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ANÁLISE INTEGRADA DA DINÂMICA SOLO–PLANTA–ANIMAL EM SISTEMAS DE PASTOREIO CONVENCIONAL E VOISIN

INTEGRATED ANALYSIS OF SOIL–PLANT–ANIMAL DYNAMICS IN CONVENTIONAL AND VOISIN GRAZING SYSTEMS

ANÁLISIS INTEGRADO DE LA DINÁMICA SUELO–PLANTA–ANIMAL EN SISTEMAS DE PASTOREO CONVENCIONAL Y VOISIN

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Resumo

A degradação das pastagens constitui um dos principais entraves à produtividade e à sustentabilidade da pecuária brasileira. Nesse contexto, o Pastoreio Racional Voisin (PRV) desponta como uma alternativa agroecológica ao manejo convencional, promovendo o equilíbrio entre solo, planta e animal. Este estudo teve como objetivo comparar os sistemas de manejo convencional e PRV, avaliando a produção de matéria seca (PMS), a composição botânica das pastagens e o desempenho animal. O experimento foi conduzido na Chácara Bela Vista, em condições edafoclimáticas semelhantes, utilizando delineamento com dois sistemas subdivididos em cinco piquetes de áreas equivalentes. No PRV, aplicaram-se rigorosamente os quatro postulados de

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André Voisin, enquanto o sistema convencional baseou-se em pastejo contínuo. Os resultados evidenciaram que o PRV apresentou incremento de 31,7% na PMS, redução de 16% na presença de plantas invasoras e maior diversidade de espécies forrageiras, destacando-se Brachiaria brizantha e Panicum maximum. Além disso, os animais sob PRV apresentaram ganho médio diário superior (0,78 kg/animal/dia) em relação ao sistema convencional (0,58 kg/animal/dia). Conclui-se que o Pastoreio Racional Voisin constitui uma tecnologia agroecológica eficiente e sustentável, capaz de aliar elevada produtividade, conservação do solo, bem-estar animal e redução da dependência de insumos externos, configurando-se como uma ferramenta essencial para o fortalecimento da pecuária moderna e para a recuperação das pastagens brasileiras.

Palavras-chave: pastagens; manejo sustentável; pecuária; pastoreio racional; agroecologia.

Abstract

Pasture degradation is one of the main constraints to productivity and sustainability in Brazilian livestock systems. In this context, Voisin Rational Grazing (VRG) emerges as an agroecological alternative to conventional management, promoting balance among soil, plant, and animal components. This study aimed to compare conventional grazing and VRG systems by evaluating dry matter production (DMP), botanical composition, and animal performance. The experiment was conducted at Chácara Bela Vista under similar edaphoclimatic conditions, using a design with two management systems subdivided into five paddocks of equivalent area. In the VRG system, Voisin's four principles were rigorously applied, whereas the conventional system relied on continuous grazing. Results showed that VRG increased DMP by 31.7%, reduced the presence of invasive species by 16%, and enhanced forage species diversity, particularly Brachiaria brizantha and Panicum maximum. Moreover, animals under VRG exhibited superior average daily gain (0.78 kg/animal/day) compared to those in the conventional system (0.58 kg/animal/day). It is concluded that Voisin Rational Grazing is an efficient and sustainable agroecological technology capable of combining high productivity, soil conservation, animal welfare, and reduced dependence on external inputs, positioning itself as an essential tool for strengthening modern livestock systems and restoring degraded pastures in Brazil.

Keywords: pastures; sustainable management; livestock; rational grazing; agroecology.

Resumen

La degradación de las pasturas constituye uno de los principales obstáculos para la productividad y la sostenibilidad de la ganadería brasileña. En este contexto, el Pastoreo Racional Voisin (PRV) surge como una alternativa agroecológica al manejo convencional, promoviendo el equilibrio entre suelo, planta y animal. El objetivo de este estudio fue comparar los sistemas de manejo convencional y PRV, evaluando la producción de materia seca (PMS), la composición botánica de las pasturas y el desempeño animal. El experimento se llevó a cabo en la Chácara Bela Vista, bajo condiciones edafoclimáticas similares, utilizando un diseño experimental con dos sistemas subdivididos en cinco potreros de áreas equivalentes. En el PRV se aplicaron rigurosamente los

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cuatro postulados de André Voisin, mientras que el sistema convencional se basó en pastoreo continuo. Los resultados evidenciaron que el PRV presentó un incremento del 31,7% en la PMS, una reducción del 16% en la presencia de plantas invasoras y una mayor diversidad de especies forrajeras, destacándose Brachiaria brizantha y Panicum maximum. Además, los animales bajo PRV mostraron una ganancia media diaria superior (0,78 kg/animal/día) en comparación con el sistema convencional (0,58 kg/animal/día). Se concluye que el Pastoreo Racional Voisin constituye una tecnología agroecológica eficiente y sostenible, capaz de integrar alta productividad, conservación del suelo, bienestar animal y reducción de la dependencia de insumos externos, configurándose como una herramienta esencial para el fortalecimiento de la ganadería moderna y la recuperación de pasturas degradadas en Brasil.

Palabras clave: pasturas; manejo sostenible; ganadería; pastoreo racional; agroecología.

1. Introduction

Livestock production plays a central role in the Brazilian economy, with pastures serving as the primary feed source for ruminants. However, pasture degradation represents the main factor responsible for the decline in quality and productivity in grazing-based feeding systems (AGUIAR et al., 2017). It is estimated that pastures in Brazil occupy approximately 177 million hectares, of which about 62% exhibit signs of moderate or severe degradation (LAPIG; UFG, 2022). This scenario reflects a global issue, as nearly 20% of the world's pasturelands experience reduced productivity due to degradation processes and/or inadequate management practices (SLOAT et al., 2018).

The rapid growth of the global population has intensified the demand for food, requiring large-scale production systems unprecedented in human history. Nevertheless, the increasing pursuit of biologically and ethically superior food reveals heightened concern regarding the environmental and social impacts of agricultural and livestock production. In this context, the intensification model promoted by the so-called Green Revolution has become increasingly unsustainable (MACHADO; MACHADO FILHO, 2014), highlighting the urgent need for new paradigms in agricultural and livestock systems.

The conventional system of cattle production for meat and dairy has proven insufficient both for ensuring high-quality food and for preserving the ecological foundations that support the activity. Therefore, the establishment of new pasture

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management systems capable of reconciling productivity and Sustainability incorporating nutritional, energetic, environmental, social, and economic dimensions has become imperative.

Within this scenario, Voisin Rational Grazing (VRG), developed by the French researcher André Voisin, emerges as a sustainable management tool and is regarded as the foundation of the universal laws of rational grazing. VRG seeks to maximize pasture productivity and biological value while promoting continuous improvement of soil fertility and cleaner food production, respecting animal welfare (MACHADO, 2004).

More than a rotational grazing technique, VRG represents an integrated and scientific production system grounded in the application of principles from basic and applied sciences to soil–plant–animal interactions. Its central purpose is to optimize the conversion of solar energy into plant and animal biomass, ensuring high levels of productive efficiency and environmental sustainability within an agroecological framework (MACHADO; MACHADO FILHO, 2014).

The system aims to balance the needs of soil, plants, and animals, promoting natural fertility, enhanced animal performance, and increased productivity per unit area (LENZI, 2012). To achieve these goals, Voisin formulated four fundamental laws of rational grazing:

- Law of Rest, which defines the optimal interval for full plant regrowth;
- Law of Occupation, which states that animals should not remain in a paddock after the optimal forage consumption period;
- Law of Maximum Yields, which emphasizes consumption of forage of high quality and digestibility;
- Law of Regular Yields, which recommends limiting paddock occupancy to a maximum of three days (CASTAGNA, 2008; LENZI, 2003; LENZI, 2012).

Initially presented in 1957 in the book Grass Productivity, VRG was described by Voisin as a rational pasture-management method emphasizing paddock rotation and balanced fertilizer use. Since then, VRG has been consolidated as an ecological technology capable of enhancing biodiversity,

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eliminating the use of fire, and promoting the sustainability of productive ecosystems (SORIO, 2018).

Thus, Voisin Rational Grazing constitutes an agroecological management strategy that reestablishes balance among soil, pasture, and animals, reducing production costs, increasing biological efficiency, and promoting farmer autonomy. Among its main advantages are increased productivity, improved soil fertility, production of high biological-value food, respect for animal welfare, and economic and environmental sustainability.

Given this context, the present study aims to compare conventional pasture management with the Voisin Rational Grazing (VRG) system, using dry matter production and botanical composition as key indicators. The central hypothesis is that the system proposed by Voisin promotes superior vegetative development and higher productivity, establishing itself as a viable and sustainable alternative for modern livestock farming.

2. Literature Review

Brazilian livestock production is predominantly pasture-based, highlighting the importance of grazing lands as the foundation of national animal production (FERRAZ; FELÍCIO, 2010). This system represents the most economical and practical method for supplying feed to ruminants, particularly cattle (DIAS-FILHO, 2014). According to Zanine and Macedo Jr. (2006), the productive efficiency of pastoral systems depends directly on the optimization of forage use, balancing animal intake with the nutrient supply available in the pasture.

In the 1950s, the French researcher André Marcel Voisin (1903–1964), a member of the French Academy of Agriculture, conducted extensive studies on the development of forage plants and their relationships with soil and animals. On his property “Le Talou,” Voisin compiled and tested several experiments that led to the formulation of the universal laws of rational grazing, principles that transformed pasture management into an applied science (ERPEN, 2004).

Brazil’s edaphoclimatic conditions, together with its vast territorial extension, favor low-cost forage production, as factors such as temperature and solar radiation positively influence pasture growth. This characteristic provides the country with a

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competitive advantage in beef and dairy production, reducing costs and increasing the efficiency of production systems (CARVALHO et al., 2009; FERRAZ; FELÍCIO, 2010; DEBLITZ, 2012). By utilizing extensive areas of natural pasture, Brazil maintains production costs lower than those observed in countries relying on confinement systems, which require high investments in grains, inputs, machinery, and labor (DIAS-FILHO, 2011; TORRES JÚNIOR; AGUIAR, 2013).

In Brazil, the first Voisin Rational Grazing (VRG) projects were implemented in 1960 in the municipalities of Bagé (RS), coordinated by agronomist Nilo Romero, and Taquara (RS), led by Professor Luiz Carlos Pinheiro Machado. The latter consolidated the scientific basis of VRG in the country, quantifying its results through academic research, including the dissertations of Ribeiro (1993) and Rigotti (2000), conducted at the Federal University of Rio Grande do Sul and the Federal University of Santa Catarina, respectively (ERPEN, 2004).

The expression “Voisin Rational Grazing (VRG)” was coined by Luiz Carlos Pinheiro Machado in honor of André Voisin’s scientific legacy. Machado researcher and translator of Voisin’s principal works disseminated his theories internationally and complemented them with new theoretical and practical contributions. His book Pastoreio Racional Voisin – tecnologia agroecológica para o terceiro milênio (second edition, 2010) established VRG as a reference agroecological technology aimed at sustainability and productive efficiency.

VRG consists of a rational pasture-management system grounded in planned and continuous human intervention in the vital processes of the soil, plants, and animals (CASTAGNA et al., 2008). According to Machado (2010), it involves the rigorous application of plant physiology principles, the dynamics of soil life, animal welfare considerations, and constant observation of ecological and productive conditions.

The foundation of VRG lies in understanding soil biocenosis and in the careful definition of rest and occupation periods for paddocks, which vary according to climate, soil fertility, botanical composition, and other factors influencing pasture response (MACHADO, 2010). The system’s central focus is the integrated management of the soil–plant–animal complex, seeking dynamic interactions

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among these components. All practices must be defined based on analyses of direct and indirect effects on this ecological balance, rejecting interventions that favor a single component to the detriment of the others.

In this regard, VRG proposes a rupture with the static concept of conventional management by adopting a dynamic and systemic view of pastures. While traditional models treat pastures as mere nutrient extractors, rational management demonstrates that, when appropriately conducted, pastures and grazing animals contribute to increased soil fertility through nutrient cycling and the biological activity of the biocenosis (MACHADO, 2010).

Understanding this continuous dynamic of transformation is the first step toward truly rational management. Well-managed pastures maintain themselves in constant renewal and productive equilibrium; conversely, degradation and the recurrent need for pasture renovation are direct consequences of a static and fragmented view of the system (MACHADO, 2010). Thus, Voisin Rational Grazing is consolidated as a scientific and agroecological approach capable of promoting sustainability, productivity, and environmental balance in livestock production systems.

3. Methodology

The present study was conducted in a rural area in the northwestern region of São Paulo State, characterized by gently undulating terrain and a humid tropical climate, with a predominance of pastures dedicated to beef and dairy cattle production. The objective of the study was to compare two pasture-management systems conventional management and Voisin Rational Grazing (VRG) with emphasis on dry matter production, botanical composition, and animal performance.

Two experimental areas with similar edaphic conditions and vegetative cover were selected to ensure uniformity in the comparative parameters. Each system was subdivided into five paddocks of equivalent size, ensuring equal total area between treatments and enabling consistent comparisons regarding productivity and management outcomes.

In the VRG system, the four principles established by André Voisin were rigorously applied:

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- Adequate rest period, ensuring full regrowth of the forage species;
- Controlled occupation period, preventing overgrazing;
- Law of maximum yields, which promotes the intake of forage with the highest nutritional value; and
- Law of regular yields, which limits the animals' stay in each paddock.

In the conventional system, animals remained under continuous grazing, with no control of stocking rate or pasture resting periods, thus reproducing traditional extensive management practices.

The experimental setup began with the demarcation of the areas and the construction of electric fences composed of two conductive wires, ensuring proper containment and handling of the animals. Water tanks connected to automatic drinkers were installed, with one unit allocated for every two paddocks to guarantee continuous access to clean and high-quality water.

In the area designated for conventional management, only land leveling and measurement procedures were carried out to ensure that the total area was equivalent to that of the VRG paddocks, allowing a direct comparison between the two management systems.

3.1 Data Collection

Dry Matter Production (DMP)

Dry matter production (DMP) was determined before and after grazing in each paddock. Forage samples were collected using a fixed 1 m^2 quadrat, randomly placed in representative points of each area. The harvested samples were first weighed to obtain fresh mass and then dried in a forced-air circulation oven at 65 °C until constant weight was achieved, following standard methodology, enabling the quantification of dry matter (kg/ha).

Botanical Composition

Botanical composition was assessed using the point-intercept method, which enabled the identification and quantification of the species present. The occurrences of grasses, legumes, and invasive plants were recorded, allowing the estimation of the relative proportion of each functional group in both management systems.

3.2 Animals and Stocking Rate

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Homogeneous animal groups were used, selected based on live weight, age, and physiological status to minimize individual variation. Stocking rate was adjusted according to the carrying capacity of each system, ensuring balance between forage availability and consumption.

In the conventional system, animals had continuous access to pastures, with no control over occupation time or plant recovery. In contrast, the Voisin Rational Grazing (VRG) system employed rotational grazing, strictly observing the resting and occupation periods recommended by the method to preserve regrowth vigor and the sustainability of the forage system.

3.3 Statistical Analysis

Data obtained for dry matter production (DMP) and botanical composition were subjected to statistical analysis. Analysis of variance (ANOVA) was used to compare the two management systems, considering a significance level of 5% ($p \leq 0.05$). Statistically significant differences between treatments were interpreted as evidence of actual management effects on the evaluated variables.

Sampling Procedures

Data collection was conducted systematically and uniformly throughout the experimental period for both Voisin Rational Grazing (VRG) and conventional systems, always respecting the operational particularities of each management modality. In each paddock, representative sampling points were established, carefully chosen to avoid areas near drinkers or locations with greater animal concentration and trampling, thereby ensuring homogeneous and precise sampling.

Dry matter production (DMP) was determined from forage samples collected before and after grazing. Samples were obtained using a 1 m^2 metal quadrat randomly positioned within each paddock. Plant material was cut at ground level, identified, weighed, and taken to the laboratory for further processing. Subsequently, samples were dried in a forced-air oven at 65 °C until constant weight, enabling calculation of average dry matter production per hectare (kg DM/ha) in each management system.

Botanical composition of the pastures was determined using the point-intercept method, which allowed the recording and quantification of forage species,

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legumes, and invasive plants. This approach enabled the assessment of plant diversity and the balance among floristic components of the pasture, providing essential information for interpreting conservation status, forage quality, and productivity of each experimental area.

4. Results and Discussion

The Voisin Rational Grazing (VRG) system exhibited a 31.7% increase in dry matter production compared with the conventional system. This result is attributed to the rational management of forage rest periods which favors the physiological recovery of plants as well as to the gradual improvement of soil fertility promoted by the balanced interaction among soil, plant, and animal components (Tables 1 and 2).

Table 1 – Dry Matter Production (DMP) in the two management systems

Management System	Mean DMP (kg DM/ha)	Variation (%) relative to Conventional
Conventional Grazing	5,200	—
Voisin Rational Grazing (VRG)	6,850	+31.7%

Table 2 – Botanical Composition of the Pastures

Forage Species / Plants	Conventional (%)	PRV (%)
Brachiaria brizantha	48	56
Panicum maximum	25	30
Leguminous plant (ex.: *Stylosanthes spp.*)	5	8
Invasive / Weedy Plants	22	6

The Voisin Rational Grazing system (PRV) exhibited greater floristic diversity and a more balanced functional composition between grasses and legumes, in addition to a marked reduction in the occurrence of invasive species (–16%). These findings demonstrate an improved conservation status and enhanced ecological stability of the pastures managed under this system (Table 3).

Table 3 – Average Daily Weight Gain (ADG) of the Animals

Management System	ADG (kg/animal/day)
Conventional Grazing	0,58
Voisin Rational Grazing (PRV)	0,78

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During the experimental period, a significant difference was observed between the two pasture management systems with respect to both dry matter production (DMP) and botanical composition. The Voisin Rational Grazing system (PRV) exhibited average DMP values approximately 25–30% higher than those of the conventional system. This increase is associated with the adequate rest period afforded to the forage plants, which enabled the restoration of leaf area index, increased photosynthetic efficiency, and consequent accumulation of plant biomass.

Additionally, the rational management adopted in the PRV prevented overgrazing, promoting the maintenance of forage species vigor and ensuring greater soil cover. In contrast, the conventional system showed a gradual reduction in canopy density, with an increase in exposed soil areas and proliferation of invasive plants such as Hypogynium sp. (razor grass) and Cyperus sp. (nutsedge), indicating early signs of pasture degradation. This condition results from continuous grazing and the absence of rest periods, factors that impair root development and reduce the regrowth capacity of desirable forage species.

Regarding botanical composition, the PRV system displayed a higher proportion of high-nutritional-value forage grasses, particularly Brachiaria brizantha and Panicum maximum, as well as a more balanced relationship between grasses and legumes. This functional plant diversity favored nutrient cycling and the progressive improvement of soil fertility, corroborating previous findings reported by Machado (2010) and Lenzi (2012).

In paddocks managed under the Voisin system, greater grazing uniformity was also observed, with animals exhibiting higher average daily gain and reduced foraging time, reflecting the greater availability and quality of forage. In the conventional system, however, animals showed increased selective grazing, forage waste, and soil compaction in areas of higher animal concentration, particularly near watering points.

From both visual and productive standpoints, the PRV system demonstrated greater resilience to water stress, remaining green and productive for longer following periods of mild drought. This characteristic is attributed to the improved physical structure of the soil and increased organic matter content resulting from the

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natural nutrient cycling promoted by rational grazing management.

Overall, the results confirm the initial hypothesis that the Voisin Rational Grazing system provides greater productivity, better soil conservation, and higher ecological and zootechnical sustainability when compared to the conventional grazing system.

5. Conclusion

The comparison between the pasture management systems revealed substantial differences in productivity, botanical composition, and ecological sustainability, confirming the superiority of the Voisin Rational Grazing (PRV) system over the conventional model. The PRV system proved more efficient in converting plant biomass into dry matter, showing an average increase of 31.7% compared to continuous grazing management. This performance is directly associated with the application of André Voisin's principles, which ensure the physiological rest of forage plants, control grazing duration, and maintain a dynamic balance among soil, plants, and animals.

The greater floristic diversity observed in PRV-managed areas, along with the significant reduction in invasive species, reflects not only improved pasture conservation but also the strengthening of soil biocenosis, with resulting increases in organic matter content and water-holding capacity. These factors contribute to the system's resilience during periods of climatic stress, enhancing production stability and the sustainability of the managed ecosystem.

From a zootechnical standpoint, rational grazing provided optimal conditions for the natural behavior of the animals, resulting in higher average daily gain and improved forage utilization. The uniform grazing pattern, reduced soil compaction, and absence of overgrazing reinforce the sustainable and efficient nature of the

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PRV system, which is grounded in the observation and respect of biological processes. This contrasts sharply with the conventional model, characterized by continuous exploitation and the progressive degradation of forage resources.

Thus, the Voisin Rational Grazing system is consolidated as a viable and scientifically grounded agroecological technology capable of integrating productivity, environmental conservation, and animal welfare into a single production model. Its adoption contributes not only to improving the technical and economic efficiency of livestock production but also to mitigating environmental impacts and restoring degraded pastures key challenges of modern livestock systems. Long-term studies on the effects of PRV across different biomes and edaphoclimatic conditions are therefore recommended to strengthen its applicability at the national scale and to reinforce the foundations of sustainable and self-sufficient livestock production in Brazil.

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