk and fat than on grazing alone (T_1). Cows in group T_2 produced 61% more milk than T_1, but only 52% more fat. With a higher stocking rate (T_4), cows produced 58% more milk but only 41% more fat than for T_1.

BODY WEIGHT

Body weight change, day 0 to 240 of lactation, is shown in fig. 2. The F values for final body weight and weight gain (table 1) were significant ($P < .01$). Body weight gains for the 2 groups receiving high levels of supplementation (T_2 and T_4) were significantly ($P < .05$) greater than for groups T_1 and T_3. When gain from the day of lowest average weight (day 30 for groups T_1 and T_2; day 60 for groups T_3 and T_4) to day 240 is considered (Table 2), cows grazing at 5 head per ha (T_4) gained significantly more than cows grazing at 2.5 head per ha (T_1, T_2 and T_3) and cows receiving supplement (T_2 and T_3) gained significantly more than cows receiving no supplement (T_1). By day 240, cows in group T_2 had gained an average of 35 kg from their lowest body weight (day 30), while cows in group T_4 had gained an average of 46 kg from their low point (day 60).

On all treatments, cows lost weight during the first 30 days, presumably the period when demand for nutrients exceeded intake. This weight loss parallels the increase in daily milk yield seen for cows on supplement in fig. 1. Cows on grazing alone failed to show a lactation peak, despite weight loss which parallels that of cows in groups T_3 and T_4. Body reserves, therefore, were insuffficent for cows on grazing alone to meet the excess demand over intake in early lactation. Following day 30, changes in body weight among cows in group T_1 were slight (fig. 2) and the decline in average daily lactation consistent (fig. 1), indicating that intake of nutrients in the form of pasture was sufficient to meet lactation demand but insufficient for weight gain. When cows received supplement at the level of 1 kg per kg of milk above 10 kg daily (T_3), nutrient intake appeared sufficient to allow for gain but weight loss in early lactation continued to day 60 (fig. 2), and final body weight was still lower than initial body weight (table 2).

McDowell et al. (4) reported the same effect of supplementation on weight gains for cows grazing at 2.5 heads per ha. However, the magnitude of weight changes was smaller, cows on grazing alone lost 13 kg over the whole lactation, while cows receiving the high level of supplementation (T_2) gained 6 kg and cows on the medium level (T_3) lost 8 kg.

BREEDING EFFICIENCY

Differences among treatment groups for measurements of breeding efficiency were not significant (table 1). Cows on T_2 were slowest in return to estrus. Cows receiving the medium level of supplementation (T_3) returned to estrus within 55 days postpartum, 12 days less than cows on grazing alone.

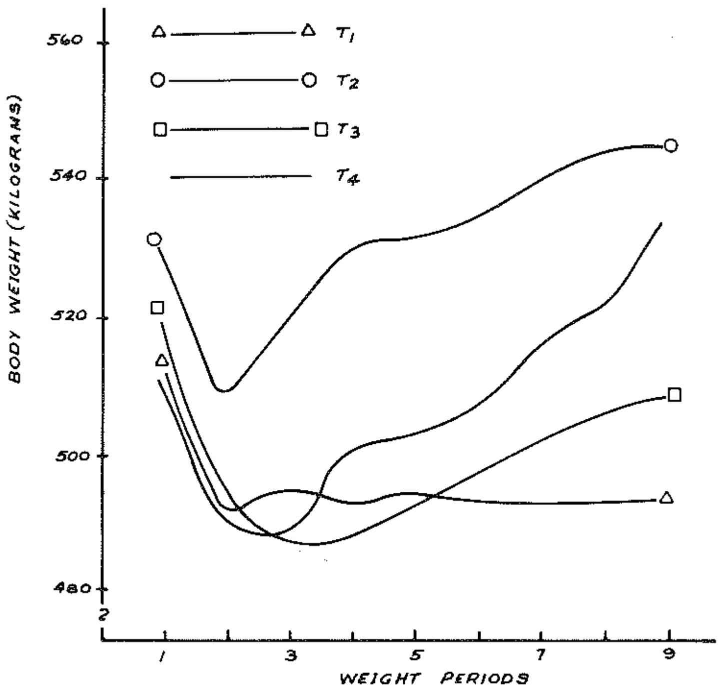

FIG. 2.—Average body weights for day of calving (0) and the following 9 months during lactation for the four treatment groups.

Despite the delay in return to estrus, cows on grazing alone (T_1) showed the shortest average period between first breeding and conception. Cows in T_3 and T_4 required an average of 36 more days than cows on group T_1 to conceive following first breeding. The long delay in conception following first breeding resulted in an average calving interval of 445 days for cows in T_4 and 431 days for cows in T_2 and T_3. Cows on grazing alone (T_1) had the lowest average calving interval, 407 days.

Why cows grazing at the rate of 5 heads per ha should exhibit such poor breeding efficiency is not directly evident from the data. Cows in T_4

returned to estrus in adequate time but exhibited poor fertility, requiring an average 3.19 inseminations per conception compared to 2.32 for cows grazing at 2.5 heads per ha (T_2). Cows in T_4 lost weight for 60 days (fig. 1) which may account for the delay in return to estrus, but gains following 60 days were adequate, indicating that dietary intake was above that required for maintenance and production. Similarly, cows in group T_2 and T_3 were in positive energy balance following day 60 compared to cows in T_1, yet average calving interval was 24 days longer.

When lactation length and calving interval were considered, cows in T_4 averaged 146 days dry compared to 136 days for T_2 and 133 days for T_3. Cows on grazing alone averaged 122 days dry. Had the milking period been extended beyond 300 days, cows in T_2, T_3 and T_4 could have been economically milked longer, an option which would reduce the length of the dry period. Though the calving intervals were similar to those reported by McDowell et al. (4), they exceeded those for DHIA herds in Puerto Rico (3), the subtropics (6,8) and temperate areas (10). Sampling variance for measures of breeding efficiency are usually high, which could be a factor in the present study, but the consistently slow rebreeding for cows on high levels of supplementation in all the tests at Gurabo shows a need for further investigation as to cause.

HEALTH PROBLEMS

Mastitis was the most frequently occurring health problem, accounting for 55% of all recorded problems (table 2). Foot problems, caused by the long distances the cows travelled over concrete and gravel roads, together with bacterial infections, accounted for 40% of reported problems. Although treatment effects were not significant, cows on grazing alone (T_1) had the fewest health problems. These results are similar to those reported earlier (7).

ECONOMIC ANALYSIS

Based on a farm milk price of $0.30 per liter (0.98 kg of milk per liter), gross income per cow averaged $1,035, $1,637, $1,413 and $1,639 for cows in T_1, T_2, T_3 and T_4 (table 3). When the amount of supplement fed per cow (table 2) was considered ($0.22 per kg), income over supplement was highest for cows receiving the medium level of supplementation. Therefore, milk yield increased per cow relative to T_1 by 61% for T_2, and 36% for T_3. Due to the higher level of supplementation for cows on T_2, expected income above cost of supplement relative to T_1 was higher for T_3 at 19% than for cows on T_2 at 10%. When the value of the increased milk produced relative to T_1 is considered, cows on T_3 returned $2.11 per $1.00 of supplement, while cows in T_2 returned only $1.18.

Expected income per lactation over cost of supplement for cows on T_4

relative to cows on T_1 was 7% higher. The return in increased milk per $1.00 of supplement was similar to that of T_1 at $1.13, but lower than that for T_3. Similarly, when the cost of lime and fertilizer per cows was deducted from the expected income above cost of supplement, cows on T_4 returned only 8% more income relative to cows on T_1, compared to 12 and 24% for cows on T_2 and T_3, respectively. However, when expected income over the cost of supplements, lime and fertilizer is computed on a per ha basis, cows on T_4 returned 141% greater expected income than those on T_1, compared to 12 and 24% greater income for T_2 and T_3, respectively.

In more practical terms, the number of cows needed to produce $100,000 in net income above cost of supplement, lime and fertilizer was

TABLE 3.—*Projected economic returns for grazing versus two levels of supplementation and stocking rate*

Item	T_1	T_2	T_3	T_4
Milk per lactation (kg)	3450	5575	4709	5462
Value of milk (dollars)	1035	1673	1413	1639
Cost of supplement (dollars)	0	540	179	534
Income over supplement				
Cost (dollars)	1035	1133	1234	1105
% deviation from T_1		10	19	7
Cost of lime and fertilizer/cow (dollars)	200	200	200	100
Income over cost of supplement, lime and fertilizer (dollars)	835	933	1034	905
% deviation from T_1		12	24	8
Income per ha (dollars)	2088	2333	2585	5025
% deviation from T_1		12	24	141
No. cows required to provide $100,000 net income/year[1]	120	107	97	110
Ha of pasture required for $100,000 income	48	43	39	20

[1] Income above cost of supplement, lime and fertilizer.

estimated at 23% less for low supplement (T_3) than for grazing alone (T_1), but only 13% less when a higher level of supplement is offered to cows grazing at 1 head per acre (T_2). When carrying capacity is 5 heads per ha, 110 cows, 3 cows more than required at 2.5 heads per ha, are necessary to produce $100,000 in net income.

When land resources are limited, and costs of fixed and variable inputs to maintain the land resource (fencing, labor, herbicides, etc.) are high, the economic advantage of carrying 5 cows per ha at a high level of supplement is evident. To produce $100,000 in net income above the cost of supplements, lime and fertilizer per ha, only 20 ha are required if the T_4 system is employed, compared to 48, 43 and 39 ha for T_1, T_2 and T_3, respectively.

RESUMEN

Los efectos de la carga animal del pasto y el nivel de suplementación con alimento concentrado de cuatro tratamientos se midieron utilizando vacas que consumieron pastos tropicales cultivados intensivamente: pasto exclusivo a razón de 2.5 vacas por ha y año (T_1); pasto más alimento concentrado a razón de 1 kg por 2 kg de leche, independientemente de la producción (T_2); pasto más alimento concentrado a razón de 1 kg por 2 kg de leche producida sobre los primeros 10 kg (T_3); y pasto a razón de 5 vacas por ha más alimento concentrado al mismo nivel que el de las vacas en T_2 (T_4). Los tres grupos suplementarios (T_2, T_3 y T_4) produjeron cantidades mayores de leche y grasa que el grupo con pasto exclusivo (T_1). Las producciones medias de leche (kg, a base del equivalente de madurez) fueron 3450, 5568, 4709 y 5462 para las vacas en los tratamientos T_1, T_2, T_3 y T_4, respectivamente. Las vacas en los niveles altos de suplementación (T_2 y T_4) ganaron significativamente más peso durante el período de lactancia que las vacas en T_1 y T_3. El efecto de la suplementación parece ser mayor durante la primera parte de la lactancia cuando las limitaciones fisiológicas en el consumo del pasto evitan el consumo de nutrimentos que suplan la exigencia del animal. Aunque la producción de leche fue mayor en vacas que recibieron los niveles altos de suplementación (T_2 y T_4), el beneficio esperado por lactancia en ingresos sobre el costo de los suplementos, cal y abono fueron mayores para T_3 (suplemento mediano). El beneficio esperado por ha fue mayor para el tratamiento T_4 con 5 vacas por ha. Los resultados indican que, donde el costo del terreno es alto, el uso más eficiente de los pastos y alimentos concentrados se pueden alcanzar, al pastar a razón de 5 vacas por ha, suplementando la alimentacion con pienso concentrado a razón de 1 kg por cada 2 kg de leche producida.

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