Principal results of the studies carried out at the Instituto de Ciencia Animal on bovine milk production

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The main results obtained in milk production under Cuban conditions, with the grass as basic foods are shown. With the appropriate interaction of stocking rate and grass varieties, dairy productions between 8 and 9 kg d^{-1} during the rainy season were reached, with stocking rate of 3.0 cows ha^{-1} in coast cross Bermuda grass (*Cynodon dactylon*), 4.0 cows ha^{-1} in pangola grass (*Digitaria decumbens* Stent) and 5.0 cows ha^{-1} in star grass (*Cynodon nlemfuensis*).For the grass rotational management, the number of paddocks per group was between four and eight. The application of the pin pointer method and followers make possible higher balance between the composition and grass quantity and the animals requirements. With the use of legumes in the system, productions of 15 kg milk cow^{-1} d^{-1} can reached, with the lower supplement use. The supplementation showed higher advantage when the differential between the grass and the animal potential was more marked. The supplementation effect was higher at the beginning of lactation. The feeding systems with restricted grazing in the dry season, complemented with silage or sugar cane as forage, reached individuals productions between 7 and 8 kg of milk d^{-1}, with complement intake between 5.8 and 7.3 kg DM cow $^{-1}$ $d^{-1}$for sugar cane and silage, respectively.

Key words: *grazing, grasses, legumes, supplementation, milk, quality*

INTRODUCTION

Under Cuban conditions, the dairy animal management should be developed based on grasses, in accordance with the systems that are adjusted to the present, in which there is not irrigation and the chemical fertilizers application is in very low quantity or null. The most appropriate genotypes for Cuban conditions are those from cattle cross Holstein x Zebu, (Siboney and Mambí de Cuba), or other genotypes that have the appropriate rustic. The semi stabulation is the most used grass management system (Senra 2005a).

The necessity that has the tropical countries of developing milk production systems based on grasses it is known, in which those factors that supposedly limit it should improve with the application of the appropriate management and the introduction of grasses of higher yield and quality, although some demand of certain quantity of inputs (irrigation and fertilization), in function of the quality benefit, that directly influences in animal intake (Pérez Infante 1982).

The objective of this review is to inform about researches carried out in the Instituto de Ciencia Animal, mainly concerning milk production based on grasses, under Cuban conditions. Factors related with the supplementation and complementation, that should be adjusted with the necessary flexibility are also analyzed.

MILK PRODUCTION BASED ON TROPICAL GRASSES AND SUPPLEMENTATION DURING THE DRY SEASON

The study of grazing method continues being object of researchers and producers interest, because opinions about which is the most appropriate method have not been to unify. The grazing methods should be applied with the necessary flexibility, according to the characteristics of each exploitation system, which covers the type of animal production, soil, climate, grass specie, animal potential, available resources, producer objectives and social aspects.

It is considered that the rotational grazing, mainly that of high density, in which the Rotational Grazing Voisin (RGV) is included, represents an advance in the grassland management, regarding to the continuous grazing. However, the application of a management system to the grass in a faster way, can present some problems that should be avoid with the right application of management and nutrition principles, besides the periodic and integral evaluation of the functioning of methods of the grassland ecosystem management(Senra *et al.* 2005b).

The possibilities of the grass intake are what determine their productive potentialities. Studies about the possible effect of three stocking rates (3.2, 4.2 and 5.0 animals/ha) in production and composition of milk from cows grazing pangola grass showed that milk production decrease ($P < 0.05$) 27.8 % with the highest stocking rate, while the other two did not differ, the same as dairy components(Pedroso and García1977).

Jerez *et al.* (1984) showed that grass variety influences in the stocking rate for the milk production. When studying the star grass, coast cross No1 bermuda grass (*Cynodon dactylon*) and pangola grass varieties, all fertilized with 50 kg N/ha every two rotations during the rainy season and three stocking rates (3.0, 4.0 and 5.0 cows/ha), the mentioned authors found interaction($P < 0.05$) between the grass specie and the stoking rate for milk production (figure 1).The higher yields in milk, with stocking rate of 5.0 cows/ha, were reached with the star grass(9.7, 9.1 and 10.5 kg/cow/d, for 3, 4 and 5 cows/ha, respectively. The opposite happened with coast cross Bermuda grass and pangola grass, grasses that keep decreasing tendency when increasing the stocking rate, since the daily supply decrease. Under tropic conditions, the availability is higher to 30 kg DM/cow/d, which not improve milk production (Stobbs 1977).

paddocks has been a matter of dispute, since in general no differences between a paddock (continuous grazing system) and several of them (rotational grazing system) are not reported, when grasses are naturals and without fertilization. However, with improved grasses, rotational grazing may exceed, in animal production, between 13 and 25% (Senra 2005b).

In many studies, the results of comparing different number of paddocks have been contradictories. The obtained advantages by increasing the number of padocks in rotational grazing are associated with high stocking rates, which were due, mainly, to the higher possibilities of preserving the grass surplus. A general opinion to follow is to reduce the number of paddocks, whenever the animal and grass performance were not affected, which is based on the possibilities of reducing the cost in investment and maintenance of fences and allies.

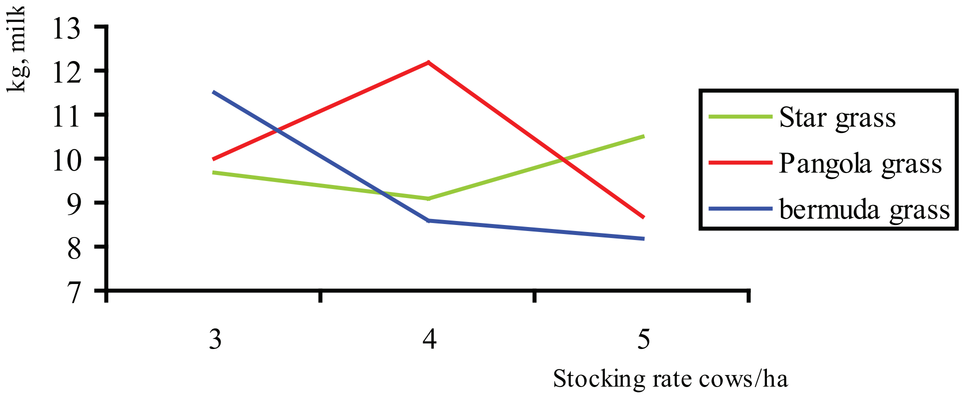

Figure1. Effect of stocking rate on milk production in different pastures (Jerez *et al.* 1984)

These results of the different stocking rate are related with the availability and quality of the grass that is supplied to the animals. Martínez and Jerez (1979), when analyzing the productive performance of cows in pagola grass grazing, divided in three groups (high, low and mid production), with leaders and followers systems, verified that daily mean productions of milk were 11.7, 7.2 and 4.3 L/cow/d, for high, mid and low groups, respectively. Martínez and Pereiro (1979) informed that in cows that graze pangola grass, the milk production was higher ($P < 0.01$) for those that calving in June- August trimester, regarding those that did it in September-November (8.3 vs 7.4 kg/cow/d).This is explained because in the June –August trimester the climate influence is positive (precipitations, luminance and temperatures), which affect the grass availability and quality during this stage in which lactation begins.

The study of factors that influence the management of grazing dairy cows has received attention from researchers and producers, because of the importance of achieving higher efficiency in milk production systems and management factors. The number of

Senra *et al.* (1985) reported that when studying three numbers of paddocks per group (eight, four and two paddocks), with fixed stocking rate of 3.66 cows/ ha, there were no differences in the individual milk production between eight and four paddocks, but both were higher ($P<0.05$) to the system of two paddocks in 8.8 and 7.5% for eight and four paddocks, respectively (table 1).

The availability and grass residue were lower in the two paddocks system, without differences between eight and four (table 1), while the live weight increase was higher ($P<0.05$) in eight paddocks, without differences between four and two (493, 479 and 473 kg / cow for 8, 4 and 2, respectively). The grassland purity, after two years, was approximately 90.0% for the three systems, so the management of four number of paddocks per group of dairy cows in star grass areas is suggested, with the purpose of not affecting the animal and grass performance.

These results are based on that the occupation days can be increased and maintain the adequate uniformity in the individual milk production, whenever increase, proportionally, the paddock area, since the milk decrease is not related, necessarily, with the occupation days, but with the total availability of grass per animal and the first day of stay in the paddock. This can be explained on the basis of Stobbs (1977) results, who noted that the "availability limit of maximum selection and consumption" exits. That is, milk production will not decrease until the occupation time has not allowed reducing the availability below this maximum selection limit and consumption (Senra 2005ab).

(*Neonotonia wightii*) bank during three hours daily, in alternate days or every third day, there were not found differences in milk production 16. 1, 16.5 and 15.9 kg/cow/d respectively. However, with the use of legume differences they were always higher (P <0.001) regarding to the use of only pangola grass (12.4 kg/cow/d). The results showed that when using the supplementary grazing, with three hours a day in glycine grass, can be performed on alternate days or every three days, without affecting cows performance.

Table 1. Performance of the grass and animal, when using different numbers of paddocks (Senra *et al.* 1985)

Indicators	Number of paddocks		
	8	4	2
Days of occupation, d	4	8	21
Paddock area, ha	0.75	1.5	3.0
Availability, kg ha $^{-1}$	3068^a ± 116	2934^a ± 111	2170^b ±111
DM digestibility, %	62.5^a ± 1.2	62.7^a ± 1.2	58.1^b ± 1.2
Milk production, kg cow^{-1} d^{-1}	13.5^a ± 0.01	13.4^a ± 0.01	12.4^b ± 0.01

An aspect of interest that support the opinion of reducing the number of paddocks is the behavior of grazing cows, because of its relation with the grass availability and quality. Senra *et al.* (1989) reported that there were not differences in time spent grazing (492, 509 and 520 minutes d^{-1}, for eight, four and two paddocks, respectively).

The need of using more efficient systems, with low external inputs for cattle production, has brought significant progress. Among them may be mentioned the possibility of using trees or creeping legumes in limited areas to the protein bank, and increase them to complete their association in 100% of the grazing area. This has been demonstrated in dairy cows, when increasing animal production and the decreasing of costs per produced liter. Legumes contribute to increasing the amount of dry matter supplied and the ration quality (Mejías *et al.* 2009).

In dairy production, Pereiro and Elías (1988) reported that when management the glycine

To cover the food deficit in the dry season has been worked in several directions: the complementation to grass with silage or other forages was used and technologies of only grazing with better performance grasses were introduced during the dry season. Thus, the technology of biomass bank was established with Cuba CT-115 (*Pennisetum purpureum* Cuba CT-115) clone, which has been the most widespread in the country in the last years, mainly in milk production. Martinez *et al.* (2012) reported that when promoting this technology during ten years, under production conditions in seven dairies of UBPC "Desembarco del Granma", dairy production per lactation increased in 73.3 L and per area, in 59.4 L/ha/year. Similarly, it was found that the areas percentage with Cuba CT-115 clone and the number of paddocks showed the highest contributions to technological change (table 2).

Table 2. Productive changes in seven dairies after ten years of biomass bank introduction with Cuba CT-115 clone (Martínez *et al.* 2012)

Indicators	Start[1]	Ten years	R	Sign.
Production per cow, kg.d^{-1}	3.4	5.4	0.44	***
Production per hectare, Lha^{-1}	245.3	1081.0	0.57	***
Total production per year, Lyear^{-1}	21581.4	105648.0	0.61	***
Production per lactation, Llactation^{-1}	927.0	1660.0	0.43	***
Calving- gestation interval , d	190.7	158.6	-0.85	***

[1]Before technology

*** P < 0.001

The use of silage as a complement in the dry season has been reported from an analysis of the production system. Lamazare *et al.* (1991) obtained productions of 11.6 kg of milk cow^{-1}d^{-1}, without affecting the physical condition of the animals and the silage intakes by cows were 7.3 kg DM d^{-1}. With the use of silage in animal feeding, rumen pH decreases, in order to stabilize in cows that intake silage. Galindo *et al.* (1982) reported that to include zeolite to the diet, the pH was stable in the hours of maximum fermentation. without differences between the different hours studied, when the zeolites proportions were 0.5 and 1% of the diet. With the same purpose, Senra *et al.* (1979) used different amounts of hay (15 and 30% of the diet) in cows receiving silage *ad libitum*. These authors found differences in milk production, for treatments received hay, but not between amounts (7.32, 7.71 and 7.89 kg/d, for 0, 15 and 30% of hay, respectively).

Pereiro *et al.* (1982) reported that when using a combination of grass pastures with three hours in glycine, and complementation with three forage variants, hay or silages, differences were not observed in dairy production and in total milk solids (TS) (12.9, 12.3 and 12.2 L/cow/d and 11.36; ll.14 and 11.40% (TS) with forages, hays and silages, respectively). The animals made higher dry matter intake (P <0.05) in the forages treatment in 11.7 and 32.17%, higher to hay and silage, respectively. The results show the possibility of using glycine restricted grazing during the dry season, when there are low-quality foods for milk production.

The studies of sugar cane forage, as complementation alternative in the dry season for milk production, have indicated variability in dairy production (between 3.3 and 13.2 kg/cow/d), as in the forage intake (3.8 to 11.6 kg DM/cow/d) (Martin 2005), apparently because of their low protein levels and soluble sugars high content (González 1995). This negatively affects in the animal behavior and makes needed to add nitrogen (urea) to improve the daily fresh forage intake (figure 2). Thus, intake increases (P <0.001) from 18.4, without urea, to 20.3 kg FM/d of sugar cane with the highest amount of urea, increasing milk production (P <0.05) from 8.21 to 9.14 kg/cow/d. It is suggested to add at least 1% of urea, regarding the forage fresh weight (Gonzalez *et al.* 1989).

Gonzalez *et al.* (1989) reported that when including other fresh forage to diets based on sugarcane integral forage, increased (P <0.001) the total diet intake, with values of 9.61; 12.02; 12.89 kg DM/animal/d, but decreased (P <0.001) sugar cane intake to values of 7.59; 7.15; and 6.75 for 0, 2.5 and 5.0% of live weight of the other forage, respectively. *In situ* digestibility of the DM and cell wall, differences were not found, confirming that the inclusion of other forages replaced, partially, the sugar cane intake as basic food, but their combination improved the total of foods, without increasing the DM digestibility and the cell wall of the diet.

Likewise, García *et al.* (1994) studied the complementation to grass in the dry season, with 15 kg FM of saccharina or 15 kg FM of sugar cane forage, with equal additive (urea and salts). They found that milk production was higher (P <0.001) with the use of saccharina (9.9 vs 9.3 kg/d). They thus showed that the previous fermentation of sugar cane forage improves the response of those animals that intake the unfermented sugar cane, regarding to those that ingested fresh, with unfermented additives.

In feeding systems studies based on improved grasses and in dry season, restricted grazing is used (three hours) plus forage of integral sugar cane as complement during three years. Alonso and Senra (1992) reported that cows showed production in that period of 9.7 kg of milk/cow/d and maintained a good physical condition. The cane forage intakes were in the order of 5.8 kg DM/cow/d.

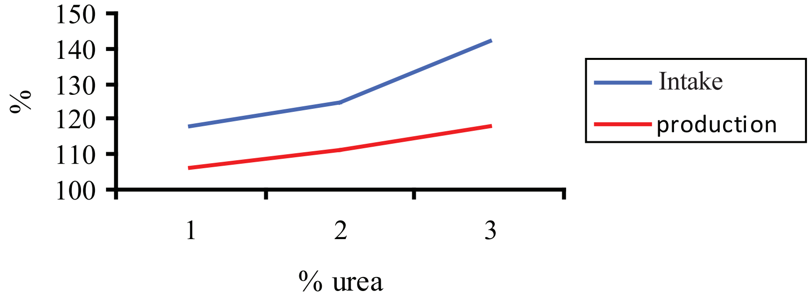

Figure 2. Increase percentage of the sugar cane DM intake and milk production, in function of urea level (Martín 2005)

USE OF SUPPLEMENTATION IN FUNCTION OF IMPROVING MILK PRODUCTION UNDER TROPICAL CONDITIONS

There have been carried out several studies with the supplements application to increase the milk productivity of cows grazing tropical pastures. It is reported that the response to this activity is low in cows with potentials lower than 4000 kg milk/lactation, and basic food with high availability and good quality (Martinez *et al.* 1976, Ruiz *et al.* 1981, and Garcia 2010). The existence of more response in milk to supplementation during the first seven weeks of lactation, offers advantage regarding the use of the concentrate to the start of lactation. As the lactation progresses, the response to supplementation level decreases, and the milk production does not differ between supplemented cows or not, or between supplementation levels (Martinez *et al.* 1976).

To improve the efficiency of supplementation use, Garcia *et al.* (1980) fractionated the concentrate to three times a day, and obtained improvements (P <0.001) in milk production (13.6, 14.0 and 14.9 kg/cow/day, for one, two or three times a day, respectively), without effect on voluntary intake or milk composition. A distribution of concentrate three times a day it is suggested, when means supplementation levels are supplied, resulting in higher efficiency in the dairy animal.

As a result of high cereals prices, researches with the objective of replacing cereals in the dairy cows feeding in grazing were carried out. It has been proven that several proportions cereal / molasses in supplementation for cows, the daily milk production, expressed in percent, and the yield during the standardization period, were negatively correlated with the amount of molasses (r = - 0.70) . There was similar trend regarding the yield of non-fatty solids (r = -0.66) (Clark *et al.* (1973).

Reyes *et al.* (2003) reported similar results, when substituting 50% of the concentrate by enriched molasses in grazing cows. These authors verify decreased (P <0.05) in the fat percentage (3.10 against 3.99%), caused that milk production, corrected to 4% fat, decrease (P<0.01) with the use of enriched molasses (11.60 against 12.54 kg/cow/d). This negative effect could be eliminating with the inclusion of 4% zeolite or calcium carbonate to the enriched molasses mixture.

Jordán and Elías (2002), when evaluating the replacement of 20% maize in the concentrate by wheat bran or raw sugar, found that in genetics dairies with improved grasses and fertilized with 200 kg Nha^{-1} year^{1} with irrigation, productions of 20.02, 21.60 and 22.28 kg of milk/cow/d for the first, second and third year were achieved, respectively. Also, these authors verified that the efficiency of the supplement use increased from 2.5 to 2.7 kg of milk kg of concentrate $^{-1}$.

In order to maintain the use of national raw materials, mainly from sugarcane, there were carried out different experiments. Garcia *et al.* (1997), when substituting 90% of cereals by saccharea concentrate (integral sugar cane milled, salt and urea mixture) to supplement grazing cows, reported that milk production did not differ. Better indicators of saccharea feed in weight gain (245 vs 113 g/cow/d), milk fat (3.5 vs 3.2%) and total so1ids (11.7 vs 11.2%) (table 3) were obtained.

Saccharina technology (Elias *et al.* 1990) it was also applied for the supplementation to grazing dairy cows. Garcia *et al.* (1999), when substituting the cereals concentrate by saccharina, in 5,000 kg of milk lactation^{-1} cows, reported that dairy production decreased between 5.2 and 8.4% for 50% substitution up to 16.1%, when the substitution reached 90% (table 3).

The cereals sources that constitute the supplement can influence in animal productivity. Reyes *et al.* (1997), when evaluating two cereals sources in feed formulation with 50% of saccharina, reported that milk production were higher (P<0.001) with the use of maize in the formulation of saccharina concentrate them with the use of wheat (15.3 and 14.2 kg milk/cow/d). In the milk composition of the animals that received these supplements differences in the percentages of protein and fat (3.13 and 3.35 and 3.12% and 3.31% for supplements with corn and wheat, respectively) were not found.

The distillers dried grains (Norgold) introduced in Cuba are high composition in protein, on the order of 30.9%, with low degradation rate in the rumen and energy, based on the fat composition of 10.7% (Herrera and Jordan 2010). This product has been used as a supplement to grazing cows. Reyes *et al.* (2008) carried

Table 3. Performance of dairy cows supplemented with concentrates with different saccharea and saccharina proportions (García *et al.* 1997 and 1999)

Indicators	Concentrate	Saccharea	Saccharina		
		90 %	50 %	70 %	90 %
Milk production, kg cow^{-1} day^{-1}	12.1 ± 0.03	11.6 ± 0.03	11.2 ± 0.01	10.4 ± 0.01	9.9 ± 0.01
Lactose, %	4.63 ± 0.08	4.82 ± 0.08	4.67 ± 0.02	4.66 ± 0.02	4.56 ± 0.02
Fat, %	3.5 ± 0.01	3.2 ± 0.01	3.4 ± 0.05	3.5 ± 0.06	3.4 ± 0.05
Totals solids , %	11.7 ± 0.02	11.7 ± 0.02	11.8 ± 0.09	11.8 ± 0.09	11.7 ± 0.09

out researches in order to compare the product regarding to commercial concentrates in different proportions. These authors reported that milk productions were not affected between treatments (14.7, 14.4 and 14.8 kg/cow/d, to 100% of feed, 50% feed - Norgold and 100 Norgold %, respectively). However, from the point of view of dairy quality, the fat milk percentage of the animals supplemented with 100% Norgold was lower (P <0.01) than the rest of the animals, which not differ each other (3.98, 3.99 and 3.73% for treatments with 100% feed, 50% of commercial feed and Norgold and 100 %Norgold, respectively). The rest of dairy components did not showed differences (table 4).

Table 4. Peformance of grazing cows, supplemented with different Norgold proportions (Reyes *et al.* 2008)

Treatments	100 % concentrate	50 % concentrate 50 % Norgold	100 % Norgold
Dairy production, kg cow^{-1} d^{-1}	2.66 ± 0.0124 (14.65)	2.65 ± 0.0118 (14.44)	2.66 ± 0.0132 (14.75)
Fat, %	1.37 ± 0.01 (3.98)	1.38 ± 0.01 (3.99)	1.31 ± 0.01 (3.73)
Protein, %	1.10 ± 0.01 (3.00)	1.09 ± 0.01 (2.99)	1.10 ± 0.01 (2.99)
Totals solids, %	2.53 ± 0.02 (12.59)	2.53 ± 0.02 (12.54)	2.51 ± 0.02 (12.36)

( ) Mean of original data

FINAL CONSIDERATIONS

From the reviewing of articles published by Cuban Journal of Agricultural Science considerations, especially those referring to milk production, it can be considered that:

-There is interaction between grass varieties and stocking rate. They can be obtained with tropical grasses dairy production between 9 and 11 kg/d during the rainy season, with stocking rate of 3.0 cows/ha in coast cross bermuda grass, 4.0 cows/ha in pangola grass and 5.0 cows/ha in star grass. It was shown that in the star grass are other factors of the species behavior that may influence in the obtaining of higher production with higher stocking rates: their growth habit, structure, availability of the youngest leaves and stems with better quality, when it is grazing.

-The use of leaders and followers grazing system show better nutritional balance between grass supply and animals requirements, according to their nutritionals demanding.

-The rotational grass management can be implemented with four paddocks per group, without affected grass and animal components

-Efficiency of supplementation to cows in grazing agrees with the differential that exists between the base diet and productive potential of the animal, which shows that at the beginning of lactation (first seven weeks), it is when higher response can be obtains from the supplement, whether concentrated or legumes foods were used.

-During the low precipitations period, the grass availability does not covers the animal needs, so the complementation with other voluminous foods should carried out, and be able to maintain the productive levels. The sugar cane forage fresh or fermented plays an important role, whenever it is supplied properly chopped and with the necessary additives (nitrogen and minerals).

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