Chapter 8 Technological options for establishing pastures and increasing yield and nutrient value forage

Capítulo 8 Opciones tecnológicas para establecer praderas e incrementar el rendimiento y valor nutritivo del forraje

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Abstract

In ruminant production systems, forage grasses are the main source of feed, as they are a relatively economical low-cost feed. However, to optimize forage production, it is suggested that pastures be established with the genotypes that best adapt to the conditions present in the production units (soil, precipitation, temperature, etc.) and consider the management that should be given to the crop during establishment (fertilization, weed and pest control, etc.). Once a pasture has been established, the dynamics of forage production during the year must be known, to plan the actions that must be carried out for when there is no availability. Forage grasses are classified as a food of low nutritional value due to their high structural carbohydrate content and low protein and digestibility values; However, in many cases, it is because they are not used at the most appropriate time, where the highest yield and nutritional value are obtained; This is achieved by harvesting or grazing before there are losses due to leaf senescence. On the other hand, during the dry season, fodder is not available, so it is suggested that it be conserved through silage.

Biofertilizer, Forage production, Silage, Crude protein, Digestibility

Resumen

En los sistemas de producción de rumiantes, las gramíneas forrajeras son la fuente principal de alimentación, por ser un alimento de bajo relativamente económico. Sin embargo, para optimizar la producción de forraje, se sugiere que se establezcan praderas con los genotipos que más se adapten a las condiciones presentes en las unidades de producción (suelo, precipitación, temperatura, etc.) y considerar el manejo que se le debe dar al cultivo durante el establecimiento (fertilización, control de malezas y plagas, etc.). Una vez que se tiene establecida una pradera, se debe conocer la dinámica de le producción de forraje durante el año, esto para planear las acciones que se deberán llevar a cabo para cuando no haya disponibilidad. Las gramíneas forrajeras son catalogadas como un alimento de bajo valor nutricional por sus altos contenidos de carbohidratos estructurales y bajos valores de proteína y digestibilidad; sin embargo, en muchas de los casos, se debe que no son aprovechadas en el momento más adecuado, donde se obtiene el mayor rendimiento y valor nutritivo; lo cual se logra al cosechar o pastorear antes de que existan pérdidas por senescencia foliar. Por otra parte, durante la época seca, no hay disponibilidad de forraje, por lo que se sugiere la conservación de éste mediante el ensilado.

Biofertilizante, Producción de forraje, Ensilaje, Proteína cruda, Digestibilidad

8 Introduction

It is estimated that by the year 2100 the world population will increase between 32 and 71%, which would represent between 9.5 and 12.3 billion people (Gerland *et al.*, 2014). It is expected that by 2050, global demand for livestock products will double, in particular due to the improvement in the living conditions of the population (Rojas-Downing *et al.*, 2017). To feed this population, beef will need to increase from 60 to 130 million tons and 70% of this production (49 million tons) is expected to come from tropical and subtropical regions of the world (Cooke *et al.*, 2020). In Mexico, livestock farming is one of the main productive activities in rural areas, with cattle, pigs, goats, sheep, and poultry being used to produce meat, milk or eggs (Bautista-Martínez *et al.*, 2019). Of these species, the most important are ruminants, especially cattle, and their production is developed under two systems: intensive and extensive, the latter being the one that predominates at the national level. Extensive systems have grasslands and cutting and/or grazing meadows as their main food source, since forage from these sites is considered a low-cost food and, therefore, production costs are lower (Albarrán-Portillo *et al.*, 2015).

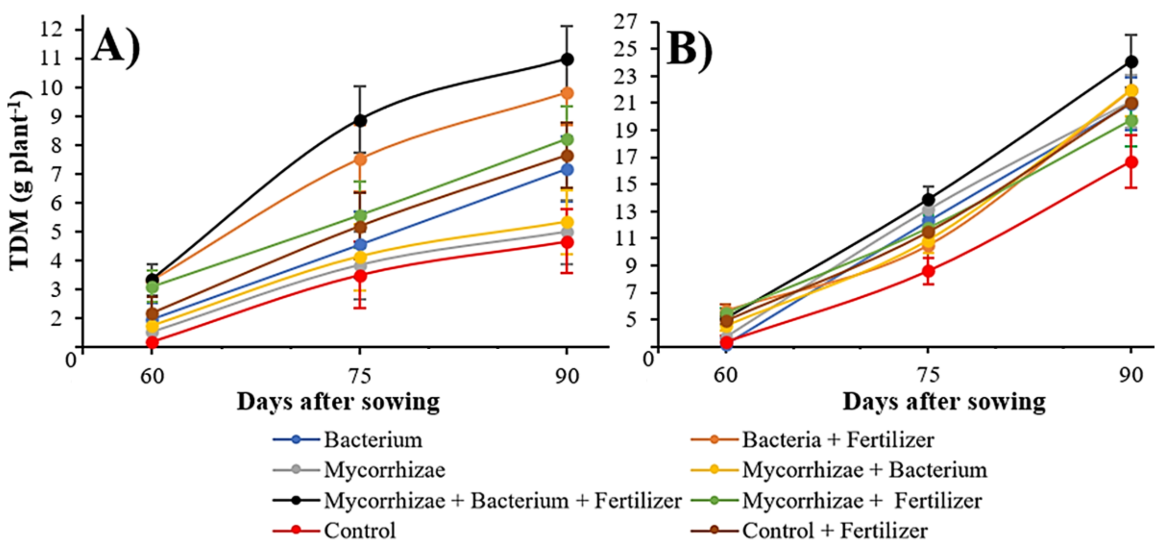
8.1 Establishment of grasslands

For a new meadow to be productive, it is necessary to ensure adequate establishment in the shortest possible time, and special attention must be paid to this stage, since it is when the root and foliar system is generated and expanded, which will determine the capacity for the use of environmental resources (water, nutrients, etc.). light, etc.) and competition with weeds (Garay *et al.*, 2012).

In this sense, nutrient availability plays an important role in plant growth and development, and some tropical grasses such as those of the genera *Pennisetum, Megathyrsus, Cynodon* and *Urochloa*, require around 60 and 30 kg ha^{-1} of nitrogen and phosphorus, respectively, during establishment. However, many of the soils have low fertility, which makes fertilization necessary, which is usually chemical (Enríquez *et al*., 2011) and currently the price of chemical fertilizers has increased by up to 60 %, which means that they are no longer used to reduce production costs.

Faced with this situation, mycorrhizae and nitrogen-fixing bacteria have been proposed as an alternative, as they have been shown to significantly increase the growth and development of *Urochloa brizantha* grass, which reduces the use of chemical fertilizers (Moreira *et al*., 2020). Microbial inoculants, also called biofertilizers, have received increasing attention in some countries, gaining prominence and market scale in the agricultural sector (Sánches *et al*., 2019). In this sense, arbuscular mycorrhizal fungi (AMF) are microorganisms that have the ability to improve plant yields, change the plant-water ratio and increase productivity, even in drought conditions. Recent studies have shown that AMF increased water use efficiency by improving stomatal conductance (Augé *et al.*, 2015*)* and increasing the activity of antioxidant enzymes to reduce peroxidative damage (Duc *et al.*, 2018). In the case of plant growth-promoting rhizobacteria, these microorganisms are able to create symbiosis with plants and generate benefits such as at least partially meeting the plant's nitrogen demands, as well as initiating a variety of processes that include the production of phytohormones, siderophores, phosphate solubilization, induction of systemic resistance intrinsic to abiotic and biotic stress, among others (Fukami *et al*., 2018). In this sense, a study was carried out and it was found that the seed of Mavuno grass inoculated with *Azospirillum brasilense*, up to 90 days after sowing, significantly increased the total dry matter yield and was similar to fertilization with 60-40-40 NPK; therefore, during this time, chemical fertilization could be dispensed with (Sánchez *et al.*, 2022; Figure 8).

Figure 8 Total dry matter (TDM) yield of Mavuno grass (*Urochloa* hybrid), fertilized and inoculated with mycorrhizae *(Glomus* spp.) and bacteria (*Azospirillum brasilense*), in two humidity regimes: 50 (A) and 100 % (B) of field capacity. *Fertilizer (60-40-40 NPK). The overlapping bars indicate that there is no statistically significant difference (Tukey; α=0.05)

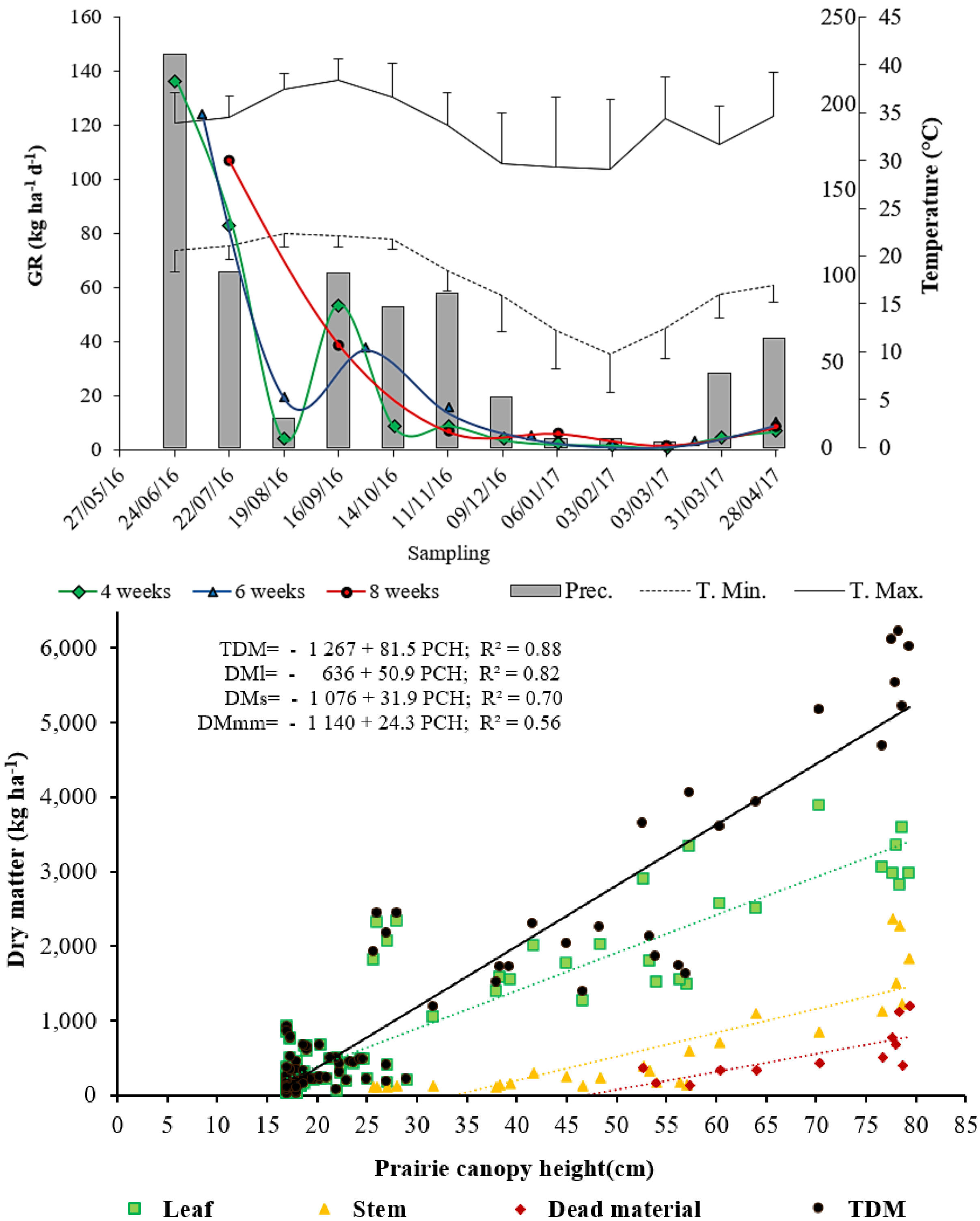


8.2 Production and nutritive value of forage

Regarding forage yield, it should be taken into account that it is influenced by genotype and fluctuations in temperature and precipitation during the year (Martínez-López *et al.*, 2014). It should be considered that the grassland is a dynamic ecosystem and as such, it needs strategic management to maintain forage production and persistence (Cruz *et al.*, 2011). Within management, practices such as fertilization and the intensity and age of regrowth, at which fodder is grazed or harvested, stand out (Cruz-Hernández *et al.*, 2017). The age of regrowth has a positive correlation with forage yield, but a negative correlation with forage quality (Garay *et al.*, 2017). This is a consequence of the maturity of the plant, which causes changes in the relationship to the morphological components; that is, there is a reduction in the proportion of leaves and an increase in stems and dead material (Garay *et al.*, 2017).

It has been mentioned that the best time to harvest a forage is before foliar senescence, to avoid losses in both yield and quality (Silva *et al.*, 2016). The height of the meadow is a practical way of knowing when the best time is to take advantage of the forage resource, as it influences the leaf area index which in turn will determine the leaf senescence of the lower stratum (Silva *et al.*, 2016). In this regard, a study was carried out (Garay *et al.*, 2019) and it was concluded that in Buffel grass forage production, environmental factors and regrowth age had a significant effect on the growth rate, which was reflected in the dynamics of forage yield and accumulation and the structural behavior of dry matter in *Pennisetum ciliare* cv. H-17 (Figure 8.1).

Figure 8.1 Growth Rate (GR) and relationship between prairie canopy height (PCH) and total dry matter yield (TDM) and morphological components [leaf (DMl), stem (DMs) and dead material (DMmm)] in *Pennisetum ciliare* cv. H-17, harvested at three regrowth ages (weeks) and distribution of the accumulated monthly precipitation (Prec.) and average monthly maximum (T. Max.) and minimum (T. Min.) temperature recorded during the evaluation



To obtain the highest forage yield and avoid losses due to foliar senescence in *Pennisetum ciliare* cv. H-17, should be harvested when the height of the meadow reaches between 40 and 50 cm (Figure 2). Likewise, when tropical forages are harvested at an early age, 4 or 6 weeks of regrowth, they can be high in crude protein and digestibility. *Urochloa* hybrids maintain forage quality even at 8 weeks after regrowth, while *Pennisetum ciliare* cv. H-17 only matched Mulato II in crude protein and digestibility at 4 weeks after regrowth. The Cobra hybrid had the highest forage yield during the season of low rainfall (Garay *et al*., 2020; Table 8).

Table 8 Total dry matter (TDM), crude protein (CP) and *in vitro* dry matter digestibility (IVDMD) of *Pennisetum ciliare* cv. H-17 and *Urochloa* hybrids (Cayman, Cobra and Mulato II) at different regrowth age (RA; weeks), during the period of maximum and minimum precipitation

RA	Cultivate	Maximum precipitation season							Minimum precipitation season					
		TDM ($t\ ha^{-1}$)		CP (%)		IVDMD (%)			TDM ($t\ ha^{-1}$)		CP (%)		IVDMD (%)	
4	Cayman	3.76	a	14.1	a	74.9	a		0.16	ab	12.4	ab	72.0	a
	Cobra	3.36	a	12.5	b	72.8	b		0.21	a	11.6	bc	71.1	ab
	Mulato II	3.63	a	11.3	bc	69.3	c		0.18	ab	12.7	ab	70.1	b
	H-17	3.28	a	10.4	c	67.3	c		0.10	b	11.5	c	68.6	c
	Average	3.51	C	12.1	A	71.1	A		0.16	C	12.0	A	70.5	A
6	Cayman	5.14	a	11.6	a	70.2	a		0.20	b	12.1	a	71.6	a
	Cobra	4.79	a	9.9	b	70.1	a		0.25	a	11.4	ab	70.5	ab
	Mulato II	5.17	a	9.9	b	67.7	b		0.23	ab	11.6	a	70.2	b
	H-17	4.85	a	7.6	c	60.6	c		0.20	b	10.5	b	67.5	c
	Average	4.99	B	9.7	B	67.1	B		0.22	B	11.4	B	69.9	A
8	Cayman	6.04	a	10.2	a	67.3	a		0.36	bc	9.5	a	66.4	a
	Cobra	5.87	ab	9.7	ab	67.1	a		0.40	a	9.0	b	66.0	a
	Mulato II	5.78	b	9.2	b	66.3	a		0.38	ab	9.5	a	65.1	a
	H-17	5.24	c	7.4	c	56.3	b		0.33	c	8.5	c	62.4	b
	Average	5.73	A	9.1	C	64.2	C		0.37	A	9.1	C	65.0	B

Different literals between cultivars (a, b, c) and regrowth ages (A, B, C) within the season indicate statistically significant differences (Tukey; α=0.05).

8.3 Forage conservation

On the other hand, to minimize the effects of poor rainfall and the consequent lack of feed during the dry season, an alternative that has been used is silage, in particular, corn (Daniel *et al*., 2019). As a feed source for ruminants, corn silage has the ability to provide forage with high energy content, starch, soluble carbohydrates, and fiber (Zhao *et al*., 2021) and is safe to use in animal feed at any stage of growth. Although corn silage is an excellent source of energy (Erdal *et al*., *2016), it is low in protein (*Zhao *et al*., 2021). For this reason, it is necessary to add additional supplements to balance ruminant diets, as protein is an essential nutrient for the development and reproduction of animals.

Due to the above, the use of legumes has been proposed as an option to increase the protein content in animal diets. This is particularly important for livestock production in tropical and subtropical climates when forages are low in protein (Wassie *et al*., 2019). In this sense, soybeans are a legume with a high protein concentration, so they can contribute to improving the nutritional quality of corn silage (Zhao *et al*., 2021). The positive effects of the combination of corn and soybean forage on silage quality have already been documented (Zhao *et al*., 2021). However, there is limited information available on the nutritional quality of these combinations in tropical and subtropical climates. Likewise, in the search for alternatives for the conservation of legume forage, some additives such as molasses have been tested (López-Herrera *et al*., 2022), however, so far there are few publications related to its application in soybean forage silage. It has been reported that, for the conservation of corn and soybean forage, the treatment that had the highest nutritional quality without seriously compromising the silage process was the combination with 60% corn and 40% soybeans (Figure 3; Garay-Martínez *et al*., 2021); whereas, for proper preservation of soybean forage through silage, 66% molasses should be applied, either in layers of 10 or 20 cm; and this ensures the proper fermentation process, having a pH in the silage that ranges between 3.8 and 4.0 (Figure 8.3; Garay-Martínez *et al*., 2023).

Figure 8.2 Chemical characteristics of corn and soybean forage silage and their different proportions. S100: 100 % soybean; M100: 100 % corn; S80M20: soybean 80 % + corn 20 %; S60M40: 60 % soybean + 40 % corn; S40M60: soybean 40 % + corn 60%; S20M80: Soybean 20 % + Corn 80 %. Different letters, indicate statistically significant difference (Tukey; α=0.05)

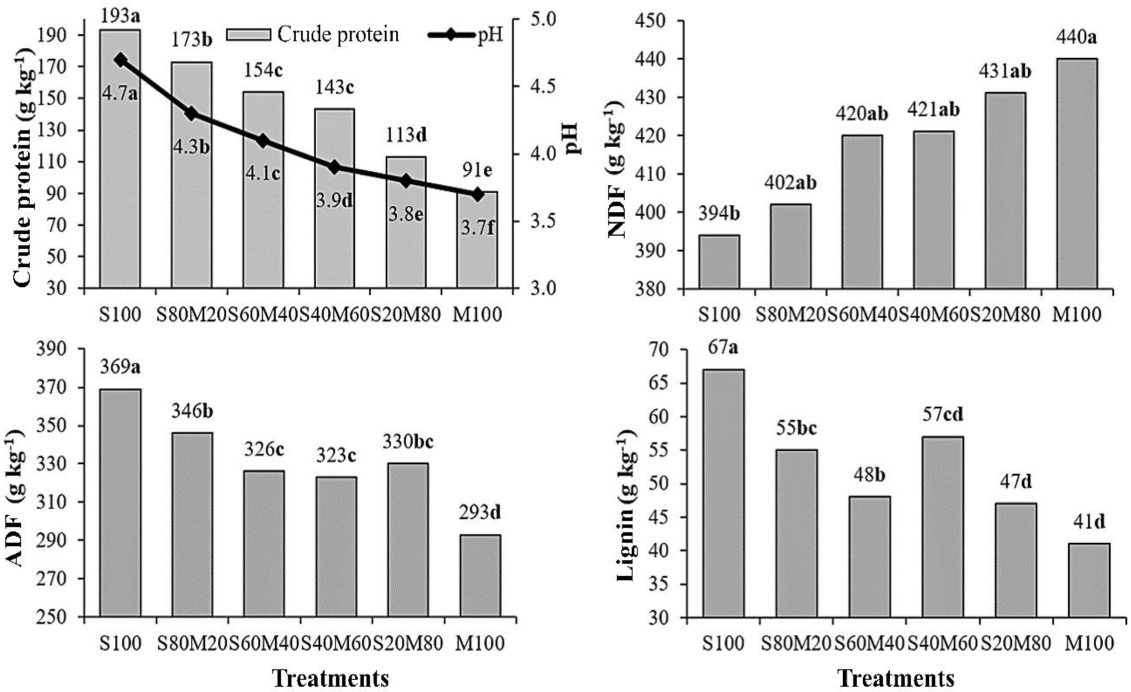
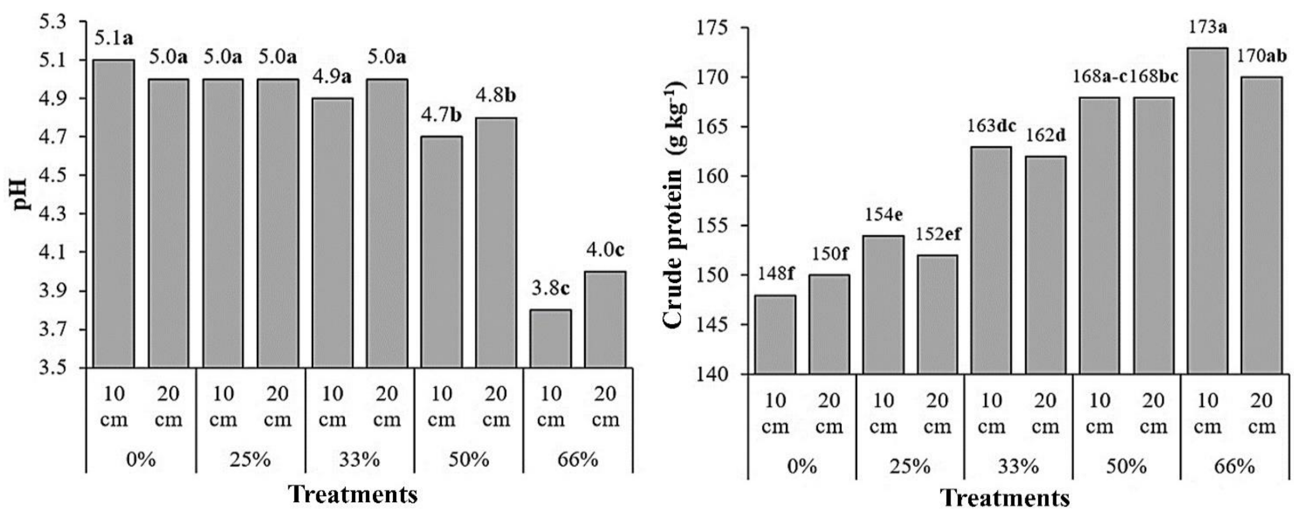


Figure 8.3 Crude protein and pH of soybean forage silage with different molasses levels (0, 25, 33, 50 and 66 %) and application in forage layers (10 and 20 cm). Different letters, indicate statistically significant difference (Tukey; α=0.05)



8.4 Conclusions

Mycorrhizae and/or nitrogen-fixing bacteria can be used to establish grasslands, which can help reduce the costs involved in purchasing and applying chemical fertilizers; in addition to reducing environmental pollution. While to increase the yield and nutritional value of the forage there are several options, among which the choice of the cultivar or genotype, the optimal harvest date and the inclusion of legumes stand out.

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