Forage Management and Methods to Improve Nutrient Intake in Grazing Cattle

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Introduction

Most of the grassland areas in Brazil are covered with tropical grasses. The majority of the milk (Stock et al, 2011) and about 92% of the beef (Millen et al., 2009) are produced on pasture based systems. The latter authors reported that only 3 to 4 million cattle were finished in feedlots in the year of their survey from a total of approximately 36 million head slaughtered. Despite the great volume of beef and milk produced in Brazil, productivity is still low because, in part, of poor pasture management practices resulting in low stocking rates and poor animal performance. Stocking rate in Brazilian grassland areas averages 0.92 animal units (**AU**)/hectare (**ha**) (1 AU = 450 kg body weight) (IBGE, 2006). This value is considered adequate during the dry winter season, but far from what can be achieved in intensive grazing systems during the hot rainy season, i.e. 6 to 10 AU//ha (Agostinho Neto, 2010; Correia, 2006). Despite the higher stock capacity, the average daily gain (**ADG**) and milk production are lower than the animals' genetic potential, even when tropical grazing systems are managed intensively. The low performance is attributed to the limited energy intake resulting from low grazing efficiency and rumen fill caused by the high fiber content in tropical grasses. Those variables are strongly influenced by pasture management. Therefore, management practices that improve energy intake by grazing cattle, such as improvement in forage quality and availability and/or energy supplementation may be implemented as tools to improve animal performance and productivity in tropical grazing systems.

Forage Intake

Nutritional Value of Tropical Forages

According to Conrad et al. (1964), forage intake is regulated by the capacity of the rumen-reticulum to digest low quality forages, also known as physical effect or rumen fill, or by the feedback caused by nutrients absorbed from high energy diets, also known as physiological effects. For grazing cattle, the physical regulation is the major mechanism controlling forage intake.

Allen (2000) recently reviewed dietary effects on short-term regulation of feed intake in lactating dairy cattle. It was found that the time spent chewing and the

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distention within the gastrointestinal tract were major factors affecting dry matter intake (**DMI**) in cattle. The rumen-reticulum is the major site in the gastrointestinal tract where the distention mechanism occurs. Tension receptors are stimulated by distension of the rumen-reticulum, which is sensed by satiety centers in the brain signaling the end of a meal. Dietary forage neutral detergent fiber (**NDF**) content, physical form of fibrous feed, NDF digestibility, and fiber particle fragility are some of the most critical feed factors that influence intake by inducing rumen distension and fill (Allen, 2000).

The chemical composition of hand plucked or grazing horizon samples of well managed tropical pastures collected during Spring, Summer and Fall are presented in Table 1. It is noted that even in well managed tropical pastures, forage NDF content is high, varying from 54.2 to 66.3%. Recently, Lopes (2011) characterized the nutrient profile and fiber digestibility of the main tropical grasses produced under intensive rotational grazing management in Brazil. One-hundred and six samples of Palisade grass (*Brachiaria brizantha*), Mulato grass (*Brachiaria hibrida*), Bermuda grass (*Cynodon dactylon*), African Bermuda grass (*Cynodon nlemfuensis*), Guinea grass (*Panicum maximum*) and Elephant grass (*Penisetum purpureum*) were used. Tropical grasses presented 14 to 21% crude protein (**CP**) and 60 to 63% NDF. Comparison between mean of *in vitro* NDF digestibility (**IVNDFD**) estimates of tropical grasses by time-point and a standard sample of alfalfa silage indicated that the tropical grasses had higher fiber digestibility than that obtained from alfalfa (Figure 1). The author concluded that tropical forages subjected to intensive grazing management practices can be relatively high in CP content and fiber digestibility (Lopes, 2011). Despite the lower IVNDFD, alfalfa presents less NDF content with more fragile particles. Allen (2000) reported that lactating cows had greater DMI when diets contained alfalfa silage compared with grass silage despite the higher NDF digestibility found in the latter source of forage. The author suggested that alfalfa caused less rumen filling because particles were more fragile and resulted in a decreased retention time in the rumen-reticulum, thereby causing less distention and allowing increased DMI. Romero (2008) evaluated *in situ* DM digestibility of Elephant grass (*Penisetum purpureum*) under intensive rotational grazing management. The author reported that DM effective digestibility was 55.9%. Furthermore, Pacheco Junior (2009) reported that DM effective digestibility of Palisade grass (*Brachiaria brizantha*) was 58.8% and for Mulato grass (*Brachiaria hibrida*) it was 58.7%.

Collectively, these data indicate that total NDF content, particle structure, and digestibility of NDF of tropical forages may all limit forage intake because of rumen fill, which in turn reduces energy intake by grazing cattle.

Sward Structure

The discussion above highlighted the importance of the physiological mechanisms regulating forage intake. However, for grazing cattle, before forage reaches the gastrointestinal tract, it has to be harvested by the animal. Hodgson et al. (1977) reported that the structure of the sward may have a greater impact on forage

DMI in grazing cattle than the physiological mechanisms discussed by Conrad et al (1964) and Allen (2000).

The structure of the sward has a great impact on grazing efficiency in cattle on either temperate grasses (Hodgson et al., 1994) or on tropical grasses (Da Silva and Pedreira, 1996; Carvalho et al., 2001; Da Silva et al., 2009). Shortly after harvesting, the grass initiates its regrowth with intense appearance and growth of leaves and minimal stem elongation. This process continues until the sward reaches a certain height and light starts to become limiting for the lower portions of the sward. That point is when more leaves become senescent and most of the elongation of stems happens. The result is an increased proportion of senescent material, a greater participation of stems and a decreased proportion of green leaves in the sward, altering the grazing efficiency and forage intake (Dórea et al., 2013a,b).

Rotational grazing, based on fixed or pre-established number of days between grazing activities, has been criticized by Da Silva and Corsi (2003). Grass dry matter production is dictated by the genetic potential of the grass variety and by environmental conditions such as temperature, sun light, soil fertility, and water availability. As these conditions vary, grazing interval must vary as well. The ideal start grazing point should be based on plant physiology aspects instead of on fixed grazing intervals.

The concept of an ideal start grazing point originated from studies with temperate grasses using the 95% light interception (LI) criterion by Hodgson (1990), which has been successfully applied to tropical grasses (Da Silva and Nascimento Júnior, 2007). The latter authors reported a number of studies conducted in Brazil with various tropical grasses and a range of canopy height values that correlated to 95% LI. The studies reported by Da Silva and Nascimento Júnior (2007) indicated that the canopy heights correlating to 95% LI vary with time of the year, but a much greater degree of variation was observed between plant species than within species. Canopy heights correlating to 95% LI in various studies with tropical grasses are presented in Table 2.

Morphological composition of plants managed based on 95% LI criterion as the start grazing point presented significantly higher proportion of leaves and less proportion of stems and senescent material compared with plants managed with fixed grazing intervals (Table 3). Carvalho et al., (2001), pointed out that the structure of the sward strongly influences forage intake in grazing cattle, having more effect than the physiological and chemical mechanisms discussed by Conrad et al (1964) and Allen (2000) due to its impact on the forage harvesting process. The impact of the sward structure on forage intake in grazing cattle has been reported by several other authors (Da Silva and Carvalho, 2005; Casagrande, 2010; Vieira, 2011; Paula et al., 2012).

There is scarce literature on animal performance studies in which the 95% LI criterion was compared with fixed grazing interval for tropical grasses. Gimenes et al. (2011) compared two sward heights as the start grazing point, 25 cm (95% LI) and 35 cm (approximately 100% LI) using Nellore yearling bulls grazing Palisade grass (Table 4). In both treatments pastures were grazed down to 15 cm height. Animals grazing the pastures managed based on 95% LI criterion gained faster and stocking capacity was greater. A relatively small modification on pasture management resulted in 55% increase in total BWG/ha. Voltolini et al., (2010) reported increased milk production, stocking rates and consequently increased production per area when cows grazed pastures of *Elephant grass* cv. Cameroon managed using 95% LI (103 cm canopy height) as the grazing starting point compared with cows grazing paddocks managed with 27 days fixed grazing intervals (Table 5). Post grazing sward heights were 62 and 71 cm for the 95% LI and for the 27 d fixed grazing interval respectively. Carvalho et al. (2001), Da Silva and Carvalho (2005), Casagrande (2010), Vieira (2011) and de Paula et al. (2012) reported greater DMI of cattle grazing pastures with better sward structure. Carvalho (1997) and Pedreira et al. (2005) reported that cattle grazing pastures with same initial forage mass but with different sward structures had different forage intake and performance.

Collectively, these data support the positive responses of beef and dairy cattle to pasture management based on the 95% LI criterion. Applying these concepts result in increased nutrient intake, primarily calories, because more forage is consumed under shorter grazing times that result in less energy expenditure, as reported by Dórea et al. (2013a,b). The greater stocking rate is the result of more efficient grazing process, with less wasted forage material.

In order to maximize forage intake of grazing animals, the ideal point to remove them from paddocks is as important as the entrance height. Mezzalira (2012) demonstrated that forage ingestion rate (g of DM/min) was depressed drastically when cattle was forced to graze down more than 40% of the initial sward height (Figure 2). Therefore, based on the discussion above, combining the 95% LI criterion to start grazing with removal of cattle when 40% of sward initial height is grazed down maximizes forage intake and animal performance. Nevertheless, meat production per area may be maximized with more severe grazing due to greater stocking capacity (Sarmento, 2007). Feeding concentrates high in energy is a tool to increase grazing cattle performance, stocking rate and beef and milk production per area (Correia, 2006, Macedo, 2012), which can minimize the detrimental effects of severe grazing on individual animal performance (Costa, 2007).

Energy Supplementation of Grazing Cattle

Beef Cattle

Multiple experiments have been conducted by our group to address performance of growing beef cattle under intensive grazing of tropical pastures with supplementation. The positive effect of energy supplementation of yearling bulls grazing Palisade grass (12.5% CP and 57% NDF, hand plucked) on rotational system during summer and autumn, using N fertilization, is presented in Table 6. Cattle were supplemented daily with increasing levels of a 20% CP supplement (Correia, 2006). Compared with non-supplemented animals (control group), supplementing at 0.9% of BW, increased ADG by 63%, pasture stocking rate by 36%, and carcass yield per hectare by 91% (Correia, 2006). Dórea (2011) tested multiple feeding schemes (0, 0.3, 0.6 and 0.9% BW as fed) of a supplement containing finely ground corn, mineral mix and monensin (mineral and monensin concentrations varied to supply same amount per treatment) using rumen cannulated Nellore steers grazing Palisade grass (13% CP; 62% NDF, hand plucked) on a rotational system (25 cm entrance height and 15 cm stubble height) (Table 7). The author found that supplementation up to 0.9% of BW had no negative effect on fiber digestibility. Feeding 0.6 or 0.9% BW had little impact on grazing time and forage intake compared with the 0.3% level. Substitution was greater for steers receiving the 0.3% supplement, which might have been caused by shifts in grazing behavior. The energy intake data of the metabolism study corroborates with performance results from the study of Correia (2006) presented in Table 6. Feeding 0.3% had no significant effect on ADG and had a large impact on pasture stocking rate. In conclusion, in intensive rotational grazing systems using tropical forages, it is necessary to supplement more than 0.3% BW of an energy supplement to increase energy intake, ADG and beef production per area.

Agostinho Neto (2010) compared two strategies to supplement energy (ground corn + monensin) to growing cattle grazing Palisade grass (11.9% CP; 66.3% NDF, hand plucked) during autumn, when forage dry matter production is low. Pastures were managed on rotational system based on the 95% LI criterion as the start grazing point. The experiment lasted 149 days. Cattle were fed no supplement (0%), or were supplemented daily with 0.6% BW for the entire experimental period or with 0.3% of BW for the first 65 days, 0.6% for the next 51 days and then 0.9% for the last 33 days of experimental period (Table 8). In general, feeding more supplement by the end of pasture growing season was more beneficial. Energy supplementation helps alleviate depression in animal performance when pastures are grazed down to lower stubble heights. Costa (2007) evaluated the efficacy of energy supplementation (0.6% BW) for cattle grazing Palisade grass pastures (15% CP; 64% NDF) managed on a rotational grazing system using the 95% LI criterion as the start grazing point (25 cm height) and two stubble heights, 15 or 10 cm (Table 9). The author found that the detrimental effects of more severe grazing on individual performance were minimized when cattle were supplemented, while higher stocking rates were achieved.

To better understand the interactions between pasture management practices and energy supplementation on forage and energy intake by grazing cattle, 7 metabolism studies were conducted by our research group. In Exp. 1 (Figures 3, 4, 5, 6 and 7), 8 rumen cannulated Nellore steers grazed Palisade grass managed with 25 vs. 35 cm sward height as the start grazing point, both treatments with 15 cm stubble height, supplemented (0 vs. 0.6% BW as fed) with energy (ground corn + monensin) (Dórea et al., 2013a). Cattle grazing pastures managed based on the 95% LI criterion (25 cm) spent less time grazing and more time resting (Figure 3), had increased biting rate (Figure 5), and consumed more forage dry matter, more total dry matter and more digestible dry matter (Figure 6) compared with cattle grazing pastures managed with 35 cm sward height as the start grazing point. Supplying a feed supplement at 0.6% BW decreased grazing time (Figure 3), but had no effect on biting rate (Figure 5), decreased forage DMI, but increased digestible dry matter intake (Figure 6) compared with no supplementation. Pasture management (25 vs. 35 cm) increased intake of digestible dry matter by 43% (1.42 vs. 0.99% BW), whereas supplementation at 0.6% of BW increased intake of digestible dry matter by 29.5% (1.36 vs. 1.05% BW) (Figure 6). The reason for these differences is that adoption of the 95% LI criterion increased total DMI from 1.52 to 2.18% BW, whereas supplementation at 0.6% BW caused a nonsignificant increase in total DMI (1.77 up to 1.93% BW). There was an interaction between sward height and supplementation (Figure 4). The decrease in grazing time and, consequently, the substitution of grain for forage was greater for pastures managed at 35 cm height most likely because cattle stopped grazing earlier in pastures with less favorable sward structure. In Experiment 2, the supplementation level was reduced to 0.3% BW (Figures 7, 8 and 9). Most results observed in this study were similar to the those of Experiment 1, except that supplementation affected digestible dry matter intake. Because of the high substitution rate, feeding only 0.3% resulted in decreased forage intake and less total DMI. The extra energy from supplement did not compensate the decreased energy intake from forage. This result is in agreement with previous studies from Correia (2006) and Dórea (2011) (Tables 6 and 7).

According to Carvalho et al. (2009) and Mezzalira (2012), forage dry matter ingestion rate is not decreased until cattle grazes down to 40% of the pre grazing sward height. In Experiments 1 and 2 from Dórea et al. (2013), post grazing height was the same, managed at 15 cm for both pre-grazing heights (25 vs. 35 cm). Raising the post grazing height to 21 cm for Palisade grass managed with 35 cm could theoretically alleviate part of the negative effects on cattle ingestive behavior, because it would represent 40% of the initial height. Preliminary data from Experiments 3, 4, 5 and 6 (Agostinho Neto, unpublished results; Santos, unpublished results) and data from Difante et al. (2009) corroborate this hypothesis.

Dairy Cattle

The main objective of supplementation of grazing dairy cows is to increase DMI and energy intake relative to that achieved with diets based exclusively on grazed forages. In a review, Bargo et al. (2003) stated that in temperate pastures with concentrate supplementation ranging from 0 to 10 kg DM/d, milk responses ranged from 0.60 to 1.45 kg milk/kg concentrate, and overall milk yield increased at 1 kg milk/kg concentrate. Macedo (2012) reviewed studies using supplements fed from 1 to 11 kg DM/d to dairy cows grazing tropical pastures. The author reported that milk yield increased at 1.42 kg milk /kg concentrate.

The addition of fat sources and more extensive processed cereal grains are efficient methods to increase energy density of supplements for dairy cows. Two studies were conducted by our research group to address fat supplementation and steam-flaking of corn with flint endosperm fed to lactating cows grazing tropical grasses. Souza et al. (2013) supplemented early lactation crossbred ½ Holstein ½ Jersey cows grazing elephant grass with 8 kg DM concentrate (ground corn + soybean meal + minerals and vitamins) with the addition or not of 400 g/cow/day of calcium salts of palm oil or of soybean oil from day 15 until 105 postpartum. After that period, the residual effect of lipid supplementation was evaluated until 280 DIM (Figure 10; Table 10). Calcium salts of palm oil supplementation was effective to increase yields of milk and total solids and had a residual effect on milk and total solids production from day 105 to 280 post calving. Calcium salts of soybean oil depressed DMI and NDF total tract digestibility, caused severe milk fat depression and did not influence yield of total solids throughout the lactation. Batistel et al. (unpublished) supplemented early lactation cows grazing Elephant grass with 9 kg DM concentrate with or without 400 g/cow/day of calcium salts of palm oil associated with two corn processing methods, ground vs. steam-flaking (Table 11). Both fat supplementation and steam-flaking of corn of flint endosperm increased milk yield and these effects were additives. However fat supplementation caused greater increase in milk yield than corn processing. In addition, steam-flaking or corn had a pronounced effect on milk protein content.

Conclusion

Increments in productivity of grazing productions systems can be met with current technology simply by changing management practices such as when animals should be placed or removed from pastures. More favorable sward structure may be reached when the 95% light interception criterion as the start grazing point is adopted, resulting in positive effects on forage intake and energy saving by grazing cattle.

In intensive rotational grazing systems, supplementing the diet of cows with ingredients rich in fermentable carbohydrates increases animal performance because of increased digestible dry matter intake and decreased energy expenditure for grazing activity. Supplementation also buffers the negative effects of more severe grazing on energy intake, which allows increments in pasture stocking rate. However, these benefits are dose dependent.

For dairy cows grazing tropical grasses, the supplementation of calcium salts of palm oil is an effective method to increase intake of digestible energy, in particular during early lactation, which results in beneficial effects on performance that last beyond the period of supplementation.

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Table 1. Chemical composition (% DM) of hand plucked or grazing horizon samples of well managed tropical pastures collected during spring, summer and fall

Forage	CP[1], %	NDF[2], %	Reference
Brachiaria brizantha cv. Marandu	12. 6	57. 4	CORREIA (2006)
Brachiaria brizantha cv. Marandu	13. 6	56. 2	CORREIA (2006)
Brachiaria brizantha cv. Marandu	15. 3	65. 0	COSTA (2007)
Brachiaria brizantha cv. Marandu	15. 4	63. 9	PACHECO, JR. (2009)
Brachiaria brizantha cv. Marandu	11. 9	66. 3	AGOSTINHO NETO (2010)
Brachiaria brizantha cv. Marandu	13. 1	62. 6	DÓREA (2011)
Pennisetum purpureum cv. Cameroon	13. 7	62. 9	MARTINEZ (2004)
Pennisetum purpureum cv. Cameroon	14. 6	65. 1	VOLTOLINI (2006)
Pennisetum purpureum cv. Cameroon	20. 6	63. 2	CARARETO (2007)
Pennisetum purpureum cv. Cameroon	17. 6	64. 4	ROMERO (2008)
Pennisetum purpureum cv. Cameroon	18. 5	61. 4	MARTINEZ (2008)
Pennisetum purpureum cv. Cameroon	18. 5	58. 7	DANÉS (2010)
Pennisetum purpureum cv. Cameroon	15. 5	60. 2	CHAGAS (2011)
Pennisetum purpureum cv. Cameroon	18. 6	54. 4	MACEDO (2012)
Pennisetum purpureum cv. Cameroon	18.3	54.2	SOUZA (2014)

[1] CP = Crude protein; [2]NDF = Neutral Detergent Fiber

Table 2. Suggested sward canopy and stubble heights for pastures managed based on 95% light interception (LI)

Plant spp.	Canopy height (cm)		Reference
	Entrance	Exit	
Mombaça	90	30 to 50	Carnevalliet al., (2006)
Tanzânia	70	30 to 50	Difante, (2005); Barbosa et al., (2007)
Xaraés	30	15 to 20	Pedreira, (2006)
Cameroon	100	40 to 50	Voltolini, (2006); Carareto, (2007)
Marandu	25	10 to 15	Zeferino, (2006); Sarmento, (2007); Costa (2007); Souza Júnior, (2007); Trindade, (2007)
Tifton-85	25	10 to 15	Da Silva and Corsi (2003)
Coastcross	30	10 to 15	Da Silva and Corsi (2003)

Mombaça = *Panicum maximum* cv. Mombaça; Tanzânia = *Panicum maximum* cv. Tanzânia; Xaraés = *Brachiaria brizantha* cv. Xaraés; Cameroon = *Pennisetum purpureum* cv. Cameroon; Marandu = *Brachiaria brizantha* cv. Marandu; Tifton-85 = *Cynodon dactylon* cv. Tifton-85; Coastcross = *Cynodon dactylon* cv. Coastcross

Table 3. Morphological composition of plants managed either based on 95% light interception (LI) criterion or on fixed grazing intervals

Reference	Forage	Grazing frequency	Leaves % DM	Stem % DM	Senescent material % DM
Voltolini et al.(2010)	Cameroon	27 fixed days	48.0	46.0	6.0
Voltolini et al. (2010)	Cameroon	95% LI	53.0	42.0	5.0
Correia (2006)	Marandu	21 fixed days	34	32.7	33.3
Costa (2007)	Marandu	95% LI	56	32	12

Cameroon = *Pennisetum purpureum* cv. Cameroon; Marandu = *Brachiaria brizantha* cv. Marandu

Table 4. Effect of start grazing point (25 vs. 35 cm sward height) on performance of Nellore yearling bulls grazing Palisade grass (Brachiaria Brizantha cv. Marandu)

Sward height	Daily gain, kg	Stocking rate, AU/ha[1]	Kg live weight gain/ha
25 cm	0.957	2.88	621
35 cm	0.769	2.43	401

Gimenes et al. (2011). Average values for summer and fall season.
[1] AU = animal unit (450 kg body weight); ha = hectare

Table 5. Effect of start grazing point (103 cm sward height vs. 27 day of fixed grazing interval) on performance of dairy cows grazing Elephant grass cv. Cameroon

Item[1]	27 d interval	95% LI (height of 103 cm)	P
3.5% FCM, kg/d	14.88	17.65	0.10
Cows/ha	5.1	7.2	0.002
Milk, kg/ha/d	75	114	0.0004

Voltolini et al. (2010).
[1] FCM = fat-corrected milk; ha = hectare.

Table 6. Effect of level of supplementation (% BW) on performance of grazing yearling bulls

	Supplementation level (% BW as fed)					
	0	0.3	0.6	0.9	Intercept a[7]	Slope P[9]
FA,[1] % BW	6.92	6.81	6.52	6.11		
AU/ha[2]	4.50	5.33	5.58	6.12	4.62 (0.26) **	1.70 (0.46) **
Initial BW, kg	223.0	226.0	218.0	219.0	225.45 (3.16)**	-7.31 (5.60) NS
Final BW, kg	287.8	301.1	308.6	320.3	288.50 (4.55)**	35.11 (8.06) **
Daily gain, kg	0.595	0.673	0.810	0.968	0,583 (0.04)**	0.408 (0.07) **
@/ha[3]	18.06	22.50	29.76	34.45	17.72 (0.70)**	18.80 (1.25) **

[1] Forage availability, DM as % of BW
[2] AU = 450 kg BW
[3] @ = 15 kg of carcass
Correia (2006)

( ) = Error
*Linear (P<0,05)
**Linear (P<0,01) t-Student test

Table 7. Effect of level of supplementation on performance of canulated grazing cattle

	Supplementation, % BW[1] as fed						Contrast[2]	
	0	0.3	0.6	0.9	SEM	P	Lin	Quad
DMI, % BW	1.90	1.94	2.10	2.35	0.12	0.01	0.05	ns
Forage DMI, % BW	1.90	1.64	1.55	1.50	0.11	0.02	0.05	ns
TDN[3] intake, % BW	1.10	1.21	1.39	1.62	0.10	0.01	0.05	ns
Substitution, kg/kg	0	1.13	0.74	0.58	0.21	0.02	ns	0.05
Grazing, min/d	441	385	372	363	9.82	0.04	0.05	ns
Rumination, min/d	395	399	358	378	9.38	0.31	-	-
Resting, min/d	441	515	548	551	6.37	0.09	0.05	ns

Dórea (2011).
[1] BW = body weight.
[2] Lin = linear effect of level of supplementation; Quad = quadratic effect of level of supplementation.
[3] TDN = total digestible nutrients.

Table 8. Effect of supplementation strategy on performance of crossbred yearling bulls

Item[2]	Supplementation strategy[1]			SEM	P
	0	0.6%	0.3 - 0.6 - 0.9		
Initial body weight, kg	208.0	207.7	208.4		
Final body weight, kg	283.7	322.4	335.7		
Supplement, kg	0	230.4	220.4		
Daily gain, kg	0.535[c]	0.787[b]	0.867[a]	0.016	0.001
Animal unit/hectare	5.94[b]	7.13[a]	6.90[a]	0.01	0.04
BW gain, kg/hectare	887[c]	1464[a]	1580[a]	276.0	0.009

Agostinho Neto (2010).
[1] Supplement offered daily as % of body weight either as constant % or at increasing %. 0 = no supplementation; 0.6 = 0.6% of BW for the entire experimental period (1490 d); 0.3-0.6-0.9: or supplemented with 0.3% of BW for 65 days, 0.6% for the next 51 days and 0.9% for the last 33 days of experimental period.
[2] Animal unit = 450 kg of body weight (BW).

Table 9. Effect of level of supplementation (0 vs. 0.6% of body weight) for cattle grazing Palisade grass managed with different stubble heights (11 vs. 15 cm)

Item[3]	Treatment[1]				P[2]		
	11 cm 0%	11 cm 0.6%	15 cm 0%	15 cm 0.6%	SH	S	SH x Sup
Daily gain, kg	0.38[d]	0.76[b]	0.51[c]	0.86[a]	0.008	0.001	0.54
Animal unit/ha	7.1[ab]	8.5[a]	5.8[b]	6.1[b]	0.009	0.12	0.36
BW gain kg/ha/d	5.7[b]	11.4[a]	5.6[b]	9.1[a]	0.48	0.02	0.52
Final BW, kg	284[c]	351[a]	306[b]	369[a]	0.04	0.001	0.82

Costa (2007).
[1] Stubble height of 11 vs. 15 cm; Level of supplementation of 0 vs. 0.6% of the body weight.
[2] SH = stubble height; Sup = level of supplementation; SH x Sup = interaction between SH and Sup.
[3] ha = hectare; BW = body weight.

Table 10. Milk yield and composition of grazing cows fed different fat sources

	Treatment[1]			SEM	P
	Control	CSSO	CSPO		
Initial BW, kg	486.5	493.3	496.2	25.2	0.43
Body condition at 75 DIM	2.75[ab]	2.84[a]	2.54[b]	0.08	0.09
Dry matter intake, kg/d	17.9[ab]	17.2[b]	18.0[a]	0.42	0.04
Yield, kg/d					
Milk	6094[c]	6575[b]	7328[a]	28.8	0.001
Fat	234.1[b]	219.2[c]	266.6[a]	5.2	0.001
Crude protein	212.1[b]	213.5[b]	232.6[a]	7.8	0.01
Lactose	274.9[b]	290.1[b]	326.2[a]	8.6	0.03
Total solids	779.4[b]	784.3[b]	894.9[a]	18.4	0.001

Souza et al. (2013).
[1] CSSO = calcium salts of soybean oil; CSPO = calcium salts of palm oil

Table 11. Total milk production and composition of cows according to fat supplementation and method of corn processing

	Ground		Steam-flaked		SEM	P		
	No fat	Fat	No fat	Fat		Corn	Fat	Corn*Fat
Milk yield, kg/d	20.3[d]	24.0[b]	22.3[c]	25.1[a]	0.35	0.001	0.0001	0.15
Fat, %	3.33[a]	3.34[a]	3.26[ab]	3.18[b]	0.054	0.01	0.33	0.26
Crude protein, %	3.17[c]	3.13[c]	3.46[a]	3.36[b]	0.038	0.0001	0.18	0.04
Lactose, %	4.64	4.62	4.61	4.62	0.062	0.68	0.32	0.27

Batistel (unpublished results).

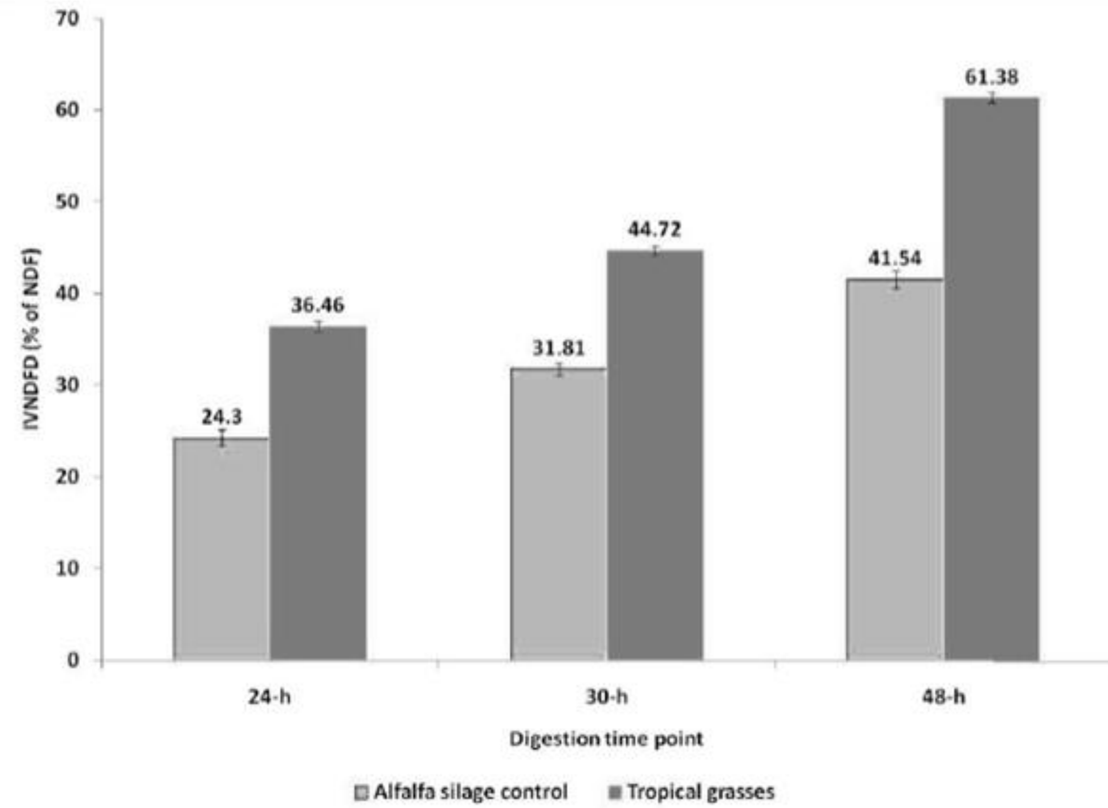

Figure 1. Comparison between mean *in vitro* NDF digestibility (IVNDFD) estimate across 6 tropical grass species and the alfalfa silage standard by time point (Lopes, 2011).

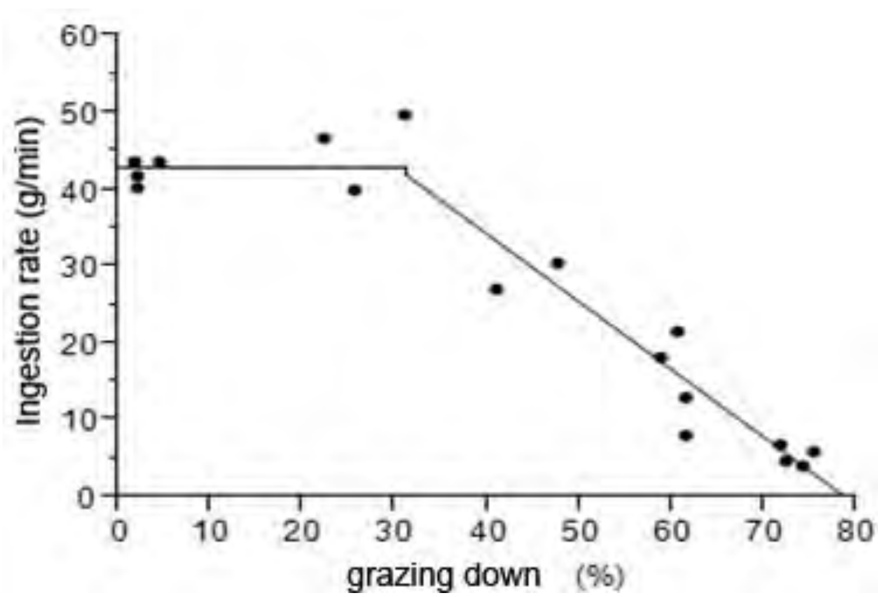

Figure 2. Effect of final grazing point (as % of initial sward height) on forage ingestion rate (Mezzalira, 2012)

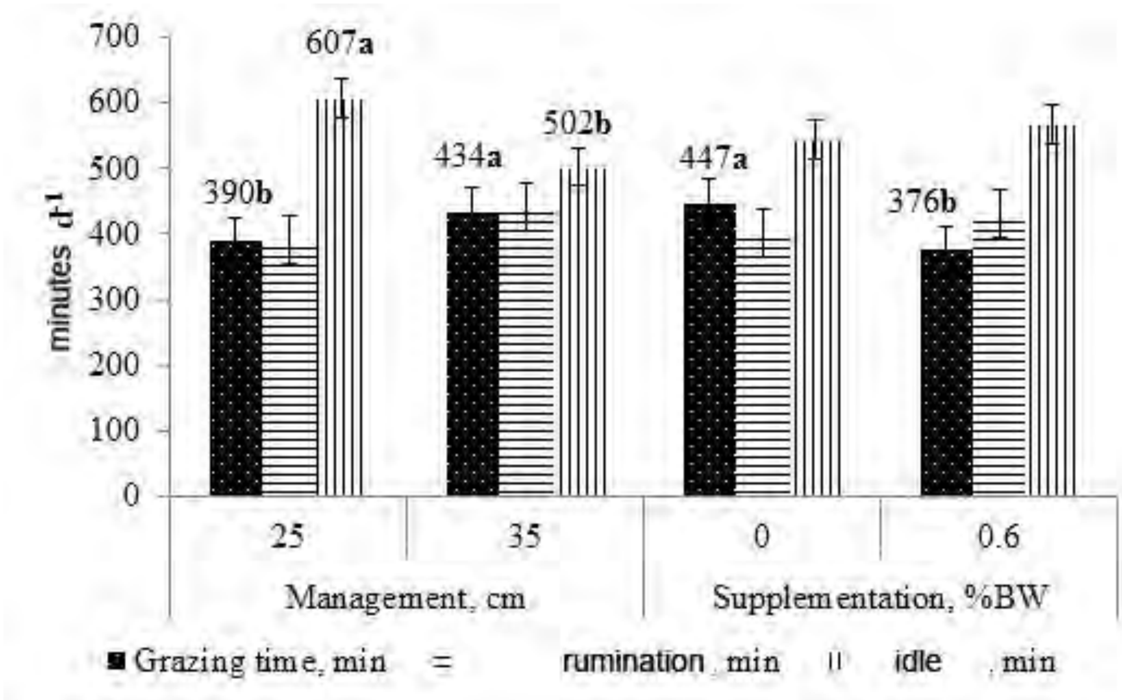

Figure 3. Ingestive behavior of grazing cattle according to management of plant height (25 vs. 35 cm) and level of supplementation 0 vs. 0.6% of body weight). [a,b] Different superscripts differ ($P < 0.05$). (Dórea et al., 2013b).

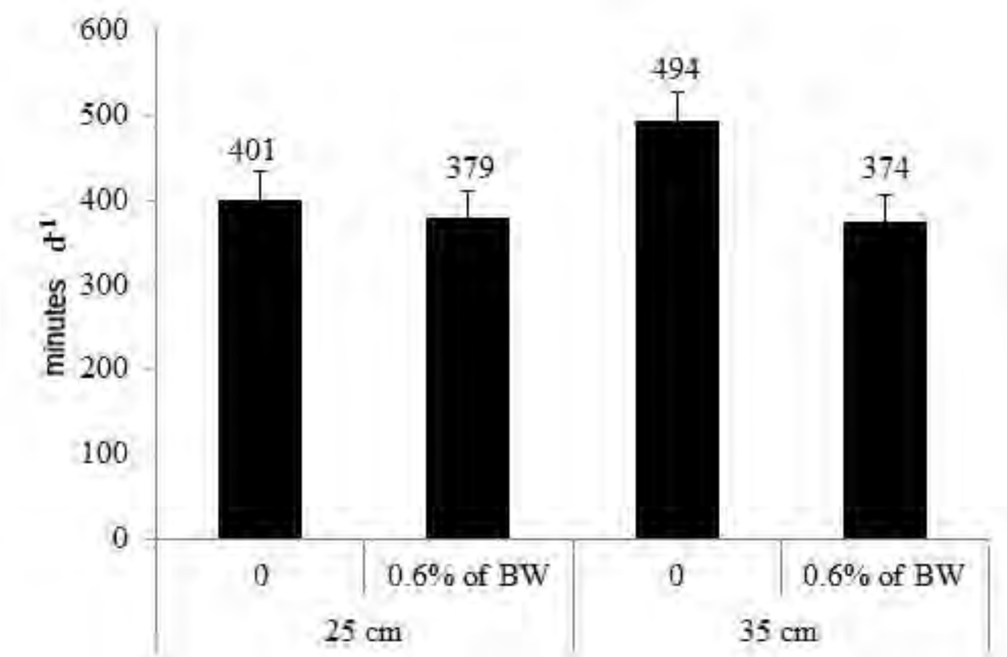

Figure 4. Ingestive behavior of grazing cattle according to plant height and level of supplementation. [a,b] Different superscripts differ ($P < 0.05$). (Dórea et al., 2013b).

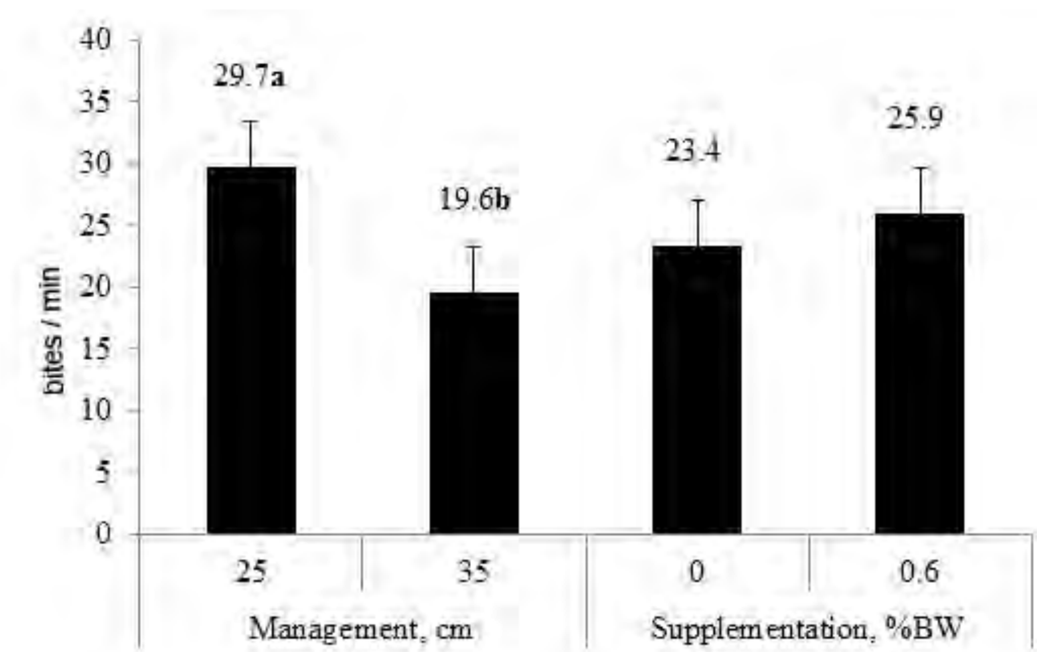

Figure 5. Effects of plant height (25 vs. 35 cm) and level of supplementation (0 vs. 0.6% of BW) on bite rate of grazing cattle. [a,b] Different superscripts differ ($P < 0.05$). (Dórea et al., 2013b).

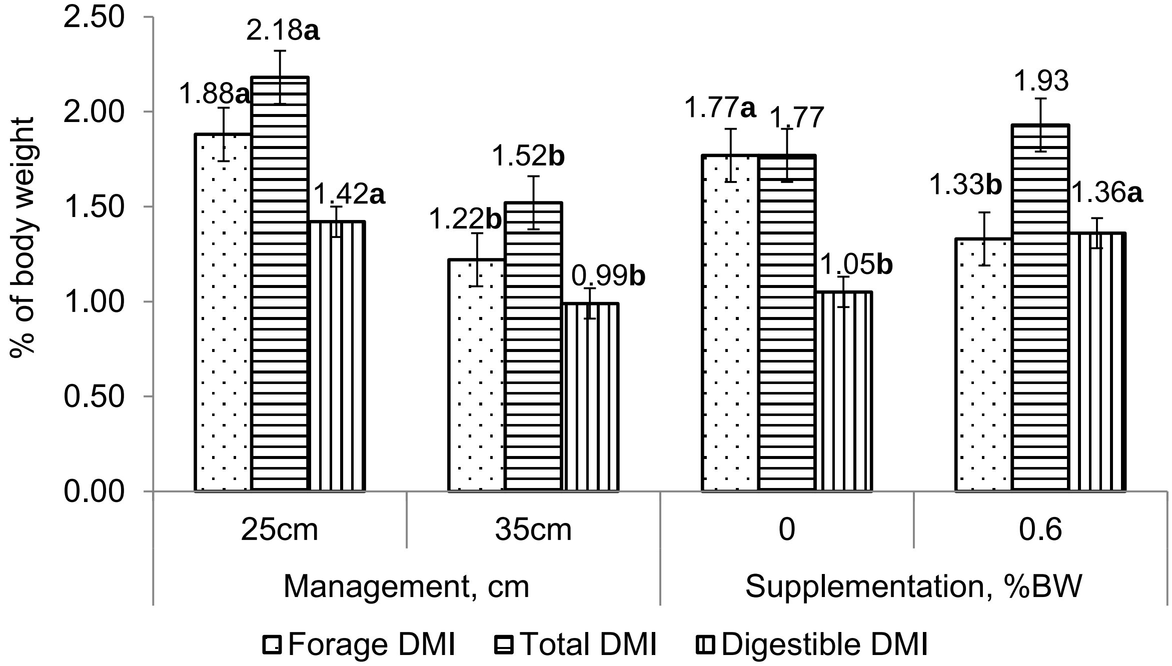

Figure 6. Effects of pasture management (height of 25 vs. 35 cm) and energy supplementation (0 vs. 0.6% of BW) on intake of forage DM, total DM, and calories by grazing cattle. [a,b] Different superscripts differ ($P < 0.05$). (Dórea et al., 2013b).

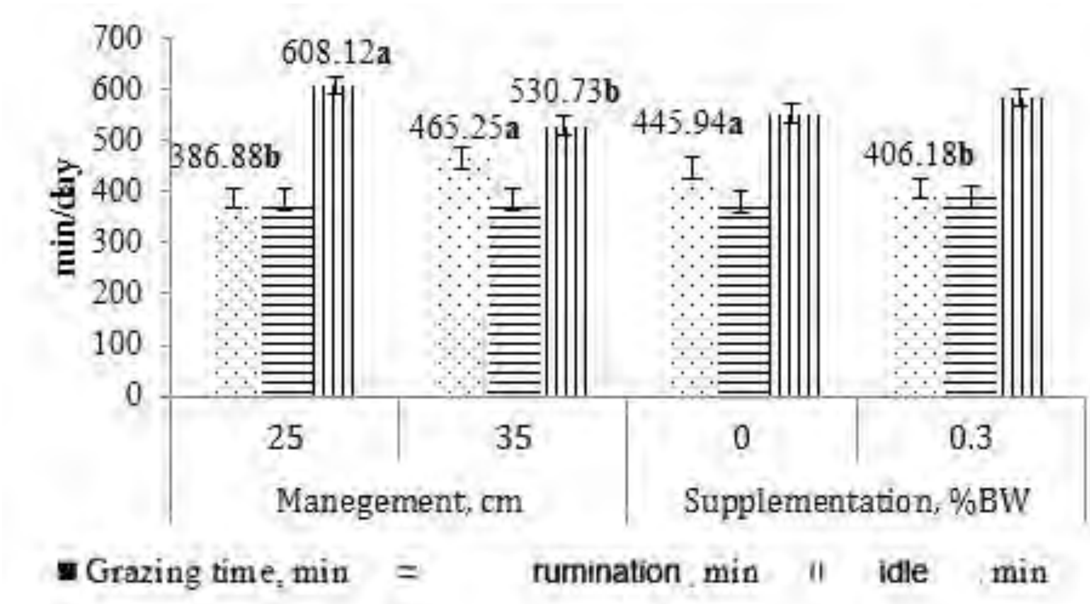

Figure 7. Ingestive behavior of grazing cattle according to plant height (25 vs. 35 cm) and level of supplementation (0 vs. 0.3% of BW). [a,b] Different superscripts differ ($P < 0.05$). (Dórea et al., 2013a).

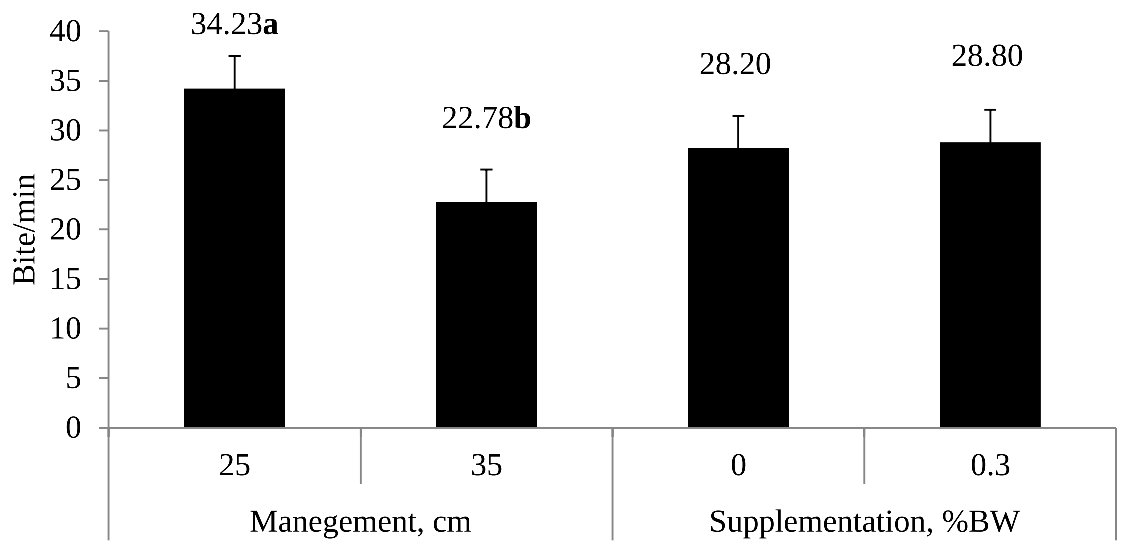

Figure 8. Effect of plant height (25 vs. 35 cm) and level of supplementation (0 vs. 0.3% BW) on biting rate of grazing cattle. [a,b] Different superscripts differ (P < 0.05). (Dórea et al., 2013a).

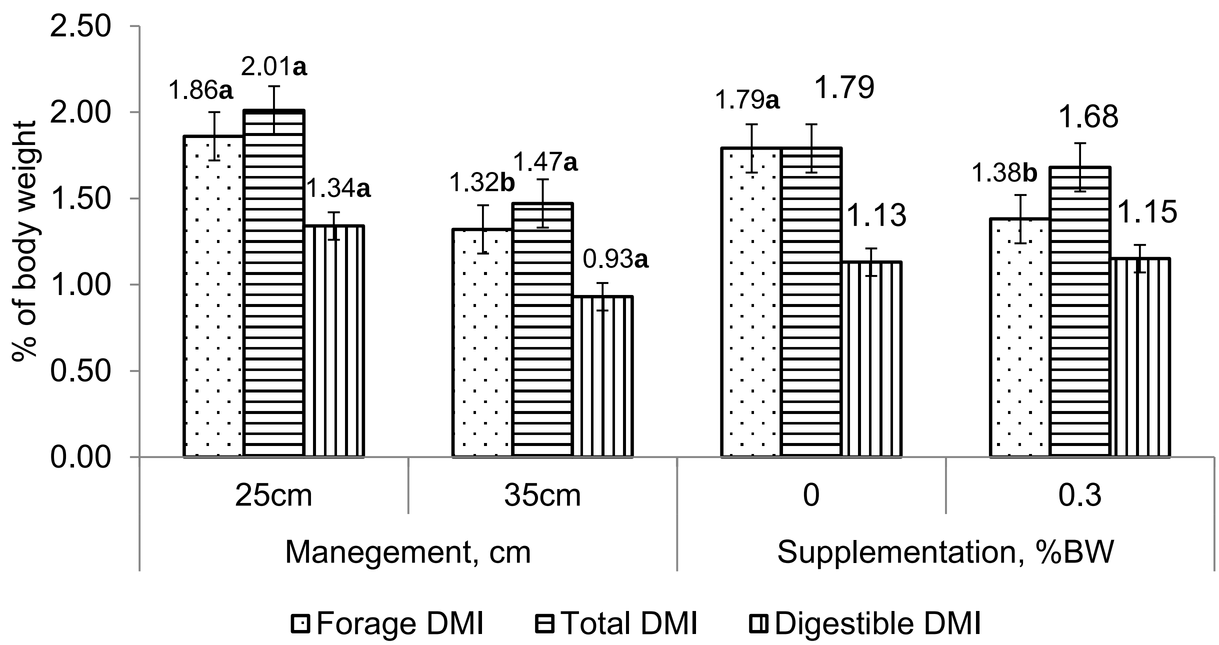

Figure 9. Effect of pasture management (plant height at 25 vs. 35 cm) and energy supplementation (0 vs. 0.3% of body weight per day) on forage dry matter (DM) intake, total DM intake, and digestible DM intake of grazing cattle. [a,b] Different superscripts differ (P < 0.05). (Dórea et al., 2013a).

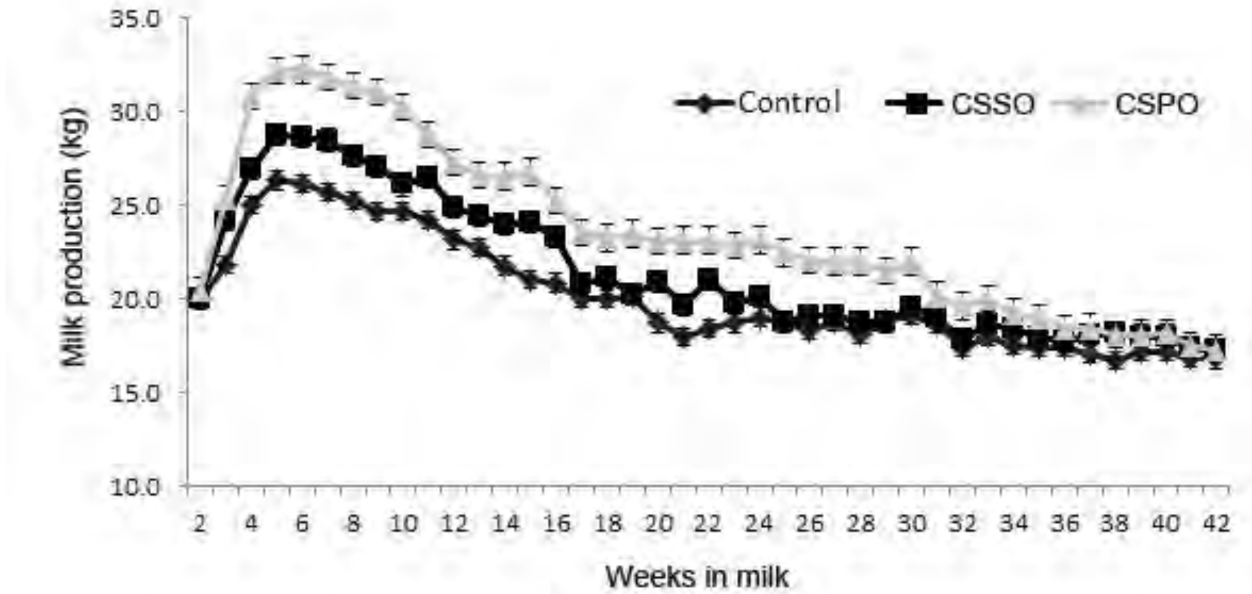

Figure 10. Lactation curves of grazing cows fed no fat (♦), 400g/d of calcium salts of soybean oil (CSSO - ■) or of palm oil (CSPO - ▲) from day 15 to 105 post calving (Souza et al., 2013).

SESSION NOTES