



# USE OF CONTROLLED RELEASE ORGANIC MINERAL FERTILIZER IN SOYBEAN CROP

## USO DE FERTILIZANTE ORGANOMINERAL DE LIBERAÇÃO GRADUAL DE NUTRIENTES NA CULTURA DA SOJA

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### ARTICLE INFO

Article history:

Received 2020-07-21

Accepted 2020-10-20

Available online 2020-10-20

#### palavras-chave

Fertilizante Organomineral

Fertilizante de Liberação Gradual

Fertilizante de Alta Performance

Adubação de Soja

#### keywords

Organic Mineral Fertilizer

Controlled Release Fertilizer

High Performance Fertilizer

Soybean Fertilization

### ABSTRACT

*This work aims to investigate the efficiency of a novel organic mineral fertilizer produced with filter cake residue from sugarcane mills. The novel fertilizer was developed based on the mixing of minerals with an organic compost, conditioning, and pelletizing of mixture. The minerals consist of conventional soluble mineral nutrients and the organic phase consists of insoluble filter cake compost obtained from an assisted composting process. Efficiency of conventional and organic mineral fertilizers was measured in real field soybean crop through a randomized block design with four replications. Variables analyzed were productivity, NPK nutrient in leaves. The experiment was carried out in Tupaciguara/MG, Brazil. Experimental results showed higher soybean productivity and leaf nitrogen content in the organic mineral treatments than mineral ones in all dosages tested, with statistical relevance for 80% and 100% NPK dosages.*

### RESUMO

*Este trabalho tem como objetivo investigar a eficiência de um novo fertilizante organomineral produzido com resíduos de torta de filtro de usinas de cana-de-açúcar. O novo fertilizante foi desenvolvido com base na mistura de minerais com composto orgânico, condicionamento e peletização da mistura. Os minerais consistem em nutrientes minerais solúveis convencionais e a fase orgânica consiste em composto insolúvel de torta de filtro, obtido a partir do processo de compostagem. A eficiência dos fertilizantes convencional e organomineral foi medida em campo na cultura da soja através de um delineamento em blocos casualizados com quatro repetições. As variáveis analisadas foram produtividade, teor de NPK nas folhas. O experimento foi realizado em Tupaciguara MG, Brasil. Os resultados experimentais mostraram maior produtividade da soja e teor de nitrogênio nas folhas nos tratamentos com organominerais do que nos tratamentos com minerais em todas as dosagens utilizadas, com diferença estatística para dosagens de 80% e 100% de NPK.*

## 1. INTRODUCTION

Nowadays organic residues from agricultural, municipal, and industrial sites have gain importance as raw material capable of improving soil conditions and increasing soil fertility (Tedesco et al., 2008). In sugarcane mills, for instance, about 30 kg of filter cake, 240 kg of sugarcane bagasse and 0.96 m<sup>3</sup> of stillage or vinasse are produced for each ton of sugar cane (Demattê, 1992). When disposed in inappropriate places these residues can pollute environment. However, when properly composted they can be used to make fertilizers for agricultural use. This type of fertilizer can improve soil fertility and increase crop yield.

Improvement in organic fertilizers can be obtained from mixture with soluble mineral fertilizers such as ammonium nitrate, urea, superphosphates, mono-ammonium phosphate, potassium chloride. Brazilian Ministry of Agriculture defines this mixture as organic mineral fertilizer. There is a specific regulation to produce and trade these fertilizers in Brazil (Brazil, 2009)

Organic fertilizer has much lower nutrient contents than mineral fertilizers. However, their solubilization is gradual over plant growing period and they can yield higher agronomic efficiency (Kiehl, 2008). However, there is a lack of long-term field experiments that allow a more accurate assessment of the agronomic efficiency of these fertilizers.

Technological evolution of the world agroindustry in recent years has provided significant increases in production and productivity, particularly in Brazil. However, nutrient supply by soil and water availability still stand out between the limiting factors of the productivity of Brazilian agriculture (Oliveira, 2011). The knowledge of the nutritional requirements of a crop consists of fundamental information capable of directing new methods and more effective forms of fertilization, indicating the actual amount of nutrients that must be provided (Coleti et al., 2006).

Studies on changes in the chemical properties of soil fertilized with organic mineral fertilizer and its influence on the production of crops are still incipient. Considering the beneficial effects of the organic matter on soil as well as its contribution to plant growth, the use of organic mineral fertilizer can be an important tool to improve soil fertility and crop yield.

Besides this, increasing costs of mineral fertilizer in the world have contributed for a higher demand for alternative fertilizers. As a consequence, Brazilian production of organic mineral fertilizer has increased in last decades (Dominguez, 2007). In order to contribute with more experimental results on efficiency of organic mineral fertilizer versus mineral fertilizer the authors tested a novel organic mineral fertilizer against conventional mineral fertilizer in soybean crop. Results support this alternative fertilizer is increasingly promising to increase soybean yield.

The organomineral fertilizer used in this study was supplied by the company Geociclo Biotecnologia S/A. This fertilizer has good NPK level, composted organic matter, superior mechanical properties such as high hardness, low dust

generation, high density, and uniform granule size. Technology used in manufacture of this fertilizer transforms it into a slow release fertilizer, which reduces leaching of mineral nutrients (nitrogen and potassium) and fixation of phosphate in the soil, increasing the agronomic efficiency of the fertilizer. A natural biodegradable organic polymer is used in manufacturing process of this fertilizer. This polymer and the pelletizing process are the key steps for providing the gradual release characteristic of the fertilizer. This polymer glues the minerals nutrients in the organic phase. So, the insoluble organic matrix protects the soluble mineral nutrients against excess of leaching and direct contact with soil clays and soil oxides. This protecting effect produces a slow-release effect that when it comes into contact with the soil it releases nutrients in a continuous and controlled fashion, reducing the possibility of losses by leaching and keep the plant up taking nutrients constantly throughout its growth cycle.

## 2. THE ORGANIC FERTILIZER DEVELOPED

The organic mineral fertilizer used in this work uses filter cake treated by assisted composting process. The residue is characterized chemically, physically, and microbiologically. Results are used in the elaboration of a protocol that involves the application of nutrients, culture medium and microbial inoculants that are added to the residue for its fast transformation into organic fertilizer.

The thermophilic process ends between 30 and 40 days. It solubilizes nutrients and decontaminates the residue. The organic compost obtained is used to produce the organic mineral. This producing process includes addition of a natural biodegradable organic polymer, appropriated conditions of temperature and pressure in pelletizing process. This process forces the mineral nutrients against organic matter forming a hard-organic matrix (pellet) involving mineral nutrients. As a consequence, the pellets acquire ability to release the nutrients progressively according to plant needs.

Main characteristic of this fertilizer is gradual release of nutrients caused by encapsulation of minerals in organic matrix. This process guarantees a significant reduction in loss of nutrients compared with traditional fertilizers, minimizing losses due to nitrogen volatilization, phosphate fixation and potassium and nitrate leaching, reducing groundwater contamination and emission of greenhouse gases, as well as the rational use of mineral inputs, reducing their environmental impact. Organic matter of this fertilizer also performs an important role as soil amended activating soil beneficial microbiota. This technology allows producing organic mineral fertilizer in large scale and reduces production costs. Figure 1 shows an aerial photo of the industrial plant and Figure 2 shows details of the filter cake treatment by assisted composting process developed.

In addition to assisted composting process used to treat the filter cake, the producing process continues with the pelletizing step. This step includes the use of a natural biodegradable organic polymer and transformation of mixture into hard pellets by using large pelletizer machines.



Figure 1 - Photo of the organic mineral plant. Assisted composting buildings are in the background and pelletizing buildings of the organic mineral are in the foreground.



Figure 2 - Details of the filter cake treatment by using the assisted composting process.

### 3. MATERIALS AND METHODS

The field experiment was carried out in HZ farm in Tupaciguara city, Minas Gerais State, Brazil. The soybean cultivar used was the “*Valiosa*”. The experimental design used was the randomized blocks with four replications. The treatments were control (no fertilizer at seeding), mineral fertilizer (formula 04-20-20) at dosage of 400 kg/ha, organic mineral fertilizer (formula 03-15-15) at dosages of 214, 320, 427 and 543 kg/ha. These organic mineral dosages represent 40, 60, 80 and 100% NPK content of the mineral treatment, respectively. Each experimental plot had eight cultivation lines spaced 0.5 m from each other and 100 m long, adding up to 400 m<sup>2</sup>. Soil of the experimental area was classified as red latosol of medium texture, with pH in water of 5.3, 49 mg/dm<sup>3</sup> of phosphorus (resin), 155 mg/dm<sup>3</sup> of potassium; 1.9 cmol/dm<sup>3</sup> of calcium, 0.9 cmol/dm<sup>3</sup> of magnesium, 2.2 cmol/dm<sup>3</sup> (H + Al), 59% base saturation (V) and 3.3 dag/kg of organic matter. Soil pH correction was not necessary because base saturation was greater than 50%. The treatments were aleatory chosen at the moment of the soybean seeding. A mechanized traction seeder was used. The stand used was 18 seeds per meter. The harvest was carried out 130 days after seeding. The variables analyzed were the crop yield and nitrogen, phosphorus, and potassium contents in leaves. A variance analysis of experimental data were carried out by using the Sisvar® software (Ferreira, 2008) and the Statistical Package for the Social Sciences software (SPSS Inc.) released 2008.

### 4. RESULTS AND DISCUSSION

The harvest of the plots was carried out after 130 days after seeding. Production of each plot was weighted, and data were statistically treated. Leaf samples were taken after 60 days from seeding in order to measure the nutrient leaf contents. Figures 3 shows a sequence of photos from some plots. This sequence reveals good expectation of the performance of organic mineral fertilizer concerning performance of mineral fertilizer. Plants seem to be more developed in plots treated with organic mineral fertilizer. Table 1 and Figure 3 show productivity data of each plots. Results from this table confirm a better performance of organic mineral fertilizer than mineral fertilizer. Soybean yields in treatments fertilized with organic mineral were higher in all NPK dosages than treatment fertilized with mineral fertilizer (Figure 3). Organic mineral treatments that were fertilized with 80% and 100% of NPK content of the mineral treatment presented statistical difference with the mineral and control treatments (Table 1).

Regression analysis between soybean yield and organic mineral dosages was performed in order to get equivalent dosage between both fertilizers. Figure 4 show the results. Inspection of regression equation of soybean yield versus organic mineral dosage shown in Figure 4 reveals a dosage of 201.4 kg/ha of organic mineral fertilizer would yield 2634 kg/ha of soybean. Summing up, 400 kg/ha of 04-20-20 mineral fertilizer yielded 2634 kg/ha of soybean, and 201.4 kg/ha of 03-

15-15 organic mineral fertilizer would yield the same 2634 kg/ha of soybean. In this dosage, organic mineral has only 37,8% of NPK content of mineral fertilizer. In other words, using 37,8% of NPK in this organic mineral fertilizer is equivalent to use 100% of NPK in a mineral fertilizer. This remarkable equivalence is due to protection of the mineral phase imposed by hard organic matrix. Organic matrix likely prevented excessive potassium leaching and phosphate fixation. This result is important to producers because it allows a production cost reduction and a crop yield improvement by using this organic mineral fertilizer.

Table 1 - Soybean yield as a function of type and dosage of fertilizer (Tupaciguara/MG, Brazil).

Fertilizer	Dosage (kg/ha)	Yield (kg/ha)
Control	0	1914 <sup>a</sup>
Mineral (04-20-10)	400	2634 <sup>b</sup>
Organic mineral (03-20-20)	214	2778 <sup>b</sup>
Organic mineral (03-20-20)	320	2838 <sup>b, c</sup>
Organic mineral (03-20-20)	427	2898 <sup>c</sup>
Organic mineral (03-20-20)	534	3090 <sup>c</sup>

Mean yields followed by different letters in the columns differ each other by the Tukey test at 5% significance.

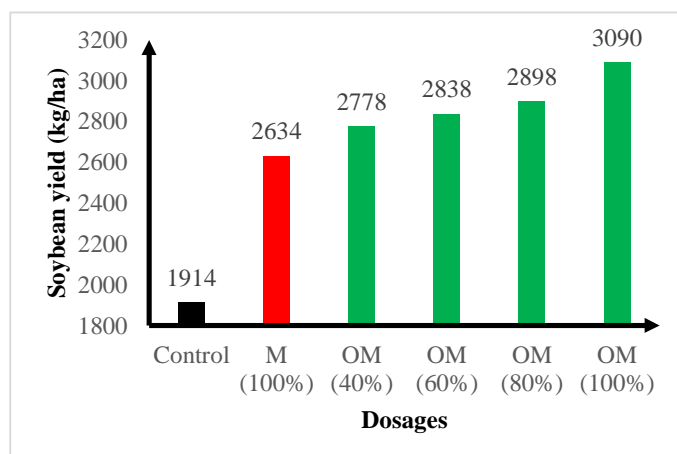


Figure 3 - Soybean yields as a function of type and dosage of fertilizer.

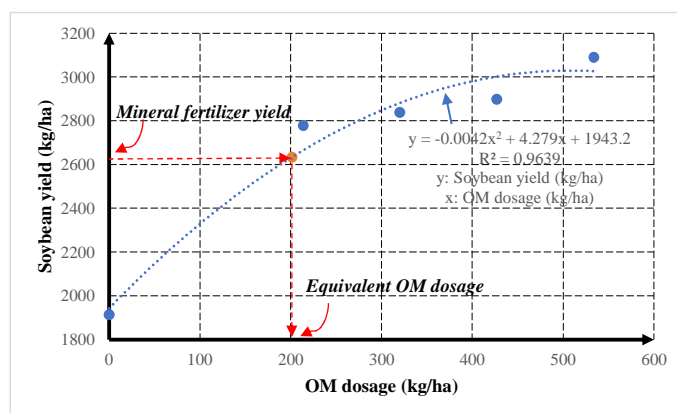


Figure 4 - Analysis of regression of soybean yields versus organic mineral dosage.



Figure 3 – Photos from plots: (a) control (no fertilizer), (b) 400 kg/ha of the mineral fertilizer 04-20-20, (c) 214 kg/ha of the organic mineral fertilizer 03-15-15, (d) 310 kg/ha of the organic mineral fertilizer 03-15-15, (e) 427 kg/ha of the organic mineral fertilizer 03-15-15, and (f) 520 kg/ha of the organic mineral fertilizer 03-15-15.

In addition, leaf nutrient content was also measured after 60 days from seeding. Table 2 show results. It is possible to note from this table that there is no statistical difference among treatments neither for type nor dosage of fertilizers concerning leaf K<sub>2</sub>O contents. In terms of phosphate, only in highest organic mineral dosage the leaf P<sub>2</sub>O<sub>5</sub> content was higher than control and mineral treatments with statistical difference. In terms of nitrogen, the leaf N contents in organic mineral treatments were statistically higher than control and mineral treatments. These data reveal a greater nitrogen up take by soybean in treatments fertilized with organic mineral than those fertilized with

mineral. This effect is most likely associated with the presence of organic matter in the organomineral fertilizer that enhances the performance of beneficial soil microorganisms (Kiehl, 1985 and 1999).

Therefore, it is possible to conclude that, in spite of lower NPK dosage in treatments fertilized with organic mineral, the soybean in all treatments did not present deficiencies of leaf NPK contents. In the contrary, the leaf N content was higher in treatments fertilized with organic mineral fertilizer.

**Table 2 - Leaf NPK content as a function of type and dosage of the fertilizer.**

Fertilizer	Dosage (kg/ha)	N (g/kg)	P (g/kg)	K (g/kg)
Control	0	38.8 <sup>b</sup>	2.3 <sup>b</sup>	18.0 <sup>a</sup>
Mineral (04-20-10)	400	38.8 <sup>b</sup>	2.6 <sup>a, b</sup>	19.0 <sup>a</sup>
Organic mineral (03-20-20)	214	51.3 <sup>a</sup>	2.7 <sup>a, b</sup>	18.8 <sup>a</sup>
Organic mineral (03-20-20)	320	46.8 <sup>a, b</sup>	2.5 <sup>a, b</sup>	16.0 <sup>a</sup>
Organic mineral (03-20-20)	427	48.3 <sup>a</sup>	2.8 <sup>a, b</sup>	17.0 <sup>a</sup>
Organic mineral (03-20-20)	543	51.8 <sup>a</sup>	3.1 <sup>a</sup>	19.5 <sup>a</sup>
Minimal Significant Difference		MSD <sub>N</sub> = 8.7	MSD <sub>P</sub> = 0.6	MSD <sub>K</sub> = 6.5
Coefficient of variation		CV= 8.3 %	CV= 10.01 %	CV= 15.8 %

## 5. CONCLUSION

Results from this experiment showed the soybean had increasing yields due to increasing dosages of the organic mineral fertilizer. The soybean yields in treatments that were fertilized with organic mineral fertilizer were higher than treatment that was fertilized with mineral fertilizer in all dosages tested. The statistical analysis showed an agronomic equivalence between 201.4 kg/ha of organic mineral 03-15-15 and 400 kg/ha of mineral 04-20-20. There were also increases in nitrogen content in soybean leaves in treatments that received organic mineral fertilizer concerning treatment that received mineral fertilizer.

Results of this agronomic experiment support the higher efficiency of the organic mineral fertilizer than mineral fertilizer to fertilize soybean. This greater efficiency is likely due to the prevention of losses and the effect of the gradual release of nutrients from this organic mineral fertilizer, provided by protection of the hard-organic matrix of the pellets. The presence of organic matter also had a positive impact on soybean yields.

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