Viabilidade econômica de Sistemas Integrados de Produção Agropecuáriacom consórcios na fase pastagem no Mato Grosso, Brasil

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Sandra Maria Monteiro de Araújo Souza
Doutoranda em Agronomia (Produção Vegetal) – Universidade Federal do Paraná (UFPR)
Instituição: Universidade Federal do Paraná (UFPR)
Endereço: Rua XV de Novembro, 1299 - Centro, Curitiba - PR, 80060-000
E-mail: **sandramonteiroaraujosouza@outlook.com**

Aguinaldo Rocha Gomes
Doutor em Meio Ambiente e Desenvolvimento Regional – Universidade Anhanguera-UniderpDoutor em Contabilidade - Universidad Nacional de Rosario (UNR)
Instituição: Universidade Federal de Rondonópolis (UFR)
Endereço: Av. dos Estudantes, 5055 - Cidade Universitária, Rondonópolis/MT – 78736-900,Brasil
E-mail: **aguinaldogomes@ufmt.br**

Omar Jorge Sabbag
Doutor em Geografia (Planejamento ambiental e Gestão) Universidade Estadual Paulista (Unesp)
Instituição: Universidade Estadual Paulista (Unesp)
Endereço: Av. Brasil Centro, 56, Ilha Solteira/SP – 15.385-000, BrasilE-mail: **omar.sabbag@unesp.br**

Leandro Pereira Pacheco
Doutor em Agronomia (Produção Vegetal) – Universidade Federal de Goiás (UFG)Instituição: Universidade Federal de Rondonópolis (UFR)
Endereço: Av. dos Estudantes, 5055 - Cidade Universitária, Rondonópolis/MT – 78736-900,Brasil
E-mail: **leandroppacheco@gmail.com**

Flávio de Jesus Wruck
Mestre em Fitotecnia – Universidade Federal de Viçosa (UFV)
Instituição: Embrapa Arroz e Feijão
Endereço: Km 12 - Zona Rural, GO-462, Santo Antônio de Goiás/GO, 75375-000E-mail: **flavio.wruck@embrapa.br**

Gustavo Wingert
Mestre em Gestão e Tecnologia Ambiental – Universidade Federal de Rondonópolis (UFR)
Instituição: Universidade Federal de Rondonópolis (UFR)
Endereço: Av. dos Estudantes, 5055 - Cidade Universitária, Rondonópolis/MT – 78736-900,Brasil
E-mail: **gustavo_wingert@hotmail.com**

Luís Otávio Bau Macedo

Doutor em Economia Aplicada – Escola Superior de Agricultura Luiz de Queiroz (ESALQ)
Instituição: Universidade Federal de Rondonópolis (UFR)
Endereço: Av. dos Estudantes, 5055 - Cidade Universitária, Rondonópolis/MT – 78736-900,Brasil
E-mail: **luis.otavio@ufr.edu.br**

Laércio Santos Silva
Doutor em Ciência do Solo – FCAV-Unesp/Jaboticabal
Instituição: Universidade Federal de Rondonópolis (UFR)
Endereço: Av. dos Estudantes, 5055 – Cidade Universitária, Rondonópolis/MT – 78736-900,Brasil
E-mail: **laerciosantos18@gmail.com**

Edicarlos Damacena de Souza
Doutor em Ciência do Solo – Universidade Federal do Rio Grande do Sul
Instituição: Universidade Federal de Rondonópolis (UFR)
Endereço: Av. dos Estudantes, 5055 - Cidade Universitária, Rondonópolis/MT – 78736-900,Brasil
E-mail: **edicarlos@ufr.edu.br**

Resumo

As particularidades dos Sistemas Integrados de Produção Agropecuária (SIPA) influenciam os custos de implantação e rentabilidade de produção. No entanto, poucas são as abordagens científicas que buscam elucidar o custo total dos SIPA para auxiliar na tomada de decisão quanto à modalidade mais adequada a ser instalada. O propósito com o estudo foi propor a aplicação do método de custeio adequado aos SIPA para uma avaliação integrada de viabilidade econômico-financeiro dos SIPA com pastos solteiros e consorciados sob plantio direto no Mato Grosso. Entre 2015 e 2017, quatro modalidades de SIPA na fase pastagem foram avaliados quanto à viabilidade econômica. Com base no fluxo de caixa foram calculados os indicadores de viabilidade econômica: Valor Presente Líquido (VPL), Índice Benefício/Custo (IBC) e Taxa Interna de Retorno (TIR). O método de custeio por absorção permitiu uma avaliação abrangente dos custos de produção dos SIPA, e por meio do critério de rateio, os custos indiretos foram integrados a todas as atividades produtivas. Os SIPA apresentam níveis diferentes de rentabilidade, dependendo da gramínea e do consórcio utilizado. Os resultados globais líquidos nas safras 15/16 e 16/17, variaram de R$ 701,81 a 1.889,01 nos pastos solteiros e de 1.435,86 a 2.129,39 nos pastos consorciados. Os sistemas apresentaram capacidade de remunerar os investimentos, principalmente quando utilizada a gramínea Piatã ou o consórcio entre gramíneas e leguminosas com melhores indicadores econômicos.

Palavras-chave: Cerrado. Credito Agricultural. SIPA.

1. Introduction

In the Brazilian Cerrado region, the type of integrated agricultural production systems (IAPS) most widespread among properties as those that integrate crops in the harvest and the single pasture in the off-season (MARTHA JÚNIOR et al., 2011). However, there is the possibility of improvements in pasture and soil quality with the insertion of consortia during the pasture phase, with a consequent increase in animal and grain production in succession (LAROCA et al., 2018; MORAES et al., 2019; PIRES et al., 2020). The adoption of production systems that use grass-legume intercropping has resulted in an increase in the efficiency of soil biological and nutrient cycling (LAROCA et al., 2018; FRANCO et al., 2020), considered important systems for carbon dynamics and nitrogen supply to agricultural soils, thus reducing the need for additional nitrogen applications to the soil.

High production costs and market competitiveness require the adoption of production systems that aim to increase production, quality, profitability and that are environmentally sustainable. In this regard, studies have proven the benefits of IAPS, such as reducing costs and increasing productivity (GARCIA et al., 2012; CORDEIRO et al., 2015). One of the main advantages being the occupation of the soil throughout the year or large part of it, which according to Silva et al. (2015) favors the supply of grains and meat at a reduced cost. According to Moraes et al. (2002), these are complementary activities that add up, because when integrated, they act in synergism providing gains in crops and livestock production, plus better economic and environmental results.

There are several economic advantages obtained with the use of IAPS, such as income diversification, resulting from plant and animal production in the same area (Fontaneli et al., 2000), the reduction of risks of economic failure (AMBROSI et al., 2001) and the increase in income in relation to non-integrated systems (FONTANELLI et al., 2000). Studies by Martha Júnior et al. (2011), Oliveira et al. (2013) and Ferraza et al. (2016) have attested greater advantages with the use of LPIS in relation to non-consortium production systems. Although scientific reports point to the technical advantages of using IAPS in Brazil (MARTHA JÚNIOR et al., 2011; OLIVEIRA et al., 2013; FERRAZA et al., 2016), little is known about the economic benefits and risks in conducting IAPS, mainly during the pasture phase.

Another opportune question raised by Reis et al. (2017), is the use of diverse methodologies in studies that evaluate the IAPS. According to these authors, the ability to evaluate the results and explain the real trajectory of the economic results from IAPS is a limiting factor, since the components of the system are treated in isolation. Thus, there is a need for economic and financial assessments of IAPS to fully address the components involved in the system and their different interactions. New technologies demand innovative administration, management and evaluation practices that maximize the use of these results.

In this way, cost accounting makes it possible to measure production costs, and subsequently show where the wastage and opportunities for increasing productivity are concentrated (MARION; RIBEIRO, 2018). Therefore, it is necessary to define a costing method that meets the demands of IAPS. With respect to this, Balbinot Jr. et al. (2009) emphasizes the need to use methods that are in sync with the other areas of the study, taking into account the methodology of economic evaluations, it is necessary to measure the profitability of each system, according to the productive configurations adopted.

The Absorption Costing method consists of appropriating all the production costs to manufactured goods, in which expenses related to production are distributed to all products or services (MARTINS, 2018). This method allows an appropriate measurement of costs, both in crop and livestock production, and generates more consistent economic and financial indicators.

Thus, this study was developed with the objective of proposing the application of an appropriate costing method to the IAPS, for an integrated evaluation of the economic-financial viability of IAPS with single and intercropped pastures under no-tillage in Mato Grosso.

2. Theoretical Framework

2.1. The concept of integrated agricultural production systems starts with this.

The practice of integrating agricultural activities forming systems in rural properties is ancient. According to Dupraz and Liagre (2011), in the 1st century CE (Common Era) this practice was already carried out in ancient Rome. However, significant changes have occurred in the food production process over time, influenced by dynamic interactions between improved technologies and the growth of the human population (Gomes and Pamplona, 2014). With the growing demand for food, energy and raw materials, a more efficient and dynamic posture was required from agriculture in order to meet such demands (SAIBRO, 2001).

IAPS is defined as an association between agricultural crops, pasture and livestock at the same location, concomitantly or sequentially, in which the synergism between these components results in economic and environmental gains (CARVALHO et al., 2018; MORAES et al., 2019). Anchored in the conservationist principle, normally this agricultural production technology is combined with the no-till technique (NT or IAPS-NT). Among the various possibilities to implement IAPS, such as legume/pasture/forest/animal, Pires et al. (2020) proposed the intercropping of grasses and legumes during the IAPS pasture phase, which consists of intercropping pasture cultivation in the off-season in succession to soybeans. Recent scientific publications have reported significant improvements in soybean productivity, animal weight gains (Laroca et al., 2018) and in the soil biogeochemical cycle (FRANCO et al., 2020; PIRES et al., 2021).

The ecosystem services provided by IAPS, compared to other production methods, come from the synergistic interactions between the components of the soil-plant-animal system. Among the benefits, we can mention the recovery of soil fertility due to decomposition and mineralization of organic residues and the availability of nutrients (PROBER et al., 2015), increased animal weight gains without harming the physical quality of the soil (VILELA et al., 2011), root symbiosis (MORAES et al., 2019; PIRES et al., 2021) and favorable conditions for soil microbiological activity (LAROCA et al., 2018; FONTES et al., 2020). Another relevant point is the reduction of risks to agricultural companies, by diversifying or rotating production activities, making the systems less sensitive to fluctuations in sales prices and input costs (VERMERSCH, 2007; WILKINS, 2008).

In all regions of Brazil, IAPS are implemented in small, medium and large properties, consisting of animal, annual and tree crops under different arrangements and meeting the producer´s needs (CARVALHO et al., 2006; SILVA et al., 2011). However, it should be considered that the introduction of any changes into the production system influences investment and production costs (FRANZLUEBBERS, 2007). However, there is a lack of studies focusing on the evaluation of the cost of implementation and maintenance, and the different economic results from each IAPS, which is essential information to better direct the most profitable modality of IAPS in the different edaphoclimatic conditions of the country.

2.2. Costing methods and absorption costing

Economic globalization, fierce competition (DIAS; PADOVEZE, 2007), advances in information technology, the increase in the distance between owners and managers are some of the contributing factors why cost accounting has developed and gained greater relevance (MARTINS; ROCHA, 2015) in the management of business dynamics. In the rural context, the need for cost control/management and the use of management tools has become essential to ensure the survival of rural properties (DUMER et al., 2013; BALZAN; DALL'AGNOL, 2017). However, such circumstances allow cost information to be manifested from three perspectives: *Corporate Accounting, Tax Accounting, Managerial Accounting and Controllership*. Each one seeks to meet specific objectives, identify events where decisions are needed that can be subsidized with cost information, such as economic viability assessment (MARTINS; ROCHA, 2015). Each method has its particularity, therefore, it is necessary to define the costing method that best fits the technical objective (MARTINS; ROCHA, 2015). The most appropriate method is the one that allows the formation of the selling price more accurately, subsidizes strategic and planning decisions, according to the company's activity (IZIDORO, 2016; SILVA et al., 2019). In this way, it is possible to consider which cost elements should or should not be measured, considering the nature and behavior of those elements in relation to the production volume, that is, fixed or variable costs. In this sense, the following methods are available: *variable costing, absorption costing and activity-based ABC costing* (MARTINS; ROCHA, 2015).

The option to use a certain costing method defines the nature of the economic resources that must be computed when calculating the cost value of the products, one method is different from the other in terms of considering the cost of the product as opposed to what will be treated as *charges over the period* (MARTINS; ROCHA, 2015). Therefore, the cost that is not part of the determination of the unit cost of products and services must be entered directly in the income statement as an expense for the period (PADOVEZE, 2014). In terms of demonstrating profitability by product, the first will be compared with the price or revenue to determine the margin, the second will be deducted from the profitability margin (MARTINS; ROCHA, 2015).

The variable costing method considers its variable costs to be exclusive to the product. All fixed costs, including those identifiable with the products, that is, direct fixed costs, are charged to income for the period in which they are incurred (MARTINS; ROCHA, 2015). For Ribeiro et al. (2018), the variable costing method in the decision-making process is the most recommended, although it is not legally accepted because it violates the fundamental principles of accounting, in particular, revenue, the competence regime and the confrontation. However, this does not prevent companies from using it for internal management purposes. The variable costing method is indicated in cost analysis for short-term decisions, however it can underestimate fixed costs linked to production capacity and long-term planning, which may lead to continuity problems for the company (PADOVEZE, 2014).

In contrast, the absorption costing method consists of assigning production costs directly or indirectly (apportionment) to products manufactured, purchased or services provided (MEGLIORINI, 2012; MARTINS, 2018). This method offers some advantages as it is in accordance with the Fundamental Principles of Accounting and Tax Law (LEONE, 2000; PADOVEZE, 2014). The absorption costing method identifies the payments related to the production effort distributed for all products or services performed (RAUP; SOUZA, 2013; SCANFERLA et al., 2017). Accepted by financial accounting, it is suitable for Balance Sheet and Income Statement purposes, as well as for Balance Sheet and Tax Income in several countries (MARTINS, 2018). Its adoption is not expensive, as there is no need to segregate manufacturing costs into fixed and variable (BISNETO, 2015).

Leone (2000) also highlights the need to obtain long-term solutions, in which, absorption costing information is normally indicated. This allows optimizing the use of resources, absorbing all production costs and allowing the calculation of the total cost of each product, making it less costly for the company (PADOVEZE, 2014; LIMA, 2014). However, the disadvantages of this method focus on its apportionment criterion, in which costs may not be directly related between products, units or departments, almost always resulting in a degree of arbitrariness (LIMA, 2014; ROCHA; PELOGIO, 2016). “In this case, even expenses not directly related to the product are apportioned according to previously established indices” (WOILER; MATHIAS, 2018).

With the aim of reducing the distortions incurred in the way in which many companies were allocating their indirect costs, Activity Based Costing also known as ABC appears. This method aims to improve the allocation of fixed costs and overheads to products (FONTOURA, 2013) and seeks accuracy in the allocation of costs to entities subject to funding, mainly to products (MARTINS; ROCHA, 2015).

As with any costing method, there are advantages and disadvantages to be considered. In the case of activity-based costing, the following advantages can be listed: more realistic information generation, less need for arbitrary apportionments, it is in accordance with fundamental accounting principles, it requires the implementation, permanence and review of internal controls. However, its high implementation cost; difficulty in extracting information; difficulty in integrating information between departments are some of the disadvantages, reported by Rocha and Pelogio (2016).

However, relating the advantages and disadvantages of the variable costing methods, absorption costing and activity costing were the objective of this study, in IAPS, it is clear that the disadvantages presented by variable costing and activity costing methods outweigh the benefits that their implementation can bring. Martha Junior et al. (2011) raise the discussion about the comparison between IAPS and specialized systems (monoculture) and suggested that it is necessary to seek to quantify the potential advantages of the mixed systems reported in their study. However, this measurement will only be really effective when the methodologies used to quantify IAPS are analyzed and understood in an integrated manner.

In IAPS, the introduction of plants and animals promotes income and benefits from the residues left in the soil, therefore, the entry of non-commercialized cultivars into the system, whose function is soil recovery and coverage, serves to reduce the entry of costs and generate higher incomes (VOLSI et al., 2021). Therefore, economic analyzes are necessary that reflect the existing synergism within the IAPS, since the productive stability caused by the diversification of activities alters the variable and fixed costs, directly or indirectly. In short, the advantages offered by the absorption costing method make it possible to analyze IAPS synergistically while assessing their economic viability.

2.3. Economic-financial feasibility analysis

Accounting assists management by generating information useful for planning and control in decision-making, especially in matters related to cost control, comparison of results and diversification of cultures (CREPALDI, 2019). Thus, it is essential to understand the factors that are useful in economic and financial feasibility analyses. Therefore, it is necessary to understand the cost formation, the origin of the revenues and the costing method used in the elaboration of the statements.

For economic-financial feasibility analysis, it is essential to know the total cost. According to Crepaldi (2019), the total cost is calculated by the sum of the total fixed cost and the total variable cost and their respective opportunity costs. The gross, or total, income from a rural activity is made up of the amount generated from product sales originating from activities operated by the seller himself. From the information obtained from costs and revenues, the company must present all items recognized in the statements covering the respective period, such as the income statement for the period (CREPALDI, 2019). Therefore, the total net income is obtained through total revenue minus total cost. Once this information is obtained, the agricultural producer will have data to carry out the economic-financial analysis of his company.

In this regard, Gitman and Madura (2003) are emphatic regarding the positioning of the statements used for economic-financial analysis, emphasizing that the financial statements of the annual income (AIS) use the same accrual basis, recognizing revenue or expenses at the time of sale or purchase, whether payment or receipt has been made or not. As for the cash flow statement (CFS), a cash basis is used, reconsidering revenues and expenses only upon payment or receipt, only gross and non-net changes in fixed assets appear in the CFS, avoiding double counting account, such as depreciation.

Assaf Neto (2012) stated that the techniques most used in these analyzes are based on the calculation of economic-financial indicators that are extracted from the financial statements produced by the companies. Therefore, it is essential to have knowledge about the reliability of each statement to have confidence in the analysis. These financial indicators are established as an instrument to support the decision-making process, since they enable analysis of the economic-financial data (JAHARA; MELLO; AFONSO, 2016). On the other hand, profitability indicators, when grouped, allow analysts to evaluate the company's profit in relation to the level of sales, assets or investments of the owners (GITMAN; ZUTER, 2017).

In this way, the organization has the ability to obtain real returns on its own capital, that is, it demonstrates certain parameters that can represent its real dimension, using an analysis in the absolute value of net income (ASSAF NETO, 2012). It is essential to apply the feasibility analysis, as it provides an assessment of whether there will be a return on the invested capital and whether the investment conditions are favorable (GRECA et al. 2014).

Defining the best approach is quite complex. For Gitman and Zutter (2017), it is difficult to choose one approach over another, as the theoretical and practical strengths of each approach are different. For the Net Present Value (NPV) and the Internal Rate of Return (IRR), from a theoretical and practical point of view, an evaluation using these techniques together is indicated. For Souza and Clemente (2008), the NPV method is the best known and most used robust investment analysis technique. It is an investment valuation procedure that compares, on the zero date of the cash flow, the present value of returns calculated with the Minimum Attractiveness Rate of Return (MARR). This interest rate represents the actual or opportunity cost of financing the company and is the minimum return that the project must generate to satisfy investors.

However, the IRR is the rate that directly comparable to the NPV, considering a certain projection horizon, to the value of the investment made (GITMAN; ZUTER, 2017), and can be used to analyze the return and risk dimension. As a measure of return, it is possible to consider that when the IRR > TMA, it is observed that there is a greater return investing in the project than in the TMA. When used as a risk measure, it is considered that the project risk increases according to the proximity between the IRR and the TMA (SOUZA; CLEMENTE 2008). Making a decision based only on NPV indicators can be quite risky (FERREIRA, 2004). A project may present a higher NPV than another, considering the same time horizon or not. However, the financial amount invested in one project may have been lower than the other, in order to obtain the same gain at the end.

According to Souza and Clemente (2008), it is important to evaluate the NPV with the help of other indicators, such as, the benefit/cost index (BCI). The combination of such parameters makes it possible to make a more precise decision regarding the return on the investment rate. In Iowa, USA, Poffenbarger et al. (2017) used the indicators gross revenue, total cost of activity and profit, in order to economically assess the opportunity cost of land and labor in IAPS. Martha Junior et al. (2011) mention that “the accurate measurement of the interactions between the crop and animal (pasture) components is a key step to be pursued”. Therefore, the joint evaluation of these indicators allows for more assertive analysis and decision-making, from different perspectives.

3. Methodological Procedures

3.1. Study area

The experiment used as the basis for the economic-financial evaluation was located at Gravataí Farm (54°51'15.51” W, 17°9'36.91” S), in the municipality of Itiquira/MT, with a dystrophic Red Latosol with a clayey texture (SANTOS et al., 2018). According to Koppen, the climate of the region is classified as Aw, with a rainy period between the months of October and April and the dry period between the months of May and September. The average precipitation in the region is 1500 mm with greater intensity between the months of December and February.

3.2. Characteristics of the experiment

The long-term experiment began in October 2014 with soybeans (TMG 1174 RR) sown at 17 plants per meter and 45 cm spacing between rows. The fertilization was performed annually for crop planting at 50 kg ha^{-1} of monoammonium phosphate, 120 kg ha^{-1} of potassium chloride and 290 kg ha^{-1} simple superphosphate. For management desiccation, glyphosate herbicide, divided into two sequential applications was used. The other cultural treatments were those recommended for the crop in the region. The soybean harvest took place 110 days after sowing in the 2015/2016 and 2016/2017 harvests, harvesting the entire plot using a self-propelled harvester. To obtain productivity, grain moisture was corrected to 13%.

For the economic-financial evaluation, four modalities of Integrated Agricultural Production Systems (IAPS) were studied and presented as follows:

- IAPS1: Soybean + Cattle (Ruziziensis);
- IAPS 2: Soybean + Cattle (Piatã);
- IAPS 3: Soybean + Cattle (Ruziziensis + Cowpea Bean);
- IAPS 4: Soybean + Cattle (Piatã + Cowpea Bean).

The experimental design was randomized blocks in a split-plot scheme with three replications, each plot with an area of 3.5 ha. Data from the 15/16 and 16/17 seasons, obtained between September 2015 and August 2017, were used. The plots were represented by the grasses *Urochloa ruziziensis* and *U. brizantha* cv. BRS Piatã. The subplots were represented by intercrops using the leguminous cowpea (*Vigna unguiculata*) cv. BRS Tumucumaque and single grasses. After the soybean harvest, the grasses were scatter sown and intercropped with the legumes, using a precision seeder with a spacing of 45 cm. The amount of grass seeds was 4 kg ha^{-1} of pure viable seeds and 21 kg ha^{-1} of legume seeds. For this phase there was no fertilization of the pastures.

The history of the experiment area, integrating agricultural and livestock activities over the two-year evaluation period, is shown in Figure 1. The grazing method used was continuous, with a variable stocking rate depending on the treatments, with stocking adjustments carried out according to the available forage mass. The animals entered the area each year when the grasses reached a height of approximately 60 cm. The animals used were Nellore females weighing between 210 and 260 kg. The animals were weighed at the end of the grazing cycle to calculate animal production per area. Grazing occurred until the end of

August. Subsequently, the pasture was rested until the end of September and desiccated before starting the new production cycle, with soybean sowing in the harvest period.

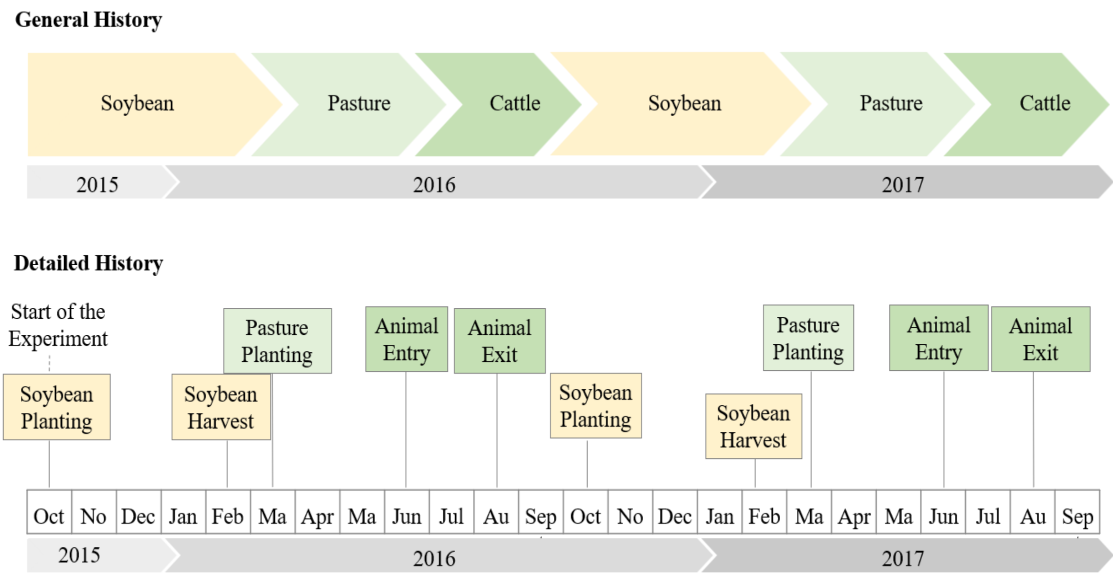

Figure 1: History of the experimental area

3.3. Cost determination

For the economic analysis of the costs, in the soybean production systems, the Instituto Mato-grossense de Economía Agropecuária (IMEA) database was used. Data on variable costs, fixed costs and factor income were tabulated and organized for the soybean crop. The implantation costs and conduction of the pasture phase were calculated from the data obtained in the experiment. Full or Full Absorption Costing was used, which aims to accumulate costs and transfer them to products in the most appropriate way (HANSEN 2003; WARREN et al., 2003). Fixed costs were apportioned according to the time used by each productive activity, composing the total cost of the product. Therefore, the following indirect costs were considered for the purpose of apportionment in the calculation of soybean cultivation and the formation/conduction of the pasture phase:

- *Fixed Costs*
- *Soybean and Pasture*

This cost includes the maintenance of machines and implements, administrative expenses, depreciation of improvements, depreciation of machines and implements, charges, fixed capital insurance, maintenance of improvements and expected remuneration on capital and land. The time used in apportionment varied according to each activity.

- *Beef cattle*

The costs considered here include depreciation of improvements, depreciation of machinery/implements, depreciation of service animals, social and labor charges, insurance of fixed capital, maintenance of improvements expected return on capital and land value.

- *Variable Costs*
- *Soybean*

Variable costs were considered, such as operation with machines/implements, labor, soybean seed, soil corrective, macro and micronutrients, fungicide, herbicide, insecticide, adjuvant/others, agricultural insurance, external transport, storage, classification and processing, taxes and fees and indirect costs.

- *Grass planting*

The quantity (kg) and price (R$/kg) of the seed, the costs of sowing (machine hour, diesel consumption, labor), fencing (helpers, fencing, wire) and the loader (labor and diesel consumption), in addition to the overhead costs described above.

- *Beef cattle*

Costing expenses were considered, with the variable cost being the acquisition of animals, labor, pastures, supplementation, sanitary and reproductive management, maintenance of machines, administrative expenses.

- *Cost with expenditure on the pasture*

The cost of pasture production and the cost of acquiring animals were incorporated. The stocking rate per hectare was calculated according to the treatments in each system. The acquisition value of the animals was obtained through data passed on by the administration of the farm that used weaned calves for the experiment.

- *Product Selling Price*

It consisted of the producer's average price, provided by the National Supply Company (CONAB) during the harvest period of each activity. For soybean, the reference was the month of February, and for beef, August.

3.4. Economic-Financial Analysis

As a method of economic and financial evaluation, the indicators used in production systems are indicators already consolidated in the literature on investment project evaluation (GITMAN, 2010; SOUZA; CLEMENTE, 2004; MARTHA JÚNIOR et al., 2011; BREALEY et al., 2013). Therefore, it was inferred from the following calculations of economic indices, according to the formulas in Table 1.

Table 1: Indexes used in the economic analysis of activities

Indexes	Formula	
Total Production Cost (TC)	TC = Fixed Costs + Variable Costs	(1)
Gross Revenue Cattle (GR)	GR_C = (((Live Animal Weight/30) *AU/h) +gain @/ha) *value @	(2)
Gross Revenue Soybean (GR)	GR_S= Productivity in sacks/h * Sack Value	(3)
Net Revenue (NR)	NR = Gross Revenue - Total Cost	(4)
Net Present Value (NPV)	$NPV = \sum_{n=1}^{n=N} \frac{CF_t}{(1+i)^n}$	(5)
Benefit/Cost Index (BCI)	$BCI = \frac{Present\ Value\ of\ Benefit\ Flow}{Present\ Value\ of\ Investment\ Flow}$	(6)
Internal Rate of Return (IRR)	$IRR = C + \sum_{t=1}^{N} \frac{F_t}{(1+i)^t}$	(7)

AU/ha = Animal Units/ Hectare; NPV Formula - CF = cash flow; t = time the cash flow occurred; i = discount rate (or minimum attractive rate); n = period of time; IRR Formula - C = Capital, investment value; N = number of periods; Ft = capital inflow in period t; i = internal rate of return

3.5. Indicators of economic viability

For the construction of economic viability indicators, the results of a 2-year period referring to the 2015/2016 and 2016/2017 harvests was evaluated. For this, the following information was used.

- Variable costs and fixed costs, disregarding accounts not associated with any cash outlay such as depreciation (GITMAN; ZUTER, 2017);
- Using the Extended National Consumer Price Index (IPCA) the MARR was obtained, based on September 2015;
- Nominal values were calculated and measured in real values, using the IPCA;
- With the quarterly cash flow discount rate for the period from September 2015 to August 2017, which accumulated at the end of the analyzed period in 11.16%.

Using the Microsoft Excel spreadsheet editor, the data were tabulated and the cash flow variables were calculated, according to the procedure outlined in Figure 2.

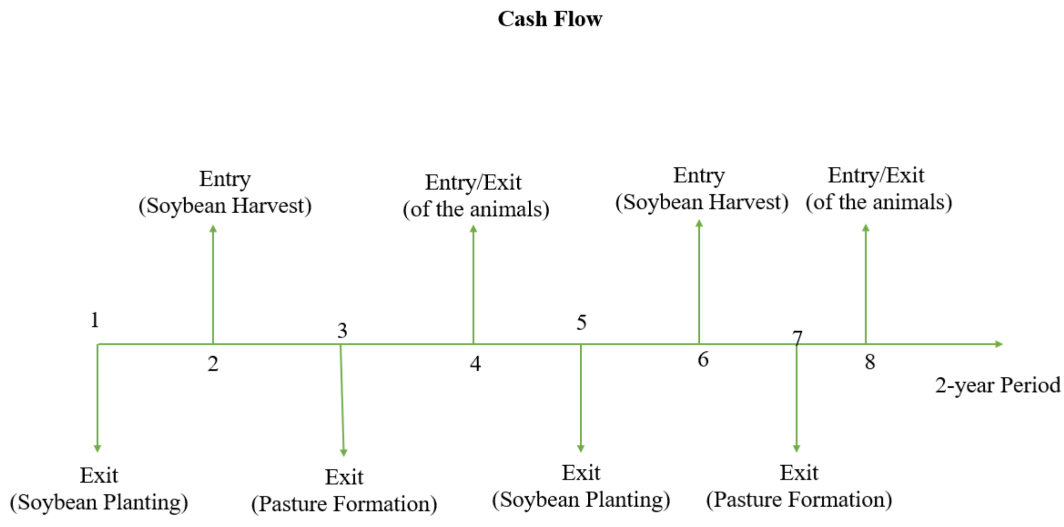

Figure 2: Diagram of the Cash Flow used in IAPS

4. Results and Discussion

In 2016, the costs of implementing pasture in the different Integrated Agricultural Production Systems (IAPS) ranged from R$ 453.42, on average for the single systems IAPS 1 and 2, and R$ 651.97 on average for systems with consortia between leguminous and grasses, IAPS 3 and 4, according to costs raised in IAPS in the present study, as shown in Table 1.

In 2017, the average costs were R$ 436.80 and R$ 635.14 for single systems (IAPS 1 and 2) and consortium systems (IAPS 3 and 4), respectively (Table 2). This higher implementation cost in the consortiums, in relation to single pasture, 44% in 2016 and 45% in 2017, was due to the costs of cowpea seeds, operations with machines and labor. The sowing process of the consortium between the grass and the cowpea requires one more operation with a precision seeder for legume planting, increasing the planting costs. This finding corroborates the results obtained by Ferrazza et al. (2016) in the intercropping of sorghum with different forage species in IAPS. Therefore, the higher effective operating cost of the intercropped system compared to the single system was due to the value of the seeds.

The use of systems with single Ruziziensis (Ruz) and Piatã (Pia) in the off-season promoted the same soybean productivity for the 2015/2016 harvest (Table 3). In turn, in the 2016 off-season (pasture phase), animal production with Pia was 16% higher than with Ruz. As a result, the Global Net Revenue (GNR), which is related to the harvest and second crop results of the systems, was favorable with Pia (Table 3). For the 2016/2017 season (Table 4), a season with fewer climatic problems, the two grasses favored higher soybean productivity in the season (77 sacks/ha) and in the off-season animal production with Pia was 51% higher. In this way, the GNR for Pia was R$ 323.90, equivalent to 17% more than with Ruz.

Table 2: Costs of Pasture Implantation in the off-season in Integrated Agricultural Production Systems in 2016

Costs	Systems			
	IAPS 1	**IAPS 2**	**IAPS 3**	**IAPS 4**
	R$/ha	**R$/ha**	**R$/ha**	**R$/ha**
A- Variable Costs	**279.20**	**274.99**	**473.54**	**477.84**
Planting Cost	**218.63**	**214.33**	**412.68**	**417.18**
Grass Seeds	82.50	78.20	82.50	78.20
Cowpea Seeds	-	-	94.50	94.50
Machine Operation	76.94	76.94	163.39	163.39
Labor	46.20	46.20	59.30	46.20
Helpers and others	5.69	5.69	5.69	5.69
Wire Fencing	7.30	7.30	7.30	7.30
II-Other Variable Costs	60.66	60.66	60.66	60.66
Administrative Costs	32.78	32.78	32.78	32.78

Maintenance	27.88	27.88	27.88	27.88
B- Fixed Costs	**36.64**	**36.64**	**36.64**	**36.64**
IV– DEPRECIATION AND EXHAUSTION	**31.16**	**31.16**	**31.16**	**31.16**
1 – Depreciation Improvements	2.33	2.33	2.33	2.33
2– Depreciation Machines/Implements	28.84	28.84	28.84	28.84
V- Other Fixed Costs	**5.48**	**5.48**	**5.48**	**5.48**
1 – Charges	2.77	2.77	2.77	2.77
2 – Fixed Capital Insurance	2.13	2.13	2.13	2.13
3 – Maintenance Improvements	0.58	0.58	0.58	0.58
C – OPERATIONAL COST (A + B)	**315.93**	**311.63**	**509.98**	**406.13**
VI – FACTOR INCOME	**139.64**	**139.64**	**139.64**	**139.64**
1- Expected Return on Capital	24.37	24.37	24.37	24.37
2 – Land	115.27	115.27	115.27	115.27
D – TOTAL COST (C + VI)	**455.57**	**451.27**	**654.12**	**649.82**

IAPS 1: Soybean + Cattle (Ruziziensis); IAPS 2: Soybean + Cattle (Piatã); IAPS 3: Soybean + Cattle (Ruziziensis + Cowpea Bean); IAPS 4: Soybean + Cattle (Piatã + Cowpea Bean). The values in the table are in R$, with the average variation of the US dollar for the periods evaluated: 2015 - R$3.3315; 2016 - 4.4901; 2017 - 3.1920. Source - Ipeadatahttp://www.ipeadata.gov.br

Table 3: Costs of Pasture Implantation in the off-season in Integrated Agricultural Production Systems in 2017

Costs	Systems			
	IAPS 1	**IAPS 2**	**IAPS 3**	**IAPS 4**
	R$/ha	**R$/ha**	**R$/ha**	**R$/ha**
A- Variable Costs	**278.20**	**273.90**	**472.25**	**368.40**
Planting Cost	**218.63**	**214.33**	**412.68**	**308.83**
Grass Seeds	82.50	78.20	82.50	78.20
Cowpea Seeds	-	-	94.50	94.50
Machine Operation	76.94	76.94	163.39	163.39
Labor	46.20	46.20	59.30	46.20
Helpers and others	5.69	5.69	5.69	5.69
Wire Fencing	7.30	7.30	7.30	7.30
II-Other Variable Costs	59.57	59.57	59.57	59.57
Administrative Costs	31.70	31.70	31.70	31.70

Maintenance	27.88	27.88	27.88	27.88
B- Fixed Costs	**36.64**	**36.64**	**36.64**	**36.64**
IV– DEPRECIATION AND EXHAUSTION	**31.16**	**31.16**	**31.16**	**31.16**
1 – Depreciation Improvements	2.33	2.33	2.33	2.33
2– Depreciation Machines/Implements	28.84	28.84	28.84	28.84
V- Other Fixed Costs	**5.48**	**5.48**	**5.48**	**5.48**
1 – Charges	2.77	2.77	2.77	2.77
2 – Fixed Capital Insurance	2.13	2.13	2.13	2.13
3 – Maintenance Improvements	0.58	0.58	0.58	0.58
C – OPERATIONAL COST (A + B)	**314.85**	**310.55**	**508.90**	**405.05**
VI – FACTOR INCOME	**124.20**	**124.20**	**124.20**	**124.20**
1- Expected Return on Capital	23.27	23.27	23.27	23.27
2 – Land	100.93	100.93	100.93	100.93
D – TOTAL COST (C + VI)	439.04	434.74	637.59	633.29

IAPS 1: Soybean + Cattle (Ruziziensis); IAPS 2: Soybean + Cattle (Piatã); IAPS 3: Soybean + Cattle (Ruziziensis + Cowpea Bean); IAPS 4: Soybean + Cattle (Piatã + Cowpea Bean). The values in the table are in R$, with the average variation of the US dollar for the periods evaluated: 2015 - R$3.3315; 2016 - 4.4901; 2017 - 3.1920. Source - Ipeadatahttp://www.ipeadata.gov.br

Table 4: Soybean and animal production. and economic results. 2015/2016 harvest. in Integrated Agricultural Production Systems with intercropping during the pasture phase.

2015/2016 Harvest	IAPS 1			IAPS 2		
	S	Os	GR	S	Os	GR
Sack Price or @ (R$)	63.12	134.83	197.95	63.12	134.83	197.95
Production (Sacks or @)	59.00	4.98	-	59.00	5.80	-
Gross Revenue (R$)	3,724.08	3,772.54	7,496.62	3,724.08	5,950.50	9.674.58
Total Production Cost (R$)	3,161.59	3,633.23	6,794.82	3,161.59	5,728.93	8,890.52

Net Revenue (R$)	562.49	139.32	701.81	562.49	221.57	784.06

2015/2016 Harvest	IAPS 3			IAPS 4		
	S	Os	RG	S	Os	GR
Sack Price or @ (R$)	63.12	134.83	197.95	63.12	134.83	197.95
Production (Sacks or @)	69.00	6.40	-	71.00	6.61	-
Gross Revenue (R$)	4,355.28	4,997.70	9,352.98	4,481.52	7,093.41	11.574.93
Total Production Cost (R$)	3,161.59	4,881.78	8,043.37	3,161.59	6,977.48	10,139.07
Net Revenue (R$)	1,193.69	115.92	1,309.61	1,319.93	115.93	1,435.86

IAPS 1: Soybean + Cattle (Ruziziensis); IAPS 2: Soybean + Cattle (Piatã); IAPS 3: Soybean + Cattle (Ruziziensis + Cowpea Bean); IAPS 4: Soybean + Cattle (Piatã + Cowpea Bean); S: Soybean Harvest; Os: off-season or second pasture harvest; GR: Global Result. The values in the table are in R$, with the average variation of the US dollar for the periods evaluated: 2015 - R$3.3315; 2016 - 4.4901; 2017 - 3.1920. Source-Ipeadatahttp://www.ipeadata.gov.br

Table 5: Soybean and animal production. and economic results. 2016/2017 harvest. in Integrated Agricultural Production Systems with intercropping during the pasture phase.

2016/2017 Harvest	IAPS 1			IAPS 2		
	S	Os	GR	S	Os	GR
Sack Price or @ (R$)	59.20	126.35	185.55	59.20	126.35	185.55
Production (Sacks or @)	77	3.87	-	77	5.84	-
Gross Revenue (R$)	4,558.40	3,395.02	7,953.42	4,558.40	5,581.30	10,139.70
Total Production Cost (R$)	2,793.50	3,270.1	6,064.41	2,793.50	5,133.29	7,926.79
Net Revenue (R$)	1,764.90	124.11	1,889.01	1.,64.90	448.01	2,212.91

2016/2017 Harvest	IAPS 3			IAPS 4		

	S	Os	GR	S	Os	GR
Sack Price or @ (R$)	59.20	126.35	185.55	59.20	126.35	185.55
Production (Sacks or @)	81	5.19	-	83	5.59	-
Gross Revenue (R$)	4,795.20	4,530.49	9,325.69	4,913.60	6,518.40	11,432.00
Total Production Cost (R$)	2,793.50	4,402.80	7,196.30	2,793.50	6,265.14	9,058.64
Net Revenue (R$)	2,001.70	127.69	2,129.39	2,120.10	253.26	2,373.36

IAPS 1: Soybean + Cattle (Ruziziensis); IAPS 2: Soybean + Cattle (Piatã); IAPS 3: Soybean + Cattle (Ruziziensis + Cowpea Bean); IAPS 4: Soybean + Cattle (Piatã + Cowpea Bean); S: Soybean Harvest; Os: off-season or second pasture harvest; GR: Global Result. The values in the table are in R$, with the average variation of the US dollar for the periods evaluated: 2015 - R$3.3315; 2016 - 4.4901; 2017 - 3.1920. Source-Ipeadatahttp://www.ipeadata.gov.br

The use of the Piatã grass in the pasture phase contributes to greater profitability of the production system when compared to Ruziziensis (Table 3). For the consortiums of Ruziziensis with Cowpea (Ruz+C) and Piatã with Cowpea (Pia+C), in the 2015/2016 harvest, higher soybean productivity was observed in Pia+C. Although, there was practically no variation in the net income related to animal production between the two systems. The GNR of Pia+C was R$ 126.25, outperforming Ruz+C. In the 2016/2017 harvest, there was a higher productivity of soybean in Pia+C (Table 4) and in the 2017 pasture phase. Animal production was also 8% higher when compared to Ruz+C. Thus, the GNR in Pia+C was R$ 243.97, 11% higher.

Decision-making about a production system is carried out under different aspects, however, Oliveira et al. (2013) pointed out that profit is not the determining factor on the use of land. In this way, economic-financial indicators, calculated on the basis of total costs of production over the 2 agricultural years, demonstrate that all treatments present conditions of remunerating a portion of the fixed factors and the risk of the undertaking, according to the GNR (Tables 3 and 4). This analysis is based on the proposal of this work which is to bring, under different assessment points, the results provided by IAPS, under different management conditions, presenting the different possibilities of productive and economical gains.

In the four production systems evaluated, the Net Present Value (NPV) was positive (Table 5). This means that these systems are economically viable, signaling that they are capable of remunerating the investments made in these production systems. However, it was possible to observe an increase in the NPV, in the order of 24%, in Pia when compared to Ruz. With the consortia, the increase in the order of 17% in the NPV for Pia+C when compared to Ruz+C. This indicated greater profitability and viability of the investment project in IAPS 4. The probable explanation for this lies in the edaphoclimatic characteristics of the grasses. Generally, Piatã has a high drought tolerance and maintains its nutritional value even in the dry period, which guarantees greater animal weight gain in relation to Ruziziensis (EUCLIDES et al. 2009; NANTES et al. 2013).

Table 6: Economic-Financial Viability Indicators in an Integrated Agricultural Production System from the 2015/2016 and 2016/2017 agricultural years

Indicators	IAPS 1	IAPS 2	IAPS 3	IAPS 4
Net Present Value (R$)	1.591.79	1.979.03	2.036.14	2.382.98
Internal Rate of Return (%)	21	24	32	36
Benefit/Cost Index	1.25	1.32	1.31	1.28

IAPS 1: Soybean + Cattle (Ruziziensis); IAPS 2: Soybean + Cattle (Piatã); IAPS 3: Soybean + Cattle (Ruziziensis + Cowpea Bean); IAPS 4: Soybean + Cattle (Piatã + Cowpea Bean). The values in the table are in R$, with the average variation of the US dollar for the periods evaluated: 2015 - R$3.3315; 2016 - 4.4901; 2017 - 3.1920. Source - Ipeadatahttp://www.ipeadata.gov.br

The technical bulletin for the Brazilian Cerrado (EMBRAPA. 2018) revealed an increase in 4% in the protein value and 3% in soybean productivity, as well as improving soil quality with the addition of 34% more total organic carbon, 26% of total nitrogen, with 11% of the carbon from the microbial biomass and 2% for nitrogen of microbial biomass, in Pia+C consortium soils when compared to the Ruz+C consortium. Thus the Ruz+C consortium resulted in better NPV values due to the lower costs with soil chemical conditioners, for example, nitrogen fertilizers. Improvement in crude protein contributed to the gain in animal weight, which together with the increase in soybean productivity, increased the revenue generated by the sale of services and products in IAPS 4 (Table 5).

Similarly, the Internal Rate of Return on investment (IRR) followed the trend of the NPV (Table 5) in which the replacement of the grass Ruziziensis with Piatã promoted greater investment returns, the same situation was observed when the leguminous grass was inserted into the pasture. The highest returns in Pia+C were a consequence of the higher productivity obtained, in both the crop and pasture phases, due to the gains driven by the consortium described in several studies (FRANCO et al. 2018; LAROCA et al. 2018; PIRES et al. 2021). The IRR results demonstrated that all the evaluated IAPS were higher than the considered discount rate of 11.16% p.p., that is, an APR of 11.16% for the period evaluated the IAPS presented an IRR above 21% demonstrating the viability of the investment. Still, it should be noted that IRR is not intended to assess absolute profitability of the cost of capital, because its objective is to find an intrinsic rate of investment, indicate viability or otherwise of the economic project (LEMES JÚNIOR et al. 2010).

The Benefit/Cost Index (BCI) was positive (>1.0) in all evaluated systems (Table 5). From the BCI, the viability of any of the IAPS studied was confirmed, with a result ranging from 1.25 to 1.32 for Ruz and Pia, respectively, that is, when revenues exceed costs by 25%. With the exception of Ruz, the other systems practically show no large differences between them, demonstrating economic improvements with replacement of single Ruziziensis (Ruz) by Piatã or consortia (Pia. Pia+C and Ruz+C). Piatã obtained a greater economic contribution. giving the producer different management options, with compatible cost and productivity. However, it should be noted that all the tested indicators demonstrated the viability of the four evaluated systems.

IAPS have demonstrated different levels of profitability, depending on the grass used and the consortium during the pasture phase. The same indicators used in this study were used by Muniz et al. (2007) to evaluate IAPS with a view to minimizing the risks through diversification, developing a System Dynamics methodological. These authors observed that the use of IAPS made it possible for all scenarios to be economically viable, corroborating the findings of the present study. This viability of the IAPS in the short term is due to the introduction of livestock activity as an additional source of revenue for the business. Nonetheless. in the medium and long term, improvements in the soil provide an increase in the efficiency in the use of inputs applied to the production system and confers greater sustainability to the system (COIMBRA et al. 2015).

Regarding the consolidated results, both for the annual behavior and for the period of analysis (2 harvests), the greater economic attractiveness of the IAPS that have greater diversity with the consortium between grasses and legumes during the pasture phase (Ruz+C and Pia+C). Given the unfavorable situation in the first year of establishment of the production systems, especially for the soybean crop due to climatic problems, IAPS provide stability to production systems, regardless of modality as evaluated in this study.

IAPS demonstrate the ability to generate sufficient income to remunerate the investment made, under adverse weather conditions, especially when Piatã grass is used in relation to Ruziziensis, or with the use of consortia between Piatã or Ruziziensis grasses and legumes during the pasture phase.

5. Conclusions

The absorption costing method allowed a comprehensive assessment of IAPS production costs and through the apportionment criterion, indirect costs were integrated to all productive activities, providing a full breakdown of costs.

IAPS demonstrated different levels of profitability, depending on the grass used and the consortium during the pasture phase. The overall net results across systems, in the 15/16 and 16/17 harvests, ranged from R$ 701.81 to R$1,889.01, with the use of single pastures and from R$1,435.86 to R$2,129.39 for intercropped pastures.

The systems showed positive results with the ability to remunerate the investments made, highlighting the consortium between Piatã and Cowpea with the best economic indicators. Therefore, the evidence presented in this study contributes towards providing the producer with more information on costs and revenues in a new model of sustainable agricultural production. This analysis also helps to indicate which activity needs greater investment or even which costs can be reduced in IAPS seeking greater profitability for the producer.

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