Review paper

Intensive rational grazing as alternative for low-emission animal husbandry

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Abstract

In order to review essential aspects of the contribution of intensive rational management to low-emission animal husbandry, a set of effects related to climate change and its repercussion on the soil-plant-animal relation were considered, in which emphasis is made on the results obtained in Cuba. The world faces extreme climate events, such as: drought, flooding, temperature increase, among others. In turn, the decrease in land productivity, soil degradation and pastures, decrease of animal production, make countries more vulnerable to climate change. The world agriculture represents 14 % of greenhouse gas emissions; while Cuba is responsible for 18 % of the total emissions. The studies conducted on intensive rational grazing have had positive repercussion in different countries of the area. There are results on the rational management of different cultivated grasses and its effect on the stability of floristic composition, dry matter availability, pests and diseases, nutrient recycling, soil biota and underground phytomass. From the contribution of the ecological management of intensive grazing systems to develop low-emission animal husbandry, results are provided that represent a resilient choice in the face of climate change and a contribution to the food self-sufficiency of countries. In this sense, the challenge is the transition or reconversion of conventional systems to agroecological, resilient systems, which allow to decrease CO_2-eq emissions and increase sinks.

Keywords: adaptation, climatic change, species

Introduction

FAO estimates that the world food production in 2050 should increase by 49 % compared with 2012 to feed an increasing population and with changing habits (FAO, 2017).

The increases in human population and poverty, changes in diet preferences for animal-derived products in the developing world and the increase of the use of arable lands for biofuels will have to be managed within the context of climate change.

It is estimated that between 2005 and 2015, 26 % of the total damages and losses caused by climate disasters in developing countries occurred in agriculture. During this period, drought caused 30 % of the agricultural losses caused by natural disasters, which is equivalent to 29 000 millions USD (FAO, 2017).

Animal husbandry in the world is responsible for 14,5 % of the anthropogenic emissions of greenhouse gases (GHG). They amount to 7,1 thousand million tons of CO_2-eq per year. The GHG emissions in the animal husbandry sector can be reduced by 14-41 %, through the adoption of improvements in: the diet, concentrate feed quality, animal health, management of herd manure and efficient energy use (FAO, 2017). In Cuba, agriculture represents 18 % of the total emissions, and from it enteric fermentation produces 45 % of the GHG emissions (CITMA, 2015).

The use of intensive animal production systems on agroecological bases is stated as a strategic possibility to mitigate the anthropogenic GHG emissions; which include intensive rational grazing systems, from the postulates proposed by Voisin (2012), based on several factors, such as: no utilization of agrotoxicals; stimulation of natural cycles; utilization of pasture at the optimum resting time and with sufficient reserves in the root to allow vigorous regrowth. In addition, the plant is used when it has the nutrients to feed livestock and thus maximizes the harvest of organic matter per area unit and is managed with the carrying capacity in that space. This flexible management contributes to eliminate overgrazing and the disappearance of the cover of adapted species, protects the soil and strengthens the root system, for which it contributes to the adaptation and mitigation.

Due to the above-explained facts, worldwide sustainable development is promoted as a viable choice for mankind's survival in harmony with nature. In that sense, the objective of this review paper was to review the essential aspects of the contribution of intensive rational grazing system management to develop low-emission animal husbandry, where the results obtained in Cuba are emphasized.

Some essential elements of Voisin's Rational Grazing (VRG)

The studies conducted by the French scientist André Voisin in temperate climate and the arguments taken from the scientific contributions of previous years in Germany and other countries, allowed him to enunciate the main principles for pasture management under those conditions.

The way in which these management principles, their basis and logics were formulated, provided them with a certain universality character, but they did not escape the reality of being formulated for a specific type of pastureland and ecological, technological and cultural environment; however, their application is possible if the principles of formulation are taken into consideration.

In the four laws formulated by Voisin (2012), the author assigns equal importance to the pasture and to the animal.

In those related to pasture, their application depends on the edaphoclimatic characteristics; nevertheless, the manager is the one in charge of determining the optimum moment for grazing and no similar recommendations could be offered for the different conditions.

Voisin (2012) defined that *grazing is the meeting of the cow with the grass*, in balance so that none affects the survival of the other, because the cow selects from the pasture the nutrients for the maintenance, growth, production and reproduction, but in turn the grass needs to be consumed, trampled, fertilized, in order to start a new growth cycle and the cow stimulates that growth with the saliva, feces and urine.

Pasture areas with adequate management have large carbon reserves. In this sense, carbon balance on Earth is related to four reservoirs: oceans, atmosphere, geological and land system with 50 Pg as biomass-vegetation and 1 550 Pg as soil organic carbon (SOC). In the land ecosystem, the largest component is SOC, followed by inorganic carbon (750-950 Pg C). The SOC makes up about two thirds of the fixed C in land ecosystems; thus, the soil represents a large carbon store in nature (Burbano-Orjuela, 2018).

On the other hand, the management methods included in the laws involve new concepts of nature balance, with neither exploitation nor deterioration and their application should be contextualized.

The first two laws were related to the pasture and the other two to the animal. In the ones enunciated for the pasture management, the most important principle is the resting between a grazing moment and the other to reach the highest productivity, and the occupation time of one paddock by the animals.

- First Law: For a grass, sheared with the animal's teeth, to achieve its maximum productivity, sufficient interval must have elapsed between two successive grazings, in order to allow the grass to accumulate in its roots the necessary reserves for a vigorous spurt of re-growth and to produce its blaze of growth.
- Second Law: The occupation period of one paddock should be sufficiently short for a grass sheared on the first day of occupation not to be cut again by the teeth of these animals before they leave the paddock.

In the laws related to the animal Voisin brings to the fore the requirements and ration quality to cover them, key aspects to guarantee that the animal expresses its potential.

- Third Law: The animals with the greatest nutritional requirements must be helped to harvest the greatest quantity of grass of the best possible quality.
- Fourth Law: For a cow to give regular milk yields she must not stay any longer than three days in the same paddock. Yields will be at their maximum if the cows do not stay in one paddock for more than one day.

Another aspect to which great importance was ascribed was the stocking rate. In this regard, in his book "Grass productivity" (Voisin, 2012), he stated: the farmer who embarks on rational grazing generally states first: How many animals can I load? I answer: I do not know, I cannot know. It is necessary to establish a time plan, from this plan the surface plans and the possible stocking rates could be deduced… If rational grazing is conveniently performed you will be led in successive years to increase considerably the global stocking rate in your pastures.

This idea, along with other principles such as resting, permanence time or paddock jumping (flexibility), speak on the one hand of true technological laws of rational grazing and, on the other hand, of the deep ecological vocation that promotes balance and moderation in the relations with nature, for which their application can contribute to low-carbon systems. The interpretation and innovation under the conditions of each site is the key to success.

In Cuba the corollaries and laws enunciated by the French scientist were known since his books were edited in the early 1960's, and the technology was assumed, to a large extent, as something finished, whose success depended only on knowing and applying it well. The expectations around it were very high and although actions were undertaken to follow up the management of the technology that was being implemented, the studies in this regard were neither systematized nor was his work further analyzed in the few research centers that existed at that time.

In 1990 the country had lost the trade with the socialist block and was undergoing double embargo, because of which fertilizers, fuel, feed supplements and medicines, among other products, drastically decreased. At that time, the topic of Voisin's rational grazing was taken up again, which was successful in some dairy farms, but the lack of minimum resources and training of the farmer as protagonist did not allow it to triumph at large scale; yet, a research program was conducted with the participation of different scientific institutions in which the system approach prevailed and commendable results were reached in the studies of the soil-plant-animal relation.

Considerations of the impact of animal husbandry on the climate change and possible actions to compensate it

World animal husbandry is responsible for two thirds of the GHG emissions (FAO, 2017). Cattle management is the main warrant, and the emissions depend on the actions that are developed. Among the most important ones are: the diet that is offered, maintaining unproductive cows and replacement animals that are not utilized later, not processing manure adequately and using imported cereals with a large carbon footprint.

In this sense, cattle cannot be accused as the main responsible for emissions, because the management practices in feeding aimed at deviating fermentation towards propionate production without affecting ruminant production, as well as providing the increase of intake or digestion rate or reducing feed permanence in the rumen, decrease methane production per unit of digested forage (Sosa *et al.*, 2007). It is also stated that when intensive feeding systems are used, lower methane amounts are produced when compared with extensive systems (Clemens and Ahlgrimm, cited by Sosa *et al.*, 2007).

On the other hand, although industrial agriculture has been the prevailing model in different geographic zones, small farmers produce most foodstuffs and promote economic development in Africa, Latin America and Asia. Five hundred million of these small farmers feed more than two thousand million people worldwide (Altieri *et al.*, 2014).

Although the industrial systems have reported gains in productivity in the last 50 years, they have also had indisputable negative impacts on the environment. For such reason, the future challenges for production systems depend on the redesign of industrial animal husbandry systems and the increase of production in small farms through a set of alternative practices to industrial agriculture. Agroecology offers a holistic framework to face these issues and their interconnections at different scales (Dumont *et al.*, 2014).

Latin America had a reduction of the emissions in 2000 with regards to 1990; however, at present it has 9,9 % of the emissions of t CO_2 eq per capita with regards to the world, in the land change and use (Loaiza-Ceró *et al.*, 2015).

The reconversion and/or agroecological transition is a transformation process of conventional production systems, towards agroecological basis systems, which comprises not only technical, productive and ecological elements, but also sociocultural and economic aspects of the farmer, his/her family and community (Vázquez and Martínez, 2015). In Cuba, during 30 years, conventional agriculture was practiced; however, during the last 20 years, a process of agroecological transition has occurred (Vázquez, 2018), in which more than one hundred thousand farmer families participate with results in the agroecological movement (Machín, 2016).

The sustainable intensification of animal husbandry in the face of climate change is a challenge. It represents a different concept from the intensification that has been practiced with the conventional systems that attempt to "increase" food production and "face" the extreme events of climate change at the expense of ecosystem and natural resource sustainability, in order to solve the problems which, precisely, have been generated by the same technological approach with external dependence on basic products and contamination, among others. Agriculture in transition towards sustainability pursues food production, from self-sufficiency, diversity, frequency, innocuousness and quantity (Vázquez, 2018).

The decrease of vulnerability and the increase of resilience (adaptation), requires a social construction, because it is in the farm, according to the soil and climate of the site, where the plant and animal species are selected. In this construction, researcher-farmer innovation processes intervene, which with adequate management can contribute to reduce the GHG emissions and increase the removal of CO_2.

Contribution of the intensive rational grazing systems to low-carbon animal husbandry

In the studies conducted in Cuba with an intensive rational management, where the agroecological management of the soil and the flexibility of animal rotation prevailed, encouraging results were found in the studies carried out on the soil and the species that populated the system.

Milera *et al.* (2016), when using the grasses *Andropogon gayanus* Kunth cv. 621; *Megathyrsus maximus* (Jacq.) B.K. Simon & S.W.L. Jacobs cv. Likoni, *Cenchrus ciliaris* L. cv. Biloela, *Urochloa mutica* (Forssk.) T.Q. Nguyen cv. Aguada [=*Brachiaria purpurascens* (Raddi) Henrard] and *Cynodon nlemfuensis* Vanderyst cv. Tocumen, in a system with intensive rational management, without application of fertilizers and the presence of herbaceous legumes, observed favorable results in the chemical and biological composition of the soil, recycling related to the discharge of excreta in the paddock, as well as the underground phytomass, floristic composition, persistence, availability and bromatological composition of the species, phenology, pests and diseases.

In this study the most important aspects in the pastureland management received priority: grazing system, necessary resting time (expressed as the optimum moment for the entrance of the animals to the paddock or plot), the intensification or high instantaneous stocking rate that would allow high discharge of excreta, and global stocking rate. For such purpose, there was a large number of paddocks, in an area well covered by pastures and with sufficient available biomass.

The new grazing design took into consideration the optimum moment to be grazed and from it the resting time and quantity of paddocks were determined; this logic had not been practiced before in management trials.

To introduce the cattle in the system with grasses, a set of factors were considered which were evaluated through a ranking-visual observation method to determine the optimum grazing moment. Due to their importance, the most important steps are summarized.

The measurements were carried out from five points or moments of grass growth, depending on visual observation. The analysis of measurements and trip notes allowed to select the best moment:

- *Point 1. Departure of the animals*: At that point the grass is not very high, but refuse is very important (neither a lot of grass nor very little), that is, the soil must not be uncovered.
- *Point 2. Slow growth and color change*: the effect of selection by the animal on the consumed leaf disappears and plant growth and height start.
- *Point 3. Linear growth*: increase of the leaf biomass, more intense color, widened leaves, more height.
- *Point 4*. Increase of leaf biomass: more dense area with higher yield; in erect pastures the leaf apex is bent down by the weight, there is little inflorescence.
- *Point 5. Maturity*: Basis with wilted leaves, maturity, change of color and more than 10 % flowering.

In this sense, the number of floral stems in *A. gayanus* started to appear since September, but in low percentages (September-November) in points 3 and 4, and it increased at point five; nevertheless, in December flower stems were observed at points 3, 4 and 5.

The number of live shoots (Sl) and total shoots (St) and the respective variables calculated depending on them (density of live shots, live shoots-diameter ratio, live shoots-dead shoots ratio, total shoots-diameter ratio and density of total shoots), were significantly higher when the pasture was rotated a higher number of times. Thus, it was confirmed that with shorter frequencies and high instantaneous rates used a beneficial stimulus was originated in shoot production. This indicates that the defoliation produced by the animals did not damage at any moment the potentially apt buds and buds-sprout to support the sequence of sprout formation, which were produced, even, in higher quantity (Machado *et al*., 2012).

Fariñas *et al.* (2017), from visits and measurements with a systemic approach and taking into consideration all the factors that have incidence on the management of the grazing system, obtained results which coincide with the ones analyzed in this paper, not only in the approach but in the flexibility and rationality to organize the pasture management.

Regarding the best moment or optimum point for the grass harvest, it was concluded that point 4 turned out to be the best for introducing the animals in the paddock. The stay was for one day with high instantaneous stocking rates, but there was a residue left that allowed vigorous regrowth. With regards to the utilization, it was taken into consideration to offer availability per animal which, according to the season, could stay in the paddock the whole day or only an amount of hours; neither the pastures nor the cows were affected, that was the premise used from the beginning.

According to Marín *et al.* (2017), the moment for the beginning of rotation was determined by the height. These authors stated that the rotational grazing is characterized by managing with high pressure when a high availability of pasture is reached upon the entrance of the animals to the paddock and this mass decreases remarkably upon the departure of the animals due to the high utilization. Then an optimum pre-grazing height will be reached which maximizes the short-term ingestion rate (STIR). That is why they recommend a pre- and post-grazing height and concluded that the maximum STIR leads to higher daily intake and animal performance, and in turn improves the intensity of the GHG emissions per unit of animal product or per area.

From the optimum moment method its principles can be adopted, but not its quantitative results related to age, height, stocking rate, because they all start from the manager's experience and the observation of the availability and quality of certain species, which are conditioned by the edaphoclimatic characteristics of the site and type of variety, growth habit, stocking rate used, among other factors.

The careful management to achieve a quality offer, besides maintaining the persistence of the species, is what contributes to the adaptation and sustainability of the system; nevertheless, adaptation cannot be extended, or imported, it is reached when the adequate management in the long term is performed in each site.

As could be observed, the determination of the optimum moment or point depends on managing flexibly each paddock with the necessary resting, taking into consideration the different species under evaluation within the system.

Pastures have their own physiological and morphological characteristics, which allow the specific adaptation for their growth and quality; however, when changes occur under the climate conditions (under the temperature, radiation, rainfall and its distribution), pastures experience morphological modifications in their yield and quality.

Milera *et al.* (2016) observed that the species that showed a higher proportion with regards to the number of established paddocks were *A. gayanus*, *M. maximus* and *C. ciliaris*. In the first year of evaluation, *M. maximus* showed the highest number of paddocks under grazing, with 3, 4, and 5 rotations, followed by *A. gayanus* with the highest percentage in 3 rotations and similar result was obtained by *C. ciliaris*; however, *M. maximus* was the one that needed less time for recovery (38 days). In the second year *M. maximus* and *C. ciliaris* had the highest percentage of paddocks with 4 rotations, but *C. ciliaris* needed more time of recovery (56 days) and in the third year *A. gayanus* and *M. maximus* reached 6 and more than 6 rotations in certain paddocks, but *C. ciliaris*, besides needing more recovery time, was below in yield and covered area.

The highest resting time coincided with the end of the rainy season and during the dry season, which had beneficial incidence on the accompanying herbaceous legumes. On these plants the long resting times had a beneficial effect on persistence, seed production, germination, development and dissemination.

Overgrazing is prevented when the necessary resting period for recovery is used, which has direct implication in adaptation because it increases the species persistence, their covered area, structure, quality; soil erosion and vulnerability of the ecosystem to the climate change were prevented, with positive incidence on biodiversity and resilience.

The soil cannot be analyzed as independent unit; in this case, the soil with established pasture species and animals that consume them form an ecosystem with biotic and abiotic characteristics.

When analyzing the general performance of nutrients in the above-mentioned area, stability could be observed in the system fertility and the discharge of excreta was higher when the rotations planned in each species were fulfilled. This is highly important if the scarcity and high costs of mineral fertilizers are taken into consideration, as well as the negative consequences their use can cause on the ecological environment.

The return of mineral elements through the animal excretions is highly important in sustainable systems. Soil fertility was not affected by the grazing system or by the absence of mineral fertilizers, and at the end of the experimental period a trend to increase was observed in the phosphorus and potassium contents in the areas established with cv. Likoni and *A. gayanus*, respectively (Milera *et al.*, 2016).

In the evaluations conducted in a commercial dairy farm, Guevara (2005) did not observe significant variations in the pH or the K contents; nevertheless, P showed a decrease in the paddocks with *C. nlemfuensis* and an increase in the ones with *M. maximus*; while the organic matter increased. However, another important aspect to be considered in the systems with high grazing intensity, besides the nutrient return, is the N that returns through the litter, because the last one is the guarantee of humus formation.

The species showed a vertical structure characteristic of tropical pastures [leaf (l)-stem (s)-dead material (dm)]. In the annual average, all of them showed a higher percentage in favor of leaves in the strata of more than 30 cm of height, accessible by the animals (l-72, s-2, dm-26 %). In the stratum of 20-30 cm of height, although the leaf percentage was also high, the dead material was favored (l-38, s-10, dm-52 %) and showed a high component of stems with regards to the higher stratum; and in the 0-20 cm stratum the stem and dead material were benefitted (l-17, s-19, dm-64 %), but it was lower than the ones reported in conventional systems by Hernández *et al.* (1992).

The leaf-stem-dead material ratio in all the studied species showed the best structure in favor of leaves in the stratum of more than 30 cm and in the rainy season; nevertheless, *A. gayanus* and *M. maximus* were higher than *C. ciliaris, C. nlemfuensis* and *U. mutica*.

In the annual average in all the strata there was presence of dead material and on the soil, senescent material cover. Intensive-flexible management, to graze each paddock at the optimum moment and with high stocking rate in one day of permanence, had a positive effect on structure in the five species, with no detriment for the litter.

The soil cover by different plant species and litter, the non-application of chemical fertilizers and the discharge of excreta due to the high instantaneous stocking rate, benefitted the main groups that make up the macrofauna, which besides contributing to burying the OM improve structure and porosity.

Soil management can affect its carbon content and lead, although paradoxical in principle, to the soil becoming an important emitter of GHG instead of being a carbon sink. For such reason, appropriate practices and adequate management should be used which recover and maintain soil potentiality and influence the amount of carbon they can store (Burbano-Orjuela, 2018).

The soil organic carbon (SOC) for a depth of 0,30 m is 677 Pg; 993 for 0,50 m, and 1 505 for 1 m. Approximately 55 % of SOC lies below the depth of 0,30 m. The agroecosystem soils have their SOC reserves depleted and low efficiency in the use of inputs to reach the agronomic yield (Rattan, 2018).

The agroecological management used contributed to improve the biological indicators, in the case of soil biota, the results were very encouraging and served as basis for other studies. The soil fauna is an appropriate bioindicator given its relatively sedentary habits and presence throughout the year, its ease of measurement and its high sensitivity and fast response to environmental stress (FAO, 2015).

A total of 540 individuals, belonging to 2 Phyla, 5 classes and 8 orders, were collected. At the beginning of the studies in the grazing of *A. gayanus*, the insects represented 75,7 % of the fauna and the rest were oligochaetes, and at the end the quantity of insects decreased to 35,5 %, due to the remarkable increase of oligochaetes (32,1 %) and to the appearance of other groups, for example: millipedes, isopods and arachnids (Sánchez *et al.*, 1997).

Earthworms participate directly or indirectly in the physical, chemical and biological soil processes; they and macroinvertebrates also act through their functional controls in the regulation of important soil functions.

They select in ingestion a large quantity of organic and mineral material, and their activity leads to the production of structures that participate directly in the soil physical properties such as: increase of porosity and aeration, improvement of water conductivity and there is better structural stability that includes the formation of macro-aggregates and micro-aggregates (Jiménez-Jaén *et al.*, 2003).

Earthworms also participate in the soil physical structure because they produce large quantities of organic-mineral aggregates. In a short time interval, of a few hours, the earthworm digestion breaks the organic residues and releases some nutrients, such as nitrogen (N) and phosphorus (P), which can then be assimilated by plants (Jiménez-Jaén *et al.*, 2003).

In general, grasslands have more earthworms than the crops that leave less quantity of residue on the field. Soil management, by not affecting the accumulation of SOC, acts on the earthworm number and weight. The soil organic C participates in the biological properties, basically acting as energy source for the soil heterotroph organisms.

In general terms, the techniques that use adequate soil management, such as: minimum tillage, adequate crop rotation on the same land, mulch or cover between crop strips, optimum use of water in irrigation systems, application of organic and organic-mineral fertilizers, adequate management of resting and use of silvopastoral systems, have caused improvements in the nutritional status of plants and in soil care, with favorable effects on the saving of chemical fertilizers and on the increase of crop yield (Crespo, 2018).

Hernández *et al.* (2011), when evaluating in five pasturelands with rotational management, found that the fine roots or rootlets (< 0,2 mm of diameter) showed significant differences in all the soil layers; while in the detritus the differences were in the surface layers, 0-20 cm, and the rhizomes were found only in the 0-5 cm layer. It was observed that in the 10-20 cm layer all the components differed statistically.

In turn, in this same study the average underground phytomass of the five studied pasturelands was 788 g m^{-2}; 30,8 % belonged to the roots, 15,3 % to the rhizomes and 53,9 % to the detritus. The components of the underground phytomass were concentrated in the soil surface layers. From the total underground phytomass 70 % was in the 0-10 cm layer and 81 % of the total was found in the total phytomass, in the first 5 cm; while the roots represented 81 %.

The total underground phytomass in all the studied soil profiles fluctuated between 355 and 1 162 g m^{-2}. The highest values were in the erect pasture species, *M. maximus* and *U. mutica*, which did not differ significantly between them, and the lowest value was shown by *A. gayanus*, differing from the others. The creeping legumes *C. nlemfuensis* and *B. purpurascens* differed between them and from the other erect species, which shows the particular behavior of each one of the species that in turn belong to different plant genera. *M. maximus* showed a high proportion of fine roots that allow it higher capacity to take up water and nutrients from the soil (Hernández *et al.*, 2011). Although it is not an endemic species of Cuba, it is one of the oldest and best adapted to the different edaphoclimatic conditions of the country.

On the other hand, Machado *et al.* (2011) classified 75 species from several plant families in a Voisin rotational grazing which showed stability in general, because some of them were not perennial and others did not withstand the grazing intensity in the experimental period. The remarkable diversity of species that characterized the plant biomass contributed by the grasses, the companion herbaceous legumes that exceeded 20 % of the total existing flora and other species which were in association with the grasses, can be selected by the animals and remain with higher stability than when they constitute pure crops, or when they are not adequately managed.

In this study, a total of 21 species were classified in the legume family, which increased at the end of the experimental period. In this sense, the species *Calopogonium mucunoides* and *Alysicarpus vaginalis* decreased their population, but increased their distribution frequency in the paddocks. However, *Centrosema, Neonotonia, Teramnus* and *Indigofera mucronata* not only increased their population in the paddocks where they were already established, but also the distribution frequency (presence in other paddocks in which they had not been present) throughout the area.

In general, herbaceous legumes had an increased evolution in the paddock and the frequency of appearance and distribution in other paddocks where they were not present at the beginning of the studies. Among the most outstanding ones were: *Neonotonia wightii, Teramnus labialis* and *Centrosema pubescens*, because their seed production occurs during the dry season, and the management carried out facilitated the fructification and seed maturation, as well as dissemination(Milera *et al.*, 2016). The species biodiversity achieved in the system, not only increased, but also contributed to the biomass availability and quality of the ingested feedstuff.

According to López-Vigoa *et al.* (2018), when *Leucaena leucocephala* and *N. wigthii* were included in addition to the improved grass, a significant increase of the ration quality and digestibility was observed in the pastureland.

In turn, in a study conducted in forage legumes by Gurbuz (2009), a negative correlation condensed tannins and methane gas production (r^2= -0,882), carbon dioxide gas production and total gas production (r^2= -0,883 and r^2 -0,867) were found, respectively, which could be due to an effect of methanogenesis, structural variation and biological activity of tannins. Although the herbaceous legumes used by this author were not the same as the ones used by Milera *et al.* (2016), this is an important aspect that should be taken into consideration in grazing systems.

The legumes favored the selective abilities of the grazing animals; yet, the intensification without fertilization requires an association of grasses with legumes in a significant percentage that has incidence not only on the productive performance, but also on the carbon capture and decrease of emissions, and the best way to achieve it is with herbaceous and tree legumes.

When analyzing the availability according to the resting days of the paddock, since 20 and until 60 days, it reached average values of 3,4 t DM/ha/rotation, and with regards to the season, in the rainy one it was higher (4,3 t DM/ha/rotation) than the dry season (3,1 t DM/ha/rotation), with significant differences for $p<0{,}01$. The protein contents were between 9,11 and 9,7 % of DM, in *M. maximus* and *A. gayanus*; *C. ciliaris* in the dry season reached 8,7 %. In cultivated grasses managed in conventional grazing, if no fertilizers are applied, these results are not achieved, which proves that it is possible to maintain the grass-legume association and recycling when intensive grazing is used, with adequate management.

From the phytosanitary point of view, the contribution to adaptation and mitigation of the effects of climate change was given by the presence and negligible affectation by insects and fungal disease causing microorganisms, mainly. This was the result of the management which was performed on the monocrop grasses (*A. gayanus* cv. CIAT-621, *M. maximus* cv. Likoni, *C. nlemfuensis* cv. Tocumen, *C. ciliaris* cv. Formidable and *U. mutica* cv. Aguada) in the intensive rational grazing system to which they were subject, standing out the resting time of the pastures; the stocking rate (global and instantaneous), which implied higher trampling at a certain moment; the grazing-browsing hours by the animals; and the fact of assigning the same value to the pasture species as to the cows, considering the essential importance of this type of feedstuff in the cattle diet.

Hence with these measures changes occurred in the system, which in addition to exerting certain influence on the pest organisms, for example: existence of lower availability of leaf mass to be consumed by the pest at a certain moment; the loss of a host pasture par excellence for not withstanding intensive grazing; the short resting time of some pasture species, which causes the animal to pass through the same paddock with higher frequency than when it is grazed with the traditional system; and finally, the fact of not applying fertilizers or inorganic pesticides (Alonso *et al.*, 2011). They could have also favored the decrease of the emissions by maintaining the biological balance in the pastureland; and as there were no mass explosions of pests that deteriorated it, given by the prevailing plant diversity such as for example the most vigorous pastures and weeds, within all the agrobiodiversity, according to the criterion expressed by Nicholls and Altieri (2017).

As the areas with species biodiversity (grasses-legumes) and the grazing rational management are maintained, the emission of CH_4/kg of animal product, the soil erosion and compaction will be lower, the species persistence will be higher and pest affectations will be lower, which in turn has economic implications because they improve productions and incomes, contributing to the food security of the family and the locality.

Conclusions

Species biodiversity in rotational grazing without the application of agrotoxicals not only contributes to healthier landscapes, but has a positive effect on the quality and innocuousness of the ration, better utilization of the biomass by the animals and contributes to a lower quantity of phytopathogens.

The intensive rational grazing of the pastureland can contribute significantly in the evolution of the edaphic biota, better utilization of organic matter by the plants, humidity holding, prevents compaction, has incidence on carbon capture and holding, for which this type of management favors the soil-plant-animal relation and resilience to the climate change.

There are results in diversified production systems which preserve natural resources, use adapted plants and animals, and show productive efficiency. The challenge is to continue working in the transition or reconversion from conventional systems to resilient, agroecological systems, which allow to increase food self-sufficiency from the diversity, quantity, frequency and innocuousness in the productions.

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