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BENEFITS OF CROP-LIVESTOCK INTEGRATION COMPARED TO TRADITIONAL AGRICULTURE AND LIVESTOCK: A DETAILED ANALYSIS

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Abstract: The evolution of the national agricultural scenario brought, in addition to positive aspects, also negative consequences from an economic and environmental point of view. Monoculture and inadequate cultural practices have caused loss of productivity, increased occurrence of pests and diseases, degradation of soil and natural resources. Integration systems between crops and livestock have the potential to increase grain and meat/milk productivity, in addition to reducing the risks of degradation. Results obtained with crop-livestock integration (ILP) demonstrate the benefits of this type of system on the physical, chemical and biological properties of the soil. Given this, the general objective was to analyze the benefits of implementing crop-livestock integration (ILP) on traditional livestock farms. Specifically, we sought to carry out a comparative analysis of yield between the conventional and ILP systems, in addition to analyzing the average daily gain index (ADG) and, finally, analyzing the area capacity and animal weight gain during the dry period. The results were carried out from a sample of 23,867 cattle in the ILP system and 17,628 cattle in the conventional system and showed that the remaining pasture left after the use of ILP generates soil cover for the plantation. There was also an improvement in rearing performance in ILP compared to the traditional system in Average Daily Gain (ADG) of around 267%, going from 0.180 kg ADG to 0.680 kg ADG.
Keywords: Crop-Livestock Integration; Beef cattle farming; Average Daily Gain; Agribusiness.

INTRODUCTION

The combined result of the operations that produce and distribute agricultural inputs is what is known as agribusiness. The theme was coined to encompass all processes including storage, processing, distribution and all elements that are part of the production chains of products of agricultural origin. From the concept of agribusiness arises the need to characterize how agricultural activities relate to industry, the so-called Agroindustrial Complex (CAI). This includes an intense division of labor, exchanges between sectors and substitution of exports, aiming to serve the market, in addition to an effective allocation of resources for the agricultural sector (MALAFAIA et al., 2021).

Figure 1 schematically presents the relationship between the sectors of a production chain for a product of agricultural origin.

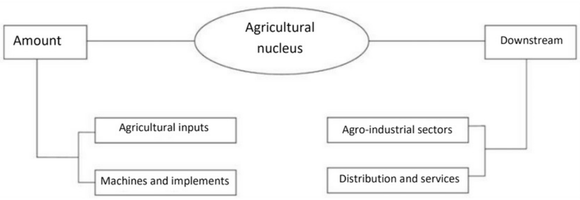

Figure1: Representation of a production chain of a product of agricultural origin.

Source: Malafaia et al., 2021.

Cordeiro et al. (2015) add that with the expansion of the agricultural frontier and the adoption of cultivation systems with soil preparation, the use of agrochemicals and irrigation, agricultural, livestock and forestry activities began to be carried out in an intensified, independent and dissociated manner. This model is predominant on rural properties; however, it is a system that presents weaknesses, due to the high demand for energy and natural resources.

On the other hand, the concern and interest in the sustainability of agriculture can be attributed to the questioning about the environmental situation in the 1950s and 1960s, despite there being ideas about sustainability in older reports. Furthermore, the sustainable management of agricultural ecosystems implies a tendency to increase net primary productivity per unit of input of external resources, together with improvements in soil quality.

Monoculture and inappropriate practices have caused loss of productivity and degradation of soil and natural resources. Reversing this situation can be achieved through technologies, minimum soil preparation, crop rotation practices, in addition to the so-called Crop-Livestock integration systems (ILP); (LOSS et al., 2011).

Several authors highlight that the crop-livestock system has the potential to increase productivity and reduce risks of degradation, by improving physical, chemical and biological properties and the productive potential of the soil. In general, pastures have the potential to maintain or even increase the organic matter content of the soil, as opposed to annual crops (SILVA et al., 2011).

Integration systems between crops and livestock have the potential to increase grain and meat/milk productivity, in addition to reducing the risks of degradation. Results obtained with crop-livestock integration demonstrate the benefits of this type of system on the physical, chemical and biological properties of the soil (VILELA, BARCELLOS and SOUSA, 2001).

Given the context presented, the following questions arise to guide the research: what are the benefits of implementing crop-livestock integration on traditional livestock farms? What is the Average Daily Gain (ADG) index between cattle in conventional and ILP systems? What is the difference between weight gain between cattle in conventional and ILP systems? It is highlighted thatthe ILP and Traditional groups are comparable in that they delimit the same livestock production area and production in @ (arrobas) per ha. Therefore, defining the productivity gain in @ for the same area and with the same climate variation, which in time brings us the security of equivalent scenarios.

To answer the central question of this research, the general objective of this work was to analyze the benefits of implementing crop-livestock integration (ILP) on traditional livestock farms.

Specifically, the present research aims to carry out a comparative analysis of performance between conventional and ILP systems; analyze the average daily gain index (ADG) and perform an analysis of area capacity and animal weight gain during the dry period.

THEORETICAL FRAMEWORK

THE CURRENT CHALLENGES OF FOOD PRODUCTION IN THE WORLD

The demographic increase in population presents several concerns and one of the main concerns is food supply. Approximately 805 million people in the world have a food deficit, that is, there is the possibility of not being able to meet the global demand for food, due to population growth (with a projected population of 9.5 billion inhabitants in the year 2050), added to other factors such as climate, economic and political changes, making the aforementioned discussion extremely important (DUARTE et al., 2018).

There are several challenges posed by humanity to agriculture, such as the production of food on a large scale, with quality, ensuring food security, production of energy, fiber, wood and other goods for humanity and also seeking to mitigate gases that cause of the greenhouse effect. Added to this is the need to meet these demands with minimal environmental disturbance. The complexity of the present scenario becomes even more evident with the inclusion of the social component, so that the challenge is to produce goods that humanity needs, reducing the environmental impact (BALBINOT JR. et al, 2009).

Furthermore, the global political agenda has been revised and has been directed in recent decades towards environmental issues, more specifically towards issues involving the impacts generated by anthropogenic activities on the environment and the consequences of this process on the economic, social and environmental sustainability of the world population (FERNANDES; FRINCO, 2014).

Duarte et al. (2018) add that the system based on monoculture has high rates of negative issues regarding factors such as greater soil degradation, decreased production, greater erosion and economic losses.

By knowing this entire context, the so-called Crop-Livestock Integration (ILP) system emerges as an alternative to contribute in a practical and sustainable way to the aforementioned challenges.

THE CROP-LIVESTOCK INTEGRATION SYSTEM AS AN ALTERNATIVE TO CONVENTIONAL PRODUCTION SYSTEMS

The first reports of the use of integrated systems occurred in parallel with the arrival of European immigrants in the mid-17th and 18th centuries, with good results in adaptability to the tropical and subtropical climate. Immigrants brought significant advances through the association of cultures, such as: use of rice reserves for animal grazing, soybean and corn crops as winter pastures, in addition to silvopastoral and agroforestry systems (DUARTE et al., 2018).

Specifically, Crop-Livestock Integration (ILP) consists of the union of two production systems, more specifically agriculture and livestock. These are production systems that encourage diversification, rotation, intercropping and succession of agricultural and livestock activities within the rural property in a planned manner, constituting a system, with benefits for both activities. One of its main advantages is that the soil is economically exploited throughout the year, favoring and facilitating an increase in the supply of grains, fibers, wood, wool, meat and milk at a relatively lower cost due to the synergism between farming and pasture. (ALVARENGA et al., 2007; CORDEIRO et al., 2015; DUARTE et al., 2018).

Balbinot Jr. et al. (2009) highlight that the ILP system presupposes the practice of five basic fundamentals, namely: correction of soil acidity and fertility, use of the direct planting system, crop rotation, use of improved animal and vegetable genotypes that present high yields. with desired qualitative and rusticity parameters and correct pasture management, especially with regard to fertilization and pasture height.

Martha Jr., Alves and Contini (2011) state that in ILP systems, improvements have been observed in the chemical, physical and biological attributes of the soil, mainly with regard to the effect of fertilization on crops, as well as the intensification of the use of the area agricultural with crops carried out throughout the year, based on crop rotation that allows the inclusion of species with different root systems, in addition to plant residues with different Carbon/Nitrogen ratios.

The use of ILP optimizes, through the correct techniques, the acceleration of soil recovery, in addition to greater availability of nutrients for plants. Furthermore, it helps control weeds, as soon as the cycle of invasive plants is broken through the management practices used in ILP (DUARTE et al., 2018).

Balbinot Jr. et al. (2009) highlight regarding the biological advantages that the ILP system can provide a high rate of nutrient cycling (grazing animals represent cycling accelerating agents, via feces and urine, with animals returning around 70 to 95% of nutrients to the soil). nutrients they ingest). It is worth highlighting the fact that the percentage of nutrients exported is higher in the case of animals destined for milk production, compared to animals destined for meat production. Regarding soil quality, the ILP system can increase organic carbon concentrations in the soil over time due to the continuous growth of plants in the area.

Regarding the benefits for animal production, it is noteworthy that farms that adopt crop-pasture rotation as an agricultural production strategy can benefit from better stability in forage production to feed the herd throughout the year. During the rainy season, pastures are more productive, due to the improvement in soil fertility by crops. During the dry period, in addition to the straw and harvest by-products, the newly established pastures remain green and with quality and quantity to confer weight gains rather than the weight loss that is common at this time of year on most farms. of the Cerrado (VILELA et al., 2011).

Environmental conservation is also another segment favored by the ILP, as in this system direct planting is easily made possible due to the initial conditioning of the soil and the greater supply of straw from the pasture through the mulch of the soil, reducing the silting of reservoirs and of water courses.

Besides, noteworthy is the reduction in the use of pesticides to control pests, diseases and invasive plants, so that the synergism between direct planting and pasture contributes to the sustainability of agricultural activity (ALVARENGA et al., 2007).

It is also noteworthy that the crop-livestock integration system (ILP) is a strategy commonly used in beef cattle farming, as internal and external trade is constantly growing, generating high demand for production systems, with the fact that the main source of food for beef cattle is pasture. If used correctly, ILP can contribute to soil recovery, in addition to greater and better production of forage mass, which will result in the formation of straw, providing greater protection to the soil, in addition to making nutrients available for the forage, bringing positive impacts for beef cattle farming, since one of the main problems faced nationally lies precisely in the degradation of pastures (SILVA, 2024).

ECONOMIC BENEFITS OF CROP-LIVESTOCK INTEGRATION

With regard to economic benefits, Cordeiro et al. (2015) highlight that the positive impacts of ILP involve increased productivity of crop and animal components in ILP systems and result from the interaction of several factors, which are often difficult to separate. The different ILP systems, in addition to contributing to a more efficient use of fertilizers, greater efficiency in the use of machines, equipment and labor, in addition to the diversification of production systems and breaking cycles of pests and diseases, contribute to an increase in system productivity. Furthermore, studies have observed increased pasture productivity in ILP, greater animal stocking, greater meat productivity per area and better pasture quality during the rainy season.

The reduced need to use certain inputs due to crop-livestock integration, such as fungicides, herbicides or insecticides, are characterized as short-term economic benefits, that is, they can be easily valued. The cost of this product and the mechanized operation necessary for its application must be debited from the production cost. Medium and long-term benefits of pastures for grain crops in ILP can also be estimated, however, in this case it is necessary to consider longer periods of time. In ILP, pastures benefit grain crops due to improved soil quality during the pasture phase (MARTHA JR. et al., 2006).

Martha Jr., Alves and Contini (2011) add that the potential benefits of the ILP system can result in lower costs for a given productivity or in increased productivity without a proportional increase in costs) or in the effects of risk reduction through diversification (the ILP can act to reduce business risk, through the diversification of agricultural activities on rural properties). From an economic perspective, it is necessary to identify these potential advantages of mixed systems, in addition to the ability to mitigate carbon in the atmosphere by increasing the organic matter content of the soil, greater efficiency in the use of inputs and the reduction of methane emissions by grazing animals can be transformed into economic gains.

The table 1 designed by Martha Jr. et al. (2011) presents an example of synergistic effects in ILP and their respective economic impacts, based on Sousa et al. (2007), Martha Jr. et al. (2010), Ricardo et al. (2010), Costa (2003) Martha Jr., Vilela and Sousa (2007). Please note that the economic impact estimate considered R$45.00 per bag of soybeans, R$70.00 per bag of beans, fungicide application cost of R$190.00 per hectare and R$850.00 Mg-1 of urea.

Benefit	**Agronomic effect**	**Economic impact (R$/ha)**
Efficiency in the use of fertilizers (Sousa et al., 2007)	Prevents the loss of 800 kg/ha of soybeans	600.00
Efficiency in the use of fertilizers (Martha Jr. et al., 2010)	Gain of 87 to 1,075 kg/ha of soybeans	65.00-785.00
White mold (Ricardo et al., 2010)	Prevents loss of 394 kg/ha of bean grains	460.00
White mold (Costa, 2003)	Reduction of fungicide applications	190.00-380.00
Residual effect of fertilizers (Martha Jr., Vilela and Sousa, 2007)	Equivalent to 360 kg/ha of Nitrogen (N) for pasture	680.00

Table 1: Examples of synergistic effects in ILP and respective economic impacts.

Source: Martha Jr. et al., 2011.

By knowing the scenario presented, it is clear that the attention given to integrated crop and livestock systems is justified by the observation of the agronomic, economic, environmental and social benefits of this integration. Decision-making in favor of specialized or mixed systems must vary according to the relative prices of products and inputs (MARTHA JR. et al., 2006; MARTHA JR. et al., 2011).

BEEF CATTLE FARMING IN BRAZIL

The Brazilian economy's pillars are the meat chain of poultry, pork, and more importantly, beef. Each of these sectors is responsible for developing activities that generate jobs, ranging from preparing animals to selling meat, contributing significantly to the country's economy. Particularly in relation to beef, Brazil stands out as one of the largest producers in the world, selling to more than 100 countries, through years of investment, implementation of technologies and improvements that were important in transforming cattle farming into one of the most important sectors of the Brazilian economy (COUTO; COQUEIRO; MARTINS, 2020).

The evolution of beef cattle farming in recent decades spans the different segments that participate in the production chain, enabling advances in production, with an increase in the effective herd, trade and market (NEVES et al., 2022).

Malafaia et al. (2021) highlight the importance of beef cattle farming in Brazil, stating that the Gross Domestic Product (GDP) of agribusiness had a share of 22.08% in the national GDP, in the last year of the period from 2005 to 2017, and in the sector, the largest share was given by the agro-services group, which had an average of 53.02% of the total agribusiness. The values found for cattle farming GDP show a share of 15.98%, also represented by agro-services.

Brazil stands out in the world production and trade of beef, as a result of efforts to increase animal weight gain, decrease mortality, increase birth rates and a significant decrease in the age at slaughter, with an improvement in beef enjoyment rates. herd, resulting in greater competitiveness and quality of the Brazilian product (NEVES et al., 2022).

The figure 2 highlights the evolution of the Brazilian cattle herd by state, between 2010 and 2021, with great emphasis on the states in the Center-South of the country.

According to information from the Brazilian Association of Meat Exporting Industries (ABIEC), it is estimated that the Brazilian herd in 2021 was 196.47 million heads, with a slaughter of 39.14 million heads. Of this total, 74.49% was destined for the domestic market, while 25.51% was sent to the foreign market. In 2021, the beef cattle sector represented 9.2% of agribusiness exports, with the main destinations being: China, the United States, Hong Kong and Chile, which together represented 68.18% of revenue, with a large highlighting the Chinese, who alone represented 42.40% of the aforementioned market (NEVES et al., 2022).

METHODOLOGY

The data was collected from the database of farms served by EXAGRO Consultoria, from which information was extracted from field surveys carried out by its consultants at their client farms with an average daily gain in kg (GMD), the production of arrobas per hectare, average stocking rate and percentage gain rate. The average stocking rate in AU/ha was also taken into consideration, where 1 Animal Unit (AU) represents 450 kg. These data compared with performance during the dry period in traditional pastures will determine the gain from crop-livestock integration (ILP).

A total of 64 farms were considered in the state of Mato Grosso do Sul, totaling 23,867 animals between the years 2018 and 2023 that used the crop-livestock integration system and 12 farms in the period between the years 2020 and 2023 totaling 17,628 heads in the traditional system. Input weight data was captured in the integration output of the integration, length of stay and capacity rate. Data from 12 farms were considered in the period between 2020 and 2023. The data presented consider rearing weight ranges in addition to the information necessary to calculate the average daily gain (ADG) and the daily percentage gain rate.

It is noteworthy that the acronym GMD refers to the average daily weight gain of the ox, an important indicator for breeding and fattening properties. It is a relevant indicator that aims to inform how many kilograms the cattle are gaining day after day. Using this indicator, it is possible to check the performance and profitability potential of a farm. Therefore, it is possible to understand whether the herd has low productivity, and in general, for it to be financially profitable, the ADG must be greater than 0.850 kg/day (VICENTE et al., 2021; FERTILI, 2024).

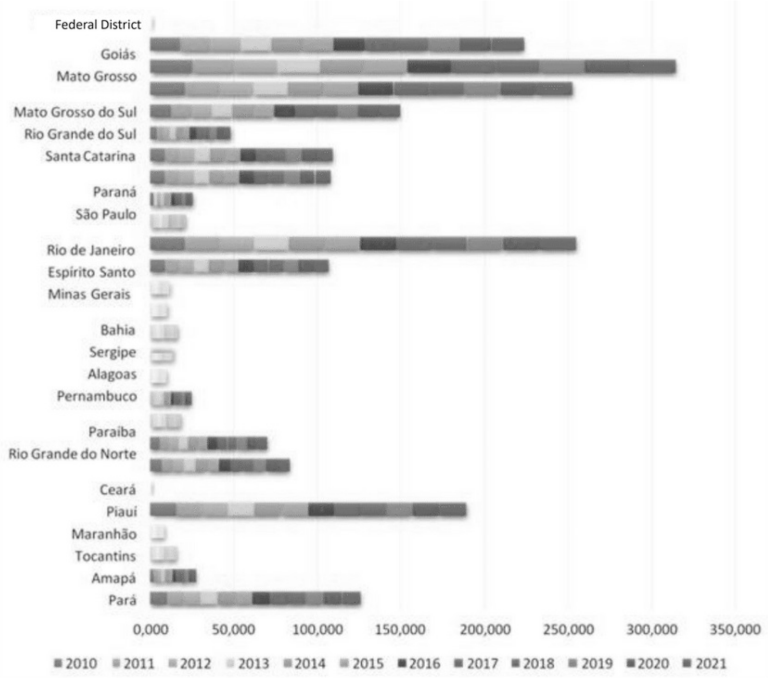

Figure 2: Evolution of the cattle herd in Brazil by state, between 2010 and 2021.

Source: Neves et al., 2022.

Based on these data, the Average Daily Gain (ADG) was verified and compared with data obtained from farms that work with continuous pasture, without crop-livestock integration.

The stocking rate is the relationship between the number of animals, or Animal Unit (AU), and the area occupied by them in a given period. In general, stocking rates in the country vary between 0.5 and 2 animals per hectare (AU/ha), with 1 AU being equivalent to cattle weighing 450 kg live weight (LW) (OLIVEIRA; MIOTO, 2023).

This index helps to define management and establish demand for food, aiming for good use of pastures by animals. The definition in Brazil that 1 AU is equivalent to 450 kg of live weight does not take into consideration, the animals' potential forage consumption. In 1974, the American Society of Range Management defined the animal unit as an adult non-lactating cow weighing 454 kg or its equivalent, with an average consumption of 12 kg DM of forage per day. The Crop Science Society of America defines the animal unit as a non-lactating bovine weighing 500 kg and fed at maintenance level, or for other animals, the equivalent in metabolic weight (AGUIAR; SANTOS; BALSALOBRE, 2006).

Equation 1 presents the way to calculate the GMD, where Pf represents the final weight, Pi indicates the initial weight and d provides the number of days.

$$GMD = \frac{P_f - P_i}{d}$$

Equation 1: Calculation of GMD.

The production of arrobas (@) per hectare (represented by $Prod^{ha}$) involves the use of the following terms: $Prod_{ha}$ indicates the Production of @ per hectare; Q gives the number of animals; P_{per} highlights the length of stay in number of days; GMD is the so-called average daily gain; A represents the area; 0.5 is the carcass yield, stipulated at 50% and 15 represents the equivalent of 1 arroba in kilograms. Equation 2 presents the way to carry out the aforementioned calculation.

$$Prod_{ha} = \frac{\left\{\left[\frac{Q * p_{per} * GMD}{A}\right] * 0,5\right\}}{15}$$

Equation 2: Production of arrobas (@) per hectare.

The average stocking rate considers the use of the Animal Unit (AU) by the number of hectares in the area. Equation 3 indicates how to calculate the average capacity rate.

$$Average\ occupancy\ rate = \frac{UA}{ha}$$

Equation 3: Calculation of the Average Capacity Rate.

The percentage gain rate involves the ratio between the GMD and the arithmetic mean between the final and initial weight. Equation 4 presents how to calculate the percentage gain rate.

$$Percentage\ win\ rate = \frac{GMD}{(Pf + Pi) * 1/2}$$

Equation 4: Calculation of Percentage Gain Rate.

The production of arroba per animal involves the following quantities: $Prod_a$= Production of @ per animal; P_{per} provides us with the stay in number of days; GMD is the average daily gain; A indicates the area; 0.5 indicates the carcass yield, stipulated at 50% and 15 indicates the equivalent of 1 arroba in kilograms.

Equation 5 indicates how the aforementioned items are related so that the production of arroba per animal can be calculated.

$$Prod_a = \frac{P_{per} * GMD * 0,5}{15}$$

Equation 5: Calculation of arroba production per animal.

RESULTS AND DISCUSSIONS

GENERAL DATABASE USING THE ILP SYSTEM

The general database for carrying out this work includes results referring to 23,867 animals in the ILP system. It is noteworthy that the average initial weight of the animals is 351 kg, while the average final weight is 428 kg, with an average length of stay of 112 days. The average area was 11,236.1 ha.

Table 1 presents the data collected, highlighting the fact that the "Source" column is related to the farms where the data was collected.

The table 2 prominently presents the data collected regarding the use of the fattening system, with emphasis on the number of animals (9,655), presenting an average initial weight (463 kg), an average final weight (540 kg), with average stay of 98 days in an average area of 5,577.7 hectares.

The table 3 highlights the data collected in the rearing system, with 14,212 animals, average initial weight of 274 kg, average final weight of 352 kg, with an average stay of 122 days in an average area of 5,658.4 hectares.

GENERAL DATABASE WITH CONVENTIONAL SYSTEM

The table 4 presents data referring to the 17,628 animals that were being raised in the conventional system. The average initial weight of 292 kg stands out, average final weight of 325 kg, with an average interval of 161 days and average weight gain of 33.2 kg. It is noteworthy that data collection was carried out between 2020 and 2023.

ADG RESULTS, ANIMALS PER HECTARE, ARROBAS PER ANIMAL, AVERAGE STOCKING RATE AND PERCENTAGE GAIN RATE

The table 5 presents a summary of the data collected for each system (ILP fattening, ILP rearing and conventional system), including general ILP data, with information on the number of animals, average initial weight, average final weight, average stay and the area. It is noteworthy that the average final weight of the ILP systems was higher than the traditional system

The table 6 highlights the averages for ADG, animals per hectare, production of arrobas per hectare, production of arrobas per animal, average stocking rate and percentage gain rate for the systems analyzed.

Comparing the rearing information in the traditional system and in the crop-livestock integration system, we can see that the average daily gain in the ILP is 0.68 kg and 0.18 kg in the traditional system, which denotes a performance increase of 267%. The gain rate in turn goes from 0.06% to 0.23% in the rearing system, a gain of 272%.

Even if it is considered that the performance is based on ADG, checking the supplementation with 50% protein feed and 25% energy protein feed, the average ADG will be 0.37 kilos, that is, even with the investment in ready-made or manufactured feed. On the farm itself, the gains from integration surpass the results obtained with feed and protein products.

PASTURE MANAGEMENT WITH AND WITHOUT ILP

Table 7 presents details of pasture management with ILP, taking into consideration, support, stocking and balance, all in UA/ha.

The figure 6 visually presents the behavior of the support and capacity regarding ILP management.

Source	Number of animals	Starting weight - kg	Final weight - kg	Stay - days	Area - ha
ARV	510	426	508	66	310
ARV	1,018	424	531	128	400
ARV	824	444	553	108	383
ARV	609	458	568	100	280
ARV	279	529	605	87	193
ARV	233	482	596	109	190
ARV	72	440	498	70	75
ARV	350	418	517	94	500
ARV	394	438	527	111	350
ARV	552	369	429	74	435
ARV	350	449	528	110	190
ARV	510	426	508	66	310
ARV	1,018	424	531	128	400
ARV	823	444	553	108	383
ARV	609	458	568	100	280
ARV	279	529	605	87	193
ARV	233	482	596	109	190
MV	401	210	281	138	208
MV	19	604	630	98	10
MV	287	343	478	149	149
MV	103	238	313	135	54
MV	88	535	572	50	46
MV	204	282	380	167	106
MV	96	400	488	155	50
MV	29	486	490	115	15
MV	113	484	531	100	59
MV	53	507	534	73	28
MV	10	527	564	55	5
MV	297	514	537	108	154
MV	893	318	411	134	464
A.K.	221	324	420	101	45
A.K.	150	401	489	107	45
A.K.	100	406	482	119	45
A.K.	100	406	482	119	45
A.K.	112	233	337	179	85
A.K.	130	233	337	179	85
A.K.	130	233	337	179	85
A.K.	160	182	270	155	60
A.K.	160	182	270	155	60
A.K.	210	182	270	155	45
A.K.	142	380	442	122	45
A.K.	97	406	446	121	45
LH	128	194	233	42	14
LH	180	224	265	44	14
LH	144	253	303	45	17
LH	88	282	337	44	15
LH	21	312	368	39	28
AS	704	239	288	98	409

AS	899	238	292	77	260
AS	1,522	262	299	86	477
JÁ	433	243	294	76	155
JA	441	386	436	77	275
JA	348	271	737	661	145
JA	921	241	308	114	398
JA	689	347	392	74	380
SL	542	231	268	135	165
SL	731	212	334	132	230
SL	387	195	265	132	122
SL	65	329	366	49	14
SL	96	301	333	63	38
SL	709	217	255	98	135
SL	525	231	294	101	316
SL	633	230	297	95	170
SL	693	371	432	75	360

Table 1: General database (ILP system)

Source: Prepared by the author, 2024.

Source	Number of animals	Starting weight - kg	Final weight - kg	Stay - days	Area - ha
ARV	510	426	508	66	310
ARV	1,018	424	531	128	400
ARV	824	444	553	108	383
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MV	287	343	478	149	149
MV	88	535	572	50	46
MV	96	400	488	155	50
MV	29	486	490	115	15
MV	113	484	531	100	59
MV	53	507	534	73	28
MV	10	527	564	55	5
MV	297	514	537	108	154

Table 2: General data: fattening system.

Source: Prepared by the author, 2024.

Source	Number of animals	Starting weight - kg	Final weight - kg	Stay - days	**Area - ha**
MV	401	210	281	138	208
MV	103	238	313	135	54
MV	204	282	380	167	106
MV	893	318	411	134	464
A.K.	221	324	420	101	45
A.K.	150	401	489	107	45
A.K.	100	406	482	119	45
A.K.	100	406	482	119	45
A.K.	112	233	337	179	85
A.K.	130	233	337	179	85
A.K.	130	233	337	179	85
A.K.	160	182	270	155	60
A.K.	160	182	270	155	60
A.K.	210	182	270	155	45
A.K.	142	380	442	122	45
A.K.	97	406	446	121	45
LH	128	194	233	42	14
LH	180	224	265	44	14
LH	144	253	303	45	17
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SL	96	301	333	63	38
SL	709	217	255	98	135
SL	525	231	294	101	316
SL	633	230	297	95	170
SL	693	371	432	75	360

Table 3: General data: rearing system.

Source: Prepared by the author, 2024.

Number of animals	Weight 1 (kg)	Weight 2 (kg)	Interval (days)	Weight Gain (Kg)
33	175	203	176	28
200	214	245	165	31
626	240	282	168	42
767	270	302	157	33
568	299	331	152	33
493	331	361	145	31
579	359	381	141	22
274	385	397	145	12
41	418	430	146	12
56	329	354	108	25.0
30	331	370	128	38.6
88	251	267	108	16.2
24	311	353	127	42.1
2	199	241	175	42
30	231	269	177	38
184	259	292	174	33
244	284	311	170	26
324	316	336	162	21
602	346	364	168	18
703	373	400	173	27
350	400	426	173	26
31	436	456	166	20
409	176	217	174	41
269	226	261	174	34
411	253	283	182	30
370	285	315	186	30
735	315	335	192	20
669	342	368	199	26
172	370	387	203	17
6	399	387	191	-12
35	639	584	155	-55
1237	186	216	167	30
739	224	269	185	45
683	254	303	197	49
504	283	335	207	52
255	313	355	182	42
221	345	374	151	29
57	368	388	144	20
3	400	398	157	-2
14	150	189	177	38
317	196	227	151	31
547	226	247	156	21
580	255	275	159	20
577	284	293	151	8
523	313	329	157	17
198	343	358	172	16
104	370	378	164	8
5	437	419	170	-18

203	251	306	158	54.8
51	211	285	186	74.1
27	211	285	184	73.5
18	301	355	169	54.0
91	255	318	175	63.0
33	372	480	182	107.7
34	282	327	162	45.0
38	290	362	194	71.9
50	273	375	209	102.5
101	303	355	170	52.2
10	255	358	171	102.6
39	249	310	195	60.7
20	323	425	173	102.1
34	347	476	193	128.4
27	243	376	209	132.8
84	314	388	162	74.3
42	341	411	180	70.3
53	335	390	181	54.5
53	329	381	168	52.6
44	347	426	177	78.8
43	368	458	198	89.8
29	357	416	173	59.5
34	377	456	160	79.7
35	353	416	160	63.0
35	334	430	161	96.9
34	378	442	200	64.1
50	361	416	165	55.4
53	352	405	168	53.4
20	360	462	151	102.3
22	371	465	151	94.0
25	349	444	151	94.8
1	319	355	126	36.0
31	373	439	133	66.0
14	378	460	165	82.0
20	365	436	139	71.6
37	395	440	125	44.8
24	370	408	135	38.6
35	286	333	131	47.5
47	380	418	131	38.1
48	348	417	172	69.4
50	363	391	125	28.4

Table 4: General data: conventional system.

Source: Prepared by the author, 2024.

	System	Number of animals	Starting weight - kg	Final weight - kg	Stay - days	Area - ha
ILP	General data	23,867	351	428	112	11,236.1
ILP	Data system fattening	9,655	463	540	98	5,577.7
ILP	System data recreates	14,212	274	352	122	5,658.4
Traditional	Data traditional drought system	17,628	292	325	161	n/a

Table 5: Summary of general data including all systems under analysis.

Source: Prepared by the author, 2024.

	System	GMD - kg	Animals/ ha	@/ animal production	@ total production	Production of @/ ha	@ total production	Tx. average capacity - AU/ha	Tx. of gain - %
ILP	General data	0.72	2.68	2.57	64,917.23	5.76	64,917	2.09	0.20%
ILP	Data system fattening	0.79	1.75	2.57	30,339.70	4.51	30,340	1.96	0.16%
ILP	System data recreates	0.68	3.31	2.58	34,577.53	6.89	34,578	2.18	0.23%
Traditional	Data traditional drought system	0.18	n/a	n/a		n/a		n/a	0.06%

Table 6: Main results for each type of system analyzed.

Source: Prepared by the author, 2024.

	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24	Jul-24	Aug-24	Sep-24	Oct-24	Nov-24	Dec-24	Average
Support	1.44	1.44	1.44	1.44	1.29	1.29	1.29	1.29	1.29	1.29	1.44	1.44	1.36
Balance	1.44	1.44	1.44	1.44	1.29	1.29	1.29	1.29	1.29	1.29	1.44	1.44	1.36

Table 7: Pasture management with ILP in UA/ha

Source: Prepared by the author, 2024.

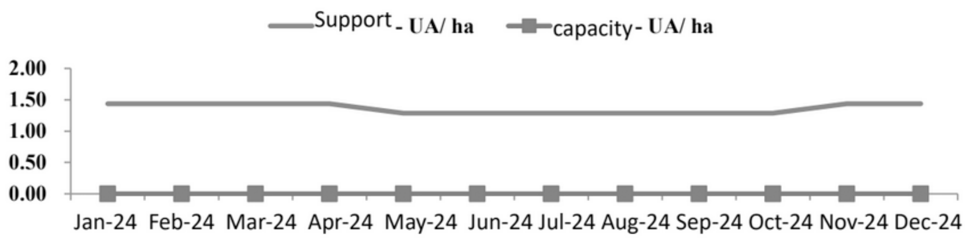

Figure 6: Support and capacity: management with ILP.

Source: Prepared by the author, 2024.

	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24	Jul-24	Aug-24	Sep-24	Oct-24	Nov-24	Dec-24	Average
Support - UA/ ha	1.44	1.44	1.44	1.44	0.87	0.87	0.87	0.87	0.87	0.87	1.44	1.44	1.16
Balance - UA/ ha	1.44	1.44	1.44	1.44	0.87	0.87	0.87	0.87	0.87	0.87	1.44	1.44	1.16

Table 8: Pasture management without ILP in UA/ha.

Source: Prepared by the author, 2024.

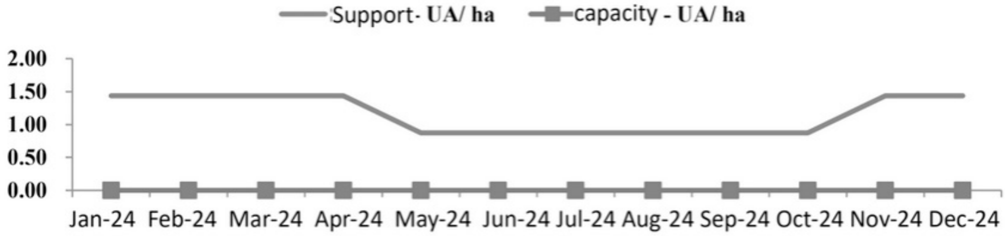

Figure 7: Support and capacity: management without ILP.

Source: Prepared by the author, 2024.

Table 8 details data relating to pasture management without ILP.

The figure 7 shows the behavior of the support and capacity regarding management without ILP.

It is worth noting that Figures 6 and 7 illustrate the behavior of both situations, making clear the advantage of the ILP system in relation to the conventional system, as the support values in UA/ha in ILP were practically constant throughout the analyzed period, while in the conventional system a sharp drop is seen between May and October.

FINAL CONSIDERATIONS

The main objective of this research was to analyze the benefits of implementing crop-livestock integration (ILP) on traditional livestock farms. To this end, it relied on analyzes involving data from farms served by EXAGRO Consultoria, from which information was extracted regarding the average daily gain in kg (ADG), the production of arrobas per hectare, average stocking rate and percentage gain rate. It is noteworthy that data were collected both in the ILP system (23,867 animals, with collection carried out between 2018 and 2023), and also from farms in the conventional system (17,628 animals, between 2020 and 2023).

It is noteworthy that the remaining pasture left after the use of ILP generates soil cover for the plantation, thus retaining soil moisture and microorganisms that favor the planting that begins. Furthermore, the movement of cattle in the ILP favors the expansion of the root system, leaving more organic matter for agriculture.

There was also an improvement in rearing performance in ILP compared to the traditional system in Average Daily Gain (ADG) of around 267%, going from 0.180 kg ADG to 0.680 kg ADG.

When the percentage gain rate is compared to the average weight of the animal, we have an improvement of 272%, going from 0.06% to 0.23%. Data on percentage gain during fattening were also compiled, which remained at 0.16%, demonstrating the importance of weight gain from the use of ILP during rearing, which generates positive impacts on the precocity and finishing of the animal.

The ADG of traditional pastures that used feed or protein supplementation in pasture was also compared. In this case the GMD was 0.370 kg while that of the ILP system was 0.680 kg GMD. An improvement of 83%, without considering production or feed acquisition costs. It is also noteworthy that farms with ILP have greater pasture stability throughout the year than traditional ones, comparing the same farm in both systems we have a 10% reduction in UA support per ha of water for drought, while in the traditional system the reduction in support is 39%.

It is important to highlight that the present work presents convergence in relation to the literature published on the topic. In the work published by Martha Jr., Alves and Contini

(2011), the authors sought to explore the economic perspective of ILP. The authors state that the potential economic benefits of the aforementioned system can be reflected in economies of scope, involve less variability and greater productivity. It was found in the research in question that in the conventional system studied, negative income was obtained. Evidence of economies of scope was found in the results presented. Another prominent factor refers to livestock farming costs. While in the conventional system the costs per arroba were R$93.05, in the ILP system the cost found was R$77.88 per arroba.

It is suggested for future research to monetize productivity gains in agriculture when we compare areas that use other crops in the off-season or winter harvest and those that use ILP, under the same soil and climatic conditions, that is, farms that plant in the summer and in winter they use ILP in part of the area, with crops such as corn, sorghum, beans, etc. in the other part. and farms that are related to the reduction in finishing time in confinement for early steers, compared to cattle of the same age and under the same conditions in the traditional system. It is also suggested for future studies, a comparison between conventional and ILP systems with regard to economic analysis using tools such as Net Present Value (NPV) and Internal Rate of Return (IRR).

REFERENCES

AGUIAR, A.S.; SANTOS, P.M.; BALSALOBRE, M.A.A. Métodos de cálculo de taxa de lotação em pastagens com suplementação. In: **43ª Reunião Anual da Sociedade Brasileira de Zootecnia**, 24-27 jul., João Pessoa, 2006.

ALVARENGA, R.C. et al. **Sistema de integração lavoura-pecuária: o modelo implantado na Embrapa Milho e Sorgo**. Circular Técnica n. 93, 2007. Disponível em: <https://www.embrapa.br/busca-de-publicacoes/-/publicacao/482993/sistema-de-integracao-lavoura-pecuaria-o-modelo-implantado-na-embrapa-milho-e-sorgo>. Acesso em: 19 fev. 2024.

BALBINO, L.C. et al. Evolução tecnológica e arranjos produtivos de sistemas de integração lavoura-pecuária-floresta no Brasil. **Pesq. Agropec. Bras**, v. 46, n. 10, p. 1-12, 2011.

BALBINOT JR. A.A. et al. Integração lavoura-pecuária: intensificação de uso de áreas agrícolas. **Ciência Rural**, v 39, n 6, p. 1925-1933, 2009.

CORDEIRO, L.A.M. et al. Integração Lavoura-Pecuária e Integração Lavoura-Pecuária-Floresta: estratégias para intensificação sustentável do uso do solo. **Cadernos de Ciência & Tecnologia**, v. 32, n. 1/2, p. 15-53, 2015.

COSTA, J.L.S. Influência da braquiária no manejo de doenças do feijoeiro com origem no solo. In: KLUTHCOUSKI, J.; STONE, J.L.; AIDAR, H. (Ed.) **Integração lavoura-pecuária**. Santo Antônio de Goiás: Embrapa Arroz e Feijão, 2003. p.523-538.

COUTO, L.A.; COQUEIRO, J.S.; MARTINS, N.C.G. Bem-estar animal na bovinocultura de corte: uma revisão sistemática. ***Profiscientia***, n. 14, p. 177-193, 2020.

DUARTE, P.M. et al. Integração Lavoura-Pecuária (ILP): uma revisão literária. **UNICIÊNCIAS**, v. 22, n. 2, p. 106-109, 2018.

FERNANDES, M.S.; FINCO, M.V.A. Sistemas de integração lavoura-pecuária e políticas de mudanças climáticas. **Pesq. Agropec. Trop.**, v. 44, n. 2, p. 182-190, 2014.

FERTILI. **Como alcançar o GMD ideal com estratégia**. Disponível em: <https://fertili.com.br/o-fim-do-prejuizo-alcance-o-gmd-ideal-comestrategia#:~:text=A%20sigla%20GMD%20significa%20Ganho,propriedade%20de%20recria%20e%20engorda>. Acesso em: 14 mar. 2023.

LOSS, A. et al. Agregação, carbono e nitrogênio em agregados do solo sob plantio direto com integração lavoura-pecuária. **Pesq. Agropec. Bras.**, v. 46, n. 10, p. 1269-1276, 2011.

MALAFAIA, G.C. et al. **A mensuração do produto interno bruto do complexo da bovinocultura de corte no Brasil**. Cadernos de Ciência & Tecnologia, v. 38, n. 2, p. 1-11, 2021.

MARTHA JÚNIOR, G.B.; VILELA, L.; SOUSA, D.M.G. de. Adubação nitrogenada. In: MARTHA JÚNIOR, G.B.; VILELA, L.; SOUSA, D.M.G. (Ed.). **Cerrado**: uso eficiente de corretivos e fertilizantes em cerrados. Planaltina: Embrapa Cerrados, 2007. p.117-144.

MARTHA, JÚNIOR, G.B.; VILELA, L.; SOUSA, D.M.G. de. Integração lavoura-pecuária. In: Simpósio sobre boas práticas para uso eficiente de fertilizantes, 2009, Piracicaba. **Boas práticas para uso eficiente de fertilizantes**. Piracicaba: IPNI, 2010b. v.3, p.1111-1131.

MARTHA JR. et al. Tecnologia integração lavoura-pecuária. ***Agroanalysis***, v. 26, n. 10, p. 45-46, 2006.

MARTHA JR., G.B.; ALVES, E.; CONTINI, E. Dimensão econômica de sistemas de integração lavoura-pecuária. **Pesq. Agropec. Bras.**, v. 46, n. 10, p. 1117-1126, 2011.

NEVES, G.V.S. et al. Bovinocultura de corte no Brasil: uma revisão sistemática da literatura. **Revista Ibero-Americana de Ciências Ambientais**, v. 13, n. 6, p. 277-293, 2022.

OLIVEIRA, A.P.; MIOTO, M. **Carta Boi – Taxa de lotação de pastagens com bovinos no Brasil**, 2023. Disponível em: <https://www.scotconsultoria.com.br/noticias/cartas/56595/#:~:text=A%20taxa%20de%20lota%C3%A7%C3%A3o%20%C3%A9,de%20peso%20vivo%20(PV)>. Acesso em: 14 mar. 2024.

RICARDO, T.R. et al. Custos associados ao mofo branco (*Sclerotinia esclerotiorum*) em feijoeiro comum de 3a safra em Goiás. In: Congresso da Sociedade Brasileira de Economia, Administração e Sociologia Rural, 2009. **Anais**. Porto Alegre: SOBER, 2010.

SILVA, M. **Sistema integração lavoura-pecuária (ILP)**: como implementar e os benefícios. Disponível em: <https://rehagro.com.br/blog/sistema-integracao-lavoura-pecuaria/>. Acesso em: 09 mar. 2024.

SILVA, R.F. et al. Análise conjunta de atributos físicos e biológicos do solo sob sistema de integração lavoura-pecuária. **Pesq. Agropec. Bra**s., v. 46, n. 10, p. 1277-1283, 2011.

SOUSA, D.M.G. de; MARTHA JÚNIOR, G.B.; VILELA, L. Adubação fosfatada. In: MARTHA JÚNIOR, G.B.; VILELA, L.; SOUSA, D.M.G. (Ed.). **Cerrado**: uso eficiente de corretivos e fertilizantes em cerrados. Planaltina: Embrapa Cerrados, 2007. p.145-177.

VICENTE, A. et al. Efeito do genótipo da miostatina nas características produtivas de bovinos de raça Preta. **Revista da UI_IP Santarém**, v. 9, n. 3, p. 33-48, 2021.

VILELA, L. et al. Integração lavoura-pecuária. **Savanas**: desafios e estratégias para o equilíbrio entre sociedade, agronegócio e recursos naturais. Planaltina: Embrapa Cerrados, v. 1, p. 933-962, 2008.

VILELA, L. et al. Sistemas de integração lavoura-pecuária na região do Cerrado. **Pesq. Agropec. Bras.**, v. 46, n. 10, p. 1127-1138, 2011.

VILELA, L.; BARCELLOS, A.O.; SOUSA, D.M.G. **Benefícios da integração entre lavoura e pecuária**, 2001. Disponível em: infoteca.cnptia.embrapa.br/bitstream/doc/567050/1/doc42. Acesso em: 08 mar. 2024.