

## Original Research Article

# Economic Opportunity for Investment in Soybean+Sunflower Crop System in Mato Grosso, Brazil

### ABSTRACT

The economic feasibility of soybean and sunflower crop system on a farm in Diamantino MT Brazil is analyzed. Data were retrieved from the 2017-2018 harvest, even though they were repeated for a six-year span. Project-inherent items were grouped in fixed and variable costs. Main financial indexes comprised total yearly income, current net rate, equivalent uniform yearly rate, return internal rate, profit index during the period and discounted payback. In the case of the suggested system, the plantation proved to be viable, with total yearly income of R\$ 3,624,000.00 at the end of six years; current net rate at R\$ 1,468,920.00; equivalent uniform yearly rate at R\$ 334,810.00; 18 % return internal rate; 33 % profit index during the period, and discounted payback of 4.53 years. However, 15 % negative variations in price, productivity or income, or positive variation at 30 % in real operation costs proved the unfeasibility of the project, with special reference to current negative net rate. Supplementary profit (hectare) from sunflower was 33 % higher than that of soybean. Fixed costs paid by soybean suggested two annual crops. Method for the application of production costs is highly relevant since it provides a good assessment on the implementation project and presents a good diagnosis for decision-taking with more profitable alternatives in planning soybean production to dilute costs and increase income.

Comment [t1]: internal rate of return

Comment [t2]: payback period

*Keywords: agribusiness; administration of costs; Glycine max L.; Helianthus annus L.; economic feasibility.*

### 1. INTRODUCTION

Agribusiness is one of the most relevant sectors in Brazilian economy, with special reference to agriculture and its basic role in economic growth. Soybean (*Glycine max* L.) is an oleaginous plant with great relevance in agriculture. Due to increasing food demands, soybean is one of the basic sources for vegetal protein and a prime matter for several products such as animal diet, oil and others [1,2,3,4,5,6,7].

Increase in demand has enhanced the economic importance of soybean and, consequently, cultivated area and production, with greater productivity rates [8], particularly in the state of Mato Grosso, Brazil, as Brazil's greatest producer (30 % of total production). The state is also the greatest national producer (78 %) in sunflower (*Helianthus annus* L.), with special reference to the municipality of Campo Novo do Parecis, due to its excellent soil and climate conditions [9,10]. Owing to demands of the region's industrial and commercial sectors triggered by high quality oil and bran [11,12,10,13], the sunflower is a relevant economic alternative in crop rotation, intercalation and succession to soybean within a second harvest system. The latter improves soil without competing with other plant species sown during the

32 period, such as corn (*Zea mays* L.), cotton (*Gossypium hirsutum* L.) and popcorn maize (*Zea*  
33 *mays everta* L.) [14,10].

34 However, agriculture is subjected to high risks and uncertainty due to economic [15] and  
35 environmental factors. It is a well-known fact that climate is one of the main factors of  
36 uncertainty in agricultural production [16]. Biological and market vicissitudes affect  
37 productivity and production costs. Consequently, income from productivity may oscillate  
38 when profit margins depend on soil and climate conditions, technology employed and  
39 management [17].

40 The structure and analysis of production costs provide the producer sufficient data for  
41 decision-taking within the production cycle and determines the best time for commercializing  
42 production with profits [18]. In fact, accounting tools have been more and more frequently  
43 employed for elucidations and strategic management, monitoring income and expenses,  
44 pinpointing mistakes and the best improvements, and even indicating where financial  
45 resources should be applied for a successful entrepreneurship [19,20,21].

46 Further, costs survey is an asset for the producer to analyze items involving production,  
47 costs and benefits, and decision-making, and, coupled to market data, to identify risks and  
48 opportunities.

49 Current study determines the economic viability of soybean+sunflower crop system on a  
50 plantation in the mid-northern region of the state of Mato Grosso, Brazil.

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## 2. MATERIAL AND METHODS

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Current study was based on data retrieved from an agricultural plantation in the municipality  
of Diamantino MT Brazil (13°37'47.87" S and 57°23'51.71" W). According to Köppen's  
classification, climate type is Aw, or rather, a tropical climate with well-defined dry and rainy  
seasons. The dry season ranges between May and September and the rainy one between  
October and April.

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The farm's produce consisted of soybean as the main crop and corn in the inter-harvest  
period. However, sunflower production as secondary crop has been proposed to replace  
corn, with one's own capital, due to the producer's eagerness. The plantation's total area  
comprises 1,630 hectares, with 800 hectares for crops, 800 hectares as legal and mandatory  
preservation area, and 30 hectares with premises, dirt roads, pasture, orchards and others.  
During the summer, soybean covers the entire crop area and sunflower crop occupies 50 %  
(400 ha) of the area.

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Machines (tractor 260 CV/191 kW; tractor 75 CV/55 kW and harvester 300 CV/220 kW) and  
new equipments (22-line sower, sunflower platform, front transporter, self-propelled sprayer,  
water tank truck, transport truck, 40-disc plowing machine and 64-disc leveler), one unit  
each, were acquired at the start of the experiment, for the installation, transport and  
harvesting of crops. Total initial investment reached R\$ 2,545,000.00 and R\$ 45,096.00 for  
the preparation and correction of the soil.

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Maintenance costs comprise expenses for fuel (diesel), spare parts, lubricants and filters,  
and eventual salaries to mechanics and electricians. Technical assistance (0.4 + 0.2 bags of  
soybean and sunflower, per hectare) was the *pro labore* of the assistant technician and  
owner (agronomic engineer) of the plantation. Eventual technical assistance provided by

**Comment [t3]:** Do these two plants have the same cultivation? how do you partially estimate the cost of producing soybeans and sunflowers? Soybeans are planted first then sunflowers, or vice versa, or both are planted simultaneously. This will determine the structure of fixed costs and / or variable costs.

77 agricultural retailers is free. Administration costs comprise telephone bills, electricity, fuel  
78 and car maintenance. Freight included in harvest costs is the cost of transporting produce to  
79 silos some 45 km distant from the farm. There are no storage costs since the producer  
80 delivers the grains to the trading firm, with sales commitment at any time. Insurance of  
81 machines and equipments costs 1.2 % per annum.

## 82 2.1. Production costs of soybean and sunflower

83 Estimates for soybean and sunflower production costs were undertaken by grouping of items  
84 into variable and fixed costs [22], namely: a) variable costs (VC), comprising inputs, seeds,  
85 crop treatments, spare parts, fuel, seasonal manpower, technical assistance, harvest,  
86 freight, trading taxes (Fethab/Facs and Funrural) and income tax (IT) of presumed profit (15  
87 %). Above-mentioned costs plus interest on working capital (WC) composed Total Variable  
88 Costs (TVC); b) Fixed costs (FC), wholly attributed to the main crop, comprised Payable  
89 Fixed Costs (soil preparation and correction, fixed manpower, management and renting  
90 (opportunity costs) and costs of capital stock (CCS) or depreciations and mortgage; leasing  
91 was anticipated capital (prior to soybean sowing); c) Total Costs (TC) as TVC plus FC.

92 Rates in Brazilian Real (R\$) for soybean (2017-2018 harvest) and sunflower (2018 harvest)  
93 production costs were retrieved during the second semester of 2017 and the first semester  
94 of 2018 during agricultural commercialization in Campo Novo do Parecis and with producers  
95 of the region. Transgenic soybean (RR and Bt) with zero tillage was featured, with straw and  
96 vegetal residues left on the soil surface. Machines and equipments had a 10-year useful life,  
97 with a 40 % residue rate which returned by the end of the sixth year as profit, when sold.  
98 Improvements were estimated at R\$ 200,000.00, and included a house made of bricks (90  
99 m<sup>2</sup>) and another made of timber (110 m<sup>2</sup>), a shed (680 m<sup>2</sup>), built some ten years ago, with  
100 another ten years of useful life, at 40 % residual rate.

101 Depreciation rate was calculated linearly and land costs were the mean leasing rate of eight  
102 sacks of soybeans ha<sup>-1</sup> year<sup>-1</sup>. WC was the sum of VC + PFC, on the former, interests at  
103 9.75 % p.a. and 9.75 % p.a. for CCS, composing opportunity costs, or rather, profits at  
104 saving account rates and activity risks.

105 Fethab/Facs was calculated following Technical Information 206/2018 by the Association of  
106 Soybean and Corn Producers of Mato Grosso<sup>1</sup> and Decree 217/2017 by the Economy  
107 Secretary of the state of Mato Grosso<sup>2</sup> (Table 1). Funrural is the 1.5 % rate on Total Income  
108 (TI), according to Act 13606 published on 9/1/2018<sup>3</sup>, on the Rural Tax Regulation Program  
109 (RTRP).

110 **Table 1. Monetary rates to Facs, FETHAB and regional FETHAB, January 2018**

Comment [t4]: Give explanation about it

<sup>1</sup> Association of Soybean and Corn Producers of Mato Grosso [APROSOJA]. 2018. Informe Técnico Aprosoja nº 206/2018. Available at: <<http://www.aprosoja.com.br/produtor/informes-tecnicos/2018>> on 22/01/2018.

<sup>2</sup> State Secretary of Revenues [SEFAZ/MT]. 2017. Decree 217/2017, of 28 Decz. 2017. Dealing with coefficients of monetary correction, applied to fiscal debts and updated rate of UPF/MT during the period and other items. Diário Oficial de Mato Grosso, Cuiabá. Available at: <<http://app1.sefaz.mt.gov.br/0325677500623408/7C7B6A9347C50F55032569140065EBBF/016721B15DCA09EA8425820A007BA97A>> on 22/01/2018].

<sup>3</sup> Planalto. President of the Republic. 2018. Act 13.606, 09/01/2018, dealing with the Program for the Regulation of Rural Tributes (PRR) of the Secretary of Federal revenue of Brazil and General Attorney. Diário Oficial da União, Brasília. Available at <[http://www.planalto.gov.br/ccivil\\_03/\\_ato2015-2018/2018/lei/L13606.htm](http://www.planalto.gov.br/ccivil_03/_ato2015-2018/2018/lei/L13606.htm)> on 22/01/2018].

Description	% FSU <sup>a</sup>	R\$ ton <sup>-1</sup>	R\$ sack <sup>-1</sup>
Fethab <sup>b</sup> soybean	9.605	12.3175	0.7390
Regional Fethab	9.605	12.3175	0.7390
Facs <sup>c</sup>	1.260	1.6158	0.0969
Total (R\$)	20.47	26.2507	1.5750

111 *Source: Elaborated by author, based on APROSOJA (2018)*

112 <sup>a</sup> Fiscal Standard Unit FSU/MT = R\$ 128.24, <sup>b</sup> State Fund for Transport and Housing, <sup>c</sup> Fund  
113 *pro soybean crop.*

## 114 2.2. Economic analysis

### 115 2.2.1. Costs system

116 The economic analysis of the costs system assessed mean productivity of crops during the  
117 last three harvests (58 sacks ha<sup>-1</sup> for soybeans and 30 sacks ha<sup>-1</sup> for sunflower) on the  
118 plantation and/or region [14] and respective mean prices (R\$ 60 sack<sup>-1</sup> soybean and R\$ 70  
119 sack<sup>-1</sup> sunflower) to constitute TI. TFC comprised FC of CCS + PFC, whereas TC was  
120 calculated by VC + interests on WC (TVC) + TFC. Taking leasing into account, Real  
121 Operation Costs (ROC) amounted to TVC + PFC. Weighted Average Revenue, weighted TC  
122 and weighted LT are, respectively, income from total soybean area + income from total  
123 sunflower area divided by available area; TC of total soybean area + TC of total sunflower  
124 area divided by available area and total yearly profit divided by available area.

125 Whereas Gross Contribution Range (GCR) consists of income minus TVC, the True  
126 Operational Contribution Margin (TOCR) comprises GCR subtracted from PFC (total yearly  
127 profit + depreciations, taking into account opportunity costs – leasing), also known as  
128 financial profit; Contribution Range Index (CRI) is the result of GCR divided by income.  
129 Profits prior to the removal of interests and depreciations consisted of TOCR + interests on  
130 WC. Operational Profit (OP) was income surplus minus TC (including interests on CCS,  
131 depreciation and mortgage); Total Profit (TP) is income surplus minus TC (excluding  
132 interests on CCS), whereas Profit Range (PR) is the profit percentage with regard to income  
133 [(income – COT) / income].

134 Further, equilibrium points (EP) were determined with regard to area (ha) by dividing TFC  
135 (R\$) by GCR (R\$ ha<sup>-1</sup>); with regard to productivity (sc ha<sup>-1</sup>), mean costs (MC, R\$ ha<sup>-1</sup>)  
136 divided by selling price (R\$ sc<sup>-1</sup>); with regard to production (sacks), TFC (R\$) divided by  
137 GCR (R\$ sc<sup>-1</sup>); with regard to income (R\$), TFC (R\$) divided by CRI; with regard to selling  
138 price (R\$ sc<sup>-1</sup>), with TC (R\$ sc<sup>-1</sup>) and equilibrium income (EI) for the activity (association of  
139 crops). In addition, Net Current Rate (NCR), Equivalent Uniform Annual Rate (EUAR),  
140 Payback Internal Rate (PIR), Profitability Index (PI) during the period and Discounted  
141 Payback (DPB) were calculated, following [23].

142 Simulations for different scenarios were performed to assess the business's sensitiveness to  
143 the market's natural oscillations, due to the seasonality of agricultural prices. Besides the  
144 basic scenario, positive and negative variations of 15 and 30 % were defined for ROC,  
145 productivity, prices and incomes of soybean and sunflower so that one could register the  
146 performance of their respective financial indexes TI, NCR, EUAR, PIR, PI during the period  
147 under analysis and DPB for each scenario.

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150 **3. RESULTS AND DISCUSSION**

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152 The 2017-2018 soybean harvest had a total production cost equivalent to R\$ 2,450,698.00  
 153 divided into R\$ 1,291,490.00 as variable costs; R\$ 835,789.00 fixed costs; R\$ 210,714.00  
 154 interests on capital stock; \$ 112,703.00 interests on working capital (Table 2), with R\$  
 155 2,745,000.00 investments in stock capital with regard to machinery, equipments and  
 156 improvements. Rates per hectare amount to R\$ 3,063.00; R\$ 1,614.00; R\$ 1,044.00; R\$  
 157 263.00 and R\$ 140.00, respectively.

158 **Table 2. Annual production costs for soybean crop for 2017-2018 harvest. Diamantino**

159 **MT Brazil, 2018**

Item	R\$ ha <sup>-1</sup>	Total (R\$ 800 ha <sup>-1</sup> )	% <sup>a</sup>
<b>I – Variable costs</b>			
<i>Inputs</i>			
Seeds	271.08	216,864.00	8.85
Seed treatment	35.00	28,000.00	1.14
Inoculants	8.00	6,400.00	0.26
Fertilizer, seeding and coverage	586.68	469,344.00	19.15
Micronutrients	23.17	18,536.00	0.76
Herbicides	67.49	53,992.00	2.20
Insecticides	45.00	36,000.00	1.47
Fungicides	70.01	56,008.00	2.29
Adjuvants	37.75	30,200.00	1.23
Periodic maintenance	20.00	16,000.00	0.65
Kitchen expenses	18.75	15,000.00	0.61
<i>Total inputs</i>	1,182.93	946,344.00	38.62
<i>Mechanized operations</i>			
Fertilization and seeding	18.07	14,456.00	0.59
Application with machines	23.22	18,576.00	0.76
Harvest and transport	170.00	136,000.00	5.55
Post-harvest management	3.87	3,096.00	0.13
<i>Total mechanized operations</i>	215.16	172,128.00	7.02
<i>Other costs</i>			
Seasonal labor	30.00	24,000.00	0.98
Divers costs <sup>b</sup>	18.72	14,976.00	0.61
Technical assistance	24.00	19,200.00	0.78
Fethab/Facs <sup>c</sup>	91.35	73,082.03	2.98
Funrural <sup>d</sup>	52.20	41,760.00	1.70
<i>Total costs (others)</i>	216.27	173,018.03	7.06
<b>SUBTOTAL I</b>	<b>1,614.36</b>	<b>1,291,490.03</b>	<b>52.70</b>
<b>II – Fixed costs</b>			
<i>Payback of fixed costs</i>			
Lime placed on the farm	52.50	42,000.00	1.71
Fixed labor	82.94	66,349.66	2.71
Management	20.00	16,000.00	0.65
Leasing (opportunity costs)	480.00	384,000.00	15.67
<i>Total payback of fixed costs</i>	635.44	508,349.66	20.74
<i>Fixed costs CCS</i>			
Insurance machines and equipments	41.18	32,940.00	1.34

Depreciation of machines and equipments	343.13	274,500.00	11.20
Depreciation of premises	25.00	20,000.00	0.82
<i>Total fixed costs CCS</i>	409.31	327,440.00	13.36
Interests on CCS	263.39	210,714.67	8.60
SUBTOTAL II (except interests on CCS)	1,044.75	835,789.66	34.10
TOTAL (I+II) (except interests on CCS)	2,659.11	2,127,279.69	86.80
Interests on WC	140.88	112,703.92	4.60
III – Interests (CCS + WC)	404.27	323,418.59	13.20
TOTAL COSTS (I+II+III)	3,063.38	2,450,698.28	100.00

Source: original results of research

<sup>a</sup> % of item on total costs; <sup>b</sup> relative costs to soil correction; <sup>c</sup> State Fund for Transport and Housing/Fund pro soybean crop; <sup>d</sup> Fund for the Assistance of the Rural Worker.

Variable costs in percentage were predominantly represented in production total costs (53 %), with inputs ranking first in financial expenditures (39 %), mainly fertilizers, (seeding, fertilizers and micronutrients) with 20 % and seeds, with 9 % (Table 2). The great importance of fertilizers and seeds in production costs may be surmised from the fact that they are responsible for R\$ 609.85 and R\$ 271.08 per hectare, respectively. Royalties have been included in seed costs at R\$ 144.00 ha<sup>-1</sup>. Fixed costs amount to 34 % of total costs, with 21 % of non-payable fixed costs, with the greatest part related to leasing (16 %) and 13 % to capital stock, specifically depreciation of machines and equipments at (11 %).

When production costs and profitability of soybean (2013-2014 harvest) for southeastern Mato Grosso are taken into account, [8] reported total costs at R\$ 2,609.90 ha<sup>-1</sup>, with R\$ 1,868.52 for real operational costs (R\$ 1,355.14 for inputs; R\$ 460.23 for activities, and R\$ 53.14 for labor) and R\$ 741.40 for other costs (depreciation, general expenditure, technical assistance, taxes on labor, contribution to social security, financial changes, taxes and trading expenditures). Inputs had the highest percentage (52 %) in total costs, with fertilizers ranking first (26 %), followed by insecticides (9 %), fungicides (7 %) and seeds (6 %).

[24] analyzed soybean production costs in the state of Mato Grosso, Brazil, for the 2014-2015 harvest, and underscored a total cost of R\$ 2,295.98 ha<sup>-1</sup>, with R\$ 1,484.97 for inputs and R\$ 811.01 for other fixed and variable costs. In the case of intakes, with 65 % of total production costs, the items with the highest percentages were fertilizers (39 %), insecticides (19 %), seeds (14 %), fungicides (11 %) and herbicides (10 %).

In the case of the second crop (sunflower/2018 harvest), total production costs reached R\$ 582,803.38 (Table 3), divided into R\$ 535,168.00 for variable costs and R\$ 47,635.38 for interests on working capital alone, due to the fact that fixed costs were allotted to the main crop. Rates per hectare were R\$ 1,457.01; R\$ 1,337.92 and R\$ 119.09, respectively.

**Table 3. Annual production costs for sunflower crop in the 2018 harvest. Diamantino**

**MT Brazil, 2018**

Item	R\$ ha <sup>-1</sup>	Total (R\$ 400 ha <sup>-1</sup> )	% <sup>a</sup>
<b>I – Variable costs</b>			
<i>Inputs</i>			
Seeds	155.17	62,068.00	10.65
Seed treatment	18.72	7,488.00	1.28
Fertilizer seeding	256.67	102,668.00	17.62

Covering fertilizer (N)	149.00	59,600.00	10.23
Micronutrients (B)	62.40	24,960.00	4.28
Herbicides	107.75	43,100.00	7.40
Insecticides	141.33	56,532.00	9.70
Fungicides	112.63	45,052.00	7.73
Periodic maintenance	10.00	4,000.00	0.69
Kitchen expenses	9.40	3,760.00	0.65
<i>Total inputs</i>	<i>1,023.07</i>	<i>409,228.00</i>	<i>70.22</i>
<i>Mechanized operations</i>			
Pre-seeding management	30.00	12,000.00	2.06
Fertilization and seeding	45.00	18,000.00	3.09
Applications with machines	100.00	40,000.00	6.86
Harvest and transport	85.00	34,000.00	5.83
<i>Total mechanized operations</i>	<i>260.00</i>	<i>104,000.00</i>	<i>17.84</i>
<i>Other costs</i>			
Diverse Costs <sup>b</sup>	9.35	3,740.00	0.64
Technical assistance	14.00	5,600.00	0.96
Funrural <sup>d</sup>	31.50	12,600.00	2.16
<i>Total costs (others)</i>	<i>54.85</i>	<i>21,940.00</i>	<i>3.76</i>
SUBTOTAL I	1,337.92	535,168.00	91.83
II – Fixed costs	-	-	-
<i>Payback fixed costs</i>	-	-	-
<i>Payback total fixed costs</i>	-	-	-
<i>Fixed costs CCS</i>	-	-	-
<i>Total fixed costs CCS</i>	-	-	-
SUBTOTAL II (except interests on CCS)	-	-	-
TOTAL (I+II) (except interests on CCS)	1,337.92	535,168.00	91.83
III – Interests on WC	119.09	47,635.38	8.17
Total costs (I+II+III)	1,457.01	582,803.38	100.00

189 *Source: original results of research*

190 <sup>a</sup> % item on total costs; <sup>b</sup> relative costs to soil correction; <sup>c</sup> Fund for the Assistance of the  
191 Rural Worker.

192 Variable costs almost reached total production costs (92 %), with inputs impacting crops (70  
193 %) with highest rates for fertilizers (32 %) and seeds (11 %) (Table 3); remaining costs  
194 comprised interests on working capital (8 %), corroborated by [12]. In fact, fertilizers and  
195 seeds amounted to R\$ 468.07 and R\$ 155.17 ha<sup>-1</sup>, respectively.

196 [25] analyzed the technical and economic viability of irrigated sunflower crop in Lavras  
197 region in the state of Minas Gerais, Brazil, and reported that the most relevant factors for  
198 increased fixed costs (25 %) were machines and equipments (17 %), followed by alternative  
199 costs (7 %), labor (5 %) and general expenditure/administration (3%). In the case of variable  
200 costs (75 %), the most relevant were fertilizers (41 %), general expenditure/post-harvest (7  
201 %) and alternative costs (4 %).

202 Further, [26] assessed costs and profitability in sunflower production in the state of Mato  
203 Grosso, Brazil, for the 2013-14 harvest and calculated total costs at R\$ 1,385.65 ha<sup>-1</sup>, with  
204 relevant costs for fertilizers (53 %), followed by machine (34 %) and manual (3 %) activities,  
205 transport and a month payment for storage (3 %). In total expenditure for inputs (R\$ 737.99  
206 ha<sup>-1</sup>), fertilizer expenses reached almost 64 %, whereas expenditure in pesticides and seeds  
207 were 30 % and 7 %, respectively. In the case of expenditure with machinery (R\$ 467.50 ha<sup>-1</sup>

208 <sup>1</sup>), the harvest had the biggest share (32 %) and expenditure with sowing and fertilizing  
 209 reached 25 %.

210 Further, the economic analysis of soybean and sunflower production determined several  
 211 economic indexes, together and alone (Table 4). For example, mean income reached R\$  
 212 3,480.00 per hectare for soybean and R\$ 2,100.00 for sunflower, with total yearly income at  
 213 R\$ 2,784,000 and R\$ 840,000, respectively. Costs per soybean sack produced were  
 214 composed of R\$ 30.26 total variable cost and R\$ 21.38 total fixed cost, with R\$ 51.64 total  
 215 costs, and a profit of R\$ 8.36 (R\$ 484.73 ha<sup>-1</sup>).

216 **Table 4. Economic analysis (costs and profit) for soybean and sunflower crops for**  
 217 **2017-2018 harvest. Diamantino MT Brazil, 2018**

Items	Soybean	Sunflower
Area (ha)	800	400
Productivity (sacks ha <sup>-1</sup> )	58	30
Production (sacks)	46,400	12,000
Price (R\$ sack <sup>-1</sup> )	60.00	70.00
Mean income (R\$ ha <sup>-1</sup> )	3,480.00	2,100.00
Mean weighted income (R\$ ha <sup>-1</sup> )	4,530.00	
Total income (R\$)	2,784,000.00	840,000.00
Initial mean VC (R\$ ha <sup>-1</sup> )	1,300.81	1,221.42
WC (R\$)	1,155,937.66	488,568.00
Interests on WC (R\$)	112,703.92	47,635.38
Total VC (R\$)	1,404,193.95	582,803.38
PFC (R\$)	499,289.66	-
FC CCS (R\$)	2,790,096.00	-
ROC (R\$)	1,903,483.60	582,803.38
Total FC (R\$ ha <sup>-1</sup> )	1,240.03	-
TC (R\$ ha <sup>-1</sup> )	2,995.27	1,457.01
Weighted TC (R\$ ha <sup>-1</sup> )	3,723.78	
TC (R\$ sc <sup>-1</sup> )	51.64	48.57
TP (R\$ ha <sup>-1</sup> )	484.73	642.99
Weighted TP (R\$ ha <sup>-1</sup> )	806.23	
Total FC (R\$ sc <sup>-1</sup> )	21.38	-
Total VC (R\$ sc <sup>-1</sup> )	30.26	48.57
TVC (R\$ ha <sup>-1</sup> )	1,755.24	1,457.01
GCM (R\$)	1,379,806.05	257,196.62
GCM (R\$ ha <sup>-1</sup> )	1,724.76	642.99
CMI (%)	49.56	30.62
TOCM (R\$)	880,516.40	257,196.62
TOCM without leasing (R\$)	753,713.02	
EBITDA (R\$)	880,516.40	257,196.62
Total annual profit (R\$)	387,785.73	257,196.62
Profit range (ML) (%)	21.50	30.62
Annual total WC + interests (R\$)	1,268,641.59	536,203.38
Total Investments (R\$)	5,186,310.27	582,803.38
Equilibrium point area (PEA) (ha)	575.17	-
Equilibrium point productivity (PEProd) (sack ha <sup>-1</sup> )	49.92	20.81
Equilibrium point production (PEPr) (sack)	33,359.57	-
Equilibrium point income (PER) (R\$)	2,001,574.48	-

**Comment [t5]:** How can we compare two commodities with different land areas. In addition, two commodities with intercropping and monoculture patterns will be analyzed differently. You have explained it in detail, but I cannot understand it



Equilibrium point price (PEP) (R\$ sack <sup>-1</sup> )	51.64	48.57
Equilibrium income (REq) (R\$)	3,076,215.47	

218 *Source: Original research results*

219 In the case of sunflower crop, each sack comprised R\$ 48.57 of total variable costs, or  
 220 rather, total costs, with a profit of R\$ 21.43 (selling price R\$ 70,00 sack<sup>-1</sup>) or R\$ 642.99 ha<sup>-1</sup>  
 221 (Table 4). The above demonstrates a 33 % complementary profit per unit (hectare) with  
 222 sunflower crop higher than that of soybean. Since the above was due to the fact that all fixed  
 223 costs belonged to soybean, producers have to exploit maximum of economic return of this  
 224 activity, with two crops per year (investment in fixed capital will not change). Further,  
 225 soybean and sunflower crop system has the best environmental performance when  
 226 compared with monocultures, due to possible synergies, sharing land use and other  
 227 resources, such as the advantages of associating nitrogen-fixing legumes (soybean) with  
 228 other plant species [27,10].

229 [25] investigated the technical and economic viability of sunflower production in irrigated and  
 230 non-irrigated conditions and reported that payback in productivity increase was due to  
 231 irrigation. In non-irrigated conditions, mean total cost was R\$ 32.71 sacks<sup>-1</sup>. If the land were  
 232 to be left fallow during the between-harvest period, it would be an asset to invest in  
 233 sunflower crop. The producer would be paying the crop's variable costs and part of the fixed  
 234 ones already invested in the main activity. This would contribute towards soil coverage and  
 235 decrease in weed infestation, enhancing the soil's conservationist system. Further, [26]  
 236 reported a gross income of R\$ 1,590.00 ha<sup>-1</sup>, operational profit of R\$ 204.35 ha<sup>-1</sup> and a 13 %  
 237 profit index for a mean productivity of 30 sacks ha<sup>-1</sup> at a unit selling price of R\$ 53.00. The  
 238 above data corroborated profitability in sunflower production worldwide [18,28,12].

239 Gross contribution range for soybean reached R\$ 1,379,806.05 (R\$ 1,724.76 ha<sup>-1</sup>), with a 50  
 240 % contribution range index and a real operation contribution range of R\$ 880,516.40 (Table  
 241 4). In the case of sunflower crop, rates reached R\$ 257,196.62 (R\$ 642.99 ha<sup>-1</sup>), 31 % and  
 242 R\$ 257,196.62, respectively. Producer will earn R\$ 753,713.02 when total real operational  
 243 contribution range (soybean + sunflower) minus opportunity costs with leasing is calculated.  
 244 Likewise, [8] obtained a gross income for soybean of R\$ 2,815.98 ha<sup>-1</sup> (54.42 sacks ha<sup>-1</sup> x  
 245 R\$ 51.75 sacks<sup>-1</sup>), with a gross range of 8 %, operational profit of R\$ 206.08 ha<sup>-1</sup> and profit  
 246 index of 7 %.

247 Discarding interests, taxes, depreciation and mortgage (EBITDA), profits were R\$  
 248 880,516.40 and R\$ 257,196.62 respectively for soybean and sunflower (Table 4). However,  
 249 after tabulating interests, taxes, depreciation and mortgage, profits were respectively R\$  
 250 387.785,73 and R\$ 257,196.62, with 22 and 31 % profit ranges.

251 The highly important equilibrium point should be analyzed and performed since production at  
 252 the equilibrium point is sufficient to cover costs of activities, or rather, profit amounts to zero.  
 253 In this case, the equilibrium point with regard to area, productivity, production, income and  
 254 price for soybean amounted to 575.17 ha, 49.92 sacks ha<sup>-1</sup>, 33,359.57 sacks, R\$  
 255 2,001,574.48 and R\$ 51.64 sack<sup>-1</sup> (Table 4), whereas for the equilibrium points for sunflower  
 256 were 20.81 sacks ha<sup>-1</sup> and R\$ 48.57 sacks<sup>-1</sup>, respectively, and income from combined  
 257 equilibrium (soybean + sunflower) reached R\$ 3,076,215.47. [8] elaborated an economic  
 258 analysis for soybean and reported equilibrium points 50.43 sacks ha<sup>-1</sup> and 47.96 R\$ sacks<sup>-1</sup>,  
 259 respectively, for productivity and selling price.

260 The above variations corroborate current study and that by [26]. The later stated that the  
 261 producer must produce at least 26 sacks to cover total costs or produce 30 sacks ha<sup>-1</sup>, and  
 262 receive at least R\$ 48.41 sack<sup>-1</sup> to cover costs.

263 It is a well-known fact that production costs of any activity is one of the issues with which  
 264 rural producers have to cope with. In fact, they have to determine the manner of production  
 265 within a determined range of production costs that would be an asset according to market  
 266 prices. These studies and their results demonstrate that the producer has to efficiently  
 267 manage the acquisition of fertilizers (with high representativeness in the costs sheet) and  
 268 harvest not merely on costs but also in efficiency and in the minimization of losses in the  
 269 field, as insisted upon by [26].

270 In the case of the analysis of sensitiveness through simulated scenarios (the best and the  
 271 worst) to compare with the real scenario (base), one should note the behavior of the financial  
 272 indicators (TI, NCR, EUAR, PIR, PI) and define the limit of variation so that the activity could  
 273 be still worthwhile. Therefore, for a combined analysis (soybean + sunflower) at the base  
 274 scenario (Table 5), indicators show a retrieval of R\$ 3,624,000.00 per year; R\$  
 275 1,468,917.29; R\$ 334,807.04; 18 %; 33 % and 4.63 years, respectively.

276 **Table 5. Synthesis of financial indexes of total annual income (TI), Net Current Rate**  
 277 **(NCR), Equivalent Uniform Annual Rate (EUAR), Payback Internal Rate (PIR), Profit**  
 278 **Index during the period (PI) and discounted payback (DPB) for the analysis of**  
 279 **sensitiveness with regard to variations ( $\Delta$ ) in price (Pr), productivity (Prod), Real**  
 280 **Operational Costs (ROC) and income (I) for soybean (S) and sunflower (F) crops.**  
 281 **Diamantino MT Brazil, 2018**

$\Delta Pr$ (R\$ $sc^{-1}$ )			Financial Indexes					
$\Delta$ (%)	PrS	PrF	TI (R\$) (1000)	NCR (R\$) (1000)	EUAR (R\$) (1000)	PIR (%)	PI (%)	DPB (years)
-30	42.0	49.0	2,536.8	-	-469.87	-2.91	-46.56	6.40
-15	51.0	59.5	3,080.4	-296.27	-67.53	7.98	-6.69	5.77
0	60.0	70.0	3,624.0	1,468.92	334.81	18.37	33.12	4.63
15	69.0	80.5	4,167.6	3,234.11	737.14	28.40	72.87	3.21
30	78.0	91.0	4,711.2	4,999.30	1,139.48	38.18	112.55	2.59
$\Delta Prod$ (sacks $ha^{-1}$ )								
	ProdS	ProdF						
-30	40.6	21.0	2,536.8	-	-556.82	-5.31	-55.09	6.75
-15	49.3	25.5	3,080.4	-487.01	-111.00	6.83	-10.98	5.90
0	58.0	30.0	3,624.0	1,468.92	334.81	18.37	33.12	4.63
15	66.7	34.5	4,167.6	3,424.85	780.62	29.49	77.23	3.07
30	75.4	39.0	4,711.2	5,380.78	1,226.43	40.32	121.34	2.44
$\Delta ROC$ (R\$ $ha^{-1}$ )								
	ROC S	ROC F						
-30	1,665.55	1,019.91	3,624.0	4,250.51	968.81	34.09	95.85	2.92
-15	2,022.45	1,238.46	3,624.0	2,859.72	651.81	26.31	64.49	3.50
0	2,379.35	1,457.01	3,624.0	1,468.92	334.81	18.37	33.12	4.63
15	2,736.26	1,675.56	3,624.0	78.12	17.81	10.22	1.76	5.52
30	3,093.16	1,894.11	3,624.0	-	-299.20	1.79	-29.60	6.51

Comment [t6]: table title should be simple, it is too long and not good. In addition, tables cannot be separated.

	$\Delta I$ (R\$ ha <sup>-1</sup> )								
	I S	I F							
-30	2,435.00	1,470.00	2,536.0	-	2,585.53	-589.31	-6.22	-58.30	6.88
-15	2,958.00	1,785.00	3,080.4	-558.30	-127.25	6.40	-12.59	5.95	
0	3,480.00	2,100.00	3,624.0	1,468.92	334.81	18.37	33.12	4.63	
15	4,002.00	2,490.00	4,197.6	3,496.14	796.87	29.89	78.84	3.02	
30	4,524.00	2,730.00	4,711.2	5,523.36	1,258.93	41.10	124.55	2.39	

282 *Source: Original research results.*

283 When there is a -15 % (worst scenario) variation in the prices of agricultural products, the  
284 sensitiveness of the activity is revealed. In other words, financial indexes have a negative  
285 behavior (Table 5), with the exception of TI (decrease) and NCR (8 %) which decrease  
286 somewhat below the minimum attractiveness rate (MAR). This shows that the activity covers  
287 costs but fails to recompense entirely the investor at the rate of 9.75 % p.a. Or rather, the  
288 activity should be discarded or, at least, the investor may opt for a lower MAR or equal to  
289 PIR. Moreover, DPB reached 5.77 years. It goes without saying that a -30 % scenario makes  
290 conditions more negative still.

291 However, for the best scenarios (15 and 30 %), profits with regard to base scenario were  
292 encouraging, at TI = R\$ 4,711,200.00 for a 30 % variation, featuring NCR, EUAR, PIR, PI  
293 during the period, and DPB at R\$ 4,999,299.80; R\$ 1,139,479.25; 39 %; 113 % and 2.59  
294 years, respectively (Table 5).

295 Although income for productive variation was stable with regard to price and income  
296 variations (Table 5), there was a change in other financial indexes. This is due to the fact  
297 that taxes Fethab/Facs (for soybean) + Funrural are applied on productivity/production.  
298 Therefore, in the case of a -15 % variation, there was a lack of attractiveness for the activity:  
299 NCR, EUAR and PI were negative, in contrast to the best scenarios. In fact, rates reached  
300 R\$ 5,380,780.62; R\$ 1,226,429.32 and 121 % for the above-mentioned indexes, besides  
301 PIR at 40 % and DPB of 2.44 years.

302 When the worst variation (15 %) was taken into account in the real operational costs (ROC),  
303 activity remained feasible (Table 5), albeit with reduced paybacks (NCR, EUAR, PIR and PI,  
304 during the period) and increased DPB (5.52 years) with regard to base scenario. However,  
305 the activity should be disregarded when the scenario changes from 15 to 30 %, due to the  
306 negativity of the indexes. However, this was not reported for the best variations at scenarios  
307 (-15 and -30 %). Regardless of these scenarios, incomes were constant since they did not  
308 depend on ROC but merely on productions and on grain prices

309 Negative variations (-15 and -30 %) in the crop income demonstrated a lack of attractiveness  
310 of the activity (Table 5), whereas positive variations improved paybacks, with NCR and  
311 EUAR increasing 3.7 times for the 30 % variation with regard to base scenario. Moreover,  
312 NCR, PI and DPB increased to 41 %, 125 % and 2.39 years, respectively.

313 Each and every plantation has its own peculiarities with regard to topography, physical  
314 conditions, soil fertility, type of machines, planted area, technological level and even  
315 management. All these items differentiate the structure and rates of production costs. Costs  
316 may be different and the equilibrium point may vary according to alterations in production  
317 costs or in the product's price, with greater or lesser profitability. Every producer must  
318 calculate his production costs, even though assessments as analyzed in current study may  
319 contribute for decision-taking.

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#### 4. CONCLUSIONS

Within the proposed system, a farm may be feasible with a total annual income of R\$ 3,624,000.00, net rate R\$ 1,468,920.00, annual equivalent uniform rate R\$ 334,810.00, internal payback rate 18 %, profitability index at 33 % and discounted payback of 4.63 years, at the end of a six-year period.

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However, a 15 % negative variation in price, productivity and income and a 30 % positive variation in real operational costs of the two crops make the project unfeasible, especially due to negative net rate.

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Complementary profit per hectare for sunflower crop is 33 % higher than that of soybean, since fixed costs are paid by soybean, suggesting two crops per year.

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The method for the application of production costs employed in current research is highly relevant since it provides a good evaluation on the implementation project with an adequate diagnosis for decision-taking by the producer. In fact, current research is a contribution to the producer since it provides more profitable alternatives to the planning of soybean production, with dilution of costs and income increase.

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#### COMPETING INTERESTS

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Authors have declared that no competing interests exist.

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**Comment [t7]:** What are your recommendations related to the results of a sensitivity analysis of the feasibility of soybean and sunflower business? It is very important and interesting.

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Comment [t8]: 29

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