SOYBEAN PRODUCTION COST IN THE NORTHERN REGION OF MATO GROSSO STATE - BRAZIL: A CASE STUDY

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ABSTRACT

The study aimed to analyze the economic feasibility of implanting two soybean varieties, NS 7901 RR and NEO 750 IPRO, grown in northern Mato Grosso state, Brazil. The study was conducted in two areas of one hectare each during the 2021/2022 harvest. For the economic analysis, the indicators Gross Revenue (RB), Net Revenue (RL), Benefit-Cost Ratio (RB/C), Leveling Point (PN), Profitability Index (IL), Safety Margin (MS) were considered, and Equilibrium Price (EP). A sensitivity analysis was also carried out with five different scenarios. Soybean NS 7901 RR presented productivity of 70 bags/ha, resulting in RB = R$ 11,711.00; RL = R$ 4,467.72; RB/C = 1.62; PN = 43.30; IL = 38%; MS = -38% and PE = R$ 103.48 and the NEO 750 IPRO soybean, which obtained a production of 65 bags/ha, presenting as results RB = R$ 10,874.50; RL = R$ 3,577.25; RB/C = 1.49; PN = 43.62; IL = 33%; MS = -33% and PE = R$ 112.27. Through sensitivity analysis, it was possible to verify that for soybean NS 7901 RR, all scenarios were positive results, while for soybean NEO 750 IPRO, scenario 5 showed negative results. Such results show that the two cultivars were viable. However, through comparisons of production costs, it was possible to observe that the RR soybean was more profitable.
KEYWORDS: Commodities, Large cultures, Profitability.

CUSTO DE PRODUÇÃO DA SOJA NA REGIÃO NORTE DO ESTADO DE MATO GROSSO - BRASIL: UM ESTUDO DE CASO

RESUMO

O estudo teve como objetivo analisar a viabilidade econômica da implantação de duas variedades de soja, NS 7901 RR e NEO 750 IPRO, cultivadas no norte do estado de Mato Grosso, Brasil. O estudo foi realizado em duas áreas de um hectare cada durante a safra 2021/2022. Para a análise econômica, foram considerados os indicadores Receita Bruta (RB), Receita Líquida (RL), Relação Custo-Benefício (RB/C), Ponto de

Nivelamento (PN), Índice de Rentabilidade (IL), Margem de Segurança (MS) e Preço de Equilíbrio (PE). Uma análise de sensibilidade também foi realizada com cinco cenários diferentes. A soja NS 7901 RR apresentou produtividade de 70 sacas/ha, resultando em RB = R$ 11.711,00; RL = R$ 4.467,72; RB/C = 1,62; PN = 43,30; IL = 38%; MS = -38% e PE = R$ 103,48 e a soja NEO 750 IPRO, que obteve uma produção de 65 sacas/ha, apresentando como resultado RB = R$ 10.874,50; RL = R$ 3.577,25; RB/C = 1,49; PN = 43,62; IL = 33%; MS = -33% e PE = R$ 112,27. Por meio da análise de sensibilidade, foi possível verificar que para a soja NS 7901 RR todos os cenários foram positivos, enquanto para a soja NEO 750 IPRO, o cenário 5 apresentou resultados negativos. Tais resultados mostram que as duas cultivares foram viáveis. Porém, por meio de comparações de custos de produção, foi possível observar que a soja RR foi mais rentável.
PALAVRAS-CHAVE: Commodities, Grandes Culturas, Rentabilidade.

INTRODUCTION

The soybean (*Glycine max L*.) belongs to the Fabaceae family (legume family) and was domesticated in the northern half of China around the 11th century BC. (BONATO; BONATO, 1987). The first mention in Brazil was in 1882 when the first test's results were published in Bahia state. Since then, several studies have been conducted in different parts of the country. In the late 1960s, two factors influenced Brazil's view of soybeans as a commercial product when wheat was the main crop in the southern region of the country. Soybeans proved to be an option for summer planting after wheat, and with the increase in the production of pigs and poultry, the demand for soybean meal has been increasing to be used in the production of feed for these species (EMBRAPA SOJA, 2019).

For the 2021/2022 harvest, total soybean production was approximately 134.93 million tons, and the production of the central-west region of Brazil was 61.3 million tons, of which Mato Grosso produced around 35.69 million tons (IBGE, 2022). The rural sector accounts for most of Brazil's GDP due to the high food production, raw materials for various products, and energy production. This is because, with the emergence of new technologies, through genetic improvement and management of the used, producers seek to reduce production costs (CARVALHO *et al.,* 2021).

Currently, the oilseed has consolidated itself as one of the main agricultural commodities, capitalizing on the country's position as one of the leading players in world agricultural trade (ARTUZO *et al.,* 2018). The crop stands out with substantial additional gains in the grain market and an important share in exports, in addition to being, directly and indirectly responsible for the main source of employment in the country (CONAB, 2016).

The relevance of this crop to the national economy is significant, so it is necessary to understand how the relationship between total cost and production is formed. Given the metric that determines the profitability of an operation, the cost of production gives control to producers who can seek cost reduction alternatives depending on the size of the business and the level of technology employed (CASTRO *et al.,* 2006). The economic viability analysis of investments in the rural sector is a tool to help producers understand the period of return on invested capital. Therefore, a good analysis of this

information is necessary to facilitate decision making by producers (KRUGER *et al.,* 2017).

It is known that soybean is a crop of national and global economic importance, but producers must quantify the profitability of growing this oilseed, as each property and region has a different reality. Therefore, the study aimed to analyze the economic feasibility of implanting two soybean varieties, NS 7901 RR and NEO 750 IPRO, grown in northern Mato Grosso, Brazil.

MATERIAL AND METHODS

The work is a case study that was carried out at Fazenda Gloria, in the municipality of Paranatinga, north of Mato Grosso - Brazil, located at 14º25'54" South latitude and 54º03'04" West longitude, with an altitude of 460 m, with an altitude of 460 m. According to the Köppen classification, the climate of the region is characterized as tropical (Aw) with a dry season. The municipality is located between Brazil's Amazon and Cerrado biomes (IBGE, 2022). The average annual temperature was a minimum of 20.17ºC and a maximum of 30.08ºC, with an average annual precipitation of 121.17 mm in 2022 (CLIMATEMPO, 2022). The predominant soil on the property is the dystrophic red-yellow oxisol (SEPLAN, 2001).

The case study proposes to investigate and understand the costs and revenues of the implantation of two soybean cultivars, namely NS 7901 RR and NEO 750 IPRO, through data collection and analysis. For the economic analysis, data collected in the 2021/2022 harvest from two areas, with one hectare each, were used.

The system used for the planting of the areas was the direct one. The sowing lines were 0.50 m apart, establishing a stand of 400,000 plants/ha, and the fertilizer used was NPK (00-18-18), which used 500 kg/ha in both areas. A few days before planting, the area was desiccated using inputs (Trunfo 280 SL – 1.5 L/ha; Kennox – 0.3 ml/ha; Iharol Gold – 0.3 ml/ha; Eddus Ec – 2 L/ha; Cipermetrina Nortox 250 CE – 0.2 ml/ha e Acido Borico + K_2O – 1 kg/ha). Then, the post-emergence was applied, followed by the application of fungicides to control diseases and insect pests, to maintain plant health and quality of the crop so that productivity was not affected. The harvest of each area was carried out 120 days after planting, with a production of 70 bags/ha for NS 7901 RR soybean and 65 bags/ha for NEO 750 IPRO soybean, which was sold for R$167.30 reais a bag.

Costs are made up of the items necessary for cultural implementation, such as inputs, machinery, manual and outsourced services, and other expenses. The machinery used in the farming belonged to the property, which was supplied with fuel purchased directly from the distributors, thus reducing the costs of this operation.

To generate production costs, the method developed by Matsunaga *et al.* (1976), which was later updated by Martin *et al.* (1998), was adapted by Furtado *et al.* (2022), composed of Effective Operating Costs (EOC), which includes the total cost of operations and inputs that are spent per hectare during the production of a given product; Total Operating Cost (TOC), established by the sum of the EOC and other operating costs, which contains the company's general costs such as Funrural, land opportunity, technical assistance, and unforeseen costs during production.

To verify the profitability and viability of the project following economic indicators were analyzed Gross Revenue (RB), Net Revenue (RL), Benefit-Cost Ratio (RB/C), Leveling Point (PN), Profitability Index (IL), Margin of Safety (DM) and Equilibrium Price (EP).

Gross Revenue (RB): It is the revenue earned by selling the production of activity at the predetermined selling price or current market price when the product is sold. (MARTIN *et al.*, 1998). The RB calculation is represented in Equation (1).

$$RB = PT \times PV \quad (1)$$

Wherein:
PT = total production/productivity;
PV = selling price.

Net Income (RL): Obtained after paying all production expenses. Being the profit of the producer (GUIDUCCI *et al.*, 2012). The RL calculation is represented in Equation (2).

$$RL = RB - TOC \quad (2)$$

Wherein:
TOC= total operating cost;
RB = gross revenue.

Benefit/Cost Ratio (RB/C): It is used to point out the economic efficiency using the comparison between inputs and outputs, that is, estimating what can be gained for each unit of invested capital (ARAÚJO *et al.*, 2015). The project is considered viable if the B/C ratio is >1 (one). If it is <1 (one), the project is not viable and considered high risk. The RB/C calculation is represented in Equation (3).

$$RB/C = RB / TOC \quad (3)$$

Wherein:
RB: Gross Revenue;
TOC: Total Operating Cost.

Leveling Point (PN): It is also known as the break-even point, which corresponds to the level at which production can reach so that it is possible to obtain a revenue capable of meeting all expenses with running the crop or any other activity (GUIDUCCI *et al.*, 2012). The PN calculation is represented in Equation (4).

$$PN = TOC / PV \quad (4)$$

Wherein:
TOC= total operating cost;
PV = selling/marketing price.

Profitability Index (IL): It is the index that demonstrates the ratio between net revenue and gross revenue in percentage, indicating how many percentages of revenue will remain for the producer after paying all expenses (CARVALHO *et al.*, 2016). The calculation of the IL is represented in Equation (5).

$$IL = (RL/ RB) * 100\% \quad (5)$$

Wherein:
RL= Net Revenue;
RB = Gross Revenue.

Margin of safety (MS): Serves to identify how much product prices or productivity can fall for them to start registering losses (ARAÚJO *et al.*, 2011). The MS calculation is represented in Equation (6).

$$MS = ((TOC – RB)/RB) * 100\% \quad (6)$$

Wherein:
TOC = Total Operating Cost;
RB = Gross Revenue.

Equilibrium Price (PE): Determines which soybean marketing price to pay production costs (CARNEIRO *et al.*, 2019). The PE calculation is represented in Equation (7).

$$PE = TOC/PT \quad (7)$$

Wherein:
TOC= total operating cost;
PT = total production/productivity;

Sensitivity analysis: It is a financial simulator that tolerates the creation of multiple conditions that can be positive or negative. It can be a forecasting method until the project is viable, being able to predict scenarios based on real conditions, taking into account changes in production, price, and commercialization of crops (VIRGENS *et al.*, 2015). In this work, five scenarios were analyzed, namely:

Scenario 1 - Real situation - The production and the real commercialization value of the product;

Scenario 2 - 15% reduction in production;

Scenario 3 - 15% reduction in product sales value;

Scenario 4 - 15% increase in production cost;

Scenario 5 - 15% reduction in production and 15% in product sales value, and 15% increase in production cost.

Electronic spreadsheets of the Microsoft Excel ® program were used to tabulate and analyze the data.

RESULTS AND DISCUSSION

After analyzing all the data collected during the research, the Total Operating Cost (TOC) for the production of NS 7901 RR soybean was R$ 7,243.28 reais and NEO 750 IPRO soybean R$ 7,297.25 reais (Table 1). Where the Effective Operating Cost (EOC), composed of inputs, mechanized operations and outsourced services, which were actively used for the production of the crop, was R$ 4,904.19 reais (NS 7901 RR) and R$ 4,964.66 reais (NEO 750 IPRO).

TABLE 1: Cost of production of Soybean NS 7901 RR and Soybean NEO 750 IPRO for one hectare in the municipality of Paranatinga, Mato Grosso- Brazil, harvest 2021/2022.

Description	Soybean NS 7901 RR (R$/ha^{-1})	Soybean NEO 750 IPRO (R$/ha^{-1})
A. Inputs		
Fertilizing	R$ 2,350.00	R$ 2,350.00
Desiccation	R$ 356.16	R$ 356.16
Planting	R$ 619.61	R$ 759.61
post-emergent	R$ 409.21	R$ 372.25
zero application	R$ 128.48	R$ 128.48
Fungicide 1ap*	R$ 333.40	R$ 333.40
Fungicide 2ap*	R$ 204.42	R$ 170.26
Fungicide 3ap*	R$ 208.77	R$ 200.36
Subtotal A	**R$ 4,610.05**	**R$ 4,670.52**
B. Mechanized Operations		
Fertilizer application	R$ 72.00	R$ 72.00
Desiccation	R$ 18.60	R$ 18.60
Planting	R$ 35.40	R$ 35.40
Pulverization	R$ 7.04	R$ 7.04
Harvest	R$ 56.10	R$ 56.10
Subtotal B	**R$ 189.14**	**R$ 189.14**
C. Outsourced Services		
Transport	R$ 105.00	R$ 105.00
Subtotal C	**R$ 105.00**	**R$ 105.00**
Effective Operating Costs - EOC	**R$ 4,904.19**	**R$ 4,964.66**
funrural	R$ 175.67	R$ 163.12
Land use opportunity	R$ 1,673.00	R$ 1,673.00
Other expenses (10% of EOC)**	R$ 490.42	R$ 496.47
Total Operating Cost - TOC	**R$ 7,243.28**	**R$ 7,297.25**

* ap = Applications

**Expenses not expected by the producer at the time of crop implantation.

*** 1US$ = R$5.20, commercial dollar exchange rate on the survey date (01/09/2022) (BCB, 2022).

Comparing the cultivars used in the study, we found a difference of R$ 53.97, where the NEO 750 IPRO soybean has a higher value. This fact is related to the differences in values between some inputs used by each cultivar, in addition to the Funrural value, which is directly related to the gross income of each one and the costs with other expenses related to the EOC.

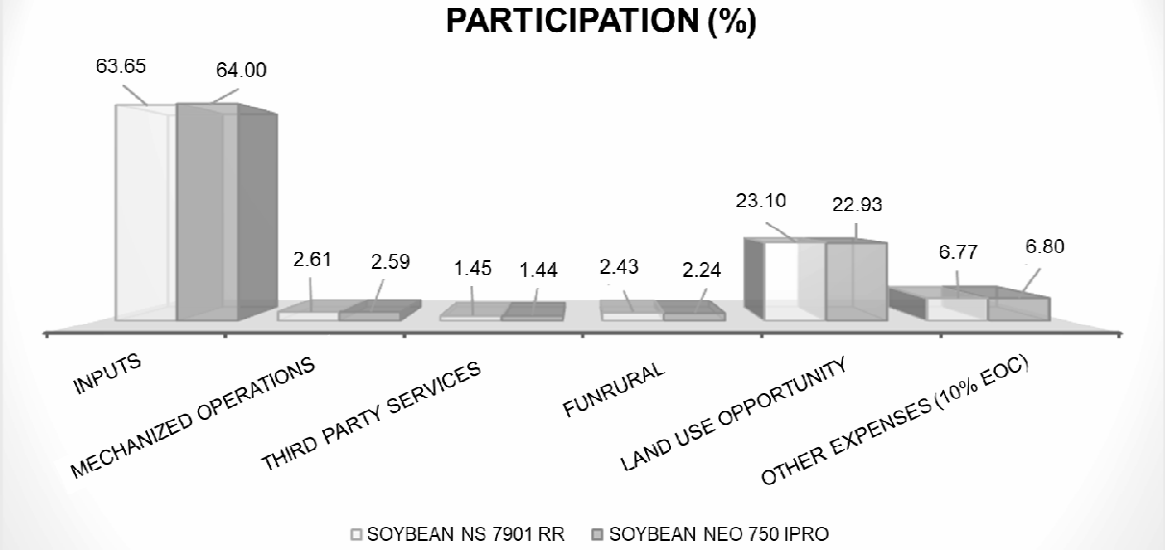
The Total Operating Cost (TOC) was R$ 7,243.28 for RR soybeans and R$ 7,297.25 for IPRO soybeans per hectare. These values are higher than those found by Richetti (2021), which for RR soybeans obtained R$ 5,102.99/ha and for IPRO soybeans presented R$ 5,045.11. This difference is due to the values used in some components that are divergent between the two works, where the study in question obtained expenses with fungicides for RR soy of R$ 746.59.

For soybean IPRO of R$ 704.02, the purchase of seeds which was R$ 619.00 for RR and R$ 759.61 for IPRO, in addition to similar expenses for both cultivars, such as application costs of fertilizer of R$ 72.00, transport expenses of R$ 105.00 and cost with the land opportunity of R$ 1,673,00 expenses that are higher than the work of Richetti (2021) who found expenses with the purchase of seeds of R$ 504.00 for RR and R$ 679.20 for IPRO, in addition to similar expenses for both cultivars, such as fungicide costs of R$ 315.00, fertilizer application of R$ 14.71, transport of R$ 84.00 and cost with the land opportunity of R$ 587.40.

The distribution of costs was almost similar for the two cultivars, showing a minor variation, in which the inputs showed 63.59% for soybean NS 7901 RR and 64% for soybean NEO 750 IPRO, followed by the opportunity costs of the land that they presented 23.10% and 22.93% respectively, even though the same amount was paid for both areas, this difference is due to the final TOC of each cultivar.

The authors Dettmer *et al.* (2021), who carried out a comparison between three different harvests, namely 2017/2018, 2018/2019 and 2019/2020, in the state of Goiás-Brazil, found a higher percentage where their inputs had participation of 75%, followed by salary costs (labor) with 22% of the total cost. This difference is due to the planting system used and the cost components taken into account in each work, in addition to the different states where each study was developed (Figure 1).

FIGURE 1. Representative share of costs for the production of Soybean NS 7901 RR and Soybean NEO 750 IPRO in 1 hectare in the municipality of Paranatinga, Mato Grosso- Brazil, harvest 2021/2022.



Profitability analysis makes it possible to find out how much return is obtained after the complete negotiation of production, with a productivity of 70 bags/ha for RR soybeans and 65 bags/ha for IPRO soybeans, sold at R$ 167.30/bag, gross revenues (RB) of R$ 11,711.00 and R$ R$ 10,874.50 reais/ha, respectively (Table 2). This value is higher than that obtained by Rocha *et al.* (2022), who conducted a study on the economic viability of soybean and corn crops in the Southeast region of Goiás- Brazil, which indicated a productivity of 48 bags per hectare. This is due to the differences between the cultivars used in each study, the management methods used and the different locations of each activity.

TABLE 2. Economic indicators of Soybean NS 7901 RR and Soybean NEO 750 IPRO in one hectare, in the municipality of Paranatinga, Mato Grosso - Brazil, harvest 2021/2022.

	INDICATORS	
	SOYBEAN NS 7901 RR	**SOYBEAN NEO 750 IPRO**
Area (hectare)	1	1
Productivity (bags)	70	65
Sale price (R$)	R$ 167.30	R$ 167.30
Gross revenue (R$)	R$ 11,711.00	R$ 10,874.50
Total Cost (R$)	R$ 7,243.28	R$ 7,297.25
Net Revenue (R$)	R$ 4,467.72	R$ 3,577.25
BC ratio	1.62	1.49
Leveling Point	43.30	43.62
Safety margin	-38%	-33%
Profitability Index	38%	33%
Equilibrium Price	R$ 103.48	R$ 112.27

* 1US$ = R$5.20, commercial dollar exchange rate on the survey date (01/09/2022) (BCB, 2022).

The BC ratio was 1.62 for RR soybeans, indicating that for every R$ 1.00 invested, the producer had a return of R$ 0.62, verifying that the revenue was higher than the costs. The ratio was also positive for soybeans IPRO with a BC of 1.49, obtaining a return of R$ 0.49 for each R$ 1.00 invested. These values are higher than those found by Ribeiro *et al.* (2021), who presented BC ratios of 1.10 to 1.26 in a study that economically and financially analyzed the implantation of soybeans with a succession of corn and second-season sunflowers. This difference is due to the increase in the selling price of soybean, which has become one of the most exported commodities nationally and worldwide.

The profitability index (IL) was 38% for RR soybeans and 33% for IPRO soybeans. This index is related to the percentage of revenue left over after paying all expenses. These values are lower than those found by Rocha *et al.* (2022), which presented a LI of 40.8% for the soybean crop in the 2018/2019 harvest in southeastern Goiás - Brazil. This difference is related to the total costs of each job because, with the increase in the prices of inputs and other services necessary for the implantation of this crop, the producer has to disburse a more significant part of his income to pay for this investment.

The safety margin (MS) showed a value of -38% for RR soybeans and -33% for IPRO soybeans. This index indicates how much the commercialization price or productivity can fall without causing damage to the producer. This value is lower than that found by Martins *et al.* (2022), who found an MS of -57%. This difference is due to the commercialization value, productivity used in each of the studies, and the consumer market at the time of each analysis.

Other indicators, such as the leveling point (PN), showed a value of 43.30 for RR soybeans and 43.62 for IPRO soybeans, these being the minimum production that each cultivar could present, which would be able to supply all the costs with the implantation. The equilibrium price (PE) for the RR soybean was R$ 103.48, a value lower than that of the IPRO soybean, which was R$ 112.27. This fact occurs due to the difference between the productivity of each cultivar presented in the work.

In order to investigate factors that may contradict the profitability of the soybean varieties used in the study, a sensitivity analysis was carried out to identify the limits in which commercial values may vary or production may be reduced while the activity gives profit to the producer. For this work, alterations were made in the cost of production, marketing price, and production, analyzing the performance of soybeans under adverse conditions (Table 3).

TABLE 3: Sensitivity analysis of Soybean NS 7901 RR and Soybean NEO 750 IPRO in one hectare in the municipality of Paranatinga, Mato Grosso- Brazil, harvest 2021/2022.

SOYBEAN NS 7901 RR					
	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
Productivity	70	59.50	70	70	59.50
Sale Price (R$)	R$ 167.30	R$ 167.30	R$ 142.21	R$ 167.30	R$ 142.21
Gross Revenue (RB)*	R$ 11,711.00	R$ 9,954.35	R$ 9,954.35	R$ 11,711.00	R$ 8,461.20
Total Cost (R$)	R$ 7,243.28	R$ 7,243.28	R$ 7,243.28	R$ 8,329.77	R$ 8,329.77
Net Revenue (R$)	R$ 4,467.72	R$ 2,711.07	R$ 2,711.07	R$ 3,381.23	R$ 131.43
BC ratio	1.62	1.37	1.37	1.41	1.02
Point of N. (PN)	43.3	43.30	50.94	49.79	58.58
Margin of S. (MS)	-38%	-27.24%	-27.24%	-28.87%	-1.55%
Index of L. (IL)	38%	27.24%	27.24%	28.87%	1.55%
Price of E. (PE)	R$ 103.48	R$ 121.74	R$ 103.48	R$ 119.00	R$ 140.00
SOYBEAN NEO 750 IPRO					
	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
Productivity	65	55.25	65	65	55.25
Sale Price (R$)	R$ 167.30	R$ 167.30	R$ 142.21	R$ 167.30	R$ 142.21
Gross Revenue (RB)*	R$ 10,874.50	R$ 9,243.33	R$ 9,243.33	R$ 10,874.50	R$ 7,856.83
Total Cost (R$)	R$ 7,297.25	R$ 7,297.25	R$ 7,297.25	R$ 8,391.84	R$ 8,391.84
Net Revenue (R$)	R$ 3,577.25	R$ 1,946.08	R$ 1,946.08	R$ 2,482.66	-R$ 535.01
BC ratio	1.49	1.27	1.27	1.30	0.94
Point of N. (PN)	43.62	43.62	51.32	50.16	59.01
Margin of S. (MS)	-33%	-21.05%	-21.05%	-22.83%	6.81%

Index of L. (IL)	33%	21.05%	21.05%	22.83%	-6.81%
Price of E. (PE)	R$ 112.27	R$ 132.08	R$ 112.27	R$ 129.11	R$ 151.89

Scenario 1. Actual scenario - The actual production and marketing value of the product; **Scenario 2.** 15% reduction in production; **Scenario 3.** 15% reduction in product sales value; **Scenario 4.** 15% increase in production cost and **Scenario 5.** 15% reduction in production, 15% reduction in product sales value and 15% increase in production cost.

* 1US$ = R$5.20, commercial dollar exchange rate on the survey date (01/09/2022) (BCB, 2022).

Scenario 1 analyzed the real work scenario in order to check the results with the other scenarios. In scenario 2, there was a reduction in production, still showing positive values for the cultivation of the crop and a quick economic return. Scenarios 3, 4 and 5 also determined the financial viability of the production system for the Soybean NS 7901 RR variety, not pointing to risks to the project. While for the Soybean variety NEO 750 IPRO, scenarios 3 and 4 presented results that would prove the viability of the implantation, however in scenario 5, the results were not viable for the cultivation of this variable.

Scenario 5 considered the most pessimistic situation for the two varieties, where they exhibited different results. For soybean NS 7901 RR obtained a net revenue of R$ 131.43/ha, and soybean NEO 750 IPRO presented a net revenue of (R$ 535.01). Lower values than those found in the sensitivity analysis of the work by Martins *et al.* (2022), which in its most pessimistic scenario, presented revenue of R$ 3,075.03. These facts are due to the values with production expenses, commercialization value and production determined in each of the works. Therefore, even if one of the varieties has presented positive values in all scenarios, it is necessary to investigate more variables before implanting these varieties under the conditions of this work so that the producer does not have any losses in the future.

Thus, analyzing the two cultivars presented in work, it is clear that both can be used in the implementation of new cultivation areas, but it will always be important to carry out studies on the demands of each area. For an investment to be profitable for a producer, it will always be necessary to analyze the current market to guarantee a better profit for the producer.

CONCLUSIONS

The case study showed the economic benefit of NS 7901 RR and NEO 750 IPRO soybeans for the studied area in the municipality of Paranatinga, Mato Grosso - Brazil, 2021/2022 harvest. Economic analysis and comparative production costs demonstrated that RR soy was more profitable and that the recommendation for the property is to plant this cultivar in more areas because it has a lower production cost and better productivity.

Soybean producers in Brazil or in hot climates can benefit from this crop, but they must be aware of production costs and market prices. Thus, they need to be prepared to deal with the volatility of marketing prices and crop productivity, as indicated by the negative margin of safety indices.

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