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ECONOMIC FEASIBILITY ANALYSIS OF ROCK-BASALT DUST FOR SOYBEAN PRODUCTION IN THE DOURADOS/MS

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ABSTRACT - With the hypothesis that the use of rock dust is an economically viable alternative for supplementary fertilization in the soybean crop in the region of Dourados, Mato Grosso do Sul (MS), this study evaluated the use of rock dust in the soybean crop, taking into account the relationship between productivity and cost of production. The experiment was installed with the application of rock dust (0, 2.5, 5.0, 7.5, and 10 Mg ha^{-1}) in soybean cultivation. Productivity, production cost, and economic viability indicators were monitored and calculated. Results showed that the application of rock dust positively influenced the total revenue, as well as the gross margin and net margin of the treatments, allowing a higher rate of return on the producer's investments. With the application of doses greater than 2.5 Mg ha^{-1} of rock dust, a higher total revenue could be obtained, however, there was a lower value of gross margin, net margin, leveling price, and leveling point components. Therefore, conclude that the application of up to 2.5 Mg ha^{-1} is a viable alternative to increase soybean profitability in the region of Dourados/MS.
Keywords: productivity, fertilizers, igneous rock, economic indicators.

ANÁLISE DE VIABILIDADE ECONÔMICA DO PÓ DE ROCHA-BASALTO PARA A PRODUÇÃO DE SOJA EM DOURADOS/MS

RESUMO - Com a hipótese que a utilização de pó de rocha é uma alternativa economicamente viável para a adubação complementar na cultura da soja na região de Dourados, Mato Grosso do Sul(MS), este estudo busca avaliar a utilização do pó de rocha na cultura da soja levando em consideração a relação entre a produtividade e o custo de produção. O experimento foi instalado com a aplicação de doses de pó de rocha (0; 2,5; 5,0; 7,5 e 10 Mg ha^{-1}) no cultivo da soja. A produtividade, custo de produção e indicadores de viabilidade econômica foram monitorados e calculados. Resultados demonstraram que a aplicação do pó de rocha influenciou positivamente a receita total, bem como a margem bruta e margem líquida dos tratamentos, permitindo uma maior taxa de retorno aos investimentos do produtor. Com a aplicação de doses maiores que 2,5 Mg ha^{-1} de pó de rocha, observou uma maior receita total entre os tratamentos, no entanto apresentaram menor valores de margem bruta, margem líquida, preço de nivelamento e ponto de nivelamento. Portanto, conclui que a aplicação até 2,5 Mg ha^{-1} é uma alternativa viável para aumentar a rentabilidade da soja na região de Dourados/MS.
Palavras-chaves: produtividade, fertilizantes, rocha ígnea, indicadores econômicos.

INTRODUCTION

The Brazilian soybean production was 369 million tons with a productivity of 3,392 kg ha^{-1} in 2022/23, considered Brazil one of the largest soybean producers and highlighting the importance of soybeans in the economy Brazilian (CONAB, 2023). With such a promising scenario for soybean cultivation, one point that causes concern for producers and the market is the cost of soybean production. In the state of Mato Grosso do Sul, there was an average annual growth of 12% in the cost of soybean production in the period from 2014/2015 to 2018/2019, this increase is due to the increase in input prices, mainly fertilizers (RICHETTI, 2019).

The supply of fertilizers produced in Brazil is lower than the demand for national production. Currently, Brazil is the second largest consumer of agricultural fertilizers in the ranking of global consumers. China is the first consumer of agricultural fertilizers. In Brazil, 70% of the fertilizers consumed are imported and soybean is the greatest demand for applied fertilizers (OLIVEIRA et al., 2019).

The use of dusty rock is presented as an alternative or complement to the use of fertilizers. Rocking is a technique that aims to apply dust from rocks or minerals to supplement minerals for plant nutrition. Currently, in Brazil, the use of rock with basalt is gaining prominence, due to the high concentration of cations in the rock structure and the lower resistance to weathering compared to other igneous rocks such as granite. Welter et al. (2011) demonstrated that the use of rock with basalt promoted an improvement in the quality of camu-camu (*Myrciaria dubia*) seedlings, recommending the application of doses between 4 and 8 Mg kg^{-1}, with particle size 0. 05 mm. Rocking with basalt improves the levels of acidity, moisture content, and biological activity of the soil. Igneous and metamorphic rocks can be used as a source of essential

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nutrients for plant development (BRITO et al., 2019), but it is necessary to determine the nutrients' release and concentration. Fertilizers based on potassium, phosphorus, and nitrogen are those most consumed in Brazil, therefore, rock can be an alternative source of potassium and phosphorus depending on the type of rock/mineral (OLIVEIRA et al., 2019). The use of rock powder also increases carbon and nitrogen mineralization, benefiting nutrient cycling over time, and positively influencing base sum values, cation exchange capacity, and pH balance (ALOVISI et al., 2020).

One of the negative aspects of using rockwork is the need to apply large amounts of rock dust to the soil. Rock dust is commonly sold as a mining byproduct, with prices differing from state to state, influenced by availability, transportation distance, interstate or intercity taxes, and type of rock. The need to apply large quantities, combined with the fluctuation in the price of the product, shows the importance of carrying out a study that analyzes its economic viability in terms of crop production costs. The objective of this work was to evaluate the use of rock dust in soybean cultivation, as a complementary fertilizer and the relationship between productivity and production cost.

MATERIAL AND METHODS

Characterization of the experimental area

The experiment was carried out at the Agricultural Sciences Experimental Farm (54º 59' 13" W; 22º 14' 08" S; and altitude of 434 m), at the Federal University of Grande Dourados (UFGD). The Dourados region has a climate classified as Cwa (humid subtropical climate, with dry winters and hot summers), with annual average temperatures of 22º C and precipitation varying between 500 and 1500 mm (FIETZ et al., 2017).

The experimental area has soil classified as Distroferric Red Oxisol, with a very clayey texture (SANTOS et al., 2013). The area has been cultivated with grains since the 2016/2017 harvest in a conventional planting system, with plowing and harrowing to incorporate crop residues. The Dourados region is located in a region with a rocky substrate, made up of basic eruptive rocks that make up the Serra Geral Formation, where there is a predominance of basalt.

According to the mining report in Mato Grosso do Sul, basalt was the 5th substance in revenue from the Financial Compensation for the Exploration of Mineral Resources (CFEM, 2017). In Dourados there are 4 basalt mining companies and the greater Dourados region is made up of 12 municipalities, including Dourados, Itaporã, Caarapó, Rio Brilhante, and others (CFEM, 2022).

Experimental design

Soybean production cost data were obtained in an experiment, conducted with five doses of basalt rock (0, 2.5, 5.0, 7.5, and 10 Mg ha^{-1}). The application of rock dust was carried out on the surface, 30 days before soybean sowing. For soybean sowing, the Monsoy 6410 IPRO variety was used, inoculated with a mixture of *Bradyrhizobium japonicum strains*, using a fertilizer seeder equipped with seven rows, using a spacing of 0.45 m between rows, at a sowing density of 16 plants m^{-1}. The plots were made up of 15.75 m^2, with seven lines spaced between 0.45 m and 5 m in length. In the plots where the treatment consisted of additional chemical fertilization, 200 kg ha^{-1} of 5-25-6 was placed.

During the experiment, weekly analyses were carried out to diagnose the presence of diseases, weeds, and pests. Visual diagnosis methodology was used, combined with the use of a beating cloth to sample pests. For weeds, control was used through the application of glyphosate and pest control with Thiamethoxam + Lambda-Cialothrin, at a concentration of 200 mL ha^{-1}. The harvest was carried out 115 days after planting, to determine grain productivity.

To determine crop productivity, grain productivity (with moisture correction to 13%), plant height (cm, 10 plants per plot), and number of seeds per legume (5 plants per plot) were analyzed. The data were analyzed using the analysis of variance test (ANOVA; $P = 0.05$), and the dose means were compared using the Regression test using a 5% probability of error. The models for adjusting the equations were chosen based on the coefficient of determination and significance ($P<0.05$). Data were analyzed using the statistical program R (version 4.0.0, Auckland, New Zealand).

Production costs

To determine the costs, we used the production cost table for soybean crops, RR, and IPRO technologies, developed by EMBRAPA (GARCIA; RICHETTI, 2019). The table is divided into input costs, agricultural operations, administrative costs, maintenance, effective operating costs, total operating cost, and total cost, which also includes factor remuneration. To adapt to the object of study, the table was organized into variable costs, fixed costs, total operational costs, and total costs.

Variable costs are those that vary proportionally to the level of activity, considering the costs of purchasing inputs (seeds, inoculants, pesticides, and fertilizers), agricultural operations (distribution of correctives, sowing, and harvesting), and administrative costs (technical assistance, administration, insurance, interest on costs, taxes, external transport, and storage). The costs of applying inputs, agricultural operations, and administrative costs were the same between doses of rock dust.

Monitoring of rock dust, seed, fertilization, and transportation costs were obtained from suppliers in the region. The cost of rock dust was monitored for collection at the local mining company (Cost: R$50.00 ton^{-1}). Therefore, it was necessary to hire a freight carrier to carry out the transport. The platform of the Treasury Department of the state of Mato Grosso do Sul provides a calculator to simulate the minimum freight value, simulating the following information: a) type of transport (agriculture), b) types of installments (internal), c) weight (1000 kg), d) month/year of installment, e) distance (100 km between the mining company and the area under study). The simulation result for the information described was an average of

R$ 23.97 ton^{-1}. To determine the cost of purchasing rock powder, depending on the dose (Equation 1).

$$\text{CPRD} = (CRD + CFC)R \quad \text{(Equation 1)}$$

Where:
CPRD = cost of purchasing rock dusty (R$ ha^{-1})
CRD = cost of rock dusty (R$ 50,00 ton^{-1})
CFC = cost of freight carrier (R$ 23,97 ton^{-1})
R = rate of rock dusty (Mg ha^{-1})

As fixed costs are those least likely to change, fixed costs were calculated for improvements and depreciation (R$ 175.85)

Economic indicators

The cost of effective operating (CEO) was calculated (Equation 2), taking into account the cost of all production resources, requiring disbursement by the producer for their recovery, that is, understood as expenses, which, effectively, incur directly in the conduct of the activity.

$$\text{CEO} = (CI + CAO + AC + CIA) \quad \text{(Equation 2)}$$

Where:
CEO = cost of effective operating (R$ ha^{-1})
CI = cost of inputs (R$ ha^{-1})
CAO = cost of agricultural operations (R$ ha^{-1})
AC = administrative cost (R$ ha^{-1})
CIA = cost of improvements and maintenance (R$ ha^{-1})

The cost of total operating (CTO) was defined as the cost to the producer in the short term, for production and replacement of machinery, improvements, and the crop itself. The determination of the value of this cost was calculated by adding the value of depreciation to the effective operating cost, using Equation 3.

$$\text{CTO (R\$ ha}^{-1}) = (CEO + DP) \quad \text{(Equation 3)}$$

Where:
CTO = cost of total operating (R$ ha^{-1})
CEO = cost of effective operating (R$ ha^{-1})
DP = depreciação dos equipamentos e estruturas (R$ ha^{-1})

Total cost (TC) was the amount spent for all factor remunerations, dealing with the capital tied up in the activity, that is, since the use of this capital in the company occurs in another alternative activity (Equation 4). The remuneration of capital deals with the estimation of the opportunity cost, based on the return that the capital has been invested in another way, other than in the company, such as, for example, if it were invested in the financial market. In the renumbering of factors, an interest of 7.23% p.y (per year) was used.

$$\text{CT} = (CEO + FC) \quad \text{(Equation 4)}$$

Where:
CTO = cost of total operating (R$ ha^{-1})
CEO = cost of effective operating (R$ ha^{-1})
RM = factor compensation (R$ ha^{-1})

The leveling point and leveling price are values that express equality between total cost and total revenue. At the leveling point, no profit or loss would be the quantity to be produced. However, the leveling price brings the minimum sales value of the product, depending on production, for the total cost to be paid. These two indices can be used in the components, such as total and effective operational cost, in addition to the total cost, determining the minimum value and guaranteeing production, without losses.

In Equation 5, the leveling price was determined by dividing the total cost of that component by the selling price of the bag of soybeans

$$\text{PTN} = {TCC}/{PS} \quad \text{(Equation 5)}$$

Where:
PTN = leveling price and quantity produced so that no financial losses occur
TCC = total cost of the component (R$ ha^{-1})
PS = price of a bag of soybeans (R$ 60 kg)

The leveling price was calculated to demonstrate the minimum value that each unit of production should be sold, in proportion to what was produced, so that no losses would occur (Equation 6).

$$\text{P\$N} = {TCC}/{PO} \quad \text{(Equation 6)}$$

Where:
P$N = leveling price,
TCC = total cost of the component (R$ ha^{-1})
PO = productivity obtained (bag ha^{-1})

The gross margin indicates the profitability from the sale of a product or service, after discounting expenses related to production and marketing. The net margin expresses the surplus value of sales after all costs have been deducted, including income tax. The gross margin and net margin were calculated using cost data. The gross margin (Equation 7) was sized, taking into account data on total production revenue and production operating cost and net margin (Equation 8), data on total production revenue and total operating cost.

$$\text{Gross margin (R\$ ha} - 1) = (TPR - CEO) \quad \text{(Equation 7)}$$

$$\text{Net margin (R\$ ha} - 1) = (TPR - CTO) \quad \text{(Equation 8)}$$

Where:
TPR = total production revenue,
CTO = cost of total operating (R$ ha^{-1})
CEO = cost of effective operating (R$ ha^{-1})

The rate of return took into account the relationship between net income and total cost, expressing what percentage of profit is generated, depending on the cost (GARCIA; RICHETTI, 2017) (Equation 9).

$$\text{TR} = \left({}^{RT}/_{TC} - 1\right) * 100 \quad \text{(Equation 9)}$$

Onde:
TR = rate of return,
RT = total production revenue (R$ ha^{-1}) e
TC = total cost (R$ ha^{-1}).

RESULTS AND DISCUSSION

Production Cost Analysis

The lowest production cost was estimated at R$ 2,847.69 ha^{-1} for the cultivation of Monsoy 6410 IPRO soybean without the application of rock dust (Table 1). When the dusty rock was applied, the production cost increased by R$ 3,032.62 (2.5 Mg ha^{-1}), R$ 3,217.54 (5.0 Mg ha^{-1}), R$ 3,402.47 (7.5 Mg ha^{-1}) and R$ 3,463.86 (8.33 Mg ha^{-1}), with an average increase in production cost equivalent to 6.5%, 12.9%, 19.5% and 21.6%, respectively. This production cost value is close to those found by Richetti (2019) for the cultivation of RR soybeans, IPRO, and conventional soybeans, in the 2019/2020 harvest, with average total costs of R$ 3,405.70; 3,448.41 and 3,546.10 ha^{-1}, respectively, without the application of rock dust. In the Mato Grosso region, the average cost of R$3,770.47 ha^{-1} was monitored by Imea for conventional soybean production (IMEA, 2020).

The total operating cost made up of fixed and variable costs corresponded to 78.9% in soybeans, without the use of rocking. When the lowest dose was applied, the total operational cost corresponded to 80.2%, with an increase of 1.3% in the total operating cost. A variation of 2.5% was observed, from the lowest dose applied to the highest, representing 82.7% of total operational cost.

Rock dust costs correspond to 6.1% to 17.7% of the TOC value, as the dose increases, where, from 7.5 Mg ha-^{1}, it becomes the component with the highest value, when analyzing the costs of agricultural inputs. The result was expected because the cost of applying and purchasing rock powder averaged R$ 184.93; 369.85; 554.78 and 616.17 ha^{-1} in application, respectively, between doses of 2.5; 5.0; 7.5, and 8.33 Mg ha^{-1} (Table 1).

Inputs were responsible for 45.9% of the total cost when costs were evaluated, without the use of rock dust. However, with use, it becomes responsible for 49.2% of the total cost, with a dose of 2.5 Mg ha^{-1}, and reaches 55.5%, when applied 8.33 Mg ha^{-1}. Seeds and fertilizers are the components with the highest cost, providing a high percentage. The high value in the cost of seeds is due to the adoption of IPRO technology (resistance to glyphosate herbicide), reaching R$ 412.40 ha^{-1}, when compared to RR soybeans, with much lower values, around R$ 191.77, as forecast for the 2017/2018 harvest (GARCIA; RICHETTI, 2017).

The use of IPRO technology reduces costs related to the application of insecticides to control pests (eg, caterpillars and borers) during the study. The relationships established between the price of products are extremely important, as it is possible for the producer and/or the person in charge of technology to adequately plan the use of existing technologies.

TABLE 1 - Production costs (R$) of soybean cultivation, cultivar Monsoy 6410 IPRO, using rock dust (0; 2.5; 5.0; 7.5 and 8.33 Mg ha^{-1}), grown in Dourados (MS), harvest 2017/2018.

Costs, R$	Rates of rock dust (Mg ha^{-1})				
	0	2.5	5.0	7.5	8.33
Variable costs	2045.57	2230.50	2415.42	2600.35	2661.74
Soybean, seeds Monsoy 6410 IPRO	412.40	412.40	412.40	412.40	412.40
Inoculant	2.07	2.07	2.07	2.07	2.07
Rock dust	-	184.93	369.85	554.78	616.17
200 kg de 5-25-6	300.74	300.74	300.74	300.74	300.74
Herbicides	127.60	127.60	127.60	127.60	127.60
Insecticides	216.72	216.72	216.72	216.72	216.72
Fungicides	214.46	214.46	214.46	214.46	214.46
Adjuvants	33.55	33.55	33.55	33.55	33.55
Agricultural Operations	295.70	295.70	295.70	295.70	295.70
Administrative costs	442.33	442.33	442.33	442.33	442.33
Fixed costs	203.60	203.60	203.60	203.60	203.60
Maintenance of improvements	27.75	27.75	27.75	27.75	27.750
Depreciations	175.85	175.85	175.85	175.85	175.85
Total Operating Cost	2249.17	2434.10	2619.02	2803.95	2865.34
Factor Compensation	598.52	598.52	598.52	598.52	598.52
Total cost	2847.69	3032.62	3217.54	3402.47	3463.86

Data for the 2017/2018 harvest.

Soybean productivity

The average soybean productivity found without the use of rock dust was 2,618.23 kg ha^{-1}, representing a decrease of 35%, compared to the application with 8.33 Mg ha^{-1} (Figure 1). The application of rock dusty promoted an estimated productivity of 3,650.6 kg ha^{-1} (2.5 Mg ha^{-1}), 3,735.29 kg ha^{-1} (5.0 Mg ha^{-1}), 3,872.28 kg ha^{-1} (7.5 Mg ha^{-1}), 4,028 kg ha^{-1} (8.33 Mg ha^{-1}). The average productivity found in the present study corroborates Almeida Júnior et al. (2020), which monitored maximum productivity of 4,836 kg ha^{-1} (9.0 Mg ha^{-1}). Revenue from the sale of soybean production varied between R$ 2,881.48 and 4,433.00 bags^{-1} and the highest total revenue was seen with the highest dose of rock powder, with a value of 4,433.00 bags^{-1} (Figure 2).

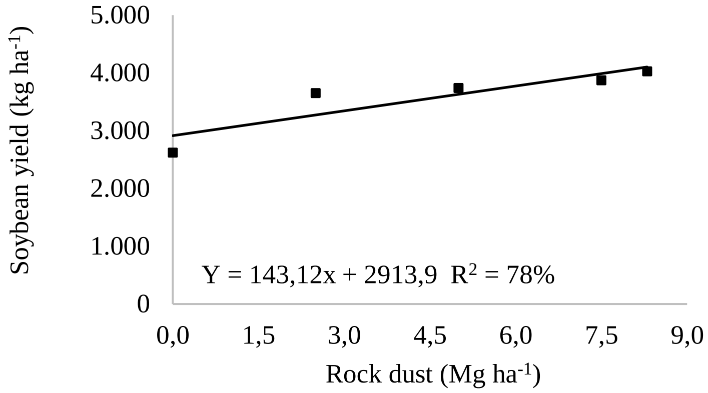

FIGURE 1 - Productivity of soybean cultivation, cultivar Monsoy 6410 IPRO, using rock dust (0; 2.5; 5.0; 7.5 and 8.33 Mg ha^{-1}), cultivated in Dourados (MS), in the 2017/2018 harvest.

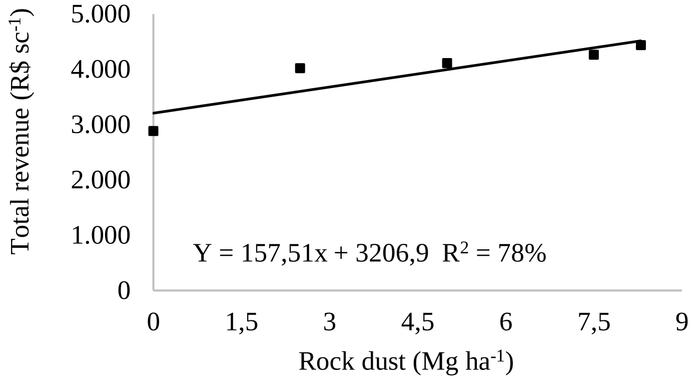

FIGURE 2 - Total revenue from soybean production, cultivar Monsoy 6410 IPRO, using rock dust (0; 2.5; 5.0; 7.5 and 8.33 Mg ha^{-1}), grown in Dourados (MS), in the 2017/2018 harvest. *To calculate total revenue, the value of a bag was considered to be R$ 66.03 ha^{-1} and a conversion of R$ 43.64; 60.84; 62.25; 64.54, and 67.13, for rock powder doses, respectively.

Economic indicators

When analyzing the effective operating cost, the gross margin was R$808.23, when there was no application of rock dust. When 2.5 Mg ha^{-1} and 8.33 Mg ha^{-1} of rock dust were applied, a higher margin of R$ 1,759.02 and R$ 1,743.10 (higher productivity) was obtained, respectively (Table 2). The gross margin values obtained in this study indicate that, even with the increase in costs caused by the application of basalt powder, the increase in productivity allows for a greater increase in revenue, so that the producer's margin is greater.

The leveling price was obtained with 31.40 bags, without the application of rock dust, 34.20 bags, with the use of 2.5 Mg ha^{-1}, and 40.73 bags, with a dose of 8.33 Mg ha^{-1}. This result indicates the quantity of soybean bags that will need to be produced per hectare, to pay off the effective operational cost. When the indicator in evidence analyzed is the leveling price, which corresponds to the sales value to guarantee the total operating cost, the values were R$47.51, R$37.12, and R$40.06, respectively. When analyzing the total operating costs, which are the effective operating costs, plus depreciation, this gross margin becomes R$632.38, without the application of rock dust. With the application of rock dust, the gross margin values are R$ 1,583.17 (2.5 Mg ha^{-1}) and R$ 1,567.25 (8.33 Mg ha^{-1}), to the point that, to pay off these values would require the production of 34.06 bags (without application), 36.86 bags (2.5 Mg ha^{-1}) and 43.39 bags (8.33 Mg ha^{-1}), reaching, respectively, the sales price in R$ 51.54, R$40.01 and R$42.68 per bag of soybeans.

When considering the cost of factor remuneration, the total cost is available, with all expenses paid, the net margin with soybeans was R$ 33.86 (without investment) and R$ 984.65 (2.5 Mg ha^{-1}), R$ 892.83 (5.0 Mg ha^{-1}), R$ 859.11 (7.5 Mg ha^{-1}) and R$ 968.73 (8.33 Mg ha^{-1}). For these values, production of 43.13 bags ha^{-1} (without application), 45.93 bags ha^{-1} (2.5 Mg ha^{-1}), 48.73 bags ha^{-1} (5.0 Mg ha^{-1}) would be required 51.53 bags ha^{-1} (7.5 Mg ha^{-1}) and 52.46 bags ha^{-1} (8.33 Mg ha^{-1}) and the leveling price, established at R$ 65.25, R$ 49.85, R$51.69, R$52.72 and R$51.60, respectively.

When analyzing this data, two important points are noticed: the first demonstrates that the increase in productivity when rock dust is applied, results in greater revenue when compared to not carrying out the application. The productivity ratio between non-application and the first dose of rock powder was 17 bags and the difference in total revenue reached R$ 1,135.72. Likewise, when analyzing costs, an increase is seen with the application of rock dust and a positive effect on gross and net margin, allowing an increase in income, when compared to not applying rock dust. Another point that should be noted is that the highest gross margin, best leveling price, and leveling point occurred with the application of 2.5 Mg ha^{-1} of rock dust, followed by 8.33 Mg ha^{-1}.

TABLE 2 - Economic indicators of soybean cultivation, cultivar Monsoy 6410 IPRO, using rock dust (0; 2.5; 5.0; 7.5 and 8.33 Mg ha^{-1}), cultivated in Dourados (MS), in the 2017/2018 harvest.

Costs, R$	Unit	Rates of rock dust (Mg ha^{-1})				
		0	2.5	5.0	7.5	8.33
Productivity	sc ha^{-1}	43.64	60.84	62.25	64.54	67.13
Price	R$ sc^{-1}	66.03	66.03	66.03	66.03	66.03
Total revenue	R$ ha^{-1}	2881.55	4017.27	4110.37	4261.58	4432.59
Effective Operating Cost	R$ ha^{-1}	2073.32	2258.25	2443.17	2628.10	2689.49
Leveling Point	sc ha^{-1}	31.40	34.20	37.00	39.80	40.73
Leveling Price	R$ ha^{-1}	47.51	37.12	39.25	40.72	40.06
Gross Margin	R$ ha^{-1}	808.23	1759.02	1667.20	1633.48	1743.10
Total Operating Cost	R$ ha^{-1}	2249.17	2434.10	2619.02	2803.95	2865.34
Leveling Point	scha^{-1}	34.06	36.86	39.66	42.46	43.39
Leveling Price	R$ ha^{-1}	51.54	40.01	42.07	43.45	42.68
Gross Margin	R$ ha^{-1}	632.38	1583.17	1491.35	1457.63	1567.25
Total cost	R$ ha^{-1}	2847.69	3032.62	3217.54	3402.47	3463.86
Leveling Point	sc ha^{-1}	43.13	45.93	48.73	51.53	52.46
Leveling Price	R$ ha^{-1}	65.25	49.85	51.69	52.72	51.60
Net margin	R$ ha^{-1}	33.86	984.65	892.83	859.11	968.73
Return rate	%	1.19	32.47	27.75	25.25	27.97

When analyzing the relationship between productivity and costs with the doses of rock powder applied, it can be seen that productivity was small, since the difference was 6 bags of soybeans between the lowest dose and the highest used, even though doses of 5.0 and 7.5 Mg ha^{-1} produced greater productivity and revenue than that of 2.5 Mg ha-1. Margins were lower, as the costs of applying rock dust practically tripled, with a cost per hectare of R$ 184.93 (2.5 Mg ha^{-1}), R$ 369.85 (5.0 Mg ha^{-1}), and R$ $554.78 (7.5 Mg ha^{-1}). Even though the dose of 8.33 Mg ha^{-1} has the highest cost related to the application of rock powder (R$ 616.17), the high productivity obtained justifies its better performance than 7.5 and 5.0 Mg ha^{-1}, and is still it's net and gross margins are almost equivalent to a dose of 2.5 Mg ha^{-1}.

When analyzing the rate of return, which demonstrates the relationship between net income and total cost, the rock powder application doses showed the following behavior: 1.19% (without application), 32.47% (2.5 Mg ha^{-1}), 27.75% (5.0 Mg ha^{-1}), 25.25% (7.5 Mg ha^{-1}) and 27.97 (8.33 Mg ha^{-1}). When comparing the percentages between applications of rock powder and without application, it can be stated that the increase in revenue was greater than the costs, justifying the use of rocking. Furthermore, it was observed that, even though the net and gross margins at doses of 2.5 and 8.33 Mg ha^{-1} were almost equivalent, the difference between the return rate was 4.5% higher for the first dose. With a return rate of 32.75%, the dose of 2.5 Mg ha^{-1} obtained the best economic result, about the economic viability of doses of rock dust, that is, for every R$ 1.00 spent on the application of 2.5 Mg ha^{-1} of rock dust, it is possible to generate R$ 0.32 in net income, while, without application, R$ 0.01 is obtained.

CONCLUSION

The application of rock powder positively influenced total revenue, as well as the gross margin and net margin of treatments, allowing a higher rate of return on the producer's investments.

The return rate was influenced by the application of rock dust, demonstrating that there was a positive analysis of the economic viability of using rock in soybean cultivation.

With the application of doses greater than 2.5 Mg ha^{-1} of rock dust, greater total revenue could be obtained between treatments, however, they were lower in the gross margin, net margin, leveling price, and leveling point components.

Application of up to 2.5 Mg ha^{-1} is a viable alternative to increase soybean profitability in the Dourados region, Mato Grosso do Sul.

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REFERENCES

ALMEIDA JÚNIOR, J.J.; BARBOSA, U.R.; LAZARINI, E.; MATOS, F.S.A.; MIRANDA, B.C.; SMILJANIC, K.B.A.; SILVA, V.J.A.; SILVA, A.R.; SIMON, G.A. Analise das variações tecnológicas na cultua da soja (*Glycine max*) com utilização de remineralizador de solo como fertilizantes. **Brazilian Journal of Development**, v.6, n.2, p.56835-56847, 2020.

ALOVISI, A.M.T.; ALOVISI, A.A.; CASSOL, C.J.; CERVI, R.F.; GNING, A.; GOMES, W.L.; MUGLIA, G.R.P.; RODRIGUES, R.B.; SILVA, J.A.M.; SILVA, R.S.; SOARES, M.S.P.; TELBAR, M.M.; VILLALBA, L.A. **Atributos químicos do solo e componentes agronômicos na cultura da soja pelo uso do pó de basalto**. p. 13-26. In: RIBEIRO, J.C. (Ed.). Impacto, excelência e produtividade das ciências agrárias no Brasil. 3ed. Atena, Ponta Grossa, Paraná, Brasil. 2020.

BRITO, R.S.D.; BATISTA, J.F.; MOREIRA, J.G.V.; MORAES, K.N.O.; SILVA, S.O. Rochagem na agricultuta: importância e vantagens para adubação suplementar. **South American Journal of Basic Education, Technical and Technological**, v.6, n.1, p.528-540, 2019.

CFEM. COMPENSAÇÃO FINANCEIRA PELA EXPLORAÇÃO DE RECURSOS MINERAIS. **Compensação Financeira pela Exploração Mineral.** Availabla at: <https://www.gov.br/anm/pt-br/acesso-a-informacao/perguntas-frequentes/contribuicao-financeira-pela-exploracao-mineral-2013-cfem>. Access in: 27 mar. 2023.

CONAB. COMPANHIA NACIONAL DE ABASTECIMENTO. **Produção nacional de grãos é estimada em 312,2 milhões de toneladas na safra 2022/23**. Available at: <https://www.conab.gov.br/ultimas-noticias/4847-producao-nacional-de-graos-e-estimada-em-312-2-milhoes-de-toneladas-na-safra-2022-23>. Access in: 27 mar. 2023.

FIETZ, C.R.; FISCH, G.F.; COMUNELLO, E.; FLUMIGNAN, D.L. **O clima da região de Dourados, MS.** Documentos, n.138. 3ed. Empresa Brasileira de Pesquisas Agropecuárias, Dourados, Mato Grosso do Sul, Brasil, 2017.

GARCIA, R.A.; RICHETTI, A. **Viabilidade econômica da cultura da soja para a safra 2017/2018, em Mato Grosso do Sul.** Comunicado Técnico, v.228, p.5, 2017.

IMEA. INSTITUTO MATO GROSSENSE DE ECONOMIA AGROPECUÁRIA. 2020. **Custo de produção soja convencional Mato Grosso**. Available at: <http://www.imea.com.br/imea-site/relatorios-mercado-detalhe?c=4&s=3>. Access in: 14 oct. 2022.

OLIVEIRA, M.P.; MALAGOLLI, G.A.; CELLA, D. Mercado de fertilizantes: dependência de importações do Brasil. **Revista Interface Tecnológica**, v.16, n.1, p.489-498, 2019.

RICHETTI, A. **Viabilidade econômica da cultura da soja para a safra 2019/2020, na região centro-sul de Mato Grosso do Sul.** Comunicado Técnico, v.251, p.1-7, 2019.

SANTOS, H.G.; ANJOS, L.H.C.; ALMEIDA, J.A.; COELHO, M.R.; CUNHA, T.J.F.; JACOMINE, P.K.T.; LUMBRERAS, J.F.; OLIVEIRA, V.A.; OLIVEIRA, J.B. **Sistema Brasileiro de Classificação de Solos.** 5ed. Brasília, Distrito Federal, Brasil, 2018.

WELTER, C.H.; CHAGAS, E.A.; GÓES, H.T.P.; MELO, V.F.; UCHÔA, S.C.P. Efeito da aplicação de pó de basalto no desenvolvimento inicial de mudas de camu-camu (*Myrciaria dubia*). **Revista Brasileira de Fruticultura**, v.33, [s.n.], p.922-933, 2011.